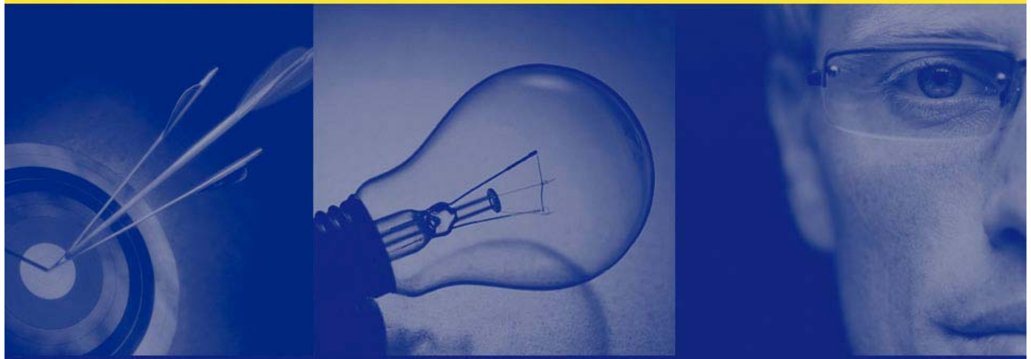
# SQL Tuning via Toad



*Tips for Optimizing SQL Performance*

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## Bert Scalzo …

**Database Expert & Product Architect for Quest Software**

Oracle Background:

- Worked with Oracle databases for over two decades (starting with version 4)
- Work history includes time at both “Oracle Education” and “Oracle Consulting”

Academic Background:

- Several Oracle Masters certifications
- BS, MS and PhD in Computer Science
- MBA (general business)
- Several insurance industry designations

Key Interests:

- Data Modeling
- Database Benchmarking
- Database Tuning & Optimization
- "Star Schema" Data Warehouses
- Oracle on Linux – and specifically: RAC on Linux

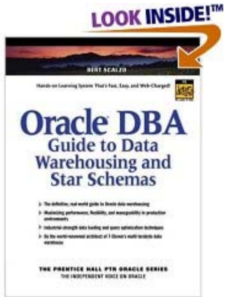
Articles for:

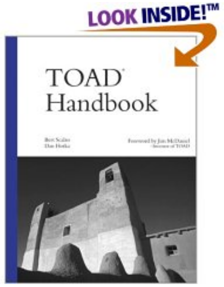
- Oracle’s Technology Network (OTN)
- Oracle Magazine,
- Oracle Informant
- PC Week (eWeek)

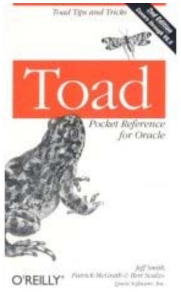
Articles for:

- Dell Power Solutions Magazine
- The Linux Journal
- www.linux.com
- www.orafaq.com

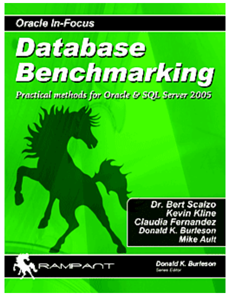
## Books by Bert …

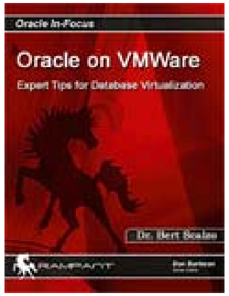

LOOK INSIDE!™
Oracle DBA Guide to Data Warehousing and Star Schemas
BERT SCALZO
THE PRENTICE HALL PTR ORACLE SERIES

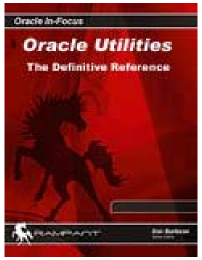




***Coming in 2009*** **…**





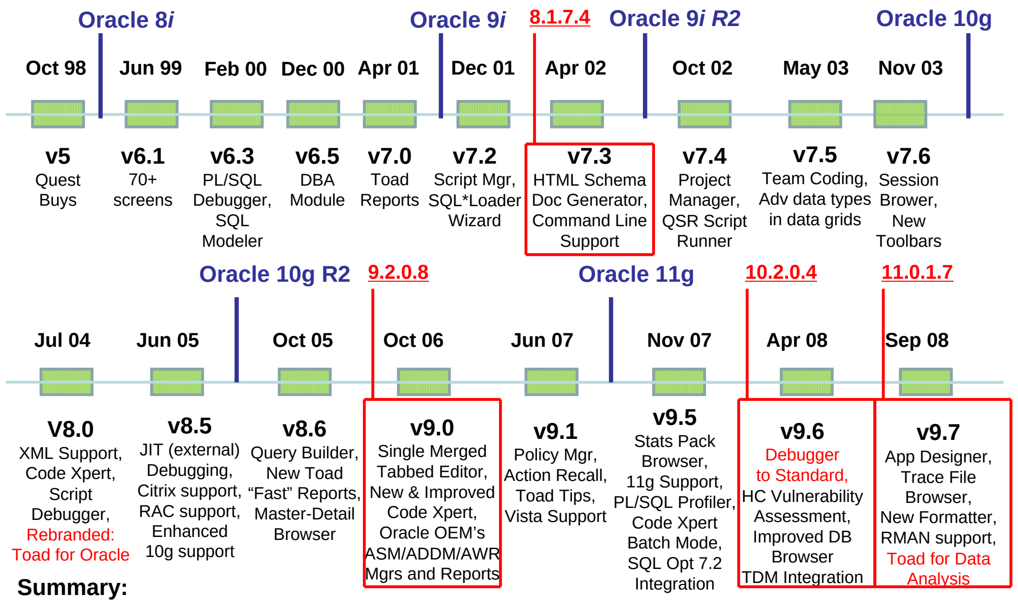


**Also: FREE Toad e-Book for Toad 10…**

# Topics …

- Pre-Reqs
  - Correct Toad vs. Oracle Database Server version
  - Correct Oracle SQL*Net Client networking version
  - SQL Tuning Approach – much more than just explain plans and run times
- Explain Plans
  - Setup and effective use of the ”Explain Plan”
  - Be careful, Explain Plan costs can sometimes not be the best way to pick the winner - sometimes (auto) trace is required to be 100% sure
  - Some guidelines on how to best or at least more easily read SQL explain plans - which is the general starting point for any SQL tuning attempt
- SQL Tuning Rules
  - Some Guidelines i.e. (“Golden Rules”) – just the tip of the iceberg
    - Efficient and fast selects & sub selects
    - Dealing with large tables
    - Parallel Hints
      Pinning SQL in Memory
    - Efficient SQL queries that use a lot of AND conditionals or sub-queries
    - How to avoid full-table scans
- Is There a Better (i.e. more productive) Way to Tune SQL
  - SQL Optimzier – automate all the above (and much more)

# Toad vs. Oracle Product Release History



Oracle 8*i* | Oracle 9*i* | 8.1.7.4 | Oracle 9*i R2* | Oracle 10g

Oct 98 — v5 Quest Buys

Jun 99 — v6.1 70+ screens

Feb 00 — v6.3 PL/SQL Debugger, SQL Modeler

Dec 00 — v6.5 DBA Module

Apr 01 — v7.0 Toad Reports

Dec 01 — v7.2 Script Mgr, SQL*Loader Wizard

Apr 02 — v7.3 HTML Schema Doc Generator, Command Line Support

Oct 02 — v7.4 Project Manager, QSR Script Runner

May 03 — v7.5 Team Coding, Adv data types in data grids

Nov 03 — v7.6 Session Brower, New Toolbars

Oracle 10g R2 | 9.2.0.8 | Oracle 11g | 10.2.0.4 | 11.0.1.7

Jul 04 — V8.0 XML Support, Code Xpert, Script Debugger, Rebranded: Toad for Oracle

Jun 05 — v8.5 JIT (external) Debugging, Citrix support, RAC support, Enhanced 10g support

Oct 05 — v8.6 Query Builder, New Toad "Fast" Reports, Master-Detail Browser

Oct 06 — v9.0 Single Merged Tabbed Editor, New & Improved Code Xpert, Oracle OEM's ASM/ADDM/AWR Mgrs and Reports

Jun 07 — v9.1 Policy Mgr, Action Recall, Toad Tips, Vista Support

Nov 07 — v9.5 Stats Pack Browser, 11g Support, PL/SQL Profiler, Code Xpert Batch Mode, SQL Opt 7.2 Integration

Apr 08 — v9.6 Debugger to Standard, HC Vulnerability Assessment, Improved DB Browser TDM Integration

Sep 08 — v9.7 App Designer, Trace File Browser, New Formatter, RMAN support, Toad for Data Analysis

**Summary:**

**Oracle 9i >= Toad 9.0 Oracle 10g >= Toad 9.6 Oracle 11g >= Toad 9.7**

# Oracle Client / Server Interoperability Support
(See Metalink Document **207303.1**)

| | Server Version | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Client Version | 11.1.0 | 10.2.0 | 10.1.0 | 9.2.0 | 9.0.1 | 8.1.7 | 8.1.6 | 8.1.5 | 8.0.6 | 8.0.5 | 7.3.4 |
| 11.1.0 | Yes | Yes #6 | Yes #6 | ES #5 | No | No | No #3 | No #3 | No #3 | No #3 | No #3 |
| 10.2.0 | Yes #6 | Yes | Yes | ES #5 | No | Was | No #3 | No #3 | No #3 | No #3 | No #3 |
| 10.1.0(#4) | Yes #6 | Yes | Yes | ES | Was | Was #2 | No #3 | No #3 | No #3 | No #3 | No #3 |
| 9.2.0 | ES #5 | ES #5 | ES | ES | Was | Was | No | No | Was | No | No #1 |
| 9.0.1 | No | No | Was | Was | Was | Was | Was | No | Was | No | Was |
| 8.1.7 | No | Was | Was | Was | Was | Was | Was | Was | Was | Was | Was |
| 8.1.6 | No | No | No | No | Was | Was | Was | Was | Was | Was | Was |
| 8.1.5 | No | No | No | No | No | Was | Was | Was | Was | Was | Was |
| 8.0.6 | No | No | No | Was | Was | Was | Was | Was | Was | Was | Was |
| 8.0.5 | No | No | No | No | No | Was | Was | Was | Was | Was | Was |
| 7.3.4 | No | No | No | Was | Was | Was | Was | Was | Was | Was | Was |

Key:

| | |
|---|---|
| Yes | Supported |
| ES | Supported but fixes only possible for customers with Extended Support . |
| Was | Was a supported combination but one of the releases is no longer covered by any of Premier Support , Primary Error Correct support , Extended Support nor Extended Maintenance Support so fixes are no longer possible. |
| No | Has never been Supported |

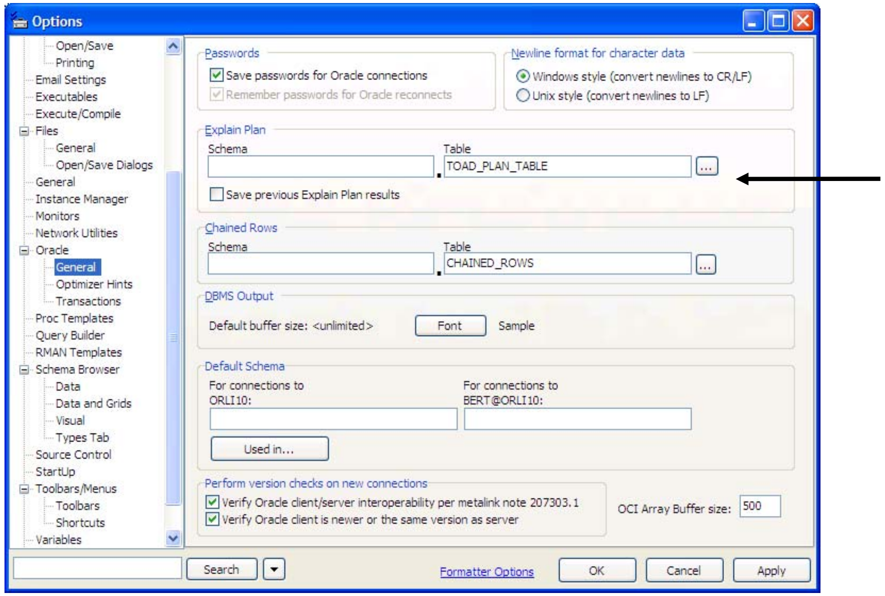
Toad may work with older client talking to newer databases - but there might be data type issues ☹

# Seven Steps for SQL Tuning Success

1. Always start by knowing (i.e. being able to say in English) what the query does
2. For queries involving more than 2 tables, a data model can be a handy road map
3. Explain plan costs alone may well lead you astray – sometimes the costs can lie
4. Sometimes equal execution times don't necessarily equate to equivalent solutions
5. You should always include (auto) trace information to divine among all the above
6. Sole reliance on automatic SQL optimization and tuning tools can be suboptimal
7. You must add human intuition and insight to the optimization process for success

# Explain Plans

- Explain Plans are the standard Oracle mechanism to peek into the possible "internal algorithm" the database engine might execute for the query (think of it as sort of like program pseudo-code)
- Explain Plans generally require an Oracle "plan table" to hold the explain plan intermediate results
  - Three Options here:
    - Central "plan table" for all users to share – managed by DBA
    - "Plan table" per schema – but be careful if users all login the same
    - "Plan table" per session -
- When doing explain plans manually
  - Method #1
    - EXPLAIN FOR SELECT * FROM emp;
    - SELECT … FROM plan_table WHERE … (fairly complex SQL)
  - Method #2
    - EXPLAIN FOR SELECT * FROM emp;
    - SELECT * FROM table(DBMS_XPLAN.DISPLAY(PLAN_TABLE));



Passwords

☑ Save passwords for Oracle connections

☑ Remember passwords for Oracle reconnects

Newline format for character data

● Windows style (convert newlines to CR/LF)

○ Unix style (convert newlines to LF)

Explain Plan

Schema:

Table: TOAD_PLAN_TABLE

□ Save previous Explain Plan results

Chained Rows

Schema:

Table: CHAINED_ROWS

DBMS Output

Default buffer size: <unlimited>   Font   Sample

Default Schema

For connections to ORLI10:

For connections to BERT@ORLI10:

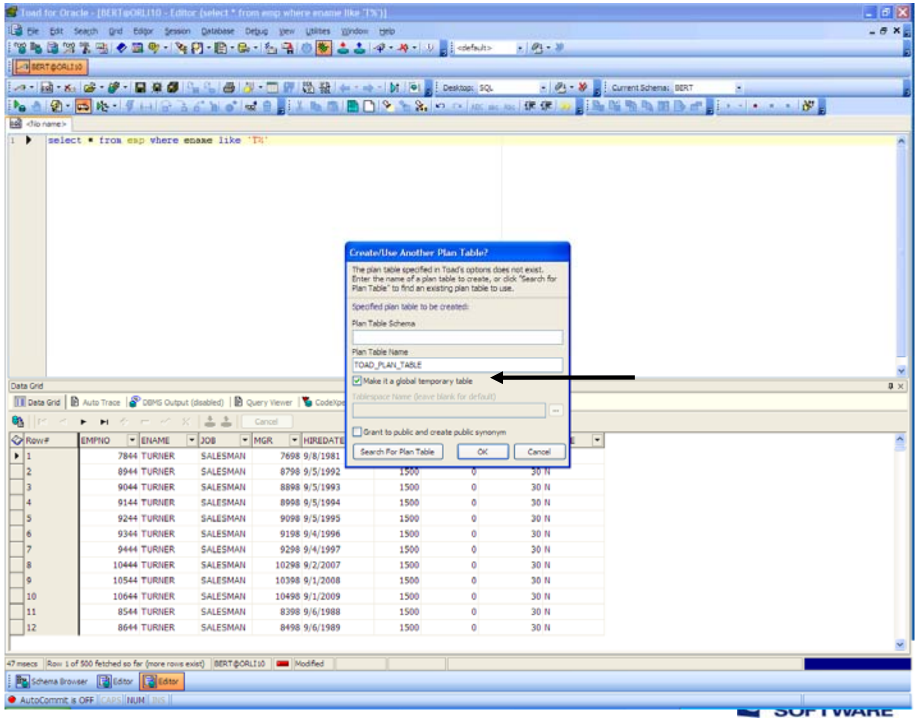
Used in...

Perform version checks on new connections

☑ Verify Oracle client/server interoperability per metalink note 207303.1

☑ Verify Oracle client is newer or the same version as server

OCI Array Buffer size: 500


Toad for Oracle - [BERT@ORLI10 - Editor (select * from emp where ename like 'T%')]

```
select * from emp where ename like 'T%'
```

Create/Use Another Plan Table?

The plan table specified in Toad's options does not exist. Enter the name of a plan table to create, or click "Search for Plan Table" to find an existing plan table to use.

Specified plan table to be created:

Plan Table Schema:

Plan Table Name: TOAD_PLAN_TABLE

☑ Make it a global temporary table

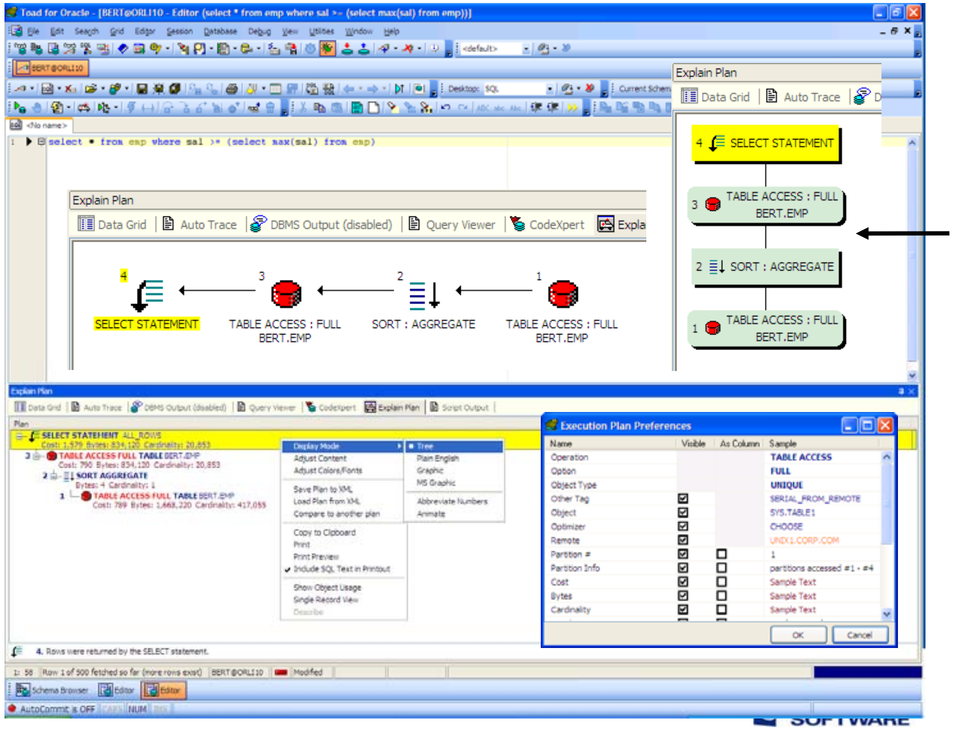
Tablespace Name (leave blank for default)

□ Grant to public and create public synonym

| Row# | EMPNO | ENAME | JOB | MGR | HIREDATE | | | |
|---|---|---|---|---|---|---|---|---|
| 1 | 7844 | TURNER | SALESMAN | 7698 | 9/8/1981 | | | |
| 2 | 8944 | TURNER | SALESMAN | 8798 | 9/5/1992 | 1500 | 0 | 30 N |
| 3 | 9044 | TURNER | SALESMAN | 8898 | 9/5/1993 | 1500 | 0 | 30 N |
| 4 | 9144 | TURNER | SALESMAN | 8998 | 9/5/1994 | 1500 | 0 | 30 N |
| 5 | 9244 | TURNER | SALESMAN | 9098 | 9/5/1995 | 1500 | 0 | 30 N |
| 6 | 9344 | TURNER | SALESMAN | 9198 | 9/4/1996 | 1500 | 0 | 30 N |
| 7 | 9444 | TURNER | SALESMAN | 9298 | 9/4/1997 | 1500 | 0 | 30 N |
| 8 | 10444 | TURNER | SALESMAN | 10298 | 9/2/2007 | 1500 | 0 | 30 N |
| 9 | 10544 | TURNER | SALESMAN | 10398 | 9/1/2008 | 1500 | 0 | 30 N |
| 10 | 10644 | TURNER | SALESMAN | 10498 | 9/1/2009 | 1500 | 0 | 30 N |
| 11 | 8544 | TURNER | SALESMAN | 8398 | 9/6/1988 | 1500 | 0 | 30 N |
| 12 | 8644 | TURNER | SALESMAN | 8498 | 9/6/1989 | 1500 | 0 | 30 N |

47 msecs | Row 1 of 500 fetched so far (more rows exist) | BERT@ORLI10 | Modified

AutoCommit is OFF | CAPS | NUM | INS


Toad for Oracle - [BERT@ORLI10 - Editor (select * from emp where sal >= (select max(sal) from emp))]

```
select * from emp where sal >= (select max(sal) from emp)
```

```
Plan
SELECT STATEMENT ALL_ROWS
Cost: 1,579 Bytes: 834,120 Cardinality: 20,853
  3 TABLE ACCESS FULL TABLE BERT.EMP
    Cost: 790 Bytes: 834,120 Cardinality: 20,853
    2 SORT AGGREGATE
      Bytes: 4 Cardinality: 1
      1 TABLE ACCESS FULL TABLE BERT.EMP
        Cost: 789 Bytes: 1,668,220 Cardinality: 417,055
```

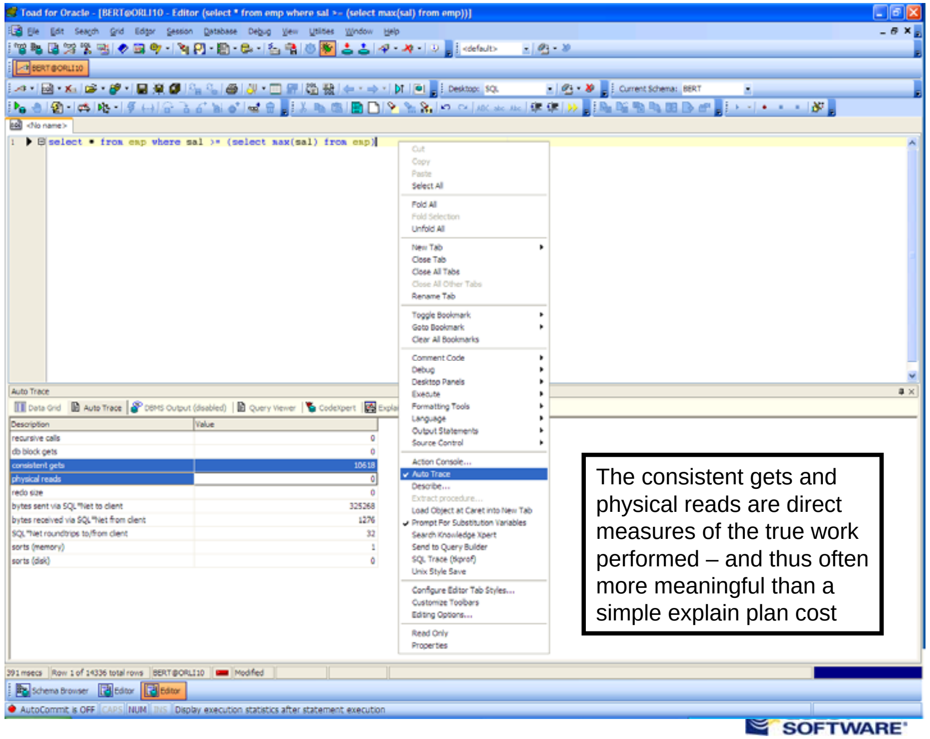
4. Rows were returned by the SELECT statement.

Execution Plan Preferences

| Name | Visible | As Column | Sample |
|---|---|---|---|
| Operation | | | TABLE ACCESS |
| Option | | | FULL |
| Object Type | | | UNIQUE |
| Other Tag | ☑ | | SERIAL_FROM_REMOTE |
| Object | ☑ | | SYS.TABLE1 |
| Optimizer | ☑ | | CHOOSE |
| Remote | ☑ | | UNIX1.CORP.COM |
| Partition # | ☑ | □ | 1 |
| Partition Info | ☑ | □ | partitions accessed #1 - #4 |
| Cost | ☑ | □ | Sample Text |
| Bytes | ☑ | □ | Sample Text |
| Cardinality | ☑ | □ | Sample Text |

1: 58 | Row 1 of 500 fetched so far (more rows exist) | BERT@ORLI10 | Modified

AutoCommit is OFF | CAPS | NUM | INS


Toad for Oracle - [BERT@ORLI10 - Editor (select * from emp where sal >= (select max(sal) from emp))]

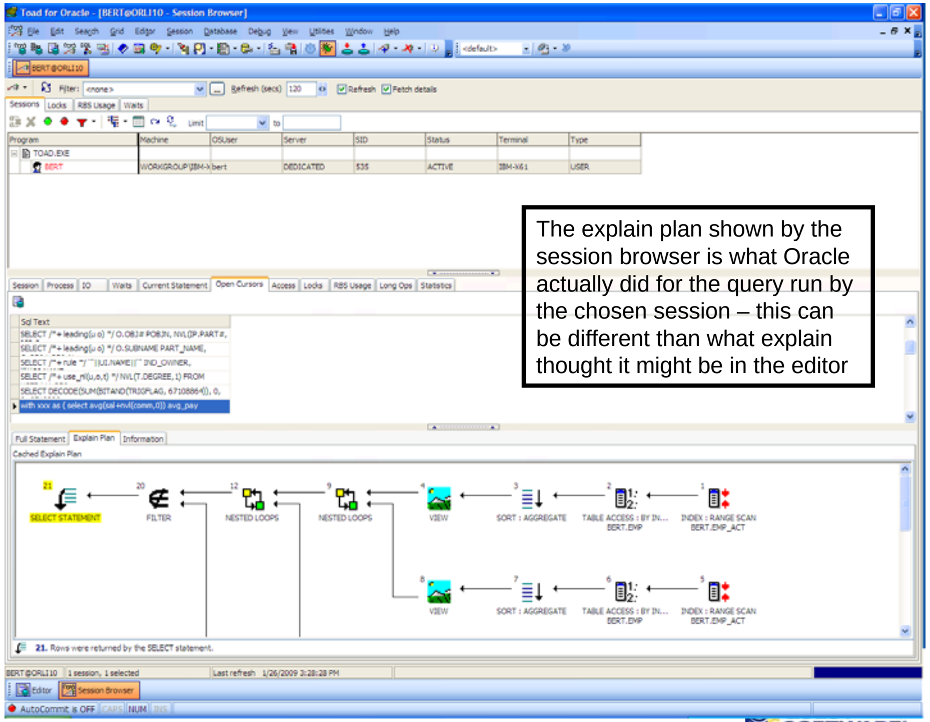
```
select * from emp where sal >= (select max(sal) from emp)
```

| Description | Value |
|---|---|
| recursive calls | 0 |
| db block gets | 0 |
| consistent gets | 10618 |
| physical reads | 0 |
| redo size | 0 |
| bytes sent via SQL*Net to client | 325268 |
| bytes received via SQL*Net from client | 1276 |
| SQL*Net roundtrips to/from client | 32 |
| sorts (memory) | 1 |
| sorts (disk) | 0 |

391 msecs | Row 1 of 14336 total rows | BERT@ORLI10 | Modified

AutoCommit is OFF | CAPS | NUM | INS | Display execution statistics after statement execution

The consistent gets and physical reads are direct measures of the true work performed – and thus often more meaningful than a simple explain plan cost



Toad for Oracle - [BERT@ORLI10 - Session Browser]

Filter: <none> Refresh (secs) 120 ☑ Refresh ☑ Fetch details

| Program | Machine | OSUser | Server | SID | Status | Terminal | Type |
|---|---|---|---|---|---|---|---|
| TOAD.EXE | | | | | | | |
| BERT | WORKGROUP\IBM-X | bert | DEDICATED | 535 | ACTIVE | IBM-X61 | USER |

| Sql Text |
|---|
| SELECT /*+ leading(u o) */ O.OBJ# POBJN, NVL(IP.PART#, |
| SELECT /*+ leading(u o) */ O.SUBNAME PART_NAME, |
| SELECT /*+ rule */ '"'\|\|UI.NAME\|\|'"' IND_OWNER, |
| SELECT /*+ use_nl(u,o,t) */ NVL(T.DEGREE,1) FROM |
| SELECT DECODE(SUM(BITAND(TRIGFLAG, 67108864)), 0, |
| with xxx as ( select avg(sal+nvl(comm,0)) avg_pay |

Cached Explain Plan

21. Rows were returned by the SELECT statement.

BERT@ORLI10 1 session, 1 selected Last refresh 1/26/2009 3:28:28 PM

AutoCommit is OFF

The explain plan shown by the session browser is what Oracle actually did for the query run by the chosen session – this can be different than what explain thought it might be in the editor

# SQL Guidelines

## Rule #1: Watch Indexed WHERE Conditions

**Assume address index has columns (city, state)**

| | |
|---|---|
| •non-leading index column references may not use indexes | |
| •where state = 'TX' | [Depends Oracle on Version] |
| •where city = 'DALLAS' | **[Index Used]** |
| •where state = 'TX' **and** city = 'DALLAS' | **[Index Used]** |
| •NOT, != and <> disable index use | |
| •where state not in ('TX', 'FL','OH') | [Index Not used] |
| •where state != 'TX' | [Index Not used] |
| •NULL value references almost never use indexes (one exception - bitmaps) | |
| •where state IS NULL | [Index Not used] |
| •where state IS NOT NULL | [Index Not used] |
| •expression references can never use indexes | |
| •where substr(city,1,3) = 'DAL' | [Index Not used] |
| •where city like 'DAL%' | **[Index Used]** |
| •where city \|\| state = 'DALLASTX' | [Index Not used] |
| •where city = 'DALLAS' **and** state = 'TX' | **[Index Used]** |
| •where salary * 12 >= 24000 | [Index Not used] |
| •where salary >= 2000 | **[Index Used]** |

# SQL Guidelines

## Rule #2: Watch Non-Indexed WHERE Conditions

•Oracle evaluates Non-Indexed conditions linked by **“AND”** bottom up

•**Bad:** select * from address where
areacode = 972 **and**
type_nr = (select seq_nr from code_table where type = ‘HOME’)

•**Good:** select * from address where
type_nr = (select seq_nr from code_table where type = ‘HOME’) **and**
areacode = 972

•Oracle evaluates Non-Indexed conditions linked by **“OR”** top down

•**Bad:** select * from address where
type_nr = (select seq_nr from code_table where type = ‘HOME’) **or**
areacode = 972

•**Good:** select * from address where
areacode = 972 **or**
type_nr = (select seq_nr from code_table where type = ‘HOME’)

# SQL Guidelines

## Rule #3: Order Table in the FROM Clause (pre-10g)

•important under rule based optimizer, and won't hurt under cost based optimizer

•order FROM clauses in descending order of table sizes based upon row counts

•for example

•select * from larger table, smaller table

•select * from larger table, smaller table, smallest table

•select * from larger table, smaller table, associative table

***Note – rule based optimizer only (pre-10g)***

# SQL Guidelines

## Rule #4: Consider IN or UNION in place of OR

- if columns are not indexed, stick with OR

- if columns are indexed, use IN or UNION in place of OR

  - IN example

```
•Bad: select * from address where
                 state = 'TX' or
                 state = 'FL' or
                 state = 'OH'
•Good: select * from address where
                 state in ('TX','FL','OH')
```

  - UNION example

```
•Bad: select * from address where
                 state = 'TX' or
                 areacode = 972
•Good: select * from address where
                 state = 'TX'
         union
         select * from address where
                 areacode = 972
```

# SQL Guidelines

## Rule #5: Weigh JOIN versus EXISTS Sub-Query

- use table JOIN instead of EXISTS sub-query

  - when the <u>percentage of rows returned from the outer sub-query is high</u>

```
select  e.name, e.phone, e.mailstop
from   employee e, department d
where e.deptno = d.deptno
   and d.status = 'ACTIVE'
```

- use EXISTS sub-query instead of table JOIN

  - when the <u>percentage of rows returned from the outer sub-query is low</u>

```
select e.name, e.phone, e.mailstop
from employee e
where e.deptno in (select  d.deptno
                   from   department d
                   where d.status != 'ACTIVE')
```

# SQL Guidelines

## Rule #6: Consider EXISTS in place of DISTINCT

- avoid joins that use DISTINCT, use EXISTS sub-query instead

```
•Bad: select distinct deptno, deptname from emp, dept where
              emp.deptno = dept.deptno

•Good: select deptno, deptname from dept where
              exists (select 'X' from emp where
                          emp.deptno = dept.deptno)
```

*Note – only has to find one match*

# SQL Guidelines

## Rule #7: Consider NOT EXISTS in place of NOT IN

- avoid sub-queries that use NOT IN, use NOT EXISTS instead

```
•Bad: select * from emp where
              deptno not in (select deptno from dept where
                                 deptstatus = 'A')

•Good: select * from emp where
              not exists (select 'X' from dept where
                                 deptstatus = 'A' and
                                 dept.deptno = emp.deptno)
```

*Note – only has to find one non-match*

# SQL Guidelines

## Rule #8: Ordering Via the WHERE Clause

- a dummy WHERE clause referencing an indexed column will
  - retrieve all records in ascending order (descending for 8i descending index)
  - not perform a costly sort operation

- **Bad:** select * from address
  **order by** city

- **Good:** select * from address where
  city > ‘’

# SQL Guidelines

## Rule #9: Use PL/SQL to reduce network traffic

- Utilize PL/SQL to group related SQL commands and thereby reduce network traffic

- **Bad:**

```
select city_name, state_code
   into :v_city, :v_sate
   from zip_codes where zip_code = ‘75022’;

insert into customer (‘Bert Scalzo’,’75022’, :v_city, v_state);
```

- **Good:**

```
begin
   select city_name, state_code
      into :v_city, :v_sate
      from zip_codes where zip_code = ‘75022’;
   insert into customer (‘Bert Scalzo’,’75022’, :v_city, v_state);
end;
/
```

# SQL Guidelines

## Rule #10: Partition Large Tables and Indexes

- **Partition Elimination**

- **Partition-Wise Join (requires Parallel too)**

- NOTE: Do not expect that merely partitioning will solve some major performance problem, it should merely make an incremental improvement to a non-partitioned explain plan. Read that as partitioning can make an already good explain plan even better.

# Partitioning Benefits: Opinion (Mine)

| | |
|---|---|
| Manageability | 40% |
| Availability | 20% |
| Capacity Management | 20% |
| **Performance** | **20%** |

Why to Partition

- Don’t over-sell/over-expect the performance aspect
- Need to experiment for best approach for a database
- Better to take longer at the start to get right, because very often it’s far too expensive to change afterwards

# Partition Pruning (Restriction Based) ☆

- From Docs: In partition pruning, the optimizer analyzes FROM and WHERE clauses in SQL statements to eliminate unneeded partitions when building the partition access list. This enables Oracle Database to perform operations only on those partitions that are relevant ...
- "Divide and Conquer" for performance
  - Sometimes can yield order of magnitude improvement
  - But once again, best not to oversell and/or over-expect
- Some Potential Issues to be aware of:
  - SQL*Plus Auto-Trace can sometimes miss partition pruning
  - "Old Style" Explain Plans via simple SELECT has issues too
  - Best to always use **DBMS_XPLAN** and/or **SQL_TRACE** ←

# Partition-Wise Join (Multi-Object Based) ☆

- From Docs: Partition-wise joins reduce query response time by minimizing the amount of data exchanged among parallel execution servers when joins execute in parallel. This significantly reduces response time & improves the use of both CPU & memory resources.
- Different Flavors:
  - Full – Single to Single
  - Full – Composite to Single
  - Full – Composite to Composite
  - Partial – Single
  - Partial – Composite
- Indexing Strategy Counts
  - Local Prefixed/Non-Prefixed
  - Global

All of these affect the explain plan

# Picture Worth 1000 Words (from Docs)

Simple Mantra: Subdivide the work into equally paired chunks, then perform all that work using many parallel processes

*Figure 4-1 Parallel Execution of a Full Partition-wise Join*

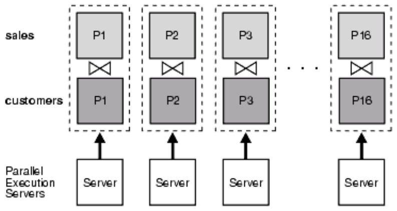
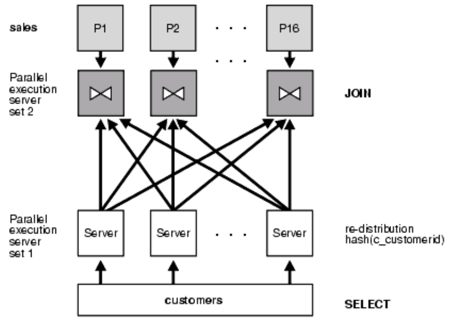


*Figure 4-3 Partial Partition-Wise Join*


sales
P1
P2
P16
Parallel execution server set 2
JOIN
Parallel execution server set 1
Server
Server
Server
re-distribution hash(c_customerid)
customers
SELECT

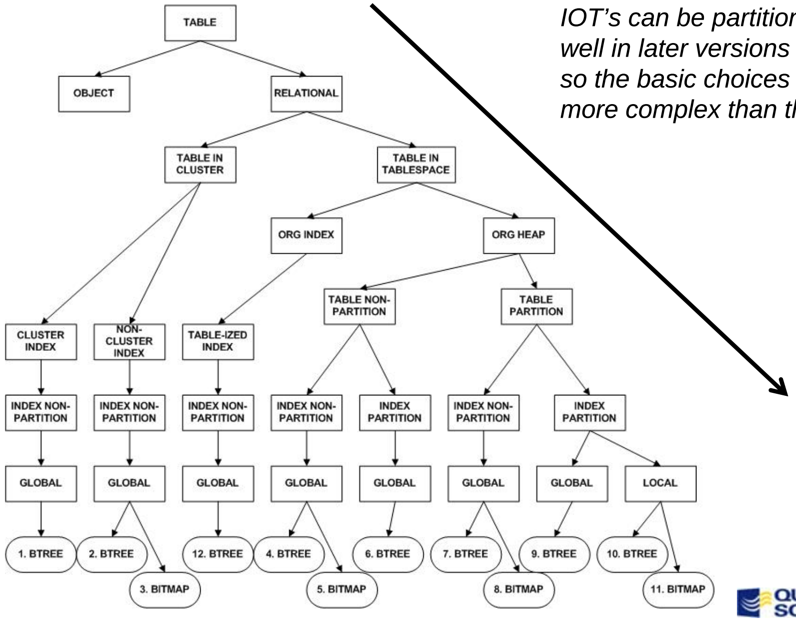
Make sure not to over-allocate CPU's – remember there will also be concurrent workload

# Partitioning History (from Oracle 11G training+)

| | |
|---|---|
| Oracle 5 | Before Tablespaces – we had partitions ☺ ← |
| Oracle 7 | Partition Views – really more of a cheat ☹ ← |

| | Core functionality | Performance | Manageability |
|---|---|---|---|
| **Oracle8** | Range partitioning<br>Global range indexes | "Static" partition pruning | Basic maintenance operations: add, drop, exchange |
| **Oracle8*i*** | Hash and composite range-hash partitioning | Partition-wise joins<br>"Dynamic" pruning | Merge operation |
| **Oracle9*i*** | List partitioning | | Global index maintenance |
| **Oracle9*i* R2** | Composite range-list partitioning | Fast partition split | |
| **Oracle10*g*** | Global hash indexes | | Local Index maintenance |
| **Oracle10*g* R2** | 1M partitions per table | "Multi-dimensional" pruning | Fast drop table |
| **Oracle Database 11*g*** | More composite choices<br>REF Partitioning<br>Virtual Column | | Interval Partitioning<br>Partition Advisor |

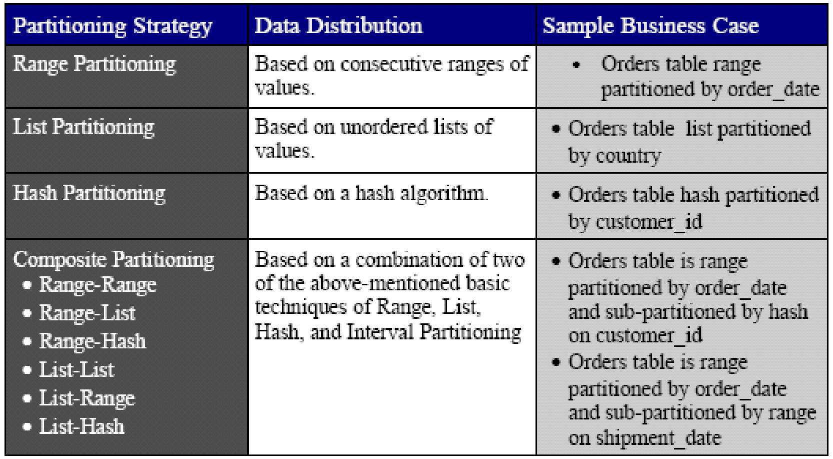
# Partitioning Options – Part 1



*IOT's can be partitioned as well in later versions of Oracle, so the basic choices are even more complex than this…*

# Partitioning Options – Part 2

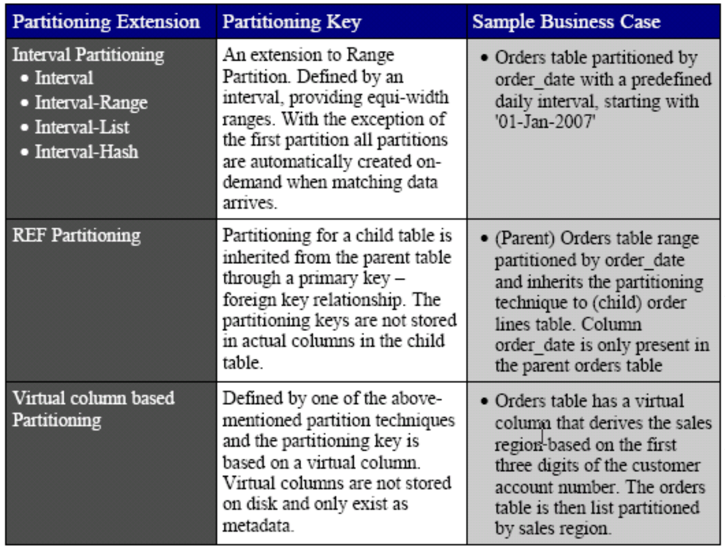
**Prior to 11G:** Oracle White Paper: 2007 Partitioning in Oracle Database 11g



| Partitioning Strategy | Data Distribution | Sample Business Case |
|---|---|---|
| Range Partitioning | Based on consecutive ranges of values. | • Orders table range partitioned by order_date |
| List Partitioning | Based on unordered lists of values. | • Orders table list partitioned by country |
| Hash Partitioning | Based on a hash algorithm. | • Orders table hash partitioned by customer_id |
| Composite Partitioning<br>• Range-Range<br>• Range-List<br>• Range-Hash<br>• List-List<br>• List-Range<br>• List-Hash | Based on a combination of two of the above-mentioned basic techniques of Range, List, Hash, and Interval Partitioning | • Orders table is range partitioned by order_date and sub-partitioned by hash on customer_id<br>• Orders table is range partitioned by order_date and sub-partitioned by range on shipment_date |

# Partitioning Options – Part 3

**Post 11G:** Oracle White Paper: 2007 Partitioning in Oracle Database 11g



| Partitioning Extension | Partitioning Key | Sample Business Case |
|---|---|---|
| Interval Partitioning<br>• Interval<br>• Interval-Range<br>• Interval-List<br>• Interval-Hash | An extension to Range Partition. Defined by an interval, providing equi-width ranges. With the exception of the first partition all partitions are automatically created on-demand when matching data arrives. | • Orders table partitioned by order_date with a predefined daily interval, starting with '01-Jan-2007' |
| REF Partitioning | Partitioning for a child table is inherited from the parent table through a primary key – foreign key relationship. The partitioning keys are not stored in actual columns in the child table. | • (Parent) Orders table range partitioned by order_date and inherits the partitioning technique to (child) order lines table. Column order_date is only present in the parent orders table |
| Virtual column based Partitioning | Defined by one of the above-mentioned partition techniques and the partitioning key is based on a virtual column. Virtual columns are not stored on disk and only exist as metadata. | • Orders table has a virtual column that derives the sales region based on the first three digits of the customer account number. The orders table is then list partitioned by sales region. |

*Very exciting new options…*

```
------------------------------------------------------------------------------------------------------
|  Operation                           |  Name                 |  Rows | Bytes|  Cost  | Pstart| Pstop |
------------------------------------------------------------------------------------------------------
| SELECT STATEMENT                     |                       |     1 |  154 |     34 |       |       |
|  SORT GROUP BY                       |                       |     1 |  154 |     34 |       |       |
|   HASH JOIN                          |                       |     1 |  154 |     29 |       |       |
|    TABLE ACCESS BY INDEX ROWID       | DW_ORDER              |     1 |   95 |     17 |       |       |
|     BITMAP CONVERSION TO ROWIDS      |                       |       |      |        |       |       |
|      BITMAP AND                      |                       |       |      |        |       |       |
|       BITMAP MERGE                   |                       |       |      |        |       |       |
|        BITMAP KEY ITERATION          |                       |       |      |        |       |       |
|         TABLE ACCESS BY INDEX ROWID  | DW_PERIOD             |     1 |   51 |      2 |       |       |
|          BITMAP CONVERSION TO ROWIDS |                       |       |      |        |       |       |
|           BITMAP AND                 |                       |       |      |        |       |       |
|            BITMAP INDEX SINGLE VALUE | DW_PERIOD_B03         |       |      |        |       |       |
|            BITMAP INDEX SINGLE VALUE | DW_PERIOD_B12         |       |      |        |       |       |
|         BITMAP INDEX RANGE SCAN      | DW_ORDER_B1           |       |      |        |       |       |
|       BITMAP MERGE                   |                       |       |      |        |       |       |
|        BITMAP KEY ITERATION          |                       |       |      |        |       |       |
|         TABLE ACCESS BY INDEX ROWID  | DW_LOCATION           |     1 |   46 |      2 |       |       |
|          BITMAP CONVERSION TO ROWIDS |                       |       |      |        |       |       |
|           BITMAP AND                 |                       |       |      |        |       |       |
|            BITMAP INDEX SINGLE VALUE | DW_LOCATION_B03       |       |      |        |       |       |
|            BITMAP INDEX SINGLE VALUE | DW_LOCATION_B41       |       |      |        |       |       |
|         BITMAP INDEX RANGE SCAN      | DW_ORDER_B2           |       |      |        |       |       |
|       BITMAP MERGE                   |                       |       |      |        |       |       |
|        BITMAP KEY ITERATION          |                       |       |      |        |       |       |
|         TABLE ACCESS BY INDEX ROWID  | DW_PRODUCT            |    17 |   1K|     10 |       |       |
|          BITMAP CONVERSION TO ROWIDS |                       |       |      |        |       |       |
|           BITMAP AND                 |                       |       |      |        |       |       |
|            BITMAP INDEX SINGLE VALUE | DW_PRODUCT_B03        |       |      |        |       |       |
|            BITMAP OR                 |                       |       |      |        |       |       |
|             BITMAP INDEX SINGLE VALUE| DW_PRODUCT_B14        |       |      |        |       |       |
|             BITMAP INDEX SINGLE VALUE| DW_PRODUCT_B14        |       |      |        |       |       |
|         BITMAP INDEX RANGE SCAN      | DW_ORDER_B3           |       |      |        |       |       |
|    TABLE ACCESS BY INDEX ROWID       | DW_PRODUCT            |    17 |   1K|     10 |       |       |
|     BITMAP CONVERSION TO ROWIDS      |                       |       |      |        |       |       |
|      BITMAP AND                      |                       |       |      |        |       |       |
|       BITMAP INDEX SINGLE VALUE      | DW_PRODUCT_B03        |       |      |        |       |       |
|       BITMAP OR                      |                       |       |      |        |       |       |
|        BITMAP INDEX SINGLE VALUE     | DW_PRODUCT_B14        |       |      |        |       |       |
|        BITMAP INDEX SINGLE VALUE     | DW_PRODUCT_B14        |       |      |        |       |       |
------------------------------------------------------------------------------------------------------
```

Non-Partitioned, Non-Parallel explain plan

```
--------------------------------------------------------------------------------------------------------
|  Operation                            |  Name                |  Rows | Bytes|  Cost  | Pstart| Pstop |
--------------------------------------------------------------------------------------------------------
| SELECT STATEMENT                      |                      |     1 |  154 |     35 |       |       |
|  SORT GROUP BY                        |                      |     1 |  154 |     35 |       |       |
|   SORT GROUP BY                       |                      |     1 |  154 |     35 |       |       |
|    HASH JOIN                          |                      |     1 |  154 |     30 |       |       |
|     PARTITION RANGE ALL               |                      |       |      |        |      1 |     10 |
|      TABLE ACCESS BY LOCAL INDEX ROWID| DW_ORDER_PART        |     0 |   20 |     18 |      1 |     10 |
|       BITMAP CONVERSION TO ROWIDS     |                      |       |      |        |       |       |
|        BITMAP AND                     |                      |       |      |        |       |       |
|         BITMAP MERGE                  |                      |       |      |        |       |       |
|          BITMAP KEY ITERATION         |                      |       |      |        |       |       |
|           SORT BUFFER                 |                      |       |      |        |       |       |
|            TABLE ACCESS BY INDEX ROWID| DW_PERIOD            |     1 |   51 |      2 |       |       |
|             BITMAP CONVERSION TO ROWID|                      |       |      |        |       |       |
|              BITMAP AND               |                      |       |      |        |       |       |
|               BITMAP INDEX SINGLE VALU| DW_PERIOD_B03        |       |      |        |       |       |
|               BITMAP INDEX SINGLE VALU| DW_PERIOD_B12        |       |      |        |       |       |
|           BITMAP INDEX RANGE SCAN     | DW_ORDER_PART_B1     |       |      |        |      1 |     10 |
|         BITMAP MERGE                  |                      |       |      |        |       |       |
|          BITMAP KEY ITERATION         |                      |       |      |        |       |       |
|           SORT BUFFER                 |                      |       |      |        |       |       |
|            TABLE ACCESS BY INDEX ROWID| DW_LOCATION          |     1 |   46 |      2 |       |       |
|             BITMAP CONVERSION TO ROWID|                      |       |      |        |       |       |
|              BITMAP AND               |                      |       |      |        |       |       |
|               BITMAP INDEX SINGLE VALU| DW_LOCATION_B03      |       |      |        |       |       |
|               BITMAP INDEX SINGLE VALU| DW_LOCATION_B41      |       |      |        |       |       |
|           BITMAP INDEX RANGE SCAN     | DW_ORDER_PART_B2     |       |      |        |      1 |     10 |
|         BITMAP MERGE                  |                      |       |      |        |       |       |
|          BITMAP KEY ITERATION         |                      |       |      |        |       |       |
|           SORT BUFFER                 |                      |       |      |        |       |       |
|            TABLE ACCESS BY INDEX ROWID| DW_PRODUCT           |    17 |    1K|     10 |       |       |
|             BITMAP CONVERSION TO ROWID|                      |       |      |        |       |       |
|              BITMAP AND               |                      |       |      |        |       |       |
|               BITMAP INDEX SINGLE VALU| DW_PRODUCT_B03       |       |      |        |       |       |
|               BITMAP OR               |                      |       |      |        |       |       |
|                BITMAP INDEX SINGLE VAL| DW_PRODUCT_B14       |       |      |        |       |       |
|                BITMAP INDEX SINGLE VAL| DW_PRODUCT_B14       |       |      |        |       |       |
|           BITMAP INDEX RANGE SCAN     | DW_ORDER_PART_B3     |       |      |        |      1 |     10 |
|     TABLE ACCESS BY INDEX ROWID       | DW_PRODUCT           |    17 |    1K|     10 |       |       |
|      BITMAP CONVERSION TO ROWIDS      |                      |       |      |        |       |       |
|       BITMAP AND                      |                      |       |      |        |       |       |
|        BITMAP INDEX SINGLE VALUE      | DW_PRODUCT_B03       |       |      |        |       |       |
|        BITMAP OR                      |                      |       |      |        |       |       |
|         BITMAP INDEX SINGLE VALUE     | DW_PRODUCT_B14       |       |      |        |       |       |
|         BITMAP INDEX SINGLE VALUE     | DW_PRODUCT_B14       |       |      |        |       |       |
--------------------------------------------------------------------------------------------------------
```

Partitioned, Non-Parallel explain plan

# SQL Guidelines

## Rule #11: Serial Explain Plans, then Parallel (maybe)

- **Parallel Full Table Scan**

- **Parallel Index Scan**

- **Parallel Fast Full Scan (FFS Index Scan)**

- NOTE: Do not expect that merely parallelizing will solve some major performance problem, it should merely make an incremental improvement to a non-paralell (i.e. serial) explain plan. Read that as parallel can make an already good explain plan even better.

- Parallel processing is controlled as follows:
  - Query has /*+parallel*/ hint
    - Some shops do NOT favor hints
      - What if database version changes
      - What happens if statistics change
      - Other questionable future scenarios
    - Cannot add hints to pre-canned applications
  - Object (table or index) has parallel degree
  - Database instance parameter for parallel
- For RAC, parallel can also span the RAC nodes too

```
-------------------------------------------------------------------------------------------------------
|  Operation                           |  Name                |  Rows | Bytes|  Cost  | Pstart| Pstop |
-------------------------------------------------------------------------------------------------------
| SELECT STATEMENT                     |                      |     1 |  154 |     34 |       |       |
|  SORT GROUP BY                       |                      |     1 |  154 |     34 |       |       |
|   HASH JOIN                          |                      |     1 |  154 |     29 |       |       |
|    TABLE ACCESS BY INDEX ROWID       | DW_ORDER             |     1 |   95 |     17 |       |       |
|     BITMAP CONVERSION TO ROWIDS      |                      |       |      |        |       |       |
|      BITMAP AND                      |                      |       |      |        |       |       |
|       BITMAP MERGE                   |                      |       |      |        |       |       |
|        BITMAP KEY ITERATION          |                      |       |      |        |       |       |
|         TABLE ACCESS BY INDEX ROWID  | DW_PERIOD            |     1 |   51 |      2 |       |       |
|          BITMAP CONVERSION TO ROWIDS |                      |       |      |        |       |       |
|           BITMAP AND                 |                      |       |      |        |       |       |
|            BITMAP INDEX SINGLE VALUE | DW_PERIOD_B03        |       |      |        |       |       |
|            BITMAP INDEX SINGLE VALUE | DW_PERIOD_B12        |       |      |        |       |       |
|         BITMAP INDEX RANGE SCAN      | DW_ORDER_B1          |       |      |        |       |       |
|       BITMAP MERGE                   |                      |       |      |        |       |       |
|        BITMAP KEY ITERATION          |                      |       |      |        |       |       |
|         TABLE ACCESS BY INDEX ROWID  | DW_LOCATION          |     1 |   46 |      2 |       |       |
|          BITMAP CONVERSION TO ROWIDS |                      |       |      |        |       |       |
|           BITMAP AND                 |                      |       |      |        |       |       |
|            BITMAP INDEX SINGLE VALUE | DW_LOCATION_B03      |       |      |        |       |       |
|            BITMAP INDEX SINGLE VALUE | DW_LOCATION_B41      |       |      |        |       |       |
|         BITMAP INDEX RANGE SCAN      | DW_ORDER_B2          |       |      |        |       |       |
|       BITMAP MERGE                   |                      |       |      |        |       |       |
|        BITMAP KEY ITERATION          |                      |       |      |        |       |       |
|         TABLE ACCESS BY INDEX ROWID  | DW_PRODUCT           |    17 |    1K|     10 |       |       |
|          BITMAP CONVERSION TO ROWIDS |                      |       |      |        |       |       |
|           BITMAP AND                 |                      |       |      |        |       |       |
|            BITMAP INDEX SINGLE VALUE | DW_PRODUCT_B03       |       |      |        |       |       |
|            BITMAP OR                 |                      |       |      |        |       |       |
|             BITMAP INDEX SINGLE VALUE| DW_PRODUCT_B14       |       |      |        |       |       |
|             BITMAP INDEX SINGLE VALUE| DW_PRODUCT_B14       |       |      |        |       |       |
|         BITMAP INDEX RANGE SCAN      | DW_ORDER_B3          |       |      |        |       |       |
|    TABLE ACCESS BY INDEX ROWID       | DW_PRODUCT           |    17 |    1K|     10 |       |       |
|     BITMAP CONVERSION TO ROWIDS      |                      |       |      |        |       |       |
|      BITMAP AND                      |                      |       |      |        |       |       |
|       BITMAP INDEX SINGLE VALUE      | DW_PRODUCT_B03       |       |      |        |       |       |
|       BITMAP OR                      |                      |       |      |        |       |       |
|        BITMAP INDEX SINGLE VALUE     | DW_PRODUCT_B14       |       |      |        |       |       |
|        BITMAP INDEX SINGLE VALUE     | DW_PRODUCT_B14       |       |      |        |       |       |
-------------------------------------------------------------------------------------------------------
```

Non-Partitioned, Non-Parallel explain plan

```
-----------------------------------------------------------------------------------------------------------------------------
|  Operation                             |  Name                  |  Rows | Bytes|  Cost  |  TQ  |IN-OUT| PQ Distrib | Pstart| Pstop |
-----------------------------------------------------------------------------------------------------------------------------
| SELECT STATEMENT                       |                        |     1 |  154 |     34 |      |      |            |       |       |
|  SORT GROUP BY                         |                        |     1 |  154 |     34 | 2,03 | P->S | QC (RANDOM)|       |       |
|   SORT GROUP BY                        |                        |     1 |  154 |     34 | 2,02 | P->P | HASH       |       |       |
|    HASH JOIN                           |                        |     1 |  154 |     29 | 2,02 | PCWP |            |       |       |
|     TABLE ACCESS BY INDEX ROWID        | DW_ORDER               |     1 |   95 |     17 | 2,01 | P->P | HASH       |       |       |
|      BITMAP CONVERSION TO ROWIDS       |                        |       |      |        |      |      |            |       |       |
|       BITMAP AND                       |                        |       |      |        |      |      |            |       |       |
|        BITMAP MERGE                    |                        |       |      |        |      |      |            |       |       |
|         BITMAP KEY ITERATION           |                        |       |      |        |      |      |            |       |       |
|          TABLE ACCESS BY INDEX ROWID   | DW_PERIOD              |     1 |   51 |      2 |      |      |            |       |       |
|           BITMAP CONVERSION TO ROWIDS  |                        |       |      |        |      |      |            |       |       |
|            BITMAP AND                  |                        |       |      |        |      |      |            |       |       |
|             BITMAP INDEX SINGLE VALUE  | DW_PERIOD_B03          |       |      |        |      |      |            |       |       |
|             BITMAP INDEX SINGLE VALUE  | DW_PERIOD_B12          |       |      |        |      |      |            |       |       |
|          BITMAP INDEX RANGE SCAN       | DW_ORDER_B1            |       |      |        |      |      |            |       |       |
|        BITMAP MERGE                    |                        |       |      |        |      |      |            |       |       |
|         BITMAP KEY ITERATION           |                        |       |      |        |      |      |            |       |       |
|          TABLE ACCESS BY INDEX ROWID   | DW_LOCATION            |     1 |   46 |      2 |      |      |            |       |       |
|           BITMAP CONVERSION TO ROWIDS  |                        |       |      |        |      |      |            |       |       |
|            BITMAP AND                  |                        |       |      |        |      |      |            |       |       |
|             BITMAP INDEX SINGLE VALUE  | DW_LOCATION_B03        |       |      |        |      |      |            |       |       |
|             BITMAP INDEX SINGLE VALUE  | DW_LOCATION_B41        |       |      |        |      |      |            |       |       |
|          BITMAP INDEX RANGE SCAN       | DW_ORDER_B2            |       |      |        |      |      |            |       |       |
|        BITMAP MERGE                    |                        |       |      |        |      |      |            |       |       |
|         BITMAP KEY ITERATION           |                        |       |      |        |      |      |            |       |       |
|          TABLE ACCESS BY INDEX ROWID   | DW_PRODUCT             |    17 |   1K|     10 |      |      |            |       |       |
|           BITMAP CONVERSION TO ROWIDS  |                        |       |      |        |      |      |            |       |       |
|            BITMAP AND                  |                        |       |      |        |      |      |            |       |       |
|             BITMAP INDEX SINGLE VALUE  | DW_PRODUCT_B03         |       |      |        |      |      |            |       |       |
|             BITMAP OR                  |                        |       |      |        |      |      |            |       |       |
|              BITMAP INDEX SINGLE VALUE| DW_PRODUCT_B14         |       |      |        |      |      |            |       |       |
|              BITMAP INDEX SINGLE VALUE| DW_PRODUCT_B14         |       |      |        |      |      |            |       |       |
|          BITMAP INDEX RANGE SCAN       | DW_ORDER_B3            |       |      |        |      |      |            |       |       |
|     TABLE ACCESS BY INDEX ROWID        | DW_PRODUCT             |    17 |   1K|     10 | 2,00 | S->P | HASH       |       |       |
|      BITMAP CONVERSION TO ROWIDS       |                        |       |      |        |      |      |            |       |       |
|       BITMAP AND                       |                        |       |      |        |      |      |            |       |       |
|        BITMAP INDEX SINGLE VALUE       | DW_PRODUCT_B03         |       |      |        |      |      |            |       |       |
|        BITMAP OR                       |                        |       |      |        |      |      |            |       |       |
|         BITMAP INDEX SINGLE VALUE      | DW_PRODUCT_B14         |       |      |        |      |      |            |       |       |
|         BITMAP INDEX SINGLE VALUE      | DW_PRODUCT_B14         |       |      |        |      |      |            |       |       |
-----------------------------------------------------------------------------------------------------------------------------
```

Non-Partitioned, Parallel explain plan

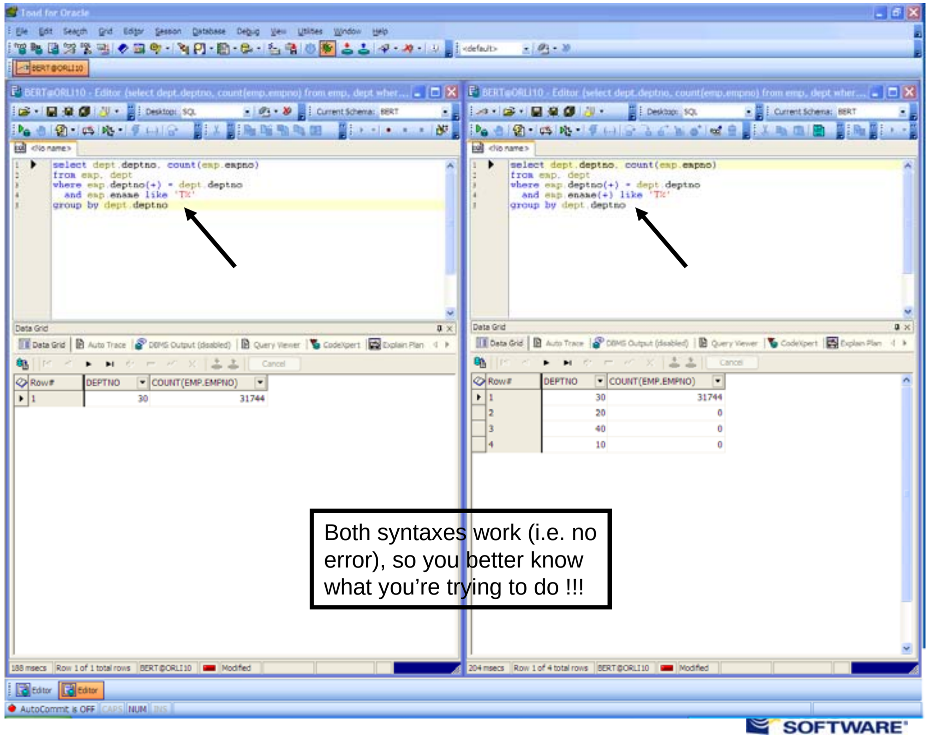
```
-----------------------------------------------------------------------------------------------------------------------------
|  Operation                             |  Name                  |  Rows | Bytes|  Cost  |  TQ  |IN-OUT| PQ Distrib | Pstart| Pstop |
-----------------------------------------------------------------------------------------------------------------------------
| SELECT STATEMENT                       |                        |     1 |  154 |     34 |      |      |            |       |       |
|  SORT GROUP BY                         |                        |     1 |  154 |     34 | 5,03 | P->S | QC (RANDOM)|       |       |
|   SORT GROUP BY                        |                        |     1 |  154 |     34 | 5,02 | P->P | HASH       |       |       |
|    HASH JOIN                           |                        |     1 |  154 |     29 | 5,02 | PCWP |            |       |       |
|     PARTITION RANGE ALL                |                        |       |      |        | 5,02 | PCWP |            |     1 |    10 |
|      TABLE ACCESS BY LOCAL INDEX ROWID| DW_ORDER_PART          |     0 |   20 |     18 | 5,01 | P->P | HASH       |     1 |    10 |
|       BITMAP CONVERSION TO ROWIDS      |                        |       |      |        |      |      |            |       |       |
|        BITMAP AND                      |                        |       |      |        |      |      |            |       |       |
|         BITMAP MERGE                   |                        |       |      |        |      |      |            |       |       |
|          BITMAP KEY ITERATION          |                        |       |      |        |      |      |            |       |       |
|           SORT BUFFER                  |                        |       |      |        |      |      |            |       |       |
|            TABLE ACCESS BY INDEX ROWID| DW_PERIOD              |     1 |   51 |      2 |      |      |            |       |       |
|             BITMAP CONVERSION TO ROWID|                        |       |      |        |      |      |            |       |       |
|              BITMAP AND               |                        |       |      |        |      |      |            |       |       |
|               BITMAP INDEX SINGLE VALU| DW_PERIOD_B03          |       |      |        |      |      |            |       |       |
|               BITMAP INDEX SINGLE VALU| DW_PERIOD_B12          |       |      |        |      |      |            |       |       |
|           BITMAP INDEX RANGE SCAN      | DW_ORDER_PART_B1       |       |      |        |      |      |            |     1 |    10 |
|         BITMAP MERGE                   |                        |       |      |        |      |      |            |       |       |
|          BITMAP KEY ITERATION          |                        |       |      |        |      |      |            |       |       |
|           SORT BUFFER                  |                        |       |      |        |      |      |            |       |       |
|            TABLE ACCESS BY INDEX ROWID| DW_LOCATION            |     1 |   46 |      2 |      |      |            |       |       |
|             BITMAP CONVERSION TO ROWID|                        |       |      |        |      |      |            |       |       |
|              BITMAP AND               |                        |       |      |        |      |      |            |       |       |
|               BITMAP INDEX SINGLE VALU| DW_LOCATION_B03        |       |      |        |      |      |            |       |       |
|               BITMAP INDEX SINGLE VALU| DW_LOCATION_B41        |       |      |        |      |      |            |       |       |
|           BITMAP INDEX RANGE SCAN      | DW_ORDER_PART_B2       |       |      |        |      |      |            |     1 |    10 |
|         BITMAP MERGE                   |                        |       |      |        |      |      |            |       |       |
|          BITMAP KEY ITERATION          |                        |       |      |        |      |      |            |       |       |
|           SORT BUFFER                  |                        |       |      |        |      |      |            |       |       |
|            TABLE ACCESS BY INDEX ROWID| DW_PRODUCT             |    17 |   1K|     10 |      |      |            |       |       |
|             BITMAP CONVERSION TO ROWID|                        |       |      |        |      |      |            |       |       |
|              BITMAP AND               |                        |       |      |        |      |      |            |       |       |
|               BITMAP INDEX SINGLE VALU| DW_PRODUCT_B03         |       |      |        |      |      |            |       |       |
|               BITMAP OR               |                        |       |      |        |      |      |            |       |       |
|                BITMAP INDEX SINGLE VAL| DW_PRODUCT_B14         |       |      |        |      |      |            |       |       |
|                BITMAP INDEX SINGLE VAL| DW_PRODUCT_B14         |       |      |        |      |      |            |       |       |
|           BITMAP INDEX RANGE SCAN      | DW_ORDER_PART_B3       |       |      |        |      |      |            |     1 |    10 |
|     TABLE ACCESS BY INDEX ROWID        | DW_PRODUCT             |    17 |   1K|     10 | 5,00 | S->P | HASH       |       |       |
|      BITMAP CONVERSION TO ROWIDS       |                        |       |      |        |      |      |            |       |       |
|       BITMAP AND                       |                        |       |      |        |      |      |            |       |       |
|        BITMAP INDEX SINGLE VALUE       | DW_PRODUCT_B03         |       |      |        |      |      |            |       |       |
|        BITMAP OR                       |                        |       |      |        |      |      |            |       |       |
|         BITMAP INDEX SINGLE VALUE      | DW_PRODUCT_B14         |       |      |        |      |      |            |       |       |
|         BITMAP INDEX SINGLE VALUE      | DW_PRODUCT_B14         |       |      |        |      |      |            |       |       |
-----------------------------------------------------------------------------------------------------------------------------
```

Partitioned, Parallel explain plan

# SQL Guidelines

## Rule #12: Use ANSI 99 JOIN Syntax – ALWAYS !!!

- Oracle proprietary (+) syntax has problems:
    - Cannot do a FULL JOIN efficiently
        - See slides that follow the next
    - Outer JOIN syntax prone to user error
        - You must specify (+) in the WHERE clause for both
            - The JOIN condition(s)
            - All other references to that table (source of many mistakes)



```
select dept.deptno, count(emp.empno)
from emp, dept
where emp.deptno(+) = dept.deptno
  and emp.ename like 'TX'
group by dept.deptno
```

| Row# | DEPTNO | COUNT(EMP.EMPNO) |
|---|---|---|
| 1 | 30 | 31744 |

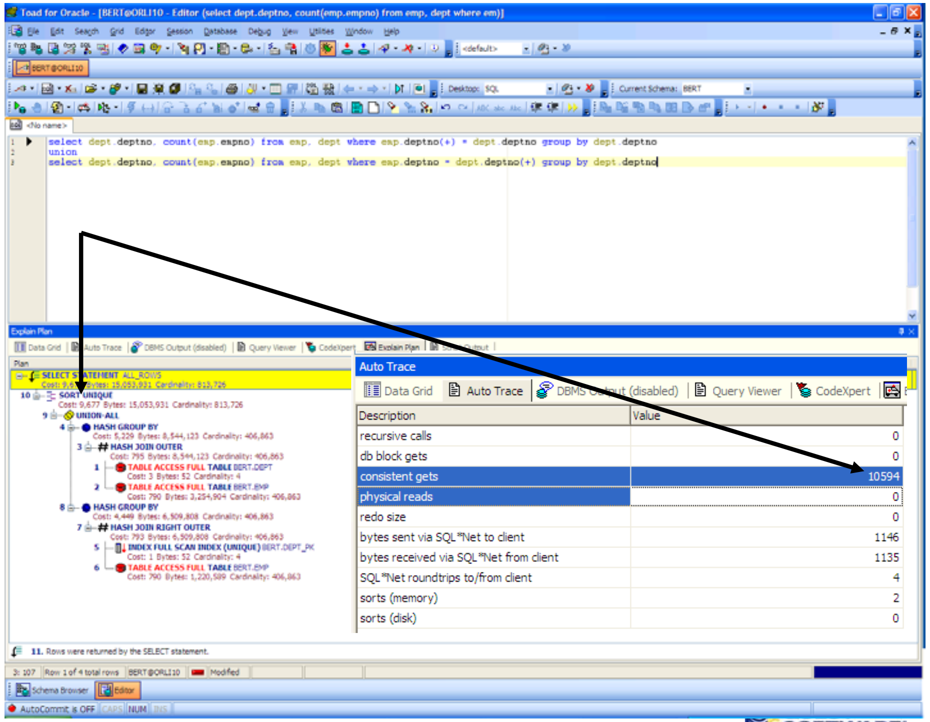
188 msecs | Row 1 of 1 total rows | BERT@ORLI10 | Modified

```
select dept.deptno, count(emp.empno)
from emp, dept
where emp.deptno(+) = dept.deptno
  and emp.ename(+) like 'TX'
group by dept.deptno
```

| Row# | DEPTNO | COUNT(EMP.EMPNO) |
|---|---|---|
| 1 | 30 | 31744 |
| 2 | 20 | 0 |
| 3 | 40 | 0 |
| 4 | 10 | 0 |

204 msecs | Row 1 of 4 total rows | BERT@ORLI10 | Modified

Both syntaxes work (i.e. no error), so you better know what you're trying to do !!!



```
select dept.deptno, count(emp.empno) from emp, dept where emp.deptno(+) = dept.deptno group by dept.deptno
union
select dept.deptno, count(emp.empno) from emp, dept where emp.deptno = dept.deptno(+) group by dept.deptno
```

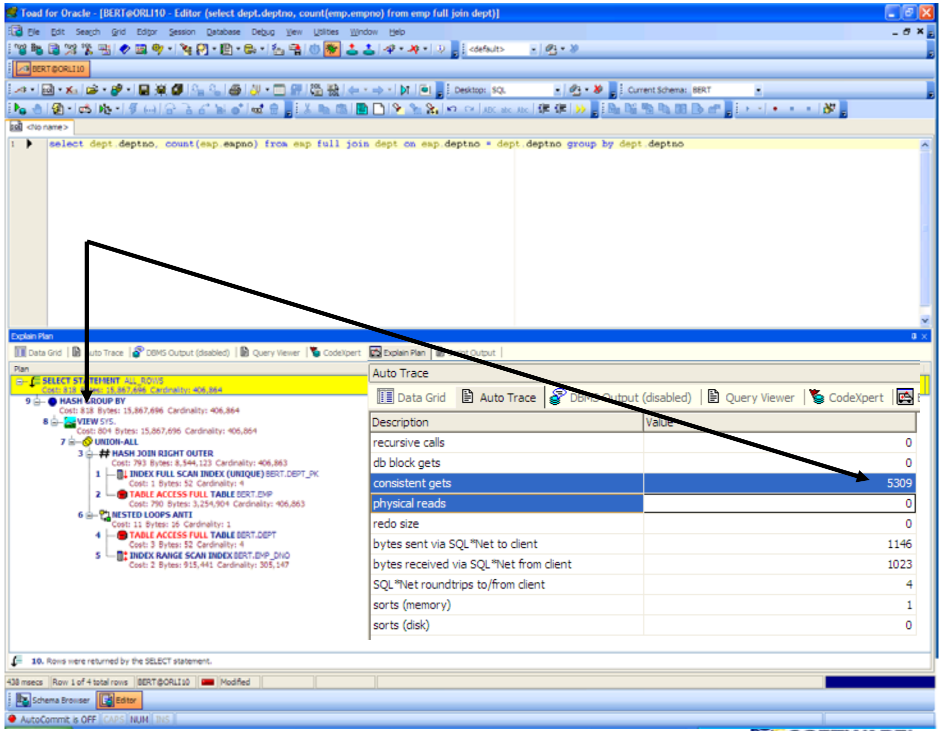
```
Plan
SELECT STATEMENT ALL_ROWS
  Cost: 9,677 Bytes: 15,053,931 Cardinality: 813,726
  10 SORT UNIQUE
     Cost: 9,677 Bytes: 15,053,931 Cardinality: 813,726
    9 UNION-ALL
      4 HASH GROUP BY
        Cost: 5,229 Bytes: 8,544,123 Cardinality: 406,863
        3 HASH JOIN OUTER
          Cost: 795 Bytes: 8,544,123 Cardinality: 406,863
          1 TABLE ACCESS FULL TABLE BERT.DEPT
            Cost: 3 Bytes: 52 Cardinality: 4
          2 TABLE ACCESS FULL TABLE BERT.EMP
            Cost: 790 Bytes: 3,254,904 Cardinality: 406,863
      8 HASH GROUP BY
        Cost: 4,449 Bytes: 6,509,808 Cardinality: 406,863
        7 HASH JOIN RIGHT OUTER
          Cost: 793 Bytes: 6,509,808 Cardinality: 406,863
          5 INDEX FULL SCAN INDEX (UNIQUE) BERT.DEPT_PK
            Cost: 1 Bytes: 52 Cardinality: 4
          6 TABLE ACCESS FULL TABLE BERT.EMP
            Cost: 790 Bytes: 1,220,589 Cardinality: 406,863
```

Auto Trace

| Description | Value |
|---|---|
| recursive calls | 0 |
| db block gets | 0 |
| consistent gets | 10594 |
| physical reads | 0 |
| redo size | 0 |
| bytes sent via SQL*Net to client | 1146 |
| bytes received via SQL*Net from client | 1135 |
| SQL*Net roundtrips to/from client | 4 |
| sorts (memory) | 2 |
| sorts (disk) | 0 |

11. Rows were returned by the SELECT statement.

3: 107 | Row 1 of 4 total rows | BERT@ORLI10 | Modified



```
select dept.deptno, count(emp.empno) from emp full join dept on emp.deptno = dept.deptno group by dept.deptno
```

```
Plan
SELECT STATEMENT ALL_ROWS
  Cost: 818 Bytes: 15,867,696 Cardinality: 406,864
  9 HASH GROUP BY
    Cost: 818 Bytes: 15,867,696 Cardinality: 406,864
    8 VIEW SYS.
      Cost: 804 Bytes: 15,867,696 Cardinality: 406,864
      7 UNION-ALL
        3 HASH JOIN RIGHT OUTER
          Cost: 793 Bytes: 8,544,123 Cardinality: 406,863
          1 INDEX FULL SCAN INDEX (UNIQUE) BERT.DEPT_PK
            Cost: 1 Bytes: 52 Cardinality: 4
          2 TABLE ACCESS FULL TABLE BERT.EMP
            Cost: 790 Bytes: 3,254,904 Cardinality: 406,863
        6 NESTED LOOPS ANTI
          Cost: 11 Bytes: 16 Cardinality: 1
          4 TABLE ACCESS FULL TABLE BERT.DEPT
            Cost: 3 Bytes: 52 Cardinality: 4
          5 INDEX RANGE SCAN INDEX BERT.EMP_DNO
            Cost: 2 Bytes: 915,441 Cardinality: 305,147
```

Auto Trace

| Description | Value |
|---|---|
| recursive calls | 0 |
| db block gets | 0 |
| consistent gets | 5309 |
| physical reads | 0 |
| redo size | 0 |
| bytes sent via SQL*Net to client | 1146 |
| bytes received via SQL*Net from client | 1023 |
| SQL*Net roundtrips to/from client | 4 |
| sorts (memory) | 1 |
| sorts (disk) | 0 |

10. Rows were returned by the SELECT statement.

438 msecs | Row 1 of 4 total rows | BERT@ORLI10 | Modified

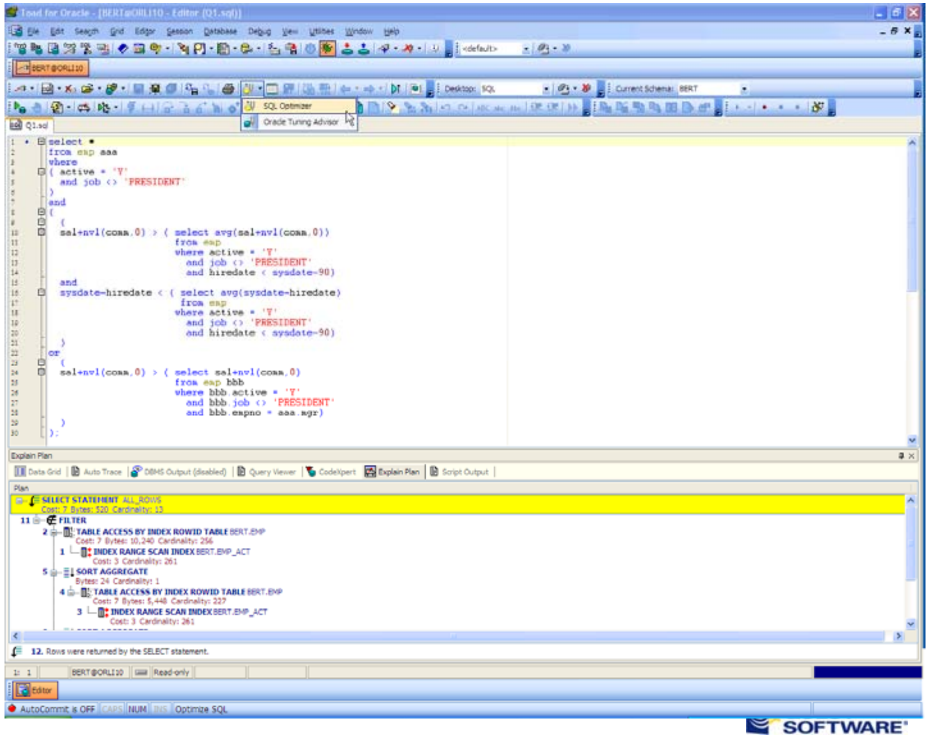
# Wow – this is becoming overwhelming

I could go on and list probably another two dozen or so "Best Practices" SQL Tuning and Optimization rules, but you should already be seeing my point – there is a lot of tuning stuff to remember while trying to get your job done.

You should focus on being **effective** – i.e. the SQL does what the business and/or user requirements mandate.

You should let Toad handle making you SQL **efficient** !!!

SQL Optimizer knows all this and much, much more: **developers can press just two buttons to get their SQL statements automatically and 100% fully tuned!**

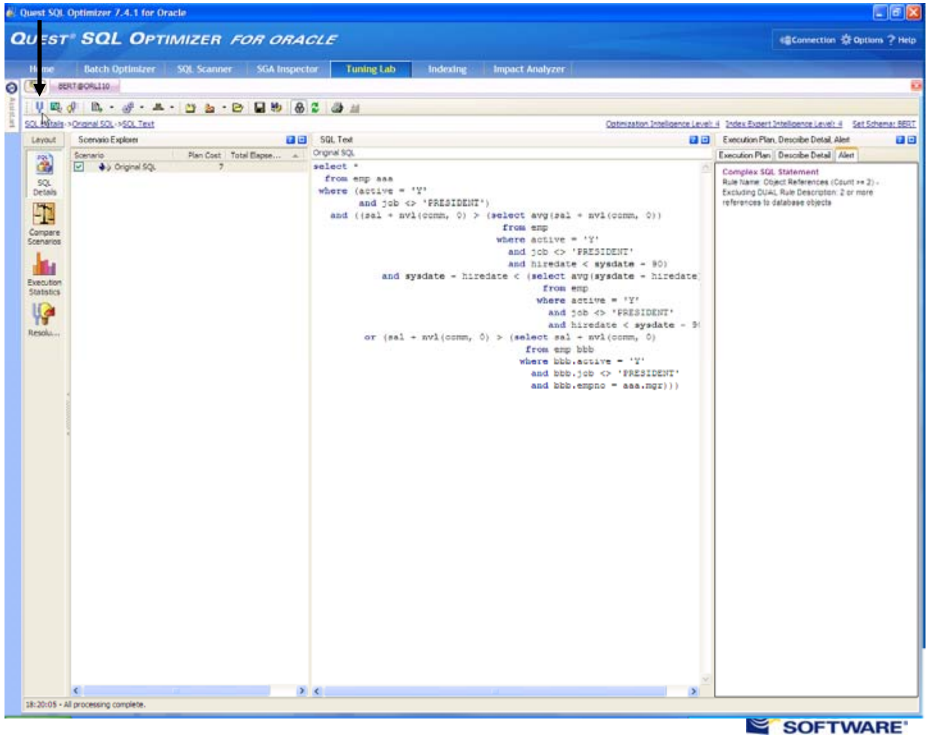


```
select *
from emp aaa
where
( active = 'Y'
  and job <> 'PRESIDENT'
)
and
(
  (
  sal+nvl(comm,0) > ( select avg(sal+nvl(comm,0))
                      from emp
                      where active = 'Y'
                        and job <> 'PRESIDENT'
                        and hiredate < sysdate-90)
  and
  sysdate-hiredate < ( select avg(sysdate-hiredate)
                        from emp
                      where active = 'Y'
                        and job <> 'PRESIDENT'
                        and hiredate < sysdate-90)
  )
or
  (
  sal+nvl(comm,0) > ( select sal+nvl(comm,0)
                      from emp bbb
                      where bbb.active = 'Y'
                        and bbb.job <> 'PRESIDENT'
                        and bbb.empno = aaa.mgr)
  )
);
```

```
Plan
SELECT STATEMENT ALL_ROWS
  Cost: 7 Bytes: 520 Cardinality: 13
  11 FILTER
    2 TABLE ACCESS BY INDEX ROWID TABLE BERT.EMP
      Cost: 7 Bytes: 10,240 Cardinality: 256
      1 INDEX RANGE SCAN INDEX BERT.EMP_ACT
        Cost: 3 Cardinality: 261
    5 SORT AGGREGATE
      Bytes: 24 Cardinality: 1
      4 TABLE ACCESS BY INDEX ROWID TABLE BERT.EMP
        Cost: 7 Bytes: 5,448 Cardinality: 227
        3 INDEX RANGE SCAN INDEX BERT.EMP_ACT
          Cost: 3 Cardinality: 261
```

12. Rows were returned by the SELECT statement.

1: 1 | BERT@ORLI10 | Read-only



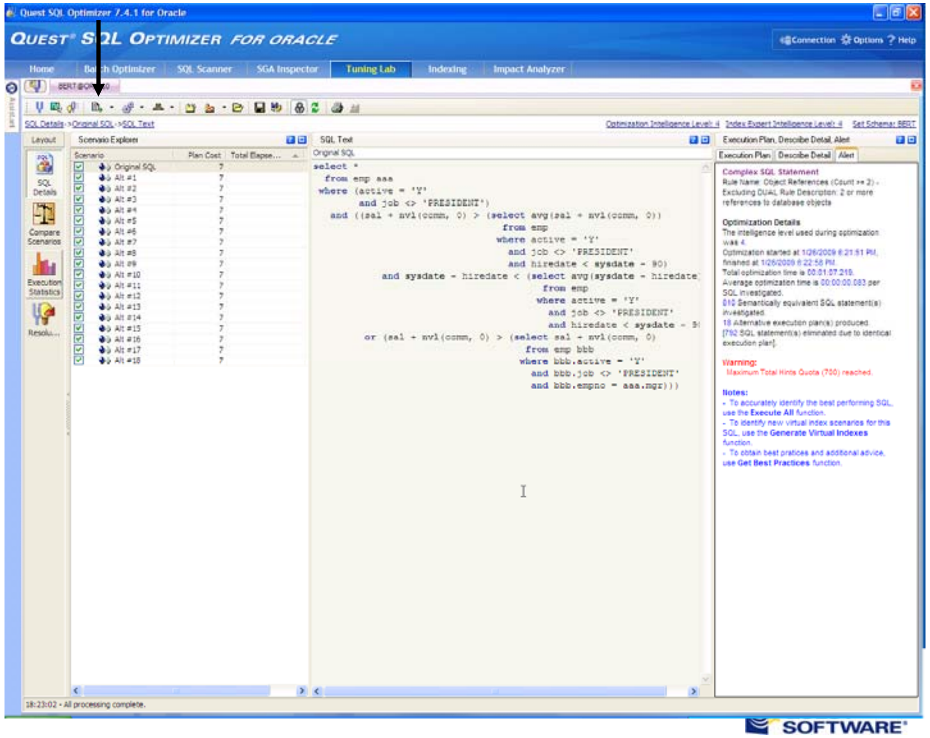
| Scenario | Plan Cost | Total Elapse... |
|---|---|---|
| ☑ Original SQL | 7 | |

Original SQL

```
select *
  from emp aaa
 where (active = 'Y'
        and job <> 'PRESIDENT')
   and ((sal + nvl(comm, 0) > (select avg(sal + nvl(comm, 0))
                                  from emp
                                 where active = 'Y'
                                   and job <> 'PRESIDENT'
                                   and hiredate < sysdate - 90)
         and sysdate - hiredate < (select avg(sysdate - hiredate)
                                     from emp
                                    where active = 'Y'
                                      and job <> 'PRESIDENT'
                                      and hiredate < sysdate - 9
        or (sal + nvl(comm, 0) > (select sal + nvl(comm, 0)
                                    from emp bbb
                                   where bbb.active = 'Y'
                                     and bbb.job <> 'PRESIDENT'
                                     and bbb.empno = aaa.mgr)))
```

Complex SQL Statement
Rule Name: Object References (Count >= 2) - Excluding DUAL Rule Description: 2 or more references to database objects

18:20:05 - All processing complete.



| Scenario | Plan Cost | Total Elapse... |
|---|---|---|
| ☑ Original SQL | 7 | |
| ☑ Alt #1 | 7 | |
| ☑ Alt #2 | 7 | |
| ☑ Alt #3 | 7 | |
| ☑ Alt #4 | 7 | |
| ☑ Alt #5 | 7 | |
| ☑ Alt #6 | 7 | |
| ☑ Alt #7 | 7 | |
| ☑ Alt #8 | 7 | |
| ☑ Alt #9 | 7 | |
| ☑ Alt #10 | 7 | |
| ☑ Alt #11 | 7 | |
| ☑ Alt #12 | 7 | |
| ☑ Alt #13 | 7 | |
| ☑ Alt #14 | 7 | |
| ☑ Alt #15 | 7 | |
| ☑ Alt #16 | 7 | |
| ☑ Alt #17 | 7 | |
| ☑ Alt #18 | 7 | |

Original SQL

```
select *
  from emp aaa
 where (active = 'Y'
        and job <> 'PRESIDENT')
   and ((sal + nvl(comm, 0) > (select avg(sal + nvl(comm, 0))
                                  from emp
                                 where active = 'Y'
                                   and job <> 'PRESIDENT'
                                   and hiredate < sysdate - 90)
         and sysdate - hiredate < (select avg(sysdate - hiredate)
                                     from emp
                                    where active = 'Y'
                                      and job <> 'PRESIDENT'
                                      and hiredate < sysdate - 9
        or (sal + nvl(comm, 0) > (select sal + nvl(comm, 0)
                                    from emp bbb
                                   where bbb.active = 'Y'
                                     and bbb.job <> 'PRESIDENT'
                                     and bbb.empno = aaa.mgr)))
```

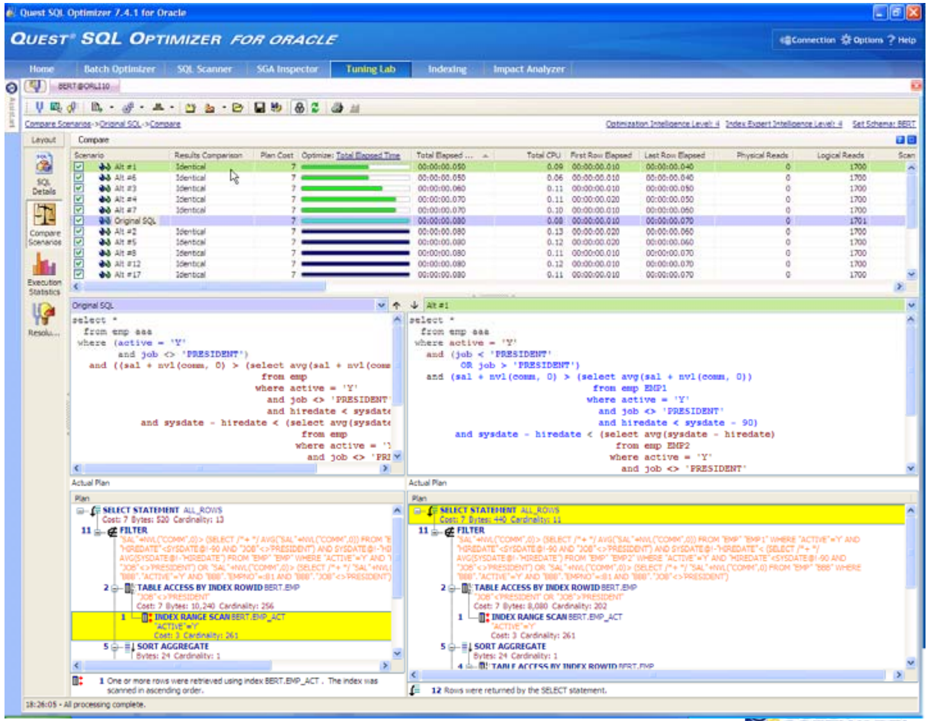
Complex SQL Statement
Rule Name: Object References (Count >= 2) - Excluding DUAL Rule Description: 2 or more references to database objects

Optimization Details
The intelligence level used during optimization was 4.
Optimization started at 1/26/2009 6:21:51 PM, finished at 1/26/2009 6:22:58 PM.
Total optimization time is 00:01:07.219.
Average optimization time is 00:00:00.083 per SQL investigated.
810 Semantically equivalent SQL statement(s) investigated.
18 Alternative execution plan(s) produced.
[792 SQL statement(s) eliminated due to identical execution plan].

Warning:
Maximum Total Hints Quota (700) reached.

Notes:
- To accurately identify the best performing SQL, use the **Execute All** function.
- To identify new virtual index scenarios for this SQL, use the **Generate Virtual Indexes** function.
- To obtain best pratices and additional advice, use **Get Best Practices** function.

18:23:02 - All processing complete.



| Scenario | Results Comparison | Plan Cost | Optimize: Total Elapsed Time | Total Elapsed ... | Total CPU | First Row Elapsed | Last Row Elapsed | Physical Reads | Logical Reads | Scan |
|---|---|---|---|---|---|---|---|---|---|---|
| ☑ Alt #1 | Identical | 7 | | 00:00:00.050 | 0.09 | 00:00:00.010 | 00:00:00.040 | 0 | 1700 | |
| ☑ Alt #6 | Identical | 7 | | 00:00:00.050 | 0.06 | 00:00:00.010 | 00:00:00.040 | 0 | 1700 | |
| ☑ Alt #3 | Identical | 7 | | 00:00:00.060 | 0.11 | 00:00:00.010 | 00:00:00.050 | 0 | 1700 | |
| ☑ Alt #4 | Identical | 7 | | 00:00:00.070 | 0.11 | 00:00:00.020 | 00:00:00.050 | 0 | 1700 | |
| ☑ Alt #7 | Identical | 7 | | 00:00:00.070 | 0.10 | 00:00:00.010 | 00:00:00.060 | 0 | 1700 | |
| ☑ Original SQL | | 7 | | 00:00:00.080 | 0.08 | 00:00:00.010 | 00:00:00.070 | 0 | 1701 | |
| ☑ Alt #2 | Identical | 7 | | 00:00:00.080 | 0.13 | 00:00:00.020 | 00:00:00.060 | 0 | 1700 | |
| ☑ Alt #5 | Identical | 7 | | 00:00:00.080 | 0.12 | 00:00:00.020 | 00:00:00.060 | 0 | 1700 | |
| ☑ Alt #8 | Identical | 7 | | 00:00:00.080 | 0.11 | 00:00:00.010 | 00:00:00.070 | 0 | 1700 | |
| ☑ Alt #12 | Identical | 7 | | 00:00:00.080 | 0.12 | 00:00:00.010 | 00:00:00.070 | 0 | 1700 | |
| ☑ Alt #17 | Identical | 7 | | 00:00:00.080 | 0.11 | 00:00:00.010 | 00:00:00.070 | 0 | 1700 | |

Original SQL

```
select *
  from emp aaa
 where (active = 'Y'
        and job <> 'PRESIDENT')
   and ((sal + nvl(comm, 0) > (select avg(sal + nvl(comm
                                  from emp
                                 where active = 'Y'
                                   and job <> 'PRESIDENT'
                                   and hiredate < sysdate
         and sysdate - hiredate < (select avg(sysdate
                                     from emp
                                    where active = 'Y
                                      and job <> 'PRE
```

Alt #1

```
select *
  from emp aaa
 where active = 'Y'
   and (job < 'PRESIDENT'
        OR job > 'PRESIDENT')
   and (sal + nvl(comm, 0) > (select avg(sal + nvl(comm, 0))
                                 from emp EMP1
                                where active = 'Y'
                                  and job <> 'PRESIDENT'
                                  and hiredate < sysdate - 90)
        and sysdate - hiredate < (select avg(sysdate - hiredate)
                                    from emp EMP2
                                   where active = 'Y'
                                     and job <> 'PRESIDENT'
```

Actual Plan (Original SQL)

```
Plan
SELECT STATEMENT ALL_ROWS
  Cost: 7 Bytes: 520 Cardinality: 13
11 FILTER
  "SAL"+NVL("COMM",0)> (SELECT /*+ */ AVG("SAL"+NVL("COMM",0)) FROM "E
  "HIREDATE"<SYSDATE@!-90 AND "JOB"<>'PRESIDENT') AND SYSDATE@!-"HI
  AVG(SYSDATE@!-"HIREDATE") FROM "EMP" "EMP" WHERE "ACTIVE"='Y' AND "
  "JOB"<>'PRESIDENT') OR "SAL"+NVL("COMM",0)> (SELECT /*+ */ "SAL"+NVL(
  "BBB"."ACTIVE"='Y' AND "BBB"."EMPNO"=:B1 AND "BBB"."JOB"<>'PRESIDENT')
  2 TABLE ACCESS BY INDEX ROWID BERT.EMP
    "JOB"<>'PRESIDENT'
    Cost: 7 Bytes: 10,240 Cardinality: 256
    1 INDEX RANGE SCAN BERT.EMP_ACT
      "ACTIVE"='Y'
      Cost: 3 Cardinality: 261
  5 SORT AGGREGATE
    Bytes: 24 Cardinality: 1
```

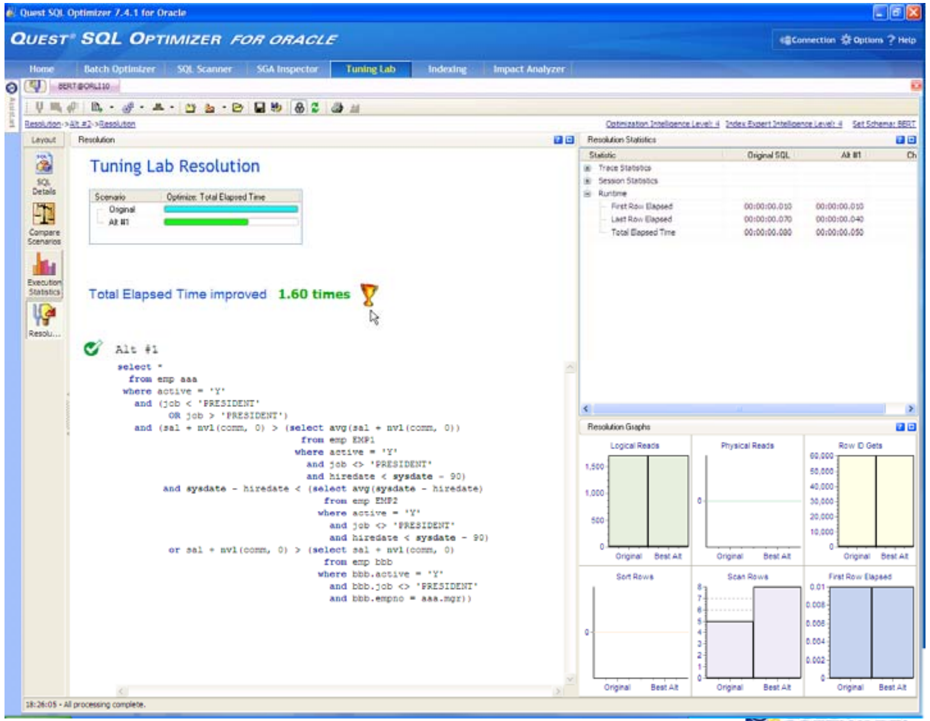
1 One or more rows were retrieved using index BERT.EMP_ACT . The index was scanned in ascending order.

Actual Plan (Alt #1)

```
Plan
SELECT STATEMENT ALL_ROWS
  Cost: 7 Bytes: 440 Cardinality: 11
11 FILTER
  "SAL"+NVL("COMM",0)> (SELECT /*+ */ AVG("SAL"+NVL("COMM",0)) FROM "EMP" "EMP1" WHERE "ACTIVE"='Y' AND
  "HIREDATE"<SYSDATE@!-90 AND "JOB"<>'PRESIDENT') AND SYSDATE@!-"HIREDATE"< (SELECT /*+ */
  AVG(SYSDATE@!-"HIREDATE") FROM "EMP" "EMP2" WHERE "ACTIVE"='Y' AND "HIREDATE"<SYSDATE@!-90 AND
  "JOB"<>'PRESIDENT') OR "SAL"+NVL("COMM",0)> (SELECT /*+ */ "SAL"+NVL("COMM",0) FROM "EMP" "BBB" WHERE
  "BBB"."ACTIVE"='Y' AND "BBB"."EMPNO"=:B1 AND "BBB"."JOB"<>'PRESIDENT')
  2 TABLE ACCESS BY INDEX ROWID BERT.EMP
    "JOB"<'PRESIDENT' OR "JOB">'PRESIDENT'
    Cost: 7 Bytes: 8,080 Cardinality: 202
    1 INDEX RANGE SCAN BERT.EMP_ACT
      "ACTIVE"='Y'
      Cost: 3 Cardinality: 261
  5 SORT AGGREGATE
    Bytes: 24 Cardinality: 1
    4 TABLE ACCESS BY INDEX ROWID BERT.EMP
```

12 Rows were returned by the SELECT statement.

18:26:05 - All processing complete.



Tuning Lab Resolution

| Scenario | Optimize: Total Elapsed Time |
|---|---|
| Original | |
| Alt #1 | |

Total Elapsed Time improved 1.60 times

✓ Alt #1

```
select *
  from emp aaa
 where active = 'Y'
   and (job < 'PRESIDENT'
        OR job > 'PRESIDENT')
   and (sal + nvl(comm, 0) > (select avg(sal + nvl(comm, 0))
                                 from emp EMP1
                                where active = 'Y'
                                  and job <> 'PRESIDENT'
                                  and hiredate < sysdate - 90)
        and sysdate - hiredate < (select avg(sysdate - hiredate)
                                    from emp EMP2
                                   where active = 'Y'
                                     and job <> 'PRESIDENT'
                                     and hiredate < sysdate - 90)
         or sal + nvl(comm, 0) > (select sal + nvl(comm, 0)
                                    from emp bbb
                                   where bbb.active = 'Y'
                                     and bbb.job <> 'PRESIDENT'
                                     and bbb.empno = aaa.mgr))
```

| Statistic | Original SQL | Alt #1 | Ch |
|---|---|---|---|
| Trace Statistics | | | |
| Session Statistics | | | |
| Runtime | | | |
| First Row Elapsed | 00:00:00.010 | 00:00:00.010 | |
| Last Row Elapsed | 00:00:00.070 | 00:00:00.040 | |
| Total Elapsed Time | 00:00:00.080 | 00:00:00.050 | |

18:26:05 - All processing complete.