Adaptive Query Optimization

DOAG Datenbank, Düsseldorf, 3 June 2014

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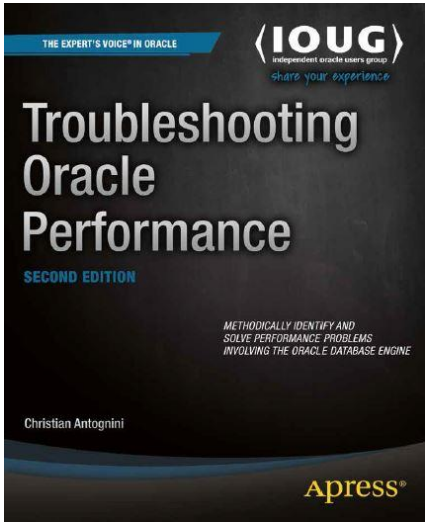

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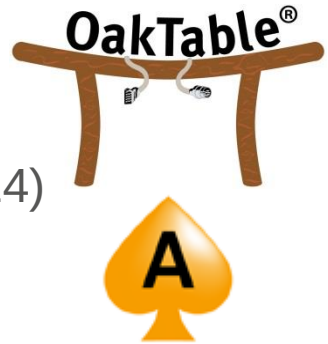
- Focus: get the most out of Oracle Database
  - Logical and physical database design
  - Query optimizer
  - Application performance management
- Author of *Troubleshooting Oracle Performance* (Apress, 2008/2014)
- Proud member of OakTable Network, Oracle ACE Director



Introduction

- Over the years Oracle has extremely improved the capabilities of the query optimizer
- Most of the improvements fall into one of the following areas
  - Enhance the quality of the inputs (e.g. objects statistics)
  - Make the gathering and management of object statistics easier and more efficient
  - Implement or enhance query transformations
  - Improve plan stability
  - Cope with poor estimations that leads to poor execution plans
- 12c is no exception, every one of these areas were improved

Adaptive Query Optimization Is a Set of Features

- Adaptive plans (Enterprise Edition only)
  - Join methods
  - Parallel distribution methods
- Adaptive statistics
  - SQL plan directives
  - Automatic reoptimization
    - Statistics feedback (evolution of *cardinality feedback*)
    - Performance feedback
  - Dynamic statistics (evolution of *dynamic sampling*)

OPTIMIZER_ADAPTIVE_FEATURES

- Enables or disables adaptive query optimization features
  - Adaptive plans
  - SQL plan directives
  - Automatic reoptimization
    - It isn't the case in 12.1.0.1 (bug 16824474)
- The default value is TRUE

OPTIMIZER_ADAPTIVE_REPORTING_ONLY

- Enables or disables reporting mode for adaptive query optimization features
- Useful to assess how an execution plan would change
- Use DBMS_XPLAN to get detail information about the analysis
  - Might fail with an ORA-1001 (bug 17270605)

```
SELECT *
FROM table(dbms_xplan.display_cursor(format=>'report'))
```

- The default value is FALSE

Adaptive Plans – Challenge

- Object statistics don’t always provide sufficient information to find an optimal execution plan
- To get additional insights, the query optimizer can take advantage of features like dynamic sampling and cardinality feedback
  - Don’t solve all issues, though

Adaptive Plans – Concept (1)

- As of 12c, the query optimizer can postpone some decisions until the execution phase
- The idea is to leverage information collected while executing part of an execution plan to determine how another part should be carried out
- The query optimizer uses adaptive plans in two situations:
  - To switch the join method from a nested loops join to a hash join
  - To switch the PX distribution method from hash to broadcast

Adaptive Plans – Concept (2)

- The query optimizer adds *subplans* to execution plans
  - One of the alternatives is the default plan
- A subplan is chosen during the first execution based on the number of rows actually processed
  - The query optimizer computes an inflection point
- A new row source operation is used to partially buffer and count the rows
  - STATISTICS COLLECTOR
- The selection of the final plan is only performed during the first execution

Adaptive Plans – Join Method Switch Example

```
SELECT * FROM t1, t2 WHERE t1.id = t2.id AND t1.n = 666

-----------------------------------------------
| Id  | Operation                     | Name  |
-----------------------------------------------
|   0 | SELECT STATEMENT              |       |
|   1 |  HASH JOIN                    |       |
|   2 |   NESTED LOOPS                |       |
|   3 |    NESTED LOOPS               |       |
|   4 |     STATISTICS COLLECTOR      |       |
|   5 |      TABLE ACCESS FULL        | T1    |
|   6 |     INDEX UNIQUE SCAN         | T2_PK |
|   7 |    TABLE ACCESS BY INDEX ROWID| T2    |
|   8 |   TABLE ACCESS FULL           | T2    |
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```

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-----------------------------------------------
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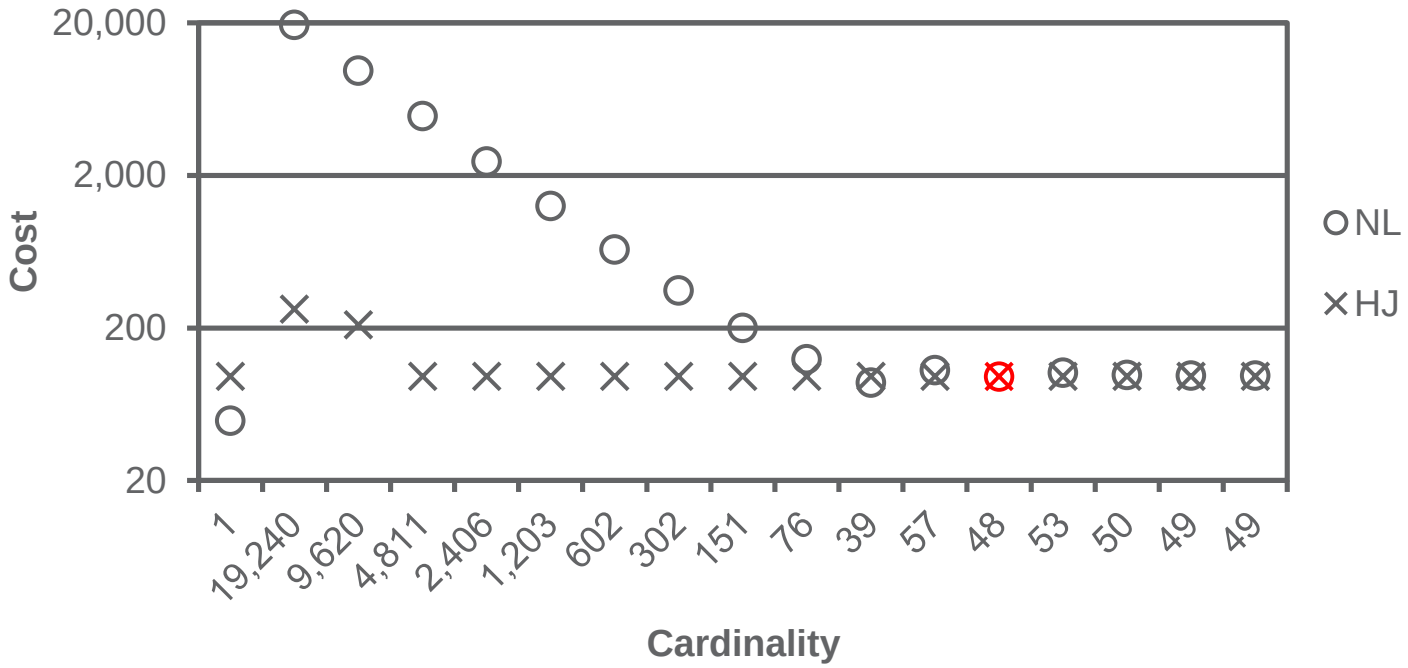
Adaptive Plans – V$SQL.IS_RESOLVED_ADAPTIVE_PLAN

- NULL means that the execution plan associated to the cursor isn't adaptive
- N means that the final execution plan hasn't been determined
- Y means that the final execution plan was determined
  - Also set if reporting mode is enabled

Adaptive Plans – Searching for Inflection Point of Join Method

- For both join methods, the cost associated to different cardinalities is estimated
  - The cardinality of the outer table varies
  - The cardinality of the inner table remain fixed
- The query optimizer uses a binary search
- The search takes place between a minimum and maximum cardinality

Adaptive Plans – Searching for Inflection Point Example



SQL Plan Directives

- SQL plan directives are automatically created when misestimates occur
  - They are temporarily stored in the SGA and flushed to disk every 15 min
- They aren't tied to a specific SQL statement, but to specific columns
  - Several of them can be used for a single SQL statement
- They instruct the database engine to automatically create extended statistics
  - Only column groups are considered
  - If creating extended statistics isn't supported/possible, they instruct the query optimizer to use dynamic sampling
- The database engine automatically maintains them
  - Some functionalities are exposed through DBMS_SPD

SQL Plan Directives – Data Dictionary

- DBA_SQL_PLAN_DIRECTIVES
- DBA_SQL_PLAN_DIR_OBJECTS

```
SQL> SELECT type, reason, count(*)
  2  FROM dba_sql_plan_directives
  3  GROUP BY type, reason;

TYPE               REASON                                    COUNT(*)
---------------- ---------------------------------------- ----------
DYNAMIC_SAMPLING SINGLE TABLE CARDINALITY MISESTIMATE             81
DYNAMIC_SAMPLING JOIN CARDINALITY MISESTIMATE                    180
DYNAMIC_SAMPLING GROUP BY CARDINALITY MISESTIMATE                  6
```

Statistics Feedback

statistics_feedback1.sql
statistics_feedback2.sql

- Evolution of cardinality feedback
- Used for single-table cardinalities as well as join cardinalities
- Information about misestimates might be persisted through SQL plan directives
  - For misestimates due to table functions no information is stored
- V$SQL.IS_REOPTIMIZABLE
  - Y means that the next execution will trigger a reoptimization
  - N means that no reoptimization is necessary
  - R means that reoptimization information is available, but reporting mode was enabled

Dynamic Statistics

- Evolution of dynamic sampling
- Used for single-table cardinalities as well as join and group-by cardinalities
- OPTIMIZER_DYNAMIC_SAMPLING has a new level: 11
  - At this level the query optimizer decides when and how to use dynamic statistics
  - Several new features are enabled only at this level
- Insights resulting from dynamic statistics can be shared and persisted through *SQL plan directives*

Summary

- Adaptive query optimization is one of the most interesting features of 12c
- The query optimizer is getting more and more dynamic

Questions and answers ...

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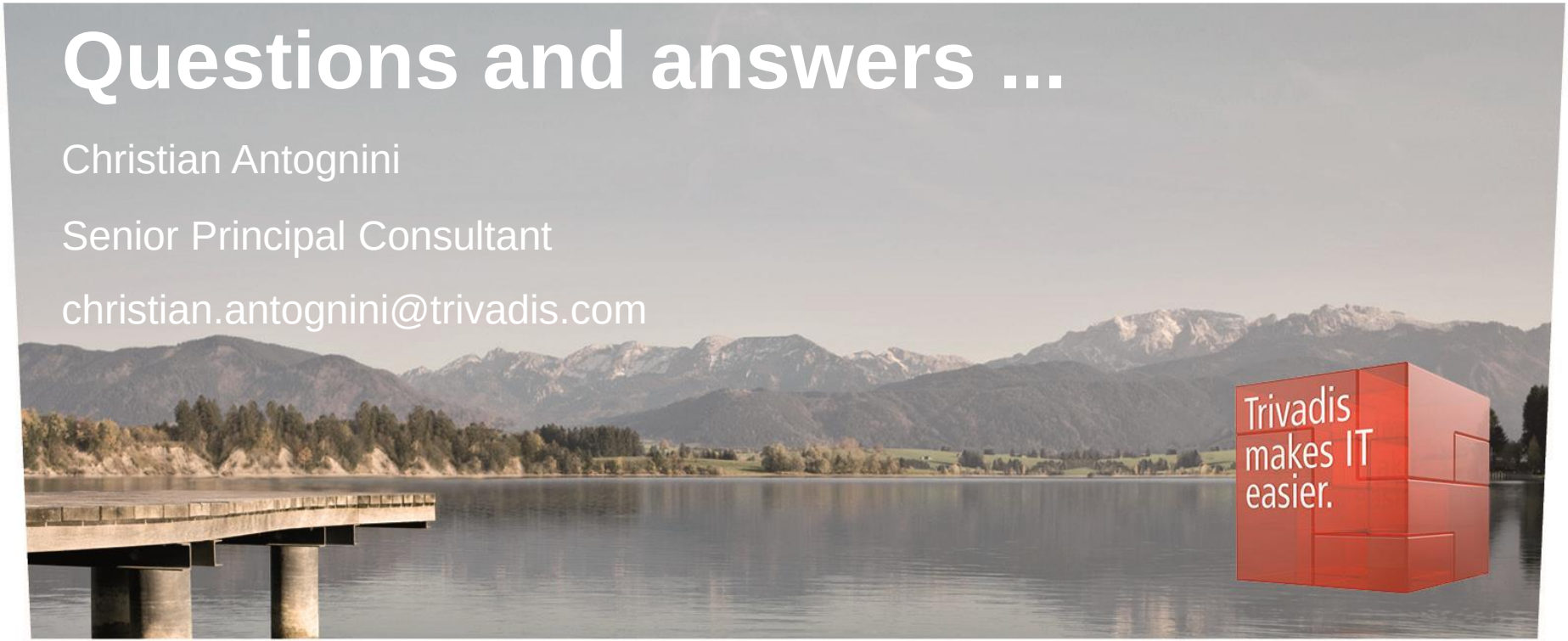

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