

Adaptive Features

or: How I Learned to Stop Worrying and Troubleshoot the Bomb

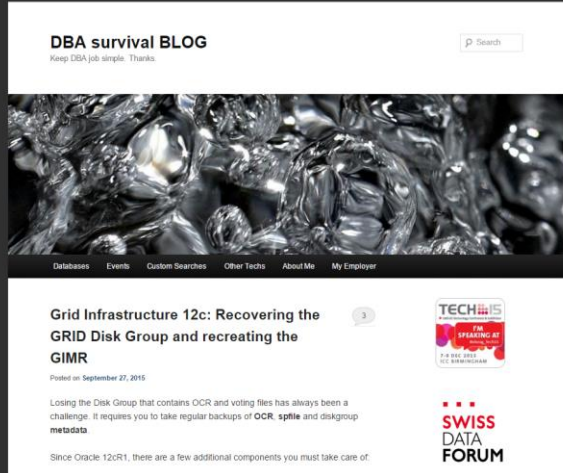
Ludovico Caldara
Oracle ACE Director
Trivadis AG




[ludodba](#)

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About Ludovico Caldara



- 17 Years DBA (Not Only Oracle)
 - I do it everywhere (even Windows)
- RAC ATTACK Ninja & co-writer
-  RAC SIG President, SOUG & ITOUG Board
- OCP (11g, 12c, MySQL) & OCE



- Italian living in Switzerland



<http://www.ludovicocaldara.net>



@ludodba




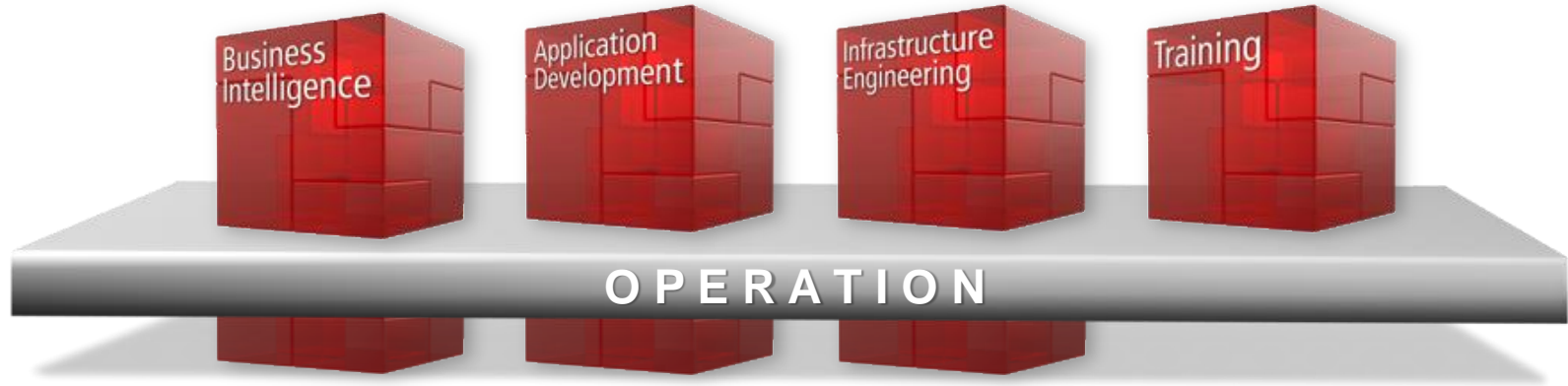
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■ Disclaimer

- All the information provided refers to **Oracle Database release 12.1.0.2**
- Some information about **12.2** at the end of the session

Dr. Strangelove

or: How I Learned to Stop Worrying and Love the Bomb.

Adaptive Features

~~Dr. Strangelove~~

or: How I Learned to Stop Worrying
and ~~Love~~ the Bomb.

Troubleshoot

■ The Bomb?



Community Feedback about Adaptive Features



Christian Antognini @ChrisAntognini · 17 set 2014

This afternoon I created 3 SR related to the management of **SQL plan directives**. A feature with a huge impact in [#DB12c](#). [#OracleDatabase](#) [#SPD](#)



Also Extensions Created Because of SQL Plan Directives Can Invalidate Packages



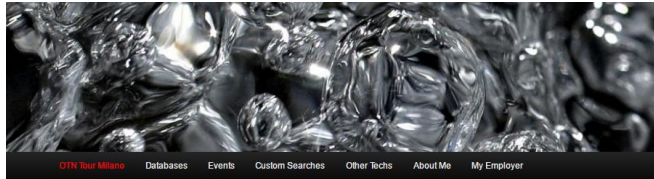
December 17, 2015 | Written by Christian Antognini

1 Comment



How to disable a SQL Plan Directive permanently

By Franck Pachot | June 12, 2015 | Database management | 3 Comments



Posted on May 21, 2015

← Previous Next →

SQL Plan Directives: they're always good... except when they're bad!



SQL Plan Directives strike again

By Franck Pachot | February 4, 2016 | Database Administration & Monitoring | No Comments

berxblog

Dienstag, 23. Juni 2015

SQL Plan Directives and result cache affects performance

Bugs Related to SQL Plan Directives Pack and Unpack



July 13, 2015 | Written by Christian Antognini

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■ Jonathan Lewis Feedback about Adaptive Features

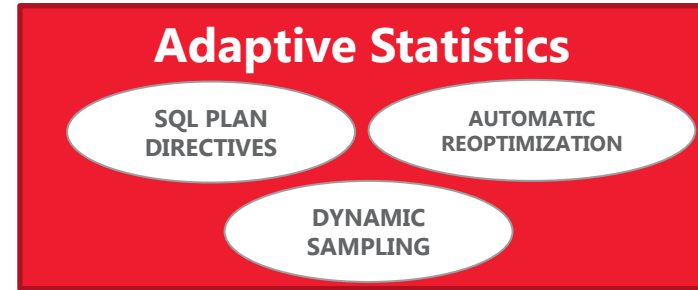
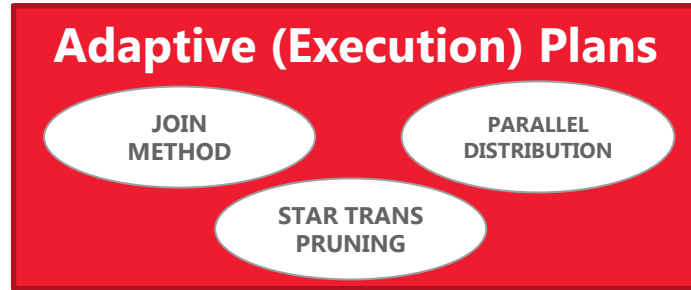
Oracle Scratchpad

August 2, 2016

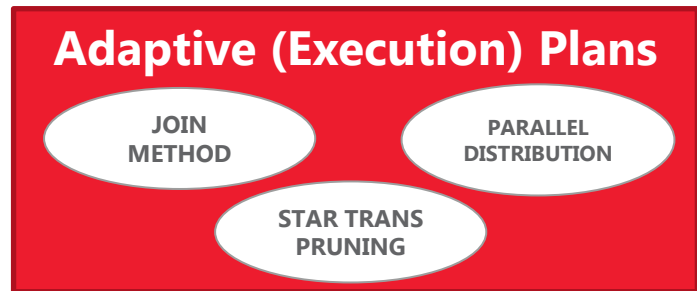
Adaptive mayhem

Filed under: [12c,Oracle](#) — Jonathan Lewis @ 4:29 pm BST Aug 2,2016

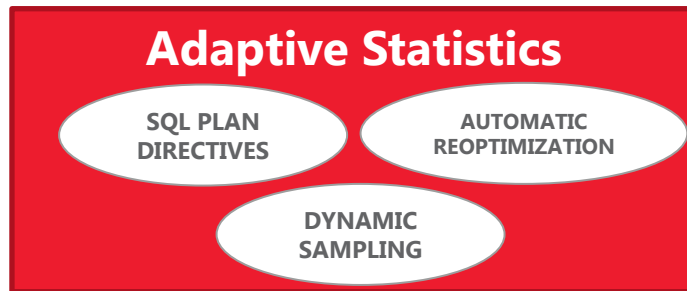
■ Adaptive Query Optimization



■ Adaptive Query Optimization

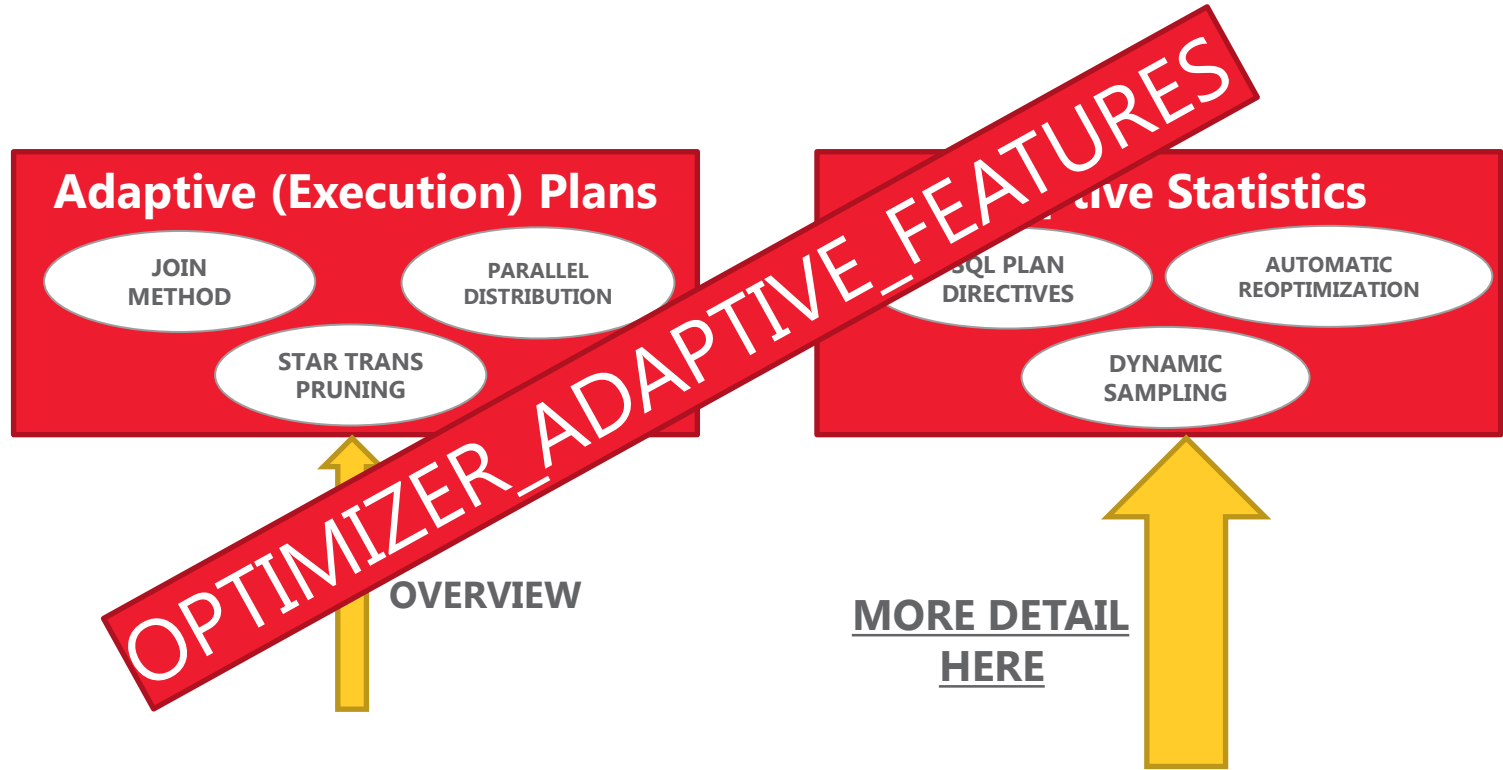


OVERVIEW

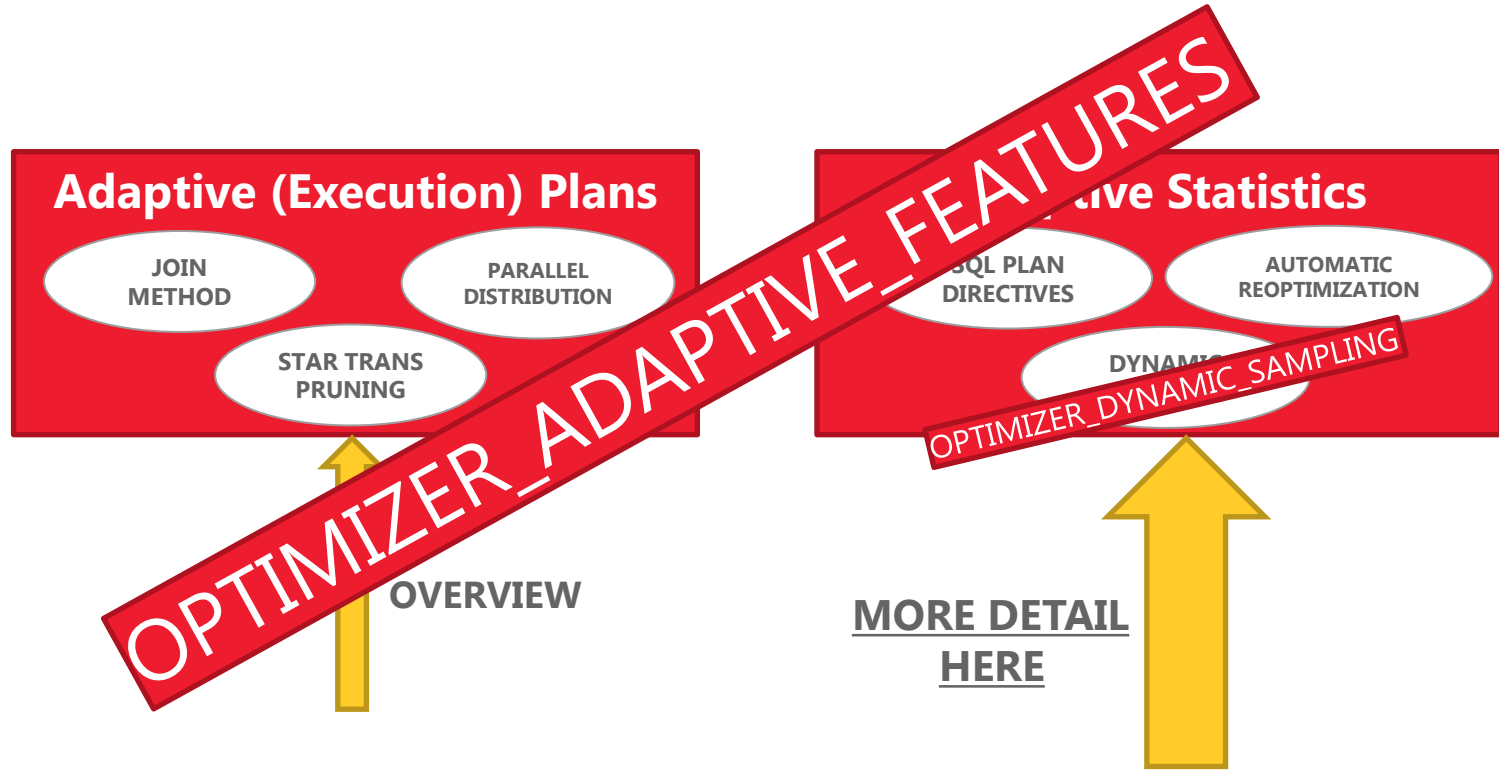


MORE DETAIL
HERE

■ Adaptive Query Optimization



■ Adaptive Query Optimization



Adaptive Plans

■ Adaptive Plans - Join Method

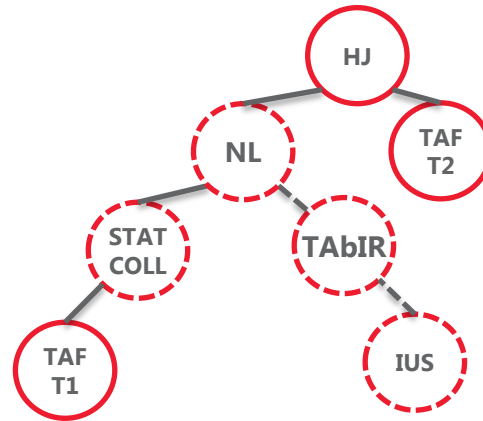
First execution. Which plan is better?



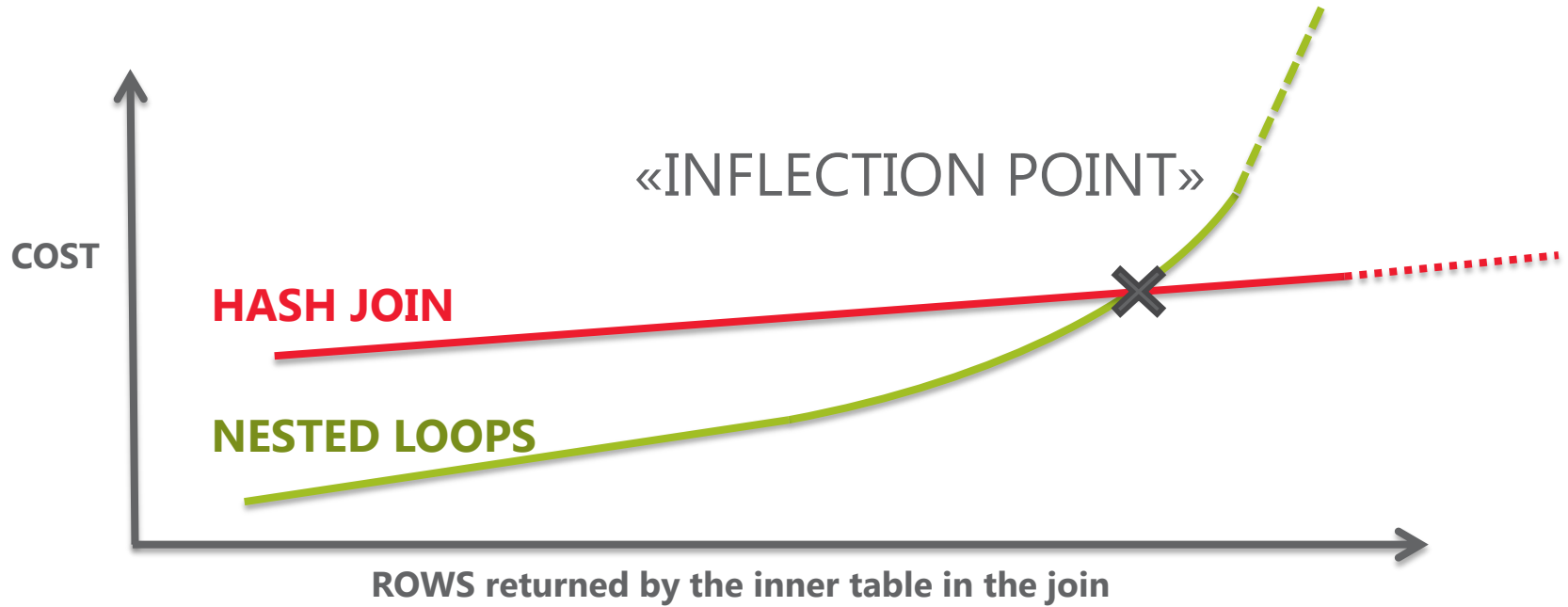
It depends on how many records are returned from the inner branch!

■ Adaptive Plans - Join Method

The optimizer prepares a **full plan** with both **sub-plans**

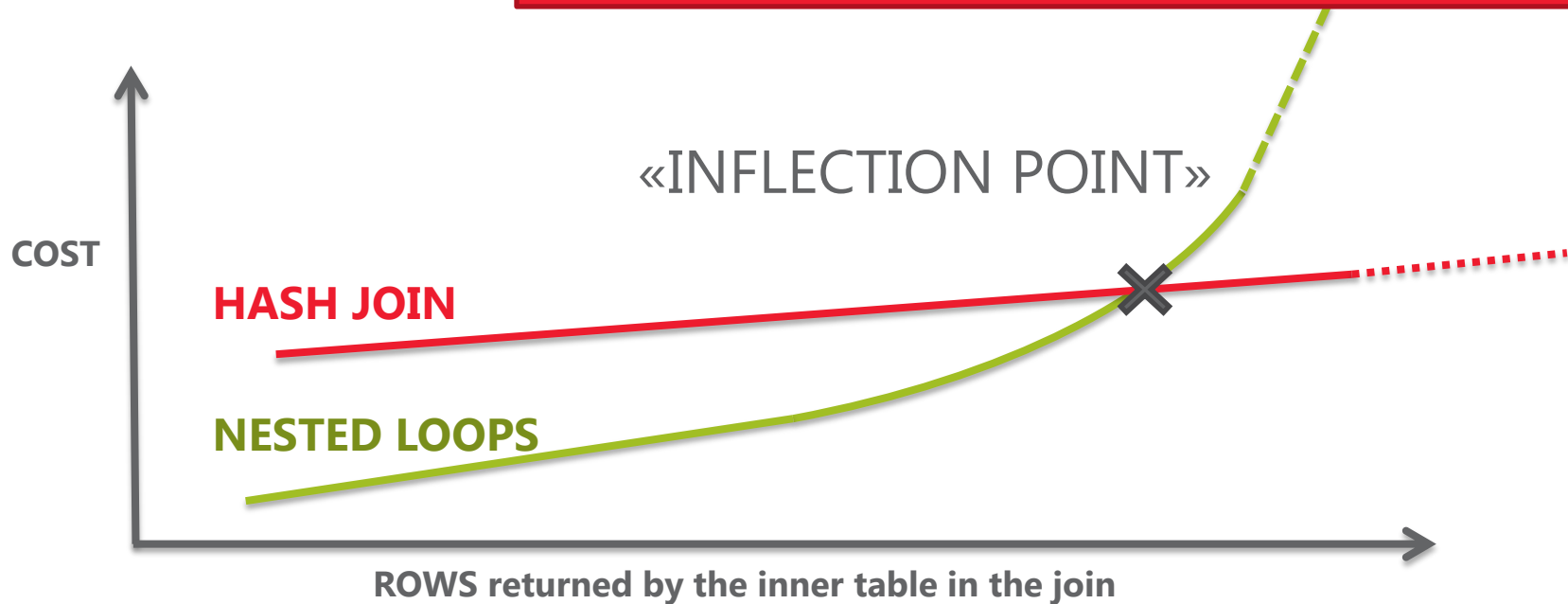


■ Adaptive Plans - Join Method



■ Adaptive Plans - Join Method

Dichotomous search, at First Execution Only



Adaptive Plans - Join Method

```
SQL> select * from table(dbms_xplan.display(format=>'adaptive'));
```

PLAN_TABLE_OUTPUT

Plan hash value: 4045828612

Id	Operation	Name	Rows	Bytes	Cost (%CPU)	Time
0	SELECT STATEMENT		665	35910	9 (0)	00:00:01
* 1	HASH JOIN		665	35910	9 (0)	00:00:01
- 2	NESTED LOOPS		665	35910	9 (0)	00:00:01
- 3	STATISTICS COLLECTOR					
* 4	HASH JOIN		105	4830	7 (0)	00:00:01
- 5	NESTED LOOPS		105	4830	7 (0)	00:00:01
- 6	STATISTICS COLLECTOR					
7	TABLE ACCESS BY INDEX ROWID BATCHED	ORDERS	105	840	2 (0)	00:00:01
* 8	INDEX RANGE SCAN	ORD_CUSTOMER_IX	105		1 (0)	00:00:01
- 9	TABLE ACCESS BY INDEX ROWID	CUSTOMERS	1	38	5 (0)	00:00:01
- * 10	INDEX UNIQUE SCAN	CUSTOMERS_PK				
11	TABLE ACCESS FULL	CUSTOMERS	319	12122	5 (0)	00:00:01
- * 12	INDEX RANGE SCAN	ORDER_ITEMS_UK	6	48	2 (0)	00:00:01
13	INDEX FAST FULL SCAN	ORDER_ITEMS_UK	665	5320	2 (0)	00:00:01

Note

- this is an adaptive plan (rows marked '-' are inactive) rrying

```
SQL> explain plan FOR
2  SELECT C.CUST_EMAIL,
3     OI.PRODUCT_ID
4  FROM CUSTOMERS C
5  JOIN orders O
6  ON O.CUSTOMER_ID=C.CUSTOMER_ID
7  JOIN order_items OI
8  ON OI.ORDER_ID=O.ORDER_ID;
```

Explained.

Adaptive Plans - Join Method

```
SQL> select * from table(dbms_xplan.display(format=>'adaptive'));
```

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Note

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```
SQL> explain plan FOR
2 SELECT C.CUST_EMAIL,
3 OI.PRODUCT_ID
4 FROM CUSTOMERS C
5 ORDER BY C.CUSTOMER_ID, OI.ORDER_ID;
-----
Plan explained.
```

OPTIMIZER_NLJ_HJ_ADAPTIVE_JOIN

■ Adaptive Plans - Parallel Distribution Method

- Conceptually similar to Join Method
- Switches parallel distribution from HASH/HASH to BROADCAST/ROUND-ROBIN
- Decision taken at EVERY execution of the cursor
- Inflection point is fixed to 2x DOP in **12.1**

■ Adaptive Plans - Parallel Distribution Method

- Conceptually similar to Join Method
- Switches parallel distribution from HASH to BROADCAST/ROUND-ROBIN
- Decision taken at EVERY movement of the cursor
- Inflection point fixed to 2x DOP in 12.1

PX_ADAPTIVE_DIST_METHOD

■ Adaptive Plans - Star Transformation

- It can skip a BITMAP MERGE branch if a dimension does not filter enough
- The filter is applied later
- The decision is taken at the first execution only

■ Adaptive Plans - Star Transformation

- It can skip a BITMAP MERGE branch if a dimension filter is applied early enough
- The filter is applied later
- The decision is taken at the filter selection only

OPTIMIZER_STRANS_ADAPTIVE_PRUNING

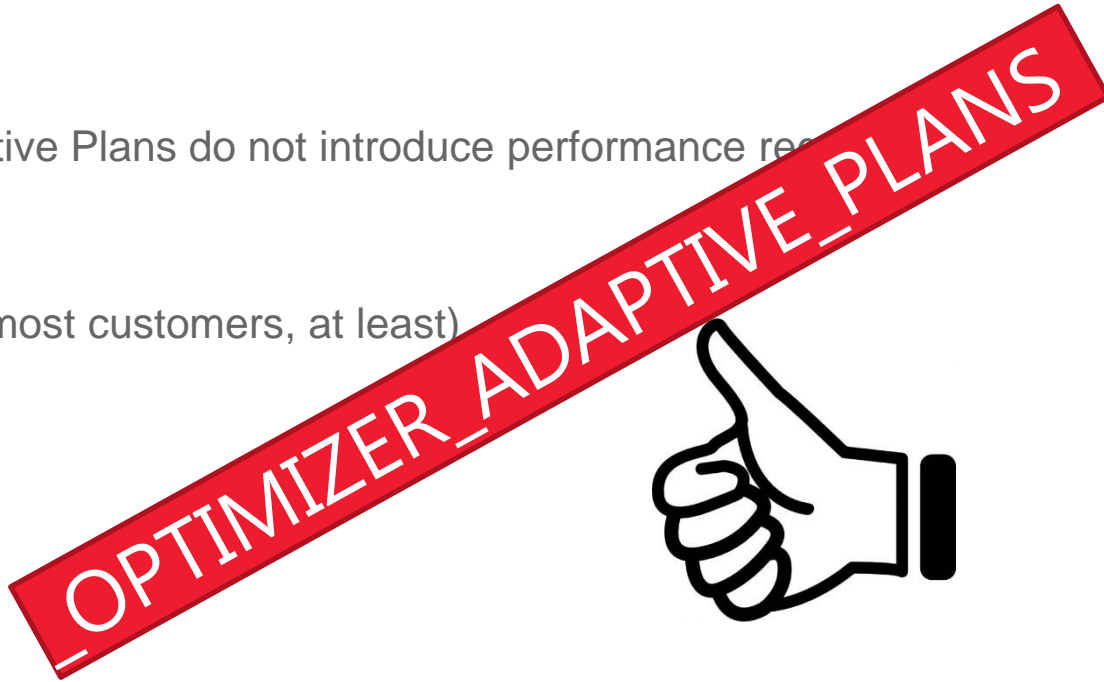
■ Adaptive Plans - Verdict

- Adaptive Plans do not introduce performance regressions
- (For most customers, at least)



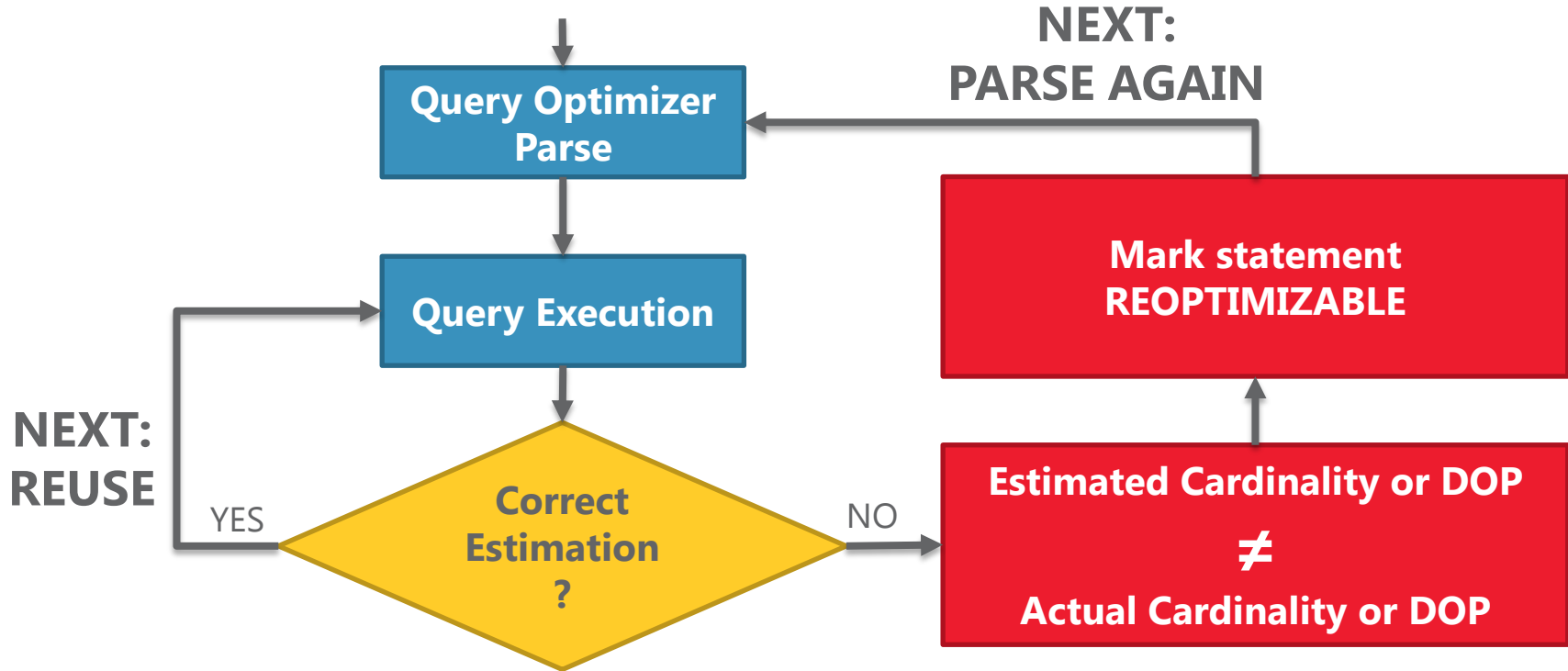
■ Adaptive Plans - Verdict

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Adaptive Statistics

■ Automatic Reoptimization - The Concept



■ Automatic Reoptimization - Performance Feedback

- If *parallel_degree_policy* is set to ADAPTIVE
- When **DOP is not optimal**
 - It stores performance statistics of the parallel execution
 - It marks the statement as reoptimizable
 - Next execution will parse and take advantage of the feedback

■ Automatic Reoptimization - Performance Feedback

- If *parallel_degree_policy* is set to ADAPTIVE
- When **DOP is not optimal**
 - It stores performance statistics of parallel execution
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PARALLEL_DEGREE_POLICY

■ Automatic Reoptimization - **Statistics Feedback**

- When there is a **misestimate**
- It stores information about the misestimate
- Again, it marks the statement as reoptimizable
- **New in 12c**: also for **join cardinalities**
- **New in 12c**: upon misestimate a **SQL Plan Directive (SPD)** is created



■ Automatic Reoptimization - Statistics Feedback

- When there is a **misestimate**
- It stores information about the misestimate
- Again, it marks the statement as **reoptimizable**
- **New in 12c:** **optimizer_gather_feedback** for cardinalities
- **New in 12c:** upon misestimate a **SQL Plan Directive (SPD)** is created

OPTIMIZER_GATHER_FEEDBACK

**Named Cardinality
Feedback** in 11gR2

■ Dynamic Statistics

- Still called **Dynamic Sampling**
- In 12c there is a new feature: Adaptive Dynamic Sampling (ADS) (level 11)
- There is no limit to the number of blocks read by the ADS queries
- ADS can introduce a big overhead to the parse of a statement (even minutes!)
- ADS: good for OLAP, bad for OLTP

■ Dynamic Statistics in trace 10046

```
PARSING IN CURSOR #139986665500256 len=330 dep=1 uid=110 oct=3 lid=110
tim=9486290642425 hv=3320227945 ad='8f845b48' sqlid='f8guurb2yda39'
SELECT /* DS_SVC */ /*+ dynamic_sampling(0) no_sql_tune no_monitoring
optimizer_features_enable(default) no_parallel result_cache(snapshot=3600) */
SUM(C1) FROM (SELECT /*+ qb_name("innerQuery") NO_INDEX_FFS( "LI" ) */ 1 AS C1
FROM ADAPTIVE."PRODUCT" SAMPLE BLOCK(1.85843, 8) SEED(1) "LI" WHERE
("LI"."ENT_ID"]=194924)) innerQuery
END OF STMT
```

```
$ grep DS_SVC theludot_ora_2905_doag16_ds_2.trc | wc -l
5
```

■ Dynamic Statistics in parse phase

```
SQL> select sql_id, executions, loads, cpu_time from v$sqlstats where sql_id='auyf8px9ywc6j';
```

```
SQL_ID          EXECUTIONS          LOADS    CPU_TIME
-----
```

```
auyf8px9ywc6j          0          11          0
```

```
SQL> select sql_id, child_number from v$sql where sql_id='auyf8px9ywc6j';
```

```
no rows selected
```

```
SQL> select * from table (dbms_xplan.display_cursor('auyf8px9ywc6j',0, 'ALL +NOTE'));
```

```
PLAN_TABLE_OUTPUT
```

```
-----
```

```
SQL_ID auyf8px9ywc6j, child number 0
```

```
...
```

```
NOTE: cannot fetch plan for SQL_ID: auyf8px9ywc6j, CHILD_NUMBER: 0
```

```
    Please verify value of SQL_ID and CHILD_NUMBER;
```

```
    It could also be that the plan is no longer in cursor cache (check v$sql_plan)
```

■ Adaptive Dynamic Sampling automatically takes place...

With **12.1.0.2 ADS is used by default:**

- Often when a **Parallel Execution** is considered by the optimizer
- Whenever the optimizer uses a **SQL Plan Directive** for the plan
- The best source for more information:

[\[PDF\] Adaptive Dynamic Sampling - SOUG](#)

www.soug.ch/...R/Christian_Antognini_AdaptiveDynamicSampling_trivadis.pdf ▼

May 21, 2015 - christian.antognini@trivadis.com ... In 12c a new implementation called **adaptive dynamic sampling** (ADS) is available. The former ...

■ Adaptive Dynamic Sampling automatically takes place...

With **12.1.0.2 ADS is used by default:**

- Often when a **Parallel Execution** is completed by the optimizer
- Whenever the optimizer uses a **Plan Directive** for the plan
- The best source of information:

[PDF] Adaptive Dynamic Sampling - SOUG

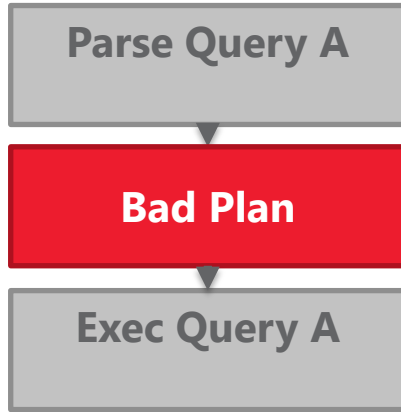
www.scottbradley.com/.../christian_antognini_AdaptiveDynamicSampling_trivadis.pdf ▼

May 2012 by christian.antognini@trivadis.com ... In 12c a new implementation called **adaptive dynamic sampling (ADS)** is available. The former ...

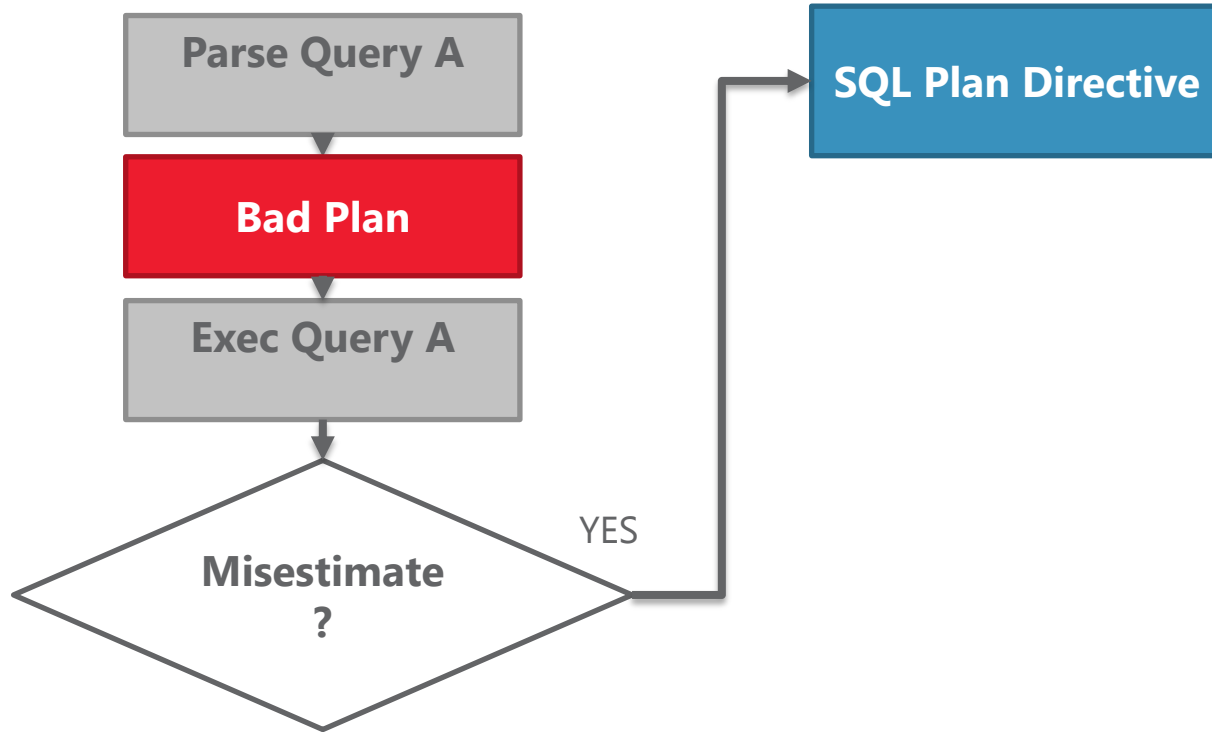
OPTIMIZER_DYNAMIC_SAMPLING

■ SQL Plan Directives

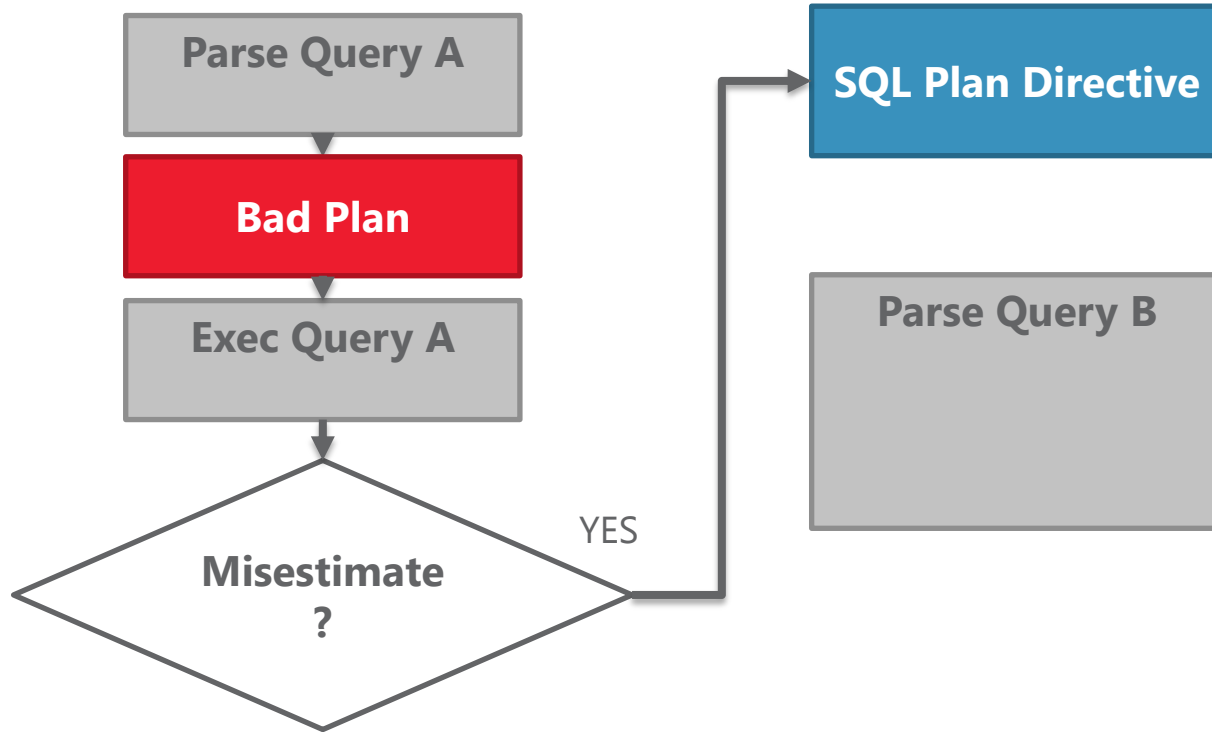
■ SQL Plan Directives



■ SQL Plan Directives

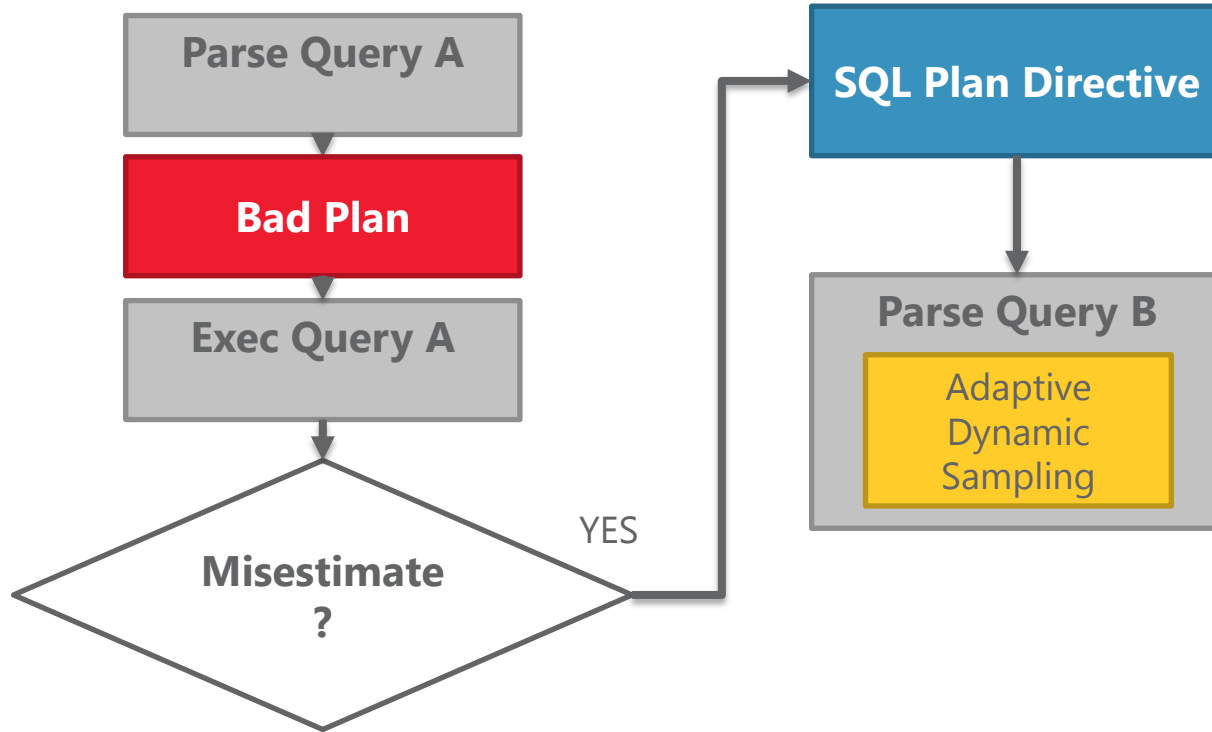


■ SQL Plan Directives



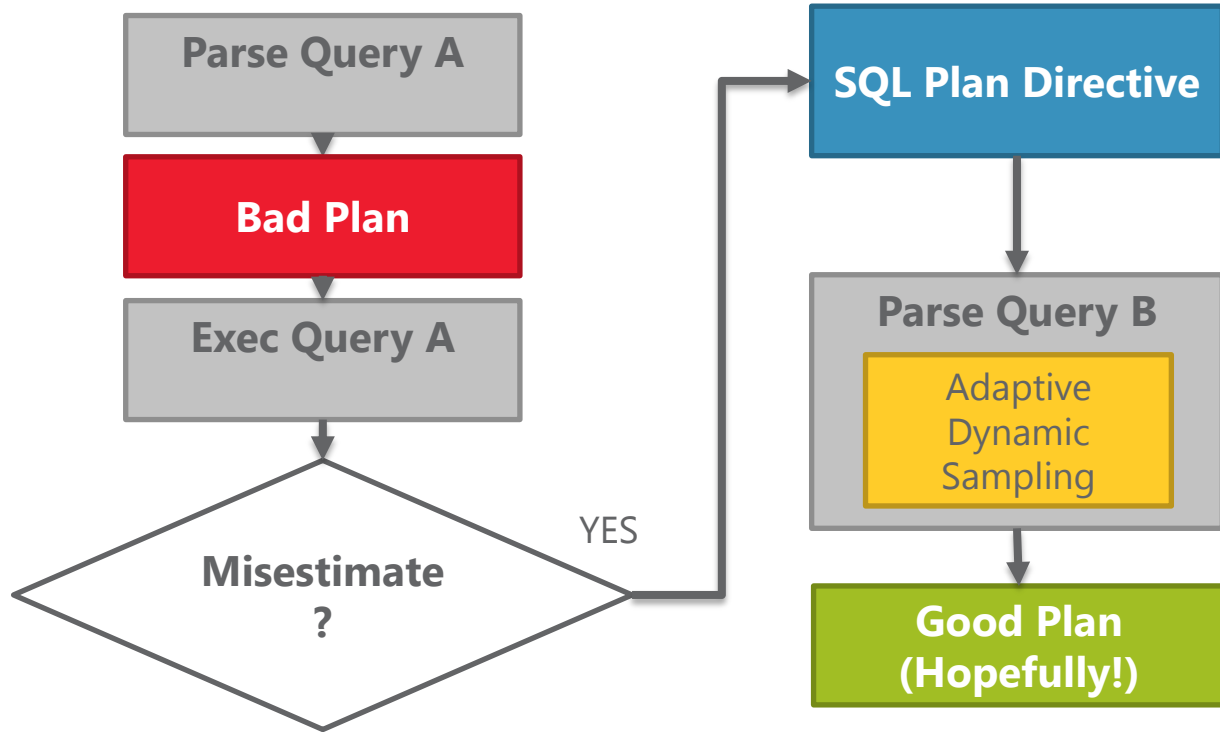
Query A and Query B have similar predicates but they are not equal!

■ SQL Plan Directives



Query A and Query B have similar predicates but they are not equal!

■ SQL Plan Directives



Query A and Query B have similar predicates but they are not equal!

■ SQL Plan Directives (SPDs)

```
SELECT * FROM t1 JOIN t2 ON (t1.id=t2.t1_id)
```

↓ MISESTIMATE

DIRECTIVE_ID	STATE	ENA	OBJ_NAME	REASON	TYPE
763369106005	USABLE	YES	T1	JOIN CARDINALITY MISESTIMATE	DYNAMIC_SAMPLING
763369106005	USABLE	YES	T2	JOIN CARDINALITY MISESTIMATE	DYNAMIC_SAMPLING

↓ NEXT QUERY **WITH THE SAME JOIN**

Note

- **dynamic statistics used: dynamic sampling (level=2)**
- this is an adaptive plan
- **1 Sql Plan Directives used for this statement**

■ SQL Plan Directives - Reasons

- JOIN CARDINALITY MISESTIMATE
- SINGLE TABLE CARDINALITY MISESTIMATE
- GROUP BY CARDINALITY MISESTIMATE

■ SQL Plan Directives - Types

- **DYNAMIC_SAMPLING** only (forces Adaptive Dynamic Sampling)
- For single tables misestimates, Column Groups (extended stats) might be created
 - Objects are often invalidated due to ALTER TABLE
 - Execution plan changes after the statistics are collected
 - Creating extended statistics is not always a good choice

■ SQL Plan Directives - Types

- **DYNAMIC_SAMPLING** only (forces Adaptive Dynamic Sampling)
- For single tables misestimates, Column Group (extended stats) might be created
 - Objects are often invalidated due to TABLE
 - Execution plan change statistics are collected
 - Creating extended stats is not always a good choice

OPTIMIZER_DSDIR_USAGE_CONTROL

■ SQL Plan Directives - Types

- **DYNAMIC_SAMPLING** only (forces Adaptive Dynamic Sampling)
- For single tables misestimates, Column Group (with extended stats) might be created
 - Objects are often invalidated due to `ANALYZE TABLE`
 - Execution plan changes when statistics are collected
 - Creating extended statistics is not always a good choice

OPTIMIZER_GATHER_FEEDBACK

■ SQL Plan Directives - Types

- **DYNAMIC_SAMPLING** only (forces Adaptive Dynamic Sampling)
- For single tables misestimates, Column Group Statistics (Column Group Stats) might be created
 - Objects are often invalidated
 - Execution plan changes
 - Creating Column Group Stats is not always a good choice

**DBMS_STATS 'AUTO_STATS_EXTENSION'
(Patch 21171382)**

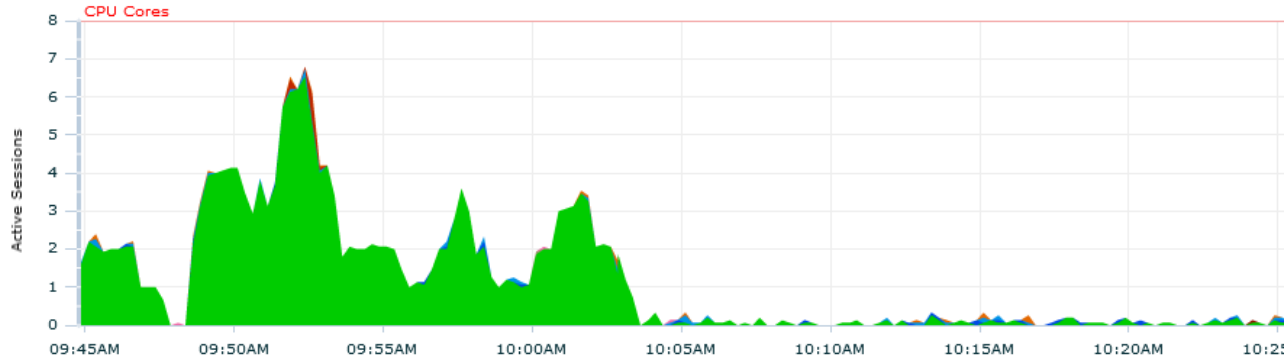
■ The Bomb!



■ The Bomb!

Top Activity

Drag the shaded box to change the time period for the detail section below.



Detail for Selected 5 Minute Interval

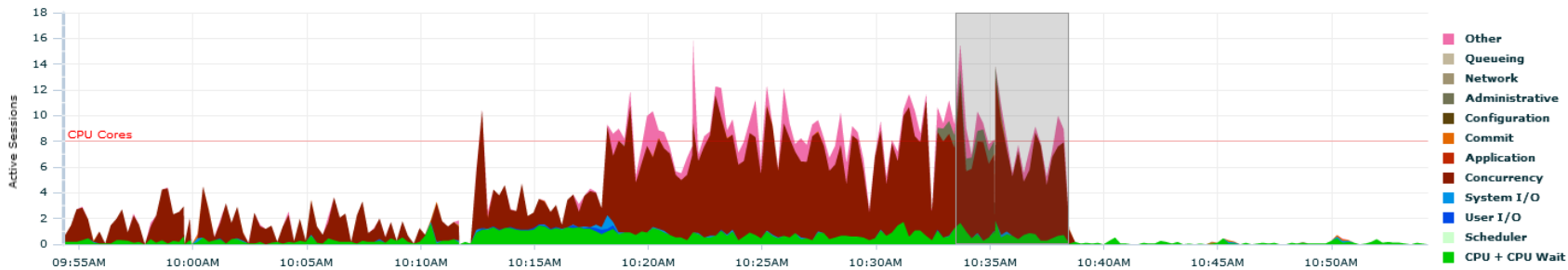
Start Time Oct 23, 2015 10:25:40 AM

■ The Bomb!

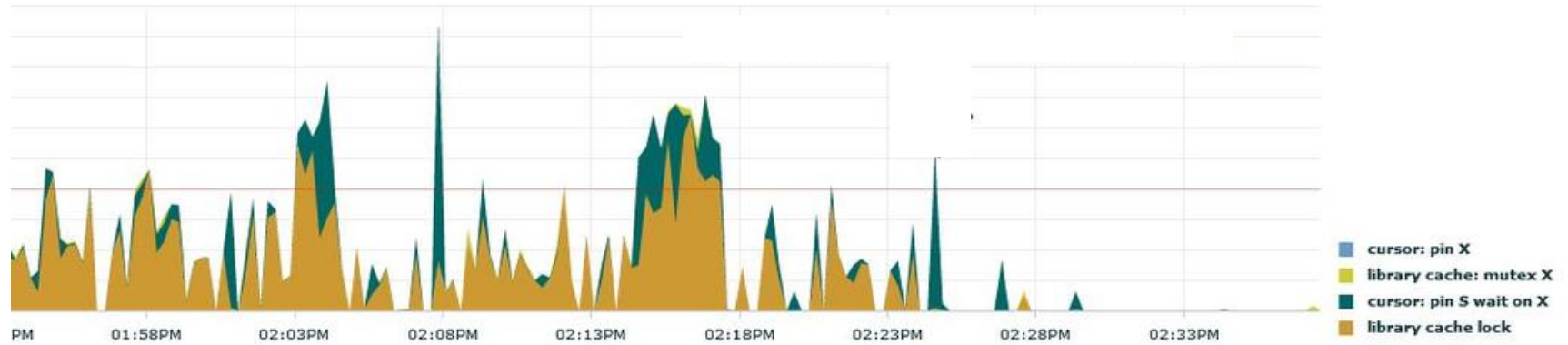
Top Activity

Drag the shaded box to change the time period for the detail section below.

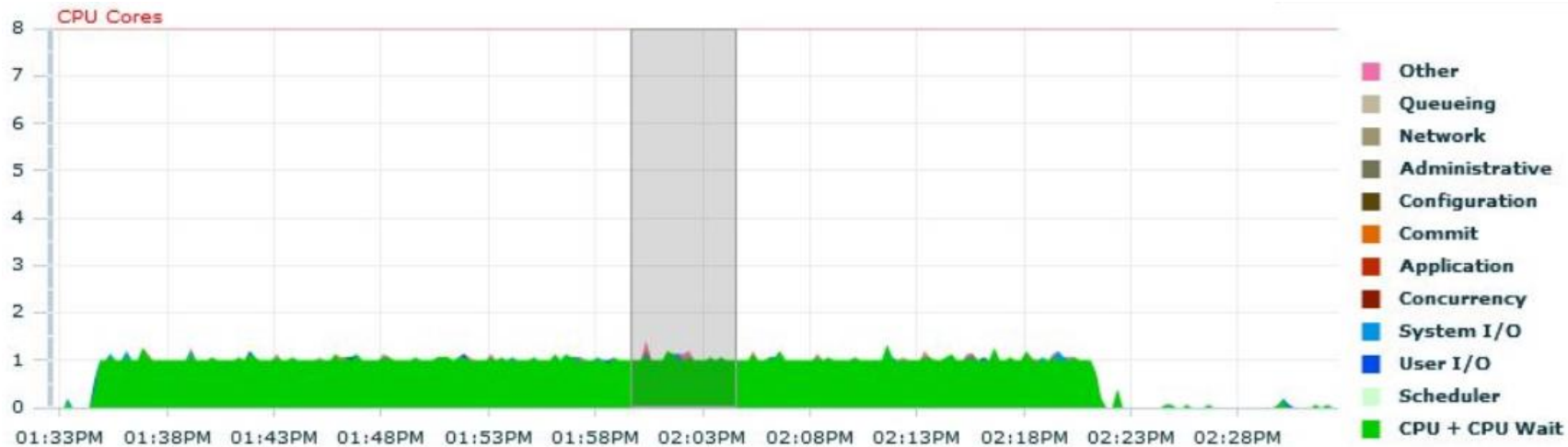
View C



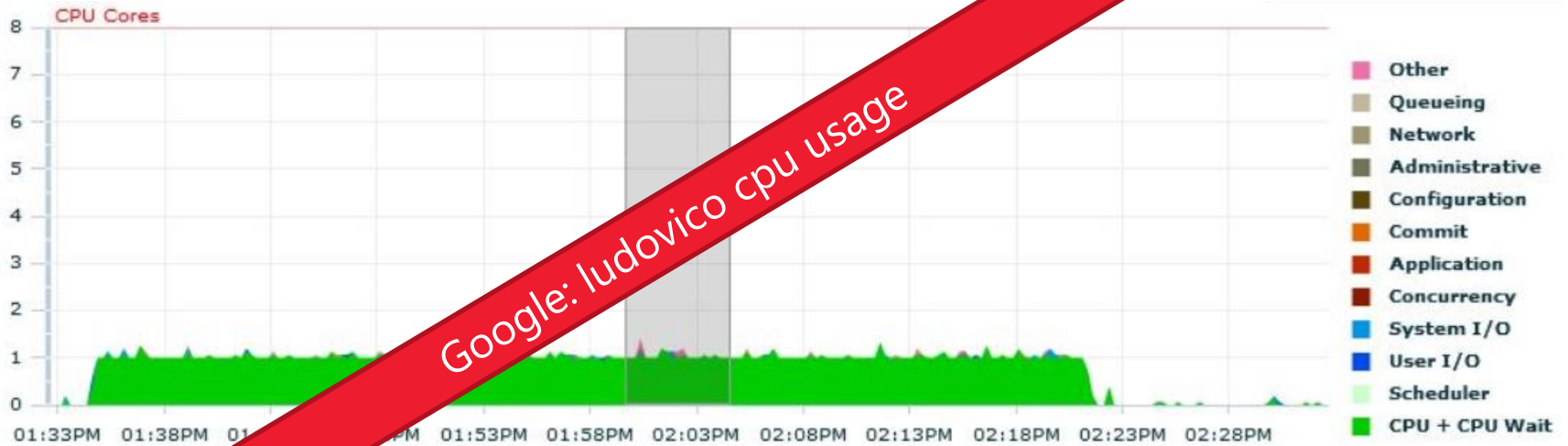
■ The Bomb!



■ The Bomb!



■ The Bomb!



■ SQL Plan Directives

- They **impact ALL the statements** that involve specific tables/columns/joins
- A few cardinality misestimates can lead to several side effects
 - Adaptive Dynamic Sampling triggered "without reason"
 - Extended Statistics created "without control"
- Different symptoms. Among others:
 - Library Cache contention
 - Result Cache problems
 - Bad Execution Plans
 - High CPU usage

■ Finding the SPDs used by a statement

■ Activate a trace 10053 (optimizer trace, much more information!)

OR

■ Explicit **EXPLAIN PLAN FOR ...** followed by **dbms_stats.display(format=>'metrics')**

```
SQL> explain plan for select count(*)+1 from t where val=1 and id>0;
Explained.
```

```
SQL> select * from table(dbms_xplan.display('format=>metrics'));
```

```
Sql Plan Directive information:
```

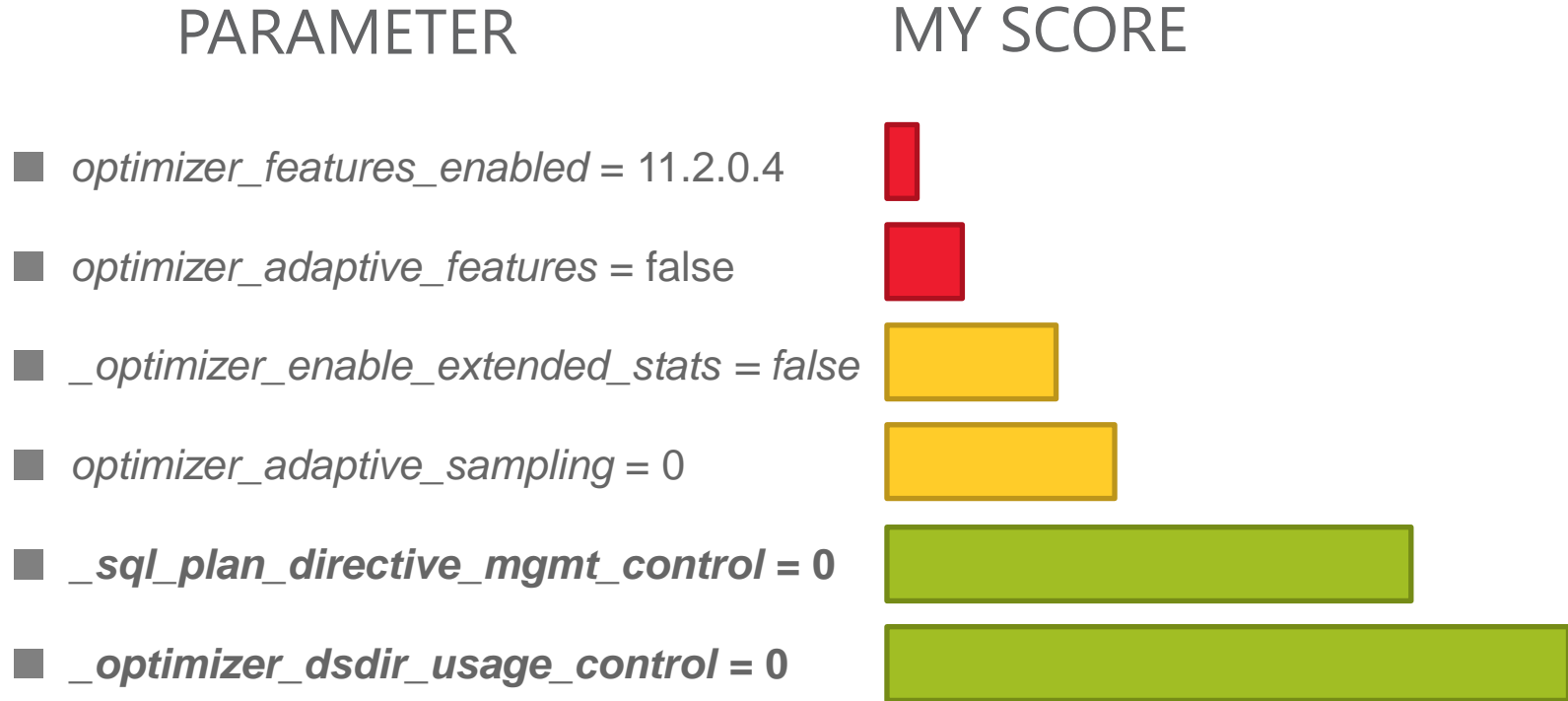
```
-----
```

```
Valid directive ids:
```

```
17154883816957472097
```

```
18093103661535947380
```

■ Resolving the problem database-wide



■ Fixing the single issue

```
SQL> BEGIN
  2   FOR rec IN
  3     (SELECT d.directive_id AS did
  4     FROM dba_sql_plan_directives d
  5     JOIN dba_sql_plan_dir_objects o
  6     ON (d.directive_id =o.directive_id)
  7     WHERE o.owner          ='OE'
  8     AND o.object_name in ('CUSTOMERS','ORDERS')
  9     )
 10  LOOP
 11     DBMS_SPD.ALTER_SQL_PLAN_DIRECTIVE ( rec.did, 'ENABLED', 'NO');
 12     DBMS_SPD.ALTER_SQL_PLAN_DIRECTIVE ( rec.did, 'AUTO_DROP', 'NO');
 13  END LOOP;
 14 END;
 15 /
```

■ Good to know

```
-- flush the directives
```

```
connect / as sysdba
```

```
BEGIN
```

```
    DBMS_SPD.FLUSH_SQL_PLAN_DIRECTIVE;
```

```
END;
```

```
/
```

■ Good to know (cont.)

```
-- list extensions
```

```
select owner,table_name,  
       listagg(column_name,',')  
         within group(order by column_name) columns,  
       extension_name  
  from dba_tab_columns join dba_stat_extensions  
     using(owner,table_name)  
 where extension like '%"'||column_name||'%"'  
and owner='OE'  
  group by owner,table_name,extension_name  
  order by owner,table_name,columns;
```

■ Good to know (cont.)

-- enable/disable trace 10053 for own session

```
alter session set events '10053 trace name context forever, level 1'  
alter session set events '10053 trace name context off'
```

-- enable/disable trace 10053 in other session

```
execute dbms_system.set_ev(si=>{SID}, se=>{SERIAL}, ev=>10053, le=>1, nm=>'');  
execute dbms_system.set_ev(si=>{SID}, se=>{SERIAL}, ev=>10046, le=>0, nm=>'');
```

-- enable/disable trace 10053 for a SQL_ID

```
alter system set events 'trace[RDBMS.SQL_Optimizer.*][sql:{SQL_ID}]';  
alter system set events 'trace[RDBMS.SQL_Optimizer.*][sql:{SQL_ID}] off';
```

-- get trace 10053 for an existing cursor

```
exec dbms_sqldiag.dump_trace('6jr7pwrk2tszg',0,'Optimizer','Optimizer_Trace');
```

■ Good to know (cont.)

```
-- list existent directives
```

```
SELECT d.directive_id, d.state,    d.enabled, o.object_name ,
o.subobject_name, d.reason,
       extract(d.notes, '/spd_note/spd_text/text()' )      spd_text,
       extract(d.notes, '/spd_note/internal_state/text()' ) internal_state
FROM dba_sql_plan_directives d
JOIN dba_sql_plan_dir_objects o
     ON (d.directive_id=o.directive_id)
WHERE o.owner='OE'
order by d.reason desc, d.directive_id,
       rank() over (partition by d.directive_id order by rownum ),
o.object_name,    o.subobject_name
;
```


■ Good to know (cont.)

```
-- pack directives from a source database
SET SERVEROUTPUT ON
DECLARE
  my_list  DBMS_SPD.OBJECTTAB := DBMS_SPD.ObjectTab();
  dir_cnt  NUMBER;
BEGIN
  DBMS_SPD.CREATE_STGTAB_DIRECTIVE (table_name => 'TAB_DIR', table_owner=> 'SYSTEM' );
  my_list.extend(1);
  my_list(1).owner := 'OE';
  my_list(1).object_name := 'PRODUCTS';
  my_list(1).object_type := 'TABLE';
  dir_cnt :=
    DBMS_SPD.PACK_STGTAB_DIRECTIVE(table_name => 'TAB_DIR', table_owner=> 'SYSTEM', obj_list =>
my_list);
  DBMS_OUTPUT.PUT_LINE('dir_cnt = ' || dir_cnt);
END;
/

-- export staging table
expdp directory=data_pump_dir dumpfile=TAB_DIR.dmp logfile=expdp_DIR.log tables=system.TAB_DIR
```

■ Good to know (cont.)

```
-- import staging table into the destination
impdp directory=data_pump_dir dumpfile=TAB_DIR.dmp logfile=impdp_DIR.log

-- remap directives (internal, not documented)
declare
dnum number;
begin
  dnum :=
dbms_spd_internal.REMAP_SPD('SYSTEM.TAB_PROP_DIRECTIVES','OE','OE_NEW','PRODUCTS','PRODUCT_NEW');
  dbms_output.put_line(to_char(dnum));
end;
/

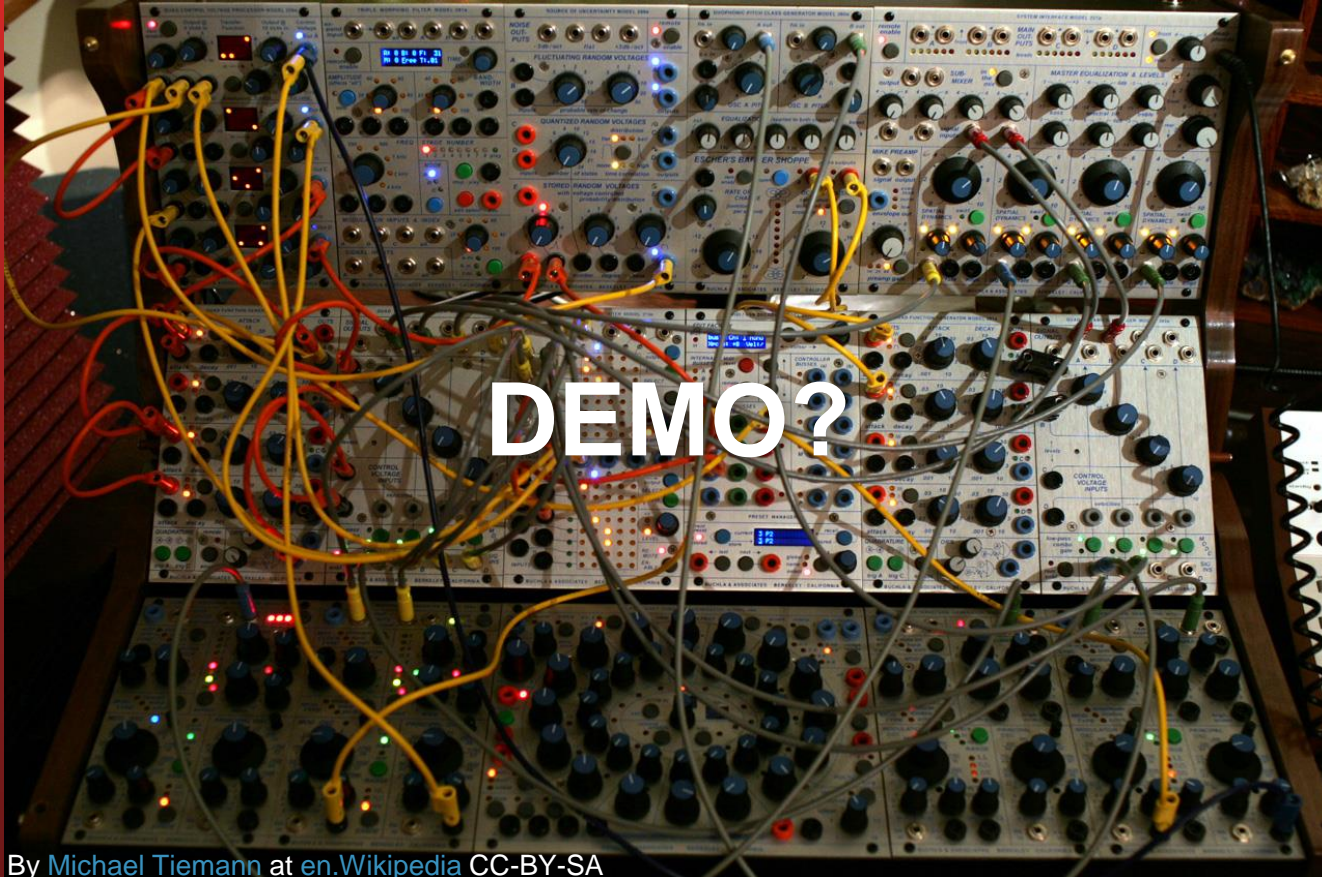
-- unpack directives
SELECT DBMS_SPD.UNPACK_STGTAB_DIRECTIVE(table_name => 'TAB_DIR', table_owner=> 'SYSTEM') FROM
DUAL;
```

■ SQL Plan Directives and Baselines

- When SPDs are used with Baselines:
 - the parse uses ADS
 - The parsed statement will be put in the Plan History
 - The cursor shows only the accepted statement! (that's SPM)

■ Beware of

- Highly normalized environments
- Statements with too many joins
- Tables with skewed data that does not fit in histograms
- Procedures making statistics stale



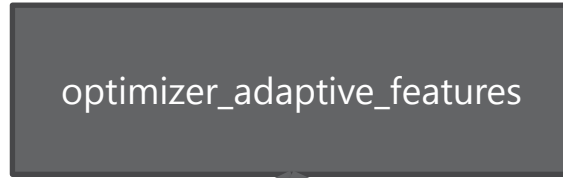
By [Michael Tiemann](#) at [en.Wikipedia](#) CC-BY-SA

12.2

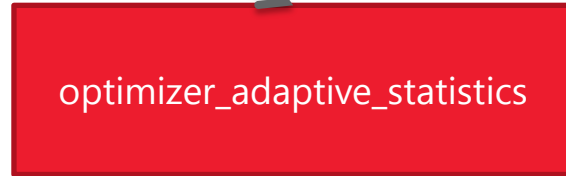
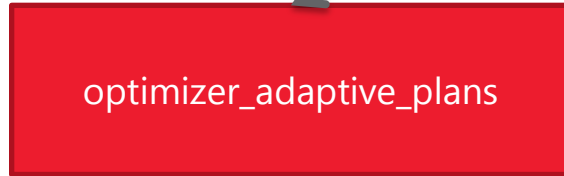
(Safe Harbor Statement)

■ New Parameters

12.1



12.2



■ 12.2 optimizer_adaptive_plans

- Enabled by default
- All the Adaptive Plans active by default
 - Join
 - Parallel Distribution
 - Star Transformation Pruning

optimizer_adaptive_plans

■ 12.2 optimizer_adaptive_statistics

optimizer_adaptive_statistics

- **Disabled** by default
- SPDs will be created but will not trigger ADS anymore
- Extended Statistics will be controlled by DBMS_STATS preference
(disabled by default)
- Parallel queries will not trigger ADS anymore
- ADS and normal Dynamic Sampling will still work if set up properly

■ 12.2 backport to 12.1

- Note: Recommendations for Adaptive Features in Oracle Database 12c Release 1 (12.1) (Doc ID **2187449.1**)
- Patch **21171382** (available) activates the new DBMS_STATS preference
 - AUTO_STATS_EXTENSION
- Patch **22652097** (available since a couple of weeks) introduces the new parameters of 12.2 in 12.1

■ More information

- <https://antognini.ch/2016/10/adaptive-query-optimization-configuration-parameters-preferences-and-fix-controls/>
- <http://www.oracle.com/technetwork/database/bi-datawarehousing/twp-optimizer-with-oracledb-12c-1963236.pdf>
- <http://www.slideshare.net/pachot/soug-2014-sqlplandirectives>
- http://www.itoug.it/wp-content/uploads/2016/05/AdaptiveDynamicSampling_OTNMI_2016.pdf
- <http://blog.dbi-services.com/matching-sql-plan-directives-and-queries-using-it/>
- <https://community.oracle.com/docs/DOC-918264>
- https://blogs.oracle.com/optimizer/entry/dynamic_sampling_and_its_impact_on_the_optimizer
- <http://www.toadworld.com/platforms/oracle/w/wiki/11453.spd-sql-plan-directives-in-12c-part-i>

Trivadis @ DOAG 2016

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