ORACLE

Performance and Migrations

A Practical Guide



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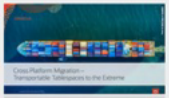
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Virtual Classroom Seminars	Slides
Episode 16 (replaces Episode 1 from Feb 2021) Oracle Database Release and Patching Strategy for 19c and 23c *115 minutes – May 10, 2023*	
Episode 17 From SR to Patch – Insights into the Oracle Database Development process *55 minutes – June 22, 2023*	
Episode 18 Cross Platform Migration – Transportable Tablespaces to the Extreme *145 min – February 22, 2024*	
Episode 19 Move to Oracle Database 23ai – Everything you need to know about Multitenant PART 1 *145 min – May 16, 2024*	
Episode 20 Move to Oracle Database 23ai – Everything you need to know about Multitenant PART 2 *100 min – June 28, 2024*	
Episode 21 One-Button Patching with AutoUpgrade – Easing every DBA's life *55 min – October 24, 2024*	

Recorded Web Seminars

https://MikeDietrichDE.com/videos

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What's the Worst That Can Happen?

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A Word about Statistics

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PHYSICAL



LOGICAL

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PHYSICAL



LOGICAL

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Statistics



Object Statistics

Statistics Preferences

Column Usage Information

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Object Statistics

Statistics



Statistics Preferences

Column Usage Information

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```
BEGIN
   DBMS_STATS.SET_TABLE_PREFS (
      OWNNAME => 'APPUSER',
      TABNAME => 'SALES',
      PNAME   => 'TABLE_CACHED_BLOCKS',
      PVALUE  => '42'
   );
END;
```


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Table 171-131 SET_TABLE_PREFS Procedure Parameters

Parameter	Description
ownname	Owner name
tabname	Table name
pname	Preference name. You can set the default value for following preferences: • APPROXIMATE_NDV_ALGORITHM • AUTO_STAT_EXTENSIONS • CASCADE • DEGREE • ESTIMATE_PERCENT • GRANULARITY • INCREMENTAL • INCREMENTAL_LEVEL • INCREMENTAL_STALENESS • METHOD_OPT • NO_INVALIDATE • OPTIONS • PREFERENCE_OVERRIDES_PARAMETER • PUBLISH • STALE_PERCENT • TABLE_CACHED_BLOCKS
pvalue	Preference value. If NULL is specified, it will set the Oracle default value.

PL/SQL Packages and Types Reference, Oracle Database 19c

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You often use statistics preferences to solve a particular problem

- Evaluate whether that problem exists in the target environment

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Statistics



Object Statistics

Statistics Preferences

Column Usage Information

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Column Usage Information

- Information on how you join tables
- Stored internally in `SYS.COL_USAGE$`
- Used by the optimizer to determine when to create histograms
  `METHOD_OPT => ... SIZE AUTO`
- When missing, statistics gathering creates no or few histograms

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1 Include statistics in Data Pump

2 Exclude statistics in Data Pump
Regather statistics after import

3 Exclude statistics in Data Pump
Import statistics using `DBMS_STATS`

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1 Include statistics in Data Pump

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Import statistics using DBMS_STATS

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Data Pump | Statistics

Data Pump includes:

- Object statistics
- Table level statistics preferences
- Column usage information

Data Pump does not include:

- Global statistics preferences

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Importing statistics using Data Pump is a convenient, but slow option

- Not recommended

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Importing or transporting statistics might be a bad idea…

When source and target database do not match

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Statistics | When Importing Stats Is Bad



Fragmented table

Blocks	12000
Leaf blocks	11000
B-level	4
Clustering factor	10000



Compacted table

Blocks	12000
Leaf blocks	11000
B-level	4
Clustering factor	10000

```
DBMS_STATS.GATHER_TABLE_STATS(...
```

Blocks	5000
Leaf blocks	4000
B-level	2
Clustering factor	20000

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Statistics | When Importing Stats Is Bad

- Potentially a problem
  - Fragmented tables
  - Changing block size
  - Changing character set
  - Compress or decompress
  - …
- Only a problem for table and index base statistics, column statistics remain accurate

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1 Include statistics in Data Pump

2 Exclude statistics in Data Pump
Regather statistics after import

3 Exclude statistics in Data Pump
Import statistics using DBMS_STATS

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```
expdp ... exclude=statistics
```


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Gather statistics fast

- Blog post by Nigel Bayliss

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```
begin
 dbms_stats.gather_database_stats(
      options => 'GATHER',
      cascade => TRUE,
      degree  => DBMS_STATS.AUTO_DEGREE);
end;
/
```


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```
begin
 dbms_stats.gather_database_stats(
      options => 'GATHER',
      cascade => TRUE,
      degree  => DBMS_STATS.AUTO_DEGREE);
end;
/
```


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```
begin
 dbms_stats.gather_database_stats(
      options => 'GATHER',
      cascade => TRUE,
      degree  => DBMS_STATS.AUTO_DEGREE);
end;
/
```


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```
begin
 dbms_stats.gather_database_stats(
      options => 'GATHER',
      cascade => TRUE,
      degree  => DBMS_STATS.AUTO_DEGREE);
end;
/
```


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You're missing statistics preferences

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```
EXEC DBMS_STATS.EXPORT_TABLE_PREFS('APPUSER', 'SALES', 'STAGING_TAB');

expdp ... tables=APPUSER.STAGING_TAB
```

```
impdp ... tables=APPUSER.STAGING_TAB

EXEC DBMS_STATS.IMPORT_TABLE_PREFS('APPUSER', 'SALES', 'STAGING_TAB');
```


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You're missing column usage information

- Statistics gathering creates no histograms

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EXCLUDE

`EXCLUDE=STATISTICS`

`COL_USAGE$` empty



REGATHER

First time only

```
METHOD_OPT =>
... SIZE SKEWONLY
```



GO LIVE

Column usage information is updated



REGATHER

Use default

```
METHOD_OPT =>
... SIZE AUTO
```


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```
begin
 dbms_stats.gather_database_stats(
      options    => 'GATHER',
      cascade    => TRUE,
      degree     => DBMS_STATS.AUTO_DEGREE,
      method_opt => FOR ALL COLUMNS SIZE SKEWONLY);
end;
/
```


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Gather Statistics

Gathering stats with `SIZE SKEWONLY` probably:

- Creates more histograms than `SIZE AUTO`
- Takes a little longer time

But better too many, than too few histograms

- Missing histograms may lead to suboptimal plans

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Further Information

Transporting statistics

- Blog post: How to Export and Import Statistics Faster Using DBMS_STATS in Parallel
- Blog post: If Importing Statistics Using DBMS_STATS Is Slow
- Blog post: Does Exporting Database Statistics Include the Dictionary Statistics?
- Video: Transporting optimizer statistics - pro tips
- Video: Transporting optimizer statistics - demo
- Video: Transporting optimizer statistics - the concept

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1 Include statistics in Data Pump

2 Exclude statistics in Data Pump
Regather statistics after import

3 Exclude statistics in Data Pump
Import statistics using `DBMS_STATS`

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```
EXEC DBMS_STATS.EXPORT_SCHEMA_STATS('APPUSER', 'STAGING_TAB');

expdp ... tables=APPUSER.STAGING_TAB
```

```
impdp ... tables=APPUSER.STAGING_TAB

EXEC DBMS_STATS.IMPORT_SCHEMA_STATS('APPUSER', 'STAGING_TAB');
```


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The database considers imported statistics as *current*

- Be sure those statistics are accurate

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Data Pump | Statistics



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You're missing statistics preferences

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You're missing column usage information

- Warm up the database before next stats gathering

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Comparing STATISTICS options

	Import with Data Pump	Regather	Import with DBMS_STATS
Time	Significant	Significant	Short
Column usage information	Included	Missing	Missing
Accuracy	Potentially inaccurate	Accurate	Potentially inaccurate
Statistics preferences	Included	Missing	Optional

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Performance Stability Prescription

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What if we had a *one-button* tool that points out the bad statements…

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SQL Performance Analyzer

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Database Licensing Information User Manual

1 Licensing Information

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- Oracle AI Database Offerings
- Permitted Features, Options, and Management Packs by Oracle AI Database Offering
- Oracle AI Database Options and Their Permitted Features
- Oracle Management Packs and Their Permitted Features
- Checking for Feature, Option, and Management Pack Usage
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PERFORMANCE STABILITY

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1

CAPTURE

2

ANALYZE

3

FIX

4

REMEDY

1

CAPTURE

Capture
workload information
into SQL Tuning Set

2

ANALYZE

3

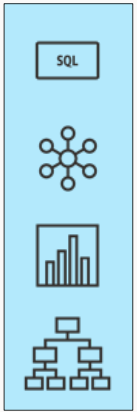
FIX

4

REMEDY

SQL Tuning Set | Definition

SQL Tuning Set



SQL statement

Context

Statistics

Plans

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```
--Capture directly from cursor cache at regular intervals
exec DBMS_SQLSET.CAPTURE_CURSOR_CACHE ( ... );

--One time sample from cursor cache
exec DBMS_SQLSET.SELECT_CURSOR_CACHE ( ... );
```


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```
--Capture directly from cursor cache at regular intervals
exec DBMS_SQLSET.CAPTURE_CURSOR_CACHE ( ... );

--One time sample from cursor cache
exec DBMS_SQLSET.SELECT_CURSOR_CACHE ( ... );

--Capture from AWR
SQL> exec DBMS_SQLSET.SELECT_WORKLOAD_REPOSITORY ( ... );
```


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```
SQL> select name, statement_count from dba_sqlset;

NAME                          STATEMENT_COUNT
_____________________________ _______________
SALES_APP_WORKLOAD                       2343
```


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```
SQL> select view_name from dba_views where view_name like
'DBA%SQLSET%';

VIEW_NAME

_____________________________
DBA_SQLSET
DBA_SQLSET_REFERENCES
DBA_SQLSET_STATEMENTS
DBA_SQLSET_BINDS
DBA_SQLSET_PLANS
```


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```
SQL> select name, statement_count from dba_sqlset;

NAME                           STATEMENT_COUNT
------------------------------ ---------------
SALES_APP_WORKLOAD                        2343
SYS_AUTO_STS                              6426
```


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Automatic SQL Tuning Set is not meant to be transported

- Collect into your own SQL Tuning Set

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Gather at least a full month of workload data

- Assist in testing your database
- Useful in solving post-migration performance problems

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```
EXEC DBMS_SQLSET.PACK_STGTAB ( ... );

...

EXEC DBMS_SQLSET.UNPACK_STGTAB ( ... );
```


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```
-- If you have many bind variables in your queries, increase the number of binds
-- to capture from 400 (default) to 3999 (max)

alter system set "_cursor_bind_capture_area_size"=3999;
```


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Further Information

SQL Tuning Set



- Blog post: Oracle SQL Tuning Sets (STS) – The foundation for SQL Tuning
- Blog post: What is the automatic SQL tuning set?

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1

CAPTURE

2

ANALYZE

Analyze performance after migration using SQL Performance Analyzer

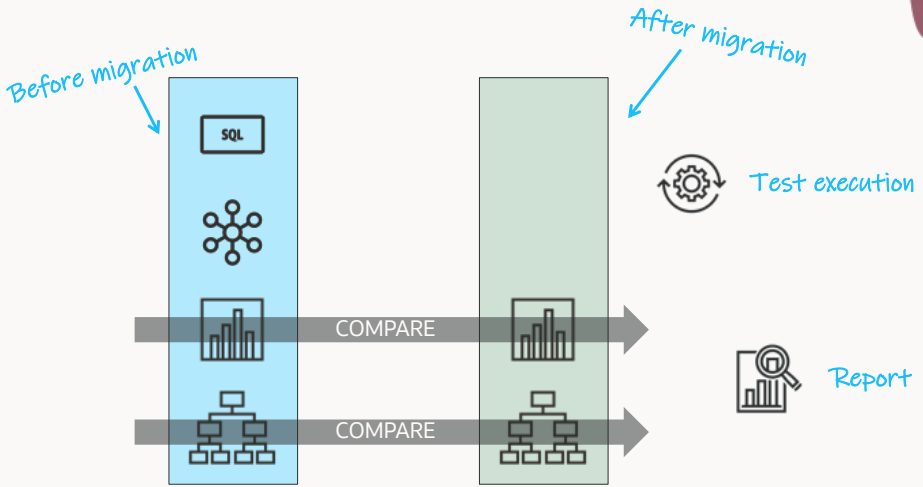
3

FIX

4

REMEDY

SQL Performance Analyzer



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Report Summary

Projected Workload Change Impact:

Overall Impact	:	**4.64%**
Improvement Impact	:	**30.98%**
Regression Impact	:	**-26.35%**

SQL Statement Count

SQL Category	SQL Count	Plan Change Count
Overall	43	5
Improved	1	1
Regressed	1	1
Unchanged	30	3
Unsupported	11	0

Top 32 SQL Sorted by Absolute Value of Change Impact on the Workload

object_id	sql_id	Impact on Workload	Execution Frequency	Metric Before	Metric After	Impact on SQL	Plan Change
83	f90zn75aphu4w	30.98%	2828	139319.505304102	41950	69.89%	y
47	0cwuxyv314wcg	-26.35%	18254	981.459680070122	13809	-1306.99%	y
80	csv0xdm9c394t	-.36%	2734	4689.26664228237	5868	-25.14%	n
60	4hbzjyh4p336s	.21%	2818	668.862668559262	10	98.5%	n
76	a8ntu3081hfqw	-.18%	2818	262.609297374024	828	-215.3%	y

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47	0cwuxyv314wcg	-26.35%	18254	981.459680070122	13809	-1306.99%	y
80	csv0xdm9c394t	-.36%	2734	4689.26664228237	5868	-25.14%	n
60	4hbzjyh4p336s	.21%	2818	668.862668559262	10	98.5%	n
76	a8ntu3081hfqw	-.18%	2818	262.609297374024	828	-215.3%	y

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47	0cwuxyv314wcg	-26.35%	18254	981.459680070122	13809	-1306.99%	y
80	csv0xdm9c394t	-.36%	2734	4689.26664228237	5868	-25.14%	n
60	4hbzjyh4p336s	.21%	2818	668.862668559262	10	98.5%	n
76	a8ntu3081hfgw	-.18%	2818	262.609297374024	828	-215.3%	y

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SQL Details:

Object ID	: 47
Schema Name	: TPCC
Container Name	: Unknown (con_dbid: 344460545)
SQL ID	: 0cwuxyv314wcg
Execution Frequency	: 18254
SQL Text	: SELECT ROWID FROM CUSTOMER WHERE C_W_ID = :B3 AND C_D_ID = :B2 AND C_LAST = :B1

Bind Variables:

1 - (NUMBER): 3
2 - (NUMBER): 7
3 - (VARCHAR2): ESEEINGOUGHT

Execution Statistics:

Stat Name	Impact on Workload	Value Before	Value After	Impact on SQL
elapsed_time	-26.35%	.000981	.013809	-1306.99%
parse_time			.000477	
cpu_time	-106.5%	.000494	.013743	-2681.43%
user_io_time			0	
buffer_gets	-130.82%	253	7252	-2759.03%
cost	-745969.19%	255	1982	-677.25%
reads	0%	0	0	0%
writes	0%	0	0	0%

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SQL Details:

Object ID : 47
Schema Name : TPCC
Container Name : Unknown (con_dbid: 344460545)
SQL ID : 0cwuxyv314wcg
Execution Frequency : 18254
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Bind Variables:

1 - (NUMBER): 3
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Stat Name	Impact on Workload	Value Before	Value After	Impact on SQL
elapsed_time	-26.35%	.000981	.013809	-1306.99%
parse_time			.000477	
cpu_time	-106.5%	.000494	.013743	-2681.43%
user_io_time			0	
buffer_gets	-130.82%	253	7252	-2759.03%
cost	-745969.19%	255	1982	-677.25%
reads	0%	0	0	0%
writes	0%	0	0	0%

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Execution Plan Before Change:

Plan Hash Value : 612465046

Id	Operation	Name	Rows	Bytes	Cost	Time
0	SELECT STATEMENT				255	
1	SORT ORDER BY		2	92	255	00:00:01
2	TABLE ACCESS BY INDEX ROWID BATCHED	CUSTOMER	2	92	254	00:00:01
3	INDEX RANGE SCAN	CUSTOMER_I1	3000		10	00:00:01

Execution Plan After Change:

Plan Id : 545

Plan Hash Value : 4040750106

Id	Operation	Name	Rows	Bytes	Cost	Time
0	SELECT STATEMENT		2	92	1982	00:00:01
1	SORT ORDER BY		2	92	1982	00:00:01
* 2	TABLE ACCESS FULL	CUSTOMER	2	92	1981	00:00:01

Predicate Information (identified by operation id):

- 2 - filter("C_LAST"=:B1 AND "C_D_ID"=:B2 AND "C_W_ID"=:B3)

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Execution Plan Before Change:

Plan Hash Value : 612465046

Id	Operation	Name	Rows	Bytes	Cost	Time
0	SELECT STATEMENT				255	
1	SORT ORDER BY		2	92	255	00:00:01
2	TABLE ACCESS BY INDEX ROWID BATCHED	CUSTOMER	2	92	254	00:00:01
3	INDEX RANGE SCAN	CUSTOMER_I1	3000		10	00:00:01

Execution Plan After Change:

Plan Id : 545
Plan Hash Value : 4040750106

Id	Operation	Name	Rows	Bytes	Cost	Time
0	SELECT STATEMENT		2	92	1982	00:00:01
1	SORT ORDER BY		2	92	1982	00:00:01
* 2	TABLE ACCESS FULL	CUSTOMER	2	92	1981	00:00:01

Predicate Information (identified by operation id):

- 2 - filter("C_LAST"=:B1 AND "C_D_ID"=:B2 AND "C_W_ID"=:B3)

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You don't need to connect your app to use SQL Performance Analyzer

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You can use SQL Performance Analyzer to test any change to your database

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Schema changes may interfere with SQL Performance Analyzer

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Further Information

SQL Performance Analyzer



- Blog post: Smooth transition to Autonomous Database using SPA

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1

CAPTURE

2

ANALYZE

3

FIX

Fix regressing statements

4

REMEDY

Fixing Statements

Most cloud offerings have access to a number of tools:

- SQL Tuning Advisor
- Real-time SQL Monitoring
- SQL Access Advisor

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Perhaps you even have access to a DBA

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You could also ask ChatGPT

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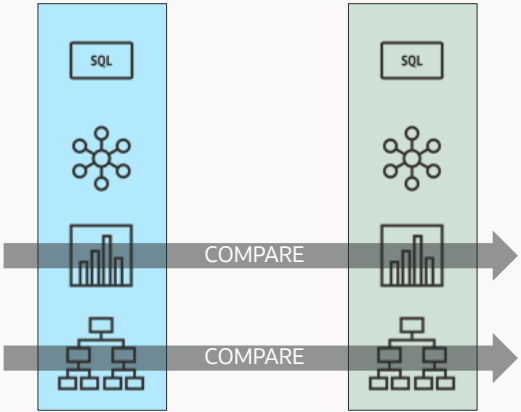


What is the best fix?

- Does it have any side effects?

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Continuous Improvement



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Continuous Improvement



Implement change



Test execute



Check outcome



Repeat

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1

CAPTURE

2

ANALYZE

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FIX

4

REMEDY

Stabilize performance
using
SQL Plan Management



SQL Plan Management is the best tool to ensure plan stability

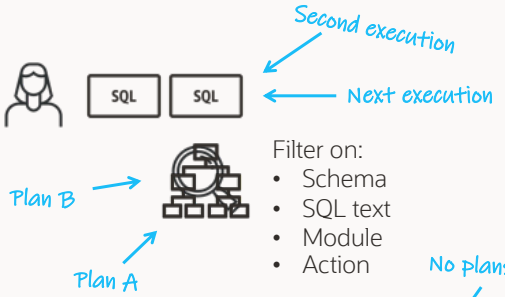
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```
-- Toggles creation of SQL plan baselines for all repeatable statements
-- Usually, not recommended to capture and create baselines for all statements

alter system set optimizer_capture_sql_plan_baselines=true;
```

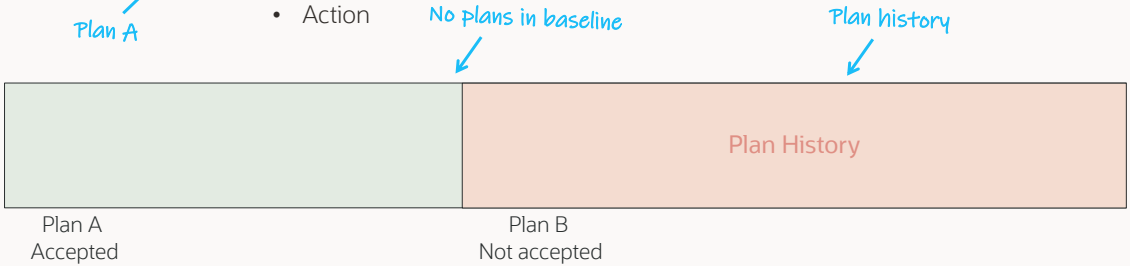

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SQL Plan Management



Filter on:
- Schema
- SQL text
- Module
- Action

Something changed:
- New statistics
- New parameters
- Upgrade



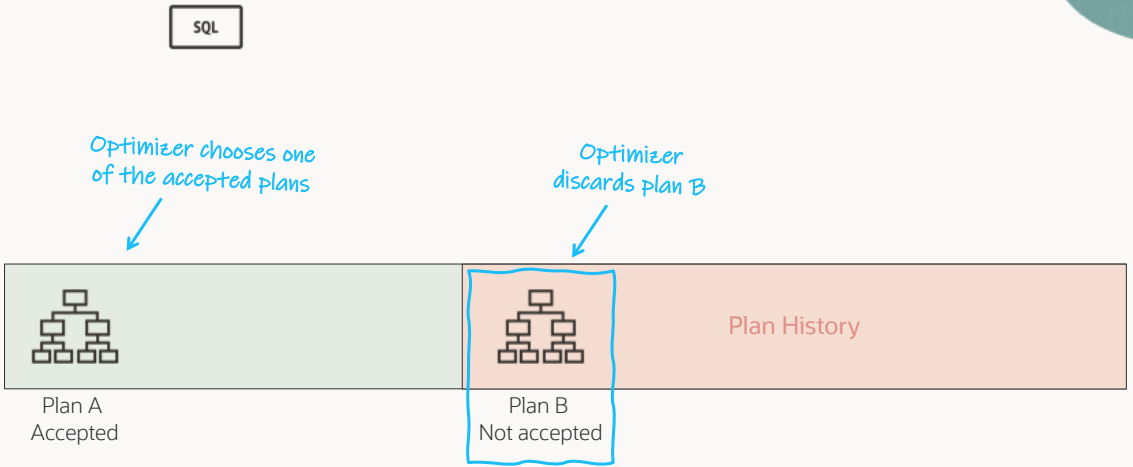
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```
-- Restricts the optimizer to only use plans that are accepted
-- This is the default value

alter system set optimizer_use_sql_plan_baselines=true;
```

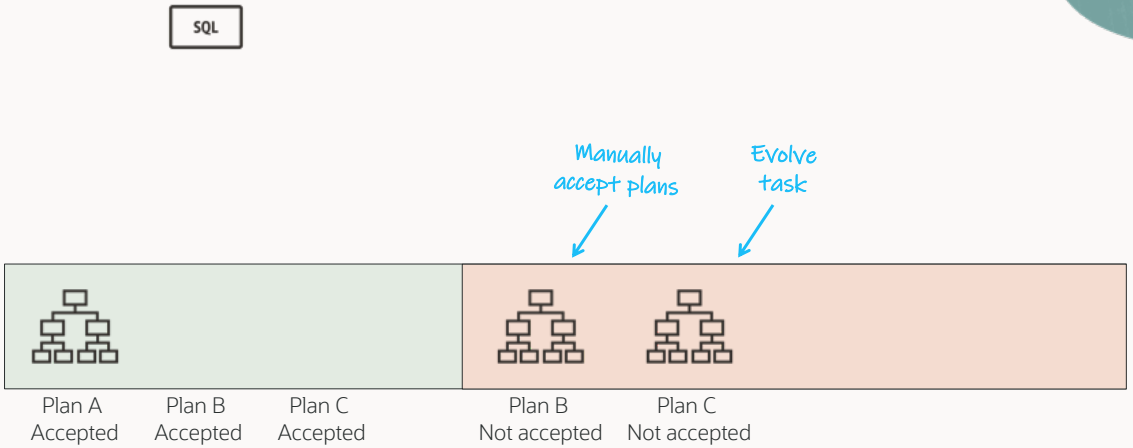

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SQL Plan Management



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```
-- The database stores plans in the plan history for 53 weeks.
-- This might consume a lot of space. Consider lowering the limit.

exec dbms_spm.configure('plan_retention_weeks', 5);
```


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You can manually create plan baselines for specific statements

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```
-- Load all plans from a SQL tuning set into plan baselines
-- Plans are accepted automatically without test execution

var cnt number;
exec :cnt := DBMS_SPM.LOAD_PLANS_FROM_SQLSET(
                basic_filter => 'sql_id=''0cwuxyv314wcg''',
                ...
             );
```


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Plan baselines are transportable; create in test, use in production

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```
-- Pack baselines from "problematic" statements into staging table
exec DBMS_SPM.PACK_STGTAB_BASELINE(sql_handle => SQL_130f372d9ffe4df9, ...);
```


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```
-- Pack baselines from "problematic" statements into staging table
exec DBMS_SPM.PACK_STGTAB_BASELINE(sql_handle => SQL_130f372d9ffe4df9, ...);
exec DBMS_SPM.PACK_STGTAB_BASELINE(sql_handle => SQL_51dc7232adc62849, ...);
exec DBMS_SPM.PACK_STGTAB_BASELINE(sql_handle => SQL_3f38bc33ae7086c9, ...);
```


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```
-- Pack baselines from "problematic" statements into staging table
exec DBMS_SPM.PACK_STGTAB_BASELINE(sql_handle => SQL_130f372d9ffe4df9, ...);
exec DBMS_SPM.PACK_STGTAB_BASELINE(sql_handle => SQL_51dc7232adc62849, ...);
exec DBMS_SPM.PACK_STGTAB_BASELINE(sql_handle => SQL_3f38bc33ae7086c9, ...);

...

-- After production migration, import plan baselines to fix regressions
exec DBMS_SPM.UNPACK_STGTAB_BASELINE( ... );
```


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Let's automate it

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Automatic SQL Plan Management







- User executes SQL
- Optimizer chooses a different execution plan
- Executes with new plan

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Automatic SQL Plan Management







- Background job (30 min)
- Finds resource-intensive SQLs
- Evaluate execution statistics against previous executions

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Automatic SQL Plan Management







- Creates a plan baseline with the best plan
- Next execution uses an accepted plan

- Oracle Database 19c Enterprise Edition, RU 19.22
- Exadata and Autonomous AI Database

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Real-Time SQL Plan Management







- User executes SQL
- Optimizer chooses a different execution plan
- Executes with new plan

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Real-Time SQL Plan Management







- Compares execution statistics with history
- Comparison is performed in the user foreground session

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Real-Time SQL Plan Management







- Creates a plan baseline with the best plan
- Next execution uses an accepted plan

- Oracle AI Database 26ai Enterprise Edition
- Autonomous AI Database 19c

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Here's one for the Top Gun DBA

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DEMO

Regressing statement
Fix using SQL Plan Management



Watch on YouTube

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```
--Loads all known plans from cursor cache, AWR,
--and automatic SQL tuning sets into a SQL plan baseline.
--Use Evolve Advisor to find the best plan and mark that as accepted.

var report clob;
exec :report := dbms_spm.add_verified_sql_plan_baseline('<sql_id>');
select :report report from dual;
```


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What Happened?

- A statement regressed
- DBA executes `DBMS_SPM.ADD_VERIFIED_SQL_PLAN_BASELINE`
- It finds all previous executions of statement
  - Cursor cache, AWR, SQL tuning set, Automatic SQL Tuning Set
- Use SQL Plan Management Evolve Advisor to find best-performing plan
- Create SQL plan baseline with best-performing plan as *accepted* plan
- Next execution of statement uses the accepted plan

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Who said literals?

- SQL Plan Management is not a good fit for an application that doesn't use bind variables

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```
--Application using literals creates many distinct statements
--You'd get 4 plan baselines
select * from sales where order_id=42;
select * from sales where order_id=56;
select * from sales where order_id=101;
select * from sales where order_id=220;
```


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```
--Application using literals creates many distinct statements
--You'd get 4 plan baselines
select * from sales where order_id=42;
select * from sales where order_id=56;
select * from sales where order_id=101;
select * from sales where order_id=220;


--Ideally change the application to use literals
--You'd get only 1 plan baseline
select * from sales where order_id=:b1;
```


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Generally, avoid setting `CURSOR_SHARING=FORCE`

- Advice from Real-World Performance Group

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Use SQL Profiles

- Part of Tuning Pack
- Included in most cloud offerings

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Further Information

SQL Plan Management



- Blog post: SQL Plan Management Cheat Sheet – Part 1
- Blog post: SQL Plan Management Cheat Sheet – Part 2
- Blog post: What is automatic SQL plan management and why should you care?
- Blog post: What is Real-time SQL plan Management?
- My Oracle Support: Things to Consider to Avoid SQL Plan Management (SPM) Related Problems on 19c (KB139467)

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1

CAPTURE

2

ANALYZE

3

FIX

4

REMEDY

Hands-on Lab

Top Gun DBA:
Zero-Turbulence Upgrades, Stable Performance

It's better to fail in our lab, than in production

Access lab on Oracle Live Labs

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Key Learnings



1. Gather workload information
2. Test with SQL Performance Analyzer
3. Use SQL Plan Management

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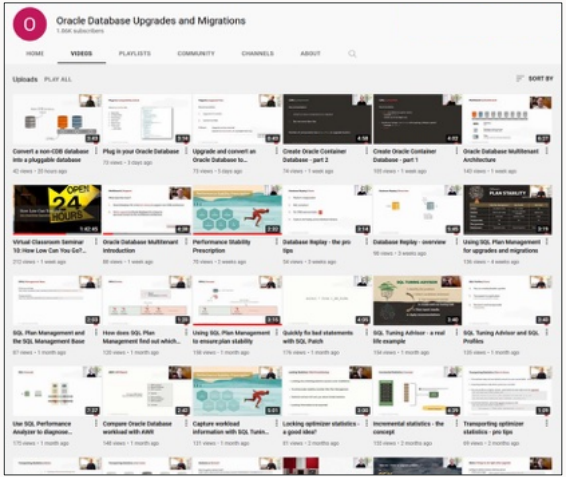
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DBAs

run the world



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https://www.youtube.com/@upgradenow

- 300+ videos
- New videos every week
- No marketing
- No buzzword
- All tech

SCAN ME

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Thank You

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