

ORACLE®

# Safe Harbor Statement

The following is intended to outline our general product direction. It is intended for information purposes only, and may not be incorporated into any contract. It is not a commitment to deliver any material, code, or functionality, and should not be relied upon in making purchasing decisions. The development, release, and timing of any features or functionality described for Oracle's products remains at the sole discretion of Oracle.

# The Optimizer in Oracle Database 12c Upgrading Without Pain

Nigel Bayliss

Optimizer Product Manager

@vlddb

<http://blogs.oracle.com/optimizer>

Data Warehousing

Product Management Team

# The Optimizer in Oracle Database 12c

## Upgrading *With Minimal Pain*

Nigel Bayliss

Optimizer Product Manager

@vlddb

<http://blogs.oracle.com/optimizer>

Data Warehousing

Product Management Team

# Upgrading to Oracle Database 12c Without Pain

- **From:**

- Oracle Database 11g Release 2 or...
- Oracle Database 12c Release 1

- **To:**

- Oracle Database 12c Release 2

- With a word about Oracle Database 12c Release 1

# Upgrading to Oracle Database 12c Without Pain

- I will cover adaptive optimizer features but...
- ...less about...
  - What adaptive features do (it doesn't matter in this context)
- ...more about...
  - When to care
  - The DBA's perspective (adaption and metadata)
  - Controlling adaptive features
  - Prioritizing stability

# Agenda

- 1 Stepping up to Oracle Database 12c
- 2 Enhancements in Oracle Database 12c Release 2
- 3 Upgrade Approach
- 4 A word about Oracle Database 12c Release 1
- 5 From test to production

# Agenda

- 1 Stepping up to Oracle Database 12c
- 2 Enhancements in Oracle Database 12c Release 2
- 3 Upgrade Approach
- 4 A word about Oracle Database 12c Release 1
- 5 From test to production

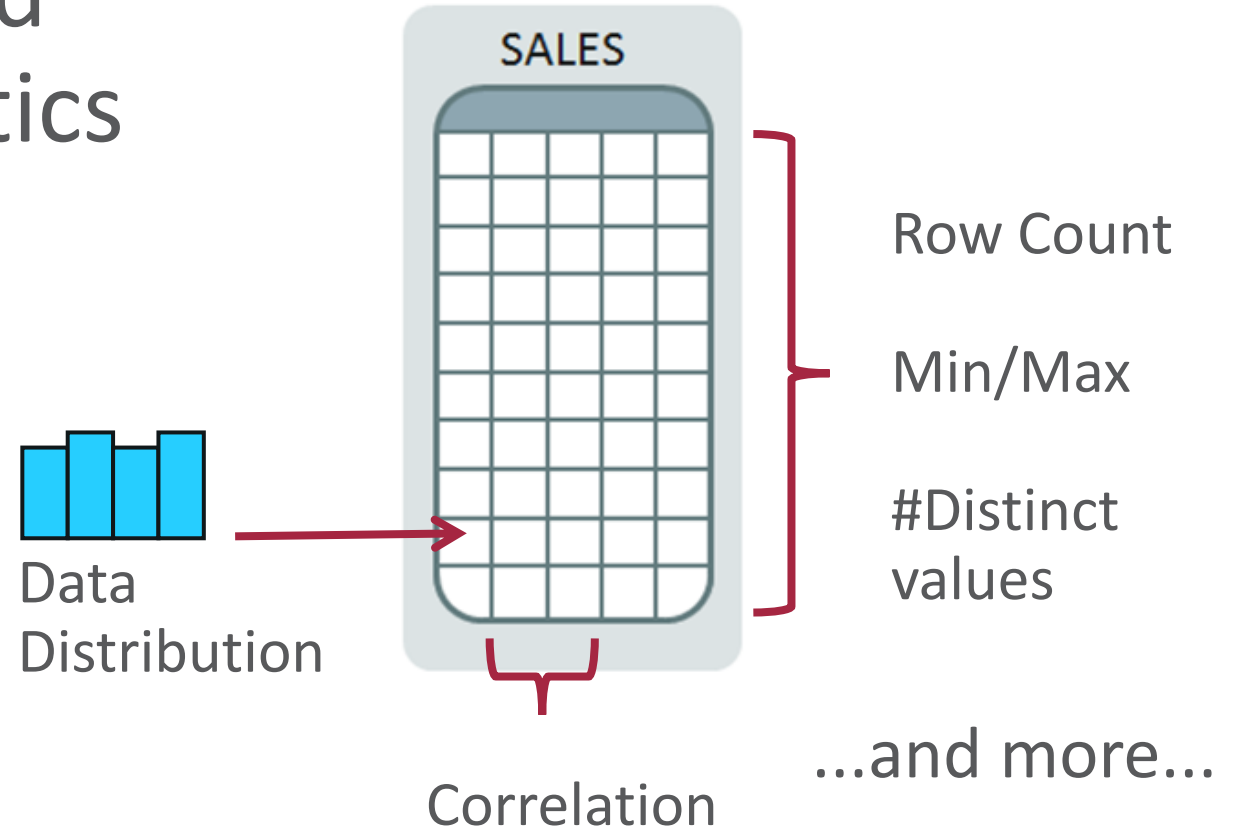


# The Goal of the Oracle Optimizer

- To find a good SQL execution plan for every query
  - Oracle must figure out **how** to execute queries
  - Better execution plans yield better performance
- The optimizer uses *cardinality* estimates to find the best execution plans
  - "How many rows?"

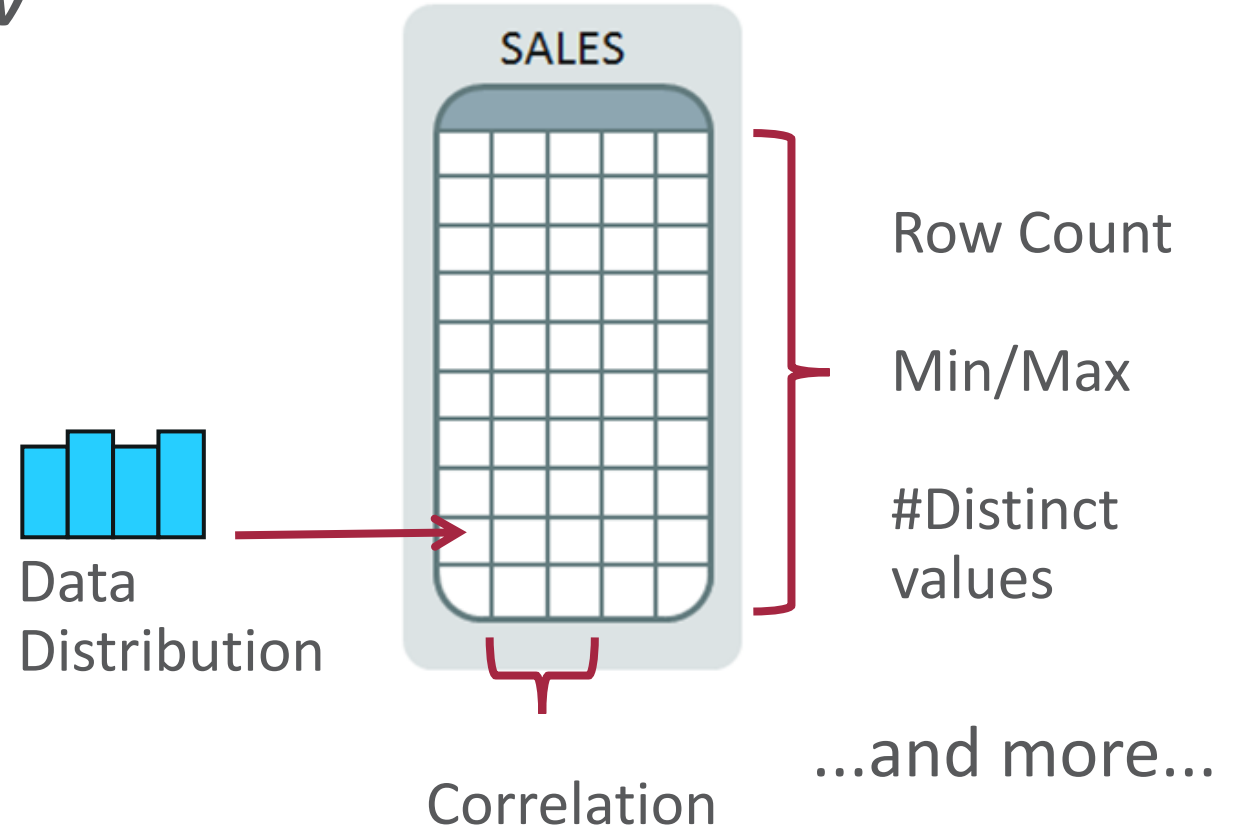
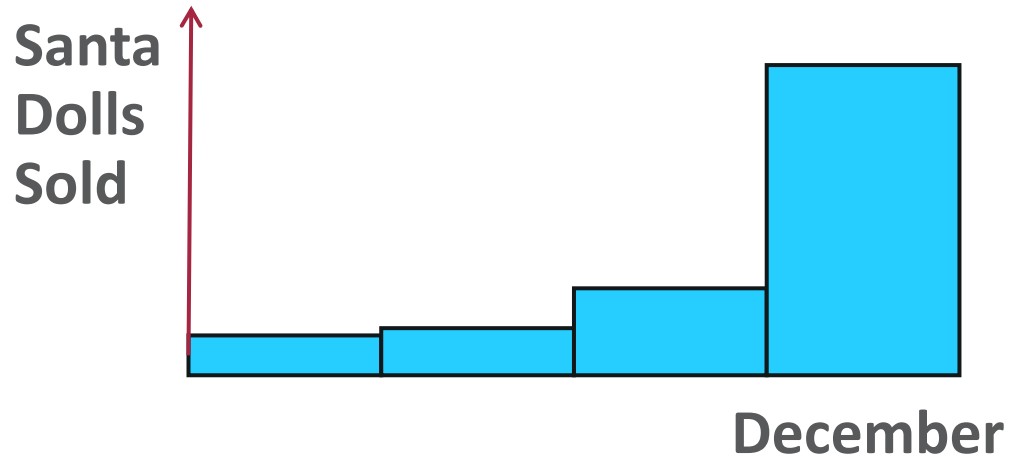
# The Cost-Based Optimizer Uses Statistics

- The database gathers and stores a rich set of statistics about your data



# The Cost-Based Optimizer Uses Statistics

- Histograms for *data skew*



# The Cost-Based Optimizer Uses Statistics

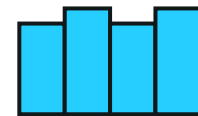
- Column Group Statistics for *correlation*

...

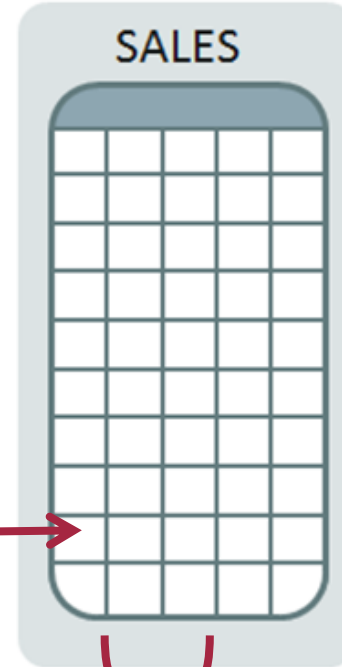
**WHERE month = 'NOVEMBER'  
AND zodiac = 'SCORPIO'**

**Month**

**Zodiac**



Data  
Distribution



Row Count

Min/Max

#Distinct  
values

...and more...

Correlation

## But Statistics Are Not Always Enough

- SQL statements can be **REALLY** complex
- Schemas can be **REALLY** complex
- Data can be **REALLY** complex

# The Goal of the **Adaptive** Optimizer

- Account for complexity
  - Identify cardinality misestimates
  - Obtain better cardinality estimates
  - Use better estimates to improve SQL execution plans
  - Improve optimizer statistics
    - Histograms
    - Column group statistics

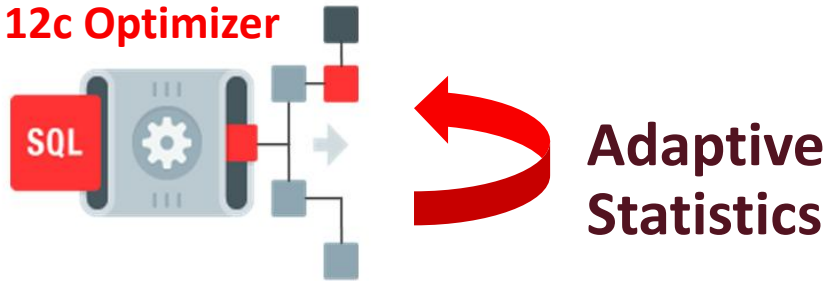
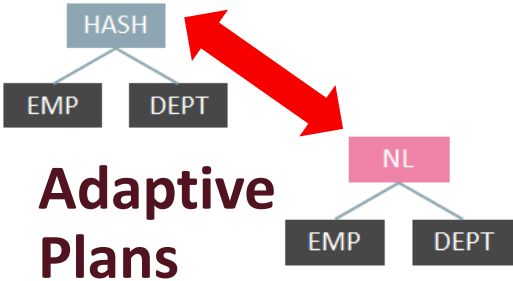
# New in Oracle Database 12c Release 1

## The Adaptive Optimizer

Optimizer Adaptive Features

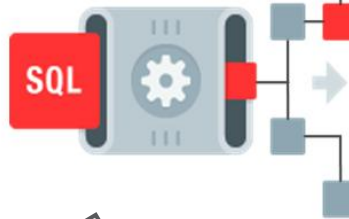
Change SQL execution plans at runtime

Learn from previous executions and choose better SQL execution plans



# Oracle Database 11g

11g Optimizer

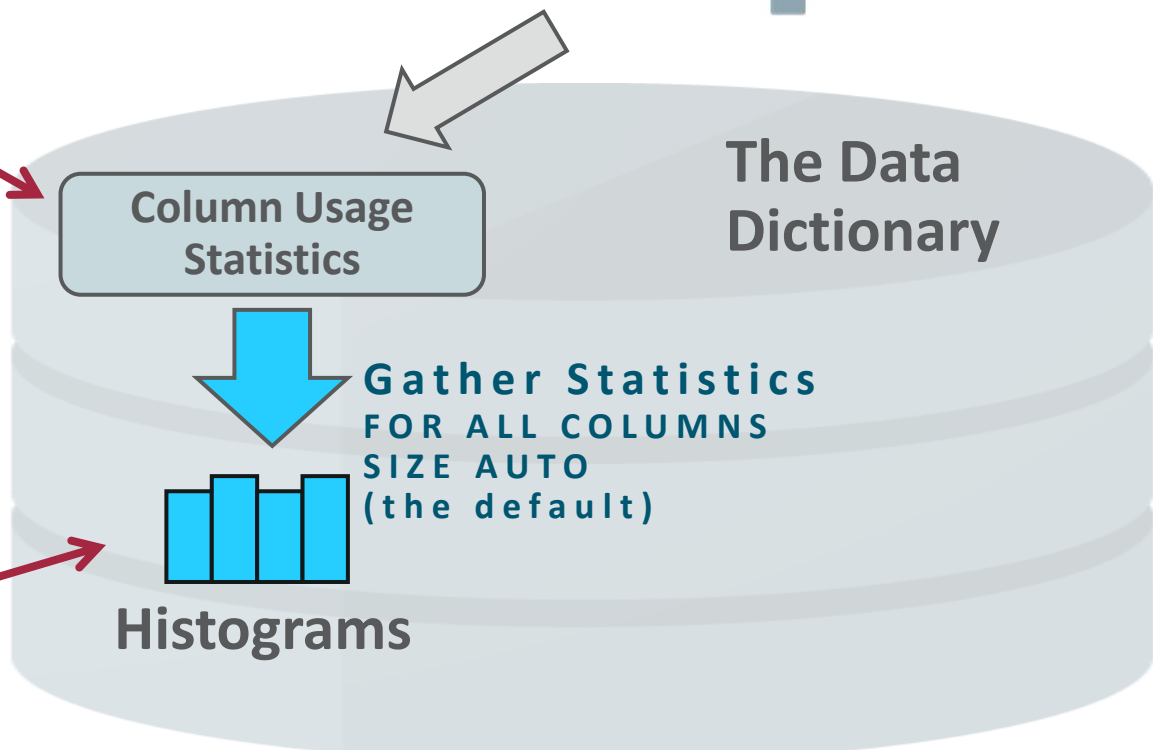


Cardinality Feedback

Answers the question, "How *are* columns used in queries?"

This metadata is persisted to the data dictionary

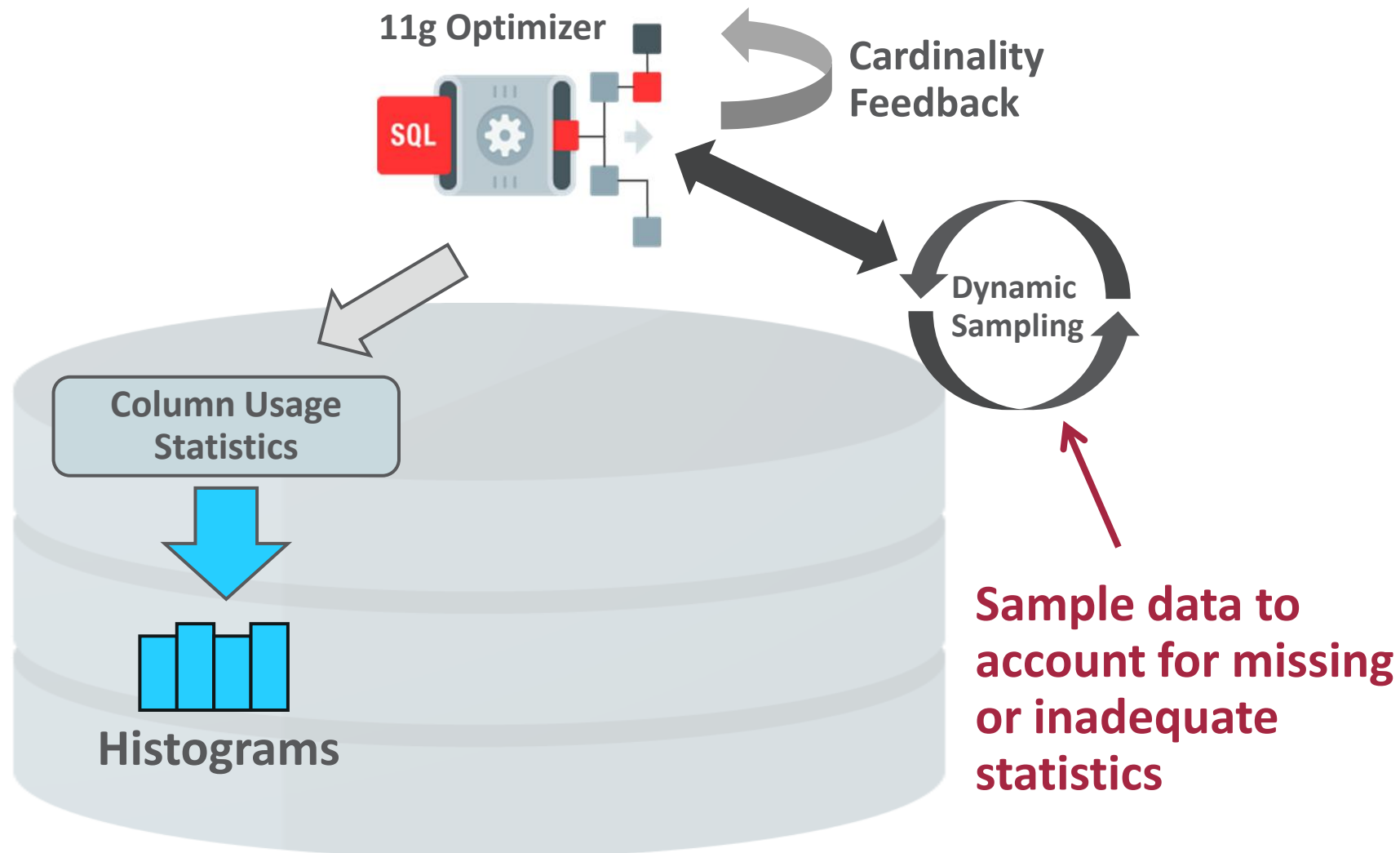
Better statistics for skewed datasets



Learn from previous executions (on a query-by-query basis)

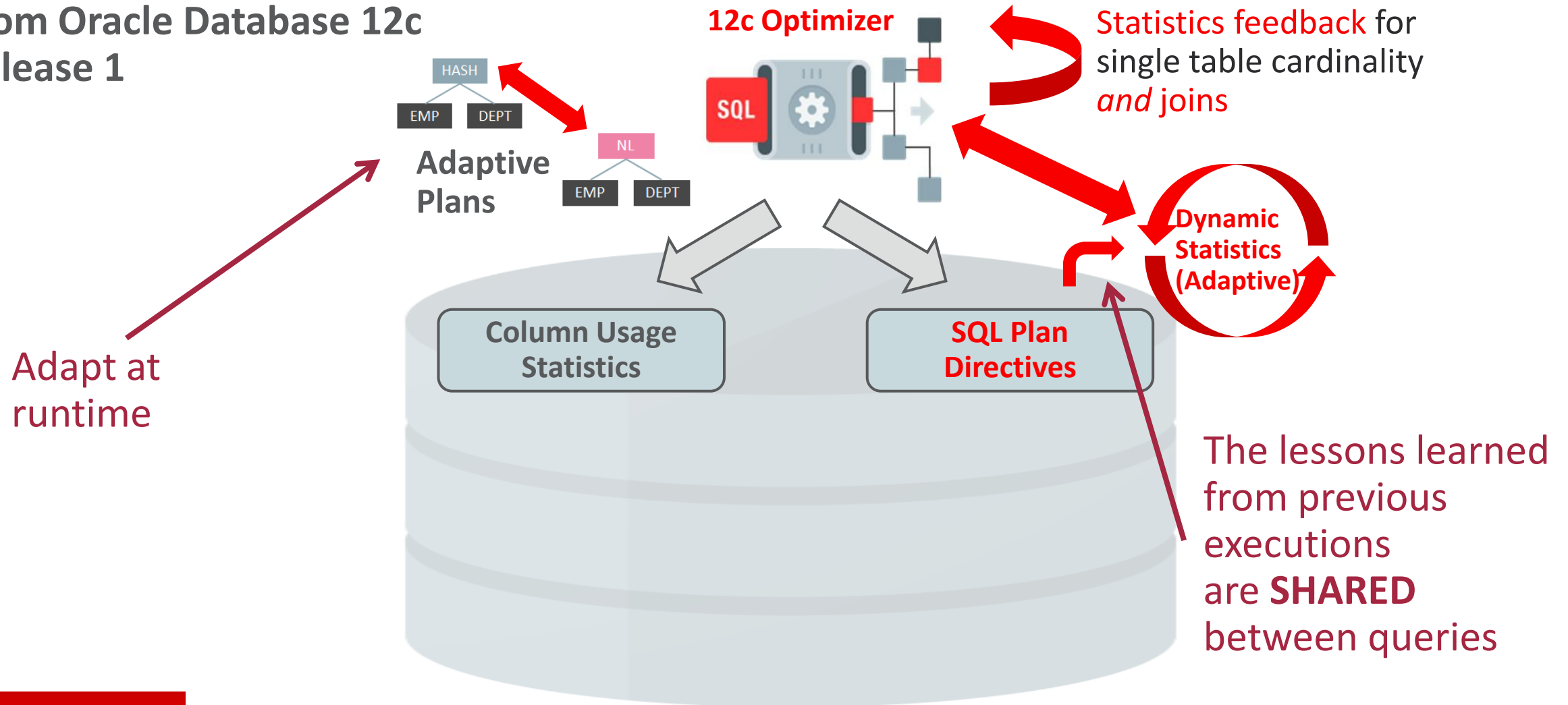


# Dynamic Sampling In Oracle Database 11g



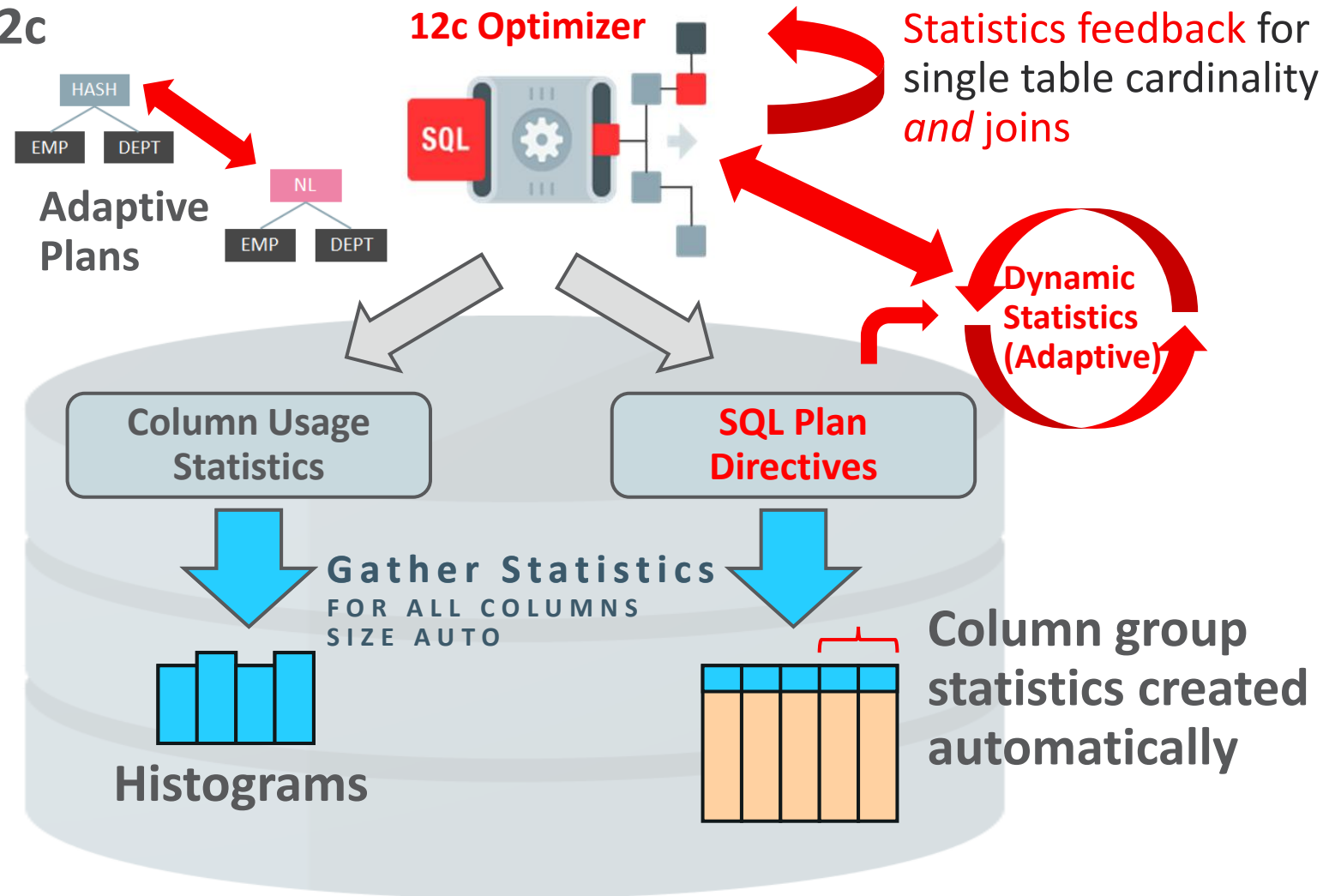
# The Oracle Optimizer in Oracle Database 12c

From Oracle Database 12c  
Release 1



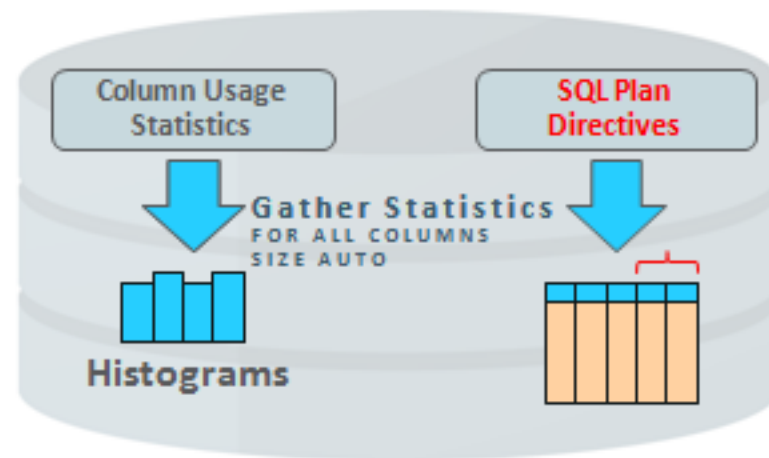
# Oracle Optimizer Adaptive Features

From Oracle Database 12c  
Release 1



# Viewing Optimizer Metadata

- **DBA\_SQL\_PLAN\_DIRECTIVES**
- HISTOGRAM column in **DBA\_TAB\_COLUMNS**
- **DBA\_STAT\_EXTENSIONS**
- `SELECT DBMS_STATS.REPORT_COL_USAGE('SH','EMP')`  
`FROM DUAL;`  
`–SYS.COL_USAGE$`



# Agenda

- 1 Stepping up to Oracle Database 12c
- 2 Enhancements in Oracle Database 12c Release 2
- 3 Upgrade Approach
- 4 A word about Oracle Database 12c Release 1
- 5 From test to production

# Oracle Database 12c Release 1

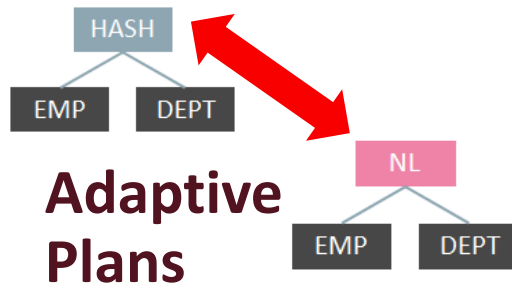
## Controlling adaptive features

**OPTIMIZER\_ADAPTIVE\_FEATURES**

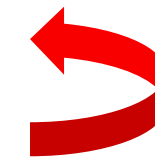
Optimizer Adaptive Features

Change plans at runtime

Learn from previous executions

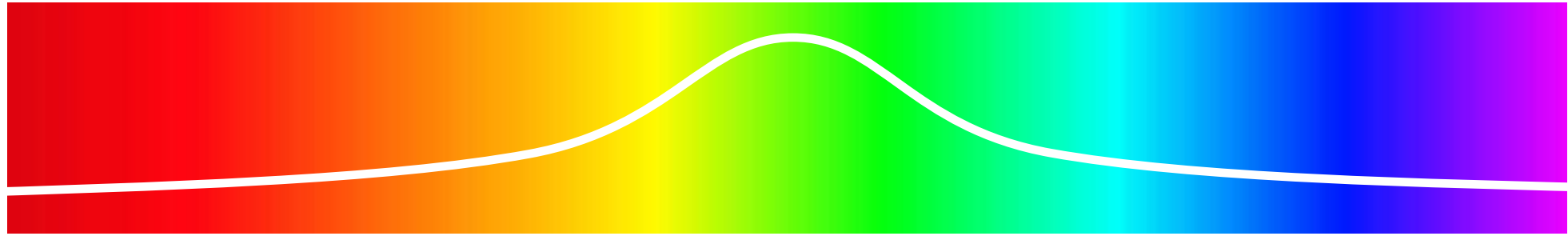


**12c Optimizer**

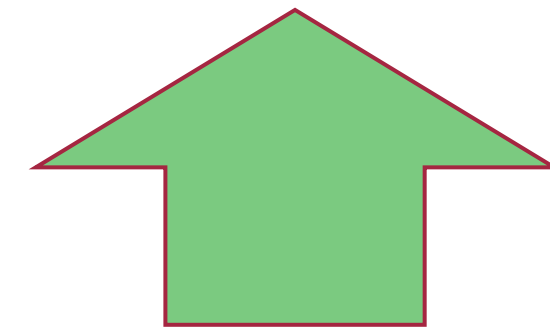


**Adaptive Statistics**

# A Wide Spectrum of Oracle Databases



Highly responsive  
Time critical -  
Strict SLAs

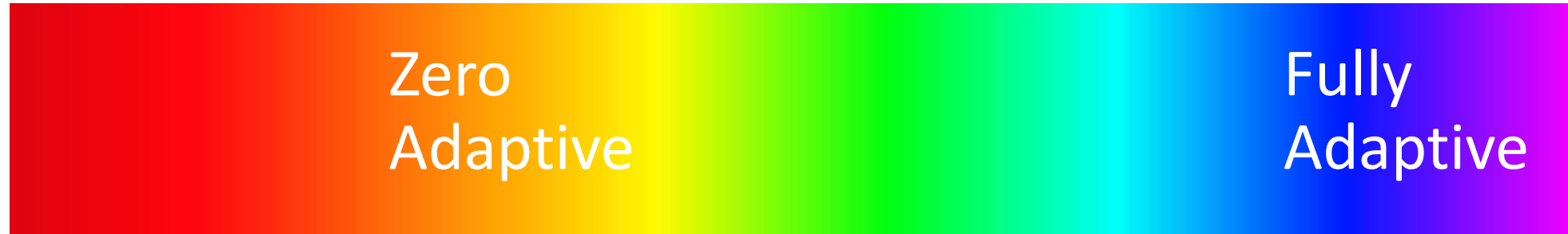


Most Databases

Long running  
High complexity  
Large datasets

# Oracle Database 12c Release 1

Adaptive features controlled with `OPTIMIZER_ADAPTIVE_FEATURES`

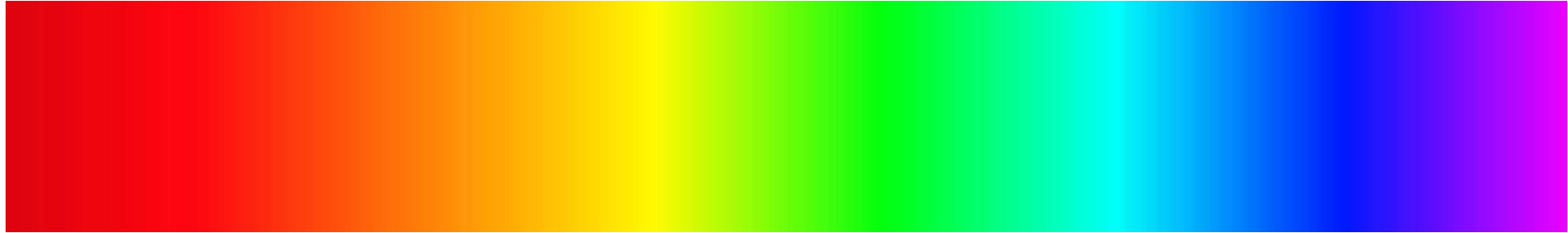


Oracle Database 12c Release 1 Default



# Oracle Database 12c Release 2

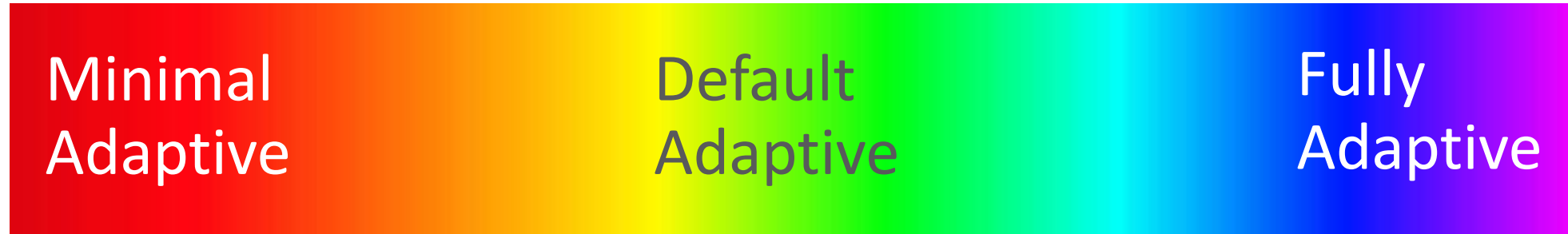
A new default



Oracle Database 12c Release 2 Default

# Oracle Database 12c Release 2

A new default and finer control

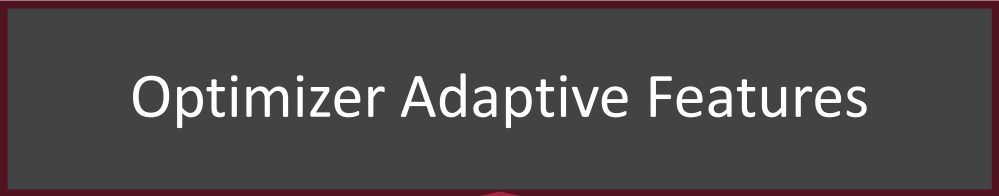


Oracle Database 12c Release 2 Default

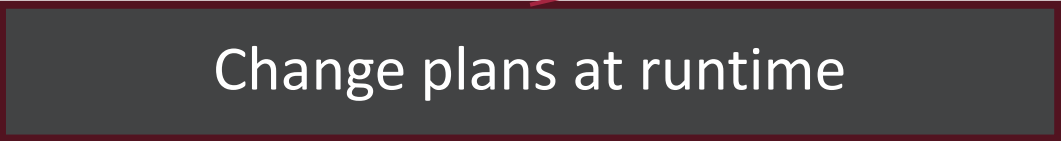
# From Oracle Database 12c Release 2

Finer control of adaptive features – new database parameters

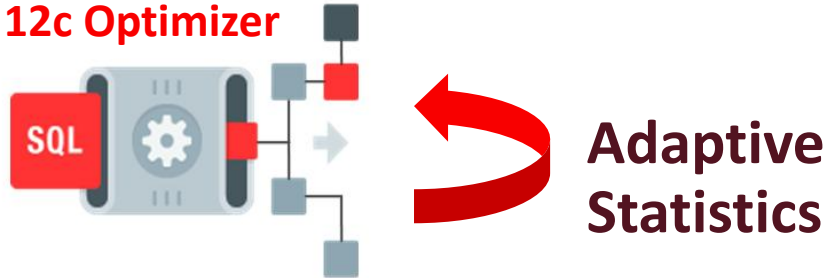
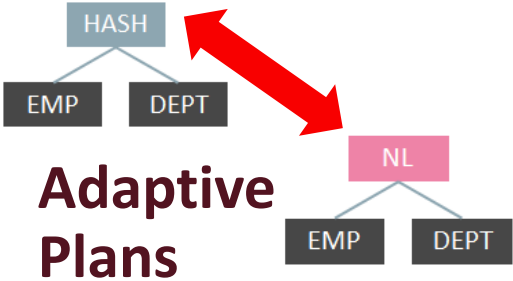
~~OPTIMIZER\_ADAPTIVE\_FEATURES~~ Obsolete



OPTIMIZER\_ADAPTIVE\_PLANS



OPTIMIZER\_ADAPTIVE\_STATISTICS



# From Oracle Database 12c Release 2

## New default behavior

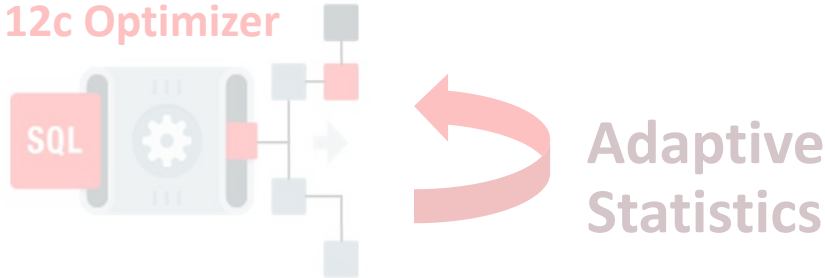
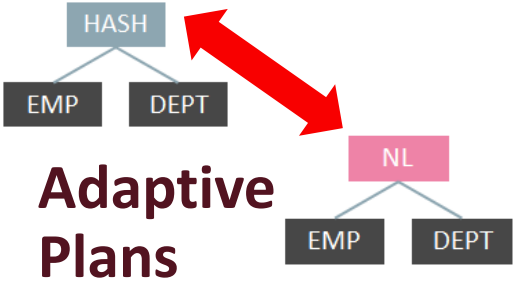
### Optimizer Adaptive Features

OPTIMIZER\_ADAPTIVE\_PLANS (TRUE)

Change plans at runtime

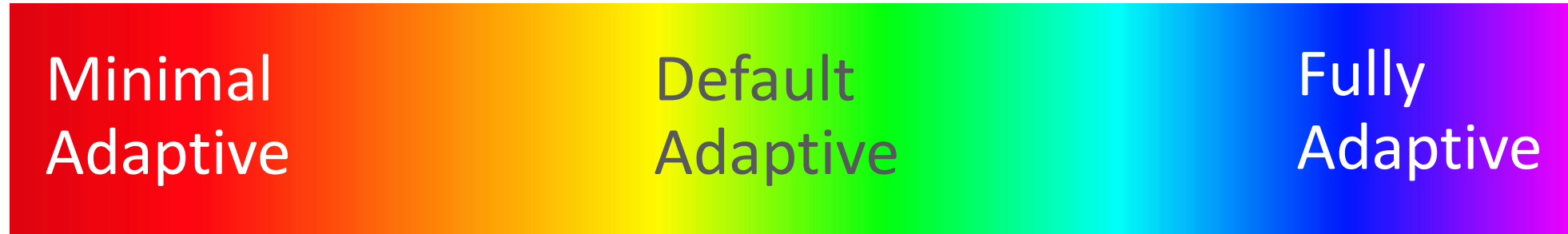
OPTIMIZER\_ADAPTIVE\_STATISTICS (FALSE)

Learn from previous executions



# Oracle Database 12c Release 2

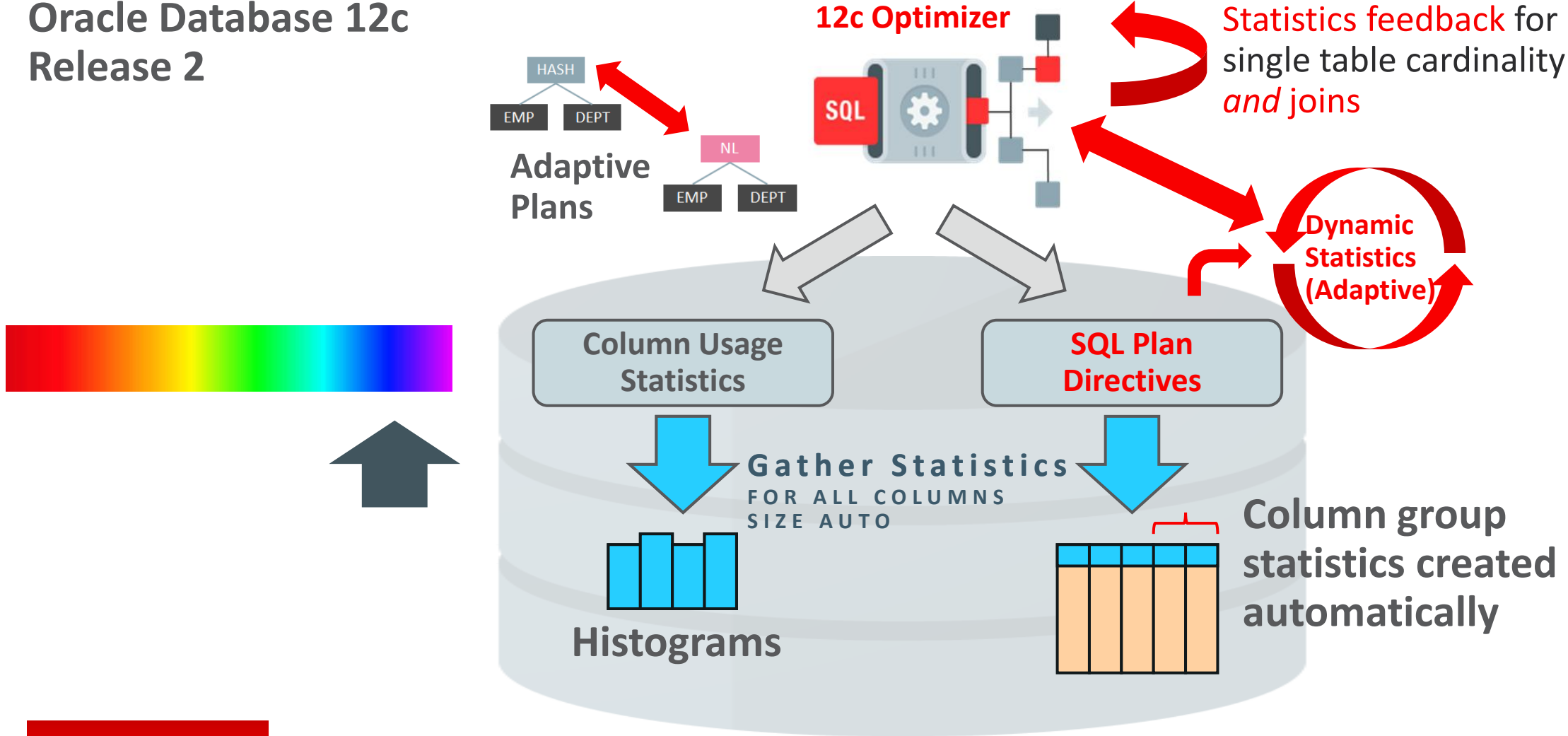
A new default and finer control



Oracle Database 12c Release 2 Default

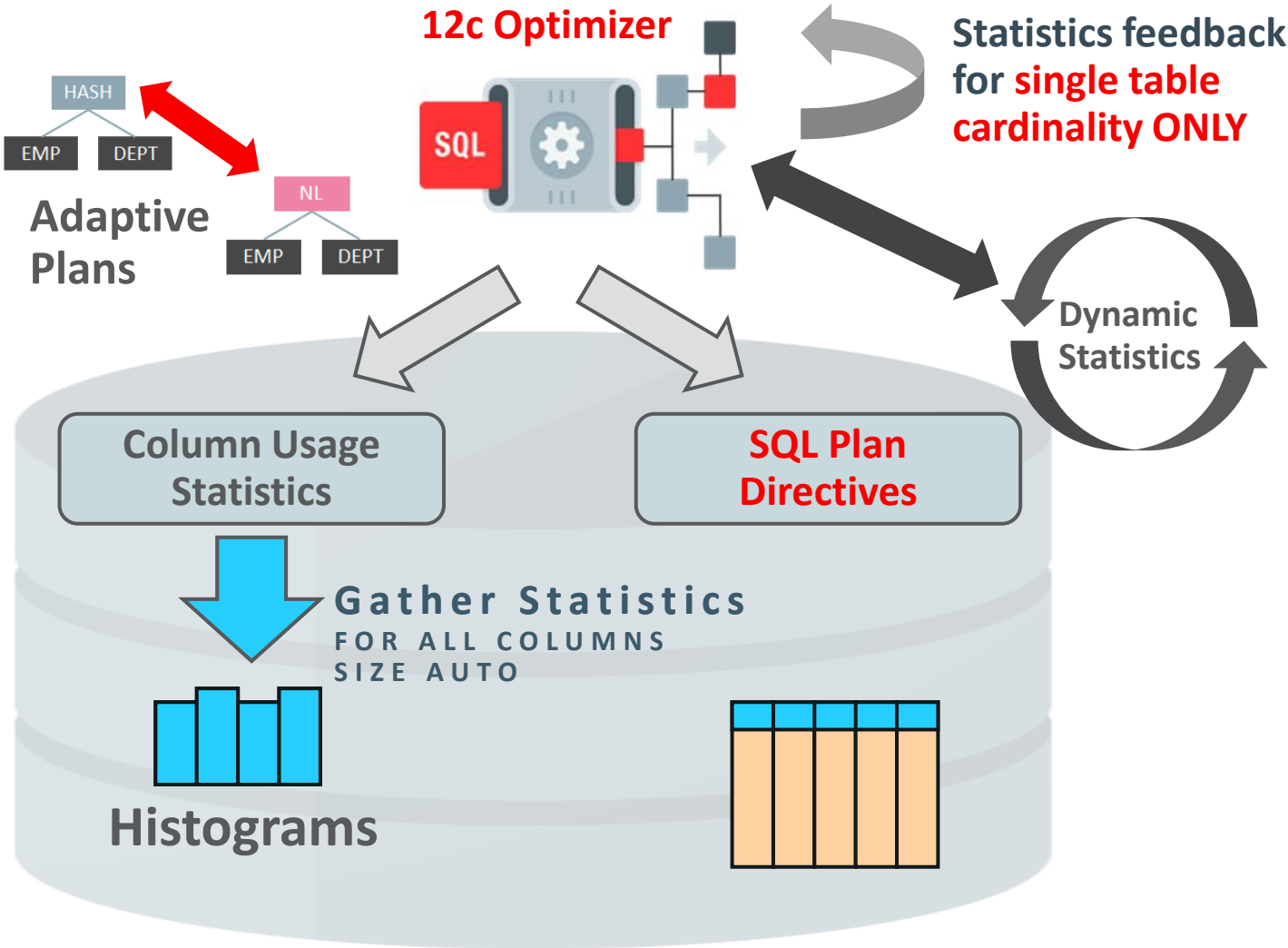
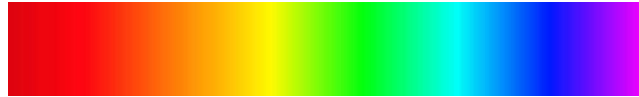
# Oracle Optimizer Adaptive Features – Fully Adaptive

Oracle Database 12c  
Release 2



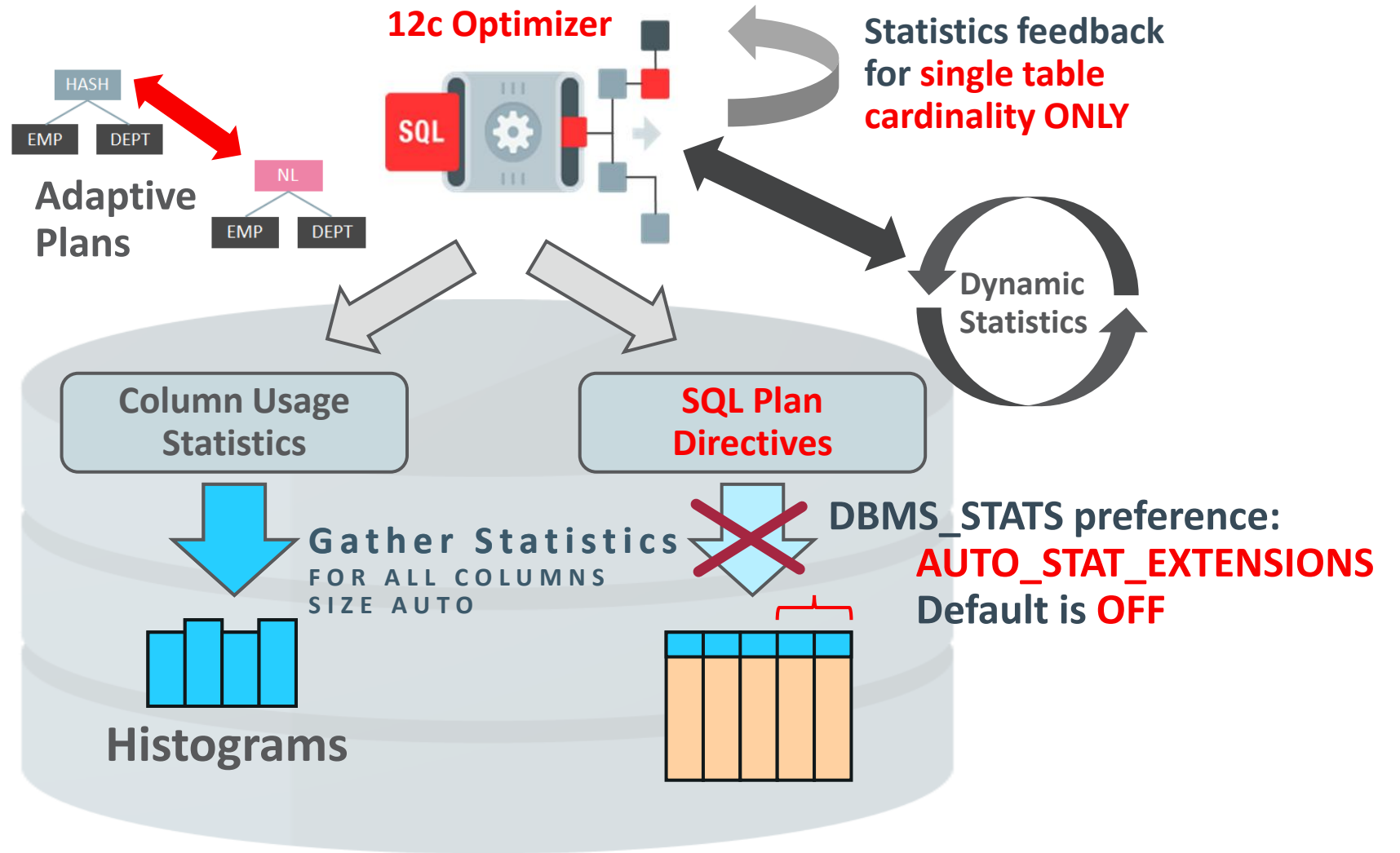
# Oracle Optimizer Adaptive Features – New Defaults

Oracle Database 12c  
Release 2



# Oracle Optimizer Adaptive Features – New Defaults

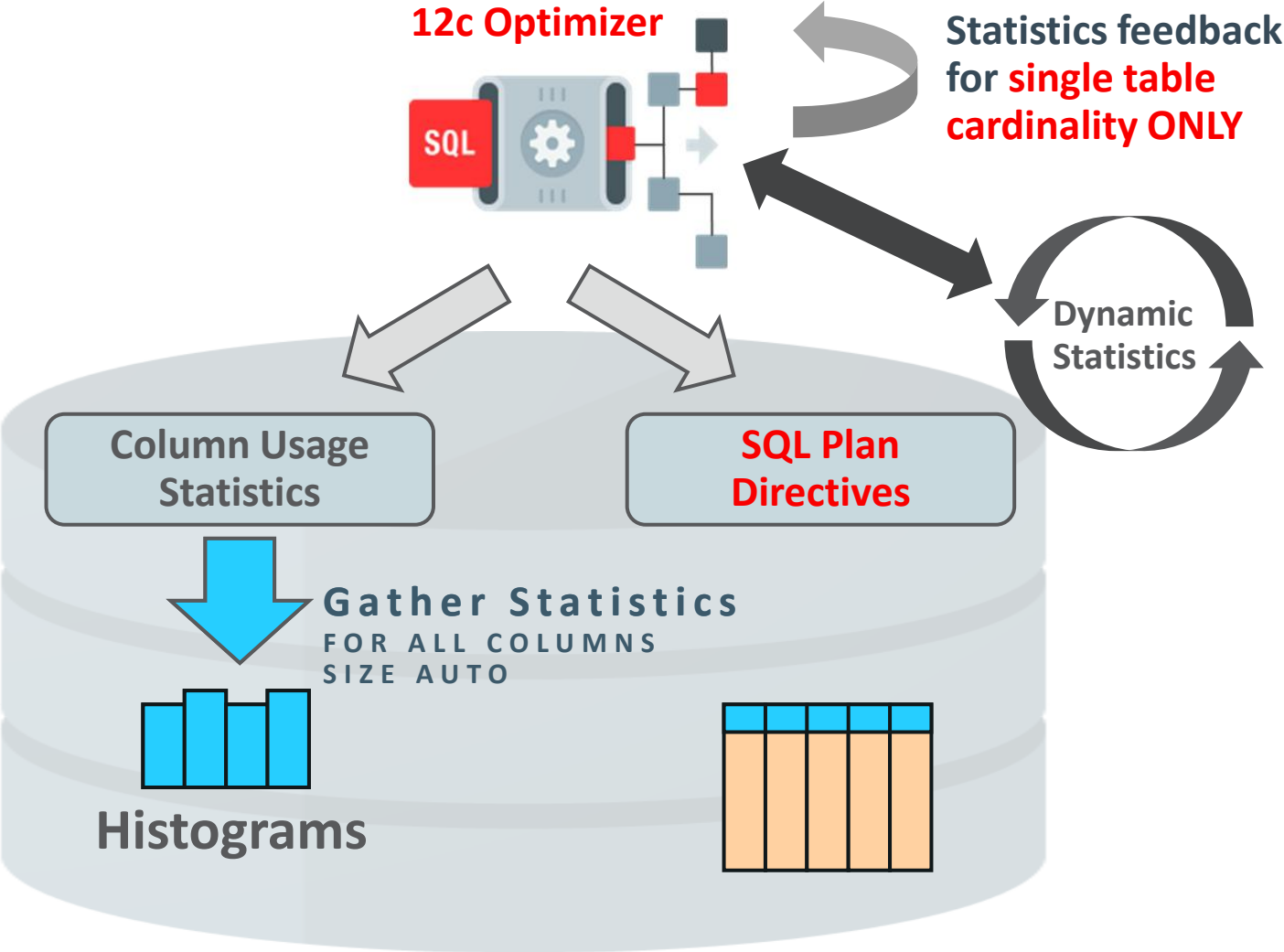
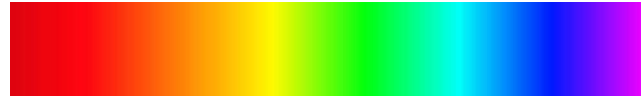
Oracle Database 12c  
Release 2





# Oracle Optimizer Adaptive Features

Oracle Database 12c  
Release 2



## Oracle Database 12c Release 2

- Adaptive features...
  - Defaults cover the widest range of workloads
  - Finer control: easy to prioritize stability without turning "everything off"
- In the context of upgrades...
  - The defaults are closer to the behavior of Oracle Database 11g

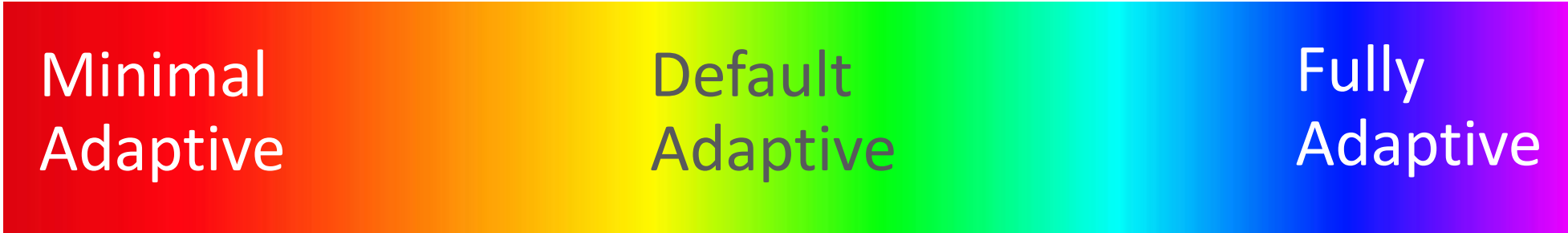
# Agenda

- 1 Stepping up to Oracle Database 12c
- 2 Enhancements in Oracle Database 12c Release 2
- 3 Upgrade Approach**
- 4 A word about Oracle Database 12c Release 1
- 5 From test to production

## You Have Hundreds of Databases

- You expect Oracle to provide defaults that deliver excellent performance for *most* systems
  - "KISS" - and use the defaults in Oracle Database 12c Release 2
- The defaults have been chosen on the basis of what works best for widest range of workloads

# Default Adaptive Features



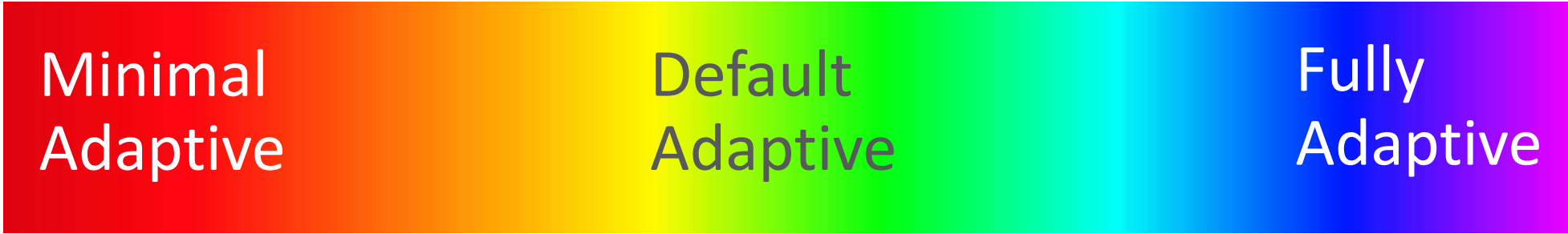
Use the defaults

OPTIMIZER\_ADAPTIVE\_PLANS      (TRUE)  
OPTIMIZER\_ADAPTIVE\_STATISTICS      (FALSE)

Traditionally, Oracle has always recognized that DBAs need more control in **complex and critical** environments

If you want more control...

# Minimal Adaptive



Set `OPTIMIZER_ADAPTIVE_PLANS=FALSE`

# Fully Adaptive



Set `OPTIMIZER_ADAPTIVE_STATISTICS=TRUE`  
Optionally, set `DBMS_STATS` preference  
`AUTO_STAT_EXTENSIONS=ON`



# Adaptive Statistics

OPTIMIZER\_ADAPTIVE\_STATISTICS=TRUE

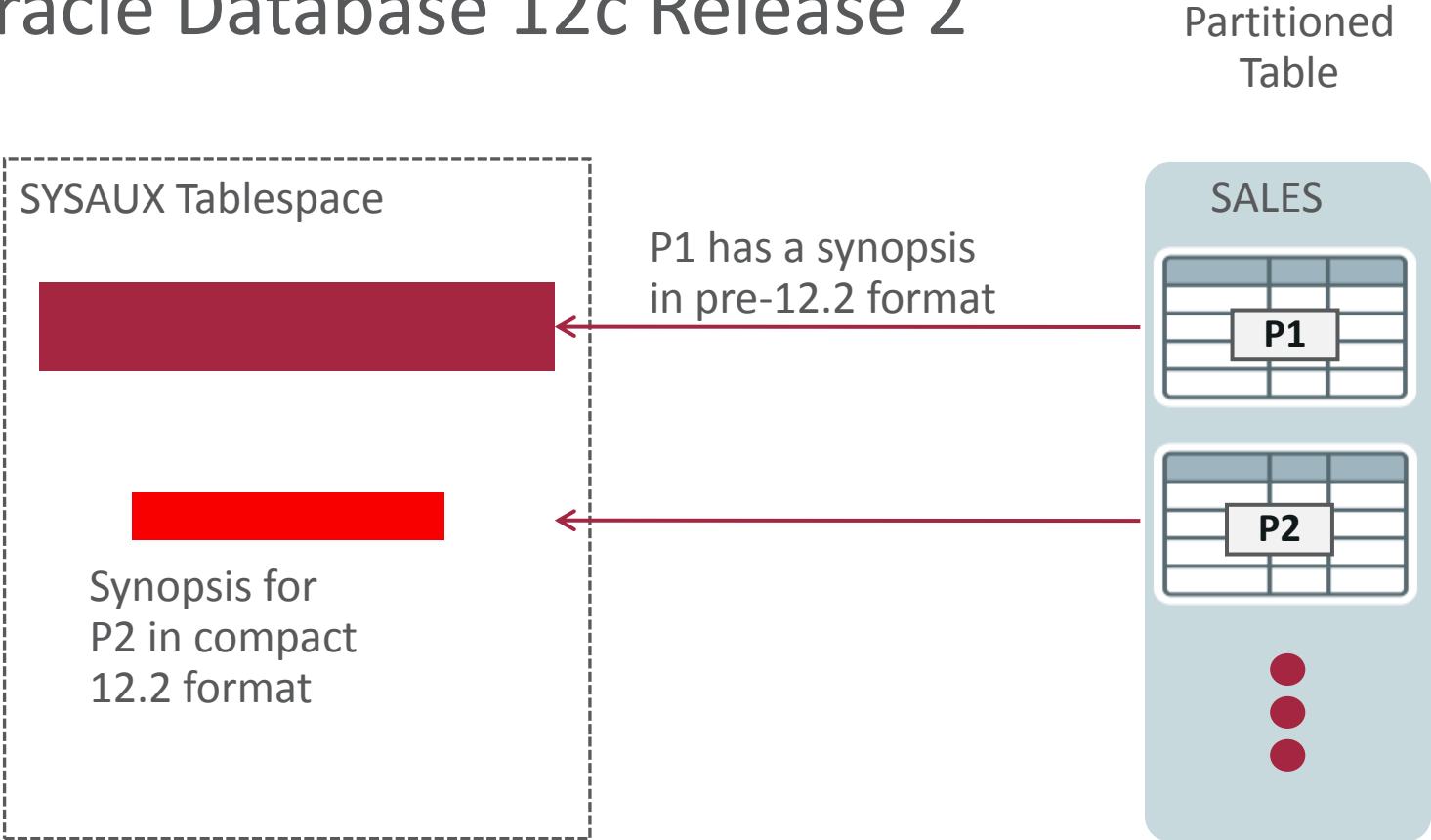
- High added value where...
  - Queries are longer-running
  - Queries are complex
  - Schema is complex
  - Data is complex
- Ad-hoc query environments
  - SQL plan directives allow the optimizer to learn from queries and share this information with others

# New in Oracle Database 12c Release 1

- New histogram types
  - HYBRID and TOP-N – gather all your statistics
  - Use SET\_TABLE\_PREFS to control what histograms you have?
- Global temporary tables – session private statistics
  - DBMS\_STATS.SET\_DATABASE\_PREFS (...  
GLOBAL\_TEMP\_TABLE\_STATS =>'SHARED') ....?
- SQL plan management evolution is automated in Oracle Database 12c
  - Do you want to use auto evolution?

# New in Oracle Database 12c Release 2

- More compact incremental statistics for partitioned tables from Oracle Database 12c Release 2



# Remember: You Have Fine Control of Optimizer Statistics

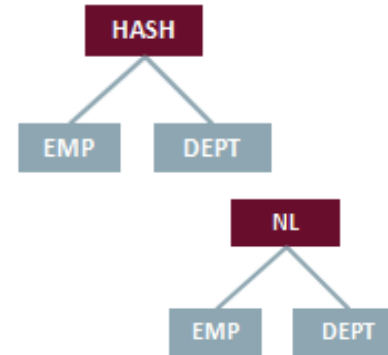
- You can test new statistics without deleting the old
  - `DBMS_STATS.SET_GLOBAL_PREFS('PUBLISH', 'false');`  
`DBMS_STATS.GATHER...`  
`optimizer_use_pending_statistics = TRUE`  
`DBMS_STATS.PUBLISH_PENDING_STATS`
- You roll out changes to statistics back to a point-in-time
  - `DBMS_STATS.RESTORE_SCHEMA_STATS`

You have a critical environment where *any* performance regression is unacceptable...

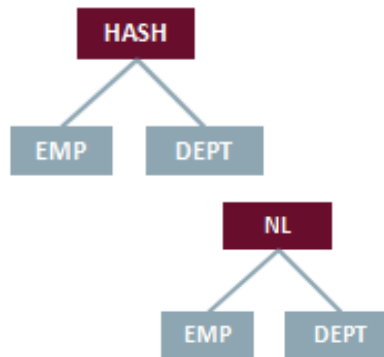
# What if You Could Do This?

Start With Oracle Database 11g

Good query execution plans = Good query performance



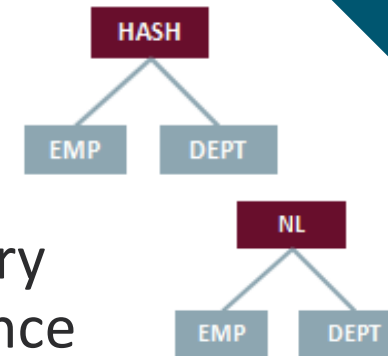
Oracle Database 12c



Evolve over time...  
Detect and verify  
**better**  
execution plans =  
**Better query performance**

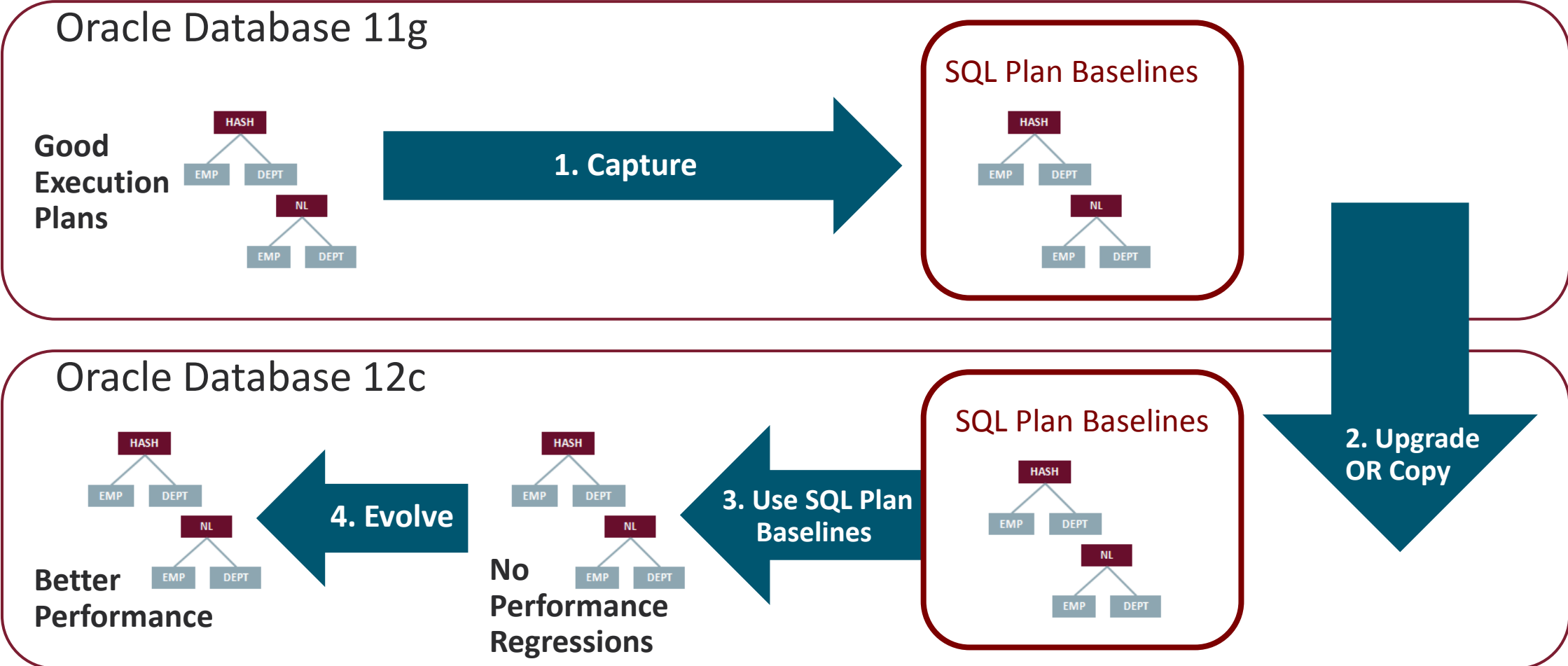


Use *same*  
execution plans =  
Good query performance



# Use SQL Plan Management

## Capture SQL plan baselines in pre-upgrade database



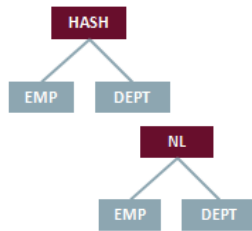
# SQL Plan Management – Even Post-Upgrade

Use `optimizer_features_enable` (OFE) to capture in post-upgrade database

Oracle Database 12c

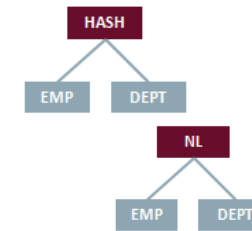
`optimizer_features_enable='11.2.0.4'`

Good Execution Plans



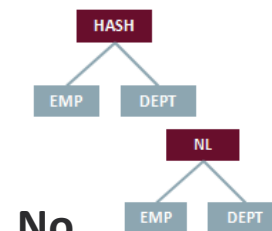
1. Capture

SQL Plan Baselines



`optimizer_features_enable='12.2.0.1'`

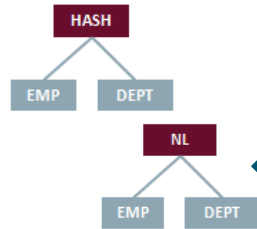
2. Use SQL Plan Baselines



No Performance Regressions

3. Evolve

Better Performance





# SQL Plan Management

## Taking control of change

- Use a known set of SQL execution plans, but without setting the system in stone
- Reduce the risk of change
  - Capture SQL plan baselines and control SQL execution plans
  - "Change"
  - Alternative SQL execution plans are validated automatically
  - Better SQL execution plans can be accepted automatically

# Upgrading from Oracle Database 12c Release 1

# Upgrading from Oracle Database 12c Release 1

- You want to continue with **everything on**, then keep things as they are
  - Set **OPTIMIZER\_ADAPTIVE\_STATISTICS=TRUE**
  - Set **DBMS\_STATS** preference **AUTO\_STAT\_EXTENSIONS** to **ON** to allow column group statistics to be created in response to SQL plan directives
- If adaptive features are disabled, **consider using adaptive plans:**
  - Default OPTIMIZER\_ADAPTIVE\_PLANS (the default is TRUE)
  - Default OPTIMIZER\_ADAPTIVE\_STATISTICS (the default is FALSE)
- Remember SQL plan management!

# Agenda

- 1 Stepping up to Oracle Database 12c
- 2 Enhancements in Oracle Database 12c Release 2
- 3 Upgrade Approach
- 4 A word about Oracle Database 12c Release 1
- 5 From test to production

# Oracle Database 12c Release 1 Production - Options

- You should probably keep things as they are
  - OPTIMIZER\_ADAPTIVE\_FEATURES
  - OPTIMIZER\_FEATURES\_ENABLE
- Defaults can be expected to work well for *most* systems
- No requirement to re-test

## Oracle Database 12c Release 1 - Options

- If you want the new adaptive parameters in Oracle Database 12c Release 1 request patch for bug# 22652097
- To control auto column group creation using DBMS\_STATS preference AUTO\_STAT\_EXTENSIONS, apply patch for bug# 21171382
- Testing will be required because plans may change

# Agenda

- 1 Stepping up to Oracle Database 12c
- 2 Enhancements in Oracle Database 12c Release 2
- 3 Upgrade Approach
- 4 A word about Oracle Database 12c Release 1
- 5 From test to production

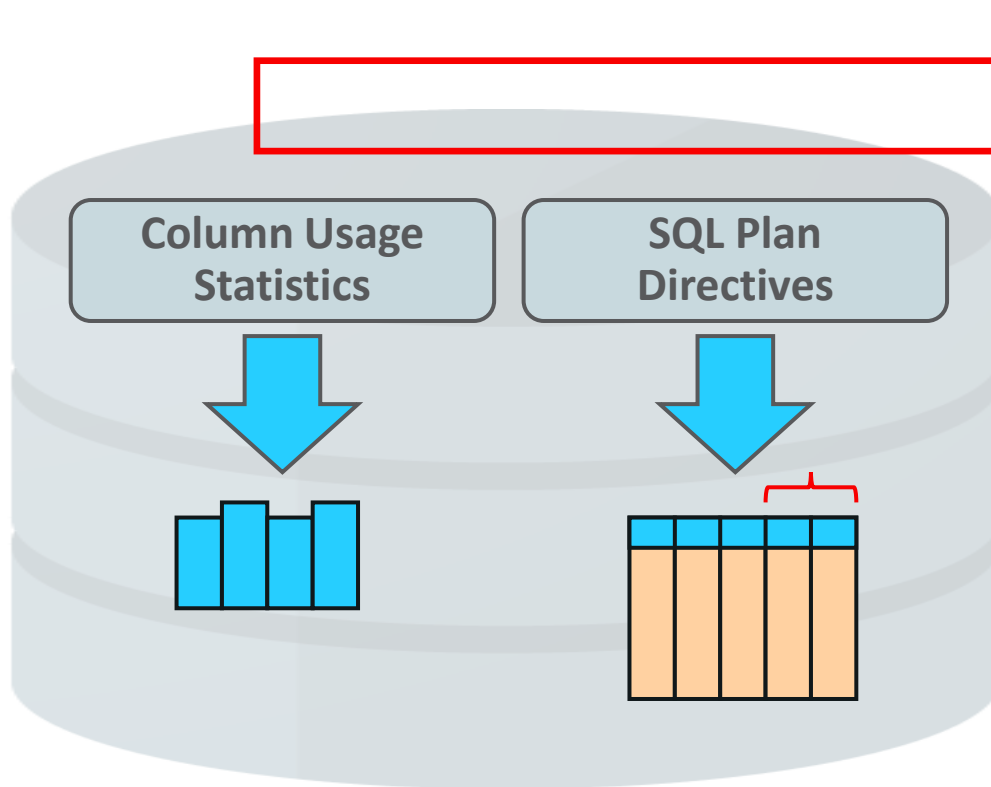
# From Test to Production

- The optimizer generates metadata, for example:
  - DBA\_SQL\_PLAN\_DIRECTIVES
  - SYS.COL\_USAGE\$
- Metadata gives rise to additional statistics, for example:
  - Histograms
  - DBA\_STAT\_EXTENSIONS
- Testing on realistic data can generate useful metadata and statistics
- You might want to transport metadata and statistics from one database to another



# Migrating Oracle Optimizer Metadata and Statistics

Keep It Simple - Data Pump!

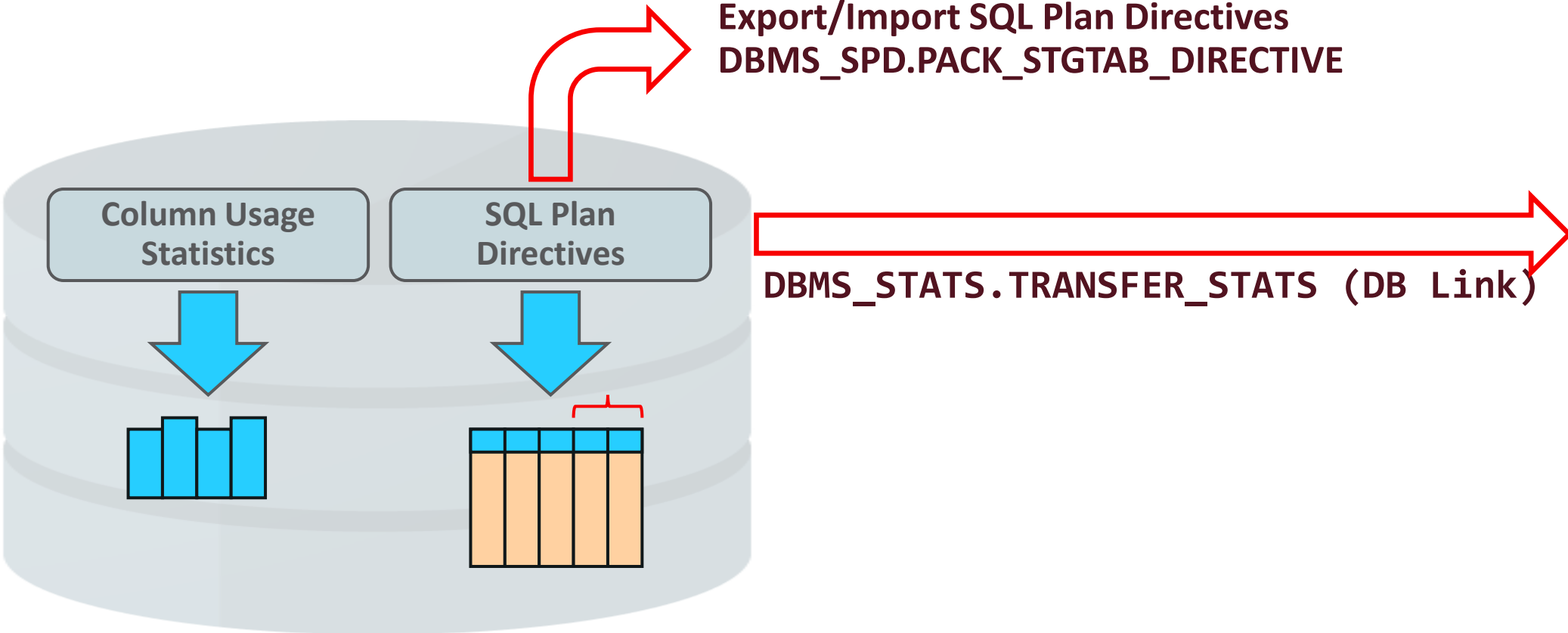


```
expdp content=metadata_only  
include=statistics
```

```
impdp table_exists_action=skip  
include=statistics  
remap_schema=s1:s2
```

# Migrating Oracle Optimizer Metadata and Statistics

## Other Recommended Methods

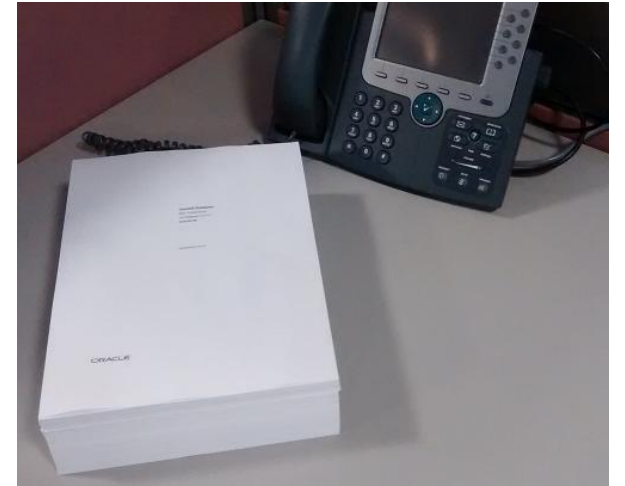


# Summary

- Oracle Database 12c Release 2 Adaptive Features
  - Have been improved
  - Have finer controls
  - By default, are closer to the behavior of Oracle Database 11g
  - Most systems should use the new default settings for adaptive features
- For complex systems, choose adaptive features to match your priorities and/or workload
- SQL plan management helps you manage change
- Optimizer metadata can be migrated from test to production

# More Information

- Oracle Optimizer Blog
  - <http://blogs.oracle.com/optimizer>
- Upgrade Blog
  - <http://blogs.oracle.com/UPGRADE>
- OTN
  - <http://tinyurl.com/zamvpzv>



# More Information

- Future white papers...

- Optimizer with Oracle Database 12c Release 2
- Understanding Optimizer Statistics with Oracle Database 12c Release 2
- Best Practices for Gathering Optimizer Statistics with Oracle Database 12c Release 2
- SQL Plan Management with Oracle Database 12c Release 2

## Safe Harbor Statement

The preceding is intended to outline our general product direction. It is intended for information purposes only, and may not be incorporated into any contract. It is not a commitment to deliver any material, code, or functionality, and should not be relied upon in making purchasing decisions. The development, release, and timing of any features or functionality described for Oracle's products remains at the sole discretion of Oracle.

# Integrated Cloud

## Applications & Platform Services

ORACLE®