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DBMS_XPLAN
We have some xplaining to do

Dallas Deeds

Nationwide

MAY 15 & 16, 2019

CLEVELAND PUBLIC AUDITORIUM, CLEVELAND, OHIO

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Dallas Deeds

- Work for Nationwide
- Oracle DBA since 1997, v 7.3
- Primarily focused on Oracle & Solaris/Linux performance since 2001
- In IT since 1995
- 1,200+ databases
  - 100+ multi-node RAC databases
  - Whole bunch of RAC one-node
  - Small number of standalones
  - 10.2 -> 18.5

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Why would I talk about dbms_xplan?

- Everyone uses it, right?
  - *most people use it, but most don't use it as well as they could*
- *Executions plans are fundamental*
- *Cloud!* *<the overlords require I say the word at least once>*
- Carol Dacko
- There are a lot of functions
  - *Do they do what you think they do?*
  - *What are the defaults giving you?*
  - *What are you giving to the functions?*
- There are a lot of formats
  - *What are they really displaying?*

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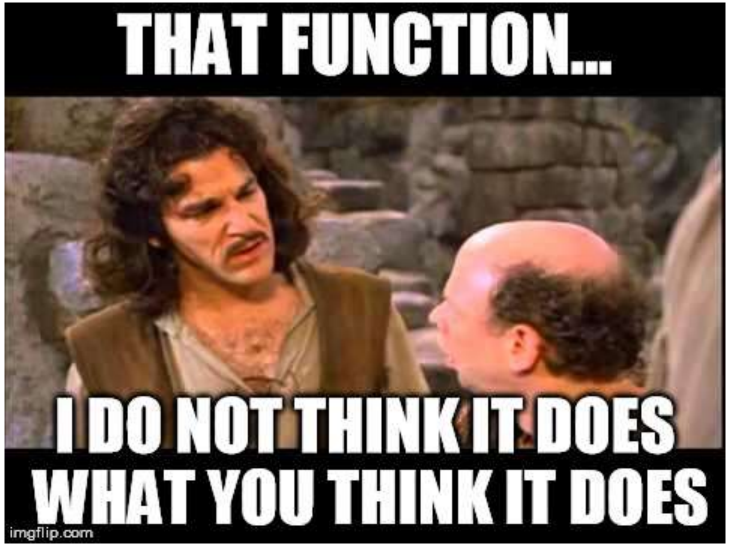
Some personal experience…

- Display()
- Cursor_child_no



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A bit of history

- First introduced in 9i
  - *Documentation only lists the display() function*
- Enhanced in each release since
  - *10g – 10 functions*
  - *11g – 21 functions*
  - *12c – 26 functions*
  - *18c – 30 functions*
  - *19c – 33 functions*

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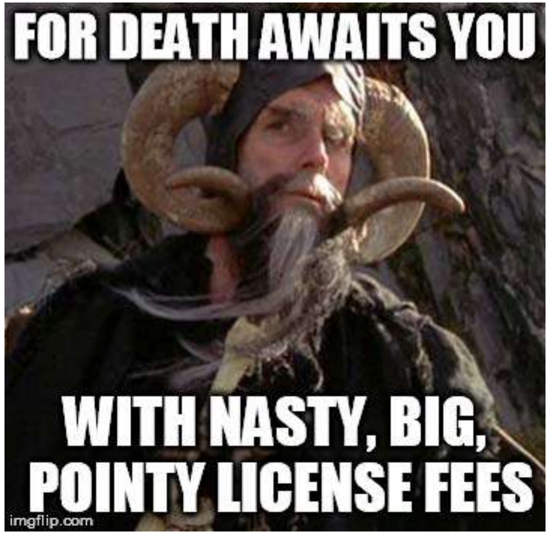
Safety slide

- Some functions (display_awr, for example) require additional licensing



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Safety slide, cont'd

- NOTE: This slide represents my interpretation of documentation I have read. Oracle frequently changes their licensing and they are the final arbiter concerning what they license. Consult your Oracle representative for current licensing requirements.
- DISPLAY_AWR
  - *Requires the diagnostic pack*
- DISPLAY_SQLSET
  - *Requires Real Application Testing Option <or Tuning Pack>, depends on version*
  - *Some API subprograms to manage STS are included in 12.1 EE*
- DISPLAY_SQL_PLAN_BASELINE
  - *License docs indicate that SPM is included in 12.1 EE*
  - *Found no mention in the 11.1 docs*

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Useful functions

- DISPLAY
- DISPLAY_CURSOR
- DISPLAY_AWR
- DISPLAY_PLAN
- DIFF_PLAN(_AWR, _CURSOR, _OUTLINE, _BASELINE)
- DISPLAY_SQLSET
- DISPLAY_SQL_PLAN_BASELINE
- DISPLAY_SQL_P[ROFILE,ATCH]_PLAN
- COMPARE_PLANS
- There are also undocumented internal functions that dbms_xplan passes around

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DISPLAY

- Displays the contents of **a** plan table
  - May be ‘**the**’ plan_table or a table with the same column names
- Returns a DBMS_XPLAN_TYPE_TABLE
- Autotrace explain uses this function (can be seen in 10046 output)

```
orcl_ora_6497.trc:SELECT PLAN_TABLE_OUTPUT FROM
     TABLE(CAST(DBMS_XPLAN.PREPARE_RECORDS(:B1 , :B2 ) AS SYS.DBMS_XPLAN_TYPE_TABLE))
orcl_ora_6497.trc:SELECT PLAN_TABLE_OUTPUT FROM
          TABLE(DBMS_XPLAN.DISPLAY('PLAN_TABLE', :1))
```

- Use caution, this is what the optimizer *thinks* will happen
- May use filter_preds option to restrict which rows are displayed
  - *Filter_preds is subject to SQL injection*

DISPLAY_PLAN

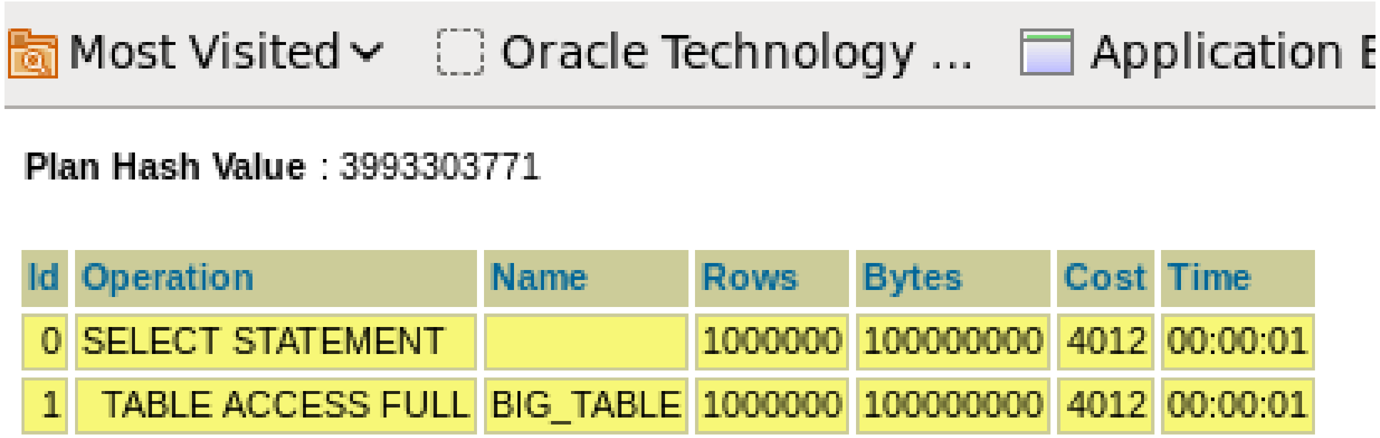
- Displays the contents of **a** plan_table with a CLOB return type
- Can produce multiple outputs (types)
  - TEXT
  - HTML
  - ACTIVE
  - XML
- ACTIVE is a rich EM-like interface
  - *Which I have been unable to get working properly*
  - *It requires outside connectivity as it downloads code to generate the ACTIVE display*
- XML doesn’t appear have a style with it, so my browser complains

DISPLAY_PLAN Syntax

```
DBMS_XPLAN.DISPLAY_PLAN (
   TABLE_NAME       IN    VARCHAR2   DEFAULT 'PLAN_TABLE',
   STATEMENT_ID     IN    VARCHAR2   DEFAULT NULL,
   FORMAT           IN    VARCHAR2   DEFAULT 'TYPICAL',
   FILTER_PREDS     IN    VARCHAR2   DEFAULT NULL,
   TYPE             IN    VARCHAR2   DEFAULT 'TEXT')
  RETURNS CLOB
```

DISPLAY_PLAN, cont'd

- Doesn't seem particularly useful, especially since it uses a plan_table



Plan Hash Value : 3993303771

Id	Operation	Name	Rows	Bytes	Cost	Time
0	SELECT STATEMENT		1000000	100000000	4012	00:00:01
1	TABLE ACCESS FULL	BIG_TABLE	1000000	100000000	4012	00:00:01

DISPLAY_CURSOR

- Displays an execution plan of a cursor from the cursor cache
- Shows what actually happened
- Plan statistics can be displayed with additional formats
- Must have select privileges to
  - V$sql_plan
  - V$sql
  - V$sql_plan_statistics_all

- Defaults to displaying the last executed statement
  - *If you don't set serveroutput off, you will get dbms_output data, not the last statement*

DISPLAY_CURSOR SYNTAX

```
DBMS_XPLAN.DISPLAY_CURSOR(
   SQL_ID            IN  VARCHAR2  DEFAULT  NULL,
   CURSOR_CHILD_NO   IN  NUMBER    DEFAULT  0,
   FORMAT            IN  VARCHAR2  DEFAULT  'TYPICAL');
RETURNS DBMS_XPLAN_TYPE_TABLE

(overloaded in recent releases to allow for sharding)
```

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Displaying past plans

- How do you *find* plans from the past?
  - Dba_hist_sql_plan
  - Dbms_xplan.display_awr
- How do you display plans from the past?
  - Dbms_xplan.display_awr

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Finding past plans

- DBA_HIST_SQL_PLAN (also requires diagnostic pack license)

```
SQL> select distinct(plan_hash_value) from dba_hist_sql_plan
  2  where sql_id = '74cpnuu24wmx7';

PLAN_HASH_VALUE
---------------
     2135018976
       75148593
      908282281
      297866626
```

DISPLAY_AWR

- Display_awr
  - Default for plan_hash_value is null, so it will display **all** plans for a SQL_ID!
- Must have select privileges on
  - Dba_hist_sqltext
  - Dba_hist_sql_plan
  - V$database

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DISPLAY_AWR Syntax

```
DBMS_XPLAN.DISPLAY_AWR(
   SQL_ID            IN     VARCHAR2,
   PLAN_HASH_VALUE   IN     NUMBER DEFAULT NULL,
   DB_ID             IN     NUMBER DEFAULT NULL,
   FORMAT            IN     VARCHAR2 DEFAULT TYPICAL,
   CON_ID            IN     NUMBER(38) DEFAULT NULL,
   AWR_LOCATION      IN     VARCHAR2 DEFAULT NULL);
RETURNS DBMS_XPLAN_TYPE_TABLE
```

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SPM, Tuning Sets, & Profiles

- STS – SQL statements, execution context/statistics, and plans
  - *Allows for grouping SQL and metadata into one object, for*
    - Input to advisors
    - Transport between databases
- SQL Profile – a database object containing supplemental stats for a particular statement
  - *Including cardinality adjustments*
  - *Doesn't tie the optimizer to a particular plan*
- SPM – 'baselines' a set of plans for a SQL handle that the optimizer is allowed to use
  - *Allows the optimizer to only use accepted plans*
  - *Prevents performance regression*

Finding plans for baselines

- DISPLAY_SQL_PLAN_BASELINE
  - *Requires select privilege on dba_sql_plan_baselines*
- Displays one or more plans for a SQL_HANDLE
- SQL_HANDLE and PLAN_NAME both default to null
  - *One might think that if both are null then all sql_handles and all plan_names would be displayed*
  - *Alas, that would be incorrect. One or the other must be supplied*
- If a PLAN_NAME is passed then that plan is displayed else all plans for a particular SQL_HANDLE are displayed

DISPLAY_SQL_PLAN_BASELINE Syntax

```
DBMS_XPLAN.DISPLAY_SQL_PLAN_BASELINE (
   SQL_HANDLE      IN VARCHAR2 := NULL,
   PLAN_NAME       IN VARCHAR2 := NULL,
   FORMAT          IN VARCHAR2 := 'TYPICAL')
 RETURNS DBMS_XPLAN_TYPE_TABLE
```

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DISPLAY_SQLSET

- Displays plan(s) for a statement from a SQL Tuning Set
- If no plan_hash_value is provided, all plans for the statement are shown
- Need administer any sql tuning set to display SQL tuning sets you don’t own

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DISPLAY_SQLSET Syntax

```
DBMS_XPLAN.DISPLAY_SQLSET(
   SQLSET_NAME       IN  VARCHAR2,
   SQL_ID            IN  VARCHAR2,
   PLAN_HASH_VALUE   IN NUMBER := NULL,
   FORMAT            IN  VARCHAR2  := 'TYPICAL',
   SQLSET_OWNER      IN  VARCHAR2  := NULL)
  RETURN DBMS_XPLAN_TYPE_TABLE
```

DISPLAY_SQL_P[ROFILE,ATCH]_PLAN

- New in 12.1
- Not sure how terribly useful these are as yet
- Display
  - *SQL_TEXT*
    - For sys-generated profiles (SYS_SQLPROF*) it appears some hints are embedded
  - *Profile/Patch name*
  - *Status*
  - *Plan rows is listed, but not stored/displayed*

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DISPLAY_SQL_P[ROFILE,ATCH]_PLAN syntax

```
DBMS_XPLAN.DISPLAY_SQL_PROFILE_PLAN(
   NAME                 IN   VARCHAR2,
   FORMAT               IN   VARCHAR2   := 'TYPICAL')
  RETURN DBMS_XPLAN_TYPE_TABLE

DBMS_XPLAN.DISPLAY_SQL_PATCH_PLAN(
   NAME                 IN   VARCHAR2,
   FORMAT               IN   VARCHAR2   := 'TYPICAL')
  RETURN DBMS_XPLAN_TYPE_TABLE
```

DIFF_PLAN

- Has a whole bunch of different variants
- _CURSOR, _OUTLINE, _SQL_BASELINE, _AWR,
- All undocumented except DIFF_PLAN, and that is spotty/variable
- Sounds really cool
- I have been unable to get *any* of them to work, they don’t seem to be ready for prime time
- Morgan’s Library has an example of diff_plan_cursor, but I could not duplicate his success

For example...

- DIFF_PLAN_SQL_BASELINE
- Seems pretty nifty
- Requires the ADVISOR privilege – this gave me hope
- But only required it to error out properly:

```
select
dbms_xplan.diff_plan_sql_baseline('SQL_PLAN_0u5f7k97ywa5jcf314e9e','
SQL_PLAN_0u5f7k97ywa5jf67ee4d1') from dual
      *
ERROR at line 1:
ORA-14552: cannot perform a DDL, commit or rollback inside a query
or DML
ORA-06512: at "SYS.PRVT_ADVISOR", line 5026
ORA-14551: cannot perform a DML operation inside a query
```

COMPARE_PLANS

- Used to compare plans
- Takes a reference_plan (must be a single plan)
- and a plan_object_list (one or more plans)
- Plan sources for the list are described in the docs
- Docs indicate that plan sources for an object list can be

PLAN_TABLE_OBJECT	CURSOR_CACHE_OBJECT	AWR_OBJECT	SQLSET_OBJECT
SPM_OBJECT	SQL_PROFILE_OBJECT	ADVISOR_OBJECT	

- Parameters vary by object

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COMPARE_PLANS, cont'd

- I have tried several of these
- And THEY WORK!!!!
- Some don't provide useful information
- But they don't barf!

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COMPARE_PLANS

```
DBMS_XPLAN.COMPARE_PLANS(
   reference_plan    IN generic_plan_object,
   compare_plan_list IN plan_object_list,
   type              IN VARCHAR2 := 'TEXT',
   level             IN VARCHAR2 := 'TYPICAL',
   section           IN VARCHAR2 := 'ALL')
 RETURN CLOB;
```

BASE Formats

- 4 simple formats
  - *Basic*
  - *Typical*
  - *Serial*
  - *All*

Basic format

- Displays *very* basic information
  - *Operation ID, Operation, Operation Options*
- Not terribly useful
  - *Unless you want an uncluttered view that shows *just* the plan steps*

```
SQL> select * from table(dbms_xplan.display_cursor(sql_id=>'akcdbbd6kxp09',format=>'BASIC'));

PLAN_TABLE_OUTPUT
----------------------------------------------------------------------------------------------
EXPLAINED SQL STATEMENT:
------------------------
SELECT REQUIREMENTDATAHISTORYID FROM REQUIREMENTDATAHISTORY WHERE
UPDATEDATE BETWEEN :B2 AND :B1

Plan hash value: 1638392505

-----------------------------------------------------
| Id  | Operation          | Name                   |
-----------------------------------------------------
|   0 | SELECT STATEMENT   |                        |
|   1 |  FILTER            |                        |
|   2 |   TABLE ACCESS FULL| REQUIREMENTDATAHISTORY |
-----------------------------------------------------
```

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Typical format

- The default
  - *if you don't specify, this is what you get*
- Columns included in BASIC format, plus
  - *Rows: number of rows the optimizer expects to return*
  - *Bytes: expected rows * avg_row_len*
  - *Cost*
  - *Time*
- If relevant, shows
  - *Partition pruning*
  - *Parallel operations (PCWP, Parallel to Serial)*
  - *Predicate information*
  - *Unused and/or errored hints*

Predicate information

- Why is it important?
- It shows which lines are access predicates and which are filter predicates
  - *Access – getting only data we need*
  - *Filter – we get more data than we need and throw some away*
- It shows datatype mismatches
  - *Where date_col = ‘string’*
  - *This is important!*
- Shows query transformations
  - *If a = b and c = b, then a = c*

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Serial format

- Typical minus parallel information
  - *Parallel is still apparent, but nothing about what it was doing*
    - No parallel operation information

ALL format

- TYPICAL + additional information
  - *Projection*
  - *Query block and object aliases*
  - *Remote*
  - *Hint_report*
- All does *not* mean everything

Projection

- Given inputs, here is the list of columns returned (and their datatypes)
- May be handy when someone has done a select *
- May be interesting to see the pile of columns you are carrying through a plan
- I’ve looked at thousands of plans and I haven’t used it once that I recall

Query Block and aliases

- Shows query block and object alias information (surprise!)
- Very useful in complicated queries to show where each plan step is occurring
- Shows up like `sel$`, etc if Oracle picks them
- User-defined via the `/*+ qb_name() */` hint

```
select /*+ qb_name(main_query) */ employee_id
from employees;
```

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Sauce for the goose, Mr. SaAvik

- Can add or subtract columns or entire sections
- May be used with ‘+’ or ‘-’ or nothing
- + means add specified format in addition to the specified (or default) base format
  - *Options separated by spaces are also legal, so ‘+’ is not required*
- - means the all of the base format *except* the specified format options
  - *The ‘-’ is NOT optional if you want to exclude formats*
- This can enhance the readability of plans by excluding the irrelevant bits

```
select * from table(dbms_xplan.display_cursor('3k4sh40hw6rum',0,'TYPICAL +ALIAS -BYTES’));
```

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Demo of base formats

- Base formats
- Additional adds and exclusions between base formats
- Like adding ‘alias’ to typical (producing qb/alias section), while removing bytes

Various add-on format options

- NOTE
- ADAPTIVE
- IOSTATS
- MEMSTATS
- ALLSTATS
- LAST
- PEEKED_BINDS
- OUTLINE
- ADVANCED
- HINT_REPORT

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How do I know what I have?

- NOTE
- Displays the notes section
  - *It appears that in 11.2 and higher that this shows up when relevant in TYPICAL format even without requesting it*
- Shows
  - *whether a plan went adaptive, but not what was changed*
  - *Cardinality feedback (statistics feedback in 12.x) was used*
  - *Dynamic sampling was used*
  - *Plan Control was used*
    - SQL Plan Directives were used
    - SQL Plan Baselines were used
    - SQL Profiles were used

Adaptive plans

- The notes section tells you when something went adaptive, but nothing else
- This is where the ADAPTIVE format comes in!
- Displays the final plan
- ‘-’ denotes plan steps that were skipped
- Only available in 12.1 and above

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IOSTATS

- If plan statistics are gathered, this format option shows the I/O statistics for the plan
- Must have one of the following set
  - *`/*+ GATHER_PLAN_STATISTICS */` hint set in the query*
  - *Alter [session|system] set statistics_level = ALL;*
  - *STATISTICS_LEVEL parameter set to ALL (default is typical)*
- *NOTE* this causes additional overhead – please do not set to ALL for the entire database and leave it that way.
- If those are not set, the NOTE section will complain (shown in demo)
- IO means logical and physical I/O
- Have to adjust linesize to display properly (I use 132, but this changes with indents)
  - *If >=18c, use set linesize window*

IOSTATS, Cont'd

- IOSTATS gives us additional data
- Starts
- E-Rows and A-Rows
  - *This gives an optimizer sanity check – are e-rows and a-rows close?*
- A-Time
- Buffers
  - *This allows you to do a sanity check on efficiency (i/os per row/table?)*
    - LIOs 10x the number of rows is really good
    - 100x should stand out as probably can be improved
- Reads
- Writes

MEMSTATS

- Displays memory statistics used for an operation
- Requires auto PGA management
- Useful for memory-intensive operations (hash joins, sorts, etc)
- Shows whether things dumped to disk
- Adds 0Mem, 1Mem, Used-Mem, Used-Tmp columns
  - *These values come from v$sql_workarea (thanks, Rob van Wijk!)*

ALLSTATS

- Shortcut for IOSTATS + MEMSTATS
- Linesize 132 is too small, I use 180
  - *If >=18c, use set linesize window*
- This is what I typically use, so I can see everything

LAST

- Use with IOSTATS, MEMSTATS, ALLSTATS
- By default these show statistics for all executions (because we are greedy by default)
- LAST shows only statistics from the last execution

Deprecated formats

- Deprecated but still work for backward compatibility
- RUNSTATS_TOT
  - Same as IOSTATS
    - Displays IOSTATS across all executions
- RUNSTATS_LAST
  - Same as IOSTATS LAST
    - Displays IOSTATS for last execution

PEEKED_BINDS

- Displays the peeked binds the query used
- Appears to come from dba_hist_sqlbind (except for STS)
- Usable for DISPLAY_CURSOR(), DISPLAY_SQLSET(), and DISPLAY_AWR()

```
SELECT REQUIREMENTDATAHISTORYID FROM REQUIREMENTDATAHISTORY WHERE
UPDATEDATE BETWEEN :B2 AND :B1

Plan hash value: 1638392505

----------------------------------------------------------------------------------------------
| Id  | Operation          | Name                      | Rows  | Bytes | Cost (%CPU)| Time     |
----------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT   |                           |       |       |   160K(100)|          |
|*  1 |  FILTER            |                           |       |       |            |          |
|*  2 |   TABLE ACCESS FULL| REQUIREMENTDATAHISTORY    |     3 |    42 |   160K  (2)| 00:00:07 |
----------------------------------------------------------------------------------------------

Peeked Binds (identified by position):
--------------------------------------

   1 - :B2 (DATE): 01/02/2018 03:30:17
   2 - :B1 (DATE): 01/02/2018 03:53:46
```

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OUTLINE

- Displays the full set of hints required to reproduce the plan
- This is particularly handy when trying to reproduce a past plan
  - *You have a query that performs poorly but used to perform well*
  - *Get the outline hints from display_awr()*
  - *Use those hints to get the good plan in cache and baseline it*
- Outline hints also shows join order (Thanks, Maria Colgan!)

ADVANCED

- Appears to give ALL + OUTLINE

HINT_REPORT[_USED|UNUSED]

- Hints can be hard to use, and may silently fail
- 19c has nifty stuff for seeing hints via DBMS_XPLAN
- _USED shows used hints
- _UNUSED shows hints that weren't used or had syntax errors
  - *Included in the TYPICAL base format*
- Status of hints
  - *No status – hint was used*
  - *U – ununsed*
  - *N – unresolved*
  - *E – syntax error*

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HINT_REPORT, cont'd

- Mutually exclusive hints, both are 'unused'
- Helpful comments are a 'syntax error'
- Query blocks that don't exist are 'not resolved'
  - don't have a status, but are associated with plan line # 0
- Multiple hints for the same thing in different places are 'unused' (one or more are overridden)
- Sometimes hints are used that cause others to be excluded, those are 'unused'

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Additional formats demo

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Questions?

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Thank you!

- Thank you for attending this presentation!
- My contact information:
  - deedsd@nationwide.com
  - @dallasdeeds

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Acknowledgements & References

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