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AskTOM Office Hours – 23c In-Memory Deep Vectorlzation Enhancements

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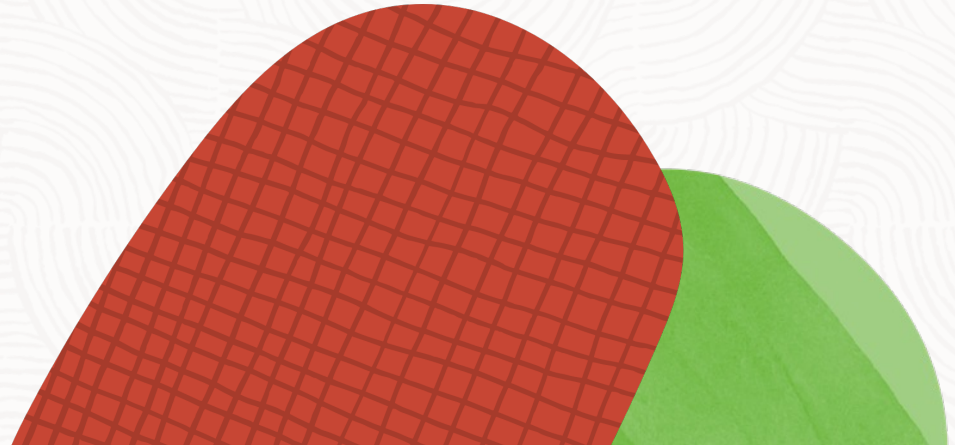
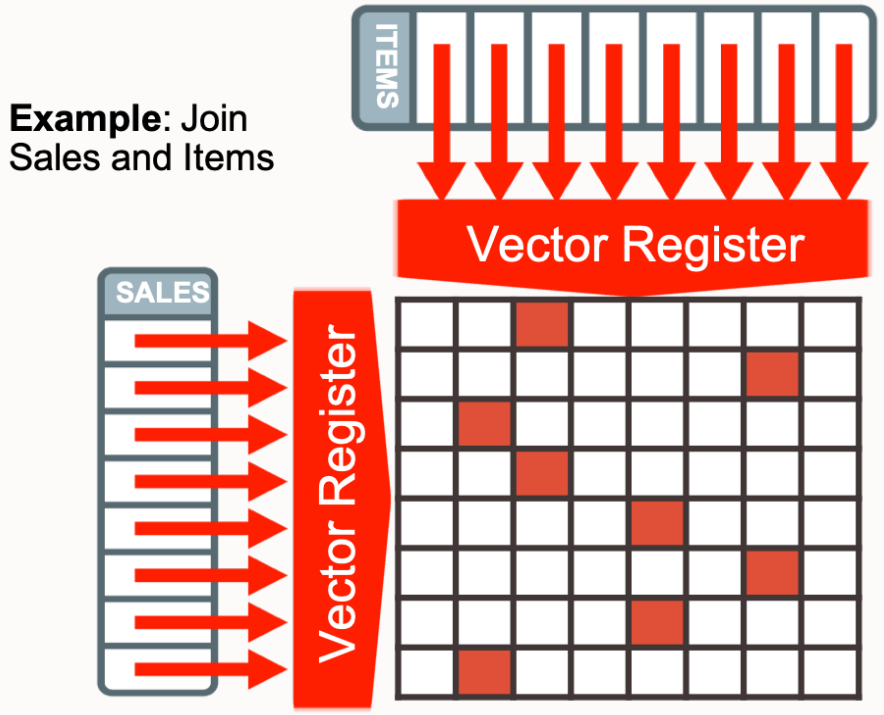
In-Memory Vectorized Joins



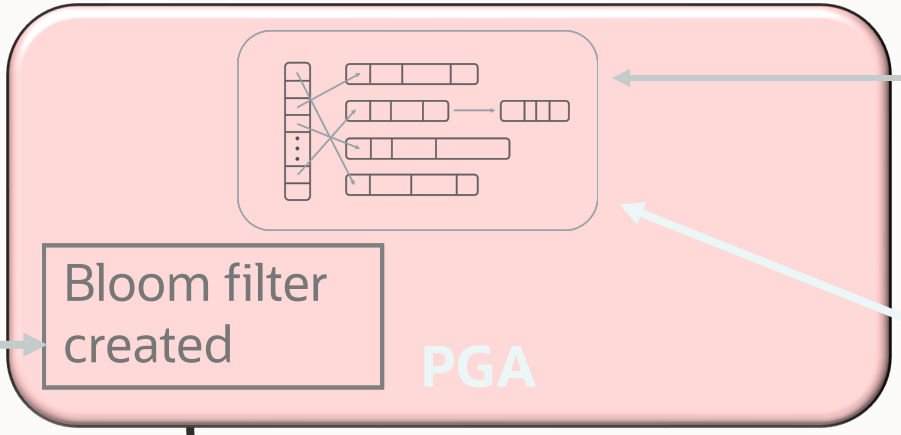
In-Memory Vectorized Joins – 21c Review

- Ask TOM Office Hours – Database In-Memory Vectorized Joins in 21c
- In-Memory Vectorized Joins uses a new *In-Memory Vectorization framework* to accelerate Complex Joins
- Optimizes Hash Joins
  - Performs join operations during in-memory scans
  - Match multiple rows between SALES and ITEMS tables in a single SIMD Vector Instruction
- AVX SIMD support provides maximum benefit
- Utilizes Join Groups for enhanced performance
- Can leverage IMDS for increased performance
- Can improve performance by up to 15x versus a non-IM hash join



Database In-Memory Hash Join With Vectorized Join

2 **Bloom Filter Creation:** A bit vector is created that has a bit set for each join column there is a value for & 0 where there is no value

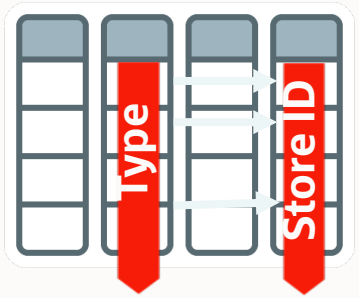


6 **Hash Join:** Join completed by probing into the hash table from the store_id to find actual matching rows

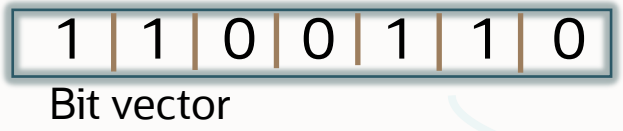
5 **Reduced rows sent:** Only rows that have a match in the bit vector get sent to the hash join

1 **Table Scan:** STORES table is scanned, filter predicates applied and matching rows sent to hash join

STORES



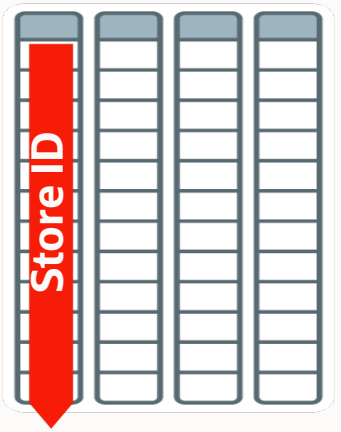
3 **Bloom Filter sent:** Bit vecter is sent as an additional filter criteria to the scan of the SALES table

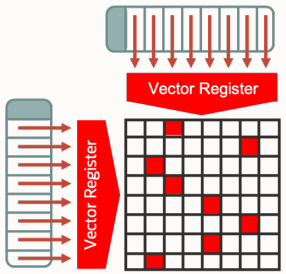


Bit vector

4 **Table Scan:** SALES table is scanned and rows are filtered based on filter predicates

SALES

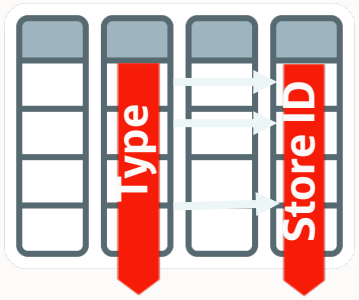


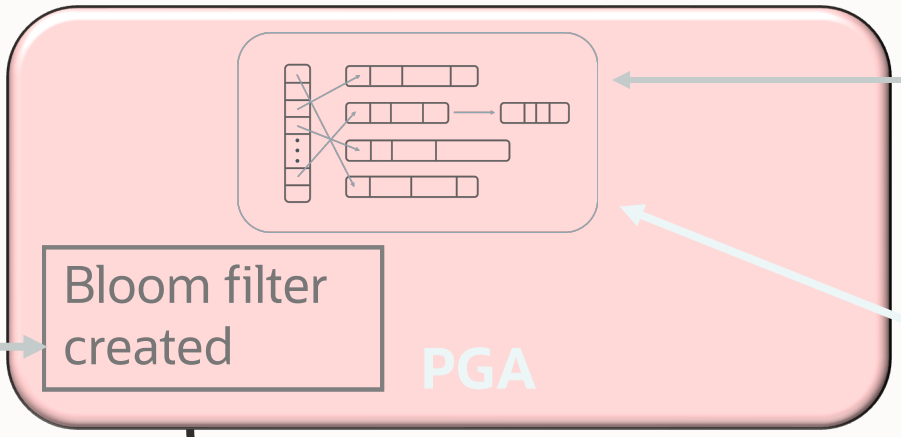


Database In-Memory Hash Join With Vectorized Join

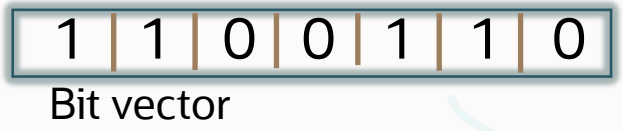
2 Bloom Filter Creation: A bit vector is created that has a bit set for each join column there is a value for & 0 where there is no value

1 Table Scan: STORES table is scanned, filter predicates applied and matching rows sent to hash join

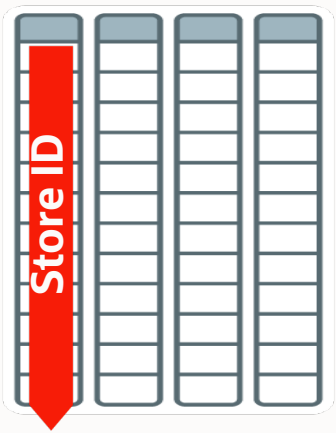




3 Bloom Filter sent: Bit vecter is sent as an additional filter criteria to the scan of the SALES table



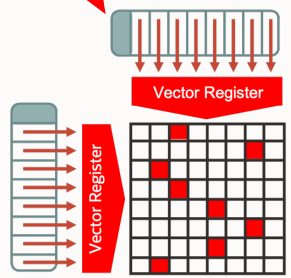
4 Table Scan: SALES table is scanned and rows are filtered based on filter predicates



5 vector get sent the hash join

6 Hash Join: Join completed by probing into the hash table from the store_id to find actual matching rows

In-Memory Vectorized Join



How Do You Enable Vectorized Joins?

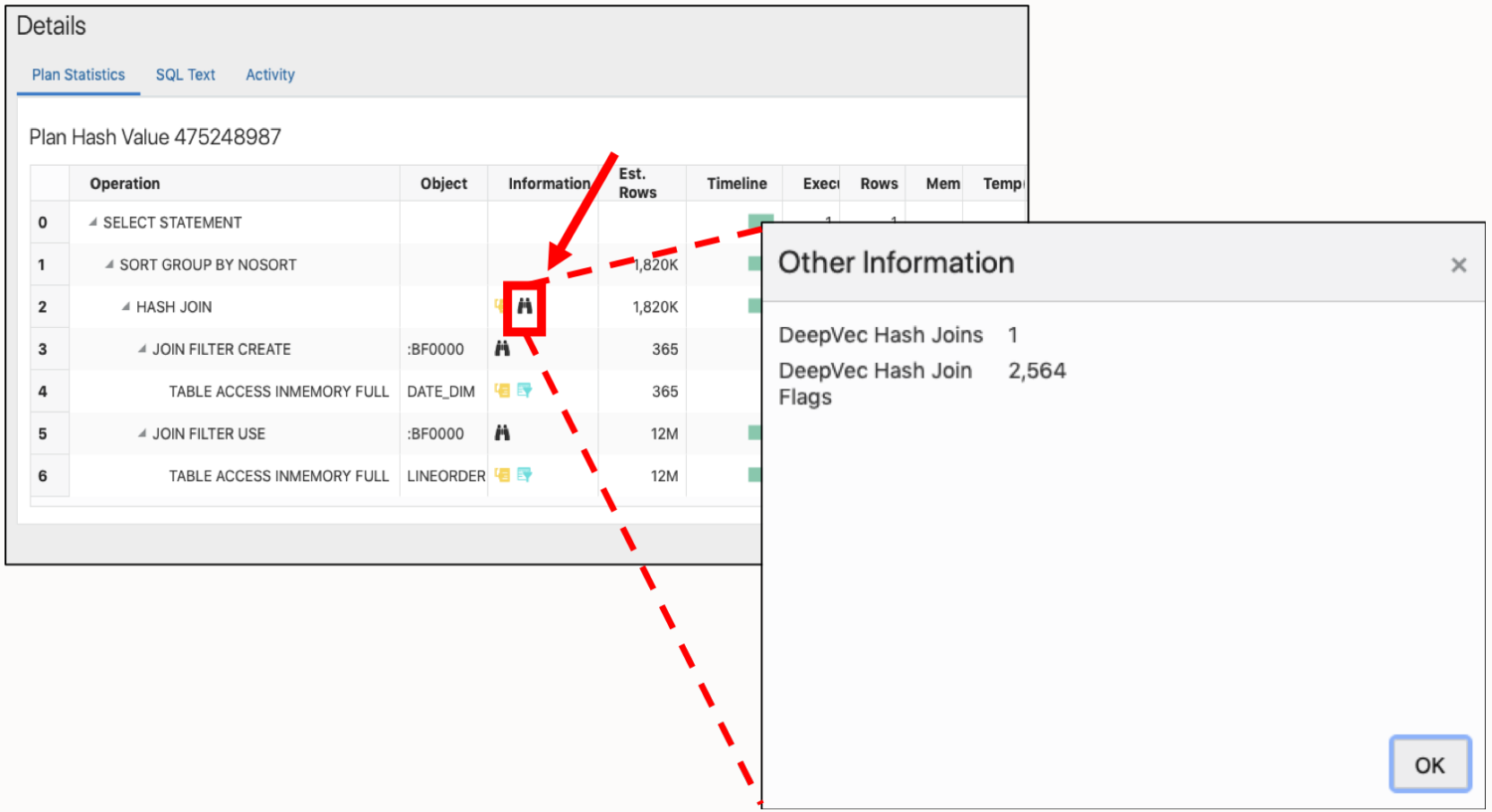
- In-Memory vectorized joins can be controlled with the following initialization parameter:

```
inmemory_deep_vectorization          boolean      TRUE
```

- Default value is TRUE and can be disabled by setting it to FALSE

How Do You Tell If a Vectorized Join Was Used?

SQL Monitor Active Report



How Do You Tell If a Vectorized Join Was Used?

SQL*Plus way to determine Deep Vector usage (similar to Join Groups)

```
PROMPT Deep Vectorization Usage: ;
PROMPT ------------------------ ;
PROMPT ;

SELECT
  '   ' || deepvec.rowsource_id || ' - ' row_source_id,
    CASE
      WHEN deepvec.deepvec_hj IS NOT NULL
      THEN
        'deep vector hash joins used: ' || deepvec.deepvec_hj ||
        ', deep vector hash join flags: ' || deepvec.deepvec_hj_flags
      ELSE
        'deep vector HJ was NOT leveraged'
    END deep_vector_hash_join_usage_info
FROM
  (SELECT EXTRACT(DBMS_SQL_MONITOR.REPORT_SQL_MONITOR_XML,
    q'#//operation[@name='HASH JOIN' and @parent_id]#') xmldata
   FROM   DUAL) hj_operation_data,
  XMLTABLE('/operation'
    PASSING hj_operation_data.xmldata
    COLUMNS
     "ROWSOURCE_ID"        VARCHAR2(5) PATH '@id',
     "DEEPVEC_HJ"          VARCHAR2(5) PATH 'rwsstats/stat[@id="11"]',
     "DEEPVEC_HJ_FLAGS"    VARCHAR2(5) PATH 'rwsstats/stat[@id="12"]') deepvec;
```

23c In-Memory Vectorized Join Enhancements

In-Memory Vectorization Framework: Multi-Level Joins and Aggregations

- In-Memory Deep Vectorization Framework was introduced on Oracle Database 21c
  - The first feature that leveraged the framework improved the performance of single level hash joins
- In Oracle Database 23c the In-Memory Deep Vectorization Framework adds more join support:
  - Multi-level hash joins
  - Multi join key
  - Semi joins
  - Outer joins
  - Full group by aggregation
- This translates to faster join performance by utilizing SIMD optimizations during join processing

Semi-Join Example

```
select /*+ MONITOR */ count(l.lo_custkey)
from lineorder l
where l.lo_partkey IN (select p.p_partkey from part p)
and l.lo_quantity <= 3;
```

```
-------------------------------------------------------------------------------------------------------
| Id  | Operation                     | Name      | Rows  | Bytes |TempSpc| Cost (%CPU)| Time     | Pstart| Pstop |
-------------------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT              |           |       |       |       |  5113 (100)|          |       |       |
|   1 |  SORT AGGREGATE               |           |     1 |    18 |       |            |          |       |       |
|*  2 |   HASH JOIN RIGHT SEMI        |           |  1640K|    28M|    12M|  5113   (8)| 00:00:01 |       |       |
|   3 |    TABLE ACCESS INMEMORY FULL | PART      |   800K|  3906K|       |    73   (3)| 00:00:01 |       |       |
|   4 |    PARTITION RANGE ALL        |           |  1640K|    20M|       |  2448  (15)| 00:00:01 |     1 |     3 |
|*  5 |     TABLE ACCESS INMEMORY FULL| LINEORDER |  1640K|    20M|       |  2448  (15)| 00:00:01 |     1 |     3 |
-------------------------------------------------------------------------------------------------------
```

Semi-Join Example, Part 2

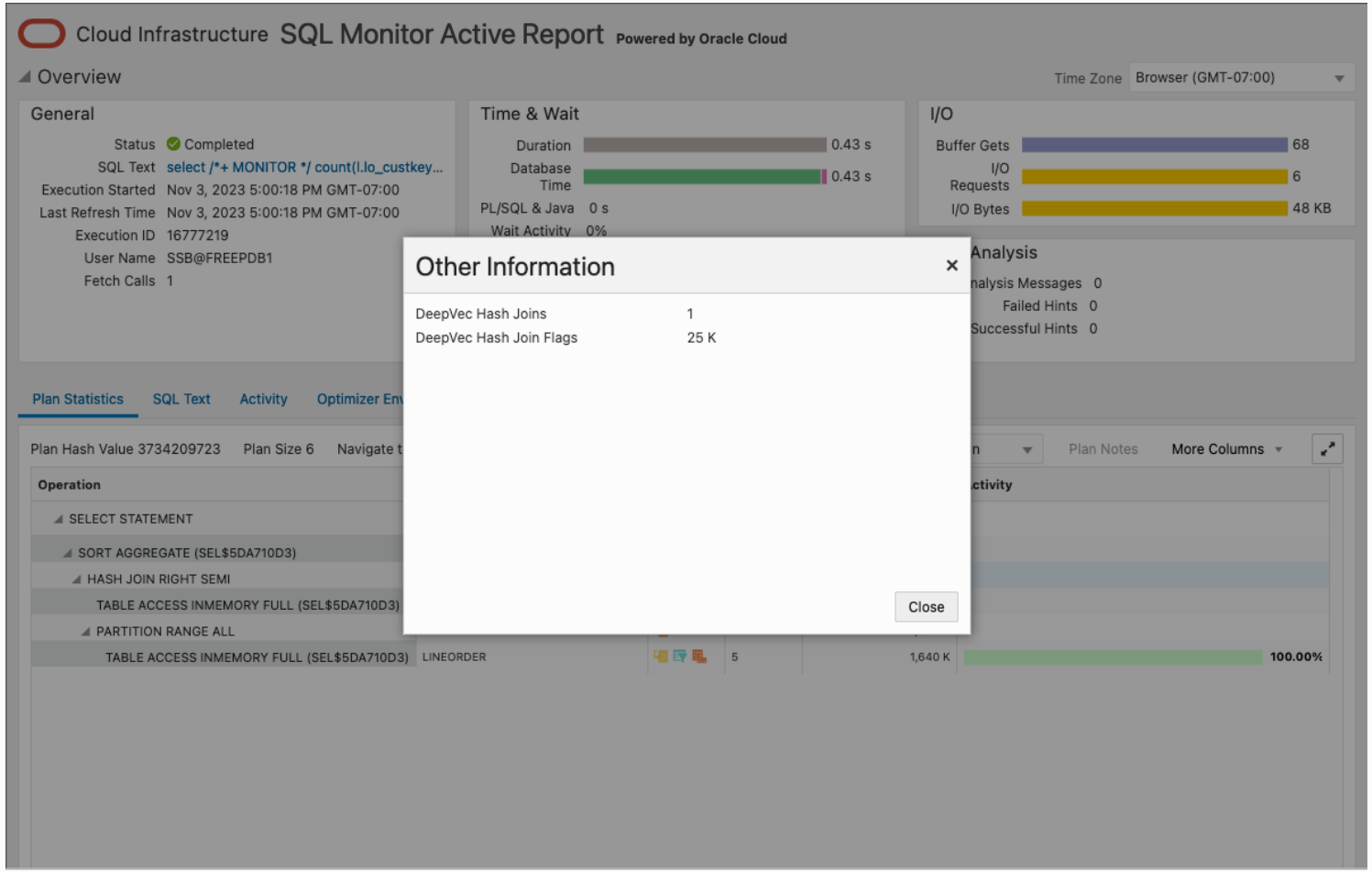
SQL*Plus way to determine Deep Vector usage (similar to Join Groups)

```
SELECT
  '   ' || deepvec.rowsource_id || ' - ' row_source_id,
    CASE
      WHEN deepvec.deepvec_hj IS NOT NULL
      THEN
        'deep vector hash joins used: ' || deepvec.deepvec_hj || ', deep vector hash join flags: ' || deepvec.deepvec_hj_flags
      ELSE
        'deep vector HJ was NOT leveraged'
    END deep_vector_hash_join_usage_info
FROM
  (SELECT EXTRACT(DBMS_SQL_MONITOR.REPORT_SQL_MONITOR_XML, q'#//operation[@name='HASH JOIN' and @parent_id]#') xmldata
   FROM   DUAL) hj_operation_data,
  XMLTABLE('/operation'
    PASSING hj_operation_data.xmldata
    COLUMNS
     "ROWSOURCE_ID"        VARCHAR2(5) PATH '@id',
     "DEEPVEC_HJ"          VARCHAR2(5) PATH 'rwsstats/stat[@id="11"]',
     "DEEPVEC_HJ_FLAGS"    VARCHAR2(5) PATH 'rwsstats/stat[@id="12"]') deepvec;
```

```
Deep Vectorization Usage:
-------------------------
   2 -      deep vector hash joins used: 1, deep vector hash join flags: 24576
```

Semi-Join Example, Part 3

SQL Monitor way to determine Deep Vector usage



Semi-Join Example, Part 4

Execution Plan Output

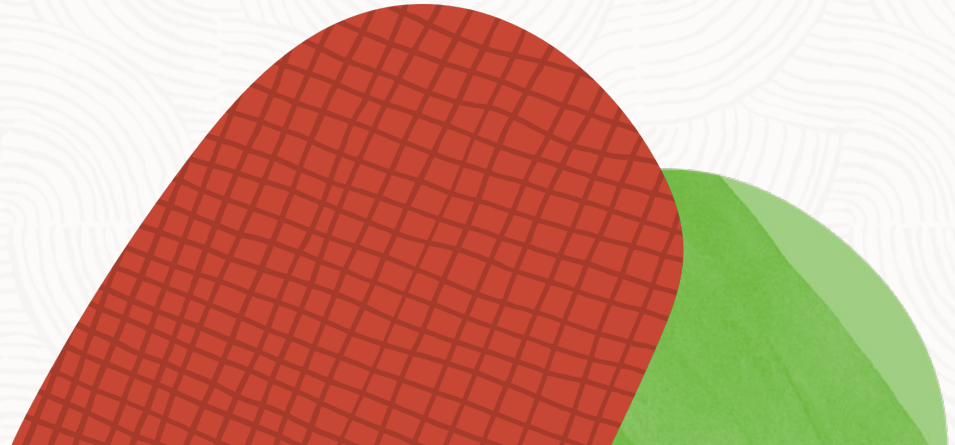
```
Plan hash value: 3734209723

-------------------------------------------------------------------------------------------------------------------
| Id  | Operation                     | Name      | Rows  | Bytes |TempSpc| Cost (%CPU)| Time     | Pstart| Pstop |
-------------------------------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT              |           |       |       |       |  5113 (100)|          |       |       |
|   1 |  SORT AGGREGATE               |           |     1 |    18 |       |            |          |       |       |
|*  2 |   HASH JOIN RIGHT SEMI        |           |  1640K|    28M|    12M|  5113   (8)| 00:00:01 |       |       |
|   3 |    TABLE ACCESS INMEMORY FULL | PART      |   800K|  3906K|       |    73   (3)| 00:00:01 |       |       |
|   4 |    PARTITION RANGE ALL        |           |  1640K|    20M|       |  2448  (15)| 00:00:01 |     1 |     3 |
|*  5 |     TABLE ACCESS INMEMORY FULL| LINEORDER |  1640K|    20M|       |  2448  (15)| 00:00:01 |     1 |     3 |
-------------------------------------------------------------------------------------------------------------------
Predicate Information (identified by operation id):
---------------------------------------------------
   2 - access("L"."LO_PARTKEY"="P"."P_PARTKEY")
   5 - inmemory("L"."LO_QUANTITY"<=3)
       filter("L"."LO_QUANTITY"<=3)
25 rows selected.

SQL>
SQL> set echo off
Deep Vectorization Usage:
-------------------------

   2 -      deep vector hash joins used: 1, deep vector hash join flags: 24576
```

Where Can You Get More Information?



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- 23c Deep Dive - In-Memory Vector Join Enhancements
- In-Memory Vectorized Joins

Database In-Memory Ask TOM Office Hours

- 23c In-Memory Deep Vectorization Enhancement
- Database In-Memory Vectorized Joins in 21c

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Database In-Memory Documentation

Database In-Memory LiveLabs

http://bit.ly/golivelabs

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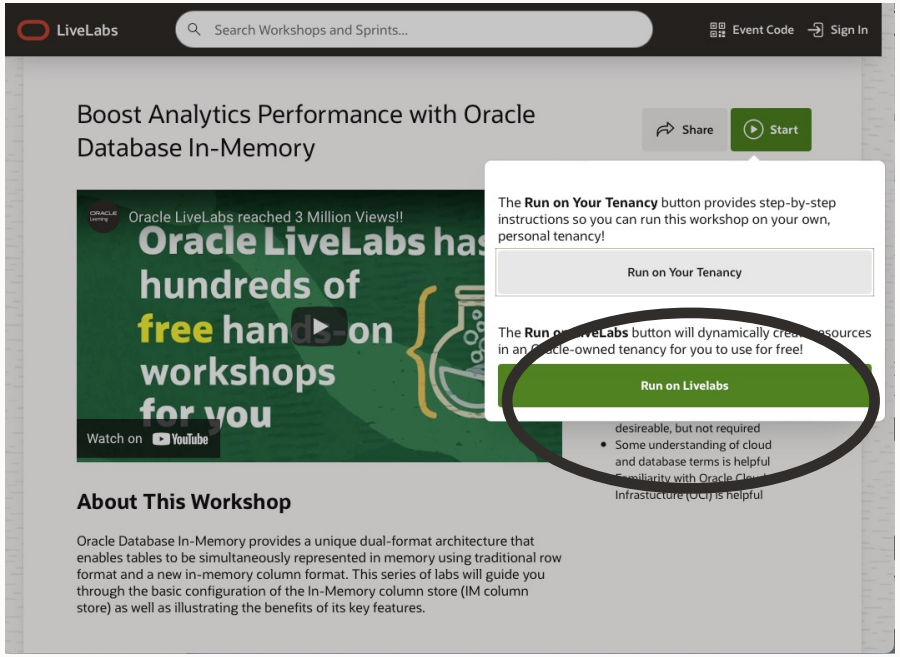
Database In-Memory Advanced Features



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