# Improving Performance With 12c In-Memory Option

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**Session ID: CON4349**

Walgreens
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# Speaker

Fong Zhuang

- Database Architect and Team Lead
- 19+ years with Walgreens
- My Specialty & Interest
  - Oracle Performance Tuning and High Availability
  - Oracle E-Business Suit (EBS) and Oracle Business Intelligence Enterprise Edition (OBIEE)
  - Oracle Engineered System
  - Data Warehouse Implementation
- Oracle Certified Professional (OCP)

# Speaker

Sergiy Smyrnov

- Lead Database Architect
- 20+ years of experience with Database Technologies
- My Areas of expertise
  - Oracle Engineered Systems
  - High Availability/DR implementations for database technologies
  - Data Warehouse/DSS and OLTP/E-commerce database systems
  - Database automation

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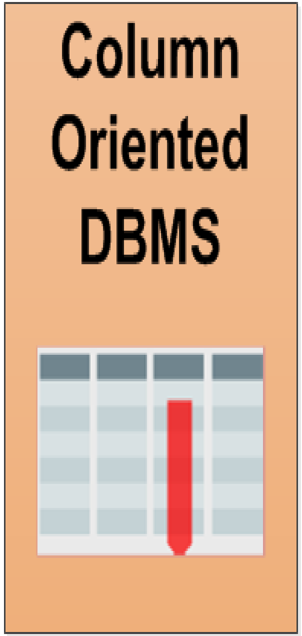
# Walgreens

- Included in the Retail Pharmacy USA Division of Walgreens Boots Alliance, Inc., the first Global Pharmacy-Led Health and Wellbeing Enterprise
- One of the nation’s largest drugstore chains
- More than 8,175 stores
- Approximately 400 Walgreens stores offer Healthcare Clinic or other provider retail clinic services
- Focused on enhancing our customers’ beauty shopping experience

# Agenda

- Row-major Oriented vs Column Oriented DBMS
- Introduction of Oracle Dual Format SGA Architecture
- Case Studies in Walgreens
  - Case 1 OLTP EBS environments (Exadata)
  - Case 2 OLAP OBIEE Data Warehouse (ODA vs. Exadata)
- Release 12.2 In-Memory enhancement
- Walgreens roadmap to use In-Memory features

# Row-major Oriented vs Column Oriented DBMS

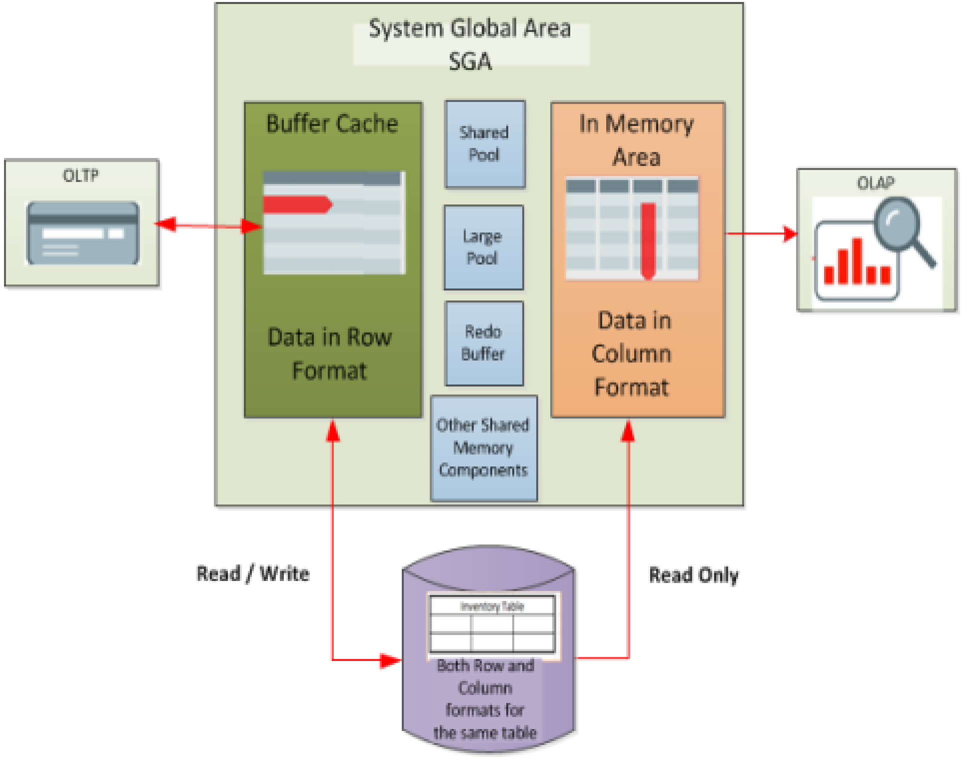

**CHALLENGE: Accelerate the performance of both OLAP and OLTP in the same database.**

**Traditional Row-major DBMS → OLTP workloads.**

**Columnar Oriented DBMS → A proven practice for OLAP / Data Warehouse**

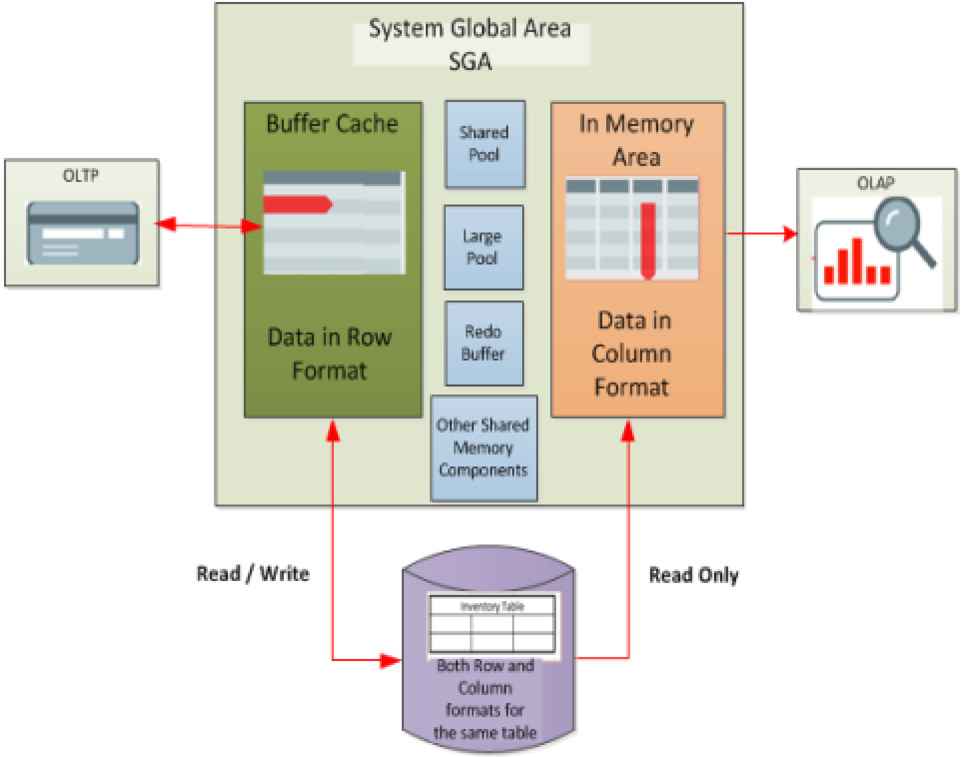
**Oracle innovative OLTAP solution**

# Innovative OLTAP Solution - Dual Format Architecture



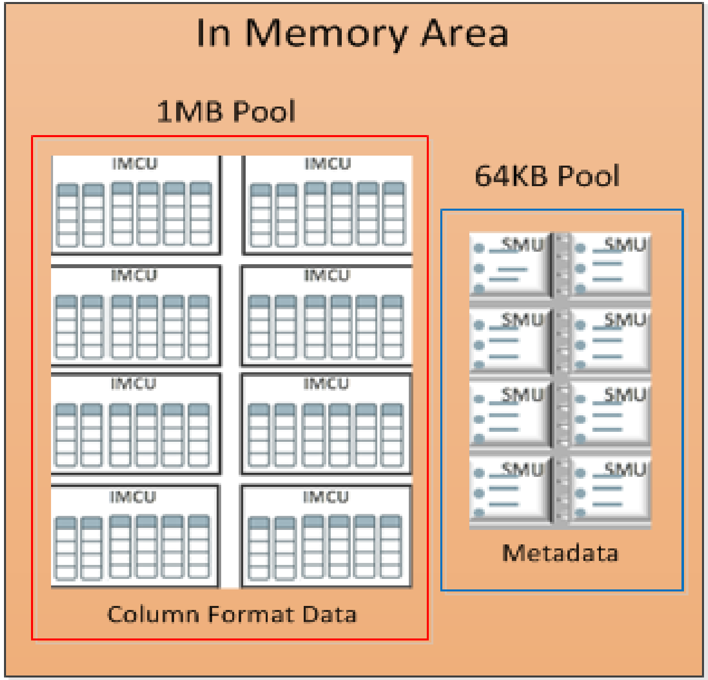

- New In-Memory Area option in Oracle Database 12*c* Release 1 (12.1.0.2)
- Static SGA pool in special columnar format for OLAP.
- Speeding up analytical queries
- Buffer Cache in row format for OLTP
- Same data stored in both Buffer Cache & In-Memory Area in different formats.

# Transactionally Consistent




- ❑ Data stored in disk in Row format
- ❑ DML <---> Buffer Cache row store.
- ❑ Read-only →In-Memory Column Store.
- ❑ Transaction (inserts, updates, and deletes) committed → Both stores.
- ❑ The population includes a transformation from row to columnar format and it consumes CPU.

# In-Memory Area Structure




- **1MB-Pool IMCU (In-Memory Compression Unit)**
  - **Logical unit of storage**
  - **Roughly equivalent to an extent within a tablespace.**
- **64KB-Pool SMU (Snapshot Metadata Unit)**
  - **Metadata about the IMCU & transactional info**
  - **Records min and max values**
  - **Serves as an In-Memory Storage Index**
- **Each IMCU maps to a SMU.**
- **NO Least-Recently-Used-Mechanism (LRU)**

# Case Study in Walgreens Financial System

- **Case 1 in EBS**
  - **OLTP mix-workload**
  - **Relational entity model in 3NF.**
- **Case 2 in OBIEE Data Warehouse**
  - **OLAP**
  - **Entity model star schema**
- **Lower environments in ODAs**
- **Performance test and PROD environments in Exadata**

# Case Study Details

## Please refer to following paper for more details:

- Published in IOUG Select:

"Improving Performance With 12c In-Memory Option"
http://select.ioug.org/blog/improving-performance-with-12c-in-memory-option by Fong Zhuang

# Case 1 OLTP - Walgreens Oracle EBS (Exadata)

Database Evaluation:

- POC Performance Test Environment
- Database host: Exadata X-3 Quarter Rack
- RAC (2 nodes)
- Host memory: 256GB / node
- 16 cores / node
- DB version 12.1.0.2

# Leverage In-Memory Advisor

Use Active Session History (ASH), Automatic Workload Repository (AWR) and optionally SQL Tuning Sets (STS)

Determine which tables, partitions and sub-partitions to place In Memory.

Licensed as part of the Database Tuning pack.

Minimum DB version to run In-Memory Advisor is 11.2.0.3.

Implemented recommendations in Database 12.1.0.2 and above.

# Leverage In-Memory Advisor(Cont.)

## Where to get it and how to install it?

- MOS note: 1965343.1
- Download imadvisor.zip from Oracle, copy to DB server-->unzip it
- Install in SQLPLUS with sysdba privilege
  - SQL> @instimadv.sql
- Run the IM advisor recommendation script with appropriate period
  - SQL> @imadvisor_recommendations.sql
- Review two outputs generated from the script

# Case 1 OLTP - Walgreens Oracle EBS

## In-Memory Advisor report highlights:

- A report based on 1 week of workload in EBS
- 67% DB time is doing analytics processing
- With 535.2GB In-Memory Size, the Estimated Analytics Processing Time Reduction is 79 hours.
- With 20GB of In-Memory, the potential time reduction is 14 hours.

# Size SGA and PGA properly

Check MOS Note 1903683.1

- ✓ Existing Single Instance:

  SGA_TARGET= Existing SGA_TARGET+ INMEMORY_SIZE

- ✓ Existing RAC:

  SGA_TARGET= Existing SGA_TARGET + INMEMORY_SIZE x 1.1

- ✓ If you are using parallel execution to reduce the possibility of spilling to TEMP on large joins and aggregations

  PGA_AGGREGATE_TARGET = PARALLEL_MAX_SERVERS * 2G

Note:

- ✓ Additional space is required for the shared_pool as IMCS allocates additional locks from the shared pool
- ✓ Avoid “ORA – 4031” - unable to allocate string bytes of shared memory

# Enable In-Memory Column Store

- Controlled by the parameter INMEMORY_SIZE
- Minimum size of 100MB
- In RAC DB, add additional 10% overhead to INMEMORY_SIZE.

  SQL> alter system set sga_max_size = 70G scope=spfile sid='*';

  SQL> alter system set sga_target = 70G scope=spfile sid='*';

  SQL> alter system set inmemory_size = 30G scope=spfile sid='*';
- Restart the database to take effect.

```
SQL> show sga

Total System Global Area 7.5162E+10 bytes
Fixed Size                  7652376 bytes
Variable Size            1.7985E+10 bytes
Database Buffers         2.4696E+10 bytes
Redo Buffers             [illegible] bytes
In-Memory Area           3.2212E+10 bytes
SQL> show parameter inmemory_size

NAME                                 TYPE        VALUE
------------------------------------ ----------- ------------------------------
inmemory_size                        big integer 30G
```

# In-Memory Area Structure

- The pool information in v$inmemory_area

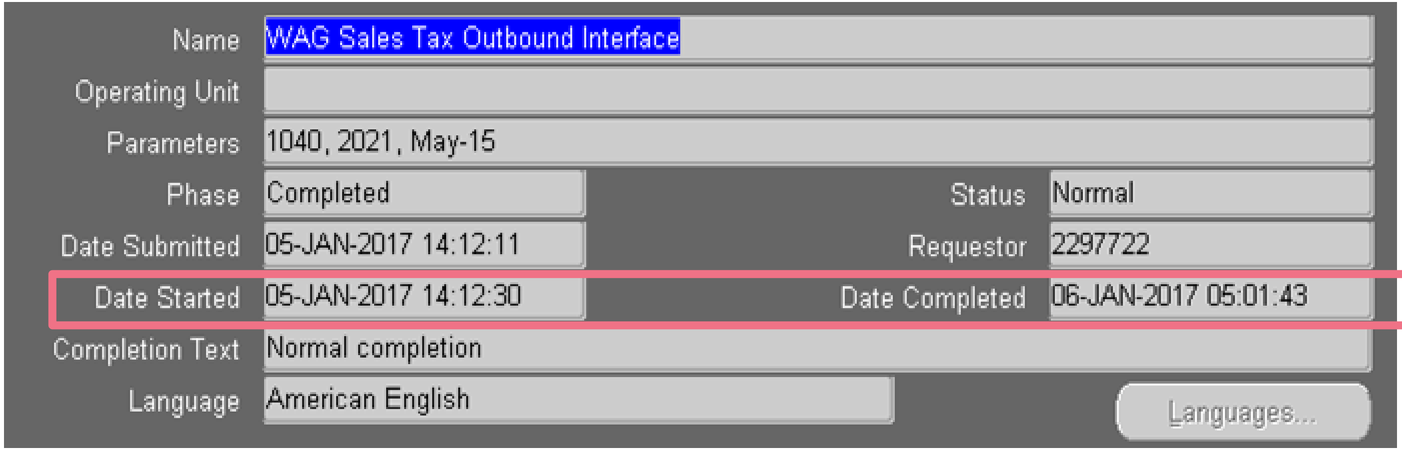
```
SQL> select * from v$inmemory_area;

POOL                       ALLOC_BYTES USED_BYTES POPULATE_STATUS                CON_ID
-------------------------- ----------- ---------- -------------------------- ----------
1MB POOL                    2.5744E+10          0 DONE                                0
64KB POOL                   6422724608          0 DONE                                0
```

- By default, 20% of the In-memory size is allocated to the 64KB pool.
- Most of the chances, 1MB pool exhausted but 64KB pool plenty of space.
- No mechanism automatically resize 1MB pool and 64KB pool.
- Option of modifying **"_inmemory_64k_percent"** parameter to reduce the size of the 64K pool with Oracle support's approval.

# Case 1 OLTP - Walgreens Oracle EBS (Cont.)

## Target the bottleneck :

- App team's request:  One EBS batch job was taking 14 hours & 39 min.  Any solutions?




**14 hours 39 min**

# Case 1 OLTP - Walgreens Oracle EBS (Cont.)

## In-Memory advisor html report analysis:

***Workload Database Usage***

| Total Database Time (Seconds) | Analytics Processing Time (Seconds) | Analytics Processing Percentage |
|---|---|---|
| 59140 | 51520 | 87% |

| In-Memory Size | Percentage of Maximum SGA Size (50.00GB) | Estimated Analytics Processing Time Reduction (Seconds) | Estimated Analytics Processing Performance Improvement Factor |
|---|---|---|---|
| 30.00GB | 60% | 17290 | 1.5X |
| 1.852GB | 4% | 17290 | 1.5X |
| 1.759GB | 4% | 17261 | 1.5X |
| 1.667GB | 3% | 17261 | 1.5X |
| 1.574GB | 3% | 17261 | 1.5X |
| 1.481GB | 3% | 17261 | 1.5X |
| 1.389GB | 3% | 17161 | 1.5X |
| 1.296GB | 3% | 17161 | 1.5X |
| 1.204GB | 2% | 17161 | 1.5X |
| 1.111GB | 2% | 17161 | 1.5X |
| 1.018GB | 2% | 17161 | 1.5X |
| 948.1MB | 2% | 17161 | 1.5X |
| 853.3MB | 2% | 17161 | 1.5X |
| 758.5MB | 1% | 17161 | 1.5X |
| 663.7MB | 1% | 17161 | 1.5X |
| 568.8MB | 1% | 17161 | 1.5X |
| 474.0MB | 1% | 17161 | 1.5X |
| 379.2MB | 1% | 17161 | 1.5X |
| [illegible] | [illegible] | [illegible] | [illegible] |
| 189.6MB | 0% | 17133 | 1.5X |
| 94.81MB | 0% | 17046 | 1.5X |

**If you add the objects to IMCS with 94.8MB in size, the time reduction is 4.7 hours.**

# Case 1 OLTP - Walgreens Oracle EBS (Cont.)

## In-Memory advisor html report analysis (Cont.)

**Only 850 sec out of 51,520 sec (14.3 hours) of Total Analytics Processing Time**

**Per AWR, this SQL took avg 0.04 sec to run. It was executed 27,072 times.**

*With 30.00GB, The One SQL Statement With Analytics Processing Benefit*

| SQL Id | SQL Text | Analytics Processing Time Used (Seconds) | Estimated Analytics Processing Time Reduction (Seconds) With Unlimited Memory | Estimated Analytics Processing Performance Improvement Factor With Unlimited Memory | Estimated Analytics Processing Time Reduction (Seconds) With 30.00GB | Estimated Analytics Processing Performance Improvement Factor With 30.00GB |
|---|---|---|---|---|---|---|
| 1223h53fh9nt9 | SELECT XGL.LOCATION_NUMBER STORE_NO ,XXGL_SALES_TAX_OUTBOUND_PKG.GET_STATE_CODE_F (XGL.STATE) STAT... | 850 | 7 | 1.0X | 7 | 1.0X |

**Only 7 sec of reduction, Seriously?**

# Case 1 OLTP - Walgreens Oracle EBS (Cont.)

## Populate Segments

→ 10 tables are recommended to populate into IMCS.

- Table Population Examples in Engineered System:

```
SQL> ALTER TABLE "GL"."GL_CODE_COMBINATIONS" INMEMORY
duplicate all  priority critical MEMCOMPRESS FOR QUERY LOW;
```

- Eligible Segments: Table, Partition, Subpartitions, Materialized Views, and tablespace.

- Tune parameter *inmemory_max_populate_servers* for segment population performance, but watch over the CPU usage carefully.
  - The default value is the less value: 1/2 X CPU thread count OR PGA_AGGREGATE_TARGET / 512M

# The IM column store compression Levels

```
SQL> ALTER TABLE "GL"."GL_CODE_COMBINATIONS" INMEMORY
duplicate all  priority critical  MEMCOMPRESS FOR QUERY LOW;
```

- No Memcompress
- Memcompress For DML
- Memcompress For Query Low (default)
- Memcompress For Query High
- Memcompress For Capacity Low
- Memcompress For Capacity High

# In-Memory Population Priority

```
SQL> ALTER TABLE "GL"."GL_CODE_COMBINATIONS"
INMEMORY duplicate all priority critical
MEMCOMPRESS FOR QUERY LOW;
```

- CRITICAL
- HIGH
- MEDIUM
- LOW
- NONE (Default)

# When "In Memory" meets RAC

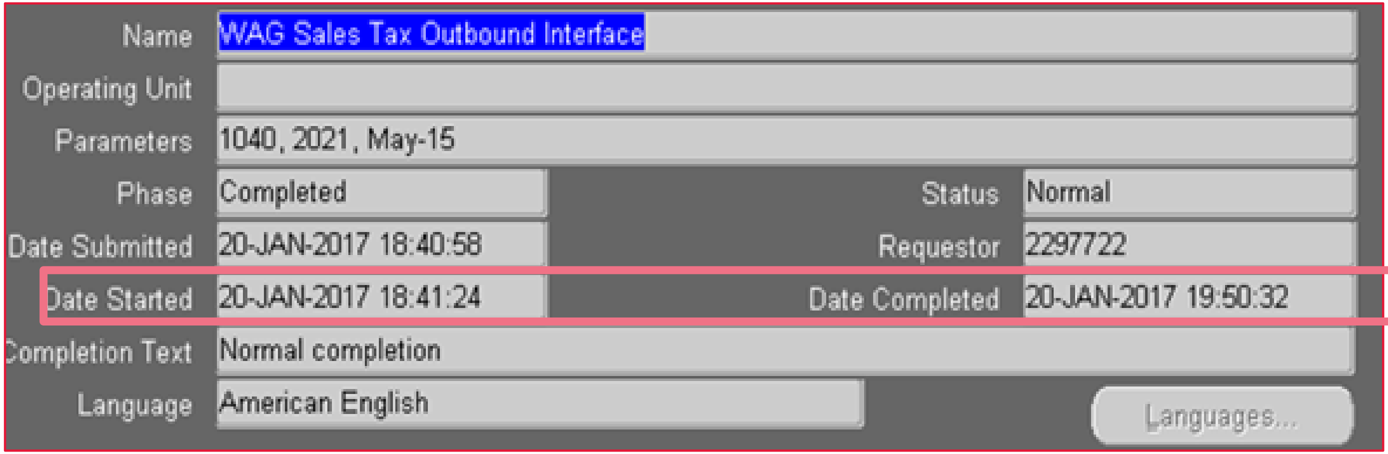
```
SQL> ALTER TABLE "GL"."GL_CODE_COMBINATIONS" INMEMORY
duplicate all priority critical  MEMCOMPRESS FOR QUERY LOW;
```

- For Non Engineered System, use "distribute" subclause
  - Distribute by rowid range
  - Distribute by partition
  - Distribute by subparitition
- Enable Auto DOP
  - Parallel_degree_policy=auto
- In Engineered System, option of using subclause "duplicate" or "duplicate all" to duplicate IMCUs into other nodes (mirroring).

# Case 1 OLTP - Walgreens Oracle EBS (Cont.)

## Check the execution results after adding tables to In-Memory:

- The job completed in 1 hour and 9 minutes.
- Compare to 14 hours and 39 minutes of the previous timing, 12X performance improvement.




**1 hour 9 min**

# Case 1 OLTP - Walgreens Oracle EBS (Cont.)

## Check the application execution results after adding tables to In-Memory (Cont.)

- Where was the performance improvement coming from ?

Reality: Per base AWR, after adding tables to In-Memory, it took 0.012 sec each time

Reality: It was executed 27,072 times

*With 30.00GB, The One SQL Statement With Analytics Processing Benefit*

| SQL Id | SQL Text | Analytics Processing Time Used (Seconds) | Estimated Analytics Processing Time Reduction (Seconds) With Unlimited Memory | Estimated Analytics Processing Performance Improvement Factor With Unlimited Memory | Estimated Analytics Processing Time Reduction (Seconds) With 30.00GB | Estimated Analytics Processing Performance Improvement Factor With 30.00GB |
|---|---|---|---|---|---|---|
| 1223h53fh9ht9 | SELECT XGL.LOCATION_NUMBER STORE_NO ,XXGL_SALES_TAX_OUTBOUND_PKG.GET_STATE_CODE_F (XGL.STATE) STAT... | 850 | 7 | 1.0X | 7 | 1.0X |

Reality: The total Processing Time Reduction is 758 Sec (12.4 Min)

Reality: The performance improvement factor is 3.3X

# Case 1 OLTP - Walgreens Oracle EBS (Cont.)

Identify the key time saving SQL from AWR Report

## SQL ordered by Elapsed Time

- Resources reported for PL/SQL code includes the resources used by all SQL statements called by the code.
- % Total DB Time is the Elapsed Time of the SQL statement divided into the Total Database Time multiplied by 100
- %Total - Elapsed Time as a percentage of Total DB time
- %CPU - CPU Time as a percentage of Elapsed Time
- %IO - User I/O Time as a percentage of Elapsed Time
- Captured SQL account for 102.4% of Total DB Time (s): 54,650
- Captured PL/SQL account for 104.1% of Total DB Time (s): 54,650

| Elapsed Time (s) | Executions | Elapsed Time per Exec (s) | % Total | % CPU | % IO | SQL Id | SQL Module | SQL Text |
|---|---|---|---|---|---|---|---|---|
| 53,129.99 | 0 | | 97.22 | 99.02 | 0.21 | 44513hm880cwn | XXGLSALESTAXOUT | BEGIN XXGL_SALES_TAX_OUTBOUND_... |
| 50,582.91 | 538 | 94.02 | 92.56 | 99.23 | 0.00 | d5v6120ykm39r | XXGLSALESTAXOUT | SELECT DISTINCT FFV.FLEX_VALUE... |
| 1,223.84 | 1 | 1,223.84 | 2.24 | 98.47 | 0.57 | 05s9358mm6vrr | | begin dbms_feature_usage_inter... |
| 1,221.63 | 1 | 1,221.63 | 2.24 | 98.54 | 0.55 | duxwqqq8un28r | | BEGIN DBMS_FEATURE_AWR(:featur... |
| 1,221.60 | 1 | 1,221.60 | 2.24 | 98.54 | 0.55 | 6tw4m9dqgpg2r | | SELECT /* DS_SVC */ /*+ dynami... |
| 1,057.61 | 27,072 | 0.04 | 1.94 | 97.56 | 1.58 | 1223h53fh9ht9 | XXGLSALESTAXOUT | SELECT XGL.LOCATION_NUMBER STO... |
| 397.77 | 349 | 1.14 | 0.73 | 94.28 | 3.32 | dfffkcnqfystw | MMON_SLAVE | WITH MONITOR_DATA AS (SELECT I... |
| 365.76 | 349 | 1.05 | 0.67 | 93.67 | 3.72 | fhf8upax5cxsz | MMON_SLAVE | BEGIN sys.dbms_auto_report_int... |
| 355.77 | 349 | 1.02 | 0.65 | 93.79 | 3.74 | 0w26sk6t6gq98 | MMON_SLAVE | SELECT XMLTYPE (DBMS_REPORT.GET... |
| 339.89 | 1 | 339.89 | 0.62 | 99.17 | 0.07 | 73629tmfbjzrh | DBMS_SCHEDULER | DECLARE job BINARY_INTEGER := ... |

# Case 1 OLTP - Walgreens Oracle EBS (Cont.)

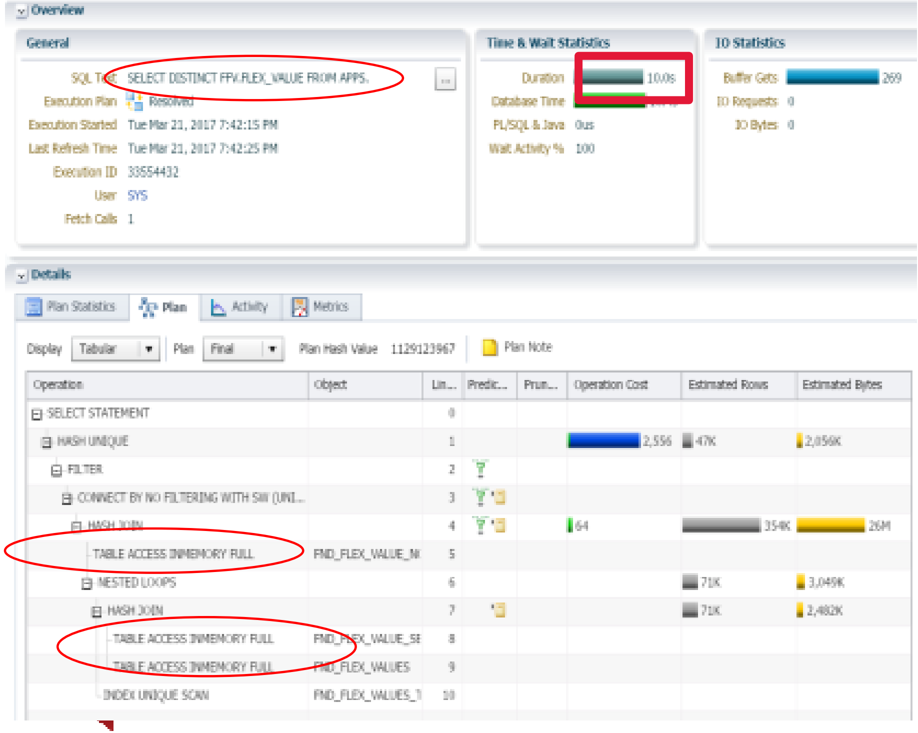
## Top SQL performance evaluation in Wag Sales Tax Outbound job

| SQL_ID | SQL Text | Executions | Average Elapsed Time per Exec (s) | Average Elapsed Time per Exec w tables In-Memory (s) | Time Reduced/Execution (s) | Performance Improvement Factor (Old Timing / New Timing) | Total time reduction(s) |
|---|---|---|---|---|---|---|---|
| 1223h53fh9ht9 | **SELECT XGL.LOCATION_NUMBER STO...** | 27,072 | 0.04 | 0.012 | 0.028 | 3.33X | 758 (s) OR 12.6 (m) |
| d5v6120ykm39r | **SELECT DISTINCT FFV.FLEX_VALUE FROM APPS.FND_FLEX_VALUE_CHILDREN_V FFV** | 538 | 94.02 | 2.16 | 91.86 | 47X | 49496 (s) OR 825 (m) OR 13.7 (h) |

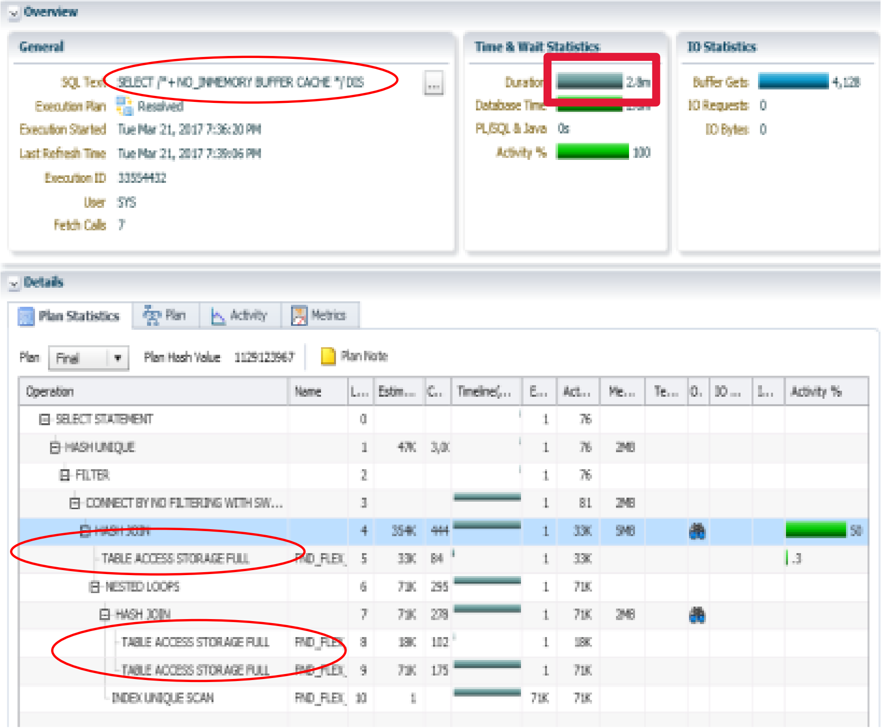
# Case 1 OLTP - Walgreens Oracle EBS (Cont.)

## Top SQL2 Execution Plan Comparison from SQL Monitor Output

### Column Store: In-Memory




### Row Store: Buffer Cache



# Case 1 OLTP - Walgreens Oracle EBS (Cont.)

Test results with good performance improvement on major EBS jobs:

| EBS Job Name | Table Disk Size | In-Memory Size | Processing Time w/o In-Memory | Processing Time with In-Memory | Time Reduced | Performance Improvement Factor (Old Timing / New Timing) |
|---|---|---|---|---|---|---|
| Outbound Interface Program | 11GB | 7GB | 9 hours | 5 hours | 4 hours | 1.8 X |
| Sales Tax Outbound Interface | 8.5GB | 1.8GB | 14 hours and 39 minutes | 1 hour 10 minutes | 13 hours | 12 X |

Note: There were 36 indexes on 10 tables. The total index disk size is 2.3 GB. Analytic indexes can be dropped after adding tables into IMCS.

# Case 1 OLTP - Walgreens Oracle EBS (Cont.)

## Sample test results without performance improvement:

| EBS Job Name | Disk Size | In-Memory Size | Processing Time w/o In-Memory | Processing Time with In-Memory | Time Reduced | Performance Improvement Factor (Old Timing / New Timing) |
|---|---|---|---|---|---|---|
| Warehouse Billing Journal Inbound Interface | 89GB | 15GB + | 1 hour and 20 minutes | 1 hour 28 minutes | N/A | N/A |

## Reasons with no improvement:

- One major table with 89GB which couldn't be fully populated to In-Memory.
- The In-Memory compression ratio is relatively high.

# Case 1 OLTP - Walgreens Oracle EBS (Cont.)

Case 1 Summary:

- Observed time reduction from 1.8X to 12X on various jobs.
- In-Memory Advisor is efficient in identifying the candidate segments.
- The real performance could be much better than the In-Memory Advisor estimation.
- Analytic indexes can be dropped for potential space saving and DML contention reduction.
- No performance change on segments with high compression ratio.

# Case 2 OLAP Oracle OBI Data Warehouse (ODA)

## Database Evaluation:

- Proof of Concept Environment
- Database host:
  Oracle Database Appliance (ODA X3-2)
- RAC (2 nodes)
- Host memory: 256GB/node
- 16 cores / node
- ODA is shared by multiple DBs
- DB version 12.1.0.2
- Plan to improve with INMEMORY_SIZE 50GB

# Case 2 OLAP Oracle OBI Data Warehouse (ODA)

Sample test results without performance improvement:

| Test Description | Disk Size | In-Memory Size | Tables NOT In Memory (HH:MM:SS.00) | Tables In Memory (HH:MM:SS.00) | Performance Improvement Factor (Old Timing / New Timing) |
|---|---|---|---|---|---|
| Count Fact Table W_GL_BALANCE_F | 58GB | 16GB | 00:01:23.42 | 00:00:00.61 | 137 X |
| A Report Accesses Fact Table W_GL_BALANCE_F and 4 Small Dimension Tables with Many aggregates | 58.6GB | 16GB | 00:02:48.88 | 00:00:09.12 | 18.5 X |
| Count Fact Table W_GL_OTHER_F | 128GB | 17GB | 00:04:42.39 | 00:00:32.55 | 8.7 X |

# Case 2 OLAP Oracle OBI Data Warehouse (ODA)

## Sample test results without performance improvement:

| Test Description | Disk Size | In-Memory Size | Tables NOT In Memory (HH:MM:SS.00) | Tables In Memory (HH:MM:SS.00) | Performance Improvement Factor (Old Timing / New Timing) |
|---|---|---|---|---|---|
| A Report Accesses Fact Table W_GL_OTHER_F and 7 Small Dimension Tables | 128.6GB | 17GB | 00:01:33.04 | 00:01:29.80 | No Significant Change |

## Reasons with no improvement:

- One major table has 128.6 GB and the In-Memory Size is 17GB.
- The In-Memory compression ratio is relatively high.

# Case 2 OLAP Oracle OBI Data Warehouse (Exadata)

Database Evaluation:

- Performance Test Environment
- Database host: Exadata X-3 Quarter Rack
- RAC (2 nodes)
- Host memory: 256GB/node
- 16 cores / node
- DB version 12.1.0.2
- Plan to improve with INMEMORY_SIZE 30GB

# Case 2 Same SQL Performance Comparison Exadata vs ODA

## Exadata X3-2

| Test Description | Disk Size | In-Memory Size | Tables NOT In Memory (HH:MM:SS.00) | Tables In Memory (HH:MM:SS.00) | Performance Improvement Factor |
|---|---|---|---|---|---|
| Count Table W_GL_BALANCE_F | 50.62GB | 13.65GB | 00:00:4.57 | 00:00:01.08 | 4.23 X |
| A Report Accesses Fact Table W_GL_BALANCE_F | 51.2GB | 14GB | 00:00:22.47 | 00:00:07.34 | 3.06 X |
| Count Table W_GL_OTHER_F | 128GB | 13.56GB | 00:00:04.22 | 00:00:01.03 | 4.09 X |
| A Report Accesses Fact Table W_GL_OTHER_F | 128.6GB | 13.60GB | 00:00:05.19 | 00:00:6.80 | No Significant Change |

## ODA X3-2

| Test Description | Disk Size | In-Memory Size | Tables NOT In Memory (HH:MM:SS.00) | Tables In Memory (HH:MM:SS.00) | Performance Improvement Factor |
|---|---|---|---|---|---|
| Count Table W_GL_BALANCE_F | 58GB | 16GB | 00:01:23.42 | 00:00:00.61 | 137 X |
| A Report Accesses Fact Table W_GL_BALANCE_F | 58.6GB | 16GB | 00:02:48.88 | 00:00:09.12 | 18.5 X |
| Count Table W_GL_OTHER_F | 128GB | 17GB | 00:04:42.39 | 00:00:32.55 | 8.7 X |
| A Report Accesses Fact Table W_GL_OTHER_F | 128.6GB | 17GB | 00:01:33.04 | 00:01:29.80 | No Significant Change |

# Case 2 OLAP Oracle OBI Data Warehouse

## Case 2 Summary:

- Promising performance improvement in both ODA and Exadata
- Exadata provides large Flash Cache, Smart Scan, and HCC.
- Recommend to keep the very hot data in In-Memory column store, keep the warm data to Exadata Flash Cache, and compress the cold data with Exadata HCC.
- For either environment, we expect to add more memory for further performance improvement.

# Exciting Future

# Is that all? Can we do more with In-Memory?

**Yes , we can (in 12cR2)!!!**

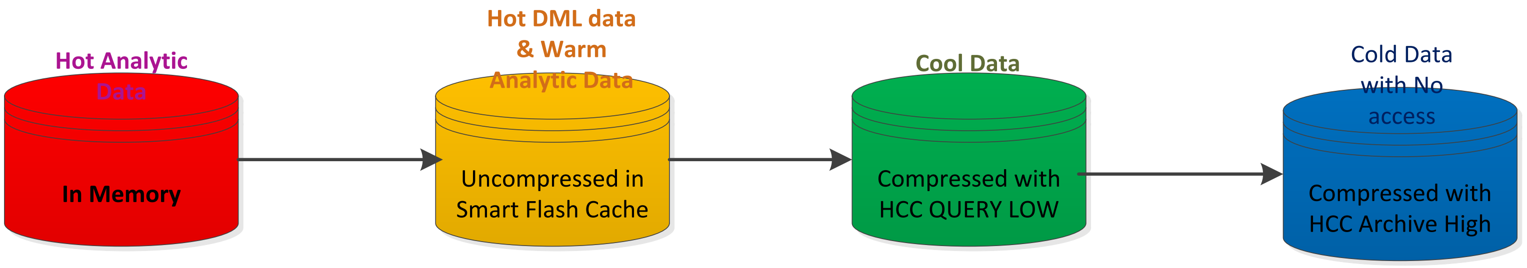
- ILM (Information Lifecycle Management) for automated data policy management for IMCS in Exadata + 12cR2
- IMCS FastStart Area in 12cR2
- IMCS in Oracle Active Data Guard in 12cR2
- Improvements of IMCS for RAC services in 12cR2
- In-Memory Expressions in 12cR2

# ILM for ADO management for IMCS in Exadata + 12cR2

The Oracle Information Lifecycle Management (ILM) has the capability of distinguish between “hot” (frequently accessed) and “cold” (infrequently accessed) data and set policy on tables and segments.

In 12.2, DBAs can set policies to mark an object as a candidate to be populated into In-Memory column store (INMEMORY) and in Exadata additionally in Flash-Cache (CELLMEMORY) to being able to use ADO policies for WARM/COLD data.

This significantly enhance and automate further the lifecycle of your core data within a database.




**Note that to in-memory ADO is only supported at the segment level**

# ILM ADO INMEMORY options

Use *ILM ADD POLICY* syntax with

- SET INMEMORY
- MODIFY INMEMORY
- NO INMEMORY

Alter MEMCOMPRESS for INMEMORY level

- After <time> of no access
- After <time> of creation
- After <time> of no modification
- On <user defined Boolean function>

Examples:

```
ALTER TABLE rx_fill ILM ADD POLICY NO INMEMORY after 3 month of creation;
ALTER TABLE rx_fill ILM MODIFY POLICY NO INMEMORY after 7 days of no access;
ALTER TABLE rx_fill ILM ADD POLICY MEMOCOMPRESS FOR QUERY LOW AFTER 30 days of creation;
ALTER TABLE rx_fill ILM ADD POLICY MEMOCOMPRESS FOR QUERY HIGH AFTER 45 days of no
modification;
```

# Exadata CELLMEMORY option

CELLMEMORY works similar to a 12.1.0.2 columnar cache but when used with INMEMORY on Exadata is enabled by default to extend columnar cache format.

You can overwrite (enable,disable, change compression level) default and use CELLMEMORY feature on tables, partitions, sub partitions, and materialized views.

The MEMCOMPRESS clause supports FOR [QUERY|CAPACITY] [LOW| HIGH].

```
ALTER TABLE member CELLMEMORY;
ALTER TABLE member NO CELLMEMORY;
ALTER TABLE sales PARTITION Q1_2017 CELLMEMORY MEMCOMPRESS FOR QUERY LOW;
```

Note that this feature requires the 12.2 release of Exadata Storage Server software, but works with the 12.1 release of the database. Use of the 12.2 release of the database enables additional performance optimizations for offloaded CELLMEMORY scan processing.

# *In-Memory FastStart Area in 12cR2*

A FastStart area is a designated tablespace where IM FastStart stores and manages data for INMEMORY objects.

Tablespace should be 2x size of INMEMORY_SIZE area

Oracle Database manages the FastStart tablespace without DBA intervention.

It can relieve the CPU overhead of population at the cost of additional disk space.

- In-memory Fast Start syntax:

```
exec DBMS_INMEMORY_ADMIN.FASTSTART_ENABLE('<fstart_tbs_name>');
```

- To check the size/status of Fast Start tablespace usage use view

V$INMEMORY_FASTSTART_AREA

Note: the actual FastStart IM data is written in LOB segment in that tablespace.

# In-Memory in Oracle Active Data Guard in 12cR2

In 12cR2 you now have option to enable IM column store on the standby Active Dataguard database (commonly a lot of applications usually take advantage of Active Dataguard for reporting purposes), or on both the primary and standby databases.

There are three configuration options to consider:

- Identical column stores in both primary and standby databases
- Column store in just the standby database
- Different column store configurations between the primary and standby databases

Those configurations are managed by the combination of 3 settings:

- INMEMORY_SIZE (primary, standby)
- INMEMORY_ADG_ENABLED is set to true on the standby instance (if needed)
- The INMEMORY with additional DISTRIBUTE FOR SERVICE clauses for IN-MEMORY objects designated for the standby role services

# *Improvements of In-Memory for RAC services in 12cR2*

In Oracle 12c R2 it become much easier to selectively populate objects to specific IM column stores in a RAC environment by taking advantage of the new DISTRIBUTE FOR SERVICE subclause when defining INMEMORY option.

This is a secondary use of that sub-clause after INMEMORY on Active Dataguard.

- Example:

*srvctl add service -db db1 -service rx_srv –preferred “inst1”*
*srvctl add service -db db1 -service catalog_srv -r preferred “inst2”*

```
ALTER TABLE rx_fill INMEMORY PRIORITY MEDIUM DISTRIBUTE FOR SERVICE rx_srv;

ALTER TABLE drugs INMEMORY PRIORITY HIGH DISTRIBUTE FOR SERVICE catalog_srv;
```

# In-Memory Join Groups in 12cR2

With Oracle Database 12.2., it is possible to declare that two tables will be joined on a set of columns using a new DDL construct known as a *Join Group*.

This enables join processing optimizations based on updated common dictionary so that joins can be performed on compact dictionary codes instead of on values.

Note that IM segments need to be re-populated after creation of Join Groups.

- Examples:

```
CREATE INMEMORY JOIN GROUP rx_fill_jg1(rx_fill(patient_id),member(patient_id));

CREATE INMEMORY JOIN GROUP rx_fill_jg2(rx_fill(drug_id),drug(drug_id));

CREATE INMEMORY JOIN GROUP rx_fill_jg3(rx_fill(rx_id),invoice(rx_id));
```

You can query USER_JOINGROUPS view to see Join Group definitions.

In order to determine if Join Group(s) are actually in use you need to check a SQL Monitor Active Report and click on the “eye glasses” icon for hash joins and check that "Columnar Encodings Leveraged" is showing value “1”.

# In-Memory Expressions in 12cR2

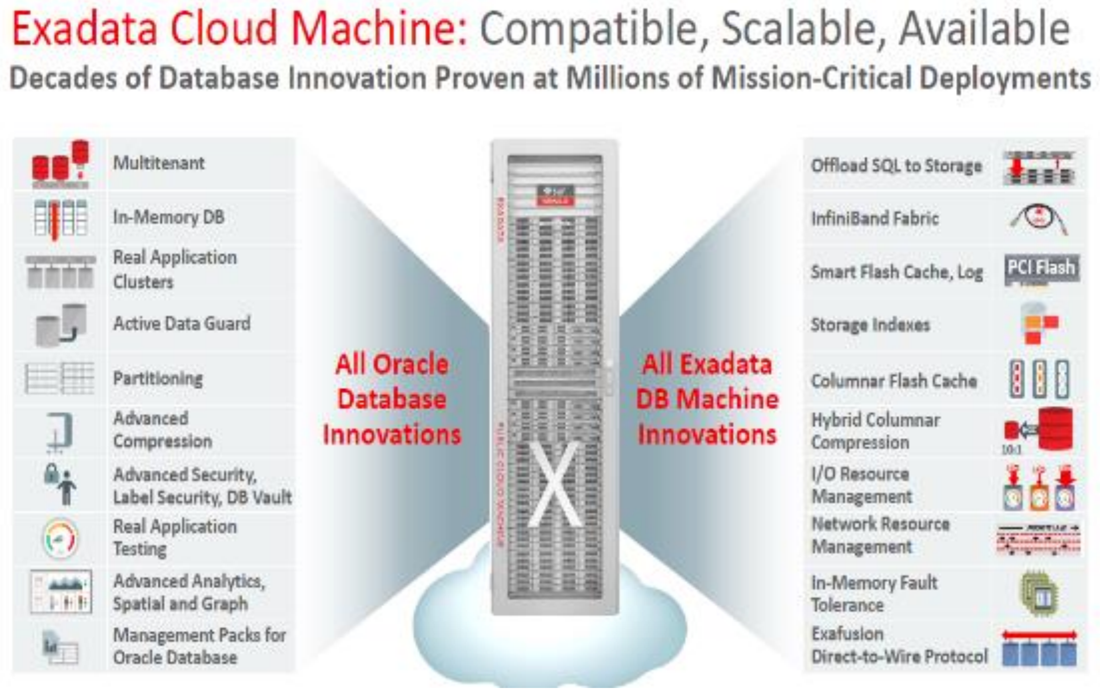
In-Memory Expressions give ability to materialize simple expressions and store them in the In-Memory column store so that they only have to be calculated once.

They are treated like any other column in the IM column store so the database can scan and filter those columns and take advantage of all Database In-Memory query optimizations

There are two types of IM expressions:

- user-defined In-Memory virtual column
- automatically detected IM expressions created by Expressions Statistics Store (ESS) which monitors workloads and store it as a hidden virtual column when captured :
  - DBMS_INMEMORY.IME_CAPTURE to capture the repeating expressions
  - DBMS_INMEMORY.IME_POPULATE to create the in-memory virtual columns.

# Walgreens roadmap to use In-Memory features



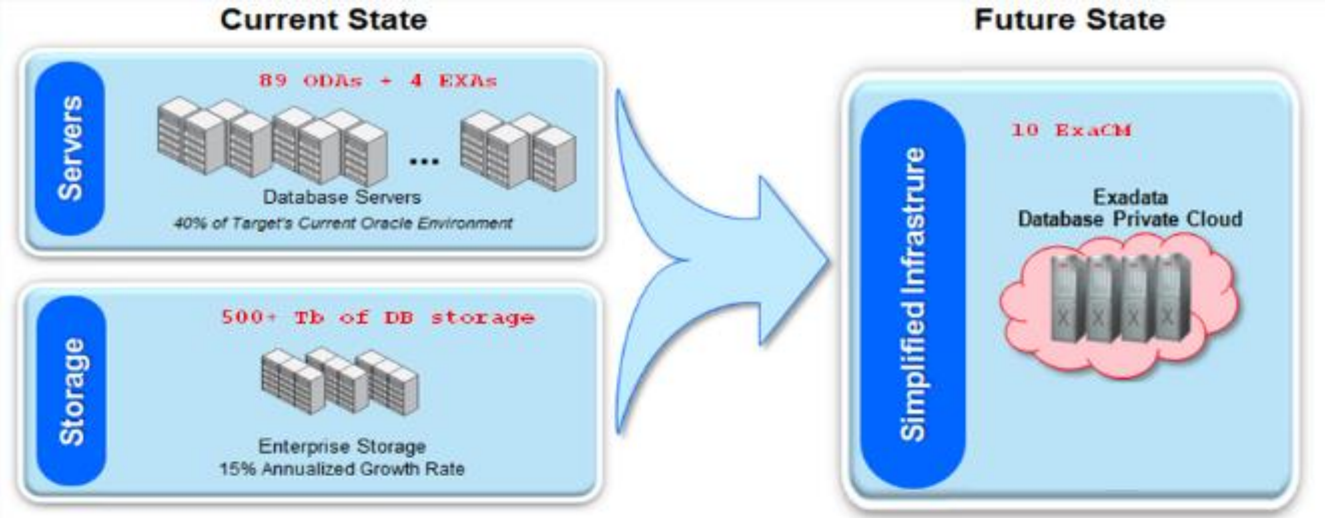

**Consolidation of Oracle DBs on Exadata Cloud Machine:**

**Taking advantage of Large Memory (720 Gb per node)**

**Taking advantage of all DB options included (in-Memory, Multitenant, Active Data Guard)**

**Taking advantage of fast storage and HCC compression options**

# Oracle DB consolidation on Exadata Cloud Machine platform




- Significantly higher DB Consolidation Density and Datacenter Footprint (Multiple VMs with multi-tenant DB consolidation per network zone/environment/business unit)
- 3x reduction in overall power usage (14.5 kVA vs 44.8 kVA)
- Spare on-demand capacity to migrate remaining ODA/Exadatas in the future or provision DBs for new applications almost instantaneously.

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- Special Thanks to senior DBA Raghav Kalakota for setting up the POC environment in ODA.

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# Questions