ORACLE

Oracle Database In-Memory

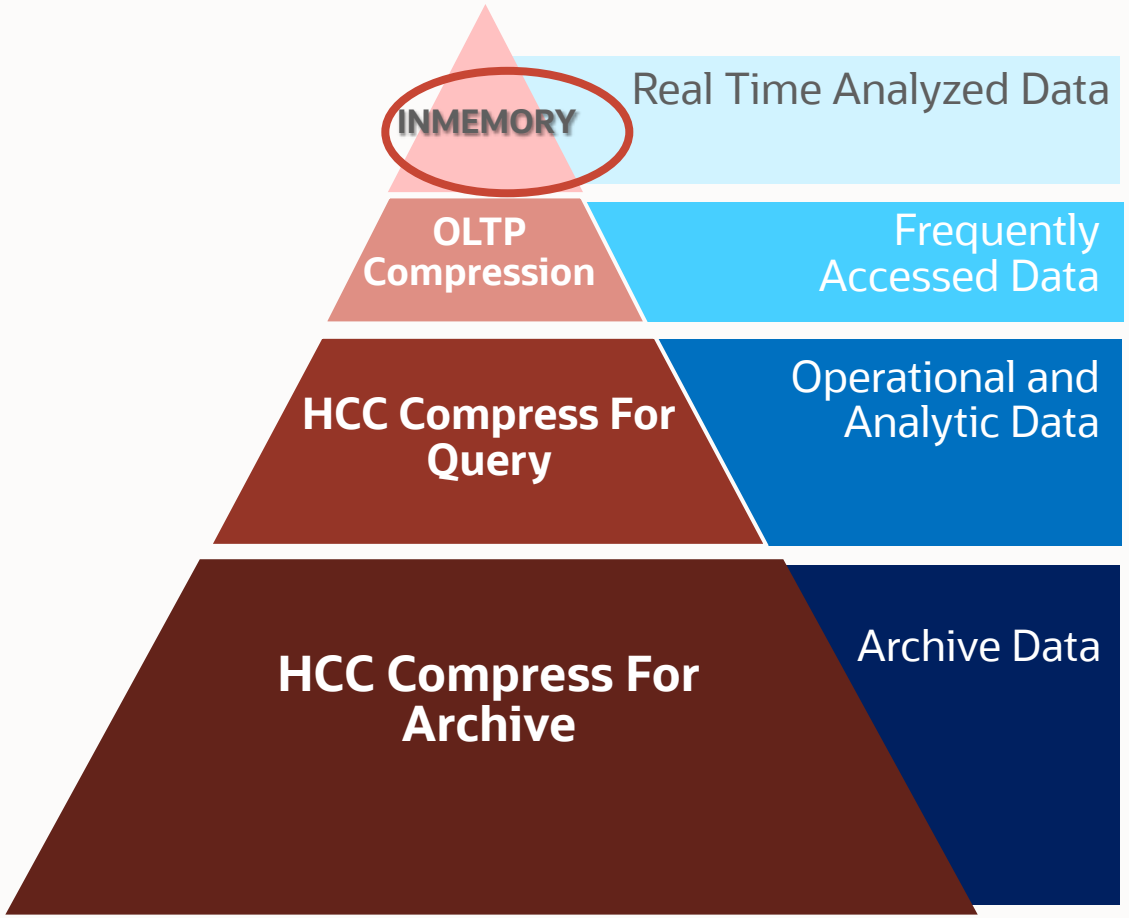
AskTOM Office Hours – Heat Map – June 22, 2022

Andy Rivenes
Database In-Memory Product Manager
Twitter: @TheInMemoryGuy
Email: andy.rivenes@oracle.com

Gregg Christman
Advanced Compression Product Manager
Twitter: @aco_gregg
Email: gregg.christman@oracle.com

Motivation

Automatic Data Optimization with Advanced Compression and Database In-Memory



- **12.1.0.2:** ADO manages compression and storage tiering as part of the Advanced Compression option.
- **12.2+:** IM column store is managed automatically as a new data tier
  - Heat map tracks data access frequency
  - Policies can be defined to
    - Bring data into the IM column store
    - Increase compression levels as data cools
    - Evict cold data from IM column store

Heat Map Details

Heat Map

Usage Tracking

- "Heat Map" tracking
  - Query and modification times tracked by segment
  - Modification times tracked for database blocks
- Comprehensive
  - Distinguishes index lookups from full table scans
  - Automatically excludes maintenance tasks:
    - Stats, DDLs, backups, table redefinitions, etc.
- High Performance
  - Object level at no cost
  - Block level << 5% cost

Enable Heat Map

- Initialization parameter => heat_map = on
- Best effort
- Flushed once a day during maintenance window, but visible in real time
- Tracks segment activity
  - Full table scan
  - Table access
  - Table writes
  - Frequency numbers (Full scan, lookup scan, segment writes)

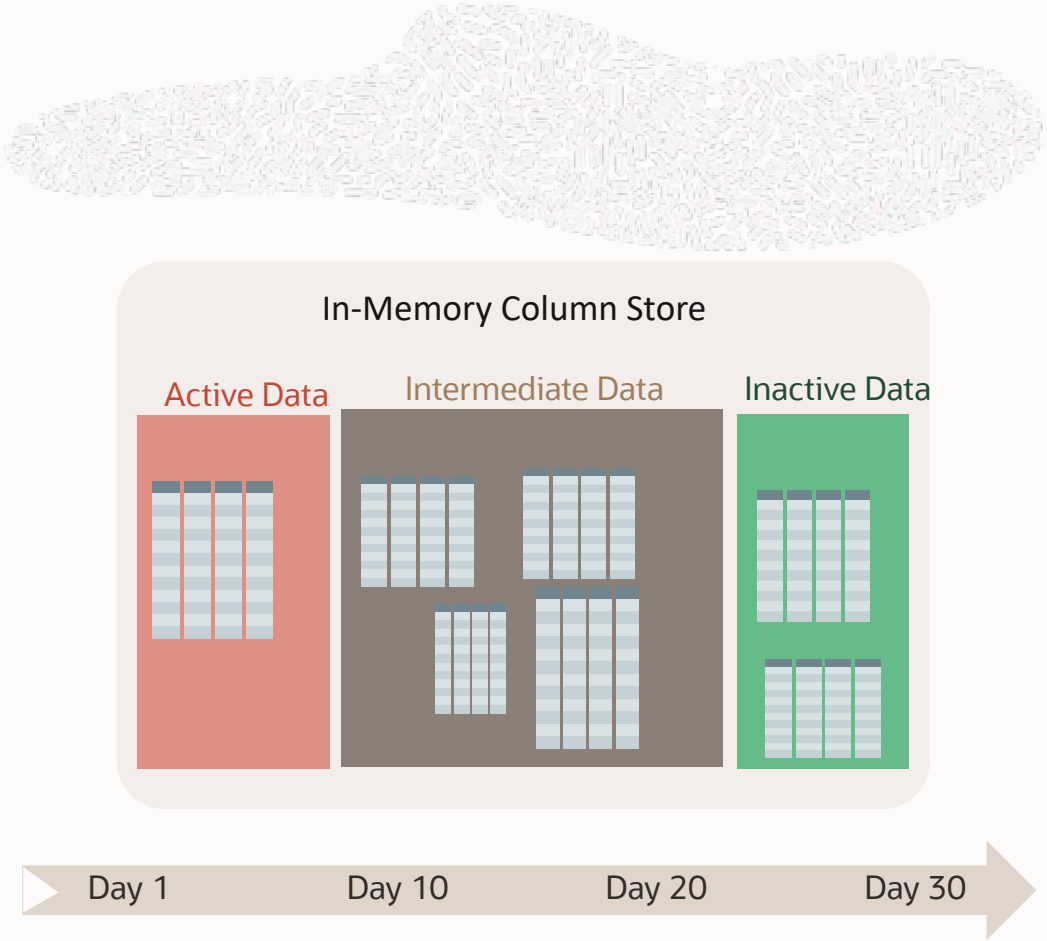
Heat Map

Data Tracking

- Heat Map data is tracked/captured in-memory and persisted to disk on a best effort basis
- Heat Map segment level data is automatically flushed to disk once a day (default)
- Accessing Heat Map data through the various views unions the current segment level data in-memory and on disk
- Heat Map session level data is flushed to segment level memory at **session exit** or every 10 minutes
- Heat Map segment level data can be flushed from memory to disk with:
  - dbms_ilm.flush_all_segments

Heat Map – AIM

- AIM evaluates Heat Map data through a day based window
- This is useful when the application has skewed data access
  - Example: Weekly processing heavily accesses a small number of objects
- Set with:
  DBMS_INMEMORY_ADMIN.AIM_SET_STATWINDOW
- Get with:
  DBMS_INMEMORY_ADMIN.AIM_GET_STATWINDOW



Heat Map Views

- Heat Map based views – NOT USED BY AIM, but can still be useful
  - DBA_HEAT_MAP_SEGMENT (requires heat_map = on)
    - Displays one line summary per object with timestamp information (no counts)
  - _SYS_HEAT_MAP_SEG_HISTOGRAM (requires heat_map = on)
    - Displays daily object history with count information
  - V$HEAT_MAP_SEGMENT
    - Includes counts
- AIM Segment Usage Tracking
  - _SYS_AIM_SEG_HISTOGRAM (requires inmemory_size > 0)
    - Displays AIM eligible object history

Heat Map Packages

- DBMS_HEAT_MAP (requires heat_map = on)
  - Displays one line summary per object with timestamp information
- DBMS_ILM
  - Various flush procedures, for example: FLUSH_ALL_SEGMENTS
- Managing usage statistics
  - DBMS_ILM_ADMIN.clear_heat_map_all
  - DBMS_ILM_ADMIN.clear_heat_map_table

Custom Uses for Heat Map

- Once enabled, Heat Map has great potential for identifying active and dormant objects

```
select OWNER, OBJECT_NAME, SUBOBJECT_NAME,
      to_char(TRACK_TIME,'MM/DD/YYYY HH24:MI') track_time,
      SEGMENT_WRITE, SEGMENT_READ, FULL_SCAN, LOOKUP_SCAN,
      N_FTS, N_LOOKUP, N_WRITE
from sys."_SYS_HEAT_MAP_SEG_HISTOGRAM" h, dba_objects o
where o.object_id = h.obj# and o.owner = 'SSB' and track_time >= sysdate-1
order by track_time, OWNER, OBJECT_NAME, SUBOBJECT_NAME;
```

SEG OWNER	SEG OBJECT_NAME	SUBOBJECT_NAME	TRACK_TIME	WRITE	READ	FULL SCAN	LOOKUP SCAN	NUM FULL SCAN	NUM LOOKUP SCAN	NUM SEG WRITE
SSB	LINEORDER	PART_1995	06/21/2022 11:18	NO	NO	YES	NO	1	0	0
SSB	LINEORDER	PART_1996	06/21/2022 11:18	NO	NO	YES	NO	1	0	0
SSB	LINEORDER	PART_1997	06/21/2022 11:18	NO	NO	YES	NO	1	0	0
SSB	LINEORDER	PART_1998	06/21/2022 11:18	NO	NO	YES	NO	1	0	0
SSB	LINEORDER	PART_1995	06/21/2022 11:21	NO	YES	YES	NO	4	0	0
SSB	LINEORDER	PART_1996	06/21/2022 11:21	NO	YES	YES	NO	9	0	0
SSB	LINEORDER	PART_1997	06/21/2022 11:21	NO	YES	YES	NO	14	0	0
SSB	LINEORDER	PART_1998	06/21/2022 11:21	NO	YES	YES	NO	19	0	0

AIM Usage Statistics

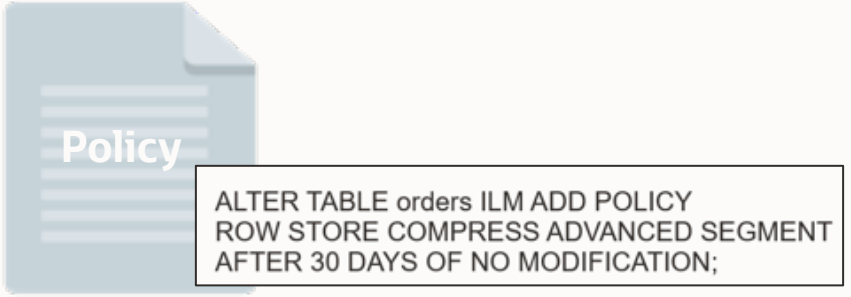
```
SQL> select o.owner, o.object_name, TRUNC(a.track_time) as track_time,
  2    a.full_scan, SUM(a.n_fts) as n_fts
  3  from dba_objects o, sys."_SYS_AIM_SEG_HISTOGRAM" a
  4  where o.object_id = a.obj#
  5  group by o.owner, o.object_name, TRUNC(a.track_time), a.full_scan
  6  order by TRUNC(a.track_time), SUM(a.n_fts);
```

OWNER	OBJECT_NAME	TRACK_TIM	FUL	N_FTS
AIM	LRGTAB1	26-APR-21	YES	1
AIM	LRGTAB2	26-APR-21	YES	1
AIM	LRGTAB3	26-APR-21	YES	51
SSB	LINEORDER	27-APR-21	YES	2
AIM	SMTAB1	27-APR-21	YES	20
AIM	MEDTAB2	27-APR-21	YES	30
AIM	MEDTAB1	27-APR-21	YES	53
AIM	LRGTAB1	27-APR-21	YES	68

Note: You have to reconnect session to see updated statistics

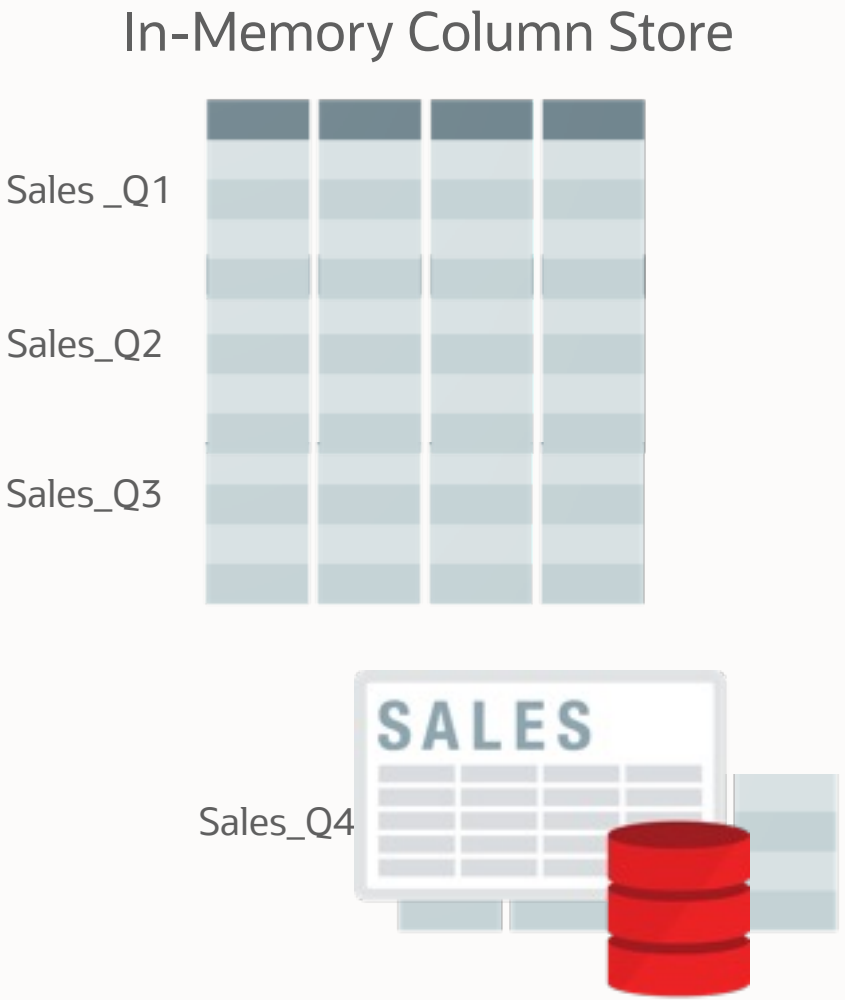
Where Does Heat Map Get Used?

Automatic Data Optimization (ADO) in 12.1



- PL/SQL scripting language
- Allows organizations to create compression tiering and/or storage tiering ADO policies
- ADO policies specify *what* conditions (of data/index access) will initiate an ADO operation – such as ***no access***, or ***no modification***, or ***creation time*** – and *when* the policy will take effect
- All operations are executed automatically in the background -- no user intervention or application changes required
- Requires Advanced Compression

Automatic Data Optimization in 12.2+



- Automatic Data Optimization extended to In-Memory
- In-Memory policies allow optimal use of column store based on heatmap
  - Requires only inmemory option, not advanced compression
- Policies can be defined to:
  - Bring data into the IM column store
  - Increase compression levels as data cools
  - Evict cold data from IM column store

Automatic Index Optimization

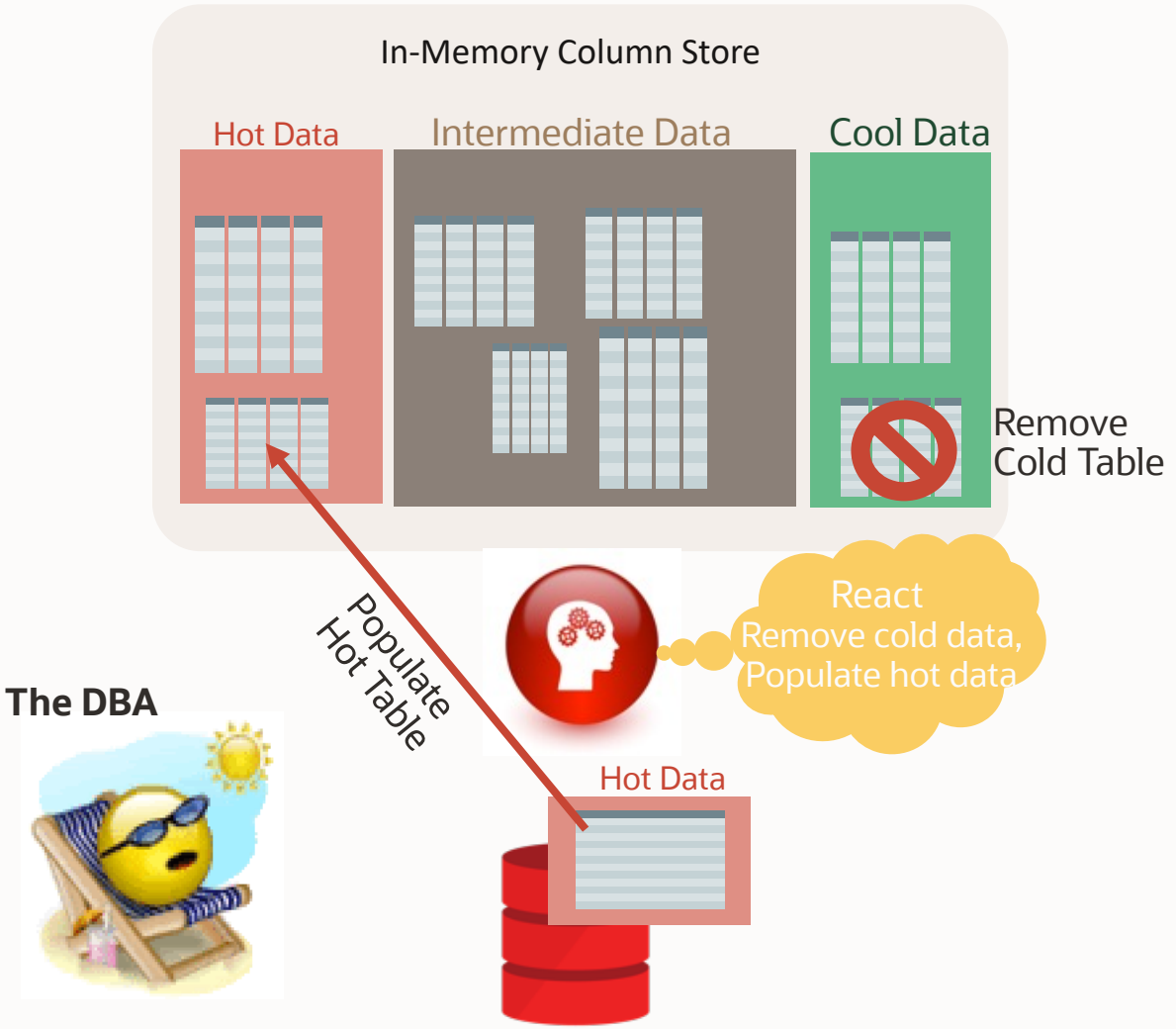
Data Lifecycle Management

- **Compression and optimization for indexes** using existing Automatic Data Optimization (ADO) framework
  - Existing Heat Map capability collects activity statistics on the index
  - Database automatically chooses best way to “optimize” index
- **Index optimizations include:**
  - **Compress:** Compresses portions of the key values in an index segment. (3x compression ratio typical)
  - **Coalesce:** Merges the contents of index blocks where possible to free blocks for reuse
  - **Rebuild:** Rebuilds index to improve space usage and access speed
- **Automates movement of indexes** to tier 2 storage when tier 1 storage under space pressure

Example

```
ALTER INDEX orders_idx ILM ADD POLICY
OPTIMIZE AFTER 3 DAYS OF NO MODIFICATION;
```

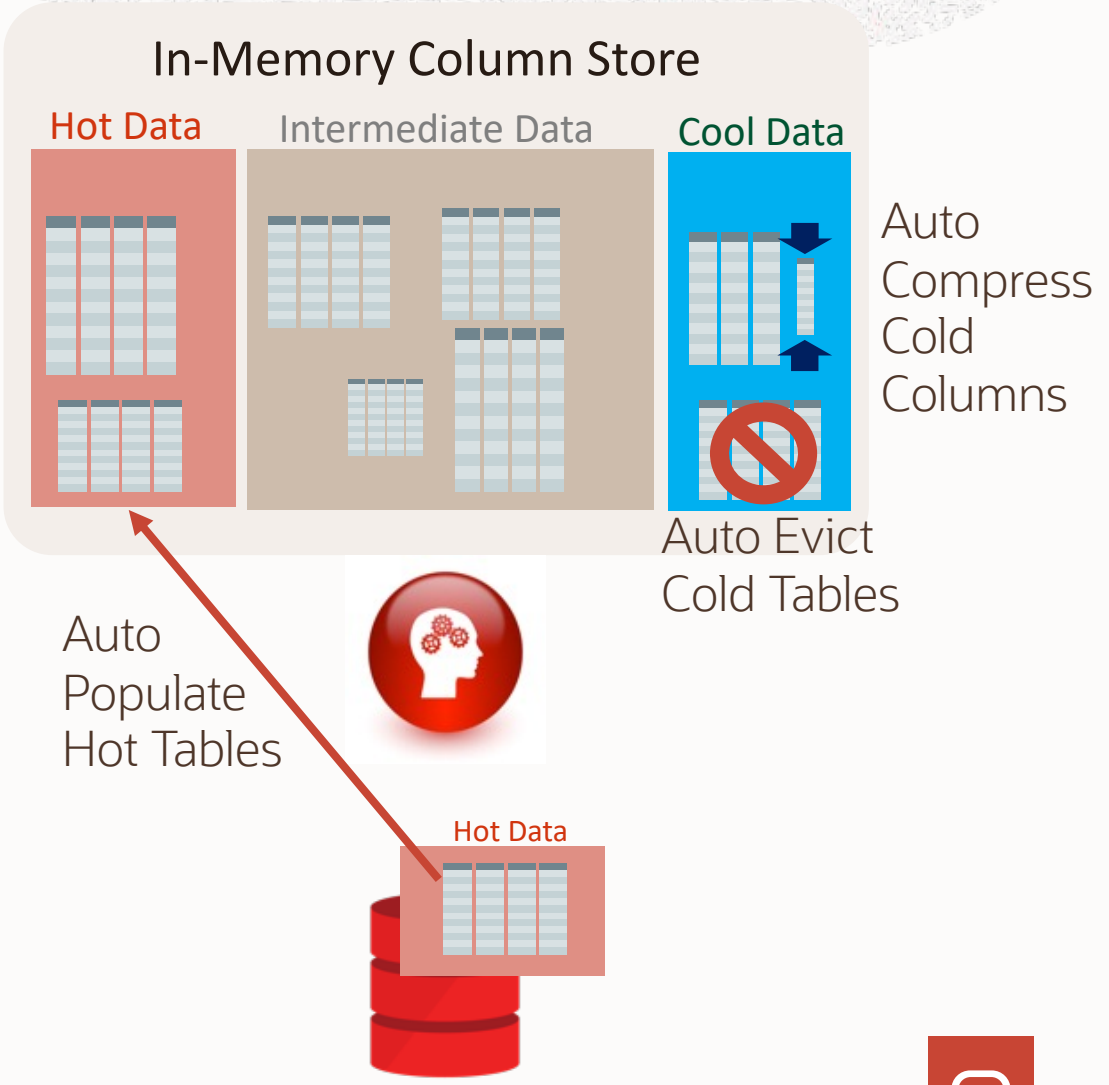
Automatic In-Memory



- Introduced in 18c
- Helps eliminate trial and error regarding in-memory area contents
- Constant background action:
  - Classifies data as hot, intermediate or cold
  - Hotter in-memory tables automatically populated
  - Colder in-memory tables automatically removed
  - Intelligent algorithm takes into account space-benefit tradeoffs
- Controlled by new parameter **inmemory_automatic_level**

AIM: Self-Managing In-Memory

- New Automatic In-Memory (AIM) option
  - inmemory_automatic_level = **HIGH**
- AIM enables a self-managing in-memory column store
  - No need to mark tables INMEMORY
- Automatically manages objects
  - Intelligent population and eviction without user input
  - Automatically compresses less frequently accessed in-memory columns



Where Can You Get More Information?

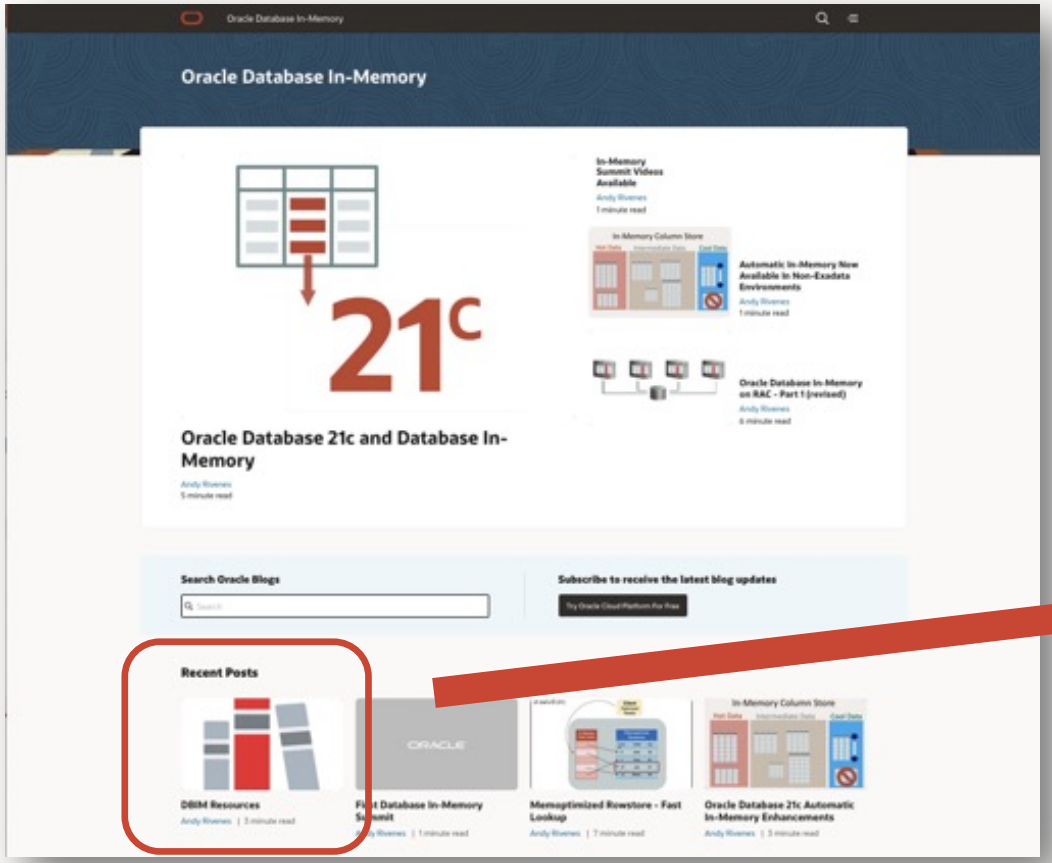
More Information

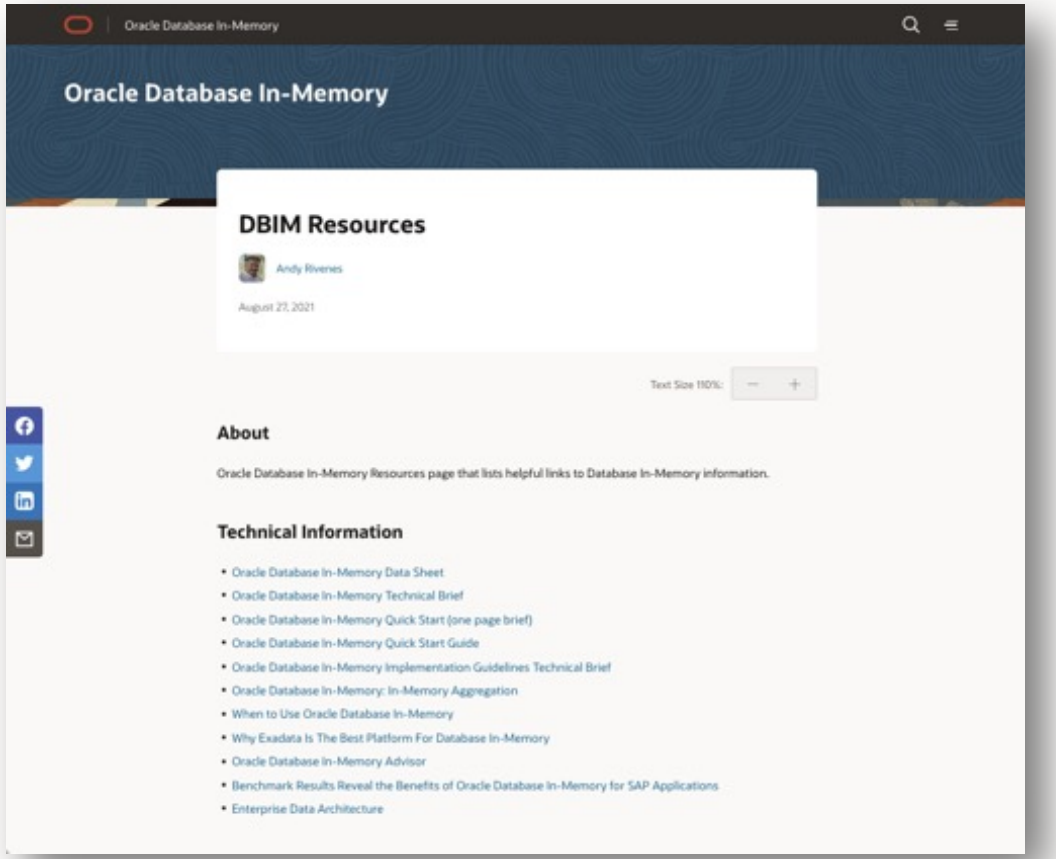
- VLDB and Partitioning Guide
  - 5 – Managing and Maintaining Time-Based Information
- Database In-Memory Guide
  - 5.2 Configuring Automatic In-Memory (18c doc)
  - 6.2 Configuring Automatic In-Memory (19c doc)
  - 4.2 Configuring Automatic In-Memory (21c doc)
- Database Reference
  - Initialization Parameters
  - Static Data Dictionary Views
- PL/SQL Packages and Types Reference
  - DBMS_ILM_ADMIN
  - DBMS_ILM
  - DBMS_HEAT_MAP

More Information

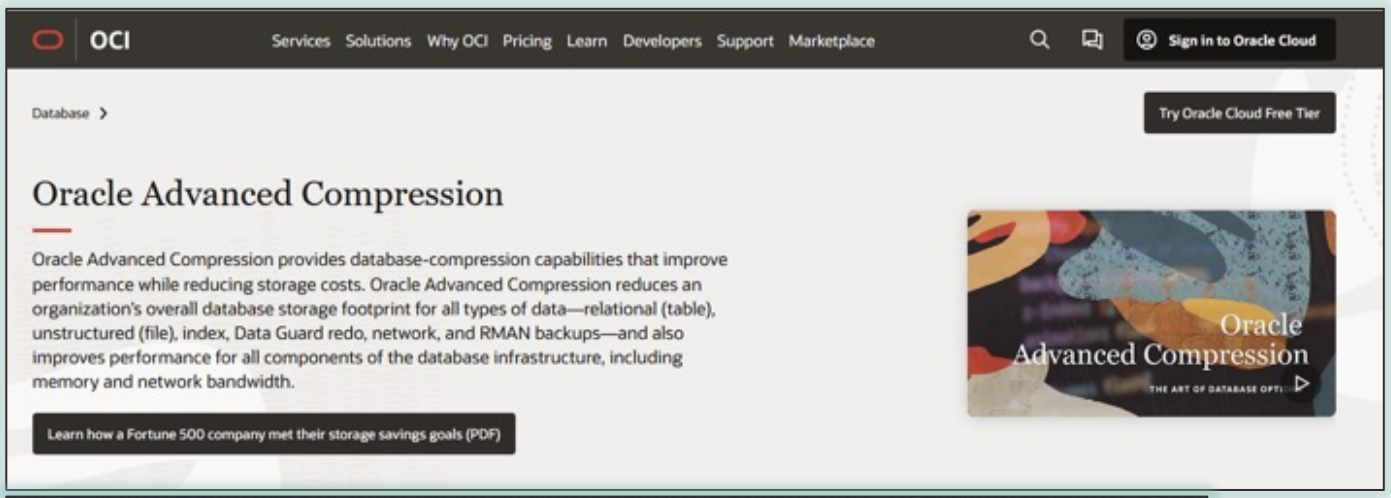
- Previous Ask TOM Office Hours Sessions
  - Automatic In-Memory – July 24, 2019
  - Automatic Data Optimization – May 29, 2019

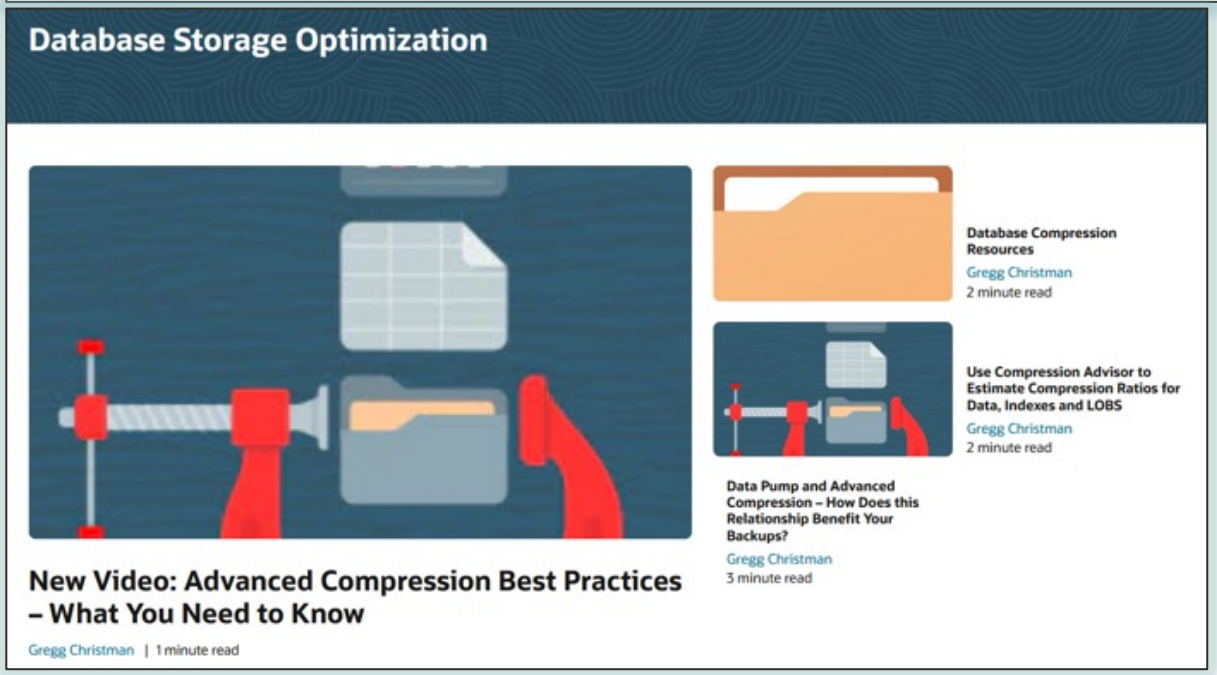
https://blogs.oracle.com/in-memory/dbim-resources





Advanced Compression Resources





Join the Conversation

- https://twitter.com/aco_gregg
- https://blogs.oracle.com/dbstorage/
- https://www.oracle.com/database/advanced-compression/