



# Oracle Database In-Memory

AskTOM Office Hours – Heat Map – June 22, 2022

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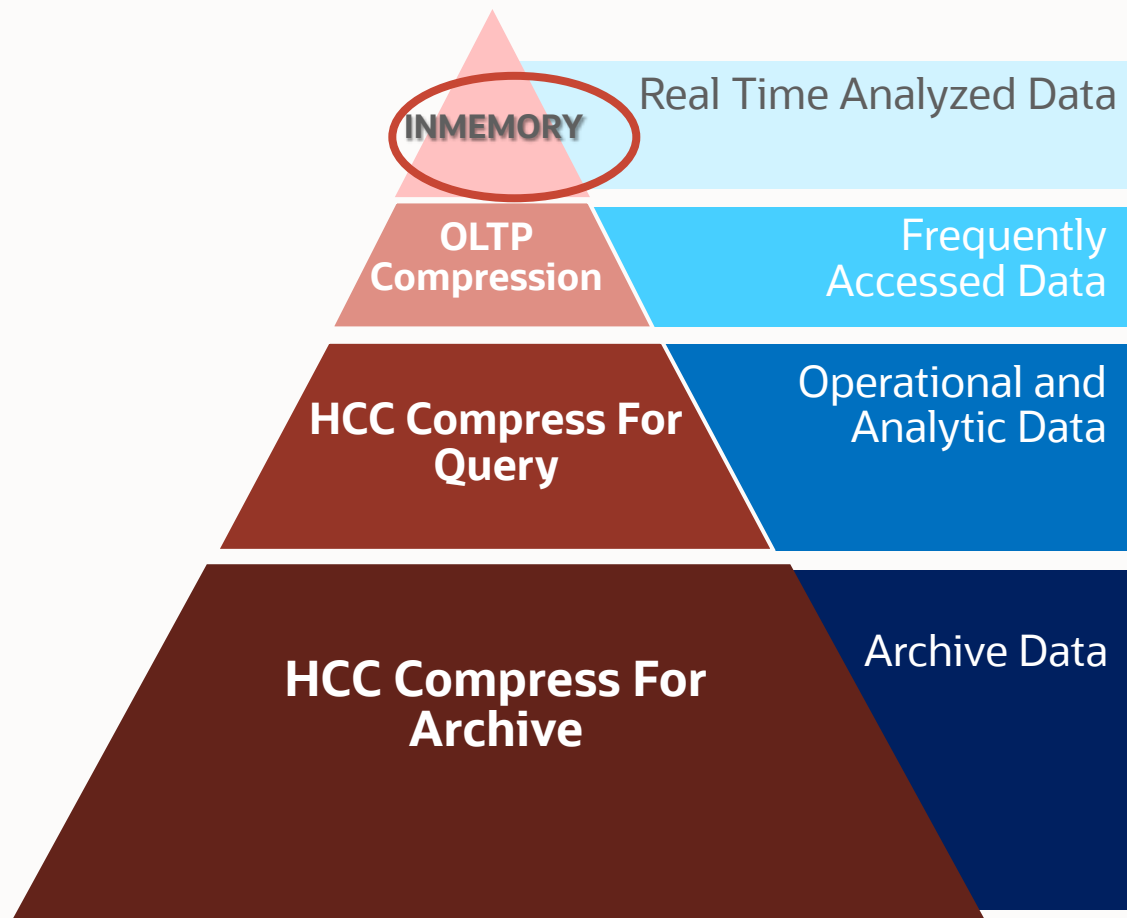
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# Motivation

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# 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

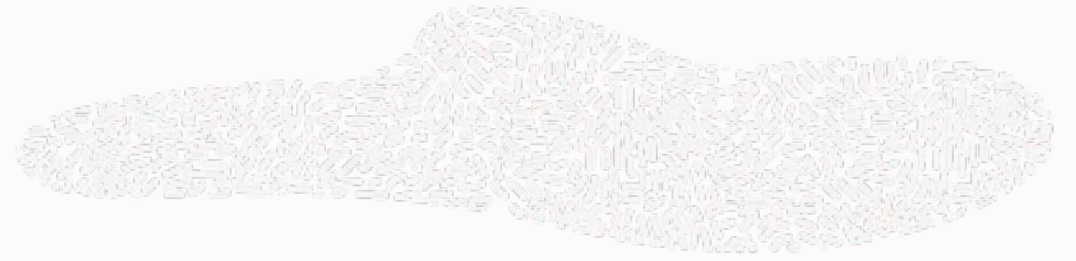


# Heat Map Details

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# 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

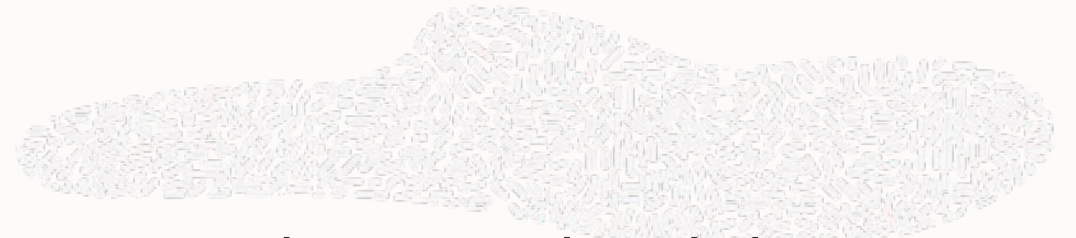


- Initialization parameter => `heat_map = on`
- Best effort
- Flushed once a day during maintenance window, but visible in real time
- Tracks segment activity
  - Full table scan
  - Table access
  - Table writes
  - Frequency numbers (Full scan, lookup scan, segment writes)



# Heat Map

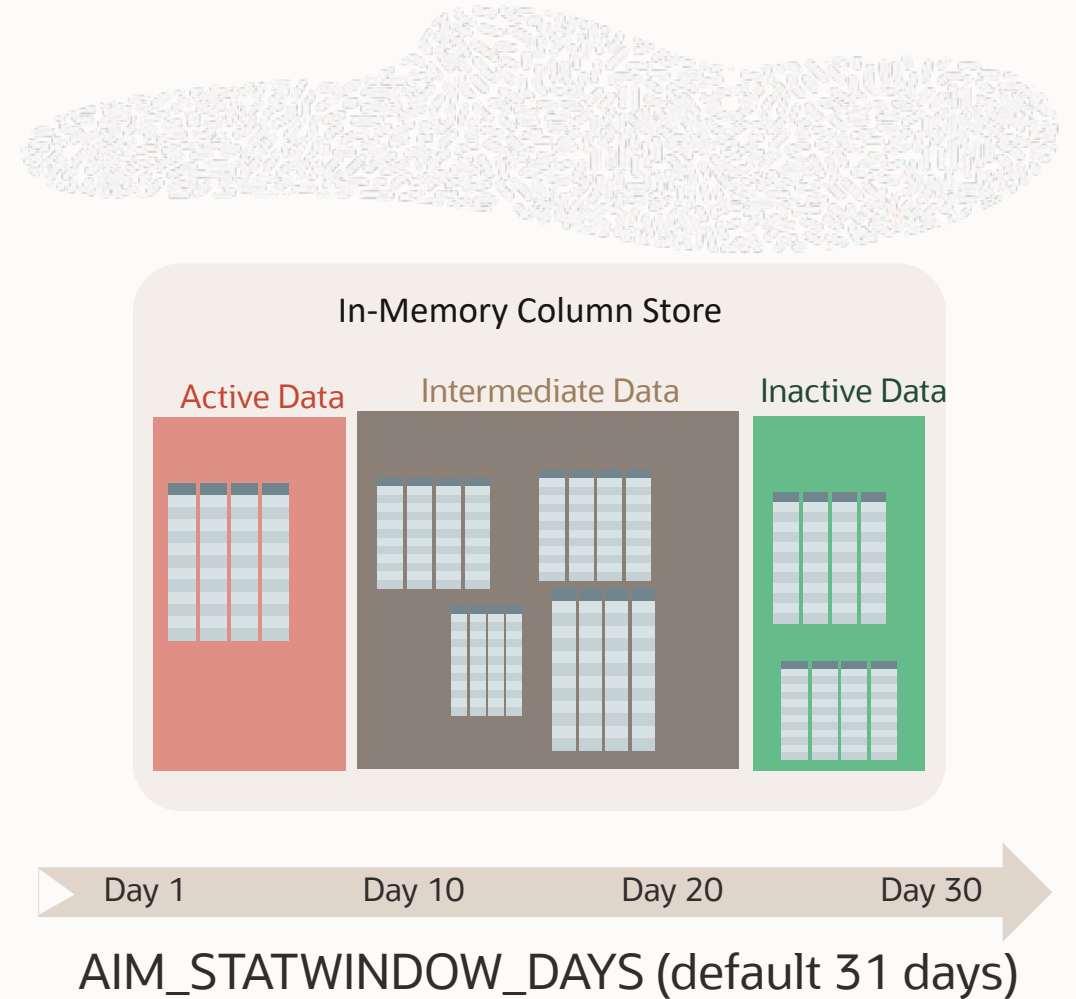
## Data Tracking



- 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`

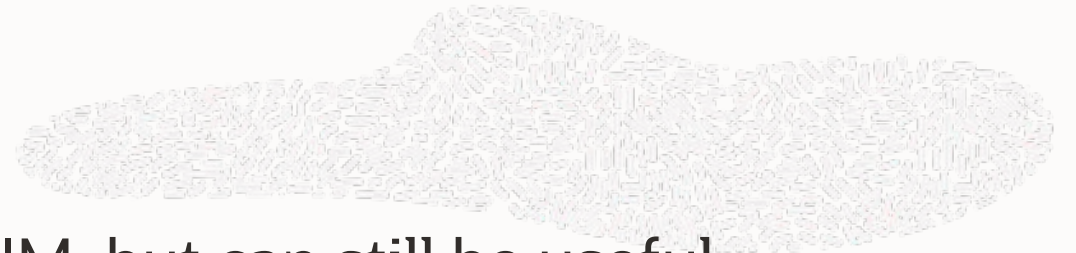
# Heat Map – AIM

- 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`



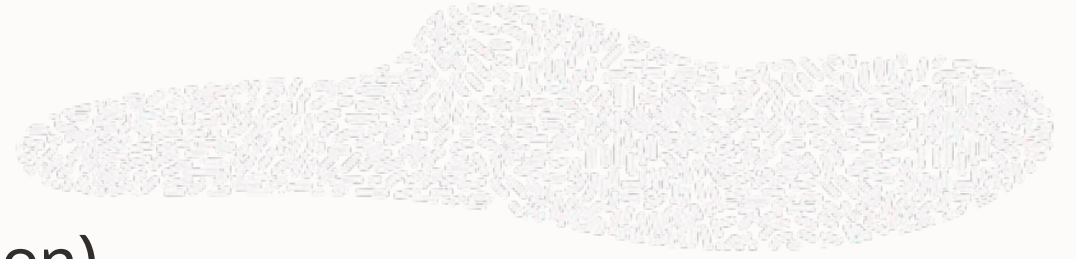


# Heat Map Views



- 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?

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# Automatic Data Optimization (ADO) in 12.1



## Policy

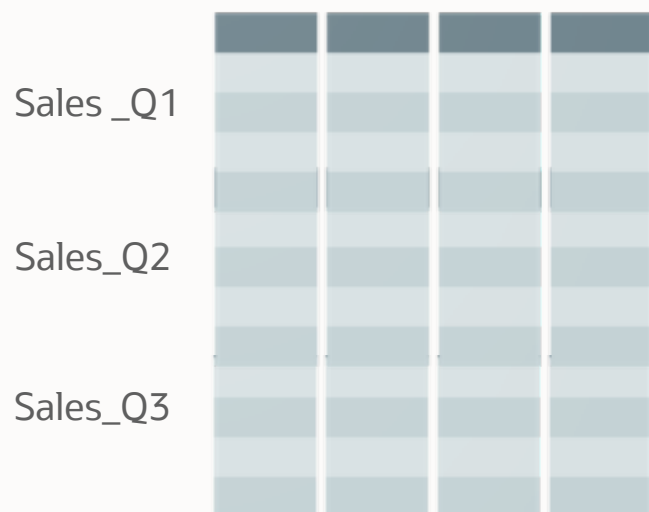
```
ALTER TABLE orders ILM ADD POLICY  
ROW STORE COMPRESS ADVANCED SEGMENT  
AFTER 30 DAYS OF NO MODIFICATION;
```

- 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+



In-Memory Column Store



- 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

21<sup>c</sup>

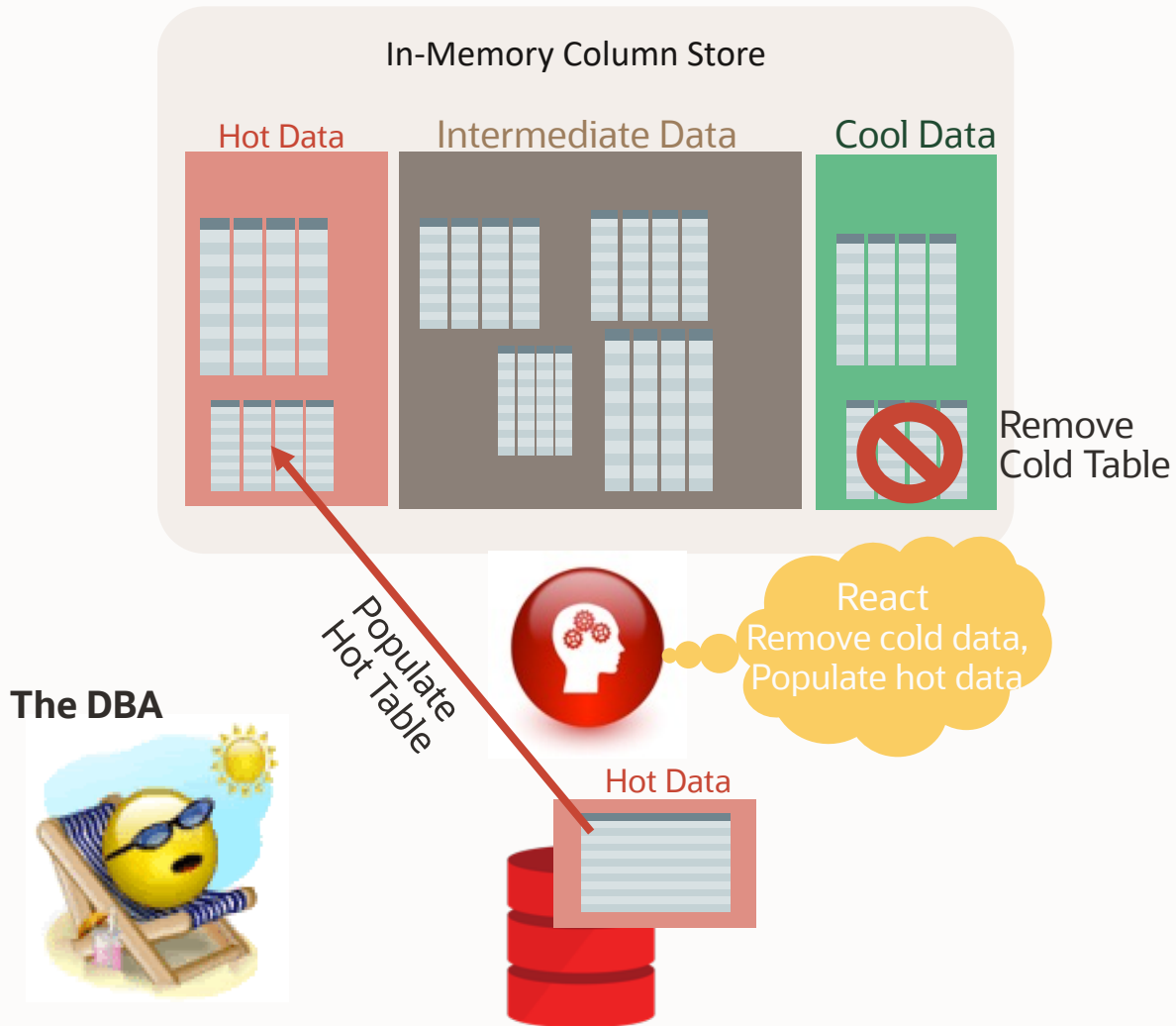
- **Compression and optimization for indexes** using existing Automatic Data Optimization (ADO) framework
  - Existing Heat Map capability collects activity statistics on the index
  - Database automatically chooses best way to “optimize” index
- **Index optimizations include:**
  - **Compress:** Compresses 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

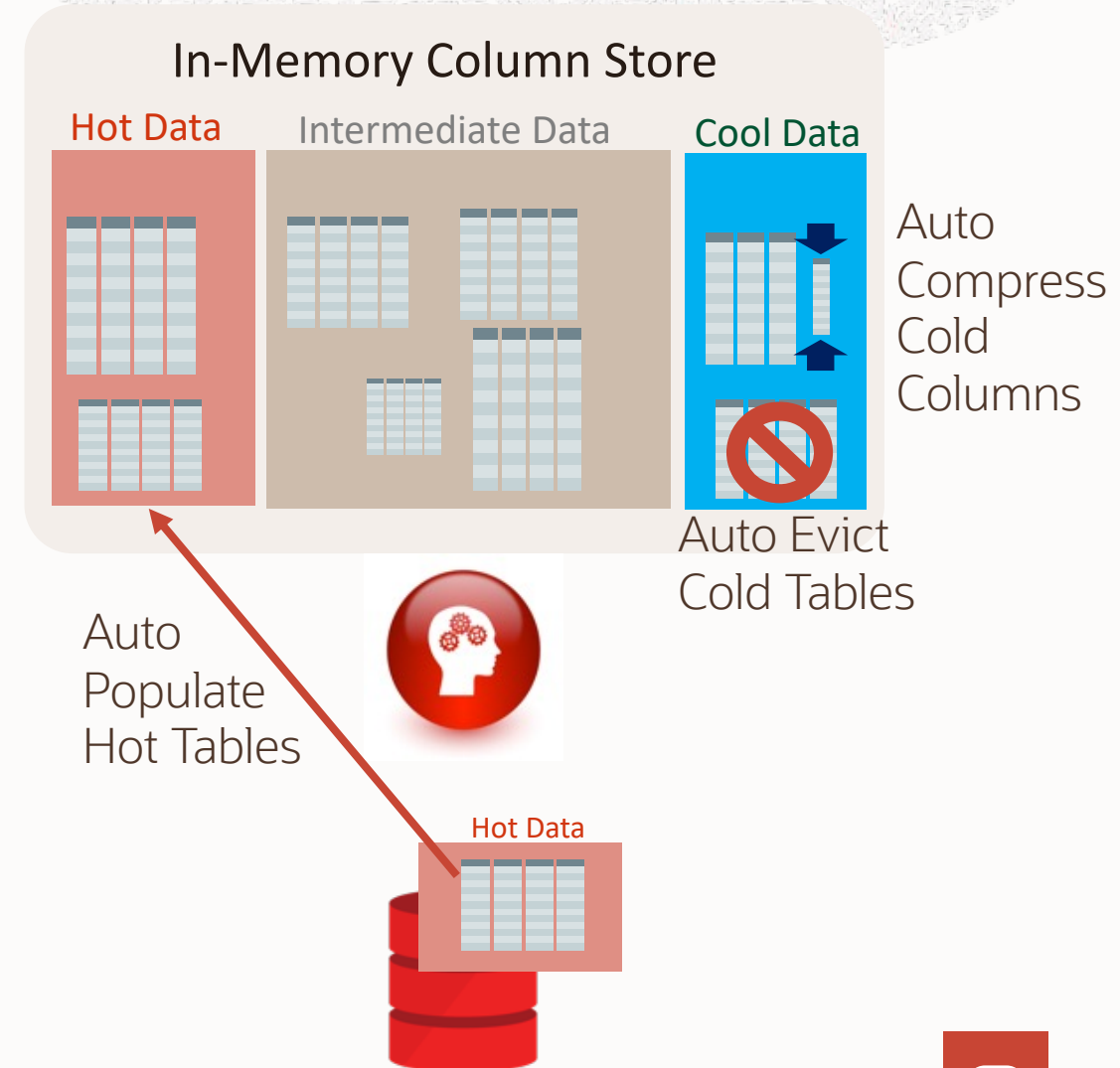


- Introduced in 18c
- Helps eliminate trial and error regarding in-memory area contents
- Constant background action:
  - Classifies data as hot, intermediate or cold
  - Hotter in-memory tables automatically populated
  - Colder in-memory tables automatically removed
  - Intelligent algorithm takes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

# AIM: Self-Managing In-Memory

21<sup>c</sup>

- 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?

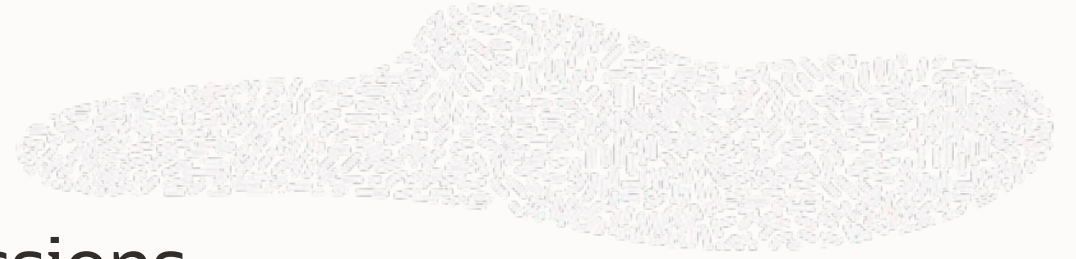
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# More Information

- 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

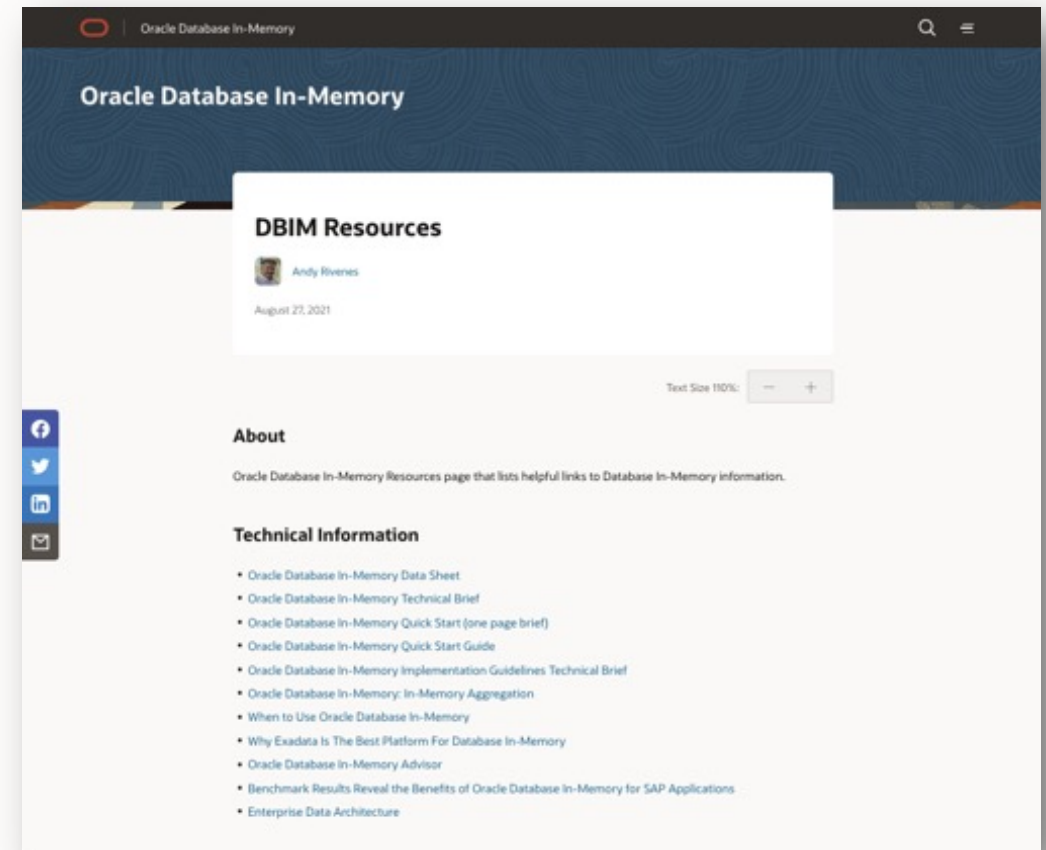
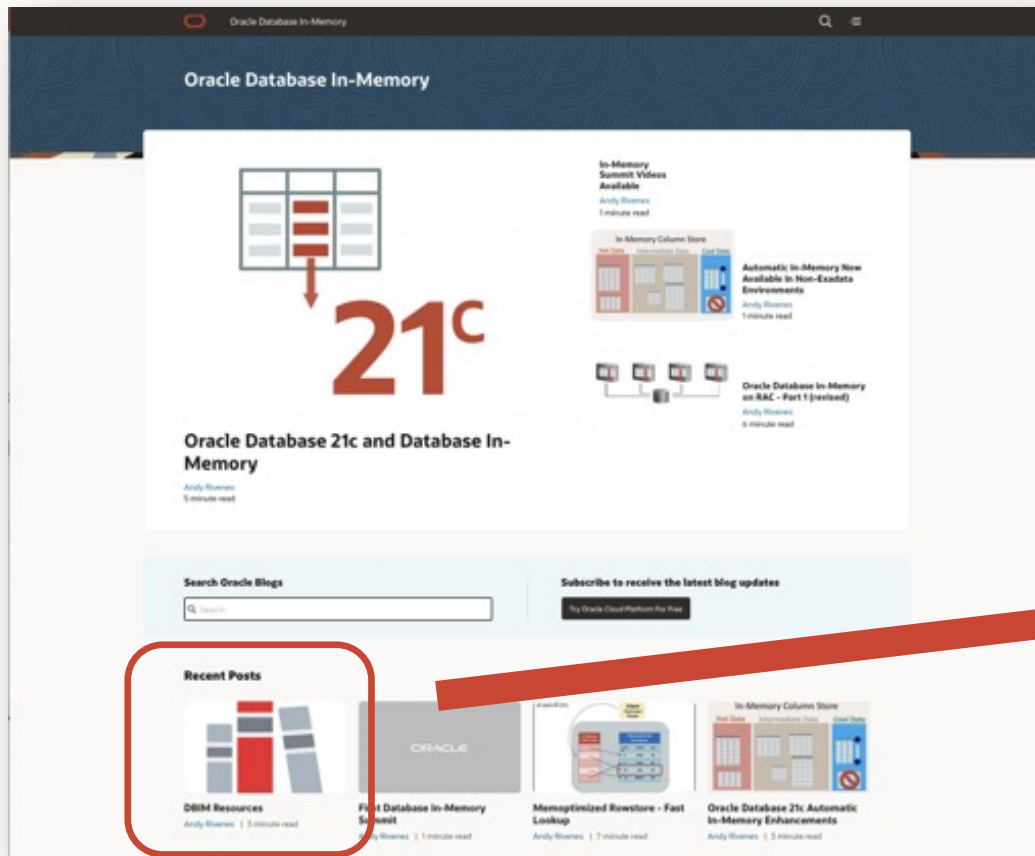


# More Information






- Previous [Ask TOM Office Hours](#) Sessions
  - [Automatic In-Memory – July 24, 2019](#)
  - [Automatic Data Optimization – May 29, 2019](#)

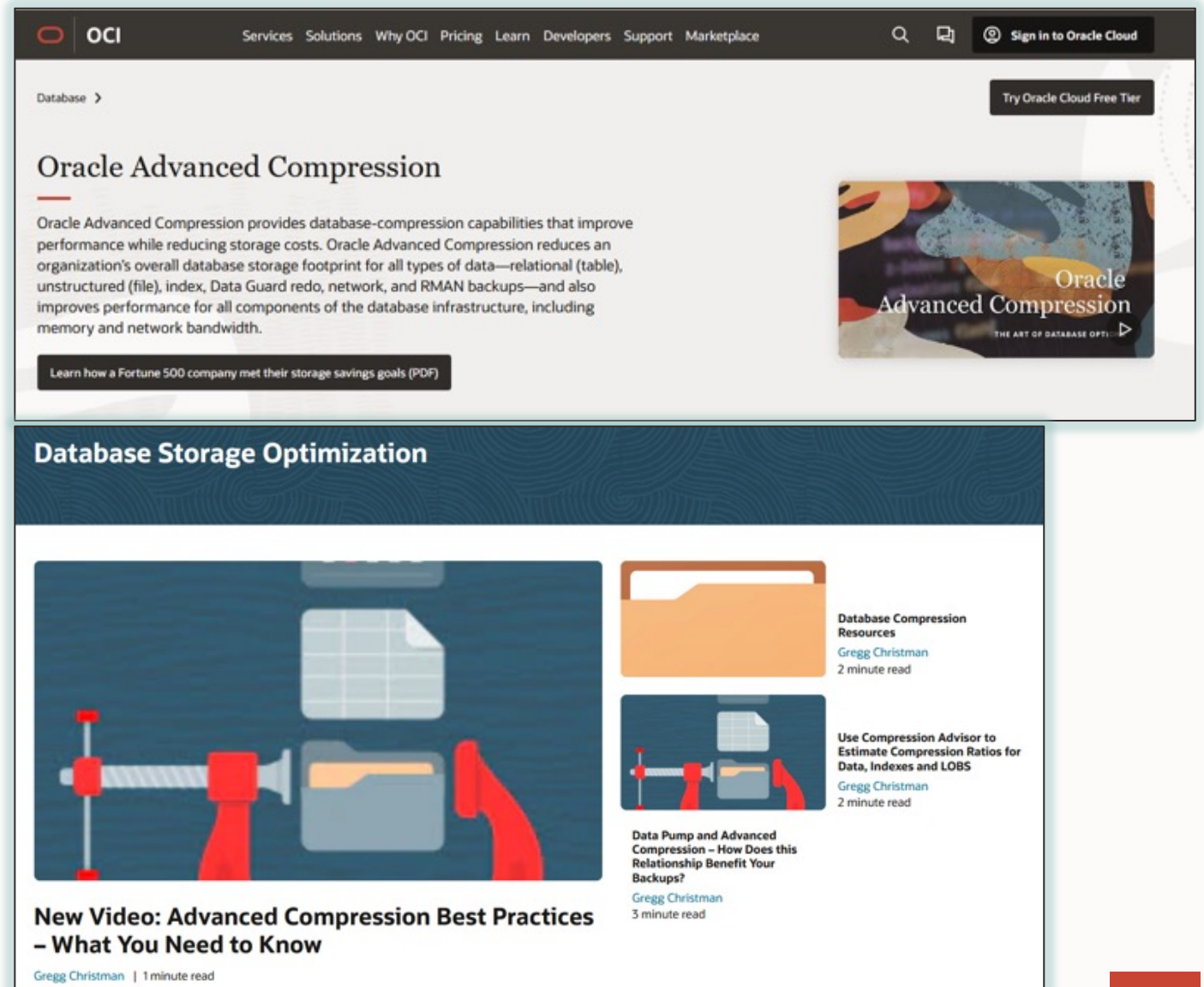
# https://blogs.oracle.com/in-memory/dbim-resources



# Advanced Compression Resources

## Join the Conversation

-  [https://twitter.com/aco\\_gregg](https://twitter.com/aco_gregg)
-  <https://blogs.oracle.com/dbstorage/>
-  <https://www.oracle.com/database/advanced-compression/>



The screenshot displays the Oracle Cloud Infrastructure (OCI) website. The top navigation bar includes the OCI logo, links for Services, Solutions, Why OCI, Pricing, Learn, Developers, Support, and Marketplace, a search icon, and a 'Sign in to Oracle Cloud' button. A 'Try Oracle Cloud Free Tier' button is also visible. The main content area features a section titled 'Oracle Advanced Compression' with a brief description of its capabilities and a link to a PDF document. Below this, a 'Database Storage Optimization' section is highlighted with a dark blue header. This section contains three articles: 'Database Compression Resources' (2 minute read), 'Use Compression Advisor to Estimate Compression Ratios for Data, Indexes and LOBS' (2 minute read), and 'Data Pump and Advanced Compression – How Does this Relationship Benefit Your Backups?' (3 minute read). A large image of a red fire hose is also present. At the bottom, a video titled 'New Video: Advanced Compression Best Practices – What You Need to Know' (1 minute read) is featured.

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### Oracle Advanced Compression

Oracle Advanced Compression provides database-compression capabilities that improve performance while reducing storage costs. Oracle Advanced Compression reduces an organization's overall database storage footprint for all types of data—relational (table), unstructured (file), index, Data Guard redo, network, and RMAN backups—and also improves performance for all components of the database infrastructure, including memory and network bandwidth.

[Learn how a Fortune 500 company met their storage savings goals \(PDF\)](#)

### Database Storage Optimization



**Database Compression Resources**  
Gregg Christman  
2 minute read

**Use Compression Advisor to Estimate Compression Ratios for Data, Indexes and LOBS**  
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