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TECHNOLOGY AND APPLICATIONS FORUM
FOR THE ORACLE COMMUNITY

DBA 3.0 - How to Become a Real-World Exadata DBA

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What Your DBA Team Needs to Know to Support Exadata.

Prepared by:
Mark Smith
Senior Staff Consultant
Database Specialists

 @hickydoo



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REMINDER

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Who Am I?

- 14 years of DBA experience:
 - From E-Business Suite to Exadata with OLTP and EDW.
 - Exadata DBA / DMA since early 2011.
- Senior Staff Consultant at Database Specialists:
 - Consultancy providing expert Oracle DBA services.
 - Based in San Francisco with DBAs across the United States.
 - Clients from ecommerce, retail, marketing, health care, financial, news media, telecoms, film and television, automotive, aviation, etc.
 - Web site: www.dbspecialists.com



Why Am I Here?

- Exadata is a significant investment:
 - Big promises made, big checks written.
- **Specialized** expertise required to support Exadata **properly**.
- Provisions often not made for support teams:
 - Training, organizational structure, new operating procedures.
- Managing Exadata like a “normal” Oracle database risks membership of the “3x Club”:
 - Performance improvement of **2-3x** instead of **10-15x**.
 - Support headaches, unhappy managers.



My Exadata Experience

- Exadata V1: HP / Oracle (2010)
 - Poor end-to-end support.
 - Unreliable hardware, no Flash Cache.

- Exadata V2: Sun / Oracle (2011)
 - Significant performance / reliability improvements.
 - Storage cells had firmware / Flash card issues.

- Exadata X3: Oracle (2013)
 - More of everything, very robust, had become “mainstream”.
 - Networking hardening / Platinum Support were problems.



Why is Exadata Different?

■ Exadata

- Integrated hardware / software.
- SmartScans retrieve only data required for query.
- EHCC saves storage, reduces I/O, increases performance.
- Smart Flash Cache intelligently manages large amounts of Flash.
- InfiniBand networking at 40GiB/s to other engineered systems.

■ Non-Exadata

- Different database / OS / network / storage vendors
- All data pulled into memory for processing.
- Row-based compression saves less storage, requires decompression.
- Smart Flash Cache available with manual operation / configuration.
- InfiniBand available with manual configuration.



The Exadata X5-2 Machine

Exadata X5-2 Hardware Overview

Complete | Optimized | Fully Redundant | Scale-Out



- **Scale-Out 2-Socket Database Servers**
 - Fastest Xeon 18-core chips, 256 to 768 GB DRAM
- **Unified Ultra-Fast InfiniBand Network**
 - 40GB InfiniBand internal connectivity
 - 10GB or 1GB Ethernet data center connectivity
- **Scale-Out 2-Socket Storage Servers**



EACH RACK STORES UP TO

Compute	Storage
684 Cores	272 Cores
14.6 TB RAM	217 TB Flash
	816 TB Disk

- 16 Xeon cores per server
- Extreme Flash Server > 8x 1.6TB PCI Flash Drives
- High Capacity Server > 4x 1.6TB PCI Flash Cards + 12x 4TB SAS disks



Components

- Compute Nodes:
 - Database instance, ASM instance, clusterware.
- Storage Cells:
 - Physical disk for ASM storage and cell filesystem.
 - Flash cards for Exadata Smart Flash Cache.
- IB Switches
 - Manages intra-machine InfiniBand network.
- ILOMs:
 - GUI to manage physical components.



Management Tools

- Standard Oracle management tools:
 - SQLPLUS, ASMCMD, SRVCTL, CRSCTL
- CELLCLI for storage cells.
- DCLI to issue Linux commands to multiple servers.
- IPMITOOL for the ILOMs
- InfiniBand commands for the switches.
 - ibqueryerrors, ibstatus, ibchecklink



DBA? DBMA? DMA? Other?

- DBA 1.0:
 - Single-instance, production databases.

- DBA 2.0:
 - Clustered production databases with standby databases.
 - RAC, ASM, Data Guard.

- DBA 3.0:
 - Exadata and other engineered systems.
 - SmartScan, EHCC, Flash Cache.
 - O/S, storage, network administration skills now required.
 - New title: Database Machine Administrator (DBMA / DMA).



Installing Exadata

- Oracle Field Services on-site for power-up.

- Oracle ACS on-site for installation
 - Customer completes Oracle Exadata Deployment Assistant
 - **Raise non-default requests AT THIS POINT!**
 - Generates “test” and “deploy” scripts.
 - “Test” scripts must pass before on-site is scheduled.
 - “Deploy” scripts run while ACS on-site.
 - Configures networking, storage, database software
 - **Remember to check for access from other servers, VLANs.**



Redundancy and ASM

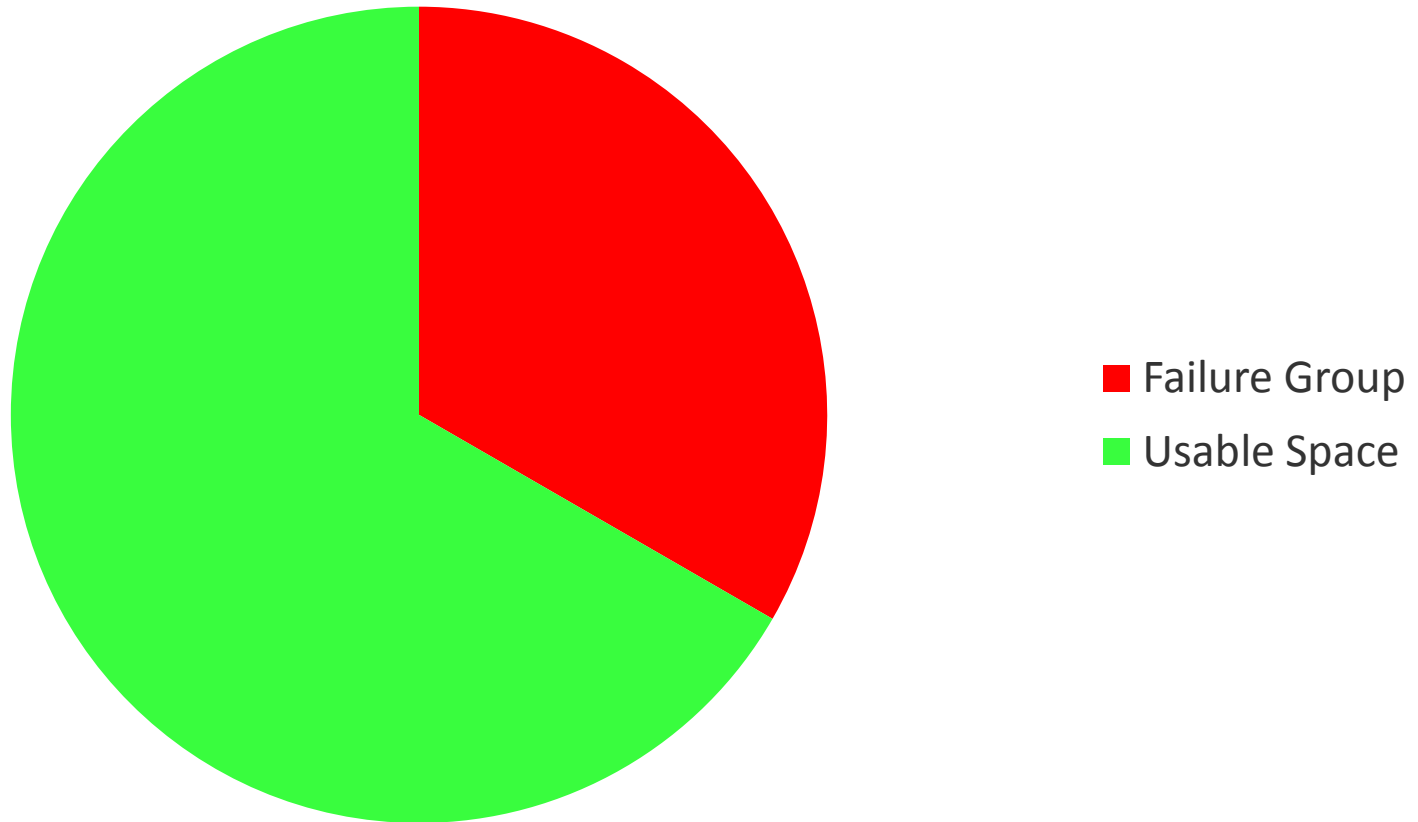
- ASM diskgroup split default is 80:20 (DATA / RECO):
 - 20% of Exadata storage is expensive!
 - DBFS diskgroup created from “spare” storage:
 - Separate Flashback (DBFS) and archive logs (RECO)

- Measure `USABLE_FILE_MB`, not `FREE_MB`:
 - ASM redundancy gives 2 or 3 copies of data (normal / high).
 - Tolerates complete loss of 1 or 2 storage cells.
 - `USABLE_FILE_MB` calculated based on Exadata’s redundancy requirements.
 - With NORMAL redundancy in 1/4-rack, 33% of storage usable.



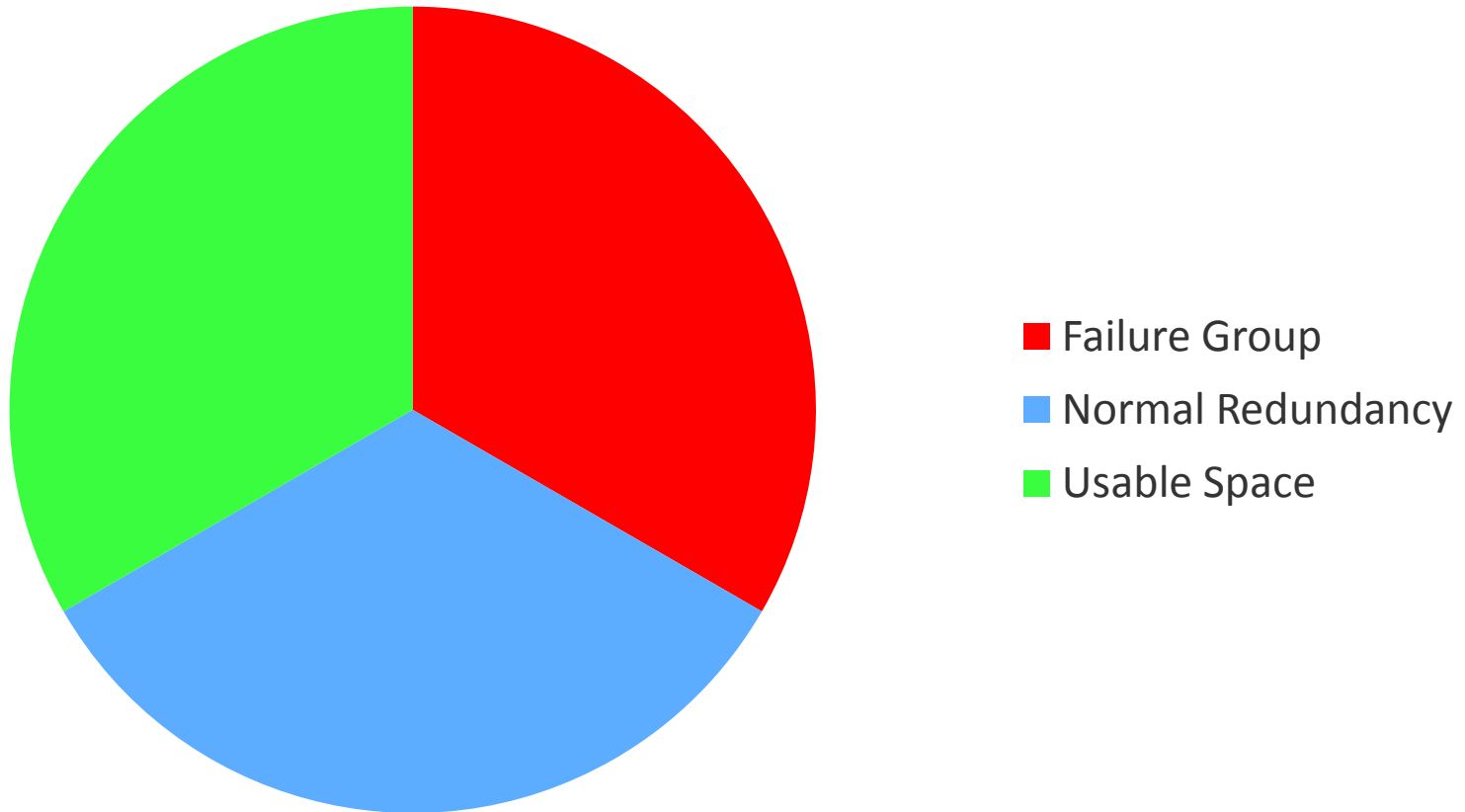
Usable Storage – Quarter-Rack

Quarter-Rack - Failure Group



Usable Storage – Quarter-Rack

Quarter-Rack - ASM Normal Redundancy



Disk Failures

- When a cell disk fails:
 - ASM drops disk if offline for > DISK_REPAIR_TIME:
 - ASM mirrors the data on failed disk to other disks:
 - **Keep as many spare disks as possible on-site.**
 - Monitor disk errors with CELLCLI and exachk:
 - Persuade Oracle Support of impending doom.

- Exadata MUST be able to satisfy its redundancy:
 - With NORMAL ASM redundancy, second disk failure before original resync operation completes = **bad day ... and night?**



Backups

- Database:
 - RMAN backups should be cell-optimized.
 - **Backups using InfiniBand network are much faster!**
 - ZFS Storage Appliance / Zero Data Loss Recovery Appliance.
- Compute Node:
 - Backup your scripts!
 - Filesystem backups
 - **LVM backups via dbnodeupdate.sh**
 - OCR, voting disk via crsctl
 - Baremetal restore via USB drive contains current ESS / OS



Backups

- Storage cells
 - Backup your scripts (CELLCLI, etc)!
 - Baremetal restore via USB drive contains current ESS / OS.
 - Check ASM alert.logs for signs of failures in other cells.
- IB switches:
 - Extract XML file from ILOM.



Patching and Upgrading

- MUCH more complicated than for just the database:
 - O/S, ESS, firmware, clusterware, Grid Infrastructure, RDBMS.
 - “Bundle Patches” contains software and management tools.
- Maintaining support:
 - Database: some versions were desupported on Exadata “early”.
 - Platinum Support: MUST run latest-1 Critical Patch Update.
- Bug fixes:
 - ShellShock, Ghost, etc.
 - Exadata Critical issues.



Why Do I Need Data Guard?

- Large, important databases on Exadata:
 - Even with ZFS / ZLDR appliances, restores take hours.

- Restore to non-Exadata environment can be difficult:
 - Need to uncompress EHCC data.
 - No storage cells / SmartScans.

- Use standby databases to minimize patch / upgrade outages.
 - (Almost) no need for rolling upgrades - just switchover.

- Consider Active Data Guard



Object, Dictionary and System Statistics

- Global statistics are not gathered automatically on partitioned tables:
 - Incremental global statistics gathering needs to be enabled.
 - Alternatively, check for “top” tables with “most stale” global statistics weekly.
- Data dictionary statistics should be updated weekly / monthly:
- It is **VERY IMPORTANT** that system statistics are up-to-date:
 - How will the database know it's on Exadata without them?
 - Before August 2012, there was no “EXADATA” option.
 - *EXEC DBMS_STATS.GATHER_SYSTEM_STATS('EXADATA');*

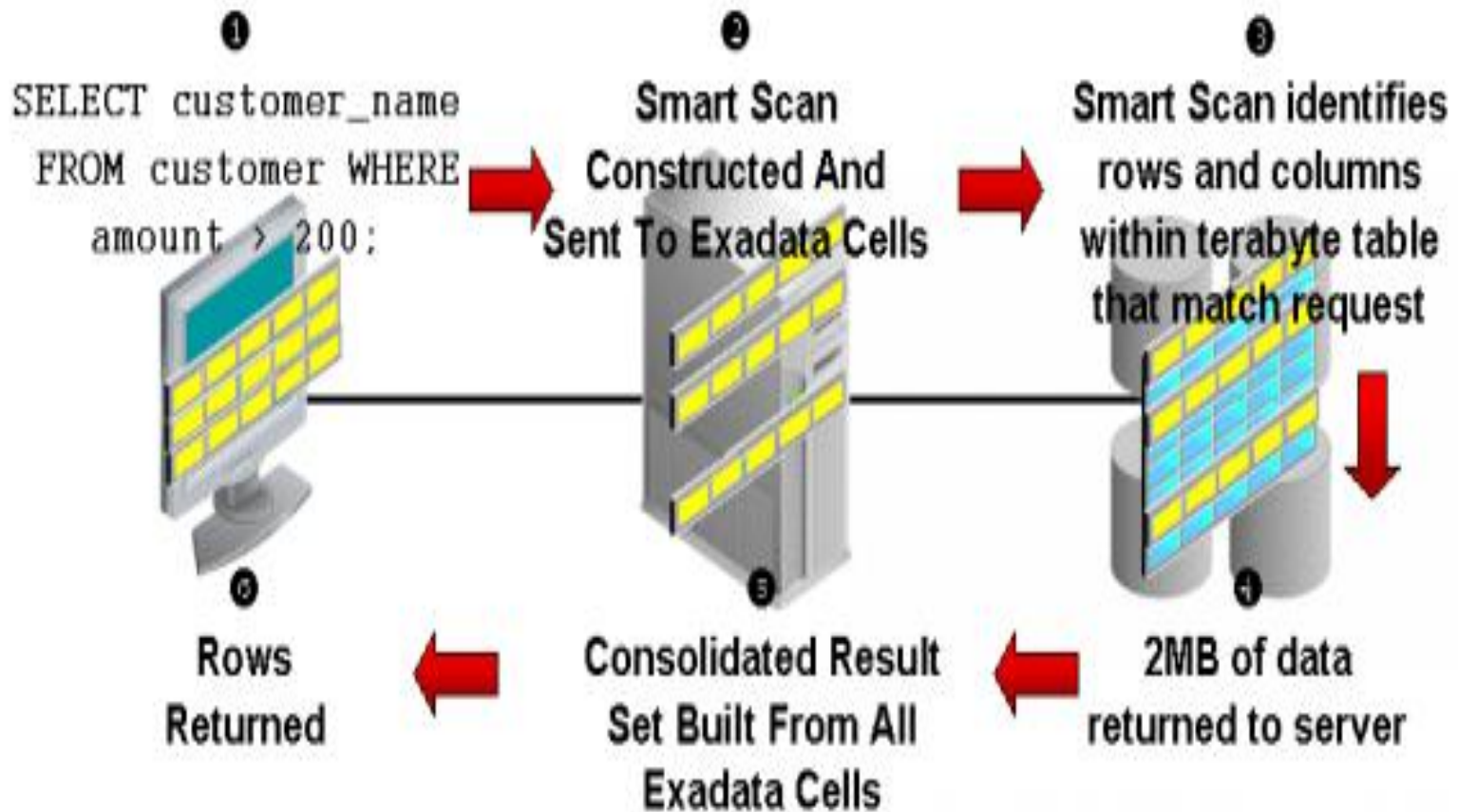


SmartScans (Storage Cell Offloading)

- Most important feature of Exadata.
- Eligible queries are offloaded to the storage cell for processing:
 - Storage cells have their own CPU / RAM / parallelism.
- Storage indexes filter out the data **not required** for the query.
- Returns **significantly** less data back to the compute nodes.
- Frees up instance resources.



SmartScan Example



SmartScan Eligibility

- The query must use **full-object scans** (table, indexes).
- The query must bypass the SGA and use direct reads into the PGA.
- The query must - ALMOST always – use parallelism.
 - Use `_SERIAL_DIRECT_READ` to force serial direct reads.
- Query eligibility does not **guarantee** SmartScans.
- Check `_SMALL_TABLE_THRESHOLD` to see if your buffer cache is too large.



SmartScans and Indexes

- Most likely reason for SmartScan ineligibility is index usage.
 - Test whether a query performs better with a FULL hint.
- Important to review non-unique indexes for usage.
 - Enable MONITORING and review usage after full batch cycle.
 - If not used, make index INVISIBLE.
 - Save DDL and drop the index.
 - Dropping unused indexes = performance improvement for DML operations.
- V\$OBJECT_USAGE view may only show USER INDEXES, not ALL_INDEXES.



Am I Getting SmartScans?

- Explain plan will contain STORAGE FULL operations:
 - *TABLE ACCESS STORAGE FULL employees.*
- ... AND ...
- SmartScan waits will use CELL SMART event names:
 - *cell smart table scan* - for full table scans.
 - *cell smart index scan* - for full index scans.
- Find metrics for SmartScan usage:
 - GV\$ views, AWR reports



Am I Getting a LOT of SmartScans?

- Best single formula is probably “SmartScan Efficiency Ratio”
 - A) "*cell physical IO bytes eligible for predicate offload*"
 - data eligible for SmartScans - e.g. 5Tb.
 - B) "*cell physical IO interconnect bytes returned by smart scan*"
 - data returned to comp nodes after SmartScans - e.g. 50Mb.
- Total I/O avoided by using SmartScans:
 - $A - B = 4.95\text{Tb}$
- SmartScan ratio:
 - $100 - ((100 / A) * B) = 99\%$



SmartScans and Parallelism

- Compute nodes have relatively low CPU_COUNT:
 - “Traditional” DW environments can have high CPU_COUNT:
 - Make extensive use of parallelism for analytical queries, etc.
- Check DEGREE setting for tables and indexes:
 - **DO NOT** use DEFAULT.
 - Ensure that large objects have at least DEGREE = 2.
 - Better to use **parallel hints** at the query-level than object-level parallelism.
- **Object inherits an DDL operation's degree of parallelism:**
 - *ALTER INDEX ... REBUILD PARALLEL 20;*



Resource Management

- Implement Database Resource Manager (DBRM) and separate users into Consumer Groups:
 - Restricts resource consumption of users / groups.
 - Prevents “power users” running multiple concurrent queries with excessive parallelism.
 - Limit each consumer group by active sessions and parallel slaves:
 - Max active sessions (4) * max degree of parallelism (4)
= 16 parallel slaves per instance.

- Use I/O Resource Manager for inter-database management:
 - Multiple databases on same machine.



Exadata Hybrid Columnar Compression (EHCC)

- EHCC is Exadata-specific and can realize both significant savings AND performance benefits:
 - EHCC can be applied to tables and partitions.
- Compression Units (CU) stores groups of rows in a table in columnar format.
 - Values of each column stored and compressed together.
 - More data compressed at once = larger CU = better compression.
- Use EHCC on table / partitions unlikely to change:
 - DML operations will reduce the compression ratio.



EHCC Compression Types

- 2 compression types (with 2 options each):
 - Warehouse compression – for query performance:
 - QUERY LOW and QUERY HIGH.
 - 6-10x compression ratio.
 - Archival compression – for maximum compression:
 - ARCHIVE LOG and ARCHIVE HIGH.
 - 15x compression ratio (and up).

- Use the Compression Advisory to predict compression ratios before deployment
 - MOS 762974.1.



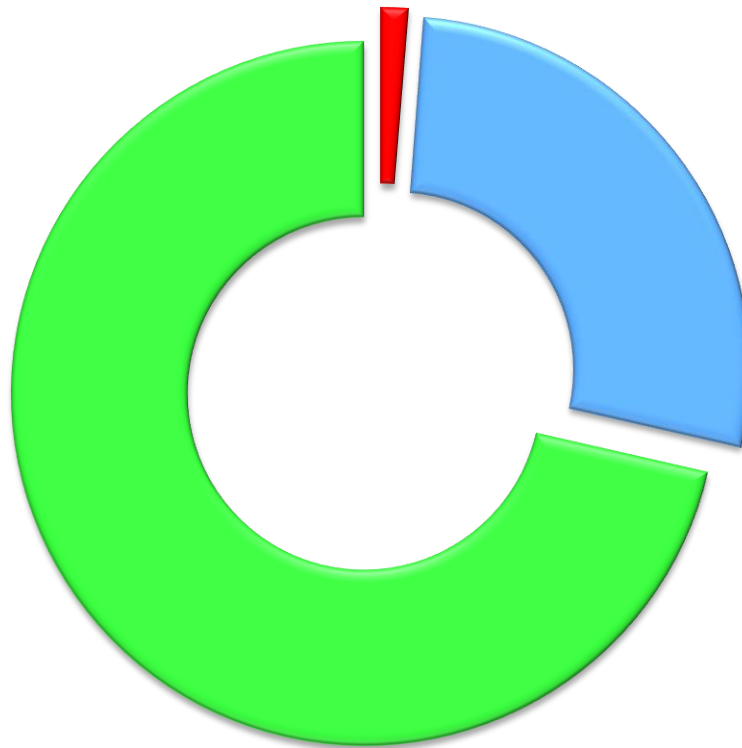
EHCC Use Case

- Use case:
 - Very large partitioned table (6Tb) with minimal DML.
 - Table has 7 years' of data partitioned by day.
 - Most queries pull back – at most - last 31 days of data.
 - Partitions compressed based on age:
 - Newest 31 days – **not compressed**.
 - Day 32 to Year 2 – **QUERY LOW compression**.
 - Years 2 to 7 – **ARCHIVE HIGH compression**.
 - Deployed EHCC using MOVE on tables / indexes partitions.
 - Space saving around 4Tb with performance **benefit**.
 - **Bitmap indexes** caused problems:
 - Hit bug where index multiplied in size by degree of parallelism!



EHCC Use Case

Compression ratios in our VVLT (Very, Very Large Table)



- Uncompressed
- QUERY LOW compression (6-10x)
- ARCHIVE HIGH compression (15-20x)



Am I Using EHCC?

- ‘%cell CU%’ statistics show EHCC usage.
- 2 statistics determine rows / compression unit:
 - *EHCC Total Rows for Decompression* – e.g. 5,000,000,000
 - *EHCC CUs Decompressed* – e.g. 5,000,000
 - **Average rows per EHCC compression unit = 1,000.**
- Determine compression used for table / partition / row:
 - DBMS_COMPRESSION procedures.
 - COMPRESS_FOR column in DBA_TABLES / DBA_INDEXES.



Exadata Smart Flash Cache

- Each storage cell has four PCI Flash cards:
 - Combined storage makes up the “Exadata Smart Flash Cache”.
 - Intelligently populated with “hot” data.
 - Consider pinning hot objects (partitions) if Flash Cache ratio is low.
- Acts as “second” database buffer cache.
- Can be used for writes with **Writable Smart FlashCache**:
 - NOT enabled by default – useful for OLTP processing.
 - Accelerates log writes via Smart Flash Log.



Am I Using Flash Cache?

- 2 statistics determine Flash Cache ratio:
 - *physical read total IO requests* – e.g. 3,000,000
 - *cell flash cache read hits* – e.g. 2,850,000
 - **Flash Cache ratio $(100 / 3,000,000) * 2,850,000 = 95\%$**
- **Target state: fit as much of the “hot” data in FlashCache:**
 - Increasing size of Flash Cache in new Exadata models.
 - Flash Cache Compression (cost option).
 - Exponential performance benefit when combined with SmartScans and EHCC.



HugePages and Memory Management

- Set `USE_LARGE_PAGES = ONLY`
- **DON'T** use Automatic Memory Management (even if you're not using HugePages).
- Use Automatic Shared Memory Management (the 10g version).
- Set minimum component sizes to avoid excessive component resizes / contention.
- Don't make the buffer cache too large!



Database Services

- Separates users / workload into groups:
 - DB_BATCH, DB_ADMIN, DB_REPORTING, etc.
- Use with DBRM to prioritize resource consumption.
- Identify / isolate problem activity.
- Simplify Data Guard switchover:
 - Use both primary / standby SCAN addresses for LDAP / TNS.
 - Main services start on the primary database only.
 - Reporting services start on the physical standby database only



New Operating Procedures

- Specialized SOPs required for DMA:
 - Exadata: Reboot Comp Node / Storage Cell / IB Switch.
 - Exadata: Replace Failed Storage Cell Disk.
 - Exadata: Check for Errors on an IB Switch.
 - Exadata: Component Backups.
 - Exadata: Install ExaWatcher.
 - Exadata: Using ILOMs.
 - Exadata: Performance Ratios and IOPS.
 - Exadata: Capacity Monitoring on Exadata.
 - Exadata: Object, Dictionary and System Statistics.



“Must-Have” Support Notes

- DMA must be aware of new problems / best practices:
 - Exadata Database Machine and Exadata Storage Server Supported Versions (Doc ID 888828.1)
 - Exadata Critical Issues (Doc ID 1270094.1)
 - Information Center: Oracle Exadata Database Machine (Doc ID 1306791.2)
 - Oracle Sun Database Machine X2-2/X2-8, X3-2/X3-8 and X4-2 Security Best Practices (Doc ID 1071314.1)
 - Oracle Exadata Database Machine exachk or HealthCheck (Doc ID 1070954.1)
 - Responses to common Exadata security scan findings (Doc ID 1405320.1)



Monitoring Exadata

- OEM Cloud Control includes Exadata-specific plug-ins.
- Configure email alerts from the storage cells.
- Oracle Configuration Manager:
 - Use OCM or OEM Harvester to send system information back to Oracle Support.
 - Simplifies creation of Support Requests.
 - **OCM-enabled Exadata systems treated with Priority Handling.**



Diagnostics and Performance

- exachk:
 - Scores out of 100 based on best practice compliance.
 - Should be run on a regular basis.
 - **Checks entire machine for problems.**
 - Suggests remedial actions and performance improvements.
 - Can report false positives:
 - UNRECOVERABLE datafiles.

- ExaWatcher:
 - Exadata version of OSW (Black Box)
 - Oracle Support **WILL** ask you for the logs.



Capacity Monitoring

- V1 and V2 machines had finite storage.
- **Very important** to determine available storage and rate of data growth.
- Capture historical information in “DBA” schema:
 - ASM diskgroup, DBA_SEGMENTS.
 - Determine IOPS during peak workload.
 - Monitor performance ratios:
 - SmartScan, EHCC rows per CU, FlashCache.
- Consider AWR Warehouse Repository.



Exadata As a Foundation (The Hub)

- Thanks to InfiniBand connectivity, Exadata integrates with other engineered systems:
 - ZFS / Zero Data Loss Recovery Appliance for fast backups/restores.
 - Exalogic Appliance for application servers.
 - Exalytics Appliance for ...?
 - Big Data Appliance:
 - Hadoop environment-in-a-box.
 - Big Data SQL allows Oracle RDBMS database to query data on Hadoop.
 - End users don't need to code their own extraction layer.
 - Advanced Oracle features (security, Data Guard, etc) available.



Exadata As a Foundation (Features)

- Oracle In-Memory Database:
 - Enable extreme OLAP performance via in-memory columnar representation of data.
 - “No” application changes (need to get rid of analytical indexes).
 - No need for OLAP repository / data marts:
 - Reduce data movement.
 - Real-time data can be used for analytical processing.
 - Save on licensing, code maintenance, support costs.

- Oracle 12c Multitenant
 - Use Exadata as a core component of “private cloud”.



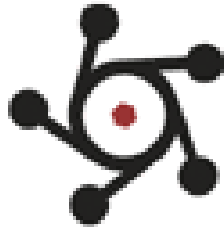
DBA 4.0?

- DBA / DMA role will continue to expand:
 - “It’s got Oracle / data in its name!”
 - Increasing emphasis on **DMA** role rather than DBA role.

- DBA 4.0:
 - Big Data systems integration.
 - On-demand service provisioning (12c, Multitenant).
 - High-performance features such as In-Memory Database.
 - Expansion into infrastructure architecture.
 - Traditional organization silos can’t support expanding scope:
 - Engineered Systems Support?
 - Enterprise Data Management?



Questions? Comments?



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www.dbspecialists.com

1-888-648-0500

msmith@dbspecialists.com



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