Exadata Database Machine Administration Workshop

Electronic Presentation

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Introduction

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Course Objectives

After completing this course, you should be able to:

- Describe the key capabilities of Exadata Database Machine
- Identify the benefits of using Exadata Database Machine for different application classes
- Describe the architecture of Exadata Database Machine and its integration with Oracle Database, Clusterware and ASM
- Complete the initial configuration of Exadata Database Machine
- Describe various recommended approaches for migrating to Exadata Database Machine
- Configure I/O Resource Management
- Monitor Exadata Database Machine health and optimize performance

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Audience and Prerequisites

- This course is primarily designed for administrators who will configure and administer Oracle Exadata Database Machine.
- Prior knowledge and understanding of the following is assumed:
  – Oracle Database 11g Release 2, including RAC and ASM
  – General operating system, network, storage, and system administration concepts
- Recommended prior training:
  – Oracle Database 11g: Administration Workshop I
  – Oracle Database 11g: Administration Workshop II
  – Oracle 11g: RAC and Grid Infrastructure Administration
  – Linux or Solaris System Administration

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Course Contents

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Terminology

- Throughout the course, “Database Machine” is used as an abbreviation for “Oracle Exadata Database Machine.”
  – Typically, Database Machine refers to the entire system including both hardware and software. However, at times there are specific references to Database Machine hardware or software components.
- Throughout the course, the terms “Exadata cell” or simply “cell” may be used as an abbreviation for “Exadata Storage Server”.
  – Typically such references refer to the combination of software and hardware used in Exadata Storage Server. However, at times there are specific references to Exadata Storage Server hardware or software.

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Additional Resources

- Oracle.com Exadata home page
  - http://www.oracle.com/exadata
- Oracle Technology Network (OTN) Exadata home page
  - http://otn.oracle.com/server-storage/engineered-systems/exadata/index.html
- Exadata documentation
  - Search for patch number 10386736 in My Oracle Support.
- OTN Exadata discussion forum
  - http://forums.oracle.com/forums/forum.jspa?forumID=829
- Oracle Learning Library
  - http://www.oracle.com/oll
  - Search for demonstrations with Exadata or Database Machine in the title.

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Practice 1 Overview: Introducing the Laboratory Environment

In this practice, you will be introduced to the laboratory environment used to support all the practices during this course.

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Exadata Database Machine: Overview

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Objectives

After completing this lesson, you should be able to:

- Provide an overview-level description of Exadata Storage Server and the different Database Machine configurations
- Outline the key capacity and performance specifications for Database Machine
- Describe the key benefits associated with Database Machine

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Introducing Database Machine

- Fully integrated platform for Oracle Database
- Based on Exadata Storage Server storage technology
- High-performance and high-availability for all Oracle Database workloads
- Balanced hardware configurations
- Well suited as a database consolidation platform
- Simple and fast to implement

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Why Database Machine?

Database Machine is designed to address common issues:

- Data Warehousing issues:
  - Supporting large, complex queries
  - Managing massive databases
- OLTP issues:
  - Supporting large user populations and transaction volumes
  - Delivering quick and consistent response times
- Consolidation issues:
  - Efficiently supporting mixed workloads
  - Prioritizing workloads
- Configuration Issues:
  - Creating a balanced configuration without bottlenecks
  - Building and maintaining a robust system that works

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Introducing Exadata Storage Server

Exadata Storage Server

- High-performance storage for Oracle Database
- 64 bit Intel-based Sun Fire Server
- Preinstalled software:
  - Exadata Storage Server Software
  - Oracle Linux x86_64
  - Drivers and Utilities
- Only available in conjunction with Database Machine

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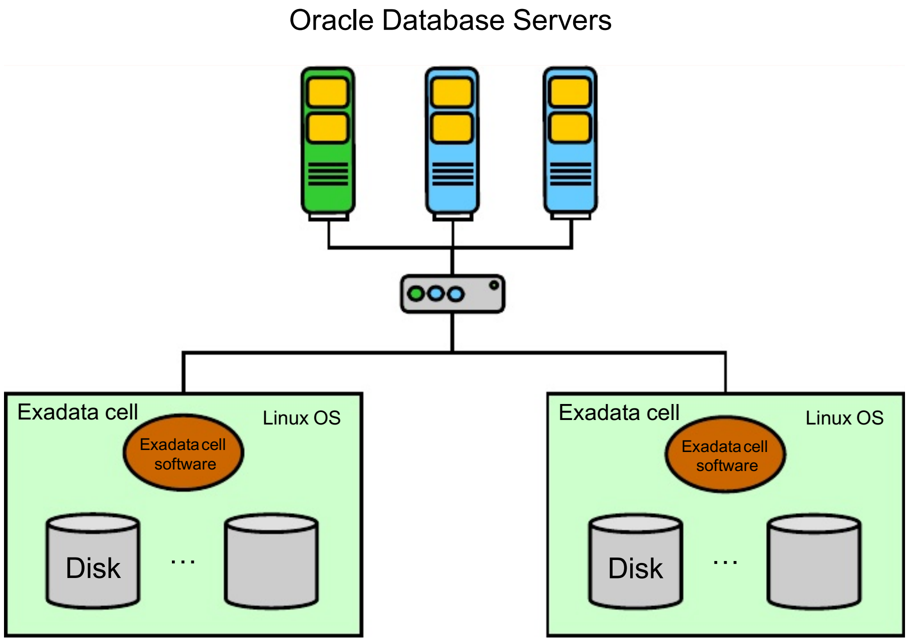
Exadata Storage Server Architecture: Overview



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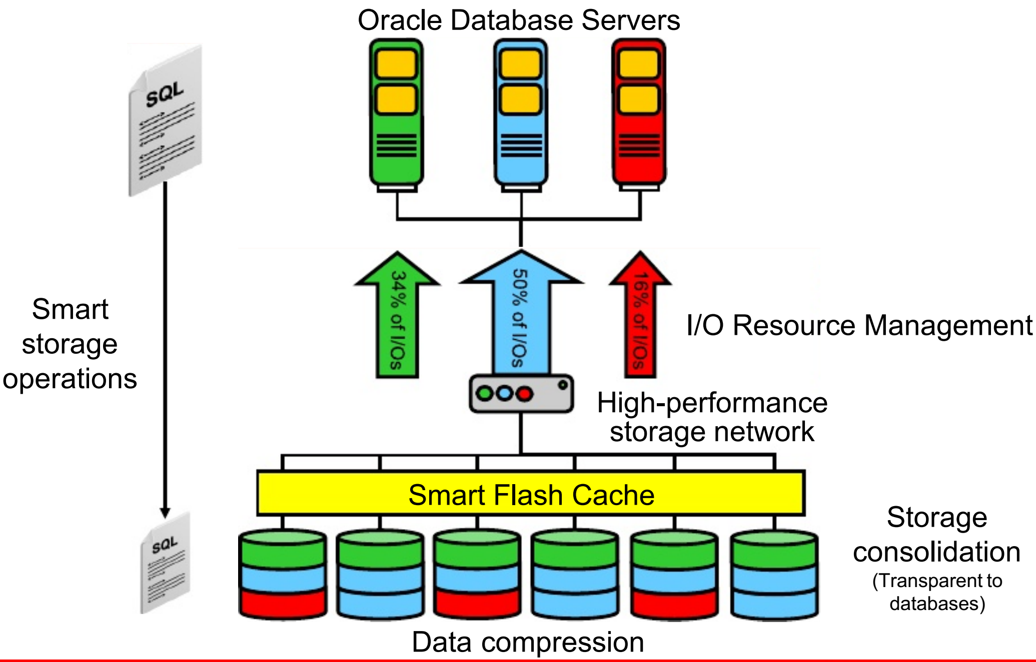
Exadata Storage Server Features: Overview



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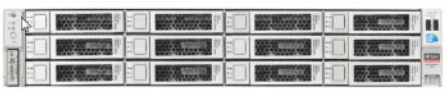
Exadata Storage Server X3-2 Hardware Overview



Processors	12 Intel CPU Cores
System Memory	64 GB
Disk Drives	12 x 600 GB 15K RPM High Performance Disk Drives *or* 12 x 3 TB 7.2K RPM High Capacity Disk Drives
Flash	1.6 TB
Disk Controller	Disk Controller Host Bus Adapter with 512 MB Battery Backed Write Cache
InfiniBand Network	Dual-Port QDR (40Gb/s) InfiniBand Host Channel Adapter
Remote Management	Integrated Lights Out Manager (ILOM) Ethernet Port
Power Supplies	2 x Redundant Hot-Swappable Power Supplies

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Exadata Storage Server X3-2 Configuration Options

	High Performance Disks	High Capacity Disks
Raw Disk Capacity[1]	7.2 TB	36 TB
Uncompressed Data Capacity[2]	3.25 TB	16 TB
Raw Disk Throughput	1.8 GB/sec	1.3 GB/sec
Flash Throughput	7.25 GB/sec	6.75 GB/sec

1 - Raw capacity calculated using 1 GB = 1000 x 1000 x 1000 bytes and 1 TB = 1000 x 1000 x 1000 x 1000 bytes.

2 - User Data: Actual space for uncompressed end-user data, computed after single mirroring (ASM normal redundancy) while also providing adequate space to re-establish the mirroring protection after a disk failure. Actual user data capacity varies by application.

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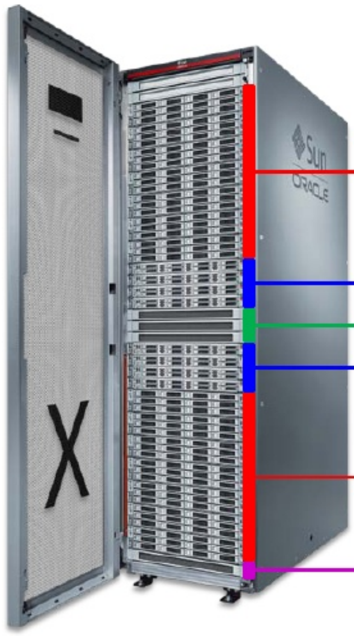
Database Machine X3-2 Full Rack



14 Exadata Storage Servers
(all high performance or all high capacity)

8 Database Servers

3 QDR (40Gb/s) InfiniBand Switches (36 port)

1 Cisco Ethernet Switch (48 port)

2 Power Distribution Units (PDUs) at rear

Spare Parts Kit:
- Two hard disk drives (high performance or high capacity)
- Two flash memory cards
- Spare InfiniBand cables

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X3-2 Database Server Hardware: Overview

Processors	16 Intel CPU Cores
System Memory	256 GB
Disk Drives	4 x 300 GB 10K RPM Disk Drives
Disk Controller	Disk Controller Host Bus Adapter with 512 MB Battery Backed Write Cache
Network Interfaces	• Dual-Port QDR (40Gb/s) InfiniBand Host Channel Adapter • Four 1/10 Gb Ethernet Ports (copper) • Two 10Gb Ethernet Ports (optical)
Remote Management	Integrated Lights Out Manager (ILOM) Ethernet Port
Power Supplies	2 x Redundant Hot-Swappable Power Supplies

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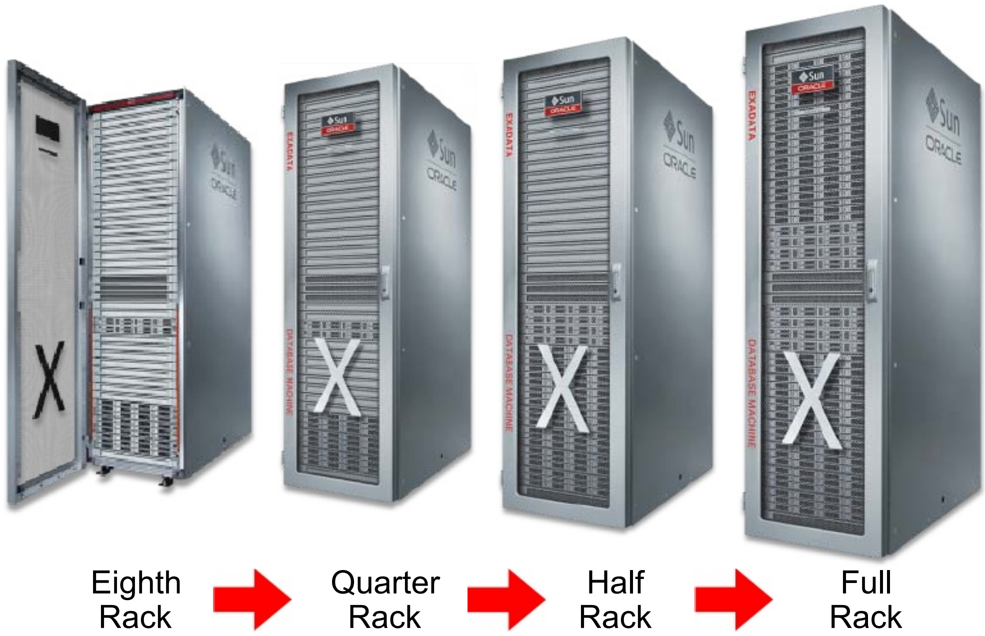
Start Small and Grow



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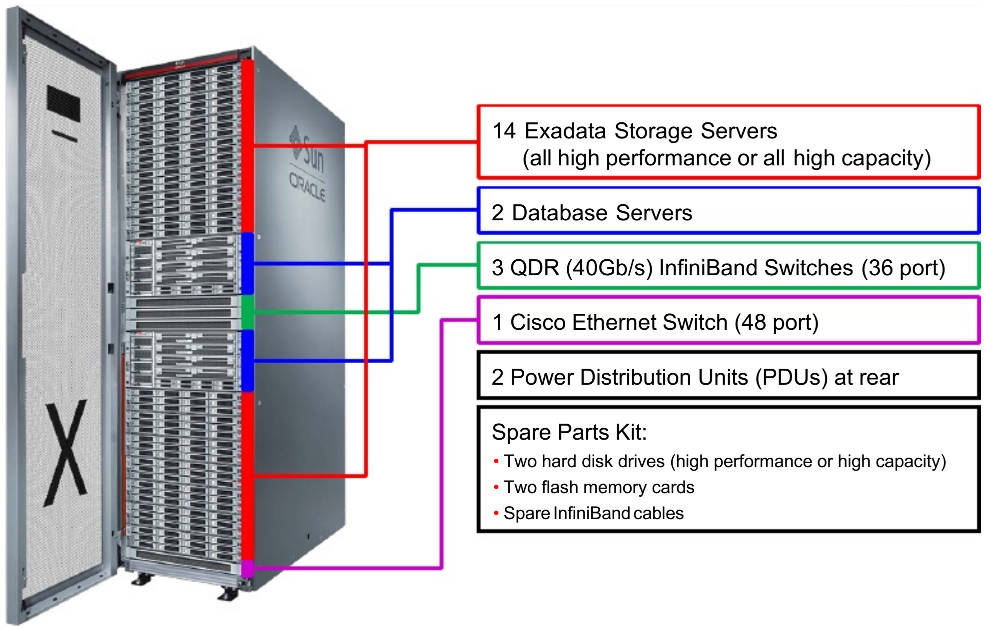
Database Machine X3-8 Full Rack



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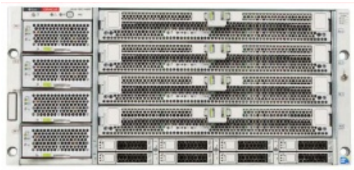
X3-8 Database Server Hardware: Overview



Processors	80 Intel CPU Cores
System Memory	2 TB
Disk Drives	8 x 300 GB 10K RPM Disk Drives
Disk Controller	Disk Controller Host Bus Adapter with 512 MB Battery Backed Write Cache
Network Interfaces	• Eight QDR (40Gb/s) InfiniBand Ports • Eight 1 Gb Ethernet Ports • Eight 10Gb Ethernet Ports
Remote Management	Integrated Lights Out Manager (ILOM) Ethernet Port
Power Supplies	4 x Redundant Hot-Swappable Power Supplies

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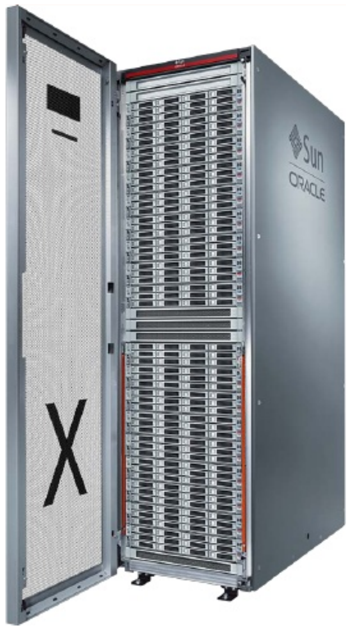
Exadata Storage Expansion Racks



- Designed to quickly and easily add storage to Database Machines
- Available in three configurations:
  - Full Rack contains:
    - 18 Exadata Storage Servers
    - 3 InfiniBand Switches
  - Half Rack contains:
    - 9 Exadata Storage Servers
    - 3 InfiniBand Switches
  - Quarter Rack contains:
    - 4 Exadata Storage Servers
    - 2 InfiniBand Switches

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InfiniBand Network: Overview

InfiniBand:

- Is the Database Machine interconnect fabric:
  - Provides highest performance available – 40 Gb/sec each direction
  - Is widely used in high-performance computing since 2002
- Is used for storage networking, RAC interconnect and high-performance external connectivity:
  - Less configuration, lower cost, higher performance
- Looks like normal Ethernet to host software:
  - All IP-based tools work transparently – TCP/IP, UDP, SSH, and so on
- Has the efficiency of a SAN:
  - Zero copy and buffer reservation capabilities
- Uses Zero-loss Zero-copy Datagram Protocol (ZDP)
  - High performance, zero-copy implementation of RDSv3
  - Open source software developed by Oracle
  - Very low CPU overhead

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Database Machine Support: Overview

Support Offering	Key Features
Oracle Hardware Warranty	• Included with Database Machine, 1 year term • Anytime web access, Local business hours phone access • 4 hour response during normal business hours • On-site response and parts exchange within 2 business days subject to availability and location
Oracle Premier Support	• Support for Oracle Database and Exadata cell software • Anytime web or phone access • Software enhancements, fixes and upgrades • Proactive tools, including alerts and configuration guidance
Oracle Premier Support for Systems	• Support for server and storage hardware and firmware; includes Oracle Linux • Anytime web or phone access • On-site hardware response with 2 hours if Database Machine is within a 2 hour service coverage area
Oracle Customer Data and Device Retention	• Provides replacements for failed disk drives • Customer retains the failed disk drives • Provides additional security for sensitive data

See also http://www.oracle.com/support/policies.html

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Oracle Platinum Services:
Enhanced Support at No Additional Cost

Platinum Service	Features	Benefits
Remote Fault Monitoring	24/7 Fault monitoring	Fastest identification, notification, and restoration of issues
	Event filtering and qualification	Focus on critical events
	Reporting on event management	Full visibility of faults detected by Oracle
	A single global knowledge base, tool set and client portal	Leverage Oracle's collective knowledge
Accelerated Response	24/7 Response Times: • 5-min fault notification • 15-min restoration or escalation to development • 30-min joint debugging	Highest level of response with the fastest path to issue resolution
	Escalation process and hotline with dedicated escalation managers	Expert support staff available 24x7
Patch Deployment	Assess and Analyze: Produce a quarterly patch plan	Proactive identification of best practice configuration for optimal performance
	Plan and Deploy: Proactively plan and deploy patches four times per year	Minimize business disruption and ensure systems performance

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Database Machine Benefits for Data Warehousing

- Modular storage cell building blocks are organized into a parallel storage grid providing large I/O throughput.
- The InfiniBand storage network is much faster than traditional SAN storage networks, which helps to deliver the potential of the storage grid.
- Query processing is moved into storage to dramatically reduce data sent to servers while unloading server CPUs.
- Exadata Hybrid Columnar Compression reduces the number of physical I/Os for large table scans.
- In-memory parallel query provides a powerful alternative query strategy that complements Exadata Storage Server.

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Database Machine Benefits for OLTP

- Modular storage cell building blocks are organized into a parallel storage grid providing large I/O throughput.
- The InfiniBand storage network is much faster than traditional SAN storage networks which helps to deliver the potential of the storage grid.
- Powerful well-balanced database servers with large amounts of RAM help to support large user populations and large database buffer caches.
- Exadata Smart Flash Cache provides a high-performance secondary cache for frequently accessed objects, which is excellent for absorbing repeated random reads.

Hundreds of
I/Os per sec

Tens of thousands
of I/Os per second

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Quiz

How many Exadata Storage Servers are contained in a Full Rack, Half Rack, and Quarter Rack Database Machine?

a. 16, 8, 4
b. 14, 7, 3
c. 12, 6, 3
d. 8, 4, 2

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Quiz

What are three unique benefits of Exadata Storage Server compared to traditional storage servers?

a. Larger disk sizes
b. Smart storage capabilities
c. Higher storage network bandwidth
d. Higher RAM capacity
e. Integrated database I/O resource management

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Summary

In this lesson, you should have learned to:

- Provide an overview-level description of Exadata Storage Server and the different Database Machine configurations
- Outline the key capacity and performance specifications for Database Machine
- Describe the key benefits associated with Database Machine

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Additional Resources

- Interactive tours
  - Database Machine X3-2
  - Database Machine X3-8

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Exadata Database Machine Architecture

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Objectives

After completing this lesson, you should be able to:

- Describe the Database Machine network architecture
- Describe the Database Machine software architecture
- Describe the Exadata Storage Server storage entities and their relationships
- Describe how multiple Database Machines can be interconnected

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Database Machine Architecture: Overview

Database Machine provides a highly available, high-performance platform for Oracle Database based on the clustered architecture supported by Oracle RAC.

Key components include:

- Powerful and intelligent shared storage provided by Exadata Storage Server
- Storage mirroring provided by ASM
- High bandwidth and low latency cluster interconnect and storage networking provided using InfiniBand technology
- Powerful and well-balanced database servers joined together in a cluster

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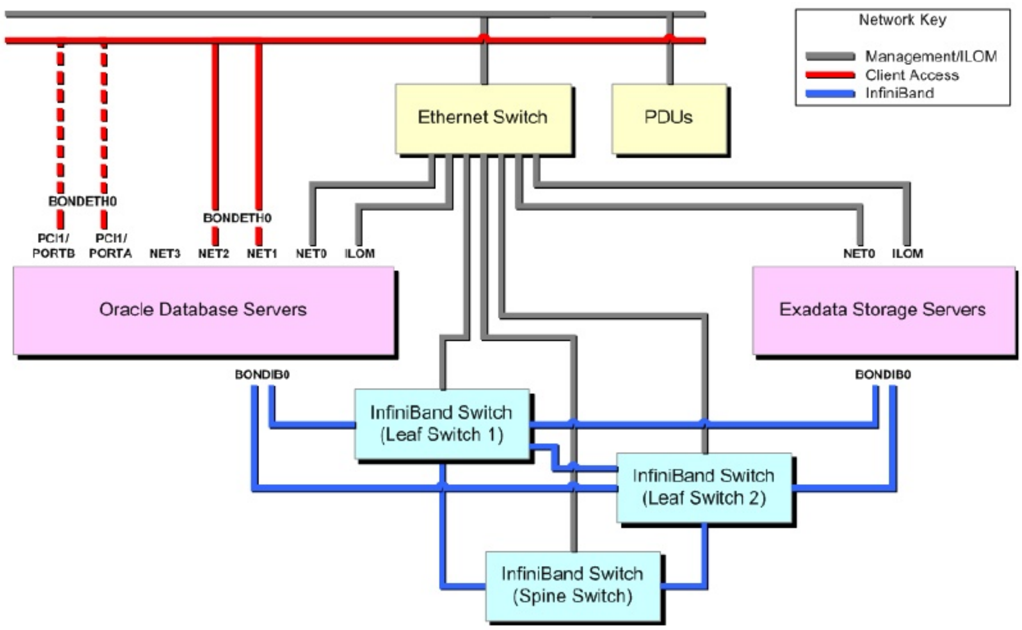
Database Machine Network Architecture



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InfiniBand Network Architecture

- Sun Datacenter 36-port managed QDR (40 Gb/s) switches
  - 2 leaf switches used to connect server InfiniBand ports
  - 1 spine switch in Full Rack and Half Rack configurations only
- Exadata Storage Servers and X3-2 Database Servers
  - Each server has one dual-port QDR (40 Gb/s) InfiniBand HCA
  - Each HCA port is connected to a different leaf switch for high availability
  - Active-passive bonding with single IP address
    - Performance is limited by PCIe bus, so active-active not needed
- X3-8 Database Servers
  - Each server has four dual-port QDR (40 Gb/s) InfiniBand HCAs
  - Each pair of HCA ports are connected to different leaf switches for high availability
  - Active-passive bonding for each bonded pair
- Connections are cabled in the factory

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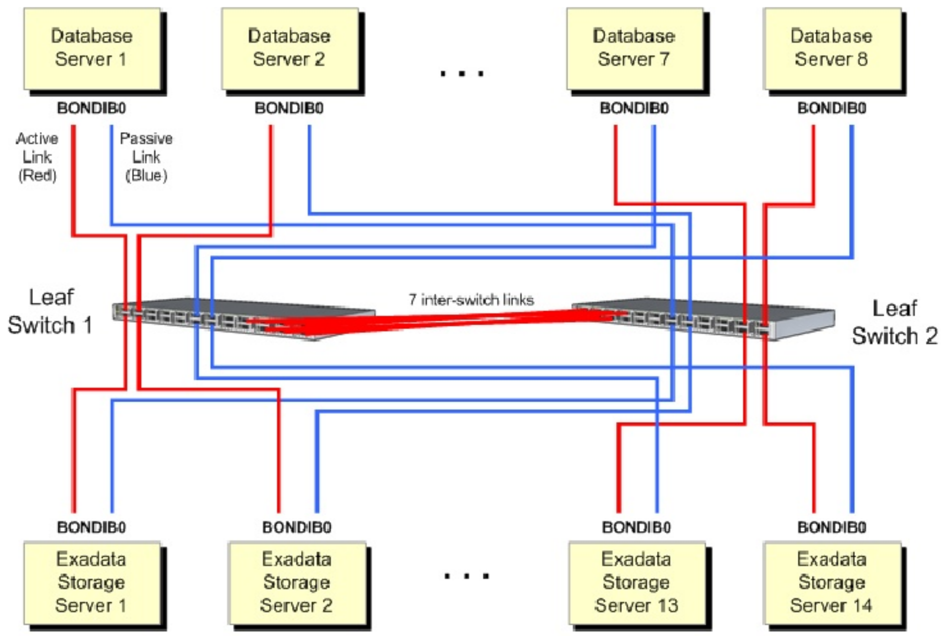
Leaf Switch Topology



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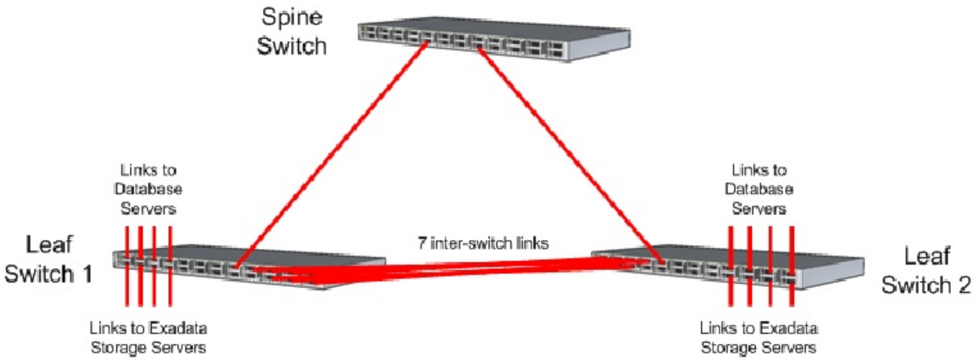
Spine and Leaf Topology



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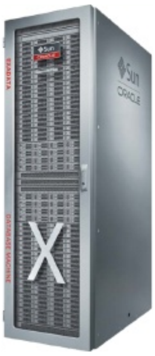
Scale Performance and Capacity



Scalable

- Scale to 18 racks by adding cables.
- Scale to hundreds of storage servers to support multi-petabyte databases.

Redundant and Fault Tolerant

- Failure of any component is tolerated.
- Data is mirrored across storage servers.

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Typical Scaling Scenarios

- Large monolithic system:
  - Multiple Database Machine X3-2 racks
    - Possibly in conjunction with Exadata Storage Expansion Racks
  - Multiple Database Machine X3-8 racks
    - Possibly in conjunction with Exadata Storage Expansion Racks
- Platform consolidation:
  - Multiple Database Machine X3-2 or X3-8 racks
    - Possibly in conjunction with Exadata Storage Expansion Racks
- Maximum capacity:
  - A Database Machine X3-2 or X3-8 rack in conjunction with Exadata Storage Expansion Racks
- Tiered storage:
  - One or more Database Machine X3-2 or X3-8 racks with high-performance disks in conjunction with one or more Exadata Storage Expansion Racks

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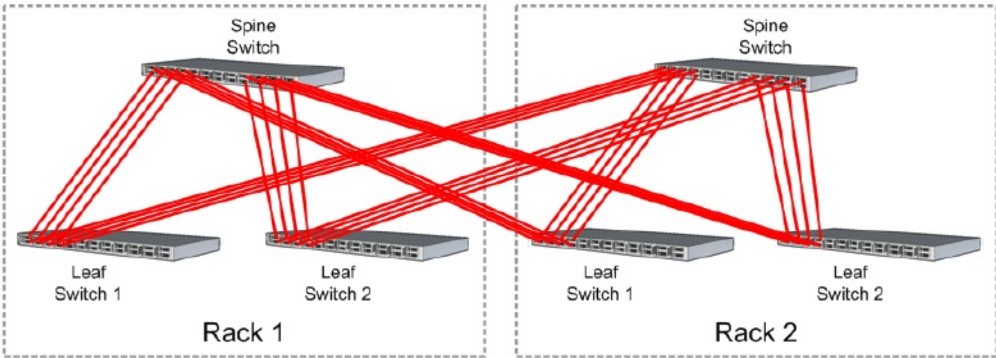
Scaling Out to Eight Racks

- Single InfiniBand network based on a Fat Tree topology
  - Database and storage server cabling unchanged
- Two rack example:



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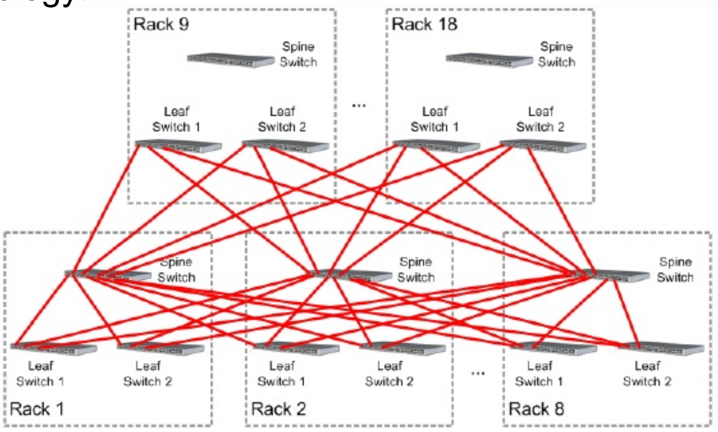
Scaling Out Between 9 and 18 Racks

- Single InfiniBand network based on a Fat Tree topology
  - Up to 18 racks supported with existing switches
  - Database and storage server cabling unchanged
- Topology:



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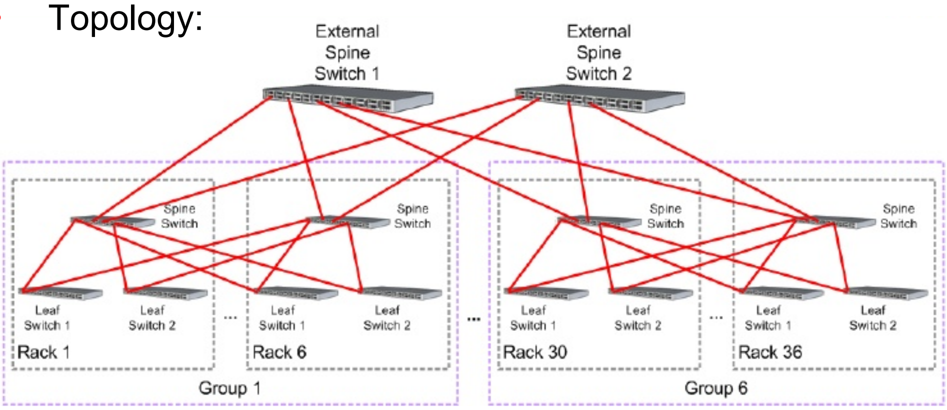
Scaling Out Between 19 and 36 Racks

- Single InfiniBand network based on a Fat Tree topology
  - Scale out to 36 racks by adding two external spine switches
  - Database and storage server cabling unchanged
  - One level is added to the Fat Tree topology
- Topology:



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Interconnecting Quarter Racks and Eighth Racks

- Quarter Racks and Eighth Racks can be interconnected in the following limited situations:
  - Interconnect two Quarter Racks, or two Eighth Racks
    - Connect each leaf switch in each rack to both leaf switches in the other rack using two links for each connection
  - Connect one Quarter Rack or one Eighth Rack to one Half Rack or one Full Rack
    - Connect each leaf switch in the Quarter Rack or Eighth Rack to both leaf switches in the other rack using two links for each connection
  - Connect one Quarter Rack or Eighth Rack to a group of up to 8 other interconnected racks
    - Remove the 7 inter-switch links between the leaf switches within the Quarter Rack or Eighth Rack
    - Connect each leaf switch in the Quarter Rack or Eighth Rack to each spine switch in the other racks
      - Use 2 links for each connection if there are 4 or less other racks
      - Use 1 link for each connection if there are more than 4 other racks

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InfiniBand Network External Connectivity

- Six ports on each leaf switch are reserved for external connectivity.
- External connectivity ports can be used for:
  - Connecting to media servers for tape backup
  - Connecting to external ETL servers
  - Client or application access
    - Including Oracle Exalogic Elastic Cloud
- Use bonded network interfaces from the external device for high availability.
  - Connect each of the bonded links to separate leaf switches.

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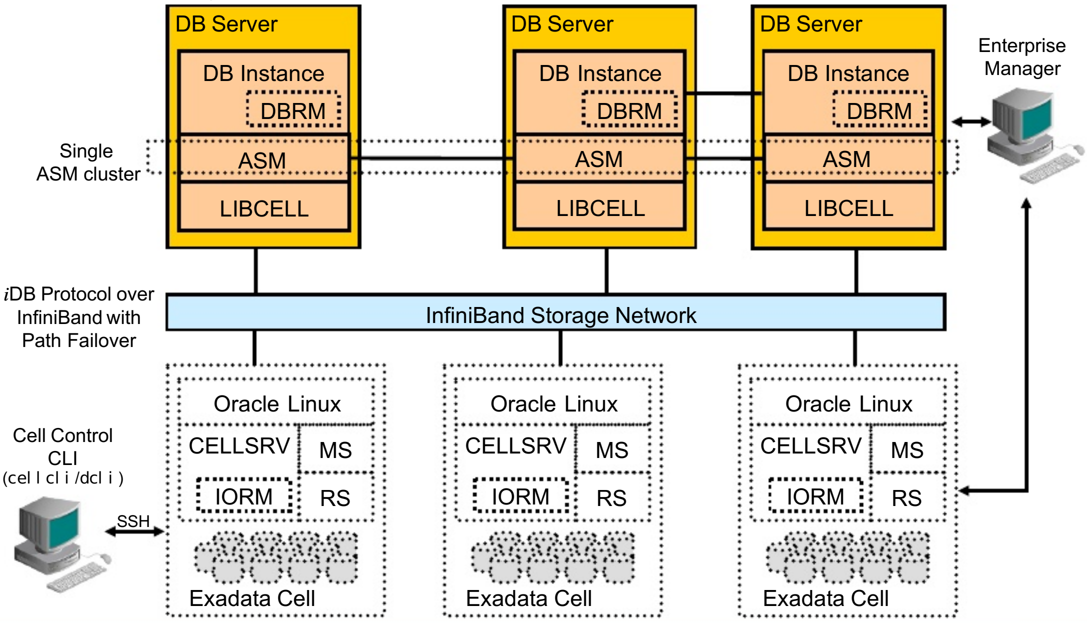
Database Machine
Software Architecture: Overview



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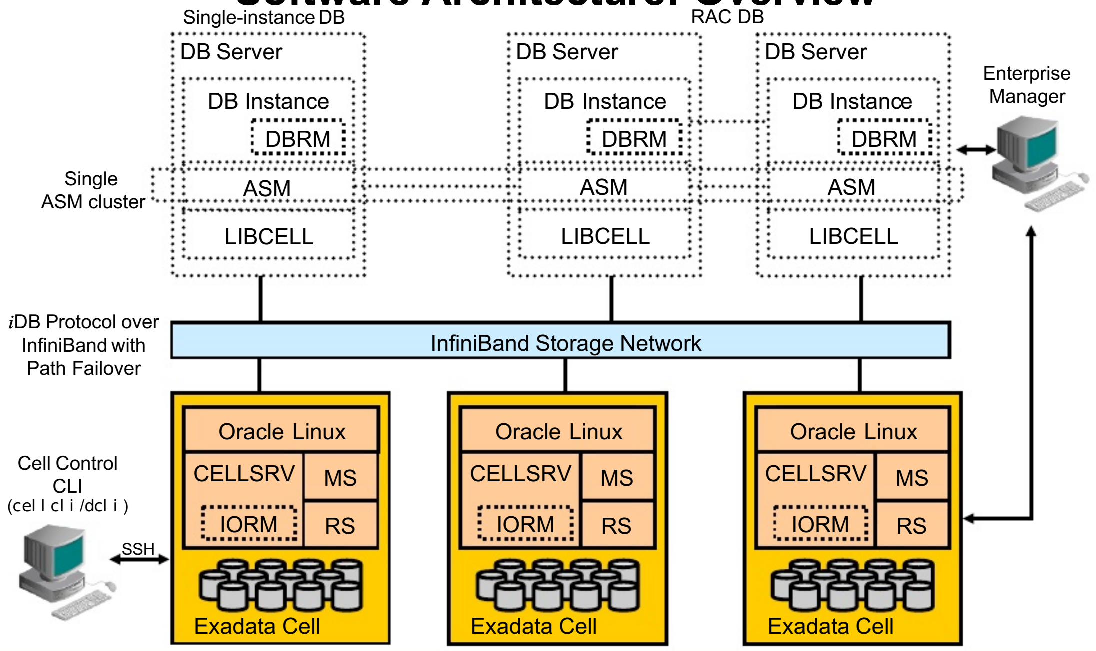
Database Machine Software Architecture: Overview



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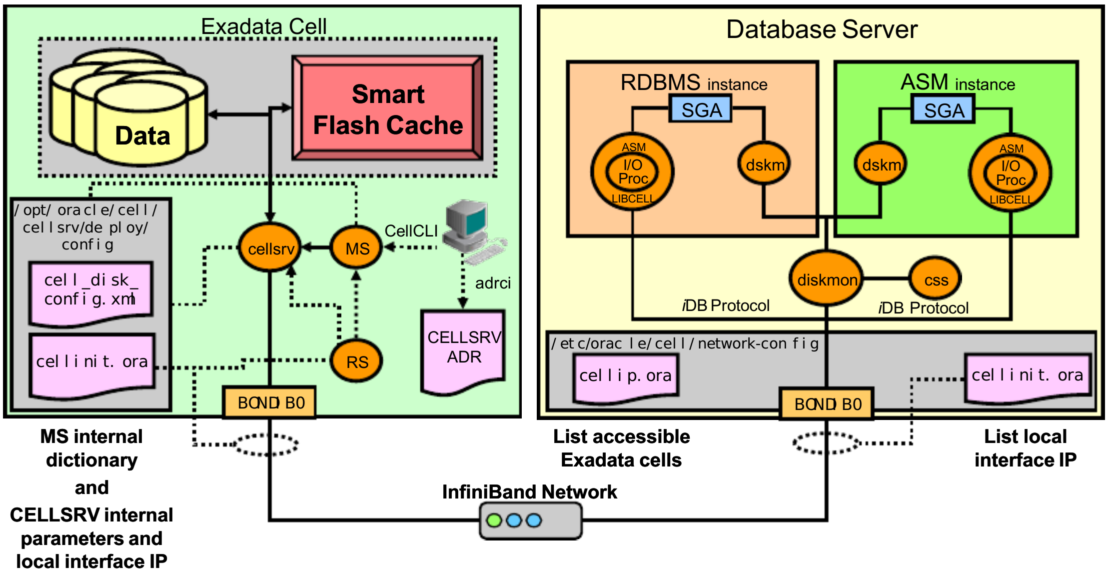
Database Machine Software Architecture Details



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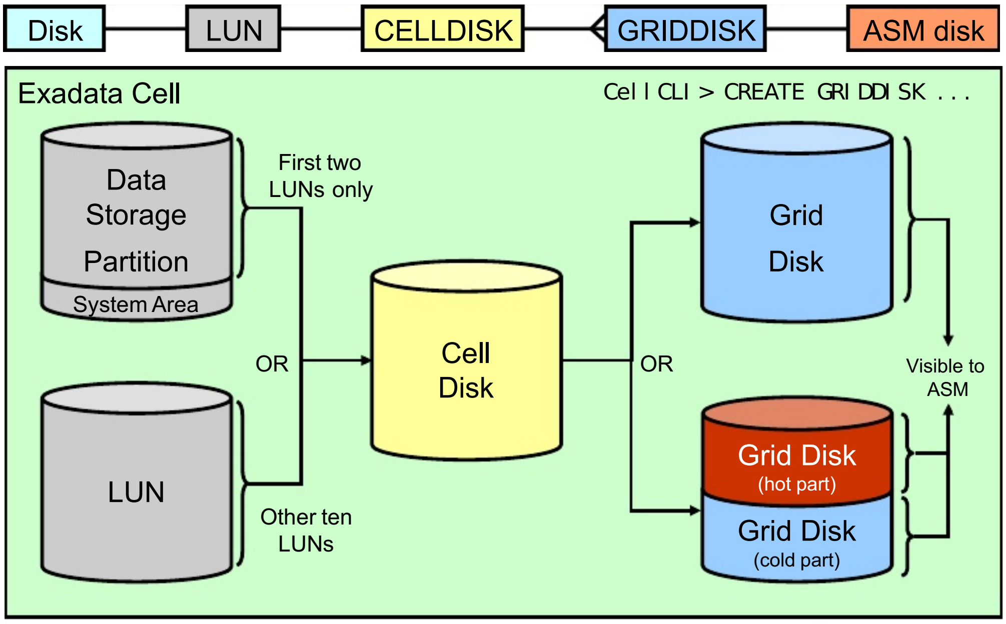
Disk Storage Entities and Relationships



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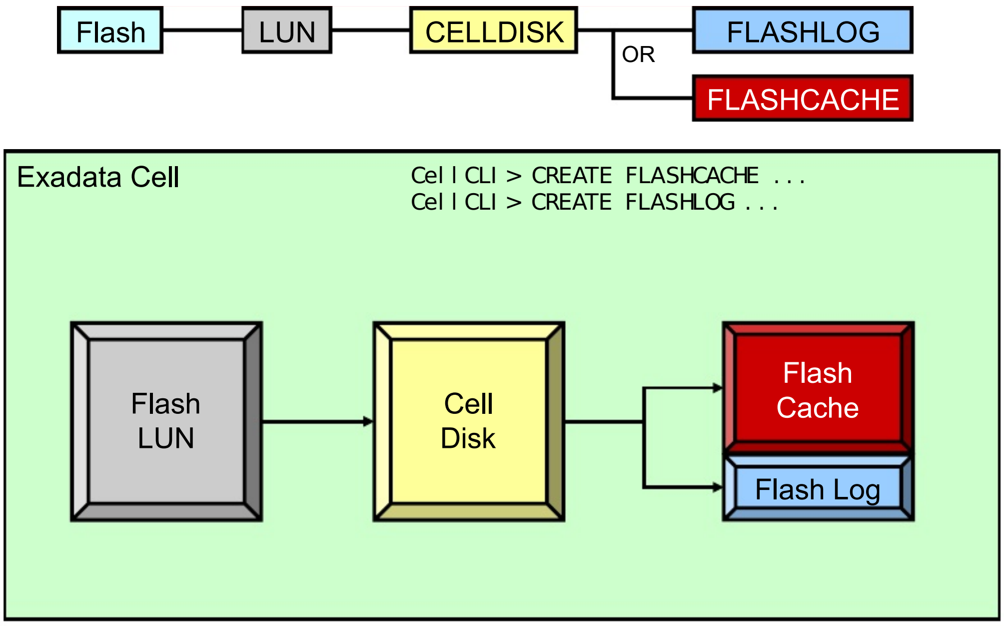
Flash Storage Entities and Relationships



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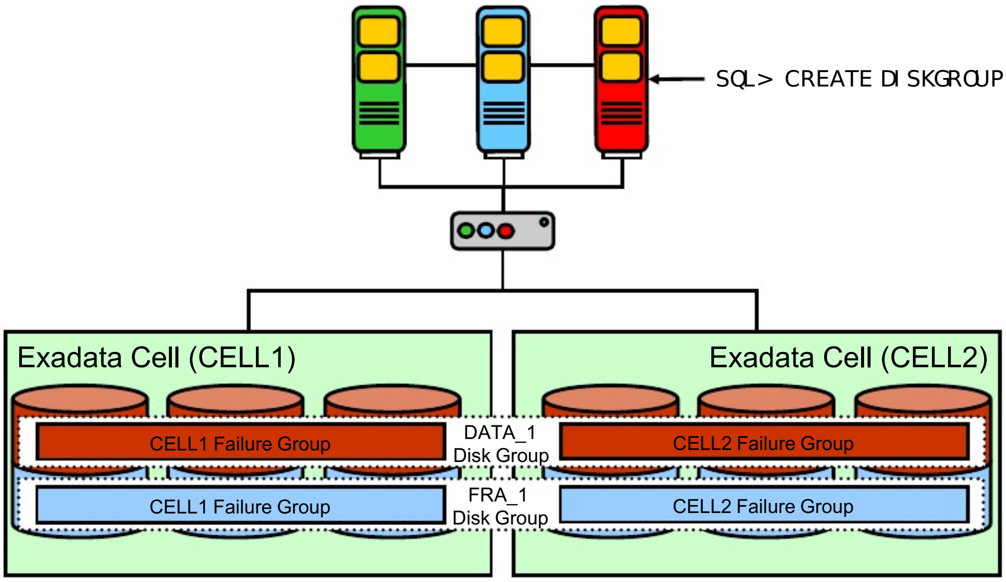
Disk Group Configuration



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Quiz

Which are the three main Exadata services?

a. OMS
b. MS
c. GMON
d. CELLSRV
e. RS

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Quiz

In which of the following scenarios will you maintain data availability if you use NORMAL ASM redundancy for all of your disk groups in conjunction with ASM failure groups spread across two or more Exadata cells?

a. A single disk failure in a single cell
b. Simultaneous failure of multiple disks in a single cell
c. Simultaneous failure of a disk in two cells
d. Complete failure of a single cell

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Quiz

Bonding is used for the InfiniBand network interfaces on Database Machine servers to provide:

a. Fault tolerance and high availability
b. Increased bandwidth and performance

c. Both of the above

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Quiz

Which of the following scalability options are supported?

a. Upgrading a Quarter Rack Database Machine to a Half Rack Database Machine
b. Upgrading a Half Rack Database Machine to a Full Rack Database Machine
c. Interconnecting two Quarter Rack Database Machines
d. Interconnecting two or more Full Rack Database Machines

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Summary

In this lesson, you should have learned how to:

- Describe the Database Machine network architecture
- Describe the Database Machine software architecture
- Describe the Exadata Storage Server storage entities and their relationships
- Describe how multiple Database Machines can be interconnected

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Practice 3 Overview: Introducing Exadata Cell Architecture

In these practices, you will be familiarized with the Exadata cell architecture. You will:

- Examine the Exadata processes
- Exercise Exadata high availability
- Examine the hierarchy of cell objects
- Examine Exadata Smart Flash Cache

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4

Key Capabilities of Exadata Database Machine

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Objectives

After completing this lesson, you should be able to describe the key features of Exadata Database Machine.

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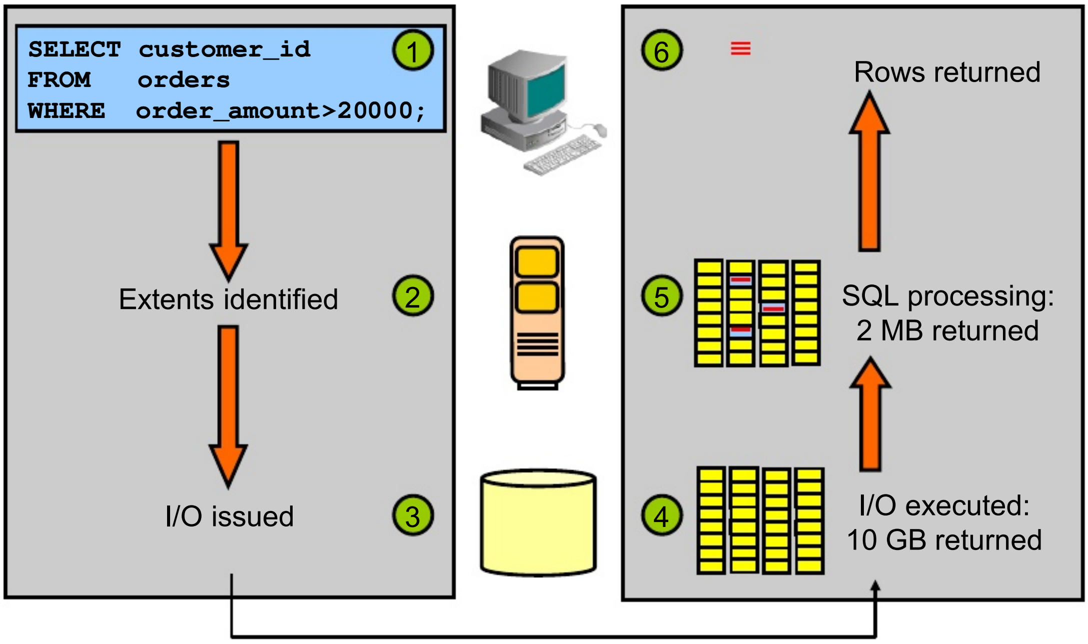
Classic Database I/O and SQL Processing Model



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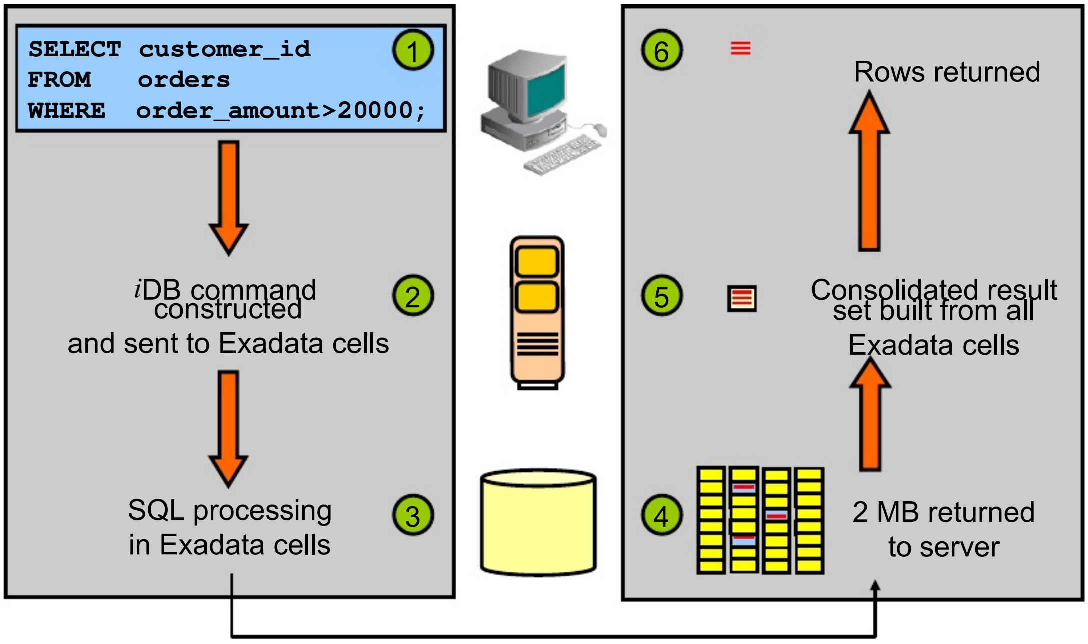
Exadata Smart Scan Model



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Exadata Smart Storage Capabilities

- Predicate filtering:
  – Only the requested rows are returned to the database server rather than all the rows in a table.
- Column filtering:
  – Only the requested columns are returned to the database server rather than all the columns in a table.
  – Example:

```
SQL> SELECT name FROM employees WHERE LENGTH(name) > 5;
```

  – With predicate and column filtering, only the employee names that are longer than five characters are sent to the database servers.
  – Without filtering, the entire `employees` table must be sent from storage to the database server.

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Exadata Smart Storage Capabilities

- Join processing:
  - Star join processing is performed within Exadata Storage Server.
- Scans on encrypted data
- Scans on compressed data
- Scoring for Data Mining
  - Example:

```
SELECT cust_id
FROM customers
WHERE region = 'US'
AND prediction_probability(churnmod,'Y' using *) > 0.8;
```


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Exadata Smart Storage Capabilities

- Create/extend tablespace:
  - Exadata formats database blocks.
- Backup and recovery:
  - I/O for incremental backups is much more efficient because only changed blocks are returned to the database server.
  - Exadata performs RMAN file restoration.

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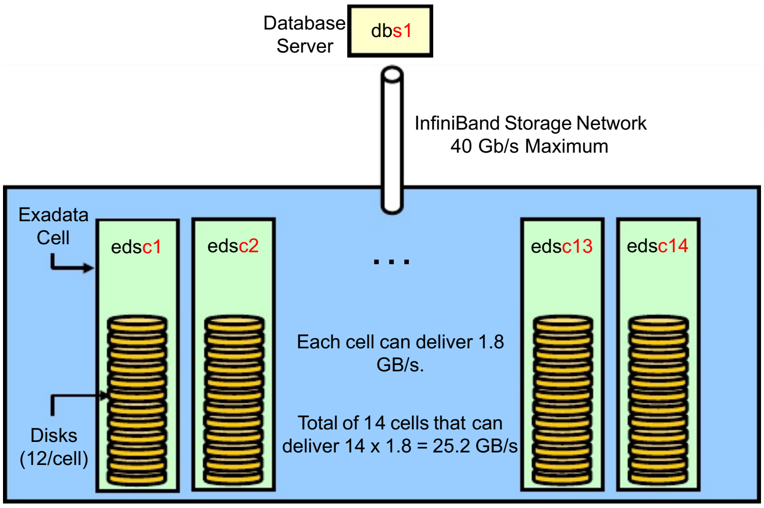
Exadata Smart Scan Scale-Out: Example



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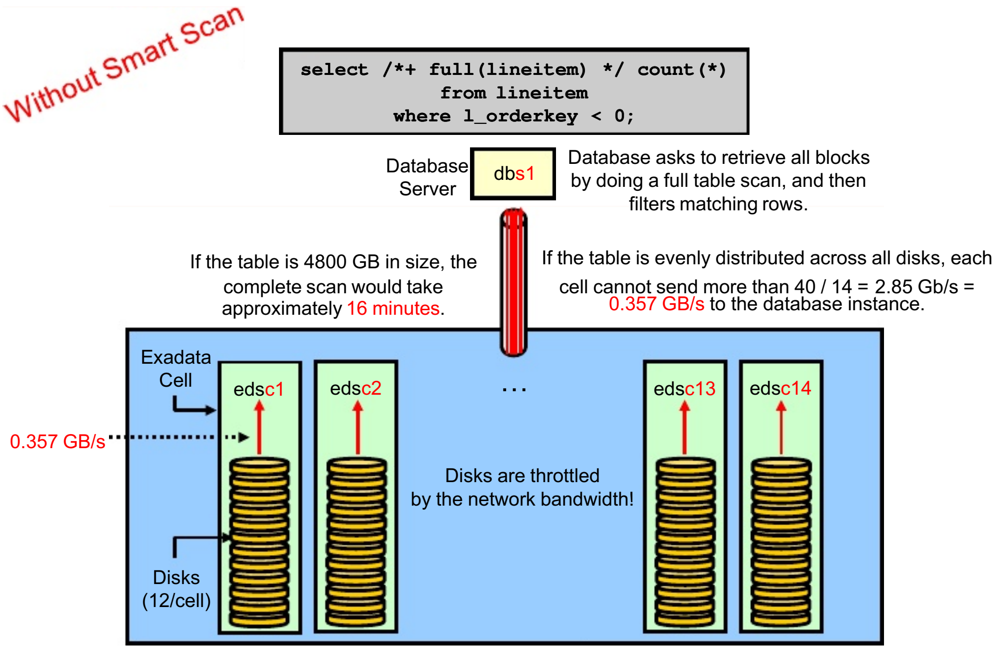
Exadata Smart Scan Scale-Out: Example



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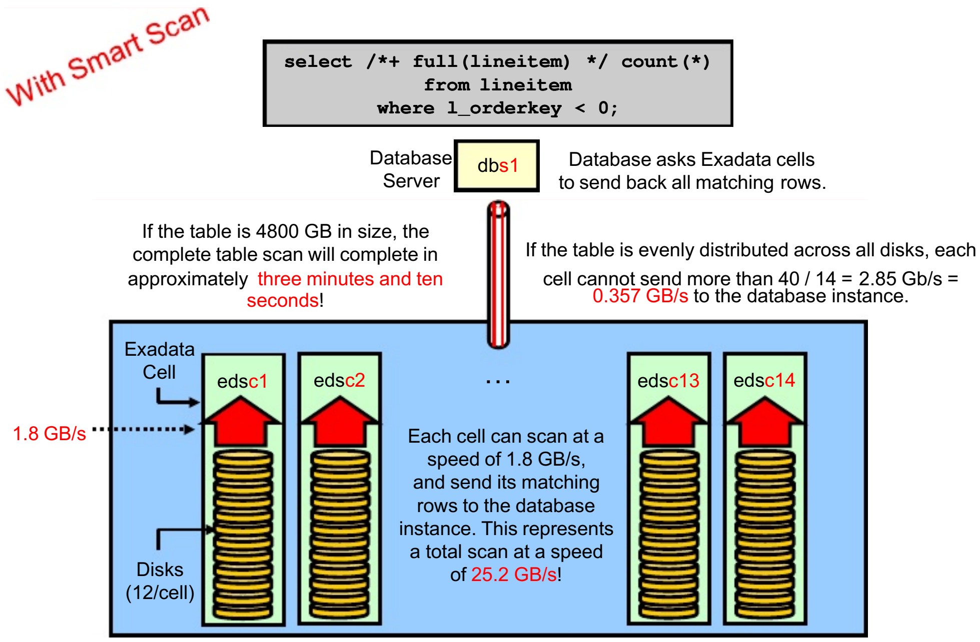
Exadata Smart Scan Scale-Out: Example



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Exadata Hybrid Columnar Compression: Overview

Warehouse Compression

Optimized for Speed

- 10x average storage savings
- 10x scan I/O reduction
- Optimized for query performance

Reduced Warehouse Size
Better Performance

Archival Compression

Optimized for Space

- 15x average storage savings
  - Up to 50x on some data
- Greater access overhead
- For cold or historical data

Reclaim Disks
Keep Data Online

Can mix compression types by partition for Information Lifecycle Management

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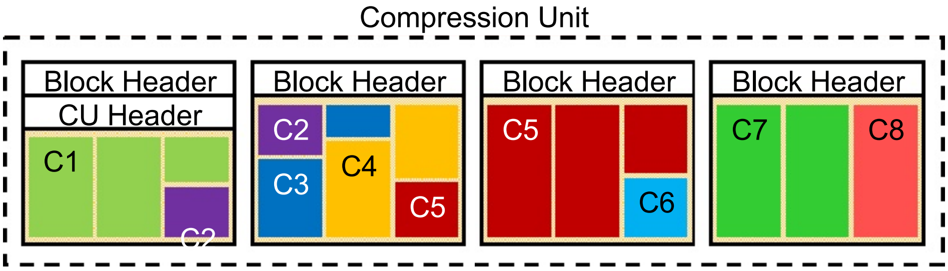
Exadata Hybrid Columnar Compression Data Organization



- A compression unit is a logical structure spanning multiple database blocks.
- Each row is self-contained within a compression unit.
- Data is organized by column during data load.
- Each column is compressed separately.
- Smart Scan is supported.

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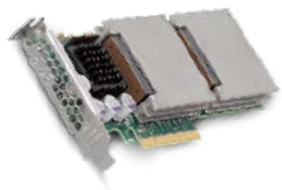
Exadata Smart Flash Cache: Overview

- High-performance cache for frequently accessed objects
- Write-through and write-back modes available
  - Write-through mode is excellent for absorbing repeated random reads.
  - Write-back mode is best for write intensive workloads.
- Allows optimization by application table

Hundreds of
I/Os per Sec

Tens of thousands
of I/Os per second



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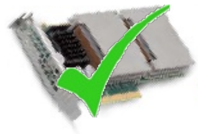
Exadata Smart Flash Cache Intelligent Caching: Overview

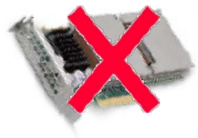
Exadata Smart Flash Cache understands different types of database I/O:

- Frequently accessed data and index blocks are cached.
- Control file reads and writes are cached.



- File header reads and writes are cached.
- DBA can influence caching priorities.

- Backup-related I/O is not cached.
- Data Pump I/O is not cached.
- Data file formatting is not cached.
- Table scans do not monopolize the cache.
- I/Os to mirror copies are managed intelligently.



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Exadata Smart Flash Cache Intelligent Caching Details

Caching is influenced by:

- The `CELL_FLASH_CACHE` storage setting:
  - `DEFAULT` uses Smart Flash Cache normally.
  - `KEEP` uses Smart Flash Cache more aggressively.
  - `NONE` specifies that Smart Flash Cache is not used.
- A cache hint, based on the reason for the I/O:
  - CACHE indicates that the I/O should be cached.
  - NOCACHE indicates that the I/O should not be cached.
  - EVICT calls for data to be removed from the cache.
- Other factors:
  - I/O size: Large I/Os are typically not cached.
  - Current load: Scans on `KEEP` objects may reference the cache to maximize overall throughput.

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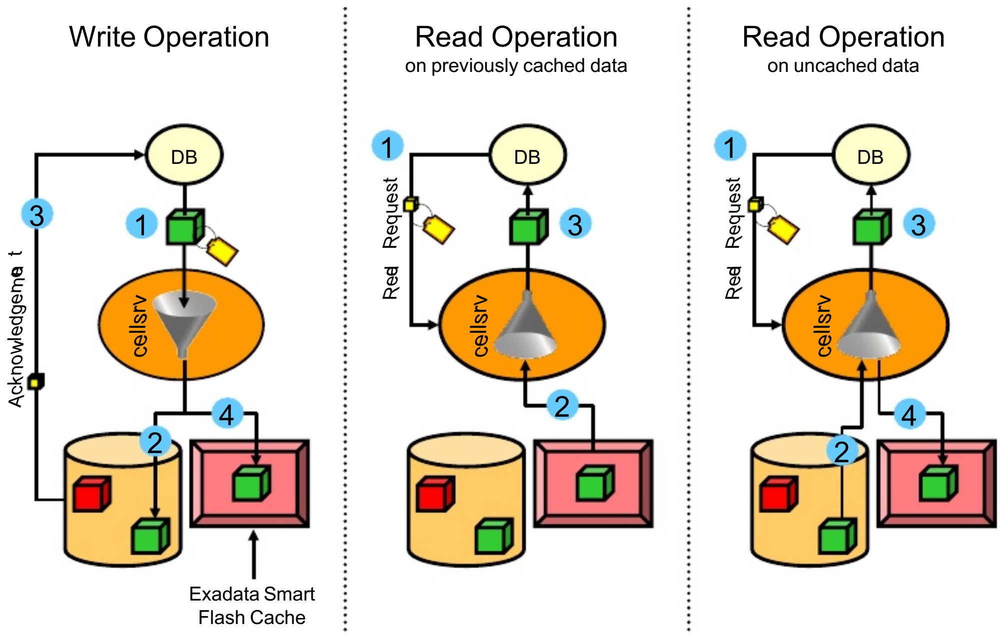
Using Exadata Smart Flash Cache: Write-Through Cache



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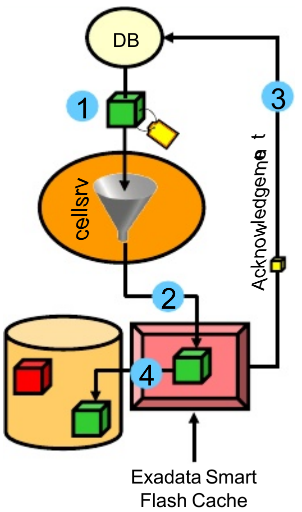
Using Exadata Smart Flash Cache: Write-Back Cache

Write Operation



- How it works:
  - Suitable writes go to flash only.
  - Data is automatically written to disk as it ages out of the cache.
  - Active data blocks can reside in flash indefinitely.
  - Reads are handled the same way as in write-through mode.
- Characteristics:
  - Ideal for write-intensive applications.
  - For many applications, most I/O is serviced by flash.
  - If a problem is detected, I/O operations transparently fail over to mirrored copies of data also on flash.

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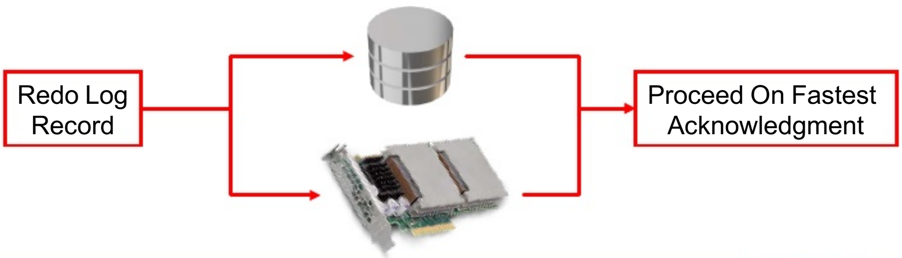
Exadata Smart Flash Log: Overview

- Exadata Smart Flash Log provides a high-performance, low-latency, reliable temporary store for redo log writes:
  - Log writes are directed to disk and Exadata Smart Flash Log.
  - Processing continues after fastest acknowledgment.
  - Conceptually similar to multiplexed redo logs.
  - Exadata Storage Server automatically manages Smart Flash Log and ensures all log entries are persisted to disk.



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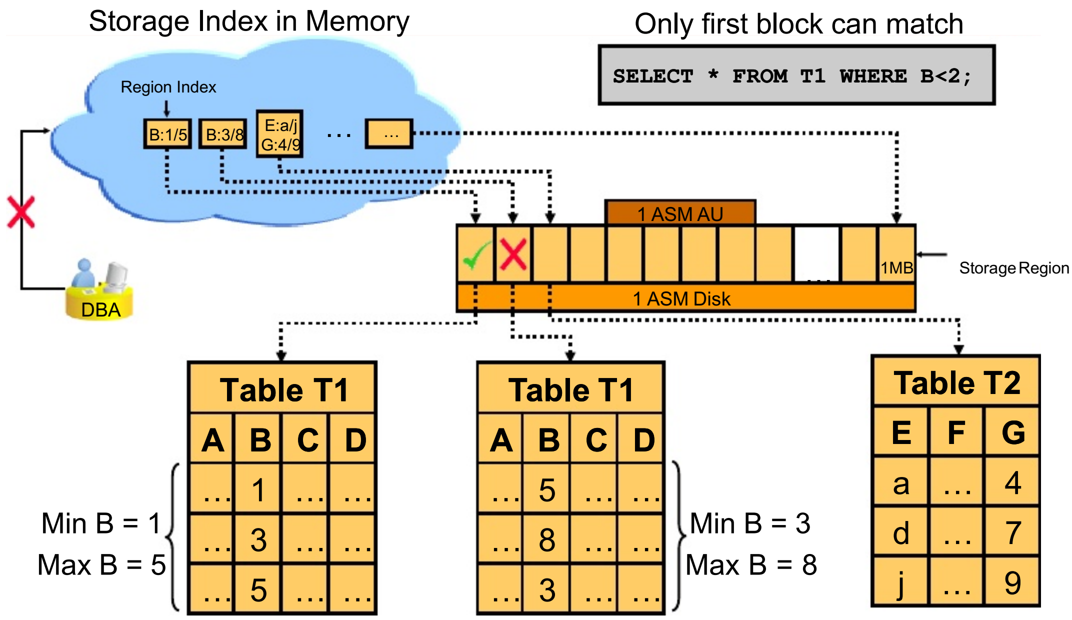
Exadata Storage Index: Overview



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Storage Index with Partitions: Example

ORDER#	ORDER_DATE (Partition Key)	SHIP_DATE	ITEM
1	2007	2007	
2	2008	2008	
3	2009	2009	

- Queries on SHIP_DATE do not benefit from ORDER_DATE partitioning:
  - However SHIP_DATE is highly correlated with ORDER_DATE.
- Storage index enhances performance for queries on SHIP_DATE:
  - Takes advantage of the ordering created by partitioning.

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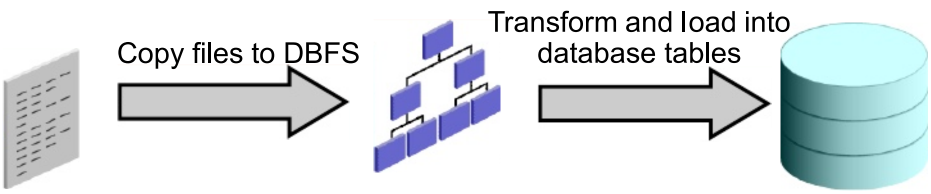
Database File System

- Database File System (DBFS) enables the database to be used as a file system.
- Files are stored as SecureFiles LOBs inside database tables:
  - Protected like any Oracle data – ASM mirroring, Data Guard, Flashback, and so on
  - Shared storage for ETL staging, scripts, reports and other application files
  - 5 to 7 GB/sec file system I/O throughput capable on a Full Rack Database Machine



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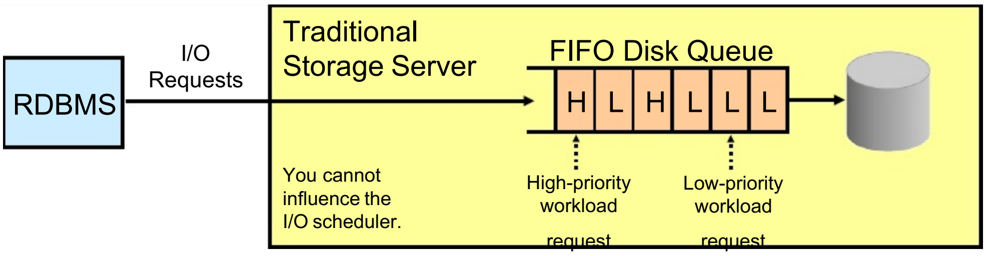
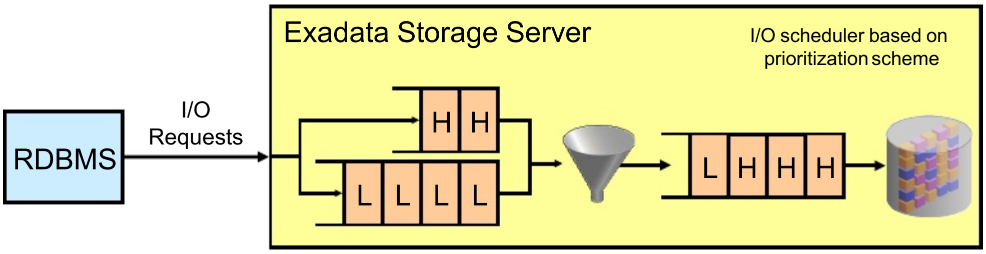
I/O Resource Management: Overview





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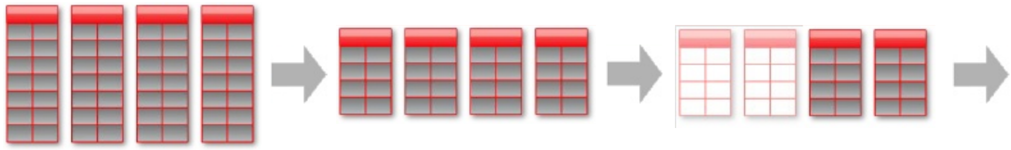
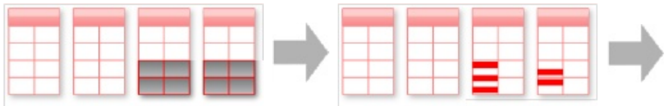
Multiplied Benefits



Multiple terabytes of user data normally requires multiple terabytes of I/O.

Less with Exadata Hybrid Column Compression

Even less with partition pruning



Storage index skips worthless I/O.

Smart scan means that only the results are returned to the database.

Results in real-time on Database Machine

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Quiz

Which of the following Exadata Database Machine features are also available on platforms other than Exadata Database Machine?

a. Smart Scan
b. Hybrid Columnar Compression
c. Smart Flash Cache
d. Storage Index
e. Database File System
f. I/O Resource Management
g. All of the above
h. None of the above

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Summary

In this lesson, you should have learned how to describe the key features of Exadata Database Machine.

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Additional Resources

- Lesson demonstrations
  - Introduction to Smart Scan
  - Introduction to Exadata Hybrid Columnar Compression
  - Introduction to Exadata Smart Flash Cache
  - Examining Exadata Smart Flash Cache
  - Exadata Smart Flash Cache Architecture
  - Smart Scan Scale Out Example
  - Storage Index

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Additional Resources

- Additional demonstrations
  – Introduction to Smart Scan
  – Introduction to Exadata Hybrid Columnar Compression
  – Introduction to Exadata Smart Flash Cache

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Practice 4 Overview: Introducing Exadata Features

In these practices, you are introduced to four major capabilities of Exadata, namely:

- Smart Scan
- Exadata Hybrid Columnar Compression
- Exadata Smart Flash Cache
- Storage Index

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5

Exadata Database Machine Initial Configuration

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Objectives

After completing this lesson, you should be able to describe:

- Installation and configuration process for Database Machine
- Default configuration for Database Machine
- Supported and unsupported customizations for Database Machine

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Database Machine Implementation: Overview

Four phases:

1. Pre-installation
   - Various planning and scheduling activities including:
     - Site planning: space, power, cooling, logistics
     - Configuration planning: host names, IP addresses, databases
     - Network preparation: DNS, NTP, cabling
   - Oracle and customer engineers can work together
2. Installation and configuration
   - Hardware and software installation and configuration
   - Result is a working system configured by using the desired configuration settings
   - Recommended to be performed by Oracle engineers

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Database Machine Implementation: Overview

3. Additional configuration
   - Additional activities for production readiness including:
     - Reconfigure storage using non-default settings.
     - Create additional databases.
     - Configure Enterprise Manager.
     - Configure backup and recovery.
     - Connect Oracle Exalogic Elastic Cloud.
   - Conducted by customer or Oracle services engagement
4. Post-installation
   - Ongoing monitoring and maintenance
   - Conducted by customer or Oracle services engagement

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Key Documentation

Oracle Exadata Database Machine Owner's Guide

- Important reference document covering:
  - Site planning
  - Network planning
  - Initial configuration
  - Core maintenance

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Database Machine Site Preparation

- Use the following sections in the Owner's Guide to direct site preparation activities:
  - Chapter 2: Site Requirements for Oracle Exadata Database Machine
    - General Environmental Requirements
    - Space Requirements
    - Flooring Requirements
    - Electrical Power Requirements
    - Temperature and Humidity Requirements
    - Ventilation and Cooling Requirements
    - Network Connection and IP Address Requirements
  - Appendix B: Site Checklists

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Oracle Exadata Deployment Assistant: Overview

Oracle Exadata Deployment Assistant :

- Captures site-specific configuration settings including:
  - Host and domain names
  - IP addresses
  - Region and time zone information
  - Name servers and NTP time servers
  - Exadata cell notification settings
- Generates files that drive the OneCommand configuration programs
- Is a Java-based program that is part of the OneCommand patch bundle
  - My Oracle Support note 888828.1 lists the latest version

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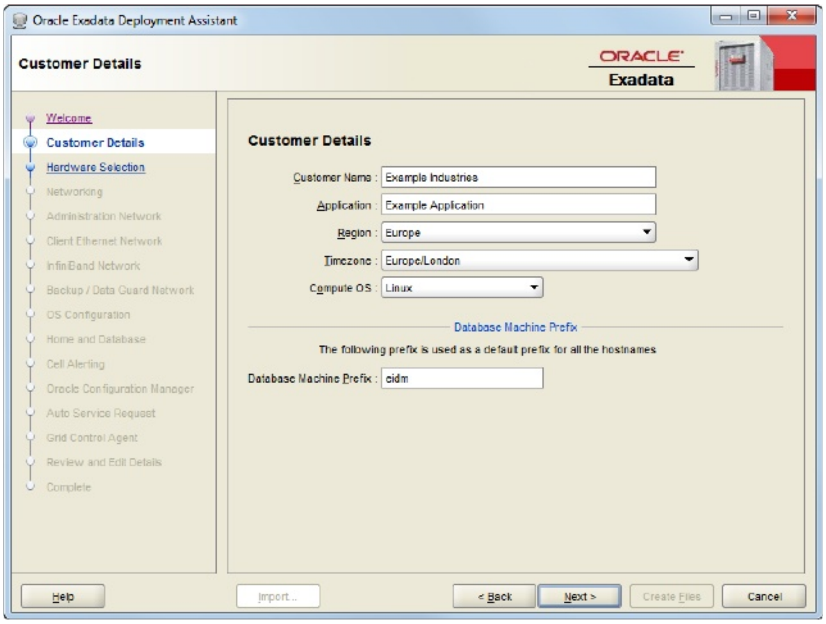
Oracle Exadata Deployment Assistant: Customer Details



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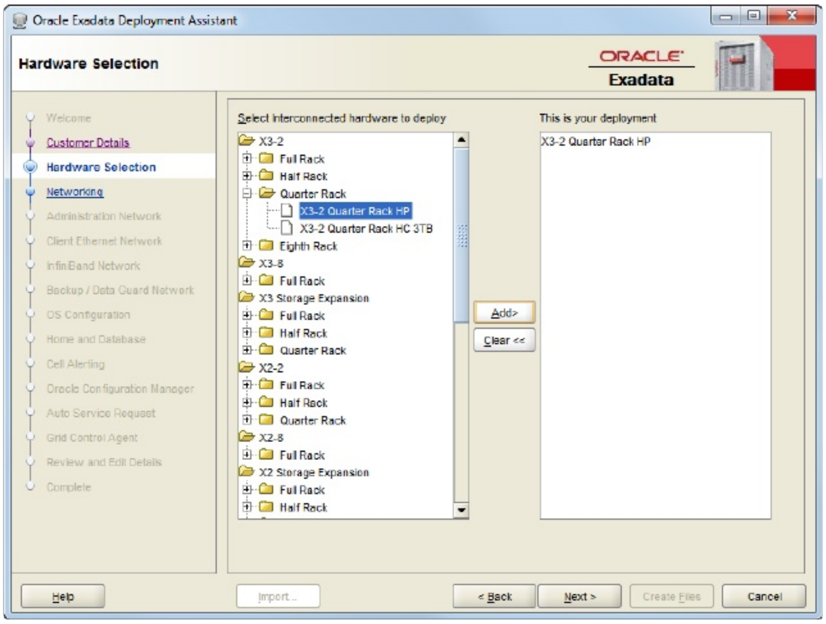
Oracle Exadata Deployment Assistant: Hardware Selection



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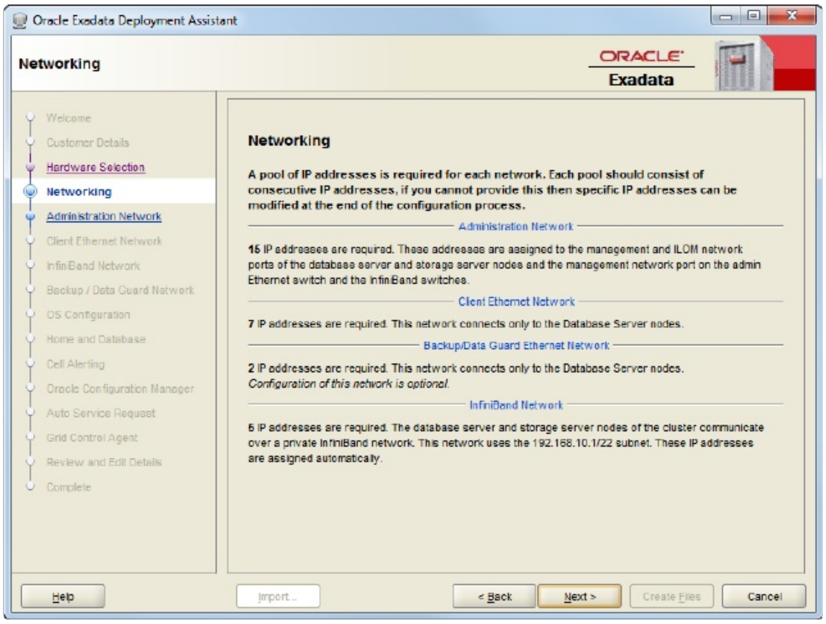
Oracle Exadata Deployment Assistant: Networking



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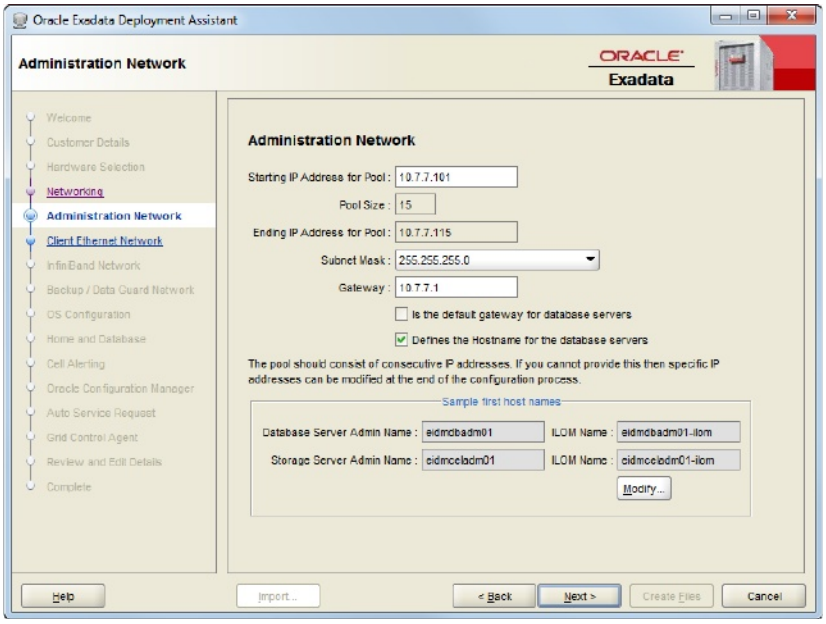
Oracle Exadata Deployment Assistant: Administration Network



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Administration Network IP Address Allocation: Example

Interface Type	Hostname	IP Address
Database server management interface	eidmdbadm01	10.7.7.101
Database server management interface	eidmdbadm02	10.7.7.102
Exadata cell management interface	eidmceladm01	10.7.7.103
Exadata cell management interface	eidmceladm02	10.7.7.104
Exadata cell management interface	eidmceladm03	10.7.7.105
Database server ILOM interface	eidmdbadm01-ilom	10.7.7.106
Database server ILOM interface	eidmdbadm02-ilom	10.7.7.107
Exadata cell ILOM interface	eidmceladm01-ilom	10.7.7.108
Exadata cell ILOM interface	eidmceladm02-ilom	10.7.7.109
Exadata cell ILOM interface	eidmceladm03-ilom	10.7.7.110
Ethernet switch management interface	eidmsw-adm0	10.7.7.111
InfiniBand switch management interface	eidmsw-iba0	10.7.7.112
InfiniBand switch management interface	eidmsw-ibb0	10.7.7.113
PDU management interface	eidm-pdua0	10.7.7.114
PDU management interface	eidm-pdub0	10.7.7.115

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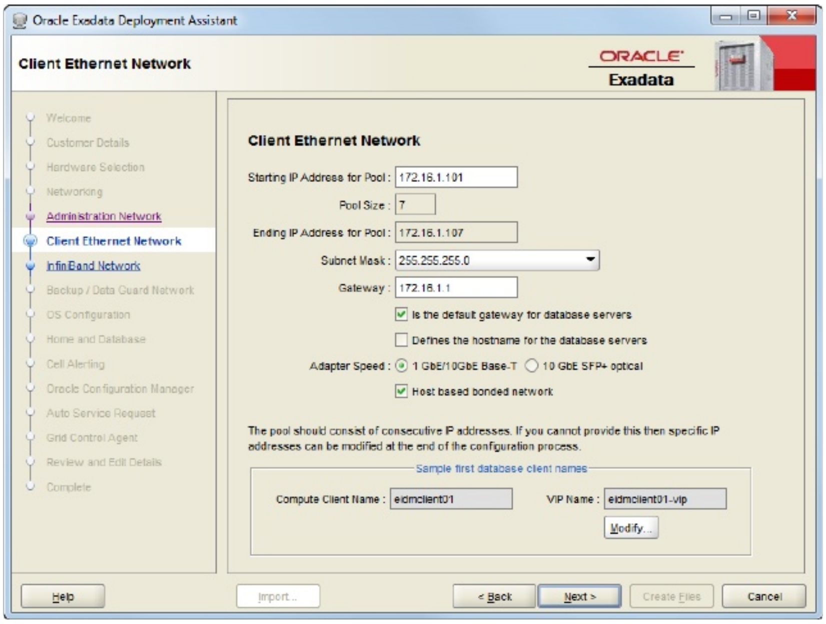
Oracle Exadata Deployment Assistant: Client Ethernet Network



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Client Ethernet Network
IP Address Allocation: Example

Address Type	Hostname	IP Address
Database server physical client access interface	eidmclient01	172.16.1.101
Database server physical client access interface	eidmclient02	172.16.1.102
Database server VIP	eidmclient01-vip	172.16.1.103
Database server VIP	eidmclient02-vip	172.16.1.104
SCAN address	eidm-scan	172.16.1.105
SCAN address	eidm-scan	172.16.1.106
SCAN address	eidm-scan	172.16.1.107

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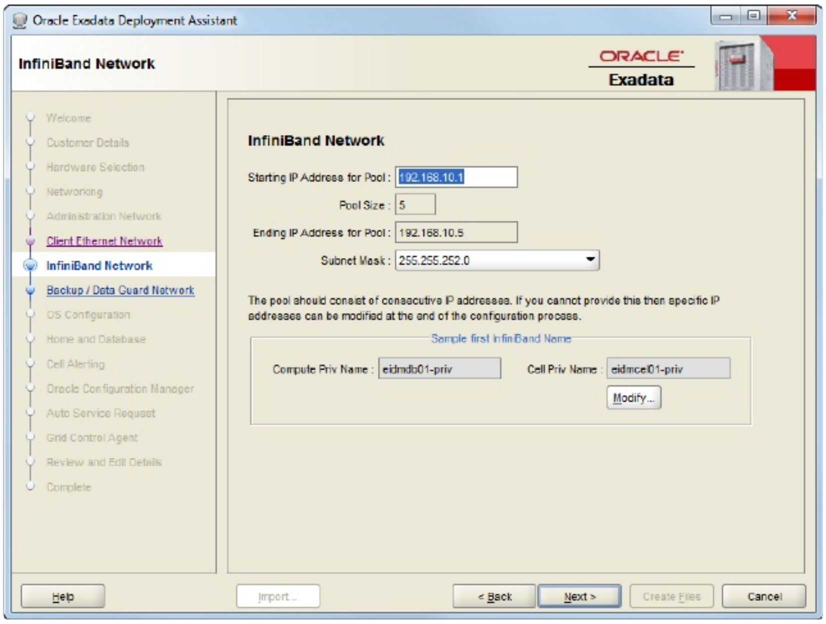
Oracle Exadata Deployment Assistant: InfiniBand Network



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InfiniBand Network IP Address Allocation: Example

Address Type	Hostname	IP Address
Database server InfiniBand network interface	eidmdb01-priv	192.168.10.1
Database server InfiniBand network interface	eidmdb02-priv	192.168.10.2
Storage server InfiniBand network interface	eidmcel01-priv	192.168.10.3
Storage server InfiniBand network interface	eidmcel02-priv	192.168.10.4
Storage server InfiniBand network interface	eidmcel03-priv	192.168.10.5

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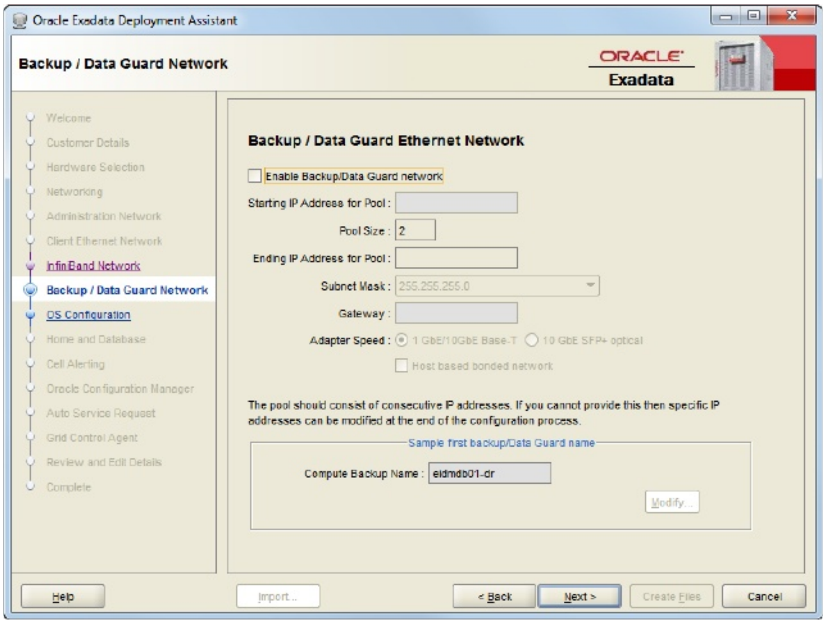
Oracle Exadata Deployment Assistant: Backup / Data Guard Network



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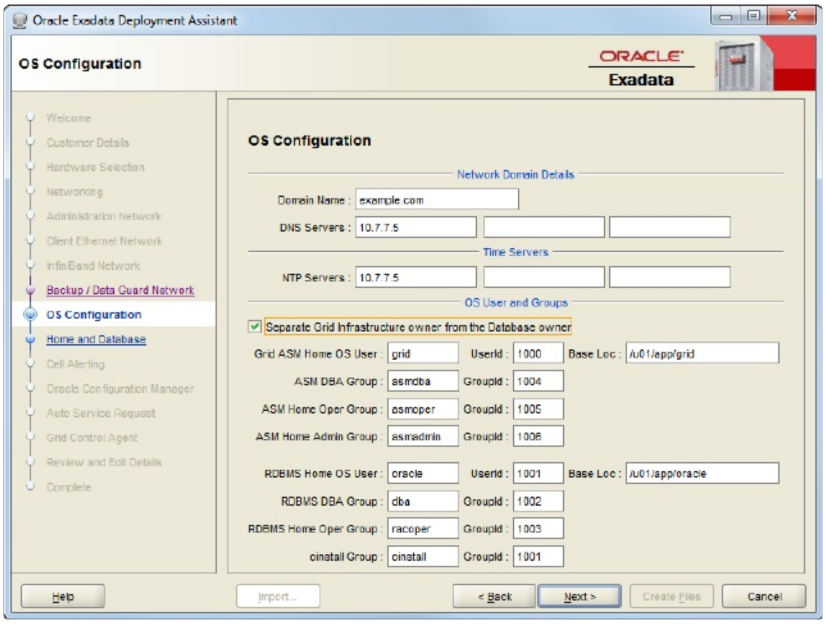
Oracle Exadata Deployment Assistant: OS Configuration



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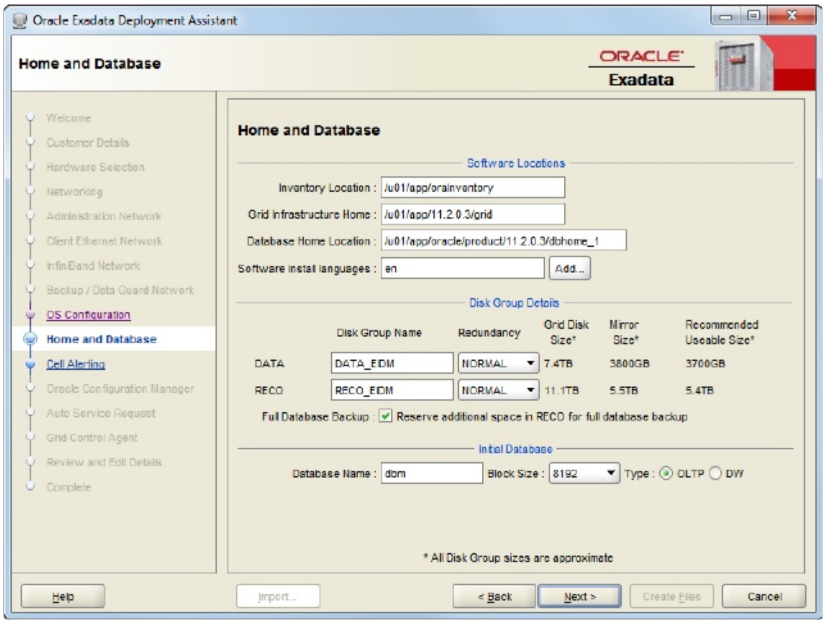
Oracle Exadata Deployment Assistant: Home and Database



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Choosing the Right Disk Group Redundancy Setting

- `HIGH` redundancy:
  - Triple mirroring across three separate storage servers
  - Provides maximum protection
    - Double mirroring still maintained if one cell is offline
  - Requires more storage capacity
  - Writes require greater I/O bandwidth.
- `NORMAL` redundancy:
  - Double mirroring across two separate storage servers
  - Provides one layer of redundancy
    - No additional protection if one cell is offline
    - Requires extra time and effort to maintain redundancy through planned maintenance
- Free space management:
  - Free space is required to preserve redundancy.
  - Consider the impact of losing a disk and the impact of losing a cell.
  - Consider also the desired protection level and the number of available cells.

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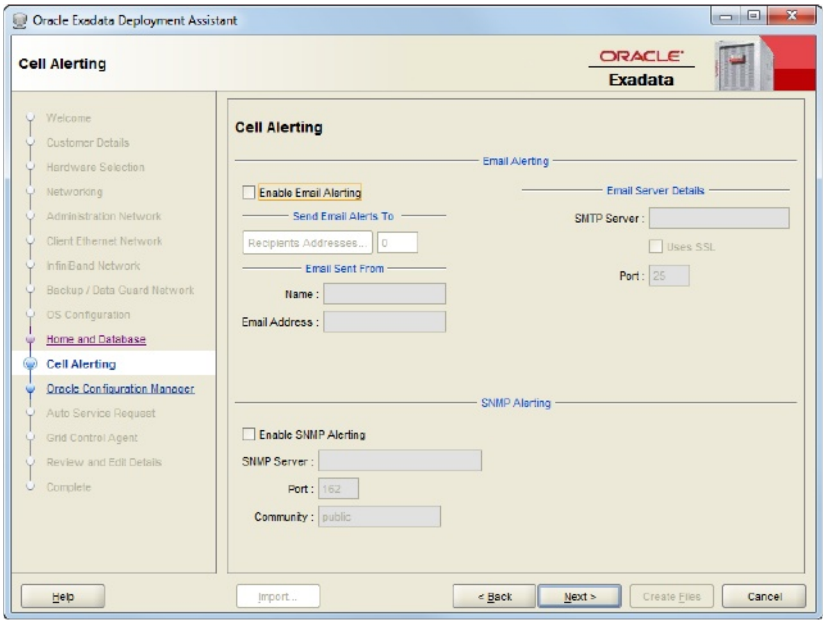
Oracle Exadata Deployment Assistant: Cell Alerting



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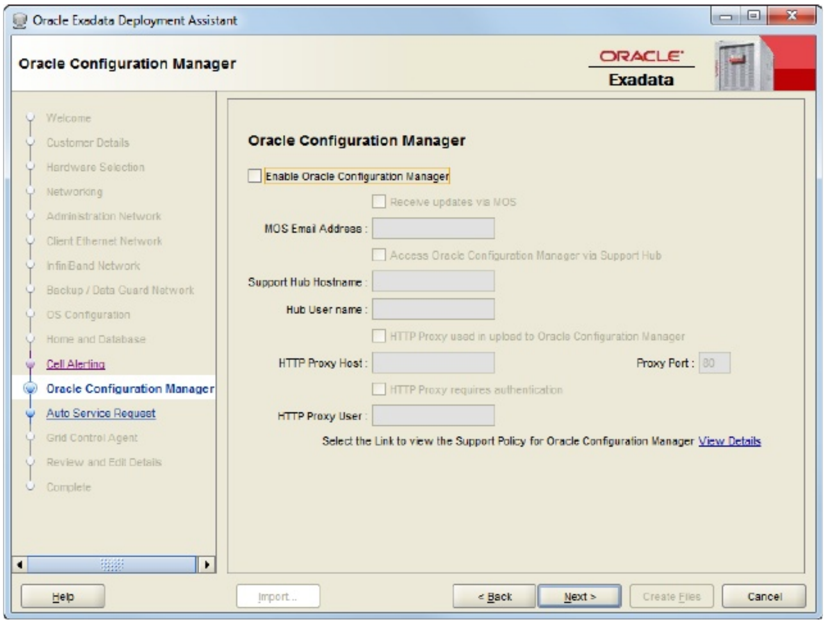
Oracle Exadata Deployment Assistant: Oracle Configuration Manager



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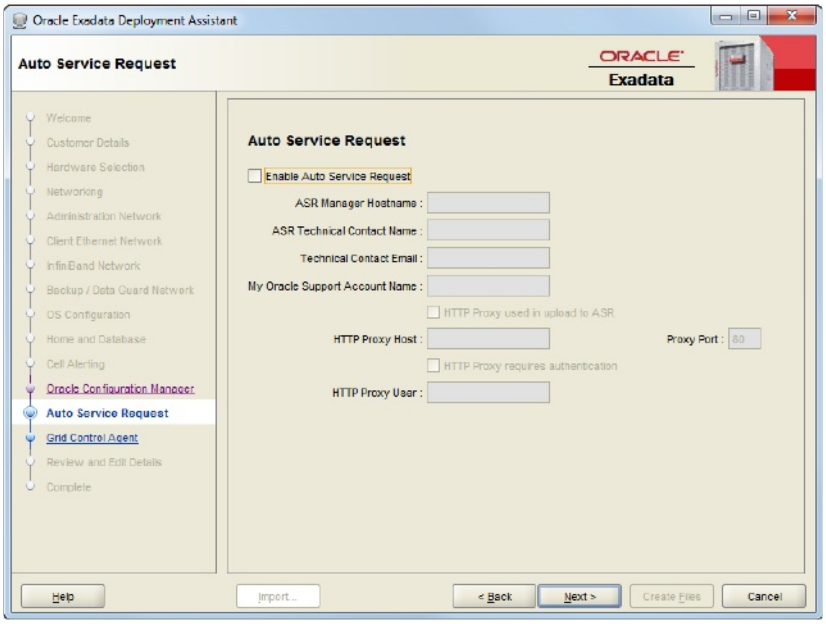
Oracle Exadata Deployment Assistant: Auto Service Request



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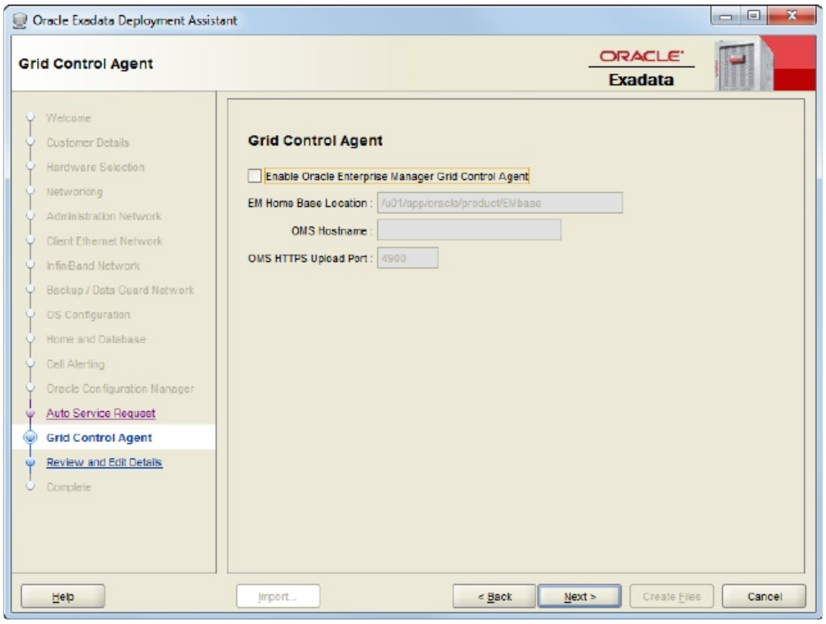
Oracle Exadata Deployment Assistant: Grid Control Agent



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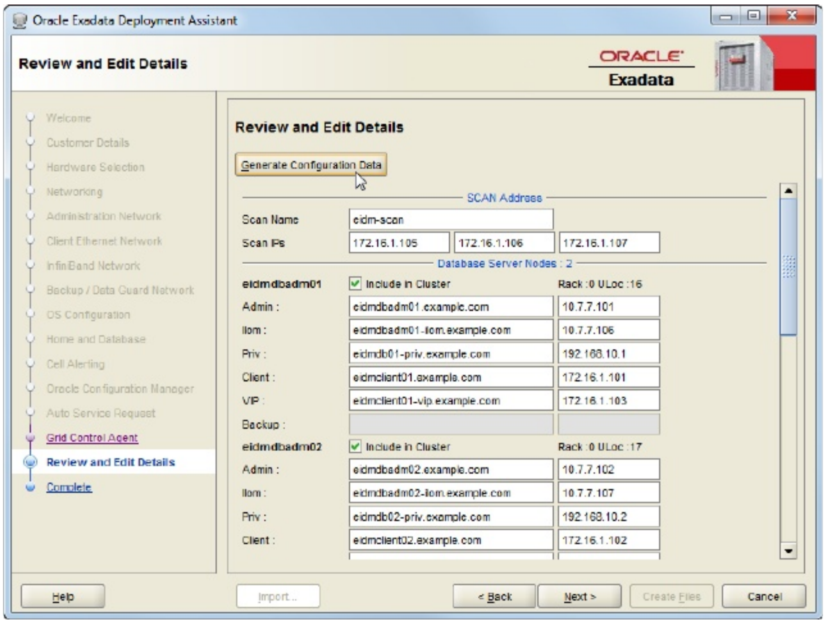
Oracle Exadata Deployment Assistant: Review and Edit Details



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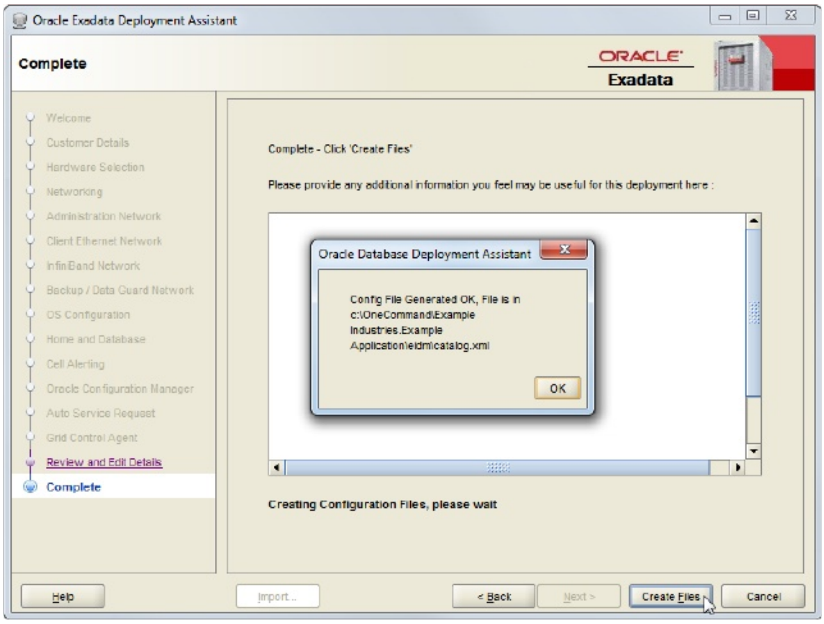
Oracle Exadata Deployment Assistant: Create Files



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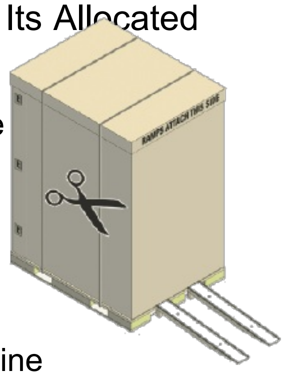
Database Machine Hardware Installation: Overview

Refer to the Owner's Guide for details on the following hardware installation tasks:

- Reviewing Safety Guidelines
- Unpacking Oracle Exadata Database Machine
- Placing Oracle Exadata Database Machine in Its Allocated Space
  - Moving Oracle Exadata Database Machine
  - Stabilizing Oracle Exadata Database Machine
  - Attaching a Ground Cable
- Powering On the System the First Time
  - Inspecting the Machine After It Is in Place
  - Connecting Power Cords
  - Powering On Oracle Exadata Database Machine



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Configuring Oracle Exadata Database Machine: Overview

- Connect to the Network.
- Configure the KVM Switch (if installed).
- Configure Sun Datacenter InfiniBand Switch 36 Switch.
- Configure the Cisco Ethernet Switch.
- Configure the Power Distribution Units.
- Check Exadata Storage Servers.
- Check Oracle Database Servers.
- Perform Additional Checks and Configuration.
- Verify the InfiniBand Network.
- Select the Operating System.
- Reclaim Disk Space After Selecting the Operating System.
- Perform Initial Network Configuration.
- Load the Configuration Information and Install the Software.
- Install Oracle Enterprise Manager.

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Selecting the Database Server Operating System

- Customers now have a choice for the database server operating system:
  - Oracle Linux X86_64 (default)
  - Oracle Solaris for x86
- Servers are shipped from the factory with both operating systems preloaded
- Space consumed by the unused operating system is reclaimed and reused

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Deploying Solaris on the Database Servers

As the `root` user on each database server:

```
# cd /opt/oracle.SupportTools
# ./defaultOSchoose.pl

Default OS is : LINUX_BOOT_0

Please choose new default OS:
[0] LINUX_BOOT_0
[1] SOLARIS_BOOT_1
[2] SOLARIS_BOOT_2
Please type the number you would like to make a new
   default OS: 1
```


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Reclaiming Unused Operating System Disk Space Using Linux

As the `root` user on each database server:

```
# cd /opt/SupportTools
# ./reclaimdisks.sh -check

<check for expected output>

# ./reclaimdisks.sh -free -reclaim

<monitor /var/log/cellos/reclaimdisks.bg.log>

# ./reclaimdisks.sh -check

<check for expected output>
```


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Reclaiming Unused Operating System Disk Space Using Solaris

As the `root` user on each database server:

```
# cd /opt/SupportTools
# ./reclaimdisks.pl

This script changes the Linux virtual and physical disks
to Solaris disks.

<Output truncated>

The virtual disks will be deleted. Do you want to
proceed? (yes/no) yes
This is an irreversible operation. Confirm that you want
to proceed.  (yes/no) yes

Deleting the virtual disks ...

<Output continues>
```


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Performing Initial Network Configuration

IP addresses and host names are applied to the Database Machine servers:

```
# cd /opt/oracle.SupportTools/firstconf
# ./applyconfig.sh -preconf \
  /opt/oracle.SupportTools/onecommand/preconf.csv \
  -dbm-node-ips <size>
```

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Loading the Configuration Information and Installing the Software

Steps performed by OneCommand:

- Step 0: Validate the environment.
- Step 1: Create work directory.
- Step 2: Unzip files.
- Step 3: Setup SSH for the `root` user.
- Step 4: Update the `/etc/hosts` file.
- Step 5: Create the `cellip.ora` and `cellinit.ora` files
- Step 6: Validate the InfiniBand network.
- Step 7: Update the cell software.
- Step 8: Validate the cells.
- Step 9: Check RDS using the ping command.
- Step 10: Run `CALLIBRATE` on the cells.
- Step 11: Create the user accounts for `celladmin` and `cellmonitor`.
- Step 12: Set up SSH for the user accounts.
- Step 13: Create the grid disks.
- Step 14: Install the grid software.
- Step 15: Patch the grid home software.
- Step 16: Relink Reliable Data Socket (RDS) for Grid Infrastructure.
- Step 17: Run the grid root scripts.
- Step 18: Install the Oracle Database software.
- Step 19: Patch the database software.
- Step 20: Create the Oracle ASM disk groups.
- Step 21: Run Oracle Database Configuration Assistant.
- Step 22: Unlock Oracle Grid Infrastructure.
- Step 23: Relink RDS for Oracle Database.
- Step 24: Lock Oracle Grid Infrastructure.
- Step 25: Apply any security fixes.
- Step 26: Configure ASR.
- Step 27: Set up storage server alerts.
- Step 28: Secure Oracle Exadata Database Machine.

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Running OneCommand on Database Machine

1. Log in as the `root` user on the first database server. The default password is `welcome1`.
   - Configuration files should already be located at `/opt/oracle.SupportTools/onecommand`
2. Download all necessary Oracle Exadata Storage Server Software and Oracle Database patches.
   - See My Oracle Support note 888828.1 for details.
3. Apply updates for the OneCommand utility.
   - See associated README file for instructions.
4. Change to the OneCommand directory:

```
# cd /opt/oracle.SupportTools/onecommand
```

5. Run the OneCommand utility using the following command:

```
# ./deploy112.sh -i [ -s <n> | -r <n>-<N> | -l ]
```


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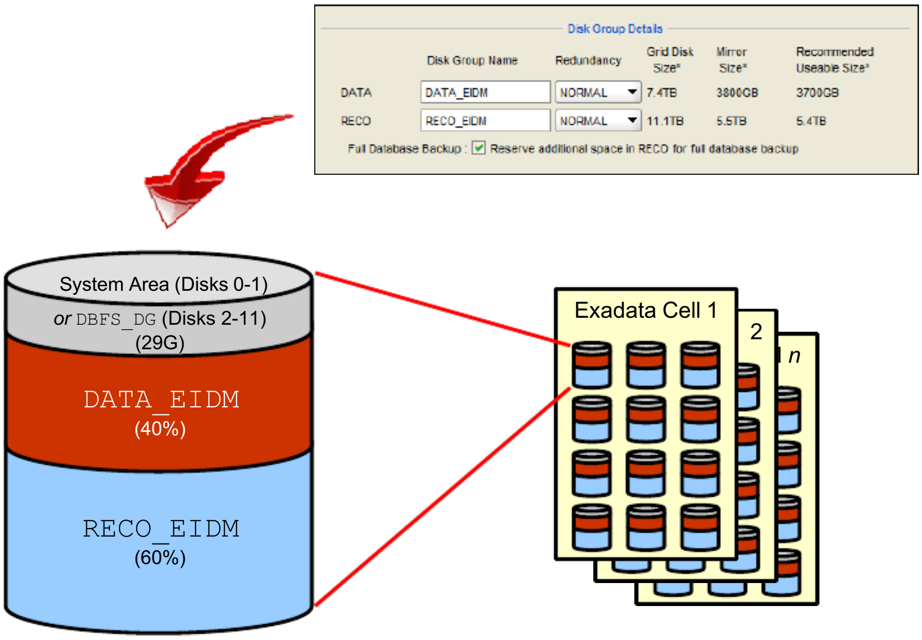
Exadata Storage Configuration



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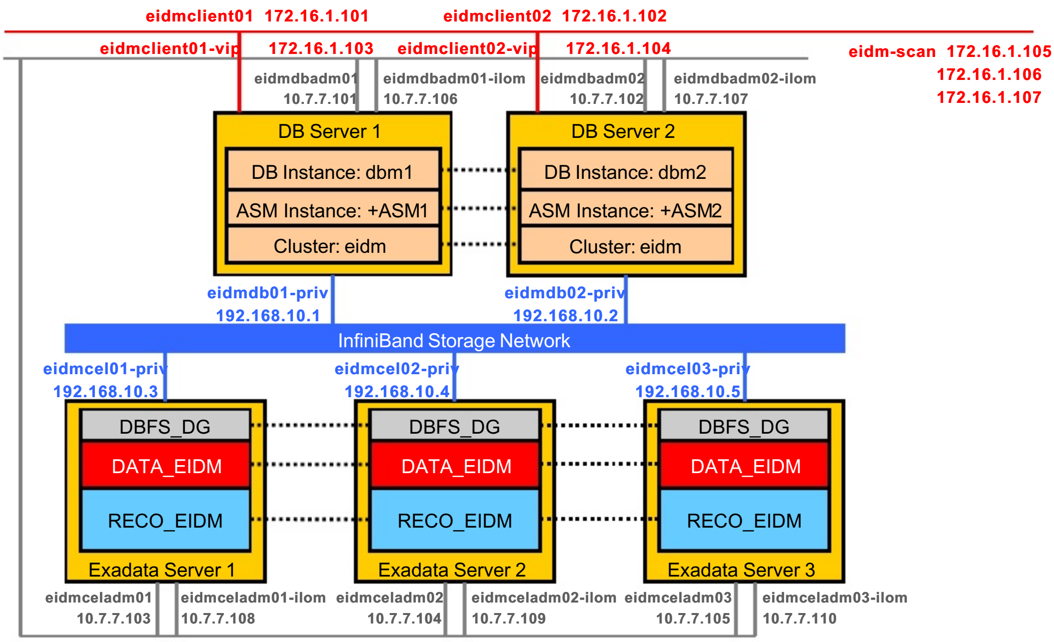
Result After Installation and Configuration



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Supported Additional Configuration Activities

- Earthquake protection using a third-party Seismic Isolation Platform

- Replace the Ethernet switch.
- Connect a tape library for backup.
- Customize the storage configuration.
- Create and configure databases.
- Configure database features.
  - Oracle Data Guard
  - Database File System (DBFS)
- Configure Enterprise Manager.

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Hardware Re-Racking

Hardware re-racking is supported subject to the following:

- Only Half Racks and smaller can be re-racked
  - Re-racking of Full Racks is not supported
- The Exadata Hardware Re-rack Service must be purchased in addition to the standard installation service.
  - Re-racking occurs prior to installation
- The customer must supply a suitable target rack.
  - The customer may also need to supply alternative PDUs
  - See your Oracle representative for detailed specifications
- The srcinal component layout must not be changed.
- No additional equipment may be installed.
- A re-racked Database Machine may be upgraded.
  - But only up to a Half Rack

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Unsupported Configuration Activities

- Adding components to servers
- Swapping Linux distributions
- Configuring ACFS

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Quiz

Using the Oracle Exadata Deployment Assistant, you can set specific IP addresses for each database server and Exadata cell in Database Machine:

a. True
b. False

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Quiz

Which of the following options for connecting to existing SAN storage is supported in conjunction with Database Machine?

a. Install a fiber channel HBA into each database server.
b. Use a server connected to the existing SAN as a storage gateway and connect it to Database Machine using NFS over Ethernet.
c. Use a server connected to the existing SAN as a storage gateway and connect it to Database Machine using NFS over InfiniBand.

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Summary

In this lesson, you should have learned how to describe:

- Installation and configuration process for Database Machine
- Default configuration for Database Machine
- Supported and unsupported customizations for Database Machine

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Practice 5 Overview: Using the Oracle Exadata Deployment Assistant

In this practice, you are introduced to the Oracle Exadata Deployment Assistant. You will use the assistant to generate a set of configuration files for an example Database Machine implementation scenario.

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Exadata Storage Server Configuration

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Objectives

After completing this lesson, you should be able to:

- Configure Exadata software
- Create and configure ASM disk groups using Exadata storage

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Exadata Storage Server Administration: Overview

- Each Exadata Storage Server is administered individually.
- Most administration is performed using CellCLI.
  - CellCLI can be executed only on the cell being administered.
  - CellCLI works in conjunction with MS to perform administration tasks.
  - CellCLI session example:

```
[celladmin@cell01 ~]$ cellcli
CellCLI: Release 11.2.3.2.1 - Production ...

CellCLI> list cell
        cell01   online

CellCLI> exit
quitting

[celladmin@cell01 ~]$
```

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Exadata Storage Server Administrative User Accounts

Three operating system users are configured for each Exadata Storage Server:

- The `root` user can:
  - Edit configuration files such as `cellinit.ora` and `cellip.ora`
  - Change network configuration settings
  - Run support and diagnostic utilities located under the `/opt/oracle.SupportTools` directory
  - Run the CellCLI `CALIBRATE` command
  - Perform all the tasks that the `celladmin` user can perform
- The `celladmin` user can:
  - Perform administrative tasks (`CREATE`, `DROP`, `ALTER`, and so on) using the CellCLI utility
  - Package incidents for Oracle Support using the `adrci` utility
- The `cellmonitor` user can only view (`LIST`) Exadata cell objects using the CellCLI utility.

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`dcli`: Overview

- The `dcli` utility allows you to simultaneously execute a command on multiple Database Machine servers.
- Command types:
  - Operating system commands
  - CellCLI commands
  - Operating system scripts
  - CellCLI scripts
- Commands are executed in separate parallel threads.
- Interactive sessions are not supported.
- Python 2.3 and SSH user-equivalence are required.
- Command output is collected and displayed in the terminal executing the `dcli` utility.

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`dcli`: Examples

```
$ dcli -g mycells date
cell01: Sun May 16 20:48:09 CDT 2010
cell02: Sun May 16 20:48:09 CDT 2010
```

```
$ dcli -c cell01,cell02 cellcli -e list cell

cell01: cell01      online
cell02: cell02      online
```

```
$ dcli -g mycells -x cellclicommands.scl
```

```
$ dcli -g mydbservers -l root -x dbwork.sh
```


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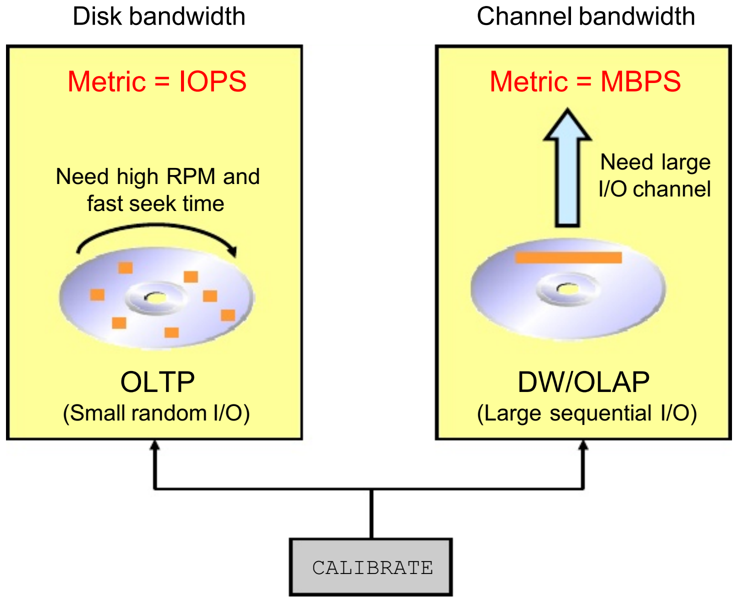
Testing Storage Server Performance by Using CALIBRATE



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CALIBRATE: Example

```
[root@cell01 ~]# cellcli
CellCLI: Release 11.2.3.2.1 ...

CellCLI> CALIBRATE FORCE
Calibration will take a few minutes...
Aggregate random read throughput across all hard disk LUNs: 1517 MBPS
Aggregate random read throughput across all flash disk LUNs: 4273 MBPS
Aggregate random read IOs per second (IOPS) across all hard disk LUNs: 4927
Aggregate random read IOs per second (IOPS) across all flash disk LUNs: 260912

Calibrating hard disks (read only) ...
LUN 0_0  on drive [20:0     ] random read throughput: 170.38 MBPS, and 412 IOPS
LUN 0_1  on drive [20:1     ] random read throughput: 168.93 MBPS, and 422 IOPS
...
LUN 0_10 on drive [20:10    ] random read throughput: 166.66 MBPS, and 424 IOPS
LUN 0_11 on drive [20:11    ] random read throughput: 171.30 MBPS, and 417 IOPS
Calibrating flash disks (read only, note that writes will be significantly slower).
LUN 1_0  on drive [FLASH_1_0] random read throughput: 270.30 MBPS, and 19946 IOPS
LUN 1_1  on drive [FLASH_1_1] random read throughput: 272.03 MBPS, and 19884 IOPS
...
LUN 5_2  on drive [FLASH_5_2] random read throughput: 271.15 MBPS, and 19861 IOPS
LUN 5_3  on drive [FLASH_5_3] random read throughput: 271.81 MBPS, and 19881 IOPS
CALIBRATE results are within an acceptable range.
Calibration has finished.

CellCLI>
```


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Configuring the Exadata Cell Server Software

```
[celladmin@cell01 ~]$ cellcli
CellCLI: Release 11.2.3.2.1 ...

CellCLI> ALTER CELL smtpServer='my_mail.example.com',          -
                   smtpFromAddr='exadata.cell01@example.com',    -
                   smtpPwd=<email_address_password>             -
                   smtpToAddr='jane.smith@example.com',         -
                   notificationPolicy='critical,warning,clear', -
                   notificationMethod='mail'
Cell cell01 successfully altered

CellCLI>
```


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Starting and Stopping Exadata Cell Server Software

```
[celladmin@cell01 ~]$ cellcli
CellCLI: Release 11.2.3.2.1 ...

CellCLI> ALTER CELL RESTART SERVICES ALL

Stopping the RS, CELLSRV, and MS services...
The SHUTDOWN of services was successful.
Starting the RS, CELLSRV, and MS services...
Getting the state of RS services...
 running
Starting CELLSRV services...
The STARTUP of CELLSRV services was successful.
Starting MS services...
The STARTUP of MS services was successful.

CellCLI>
```


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Configuring Cell Disks

```
CellCLI> CREATE CELLDISK ALL HARDDISK
CellDisk CD_00_cell01 successfully created
...
CellDisk CD_10_cell01 successfully created
CellDisk CD_11_cell01 successfully created

CellCLI> LIST CELLDISK
         CD_00_cell01    normal
         ...
         CD_10_cell01    normal
         CD_11_cell01    normal
         FD_00_cell01    normal
         ...
         FD_14_cell01    normal
         FD_15_cell01    normal

CellCLI>
```


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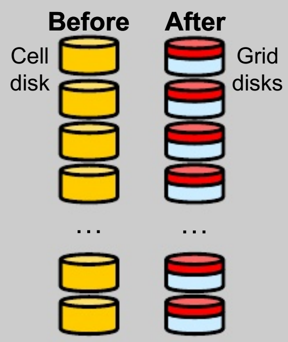
Configuring Grid Disks

```
CellCLI> CREATE GRIDDISK ALL PREFIX=data, SIZE=300G
GridDisk data_CD_00_cell01 successfully created
...
GridDisk data_CD_11_cell01 successfully created

CellCLI> CREATE GRIDDISK ALL PREFIX=fra
GridDisk fra_CD_00_cell01 successfully created
...
GridDisk fra_CD_11_cell01 successfully created

CellCLI> LIST GRIDDISK
         data_CD_00_cell01       active
         ...
         data_CD_11_cell01       active
         fra_CD_00_cell01        active
         ...
         fra_CD_11_cell01        active
CellCLI> exit
[celladmin@cell01 ~]$
```

Use fastest disk portion



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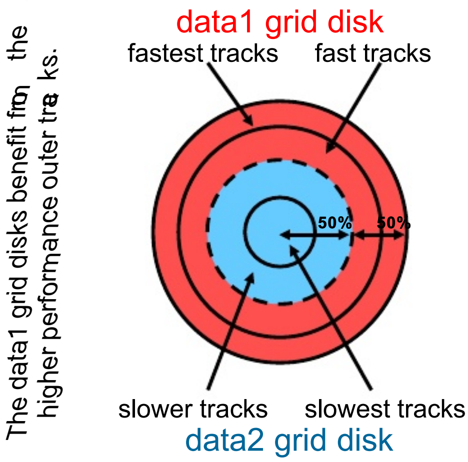
Interleaved Grid Disks

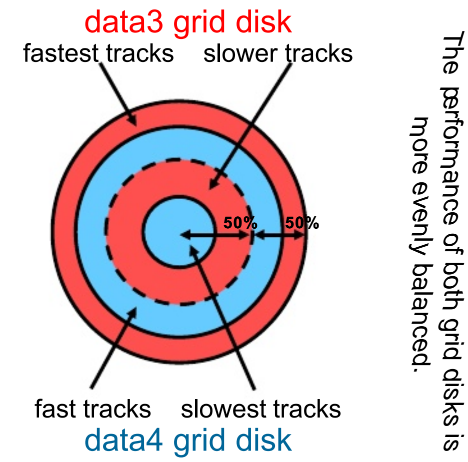
Default Grid Disk Allocation

```
CellCLI>CREATE CELLDISK ALL HARDDISK
CellCLI>CREATE GRIDDISK ALL PREFIX=data1, -
        SIZE=300G
CellCLI>CREATE GRIDDISK ALL PREFIX=data2
```



Interleaved Grid Disks

```
CellCLI>CREATE CELLDISK ALL HARDDISK –
        INTERLEAVING='normal_redundancy'
CellCLI>CREATE GRIDDISK ALL PREFIX=data3, -
        SIZE=300G
CellCLI>CREATE GRIDDISK ALL PREFIX=data4
```



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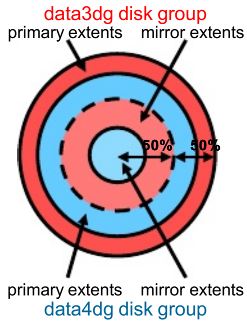
Interleaved Grid Disks and ASM Intelligent Data Placement

- Interleaved grid disks work in conjunction with ASM intelligent data placement:
  - Primary extents on the upper portion
    - Ensures that the most commonly accessed extents are on the best performing portion of disk
  - Mirror extents on the lower portion
- Intelligent data placement is automatically enabled when the disk group `REDUNDANCY` setting is compatible with the underlying `INTERLEAVING` setting
  - Incompatible settings are not allowed:
    - Cannot create disk group with incompatible settings
    - Cannot add incompatible disks to an existing disk group

```
SQL> CREATE DISKGROUP data3dg
  2  NORMAL REDUNDANCY
  3  DISK 'o/*/data3*' ...
SQL> CREATE DISKGROUP data4dg
  2  NORMAL REDUNDANCY
  3  DISK 'o/*/data4*' ...
```



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Creating Smart Flash Log

```
CellCLI> DROP FLASHCACHE
Flash cache cell01_FLASHCACHE successfully dropped

CellCLI> CREATE FLASHLOG ALL
Flash log cell01_FLASHLOG successfully created

CellCLI> CREATE FLASHCACHE ALL
Flash cache cell01_FLASHCACHE successfully created

CellCLI> exit
[celladmin@cell01 ~]$
```


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Configuring Hosts to Access Exadata Cells

- Configuration files on each database server enable access to Exadata storage.
  - `cellinit.ora` identifies the storage network interface on the database server.
  - `cellip.ora` identifies the Exadata cells that are accessible to the database server.
  - Example:

```
$ cat  /etc/oracle/cell/network-config/cellinit.ora
ipaddress1=192.168.50.23/24

$ cat  /etc/oracle/cell/network-config/cellip.ora
cell="192.168.51.27"
cell="192.168.51.28"
cell="192.168.51.29"
```


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Configuring ASM and Database Instances to Access Exadata Cells

- Ensure that a compatible version of the Oracle Database software is being used:
  – See My Oracle Support note 888828.1 for an up-to-date list of the supported versions for the Database Machine software components.
- Set the `ASM_DISKSTRING` ASM initialization parameter:
  – `ASM_DISKSTRING='o/*/*'`
- Set the `COMPATIBLE` database initialization parameter:
  – `COMPATIBLE='11.2.0.0.0'`

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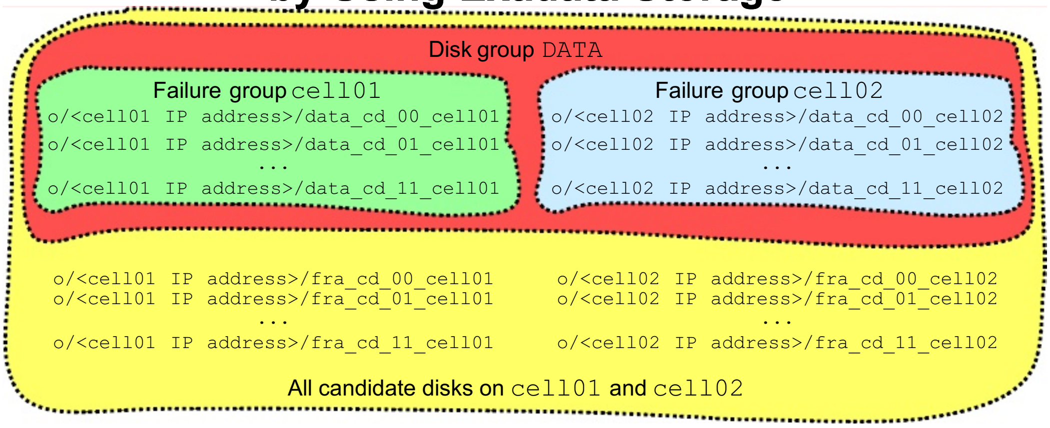
Configuring ASM Disk Groups by Using Exadata Storage




```
CREATE DISKGROUP data NORMAL REDUNDANCY
DISK 'o/*/data*'
ATTRIBUTE 'compatible.rdbms' = '11.2.0.0.0',
          'compatible.asm' = '11.2.0.0.0',
          'cell.smart_scan_capable' = 'TRUE',
          'au_size' = '4M';
```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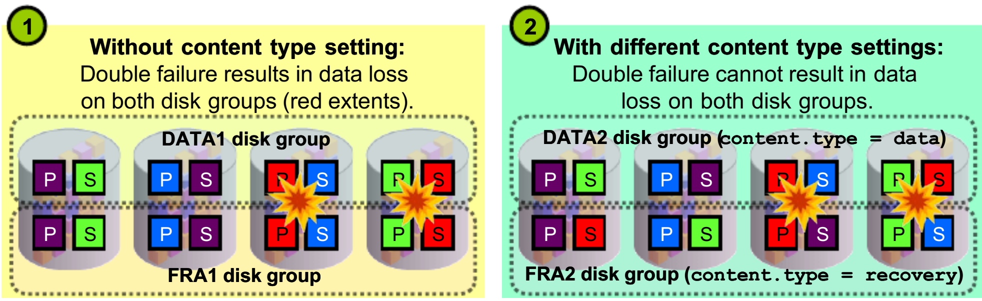
Specifying Content Type for a Disk Group

New disk group attribute in version 11.2.0.3: `content.type`

- Possible values: `data`, `recovery` or `system`
- Configuration example:

```
SQL> ALTER DISKGROUP DATA SET ATTRIBUTE 'content.type'='data';
SQL> ALTER DISKGROUP DATA REBALANCE POWER <power>;
```

- Decreases the likelihood that multiple failures impact disk groups with different content type settings



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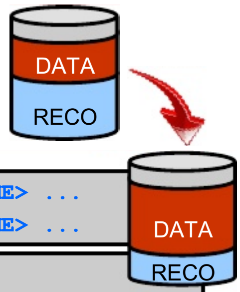
Reconfiguring Exadata Storage

Reallocating space between DATA and RECO disk groups:

- Can be performed online (without downtime)
- Can be a time consuming process
- Sufficient free space is required



- Procedure outline:

```
SQL> ALTER DISKGROUP DATA DROP DISKS IN FAILGROUP <CELLNAME> ...
SQL> ALTER DISKGROUP RECO DROP DISKS IN FAILGROUP <CELLNAME> ...
```

```
CellCLI> DROP GRIDDISK ALL PREFIX='DATA' ...
CellCLI> DROP GRIDDISK ALL PREFIX='RECO' ...
CellCLI> CREATE GRIDDISK ALL PREFIX='DATA', SIZE=<NEWSIZE>
CellCLI> CREATE GRIDDISK ALL PREFIX='RECO'
```

```
SQL> ALTER DISKGROUP DATA ADD DISK 'o/<CELL_IB_IP>/DATA*';
SQL> ALTER DISKGROUP RECO ADD DISK 'o/<CELL_IB_IP>/RECO*';
```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Optional Configuration Tasks

- Configure Exadata Storage Server security.
  – Covered in the next part of this lesson
- Configure I/O Resource Management (IORM).
  – See the lesson titled "I/O Resource Management."

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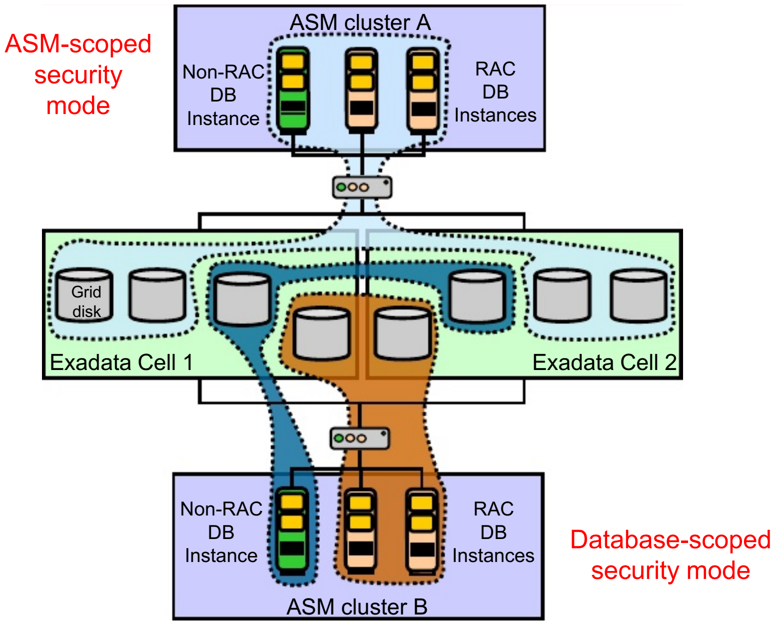
Exadata Storage Security: Overview



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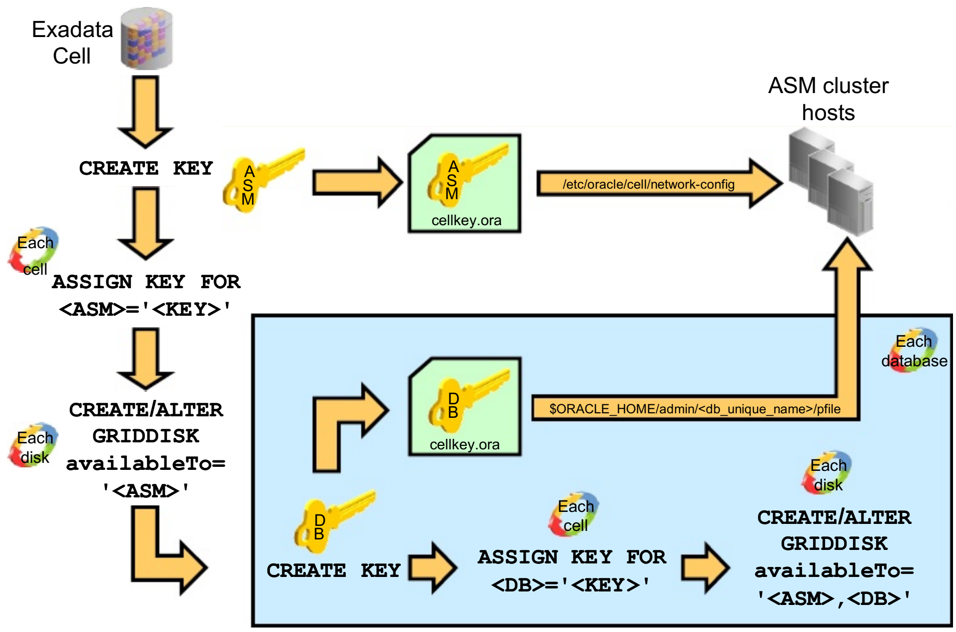
Exadata Storage Security Implementation



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Quiz

Grid disks can be viewed in ASM by using a discovery string that starts with:

a. `c/`
b. `o/`
c. `g/`
d. `e/`

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Quiz

The first grid disk you create uses the slowest tracks of the corresponding physical disk:

a. True
b. False

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Quiz

To create a disk group with Exadata smart storage capabilities enabled, which three attributes must be specified?

a. `compatible.rdbms`

b. `compatible.asm`

c. `au_size`

d. `disk_repair_time`

e. `cell.smart_scan_capable`

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Summary

In this lesson, you should have learned how to:

- Configure Exadata software
- Create and configure ASM disk groups using Exadata storage

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Additional Resources

- Lesson demonstrations
  - Exadata Storage Provisioning
  - Consuming Exadata Grid Disks Using ASM
  - Exadata Cell User Accounts
  - Using the distributed command line utility (`dcli`)

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Practice 6 Overview: Configuring Exadata

In these practices, you will perform a variety of Exadata configuration tasks, including:

- Configuring a cell
- Reconfiguring the storage in a Database Machine
- Consuming Exadata storage by using ASM
- Configuring Exadata storage security
- Exercising the privileges associated with the different cell user accounts
- Using the distributed command-line utility (`dcli`)

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7

I/O Resource Management

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Objectives

After completing this lesson, you should be able to use Exadata Storage Server I/O Resource Management to manage workloads within a database and across multiple databases.

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I/O Resource Management: Overview

- Traditional benefits of shared storage:
  - Lower administration costs
  - More efficient use of storage
- Common challenge for shared storage:
  - Workloads interfere with each other. Examples:
    - Large queries interfere with each other.
    - Data loads interfere with warehouse queries.
    - Batch workloads interfere with OLTP performance.
- Exadata Storage Server I/O Resource Management allows you to govern I/O resource usage among different:
  - User types
  - Workload types
  - Applications
  - Databases

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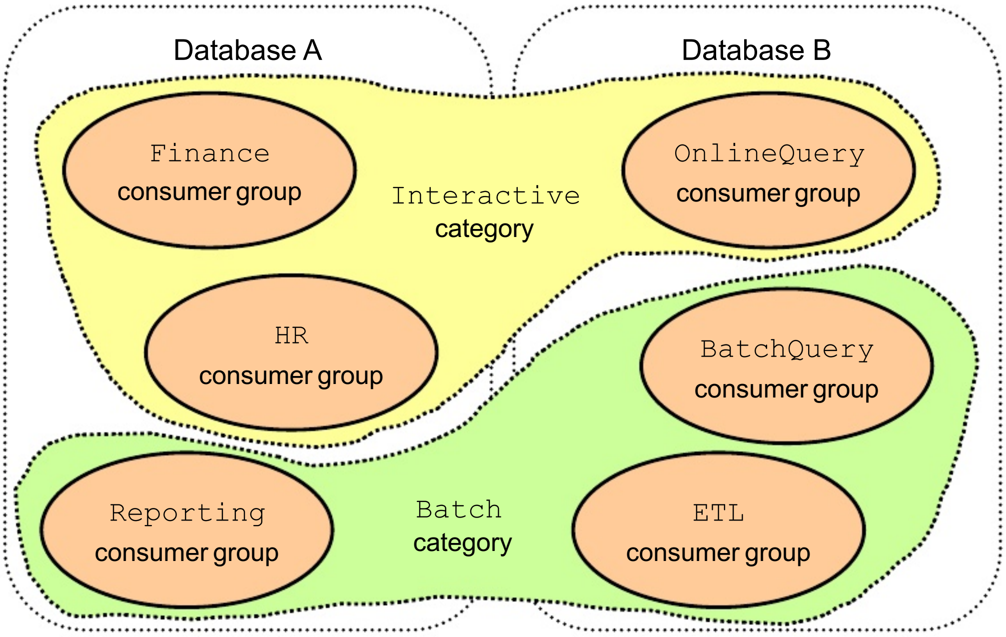
I/O Resource Management Concepts



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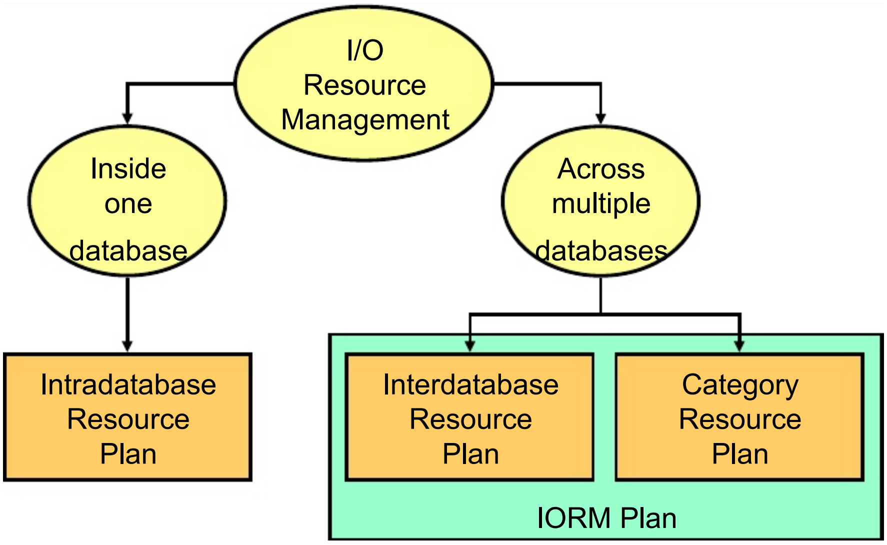
I/O Resource Management Plans



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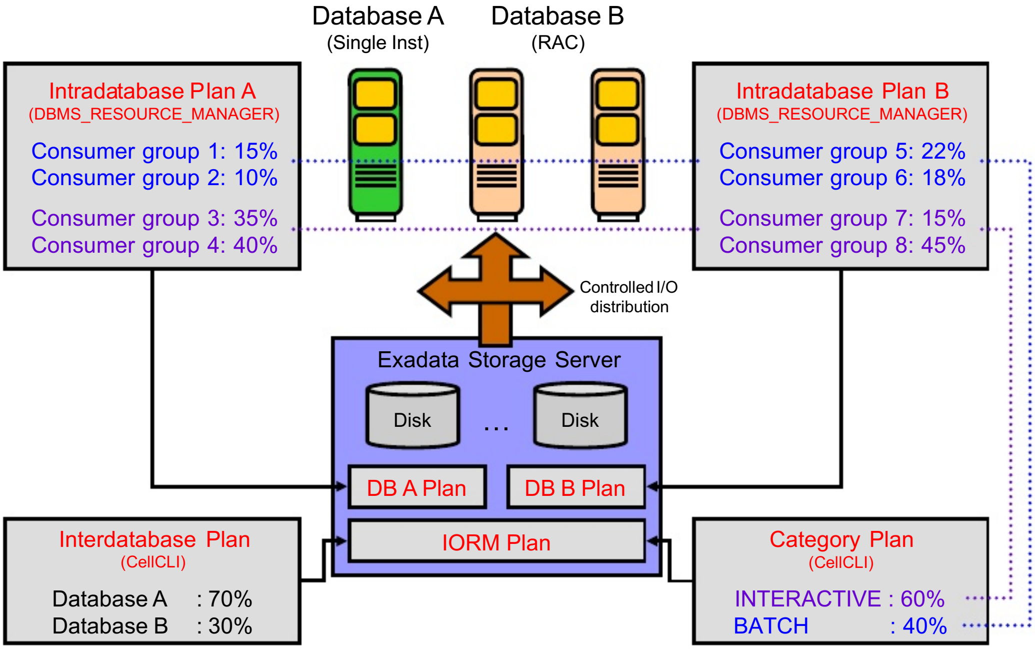
I/O Resource Management Plans: Example



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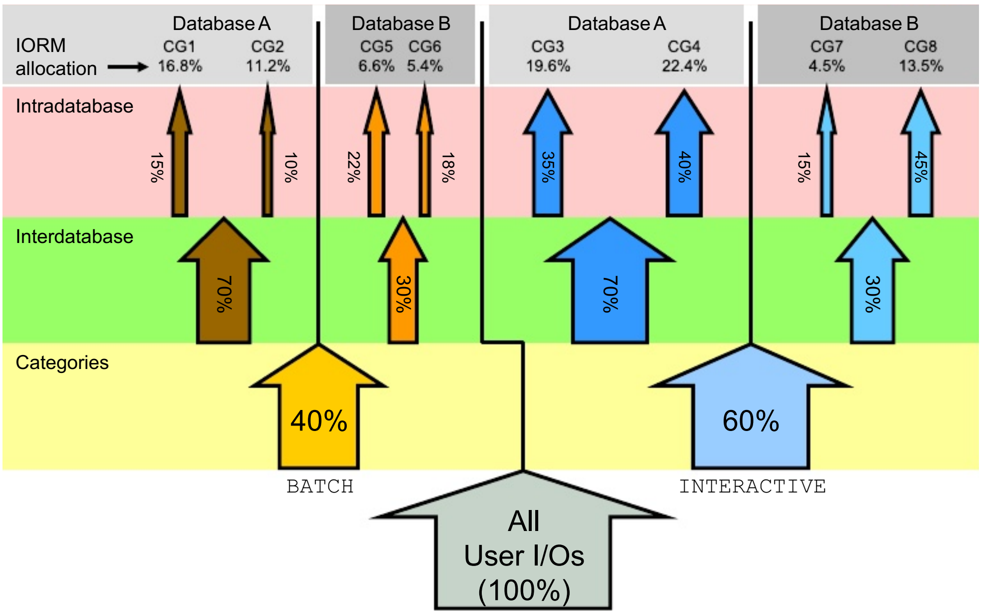
I/O Resource Management Plans: Example



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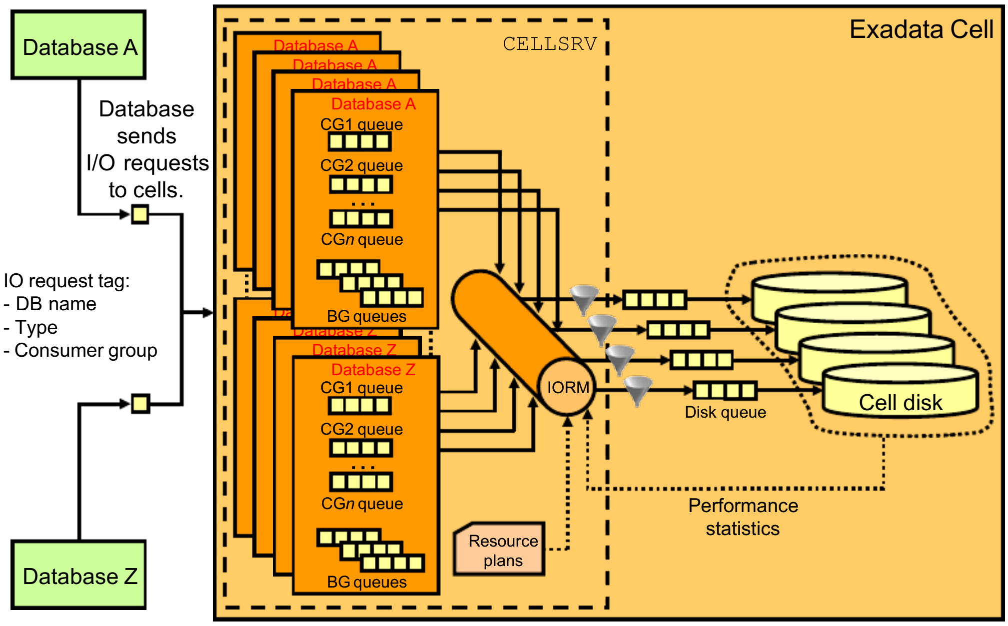
IORM Architecture



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Getting Started with IORM

```
CellCLI> list iormplan detail
         name:                    cell01_IORMPLAN
         catPlan:
         dbPlan:
         objective:               basic
         status:                  active

CellCLI> alter iormplan objective=balanced
IORMPLAN successfully altered

CellCLI> list iormplan detail
         name:                    cell01_IORMPLAN
         catPlan:
         dbPlan:
         objective:               balanced
         status:                  active
```


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Setting the IORM Objective

- Available IORM objective settings:
  - `basic`
    - IORM does not enforce user-defined plans.
    - IORM protects against extreme latencies for small I/O requests.
    - Maximum throughput is maintained.
  - `low_latency`
    - Minimizes latency by limiting the number of concurrent I/O requests
    - Useful for critical OLTP workloads
    - Performance of high-throughput workloads may suffer
  - `high_throughput`
    - Maximizes throughput by not limiting concurrent I/O requests
    - Useful for DSS and data warehouse workloads
    - Performance of latency-critical workloads may suffer
  - `balanced`
    - Balances low disk latency and high throughput
    - Useful for mixed workloads
  - `auto`
    - IORM decides the best objective setting based on active plans and workloads.

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Enabling Intradatabase Resource Management

- You can enable intradatabase resource management:
  - Manually:
    - Set the database's RESOURCE_MANAGER_PLAN parameter.
  - Automatically:
    - Create a job scheduler window.
    - Associate a resource plan with the window.
- Exadata Storage Server is notified when an intradatabase resource plan is set or modified:
  - Enabled or modified plan sent to each cell using *i*DB
- You must set the IORMPLAN objective on all Exadata cells.
- The following are the commonly used intradatabase plans:
  - mixed_workload_plan
  - dss_plan
  - default_maintenance_plan

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Intradatabase Plan: Example

```
BEGIN
 DBMS_RESOURCE_MANAGER.CREATE_SIMPLE_PLAN(SIMPLE_PLAN => 'my_plan',
          CONSUMER_GROUP1 => 'high_priority', GROUP1_PERCENT => 80,
          CONSUMER_GROUP2 => 'low_priority' , GROUP2_PERCENT => 20);
END;
/
```

```
ALTER SYSTEM SET RESOURCE_MANAGER_PLAN = 'my_plan';
```

The plan is sent directly to the Exadata cells via *i*DB.

Consumer Group	Level 1	Level 2	Level 3
SYS_GROUP	100%		
HIGH_PRIORITY		80%	
LOW_PRIORITY		20%	
OTHER_GROUP			100%

Percentages are used for both CPU and I/O resources.

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Enabling IORM for Multiple Databases

- Enable IORM for multiple databases by configuring an `IORMPLAN`:
  - The category plan assigns I/O resources using categories.
  - The interdatabase plan assigns I/O resources using database names.
  - All combinations are possible.
- Use CellCLI to define and activate the `IORMPLAN` on each cell.
- Configure the same `IORMPLAN` on each cell.
- Only one `IORMPLAN` can be active at a time on a cell.
- `IORMPLAN` settings are persistent across cell reboots.
- All databases get equal allocations in the absence of an `IORMPLAN`.

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Interdatabase Plan: Example

```
CellCLI> alter iormplan                                              -
>           dbplan=((name=sales_prod, level=1, allocation=80),       -
>                   (name=finance_prod, level=1, allocation=20),     -
>                   (name=sales_dev, level=2, allocation=100),       -
>                   (name=sales_test, level=3, allocation=50),       -
>                   (name=other, level=3, allocation=50)),           -
>           catplan=''
```

Database	Level 1	Level 2	Level 3
sales_prod	80%		
finance_prod	20%		
sales_dev		100%	
sales_test			50%
other			50%

Maximum of 32 directives.

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Using Share-Based Allocation in the Interdatabase Plan

```
CellCLI> alter iormplan                                     -
>          dbplan=((name=sales_prod, share=8),              -
>                  (name=finance_prod, share=2),            -
>                  (name=sales_dev, share=10),              -
>                  (name=sales_test, share=5),              -
>                  (name=default, share=5),                 -
>          catplan=''
```

Maximum of 1024 directives.

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Setting Database I/O Utilization Limits

```
CellCLI> alter iormplan                                              -
>          dbplan=((name=db1, level=1, allocation=50, limit=75), -
>                 (name=db2, level=1, allocation=30, limit=75), -
>                 (name=db3, level=1, allocation=20, limit=50), -
>                 (name=other, level=2, allocation=100)),       -
>          catplan=''
```


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Interdatabase Plans and Database Roles

```
CellCLI> alter iormplan                                                    -
>         dbplan=((name=sales1, level=1, allocation=30, role=primary), -
>                 (name=sales2, level=1, allocation=35, role=primary), -
>                 (name=sales1, level=2, allocation=20, role=standby), -
>                 (name=sales2, level=2, allocation=25, role=standby), -
>                 (name=other, level=3, allocation=50)),               -
>         catplan=''
```


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Category Plan: Example

DBA_RSRC_CONSUMER_GROUPS

```
CONSUMER_GROUP                CATEGORY
----------------------------  ---------------
SYS_GROUP                     ADMINISTRATIVE
BATCH_GROUP                   BATCH
INTERACTIVE_GROUP             INTERACTIVE
ORA$…                         MAINTENANCE
OTHER_GROUPS                  OTHER
DEFAULT_CONSUMER_GROUP        OTHER
LOW_GROUP                     OTHER
AUTO_TASK_CONSUMER_GROUP      OTHER
```

```
DBMS_RESOURCE_MANAGER.CREATE_CATEGORY
```

Category	Level 1	Level 2	Level 3
Interactive	90%		
Batch		80%	
Maintenance			50%
Other			50%

```
CellCLI> alter iormplan     -
>          dbplan= ''       -
>          catplan=(        -
>                   (name=interactive, level=1, allocation=90) , -
>                   (name=batch, level=2, allocation=80) ,       -
>                   (name=maintenance, level=3, allocation=50) , -
>                   (name=other, level=3, allocation=50)         -
>                 )
```


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Using Database I/O Metrics

- There are separate metrics for small I/Os (128 KB or less) and large I/Os (greater than 128 KB).
- You can monitor IORM to understand resource consumption and make required adjustments.
  - Which database has the heaviest load?
    - Look for highest `DB_IO_RQ_SM + DB_IO_RQ_LG` values.
  - Which database was throttled the most?
    - Look for highest `DB_IO_WT_SM + DB_IO_WT_LG` values.

Name	Description
DB_IO_RQ_SM DB_IO_RQ_LG	Total number of I/O requests issued by the database since any resource plan was set
DB_IO_RQ_SM_SEC DB_IO_RQ_LG_SEC	I/O requests per second issued by the database in the past minute
DB_IO_WT_SM DB_IO_WT_LG	Total number of seconds that I/O requests issued by the database waited to be scheduled

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IORM and Exadata Storage Server Flash Memory

- IORM manages only I/O queues for physical disks.
  - IORM does not arbitrate requests serviced by Exadata Smart Flash Cache.
- IORM can control whether a database can use Exadata Smart Flash Cache.
- IORM can control whether a database can use Exadata Smart Flash Log.

```
CellCLI> alter iormplan                                                          -
>        dbPlan=((name=oltp, level=1, allocation=80, flashCache=on, flashLog=on),  -
>        (name=dss, level=1, allocation=20, limit=50, flashCache=off, flashLog=on), -
>        (name=other, level=2, allocation=100, flashCache=off, flashLog=off))
```


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Complete Example

Database A

```
BEGIN
 DBMS_RESOURCE_MANAGER.CREATE_SIMPLE_PLAN(SIMPLE_PLAN => 'DB_A_Plan',
                         CONSUMER_GROUP1 => 'CG1', GROUP1_PERCENT => 15,
                         CONSUMER_GROUP2 => 'CG2', GROUP1_PERCENT => 10,
                         CONSUMER_GROUP3 => 'CG3', GROUP1_PERCENT => 35,
                         CONSUMER_GROUP4 => 'CG4', GROUP2_PERCENT => 40);
 DBMS_RESOURCE_MANAGER.CREATE_PENDING_AREA();
 DBMS_RESOURCE_MANAGER.UPDATE_CONSUMER_GROUP(CONSUMER_GROUP => 'CG1',
                         NEW_CATEGORY => 'BATCH');
 DBMS_RESOURCE_MANAGER.UPDATE_CONSUMER_GROUP(CONSUMER_GROUP => 'CG2',
                         NEW_CATEGORY => 'BATCH');
 DBMS_RESOURCE_MANAGER.UPDATE_CONSUMER_GROUP(CONSUMER_GROUP => 'CG3',
                         NEW_CATEGORY => 'INTERACTIVE');
 DBMS_RESOURCE_MANAGER.UPDATE_CONSUMER_GROUP(CONSUMER_GROUP => 'CG4',
                         NEW_CATEGORY => 'INTERACTIVE');
 DBMS_RESOURCE_MANAGER.SUBMIT_PENDING_AREA();
END;
/
```

```
ALTER SYSTEM SET RESOURCE_MANAGER_PLAN = 'DB_A_Plan';
```


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Complete Example

Database B

```
BEGIN
 DBMS_RESOURCE_MANAGER.CREATE_SIMPLE_PLAN(SIMPLE_PLAN => 'DB_B_Plan',
                        CONSUMER_GROUP1 => 'CG5', GROUP1_PERCENT => 22,
                        CONSUMER_GROUP2 => 'CG6', GROUP1_PERCENT => 18,
                        CONSUMER_GROUP3 => 'CG7', GROUP1_PERCENT => 15,
                        CONSUMER_GROUP4 => 'CG8', GROUP2_PERCENT => 45);
 DBMS_RESOURCE_MANAGER.CREATE_PENDING_AREA();
 DBMS_RESOURCE_MANAGER.UPDATE_CONSUMER_GROUP(CONSUMER_GROUP => 'CG5',
                        NEW_CATEGORY => 'BATCH');
 DBMS_RESOURCE_MANAGER.UPDATE_CONSUMER_GROUP(CONSUMER_GROUP => 'CG6',
                        NEW_CATEGORY => 'BATCH');
 DBMS_RESOURCE_MANAGER.UPDATE_CONSUMER_GROUP(CONSUMER_GROUP => 'CG7',
                        NEW_CATEGORY => 'INTERACTIVE');
 DBMS_RESOURCE_MANAGER.UPDATE_CONSUMER_GROUP(CONSUMER_GROUP => 'CG8',
                        NEW_CATEGORY => 'INTERACTIVE');
 DBMS_RESOURCE_MANAGER.SUBMIT_PENDING_AREA();
END;
/
```

```
ALTER SYSTEM SET RESOURCE_MANAGER_PLAN = 'DB_B_Plan';
```


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Complete Example

Exadata Cells

```
CellCLI> alter iormplan objective=balanced

CellCLI> alter iormplan                                              -
>           dbplan=((name=Database_A, level=1, allocation=70),      -
>                   (name=Database_B, level=1, allocation=30)),     -
>           catplan=((name=INTERACTIVE, level=1, allocation=60),    -
>                   (name=BATCH, level=1, allocation=40))
```


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Quiz

What happens to the leftover allocation if a consumer group does not require its full resource allocation?

a. It remains unused.

b. It is divided equally among other consumer groups.

c. It is allocated to other active consumer groups, according to the resource plan.

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Quiz

Which of the following conditions are required for IORM to arbitrate the allocation of I/O resources?

a. The IORM plan objective must be set to a value other than `basic`.

b. The IORM plan must be active.

c. More than one consumer group or database must be active.

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Quiz

In which order are the different I/O resource plans applied to allocate I/O resources?

a. Category, intradatabase, interdatabase
b. Interdatabase, category, intradatabase
c. Category, interdatabase, intradatabase
d. Interdatabase, intradatabase, category
e. Intradatabase, interdatabase, category

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Quiz

You can create categories using the CellCLI utility:

a. True

b. False

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Summary

In this lesson, you should have learned how to use Exadata I/O Resource Management to manage workloads within a database and across multiple databases.

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Additional Resources

- Lesson demonstrations
  - Intradatabase I/O Resource Management
  - Interdatabase I/O Resource Management

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8

Recommendations for Optimizing Database Performance

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Objectives

After completing this lesson, you should be able to describe the recommendations for optimizing database performance in conjunction with Exadata Database Machine.

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Optimizing Performance

- Start with best practices for ASM and Oracle Database.
- Areas for special consideration:
  - Flash memory usage
  - Compression usage
  - Index usage
  - ASM allocation unit size
  - Minimum extent size
  - Exadata specific system statistics

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Flash Memory Usage

- Each Exadata Storage Server X3-2 contains 1600 GB of high-performance flash memory. Primary uses include:
  - Exadata Smart Flash Cache:
    - Speeds up access to frequently accessed data
    - Uses most of the available flash memory by default
    - Can be managed automatically for maximum efficiency
      - Users can provide optional hints to influence caching priorities.
      - Administrators can disable Smart Flash Cache for specific databases.
    - Can be configured in write-through mode or write-back mode
    - Beneficial for OLTP and Data Warehouse workloads
  - Exadata Smart Flash Log:
    - Small (512 MB) high-performance temporary store for redo log records
    - Managed automatically by Exadata Storage Server software
      - Administrators can disable Smart Flash Log for specific databases.

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Influencing Caching Priorities

- Users can influence caching priorities using the `CELL_FLASH_CACHE` storage attribute:
  - `DEFAULT` uses Smart Flash Cache normally.
  - `KEEP` uses Smart Flash Cache more aggressively.
    - `DEFAULT` objects cannot steal cache space from `KEEP` objects.
    - `KEEP` objects can consume up to 80% of the cache.
    - Unused `KEEP` object data is periodically flushed to disk.
  - `NONE` specifies that Smart Flash Cache is not used.
- Examples:

```
SQL> CREATE TABLE calldetail (
     ... )
     STORAGE (CELL_FLASH_CACHE KEEP);
```

```
SQL> ALTER TABLE calldetail STORAGE (CELL_FLASH_CACHE NONE);
```


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Choosing the Flash Cache Mode

Write-through mode	Write-back mode
Writes go to disk though the battery-backed disk controller cache	Writes go directly to flash
Cached reads free up disks and help to improve write performance	Data is automatically flushed to disk to free up space for more frequently used data
Mirror copies are generally not cached resulting in a larger effective cache	All mirror copies are written to cache effectively reducing the cache size
Broadly applicable for most applications	Especially useful for write-intensive applications
Use write-through mode by default	Enable write-back mode if write I/Os are a performance bottleneck: • High `free buffer waits` in the database wait event statistics • High disk I/O latency and a large percentage of writes

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Setting the Flash Cache Mode

- Enabling write-back mode:

```
CellCLI> DROP FLASHCACHE
CellCLI> ALTER CELL SHUTDOWN SERVICES CELLSRV
CellCLI> ALTER CELL flashCacheMode = WriteBack
CellCLI> ALTER CELL STARTUP SERVICES CELLSRV
CellCLI> CREATE FLASHCACHE ALL
```

- Enabling write-through mode:

```
CellCLI> ALTER FLASHCACHE ALL FLUSH
CellCLI> DROP FLASHCACHE
CellCLI> ALTER CELL SHUTDOWN SERVICES CELLSRV
CellCLI> ALTER CELL flashCacheMode = WriteThrough
CellCLI> ALTER CELL STARTUP SERVICES CELLSRV
CellCLI> CREATE FLASHCACHE ALL
```


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Compression Usage

Compression Method	`CREATE/ALTER TABLE` Syntax	Compression Ratio	CPU Consumption	Typical Applications
Basic Compression	`COMPRESS [BASIC]`	High for direct path inserts Conventional path inserts and updates are not compressed	Low: Oracle Database performs compression and decompression	DSS
OLTP Compression	`COMPRESS FOR OLTP`	High for all transaction types	Low: Oracle Database performs compression and decompression, compression for DML is performed in batches	OLTP and DSS
Warehouse Compression	`COMPRESS FOR QUERY [LOW|HIGH]`	Higher for direct path inserts High for conventional path inserts and updates	Medium: Decompression is performed by Exadata Storage Server	DSS
Online Archival Compression	`COMPRESS FOR ARCHIVE [LOW|HIGH]`	Highest for direct path inserts High for conventional path inserts and updates	High: Decompression is performed by Exadata Storage Server	Archiving

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Index Usage

- Queries that require indexes on a previous system might perform better using Exadata Database Machine and Smart Scan.
- Consider removing indexes where Smart Scan delivers acceptable performance.
- Removing unnecessary indexes will:
  - Improve DML performance
  - Save storage space
- Test the effect of removing indexes by making them invisible:

```
SQL> ALTER INDEX <index_name> INVISIBLE;
```


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ASM Allocation Unit Size

- By default, ASM uses an allocation unit (AU) size of 1 MB.
- For Exadata storage, the recommended AU size is 4 MB.
  - AU size must be set when a disk group is created.
  - AU size cannot be altered after a disk group is created.
  - AU size is set using the `AU_SIZE` disk group attribute.
    - Example:

```
SQL> CREATE DISKGROUP data NORMAL REDUNDANCY
     DISK 'o/*/data_CD*'
     ATTRIBUTE 'compatible.rdbms' = '11.2.0.0.0',
               'compatible.asm' = '11.2.0.0.0',
               'cell.smart_scan_capable' = 'TRUE',
               'au_size' = '4M';
```


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Minimum Extent Size

- Large segments should have initial extents of 8 MB:
  - Stops needless proliferation of small extents in the database
  - Minimizes sub-optimal reads for small extents
  - Compliments the 4 MB ASM AU size recommendation
  - Examples:

```
SQL> CREATE TABLE t1
     (col1 NUMBER(6), col2 VARCHAR2(10))
     STORAGE ( INITIAL 8M MAXSIZE 1G );
```

```
SQL> CREATE BIGFILE TABLESPACE ts1
     DATAFILE '+DATA' SIZE 100G
     DEFAULT STORAGE ( INITIAL 8M NEXT 8M );
```


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Exadata Specific System Statistics

- Gather Exadata specific system statistics:

```
SQL> exec dbms_stats.gather_system_stats('EXADATA');
```

  – Enables the optimizer to more accurately cost operations using actual performance information:
    - CPU speed
    - IO Performance
  – Sets multi block read count (`MBRC`) correctly for Exadata
  – Requires at least Oracle Database version 11.2.0.2 BP 18 or 11.2.0.3 BP 8
  – Recommended for all new databases
    - Test thoroughly before changing existing databases.
    - Databases with stable good plans do not require a change.

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Quiz

Under what circumstances should you enable write-back Smart Flash Cache?

a. Always. Write-back flash cache offers superior performance for all applications.
b. For any application that performs more writes than reads.
c. For situations where write IOs are a performance bottleneck.

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Quiz

Which of the following CREATE TABLE compression clauses are available for use only in conjunction with Exadata Database Machine?

a. `COMPRESS BASIC`
b. `COMPRESS FOR OLTP`
c. `COMPRESS FOR QUERY`
d. `COMPRESS FOR ARCHIVE`

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Summary

In this lesson, you should have learned how to describe the recommendations for optimizing database performance in conjunction with Exadata Database Machine.

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Additional Resources

- Lesson demonstrations
  - Configuring Flash-Based Disk Groups
  - Examining Exadata Hybrid Columnar Compression
  - Index Elimination with Exadata

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Practice 8 Overview: Optimizing Database Performance with Exadata

In these practices, you will explore the following performance optimization techniques and technologies:

- Configuring write back flash cache
- Using Exadata Hybrid Columnar Compression
- Testing index elimination

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9

Using Smart Scan

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Objectives

After completing this lesson, you should be able to:

- Describe Smart Scan and the query processing that can be offloaded to Exadata Storage Server
- Describe the requirements for Smart Scan
- Describe the circumstances that prevent using Smart Scan
- Identify Smart Scan in SQL execution plans
- Use database statistics and wait events to confirm how queries are processed

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Exadata Smart Scan: Overview

- Smart Scan includes:
  - Table and Index Scans: Scans are performed inside Exadata Storage Server rather than transporting all the data to the database server.
  - Predicate filtering: Only the requested rows are returned to the database server rather than all the rows in a table.
  - Column filtering: Only the requested columns are returned to the database server rather than all the table columns.
  - Join filtering: Join processing using Bloom filters are offloaded to Exadata Storage Server.

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Smart Scan Requirements

Smart Scan is not governed by the optimizer, but it is influenced by the results of query optimization.

- Query-specific requirements:
  - Smart Scan is possible only for full table or index scans.
  - Smart Scan can only be used for direct-path reads:
    - Direct-path reads are automatically used for parallel queries.
    - Direct-path reads may be used for serial queries.
      - They are not used by default for serial small table scans.
      - Use `_serial_direct_read=TRUE` to force direct-path reads.
- Additional general requirements:
  - Smart Scan must be enabled within the database.
  - Segments must be stored in appropriately configured disk groups.

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Situations Preventing Smart Scan

Smart Scan cannot be used in these circumstances:

- Scan on a clustered table
- Scan on an index-organized table
- Fast full scan on a compressed index
- Fast full scan on a reverse key indexes
- Table has row-level dependency tracking enabled
- `ORA_ROWSCN` pseudocolumn is being fetched
- Optimizer wants the scan to return rows in `ROWID` order
- Command is `CREATE INDEX` using `NOSORT`
- `LOB` or `LONG` column is being selected or queried
- `SELECT ... VERSIONS` flashback query is being executed
- More than 255 columns are referenced in the query
- Data is encrypted and cell-based decryption is disabled
- To evaluate a predicate based on a virtual column

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Monitoring Smart Scan in SQL Execution Plans

Relevant Initialization Parameters:

- `CELL_OFFLOAD_PROCESSING`
  - `TRUE` | `FALSE`
  - Enables or disables Smart Scan and other smart storage capabilities
  - Dynamically modifiable at the session or system level using `ALTER SESSION` or `ALTER SYSTEM`
  - Specifiable at the statement level using the `OPT_PARAM` hint
- `CELL_OFFLOAD_PLAN_DISPLAY`
  - `NEVER` | `AUTO` | `ALWAYS`
  - Allows execution plan to show offloaded predicates
  - Dynamically modifiable at the session or system level using `ALTER SESSION` or `ALTER SYSTEM`

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Smart Scan Execution Plan: Example

```
SQL> explain plan for select count(*) from customers where cust_valid = 'A';

Explained.

SQL> select * from table(dbms_xplan.display);

-----------------------------------------------------------------------------
| Id  | Operation                  | Name      | Rows  | Bytes | Cost (%CPU)|
-----------------------------------------------------------------------------
|   0 | SELECT STATEMENT           |           |     1 |     2 |   627K  (1)|
|   1 |  SORT AGGREGATE            |           |     1 |     2 |            |
|*  2 |   TABLE ACCESS STORAGE FULL| CUSTOMERS |    38M|    73M|   627K  (1)|
-----------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------

   2 - storage("CUST_VALID"='A')
       filter("CUST_VALID"='A')
```


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Smart Scan Execution Plan: Example

```
SQL> explain plan for select count(*) from customers where cust_id > '10000';

Explained.

SQL> select * from table(dbms_xplan.display);

-----------------------------------------------------------------------------
| Id  | Operation                        | Name          | Rows   | Bytes |
-----------------------------------------------------------------------------
|   0 | SELECT STATEMENT                 |               |     1 |     6 |
|   1 |  SORT AGGREGATE                  |               |     1 |     6 |
|   2 |   PX COORDINATOR                 |               |       |       |
|   3 |    PX SEND QC (RANDOM)           | :TQ10000      |     1 |     6 |
|   4 |     SORT AGGREGATE               |               |     1 |     6 |
|   5 |      PX BLOCK ITERATOR           |               |   77M|   443M|
|*  6 |       INDEX STORAGE FAST FULL SCAN| CUSTOMERS_PK|   77M|   443M|
-----------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------

   6 - storage("CUST_ID">10000)
       filter("CUST_ID">10000)
```


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Example of a Situation Preventing Smart Scan

```
SQL> explain plan for select count(*) from cust_iot where cust_id > '10000';

Explained.

SQL> select * from table(dbms_xplan.display);


--------------------------------------------------------------------------
| Id  | Operation         | Name    | Rows   | Bytes | Cost (%CPU)| Time     |
--------------------------------------------------------------------------
|   0 | SELECT STATEMENT  |         |     1 |     13 | 21232   (1)| 00:04:15 |
|   1 |  SORT AGGREGATE   |         |     1 |     13 |            |          |
|*  2 |   INDEX RANGE SCAN| CUST_PK |    86M|  1071M| 21232   (1)| 00:04:15 |
--------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------

   2 - access("CUST_ID">10000)
```


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Smart Scan Join Processing with Bloom Filters

- A Bloom filter is a data structure that can be used to test if an element is a member of a set.
- Bloom filter properties:
  - The amount of data used in the Bloom filter is much smaller than the set being tested.
  - The time required to check whether an element is a member of the set is constant.
  - False positives are possible but their frequency can be managed.
  - False negatives are not possible.
- Since Oracle 10*g* Release 2, Bloom filters have been used to optimize parallel joins.
- With Exadata, the Bloom filter can be processed by the storage server, reducing the amount of data unnecessarily transported to the database server.

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Smart Scan Join Filtering: Example

```
SQL> SELECT AVG(s.amount_sold) FROM customers cu, sales s
  2  WHERE cu.cust_id = s.cust_id
  3  AND cu.cust_credit_limit > 5000;

------------------------------------------------------------------------------------------------------------------
| Id  | Operation                        | Name     | Rows  | Bytes | Cost (%CPU)|Time     |    TQ  |IN-OUT|PQ Distrib|
------------------------------------------------------------------------------------------------------------------
|   0 | SELECT STATEMENT                 |          |     1 |    19 | 55979   (1)| 00:11:12|        |      |          |
|   1 |  SORT AGGREGATE                  |          |     1 |    19 |            |         |        |      |          |
|   2 |   PX COORDINATOR                 |          |       |       |            |         |        |      |          |
|   3 |    PX SEND QC (RANDOM)           | :TQ10002 |     1 |    19 |            |         |  Q1,02 | P->S | QC (RAND) |
|   4 |     SORT AGGREGATE               |          |     1 |    19 |            |         |  Q1,02 | PCWP |          |
|*  5 |      HASH JOIN                   |          |  577M |   10G | 55979   (1)| 00:11:12|  Q1,02 | PCWP |          |
|   6 |       JOIN FILTER CREATE         | :BF0000  |   57M |  547M | 14499   (1)| 00:02:54|  Q1,02 | PCWP |          |
|   7 |        PX RECEIVE                |          |   57M |  547M | 14499   (1)| 00:02:54|  Q1,02 | PCWP |          |
|   8 |         PX SEND HASH             | :TQ10000 |   57M |  547M | 14499   (1)| 00:02:54|  Q1,00 | P->P | HASH     |
|   9 |          PX BLOCK ITERATOR       |          |   57M |  547M | 14499   (1)| 00:02:54|  Q1,00 | PCWC |          |
|* 10 |           TABLE ACCESS STORAGE FULL| CUSTOMERS |   57M |  547M | 14499   (1)| 00:02:54|  Q1,00 | PCWP |          |
|  11 |       PX RECEIVE                 |          |  774M | 6651M | 24044   (1)| 00:04:49|  Q1,02 | PCWP |          |
|  12 |        PX SEND HASH              | :TQ10001 |  774M | 6651M | 24044   (1)| 00:04:49|  Q1,01 | P->P | HASH     |
|  13 |         JOIN FILTER USE          | :BF0000  |  774M | 6651M | 24044   (1)| 00:04:49|  Q1,01 | PCWP |          |
|  14 |          PX BLOCK ITERATOR       |          |  774M | 6651M | 24044   (1)| 00:04:49|  Q1,01 | PCWC |          |
|* 15 |           TABLE ACCESS STORAGE FULL| SALES  |  774M | 6651M | 24044   (1)| 00:04:49|  Q1,01 | PCWP |          |
------------------------------------------------------------------------------------------------------------------

Predicate Information (identified by operation id):
---------------------------------------------------

   5 - access("CU"."CUST_ID"="S"."CUST_ID")
  10 - storage("CU"."CUST_CREDIT_LIMIT">5000)
       filter("CU"."CUST_CREDIT_LIMIT">5000)
  15 - storage(SYS_OP_BLOOM_FILTER(:BF0000,"S"."CUST_ID"))
       filter(SYS_OP_BLOOM_FILTER(:BF0000,"S"."CUST_ID"))
```


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Other Situations Affecting Smart Scan

- Seeing `STORAGE` in the execution plan does not guarantee that the query is satisfied using Smart Scan alone.
- Even when Smart Scan is indicated by the execution plan, other block I/O might also be used. Example:
  - If Exadata Storage Server is not sure that a block is current it transfers that block read to the buffer cache.
  - If chained or migrated rows are detected, then additional non-Smart Scan block reads may be required.
  - If dynamic sampling is used, then the sampling IO will not use Smart Scan.
  - If Exadata Storage Server CPU utilization is significantly greater than CPU utilization on the database server, then Smart Scan may send additional data to the database server.
  - If all the required data already resides in the database buffer cache, the buffer cache copy is used and no disk I/O is performed.
- Statistics and wait events can be used to confirm what is happening.

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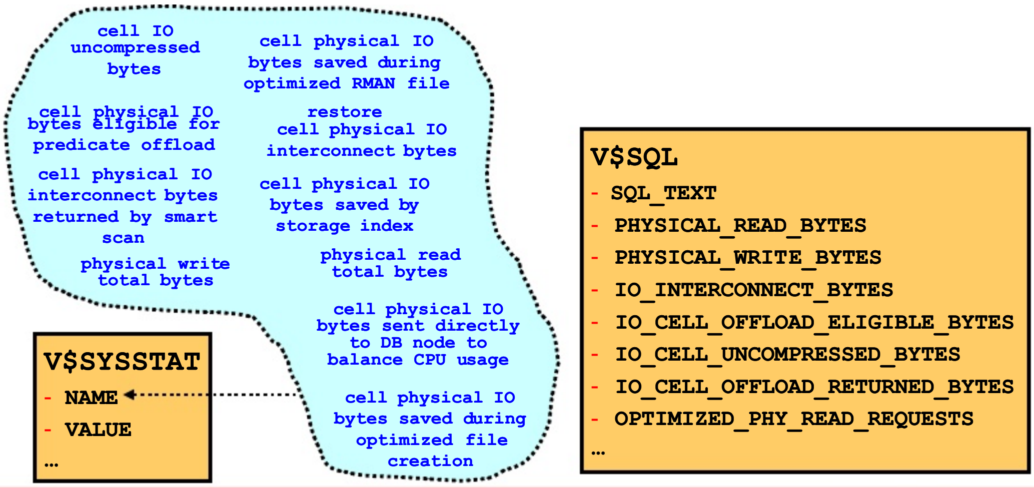
Exadata Storage Server Statistics: Overview

```
SELECT s.name, m.value/1024/1024 MB FROM V$SYSSTAT s, V$MYSTAT m
WHERE s.statistic# = m.statistic# AND
(s.name LIKE 'physical%total bytes' OR s.name LIKE 'cell phys%'
OR s.name LIKE 'cell IO%');
```



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Exadata Storage Server Wait Events: Overview

```
SELECT DISTINCT event, total_waits, time_waited/100 wait_secs,
                average_wait/100 avg_wait_secs
FROM V$SESSION_EVENT e, V$MYSTAT s
WHERE event LIKE 'cell%' AND e.sid = s.sid;
```

Wait Event	Description
`cell interconnect retransmit during physical read`	Database wait during retransmission for an I/O of a single-block or multiblock read
`cell list of blocks physical read`	Cell equivalent of `db file parallel read`
`cell single block physical read`	Cell equivalent of `db file sequential read`
`cell multiblock physical read`	Cell equivalent of `db file scattered read`
`cell smart table scan`	Database wait for table scan to complete
`cell smart index scan`	Database wait for index or IOT fast full scan
`cell smart file creation`	Database wait for file creation operation
`cell smart incremental backup`	Database wait for incremental backup operation
`cell smart restore from backup`	Database wait during file initialization for restore
`cell statistics gather`	Wait during query of `V$CELL` views

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Smart Scan Statistics: Example

```
SQL> select count(*) from customers where cust_valid = 'A';

  COUNT(*)
----------
   8602831

Elapsed: 00:00:11.76

SQL> SELECT s.name, m.value/1024/1024 MB FROM V$SYSSTAT s, V$MYSTAT m

  2  WHERE s.statistic# = m.statistic# AND
  3  (s.name LIKE 'physical%total bytes' OR s.name LIKE 'cell phys%'
  4  OR s.name LIKE 'cell IO%');

NAME                                                                  MB
--------------------------------------------------------------- ----------
physical read total bytes                                       18005.6953
physical write total bytes                                               0
cell physical IO interconnect bytes                             120.670433
cell physical IO bytes sent directly to DB node to balance CPU u         0
cell physical IO bytes saved during optimized file creation              0
cell physical IO bytes saved during optimized RMAN file restore          0
cell physical IO bytes eligible for predicate offload           18005.6953
cell physical IO bytes saved by storage index                            0
cell physical IO interconnect bytes returned by smart scan      120.670433
cell IO uncompressed bytes                                      18005.6953
```


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Smart Scan Wait Events: Example

```
SQL> select count(*) from customers where cust_valid = 'A';

  COUNT(*)
----------
   8602831

Elapsed: 00:00:11.76

SQL> SELECT DISTINCT event, total_waits, time_waited/100 wait_secs,
  2  average_wait/100 avg_wait_secs
  3  FROM V$SESSION_EVENT e, V$MYSTAT s
  4  WHERE event LIKE 'cell%' AND e.sid = s.sid;

EVENT                                    TOTAL_WAITS  WAIT_SECS AVG_WAIT_SECS
---------------------------------------- ----------- ---------- -------------
cell smart table scan                           9026      11.05         .0012
```


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Concurrent Transaction: Example

```
SQL> select count(*) from customers where cust_valid = 'A';

  COUNT(*)
----------
   8602831

Elapsed: 00:02:13.55

NAME                                                                 MB
---------------------------------------------------------------- ----------
physical read total bytes                                        19047.2266
physical write total bytes                                                0
cell physical IO interconnect bytes                              4808.85828
cell physical IO bytes sent directly to DB node to balance CPU u          0
cell physical IO bytes saved during optimized file creation               0
cell physical IO bytes saved during optimized RMAN file restore           0
cell physical IO bytes eligible for predicate offload            18005.6953
cell physical IO bytes saved by storage index                             0
cell physical IO interconnect bytes returned by smart scan       3767.32703
cell IO uncompressed bytes                                       18005.6953

EVENT                                    TOTAL_WAITS  WAIT_SECS AVG_WAIT_SECS
---------------------------------------- ----------- ---------- -------------
cell list of blocks physical read                  1          0         .0006
cell smart table scan                          19238       32.7         .0017
cell single block physical read               133286      74.91         .0006
```


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Extreme Concurrent Transaction: Example

```
SQL> select count(*) from customers where cust_valid = 'A';

  COUNT(*)
----------
   8602831

Elapsed: 00:15:04.29

NAME                                                                   MB
---------------------------------------------------------------- ----------
physical read total bytes                                        28550.3125
physical write total bytes                                                0
cell physical IO interconnect bytes                              28537.5555
cell physical IO bytes sent directly to DB node to balance CPU u          0
cell physical IO bytes saved during optimized file creation               0
cell physical IO bytes saved during optimized RMAN file restore           0
cell physical IO bytes eligible for predicate offload            18005.6953
cell physical IO bytes saved by storage index                             0
cell physical IO interconnect bytes returned by smart scan       17992.9383
cell IO uncompressed bytes                                       18005.6953

EVENT                                    TOTAL_WAITS  WAIT_SECS AVG_WAIT_SECS
---------------------------------------- ----------- ---------- -------------
cell list of blocks physical read                  1          0         .0006
cell single block physical read              1349704     683.94         .0005
cell smart table scan                           9191       3.29         .0004
```


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Migrated Rows: Example

```
SQL> select count(*) from customers where cust_valid = 'A';

  COUNT(*)
----------
   8602831

Elapsed: 00:00:14.02

NAME                                                                    MB
---------------------------------------------------------------- ----------
physical read total bytes                                        22327.5781
physical write total bytes                                                0
cell physical IO interconnect bytes                              130.069008
cell physical IO bytes sent directly to DB node to balance CPU u          0
cell physical IO bytes saved during optimized file creation               0
cell physical IO bytes saved during optimized RMAN file restore           0
cell physical IO bytes eligible for predicate offload            22324.6094
cell physical IO bytes saved by storage index                             0
cell physical IO interconnect bytes returned by smart scan       127.100258
cell IO uncompressed bytes                                       22324.6094

EVENT                                     TOTAL_WAITS  WAIT_SECS AVG_WAIT_SECS
---------------------------------------- ----------- ---------- -------------
cell single block physical read                  236        .14         .0006
cell smart table scan                          10880      13.19         .0012
cell multiblock physical read                     17        .02         .0009
```


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I/O Sent Directly to Database Server to Balance CPU Usage: Example

```
SQL> select count(*) from customers where cust_valid = 'A';

  COUNT(*)
----------
   8602831

Elapsed: 00:01:42.59

NAME                                                                 MB
---------------------------------------------------------------- ----------
physical read total bytes                                        18005.6953
physical write total bytes                                                0
cell physical IO interconnect bytes                              2475.24233
cell physical IO bytes sent directly to DB node to balance CPU u 2394.57133
cell physical IO bytes saved during optimized file creation               0
cell physical IO bytes saved during optimized RMAN file restore           0
cell physical IO bytes eligible for predicate offload            18005.6953
cell physical IO bytes saved by storage index                             0
cell physical IO interconnect bytes returned by smart scan       2475.24233
cell IO uncompressed bytes                                       18005.6953

EVENT                                    TOTAL_WAITS  WAIT_SECS AVG_WAIT_SECS
---------------------------------------- ----------- ---------- -------------
cell smart table scan                           9128      98.19         .0108
```


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Column Filtering: Example

```
SQL> select * from customers;
---------------------------------------------------------------------------
| Id  | Operation                  | Name      | Rows  | Bytes | Cost (%CPU)|
---------------------------------------------------------------------------
|   0 | SELECT STATEMENT           |           | 1239K|   244M| 10242   (1)|
|   1 |  TABLE ACCESS STORAGE FULL| CUSTOMERS | 1239K|   244M| 10242   (1)|
---------------------------------------------------------------------------

NAME                                                                 MB
----------------------------------------------------------------  ----------
physical read total bytes                                          290.335938
cell physical IO interconnect bytes                                290.335938
cell physical IO bytes eligible for predicate offload                       0
cell physical IO interconnect bytes returned by smart scan                  0
```

```
SQL> select cust_email from customers;
---------------------------------------------------------------------------
| Id  | Operation                  | Name      | Rows  | Bytes | Cost (%CPU)|
---------------------------------------------------------------------------
|   0 | SELECT STATEMENT           |           | 1239K|    20M| 10235   (1)|
|   1 |  TABLE ACCESS STORAGE FULL| CUSTOMERS | 1239K|    20M| 10235   (1)|
---------------------------------------------------------------------------

NAME                                                                 MB
----------------------------------------------------------------  ----------
physical read total bytes                                          290.289063
cell physical IO interconnect bytes                                29.0223618
cell physical IO bytes eligible for predicate offload              290.289063
cell physical IO interconnect bytes returned by smart scan         29.0223618
```


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Summary

In this lesson, you should have learned how to:

- Describe Smart Scan and the query processing that can be offloaded to Exadata Storage Server
- Describe the requirements for Smart Scan
- Describe the circumstances that prevent using Smart Scan
- Identify Smart Scan in SQL execution plans
- Use database statistics and wait events to confirm how queries are processed

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Quiz

The `CELL_OFFLOAD_PLAN_DISPLAY` initialization parameter enables Smart Scan:

a. True

b. False

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Quiz

Smart Scan is enabled and the query plan indicates the use of Smart Scan. However, the `cell physical IO interconnect bytes returned by smart scan` statistic shows values that are much larger than expected.

Which of the following could be the cause?

a. Migrated rows
b. Full table scan over an index organized table
c. Concurrent uncommitted transactions
d. A fast full scan of a compressed index

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Practice 9 Overview: Using Smart Scan

In these practices, you will exercise Exadata Smart Scan and examine various statistics and wait events to determine what is occurring.

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10

Consolidation Options and Recommendations

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Objectives

After completing this lesson, you should be able to:

- Describe the options for consolidating multiple databases on Database Machine
- Explain the benefits and costs associated with the different options

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Consolidation: Overview

- Why consolidate:
  - To minimize idle resources
  - To maximize efficiency
  - To lower costs
- Consolidation examples:
  - Hosting multiple virtual servers on one physical server
  - Hosting multiple applications on one server
  - Supporting different users on one application instance

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Different Consolidation Types

- Application schema:
  - Multiple application schemas consolidated into a single database
  - One database instance (or one set of Real Application Clusters [RAC] instances)
  - One database to manage
- Database:
  - Multiple databases consolidated on to a single platform
  - Separate instances for each database
  - Separate database management
  - Platform resources shared by databases

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Core Principles for Database Consolidation

- Consolidate databases with similar availability and planned maintenance objectives.
- Other considerations include performance, system requirements, security, and organization boundaries.
- Consolidating applications onto Database Machine is possible but not recommended.

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Recommended Consolidation Approach

- Categorize databases into three groups:
  - **Critical:** Core business, revenue generating, customer facing
  - **Standard:** Other non-critical production databases
  - **Non-production:** Development and test databases
- Create hardware pools that consolidate databases within each group but not across groups:
  - Consolidate databases using one or two Exadata Database Machine racks per hardware pool.
  - Databases that require more than two racks should have a dedicated hardware pool.

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Recommended Storage Configuration for Consolidation

- One shared Exadata storage grid per hardware pool:
  - The following are the recommended disk groups:
    - DATA for database files
    - RECO for fast recovery area (FRA)
    - DBFS_DG for clusterware shared files and DBFS
  - Use high redundancy for DATA.
  - Stripe disk groups across all cells and all disks.
  - Use IORM to manage and allocate I/O resources.
  - Set the `COMPATIBLE.RDBMS` disk group attribute to the minimum database software version being used.
- Benefits:
  - Standard configuration: Is the easiest to manage
  - Balanced configuration: Provides high availability and performance, and suits most circumstances

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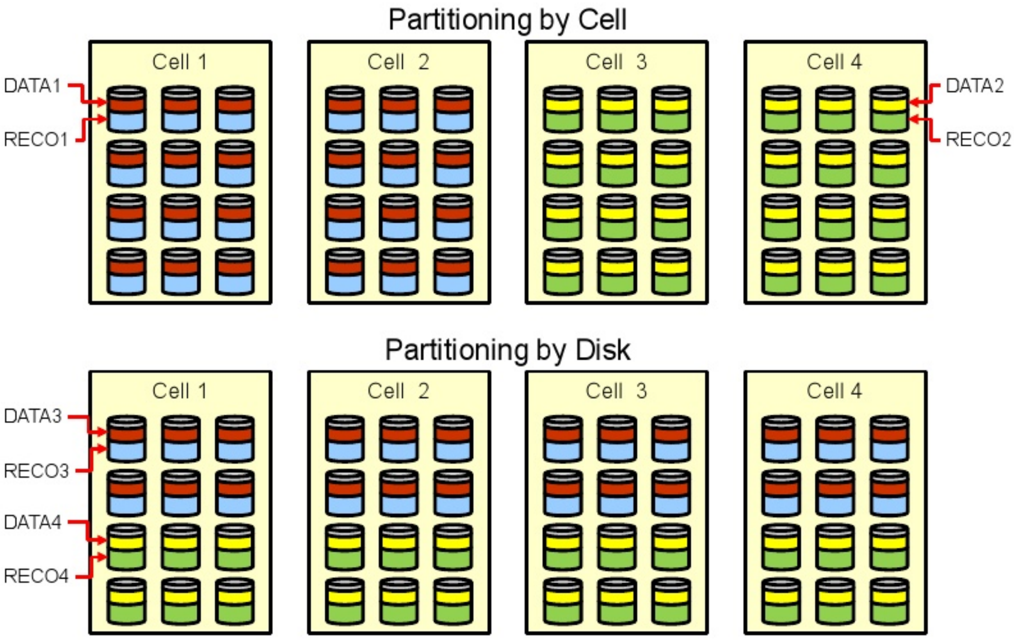
Alternative Storage Configurations



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Benefits and Limitations of Partitioned Storage Configurations

- Benefits:
  - ✓ Storage isolation
    - Different disks groups and databases can occupy separate cells or disks.
  - ✓ Patch isolation
    - Different sets of cells can be patched to different levels.
- Limitations:
  - × Manual configuration
    - Partitioned configurations need to be hand-crafted.
  - × Reduced I/O bandwidth
    - A single operation cannot leverage the entire storage grid.
  - × Additional management overhead
    - Commands need to be duplicated.
    - Special adjustments may be required.

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Cluster Configuration Options

- Recommended configuration:
  - Use one cluster per hardware pool.
  - Use database services to manage database workloads across the available database servers.
  - Use Oracle Data Guard to protect against cluster failure for critical hardware pools.
- Alternative configuration:
  - Configure multiple clusters per hardware pool:
    - ✓ Better isolation for cluster failure and patching
    - × Requires manual configuration
    - × Additional management effort and complexity
    - Requires a separate set of disk groups for each cluster
    - A minimum of three nodes per cluster is recommended.

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Operating System Parameter Recommendations

- Set the number of shared memory segments (`SHMMNI`) greater than the number of databases.
- Set the maximum shared memory segment size (`SHMMAX`) to 85% of physical memory size.
- Set the maximum total number of system semaphores (`SEMMNS`) greater than the sum of all database processes.
- Set the maximum number of semaphores in a semaphore set (`SEMMSL`) greater than the largest number of processes in any single database.
- For Linux, if `PageTables` in `/proc/meminfo` is > 2% of physical memory size, consider setting HugePages equal to the sum of all shared memory segments:
  - See My Oracle Support notes 401749.1 and 361468.1.

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Database Memory Recommendations

- Calculate the Oracle Database memory usage as follows:
  - For OLTP: (sum(`PGA_AGGREGATE_TARGET` + `SGA_TARGET`) + (4 MB * Maximum Processes))
  - For data warehousing: sum((3 x`PGA_AGGREGATE_TARGET`) + `SGA_TARGET`)
- Ensure that the Oracle Database memory usage does not exceed:
  - The database server physical memory size for non-critical hardware pools
  - 75% of the database server physical memory size for critical hardware pools
- Monitor memory usage and maintain a free memory target of at least 5% at all times.

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CPU Management Recommendations

- Use instance caging to prevent individual databases from consuming too much CPU.
- Recommended CPU_COUNT parameter settings:
  - For critical hardware pools: sum(CPU_COUNT) < 75% of the total number of CPU cores
  - Otherwise:
    - For CPU intensive databases: sum(CPU_COUNT) <= the total number of CPU cores
    - For lightweight CPU usage databases: sum(CPU_COUNT) <= three times the total number of CPU cores
- Use the database resource manager to control CPU allocation within each database.
  - Use the MAX_UTILIZATION_LIMIT directive attribute to limit the CPU utilization for consumer groups.

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Process Management Recommendations

- Adjust PROCESSES for ASM:
  - For 2 to 10 databases: PROCESSES = 50 + (50 * number of databases)
  - For 11 or more databases: PROCESSES = 450 + (10 * number of databases)
- Limit PARALLEL_MAX_SERVERS:
  - For X2-2 and X3-2: sum(PARALLEL_MAX_SERVERS) <= 240
  - For X2-8 and X3-8: sum(PARALLEL_MAX_SERVERS) <= 1280
- Limit Data Guard redo apply parallelism to 16 or less.
- Process and connection guidelines:
  - Limit active processes:
    - For average applications: Active processes <= 5 x CPU_COUNT
    - For very CPU-intensive applications: Active processes <= CPU_COUNT
  - Use connection pools to manage application connections.
  - Use database shared server processes to reduce the process count.
  - Use the connection rate limiter to prevent connection storms.

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Other Recommendations

- Configure IORM.
- Set DB_RECOVERY_FILE_DEST_SIZE:
  - sum(DB_RECOVERY_FILE_DEST_SIZE) < usable FRA size

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Isolating Management Roles

- Separate DBA and ASM administration roles.
  - They can be configured as part of the OneCommand process.
- Separate `OSDBA` and `OSOPER` groups, and separate administrator OS accounts for each database.
  - They must be configured manually.
  - They can be used for audit purposes or to enforce isolation.
  - Enforced isolation requires a separate Oracle Database software installation for each database.
- Separate disk groups for each database.
  - See the discussion on non-standard storage configurations earlier in this lesson.
  - Database-scoped Exadata storage security can also be implemented to enforce storage isolation.

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Schema Consolidation Recommendations

- Isolate application schemas into their own tablespaces:
  - Simplifies space management
  - Enables fast and granular recovery using tablespace point-in-time recovery (TSPITR)
- Tune tablespace backup, restore, and recovery practices.
  - Understand the overheads and requirements of different approaches:
    - TSPITR
    - Flashback technologies
    - Logical export and import
  - Evaluate if TSPITR meets the recovery time objectives for the applications:
    - Consider using image copies for faster TSPITR.

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Maintenance Considerations

- Additional headroom and specialized procedures may be required to accommodate server outages or rolling patches.
  - How is the environment impacted by the absence of a database server or an Exadata Storage Server?
  - Use policy-managed databases and services to adapt.
- Isolate changes in a new Oracle home directory, and then migrate and validate each database.
  - Validate in test and standby first if possible.
- Maintain only a few active Oracle software versions:
  - Example: 11.2.0.1 BP9, 11.2.0.2 BP7, and 11.2.0.3 BP2
  - Remember that the Grid Infrastructure version must be the same as, or later than, the database kernel version.

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Quiz

Exadata Database Machine is suitable for:

a. Application schema consolidation
b. Database consolidation
c. Both of the above

ORACLE

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Quiz

When practicing database consolidation on Exadata Database Machine, Oracle recommends creating a separate set of ASM disk groups for each database.

a. True
b. False

ORACLE

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Summary

In this lesson, you should have learned how to:

- Describe the options for consolidating multiple databases on Database Machine
- Explain the benefits and costs associated with different options

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Additional Resources

- Documentation and white papers
  - Best Practices For Database Consolidation On Oracle Exadata Database Machine

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11

Migrating Databases to Exadata Database Machine

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Objectives

After completing this lesson, you should be able to:

- Describe the general steps to migrate your database to Database Machine
- List the main approaches for migrating your database to Database Machine
- Identify the most appropriate approach for different circumstances

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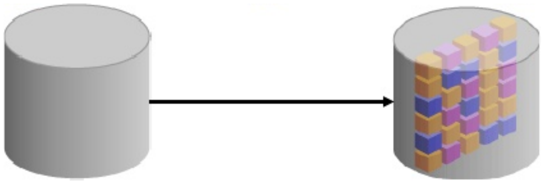
Migration Best Practices: Overview



Legacy storage to Database Machine

1 → 2 → 3 → 4

1. Capacity planning
2. Choosing the migration approach
3. Migration
4. Post-migration tasks

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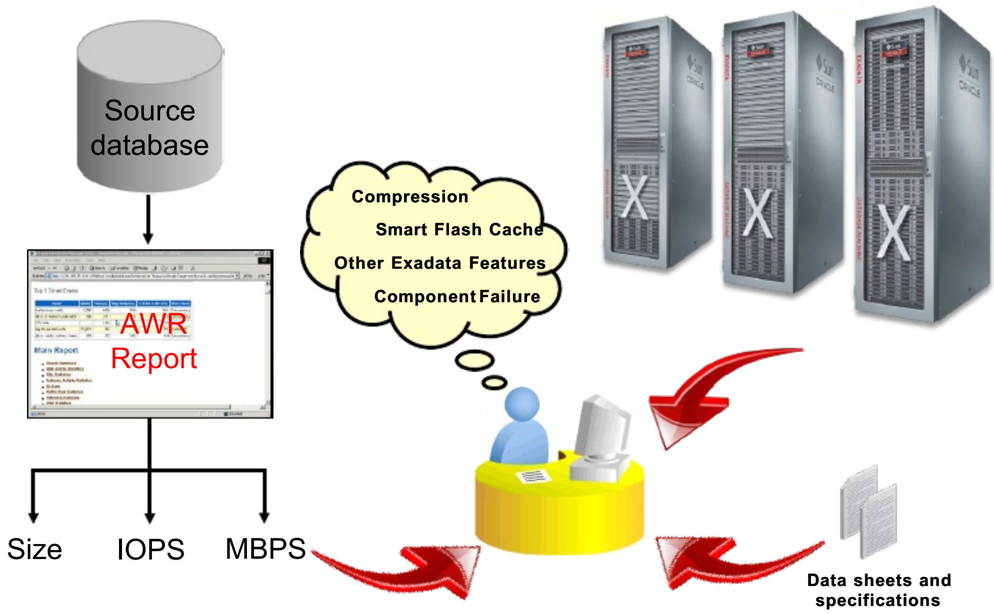
Performing Capacity Planning



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Database Machine Migration Considerations

- Platform is 64-bit Intel.
  – Byte order is little endian.
- Exadata, ASM, and database software must run release 11.2.0.1 or greater.
- ASM disk group attributes:
  – `COMPATIBLE.ASM=11.2.0.0.0`
  – `COMPATIBLE.RDBMS=11.2.0.0.0`
  – `CELL.SMART_SCAN_CAPABLE=TRUE`
  – `AU_SIZE=4M`
- Database initialization parameters:
  – `COMPATIBLE=11.2.0.0.0`
  – `DB_BLOCK_CHECKSUM=TYPICAL|FULL`
- Database extent sizes should be a multiple of 4 MB.

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Choosing the Right Migration Path

- Determine what to migrate:
  - Avoid methods that migrate what you will discard.
- Consider the configuration of the source system:
  - Source Oracle Database version and platform matters.
  - Target system is fixed: 11.2, ASM, and little endian.
- Weigh up the costs and favor methods that facilitate best practices:
  - Implementing best practices is important in the long term because your future performance depends on it.
  - Remember:
    - ASM AU size of 4 MB can be set only at disk group creation.
    - Database extent sizes are set at extent allocation.

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Logical Migration Approaches

Migration approach	Source database must be release 11.2	Can adjust ASM AU size to 4 MB	Source platform support	Time and effort requirement	Migration outage time
Logical standby database *Minimal down time*	No	Yes	Limited	High	Low
Streams *Minimal down time*	No	Yes	Broad	High	Low
Data Pump *For migration during a planned maintenance period*	No	Yes	Broad	Low	High

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Physical Migration Approaches

Migration approach	Source database must be 11.2	Can adjust ASM AU size to 4 MB	Source platform support	Time and effort requirement	Migration outage time
ASM Online Migration *Best when already using ASM and 4 MB AUs*	Yes	No	Same as Database Machine only	Medium	Low
Recovery Manager *Tablespace-level migration*	Yes	Yes	Same as Database Machine only	Medium	Low
Create new tablespaces *In conjunction with rolling partitions*	Yes	Yes	Same as Database Machine only	Medium	Low
Physical standby database *Migration of DB server and storage*	No	Yes	Limited	Low	Low
Transportable Database *Migration to a different platform with the same endian format*	Yes	Yes	Little endian	Low	Medium
Transportable Tablespaces *Migration to a different platform with a different endian format*	No	Yes	Broad	Medium	Medium

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Reducing Down Time for Migration by Using Transportable Tablespaces

Traditional Migration Using Transportable Tablespaces

1. Make the source tablespaces READ ONLY.
2. Transfer the data files to the destination system.
3. Convert the data files to the destination system endian format.
4. Export the metadata of objects in the tablespaces from the source database by using Data Pump.
5. Import the metadata into the destination database.
6. Make the destination tablespace READ WRITE.

Data unavailable for update during entire process.

Migration Using Cross Platform Incremental Backup

Phase 1 - Prepare Phase

1. Transfer data file copies to the destination system.
2. Convert data file copies to the destination endian format.

Phase 2 - Roll Forward Phase

1. Create and incremental backup on the source system.
2. Transfer the incremental backup to destination system.
3. Convert the incremental backup to the destination system endian format and apply it to the destination data file copies.

Repeat Phase 2 until the destination system is almost up to date.

Source database remains available for updates throughout Phase 1 and Phase 2.

Phase 3 - Transport Phase

1. Make the tablespaces in the source database READ ONLY.
2. Repeat Phase 2 once more to bring the destination data files up to date with the source data files.
3. Export the metadata of objects in the tablespaces from the source database by using Data Pump.
4. Import the metadata into the destination database.
5. Make the tablespaces in the destination database READ WRITE.

Data unavailable for update in Phase 3 only.

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Other Approaches

- Data Integration Tools
  - Oracle GoldenGate
  - Oracle Data Integrator
- Custom Code
  - Query over database link
  - PL/SQL routines
- Hybrid Approaches
  - For example, use Transportable Tablespaces to migrate data from the current production database to a staging database outside Database Machine, and then use Data Pump to unload data from the staging database and load it into Database Machine.

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Post-Migration: Best Practices

- Check whether ASM disk groups are balanced:
  - Manual rebalance may be needed.
  - Script is available in My Oracle Support note 367445.1.
  - Enterprise Manager alert for disk group imbalance
- Assess index requirements:
  - With Exadata, full scans might deliver acceptable performance.
  - Determine the indexes that are not required and remove them.
- Configure I/O Resource Management.

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Quiz

What are two recommended practices when migrating to Exadata storage?

a. Double the size of your SGA.
b. Configure ASM allocation units to 4 MB.
c. Double the size of your ASM disk groups.
d. Configure database extents to multiples of 4 MB.

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Quiz

Which of the following physical migration approaches is most universally applicable?

a. ASM Online Migration
b. Physical Standby Database
c. Transportable Tablespaces

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Summary

In this lesson, you should have learned how to:

- Describe the general steps to migrate your database to Database Machine
- List the main approaches for migrating your database to Database Machine
- Identify the most appropriate approach for different circumstances

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Additional Resources

- Lesson demonstrations
  - Migrating to Database Machine Using Transportable Tablespaces
- My Oracle Support notes
  - Changing Storage Definition in a Logical Standby Database
  - Data Guard Support for Heterogeneous Primary and Standby Systems in Same Data Guard Configuration
  - Script to Report the Percentage of Imbalance in all Mounted Diskgroups

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Additional Resources

- Documentation and white papers
  - Oracle Streams Concepts and Administration 11*g* Release 2 (11.2)
  - Oracle Database Storage Administrator's Guide 11*g* Release 2 (11.2)
  - Platform Migration Using Transportable Database

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Practice 11 Overview: Migrating to Databases Machine by Using Transportable Tablespaces

In this practice, you will use Oracle Recovery Manager (RMAN) in conjunction with the Transportable Tablespaces feature of Oracle Database to migrate data from a big-endian platform to Database Machine (which is a little-endian platform).

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12

Bulk Data Loading by Using Oracle DBFS

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Objectives

After completing this lesson, you should be able to:

- Use Oracle DBFS for bulk data loading into Database Machine
- Configure the Database File System (DBFS) feature for staging input data files
- Use external tables based on input data files stored in DBFS to perform high-performance data loads

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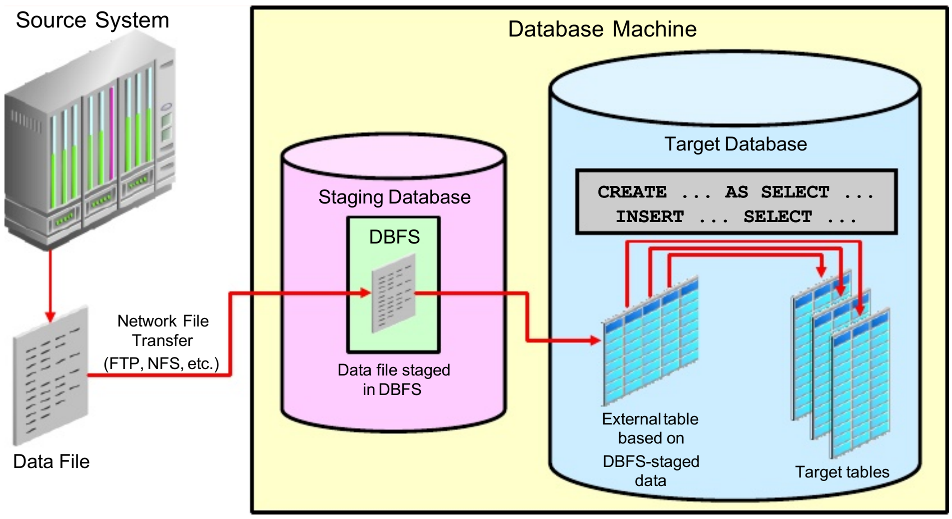
Bulk Data Loading Using Oracle DBFS: Overview



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Preparing the Data Files

- Data files can be in any format supported by the external table feature.
- To facilitate high-performance parallel access:
  - Oracle automatically divides the files into 10 MB granules.
    - Exceptions include compressed files, or data read from a tape.
  - If granules cannot be created:
    - Each file is treated as a granule
    - The number of files determines the maximum degree of parallelism
    - You must use multiple files to manually enable parallelism
  - General rules of thumb:
    - If using multiple files, try to keep them similar in size.
    - If the file sizes vary significantly, list them in order from largest to smallest in the external table definition.

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Staging the Data Files

- Data files should always be staged in DBFS:
  – Not in database server internal drives
- DBFS enables the database to be used as a file system.
  – DBFS provides shared storage for staging or storing data files, scripts, reports, and other application files.
  – Files are stored as SecureFiles LOBs in database tables that are stored in Exadata.
  – Files are exposed to the database servers by using a POSIX-compatible file system interface.
  – Files are protected like any Oracle data by using ASM mirroring, Data Guard, Flashback, and so on.

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Configuring the Staging Area

DBFS should be configured in a separate staging database.

- Use DBCA to create the staging database.
  - See My Oracle Support note 1191144.1 for recommendations.
- Create a bigfile tablespace for DBFS storage:

```
SQL> CREATE BIGFILE TABLESPACE DBFS DATAFILE '+DBFS_DG'
     SIZE 32G AUTOEXTEND ON NEXT 8G MAXSIZE 300G
     NOLOGGING ONLINE PERMANENT EXTENT MANAGEMENT LOCAL
     AUTOALLOCATE SEGMENT SPACE MANAGEMENT AUTO;
```

- Create a DBFS user account:

```
SQL> create user dbfs identified by dbfs
     quota unlimited on DBFS;
SQL> grant create session, create table, create
     procedure, dbfs_role to dbfs;
```


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Configuring the Staging Area

Additional database server operating system configuration:

- Add the Oracle software owner, or the user that will mount the DBFS file system, to the `fuse` group:

```
# usermod -a -G fuse oracle
```

- As `root`, create `/etc/fuse.conf` containing the entry `user_allow_other`:

```
# echo "user_allow_other" > /etc/fuse.conf
# chmod 644 /etc/fuse.conf
```

- Create a mount point for DBFS with ownership and group permissions set to the Oracle software owner, or the user that will mount the DBFS file system:

```
# mkdir /data
# chown oracle:dba /data
```


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Configuring the Staging Area

- Creating the DBFS store:

```
$ cd $ORACLE_HOME/rdbms/admin
$ sqlplus dbfs/dbfs
SQL> @dbfs_create_filesystem_advanced.sql DBFS mydbfs
     nocompress nodeduplicate noencrypt non-partition
```

- Mounting DBFS:

```
$ nohup $ORACLE_HOME/bin/dbfs_client dbfs@<StagingDB>
  -o allow_other,direct_io /data < passwd.txt &
```

  – See My Oracle Support note 1054431.1 for automatic mounting configuration details.

- Using DBFS:
  – Access DBFS through the mount directory.
  – Copy files to DBFS by using methods such as FTP and NFS.

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Configuring the Target Database

- Prerequisites for data file access using external tables:
  - Create an Oracle directory object that references the DBFS staging area directory.
  - Grant the required permissions on the Oracle directory object.
  - Create the required external tables.
- Ensure efficient space management.
  - Use bigfile tablespaces.
  - Use 8 MB initial extents for large segments.
    - Set the `INITIAL` storage parameter to `8 MB`.
    - Set the `CELL_PARTITION_LARGE_EXTENTS` initialization parameter to `TRUE` or `ALWAYS`.
- Use unlimited quotas to bypass quota management.
- Use the parallel clause to set the default degree of parallelism for the target tables.

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Loading the Target Database

- The recommended approach uses external tables:
  - Parallel direct path loading for high performance
  - In-flight processing using SQL
    - Transformations using SQL functions
    - Sort data while loading to optimize Exadata storage indexes
  - No need to restage the data
  - Other advanced features
    - Example: Input file preprocessing
- SQL*Loader can also be used:
  - Parallel direct path loading can also be achieved.
  - There is less processing flexibility compared with external tables.
  - Existing SQL*Loader scripts can be easily reused.

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Loading the Target Database

- Parallel loading using external tables:
  - A `CREATE TABLE ... AS SELECT` statement automatically uses the default degree of parallelism.
  - An `INSERT ... SELECT` statement needs parallel DML to be enabled:

```
SQL> alter session enable parallel dml;
```

- Direct path loading using external tables
  - A `CREATE TABLE ... AS SELECT` statement automatically uses direct path loading.
  - An `INSERT ... SELECT` statement needs an `APPEND` hint to enable direct path loading:

```
SQL> insert /*+ APPEND */ into my_table
     select * from my_external_table;
```


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Quiz

To facilitate parallel loading from typical flat files, external table definitions must reference numerous smaller data files rather than one file containing all the data.

a. True
b. False

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Quiz

Although DBFS is fully functional if it is co-located with the target database, it is recommended to configure DBFS in a separate staging database.

a. True
b. False

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Summary

In this lesson, you should have learned how to:

- Use Oracle DBFS for bulk data loading into Database Machine
- Configure the Database File System (DBFS) feature for staging input data files
- Use external tables based on input data files stored in DBFS to perform high-performance data loads

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Additional Resources

- Lesson demonstrations
  - Bulk Data Loading with Database Machine
- My Oracle Support notes
  - Configuring a Database for DBFS on Oracle Database Machine
  - Configuring DBFS on Oracle Database Machine

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Practice 12 Overview: Bulk Data Loading Using Oracle DBFS

In this practice, you will perform a bulk data load on Database Machine. You will configure a database file system (DBFS) and use it to stage a CSV-formatted file. You will then use the external table feature of Oracle Database to reference the CSV file. Finally, you will use a `CREATE TABLE AS SELECT` statement to copy the CSV file data into a table in your database.

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13

Exadata Database Machine Platform Monitoring: Introduction

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Objectives

After completing this lesson, you should be able to describe the key monitoring infrastructure technologies associated with Exadata Database Machine.

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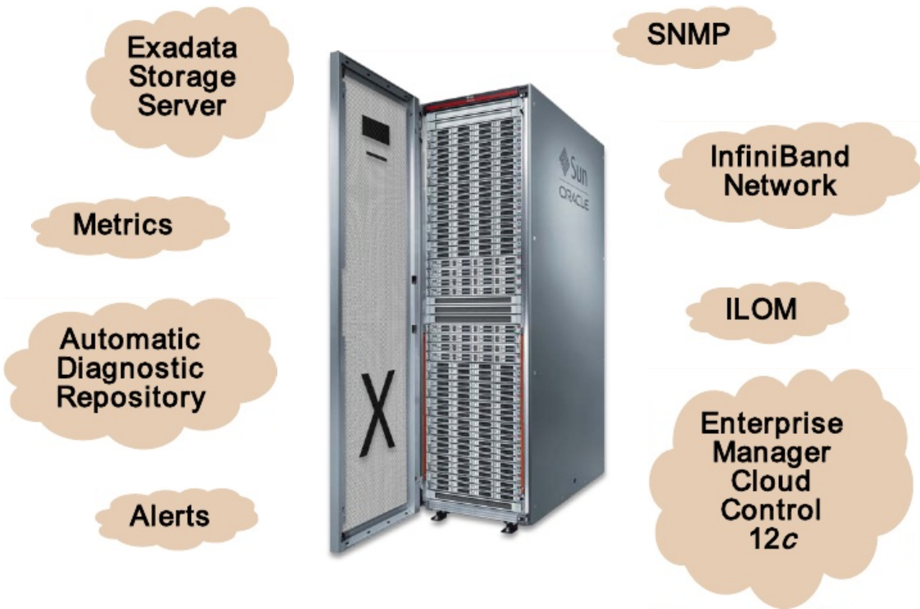
Monitoring Technologies and Standards



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Simple Network Management Protocol (SNMP)

- What is it?
  - A standard protocol for managing devices on a network
- What does it do?
  - Primarily used to propagate information about a device to a monitoring console somewhere on the network
    - Report alerts for hardware or software issues
  - Can be used to set device configuration parameters
- Where is it found?
  - Throughout Database Machine, including database servers, storage servers, InfiniBand switches, Ethernet switch, KVM (Keyboard Video and Mouse) switch, and Power Distribution Units (PDUs)

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Intelligent Platform Management Interface (IPMI)

- What is it?
  - An open, industry-standard interface for server management
- What does it do?
  - Primarily used to perform server configuration and management independently of the server operating system
- Where is it found?
  - Exadata Database Machine database servers and Exadata Storage Servers

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Integrated Lights Out Manager (ILOM)

- What is it?
  - An integrated service processor hardware and software
- What does it do?
  - Provides out-of-band server monitoring and management to:
    - Remotely control the power state of a server
    - View the status of sensors and indicators on the system
    - Provide a remote server console
  - Generates alerts for hardware errors and faults as they occur
- Where is it found?
  - Exadata Database Machine database servers and Exadata Storage Servers

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Exadata Storage Server Metrics, Thresholds, and Alerts

- What are they?
  - Metrics, thresholds, and alerts provide the foundation for monitoring Exadata Storage Server.
- What do they do?
  - Metrics provide a measure relating to some aspect of storage server status or performance.
  - Thresholds are metric levels, which if crossed automatically, generate an alert notification.
  - Alerts are automatically generated notifications of system events.
- Where are they found?
  - Exadata Storage Server

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Automatic Diagnostic Repository (ADR)

- What is it?
  - A file-based repository for diagnostic data such as traces, dumps, and logs
- What does it do?
  - Provides a consistent organization for diagnostic data, which enables administrators and Oracle Support to correlate and analyze diagnostic data more easily and effectively
- Where is it found?
  - Exadata Database Machine database servers and Exadata Storage Servers

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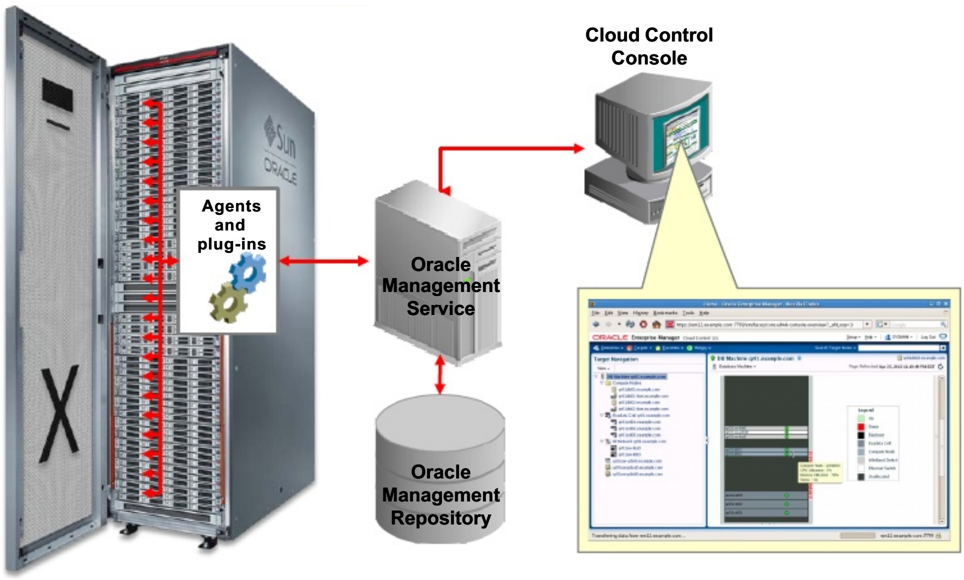
Enterprise Manager Cloud Control 12*c*



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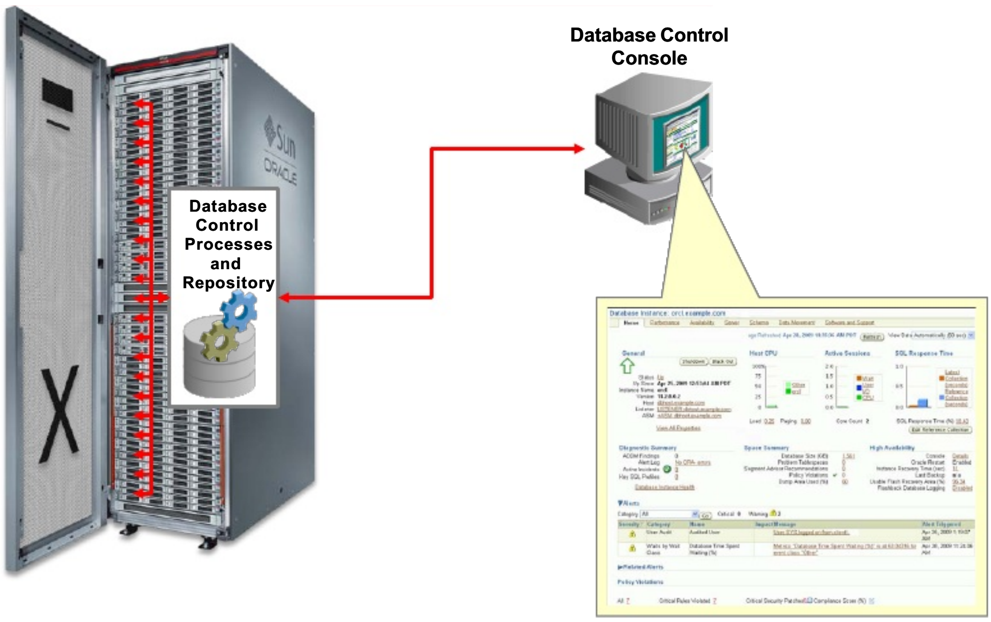
Enterprise Manager Database Control



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Quiz

Which of the following monitoring infrastructure technologies can be used in conjunction with Exadata Storage Servers?

a. Simple Network Management Protocol (SNMP)
b. Integrated Lights Out Manager (ILOM)
c. Exadata metrics, thresholds, and alerts
d. Automatic Diagnostic Repository (ADR)
e. Enterprise Manager Cloud Control 12*c*

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Summary

In this lesson, you should have learned how to describe the key monitoring infrastructure technologies associated with Exadata Database Machine.

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Practice 13 Overview: Environment Reconfiguration

In this practice, you will reconfigure your laboratory environment in preparation for the practices associated with future lessons.

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14

Configuring Enterprise Manager Cloud Control 12^c to Monitor Exadata Database Machine

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Objectives

After completing this lesson, you should be able to describe:

- Enterprise Manager Cloud Control 12*c* architecture as it specifically applies to Exadata Database Machine
- How to configure Enterprise Manager Cloud Control to monitor Exadata Database Machine
- The guided discovery process for Exadata Database Machine
- How to configure a dashboard for Exadata Database Machine

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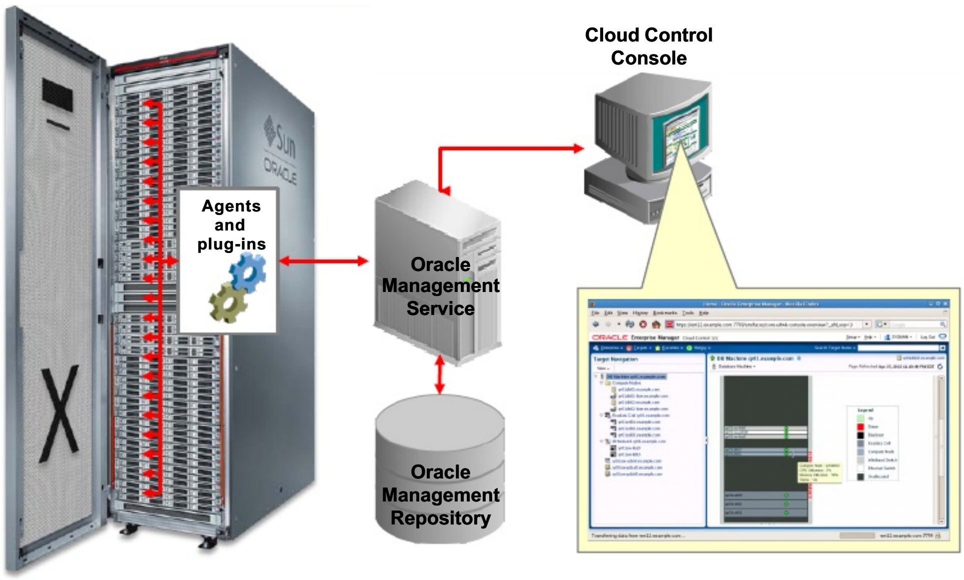
Enterprise Manager Cloud Control 12*c*: Architecture Overview



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Enterprise Manager Cloud Control 12*c*: Supported Exadata Configurations

- Supported Exadata Database Machine configurations:
  - V2
  - X2-2: Full rack, half rack, and quarter rack
  - X2-8: Full rack
  - X3-2: Full rack, half rack, quarter rack, and eighth rack
  - X3-8: Full rack
  - Partitioned Exadata Database Machine: Logically splitting a Database Machine rack into multiple separate environments
- Unsupported configurations:
  - Exadata V1
  - Exadata Storage Expansion Racks
  - Multi-rack Exadata Database Machine

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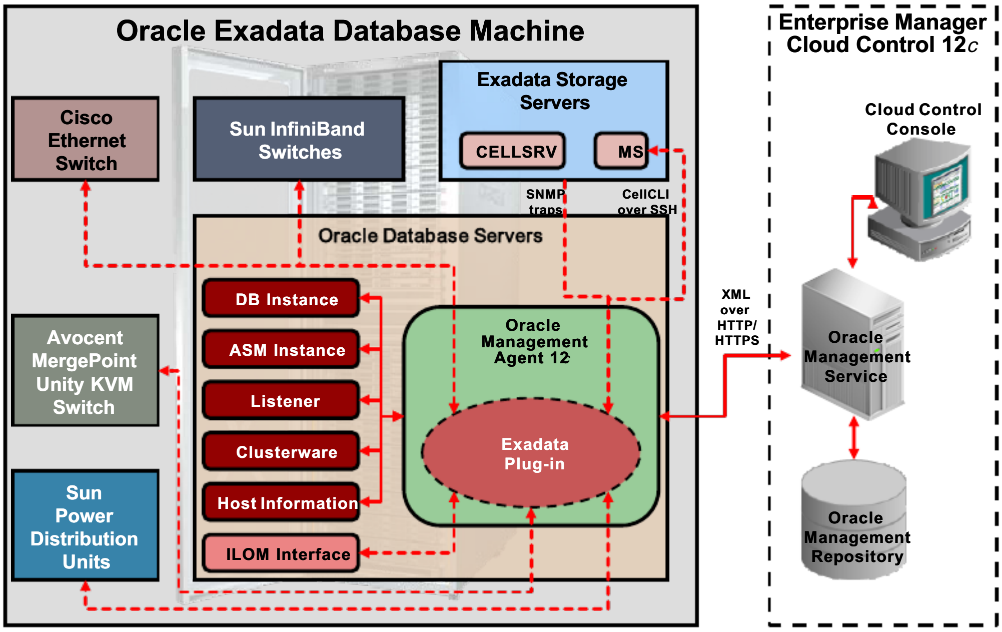
Cloud Control Monitoring Architecture for Exadata Database Machine



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Configuring Cloud Control to Monitor Exadata Database Machine

Prerequisites: Install and configure Exadata Database Machine and Enterprise Manager Cloud Control 12*c*.

1. Perform pre-discovery configuration and verification.
2. Deploy Oracle Management Agent to all database servers.
3. Discover Exadata Database Machine.
4. Perform post-discovery configuration and verification.
5. Discover additional targets.
6. Configure an Exadata Database Machine dashboard.

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Pre-Discovery Configuration and Verification

- Create dedicated ILOM user IDs on the database servers.
- Verify software versions:
  - Exadata Storage Server
  - ILOM `ipmitool`
  - InfiniBand Switch firmware
  - PDU firmware
  - KVM application
- Verify host name resolution:
  - OMS to database servers
  - Database servers to other components
- Verify access to network ports and services, and modify firewalls.
- Configure Enterprise Manager roles and users.

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Deploying the Oracle Management Agent

- Where to deploy:
  - All Database Machine database servers
- Recommended version:
  - 12*c* Release 1 version 12.1.0.2 or later
- How to deploy:
  - During the initial configuration of Exadata Database Machine
  - Using the Cloud Control Agent Installation Wizard
  - May require manual installation of some OS packages

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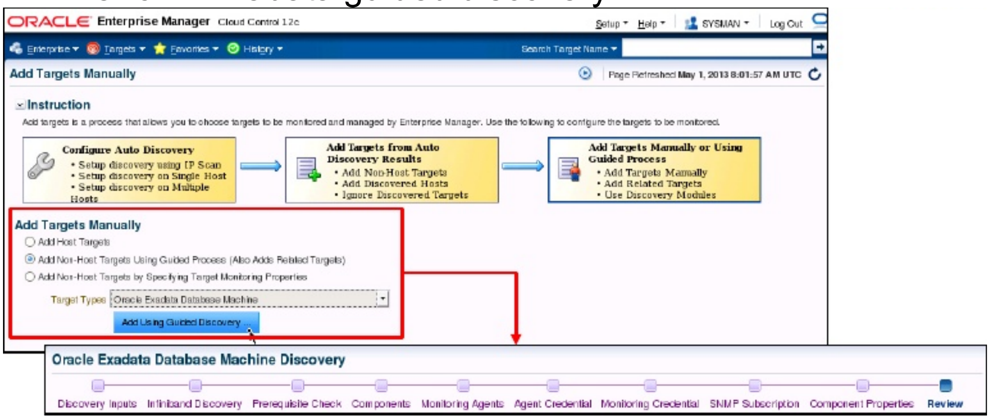
Discovering Exadata Database Machine

- Verify the prerequisites:
  - Run the `exadataDiscoveryPreCheck.pl` precheck script.
  - Perform additional manual verification tasks.
- Perform Exadata guided discovery.



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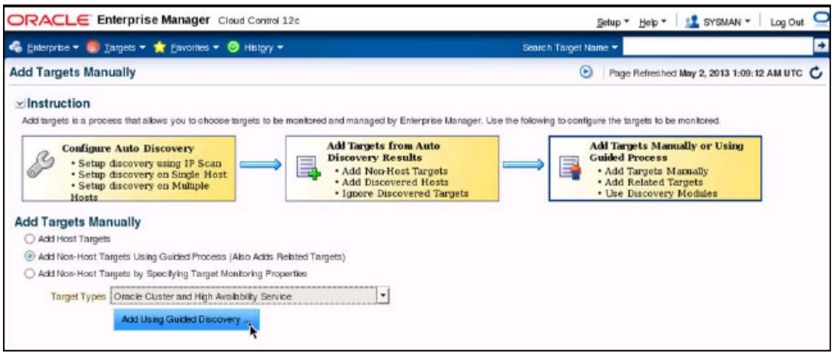
Discovering Additional Targets

- Perform additional guided discovery for:
  - Oracle Cluster and High Availability Service
  - Oracle Database, Listener, and ASM
- Procedures are essentially the same regardless of the Exadata Database Machine involvement.



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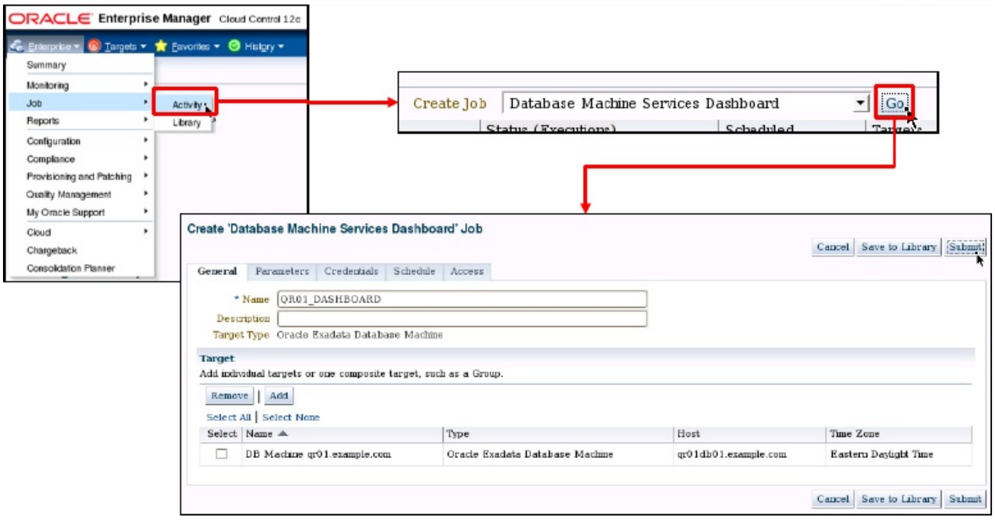
Configuring an Exadata Database Machine Dashboard

Configure an Exadata Database Machine dashboard to monitor Exadata hardware and software components:



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Post-Discovery Configuration and Verification

- Configure agent hosts to forward SNMP notifications.
- Verify SNMP settings for storage cells and InfiniBand switches.
- Configure and verify SNMP settings for:
  - Oracle ILOM Server targets
  - Cisco Ethernet Switch targets
  - Power Distribution Unit (PDU) targets
  - KVM switch targets

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Quiz

The Oracle Management Agent should be deployed to every Database Machine database server because:

a. An agent is required to monitor the cluster and database software components on that database server
b. Multiple agents communicate with each other to cooperatively monitor the other Database Machine system components
c. Multiple agents enhance the availability and performance of Database Machine monitoring

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Quiz

The Exadata Database Machine discovery process configures Enterprise Manager to monitor all Database Machine hardware and software components.

a. True
b. False

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Quiz

The discovery processes for Oracle Grid Infrastructure and Oracle Database software components are essentially the same regardless of whether Database Machine is involved or not.

a. True
b. False

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Summary

In this lesson, you should have learned to describe:

- Enterprise Manager Cloud Control 12*c* architecture as it specifically applies to Exadata Database Machine
- How to configure Enterprise Manager to monitor Exadata Database Machine
- The guided discovery process for Exadata Database Machine
- How to configure a dashboard for Exadata Database Machine

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Additional Resources

- My Oracle Support notes
  - Oracle Database Machine Monitoring Best Practices

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Practice 14 Overview: Exadata Monitoring Configuration

In these practices, you will configure Enterprise Manager Cloud Control 12*c* to monitor Exadata Database Machine. You will also perform a selection of post-discovery configuration and verification tasks.

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15

Monitoring Exadata Storage Servers

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Objectives

After completing this lesson, you should be able to:

- Describe Exadata Storage Server metrics, alerts, and active requests
- Identify the recommended focus areas for Exadata Storage Server monitoring
- Describe how to monitor the recommended Exadata Storage Server focus areas

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Lesson Overview

- Exadata Metric and Alerts Architecture
- Monitoring Exadata Storage Server with Enterprise Manager: Overview
- Monitoring Hardware Failure and Sensor State
- Monitoring Exadata Storage Server Availability
- Checking for Undelivered Alerts
- Checking for Disk I/O Errors
- Checking for Network Errors
- Monitoring File System Free Space
- Comparing Metrics Across Multiple Storage Servers
- Monitoring Metrics Within a Storage Server
- Third-Party Monitoring Tools

What to Monitor

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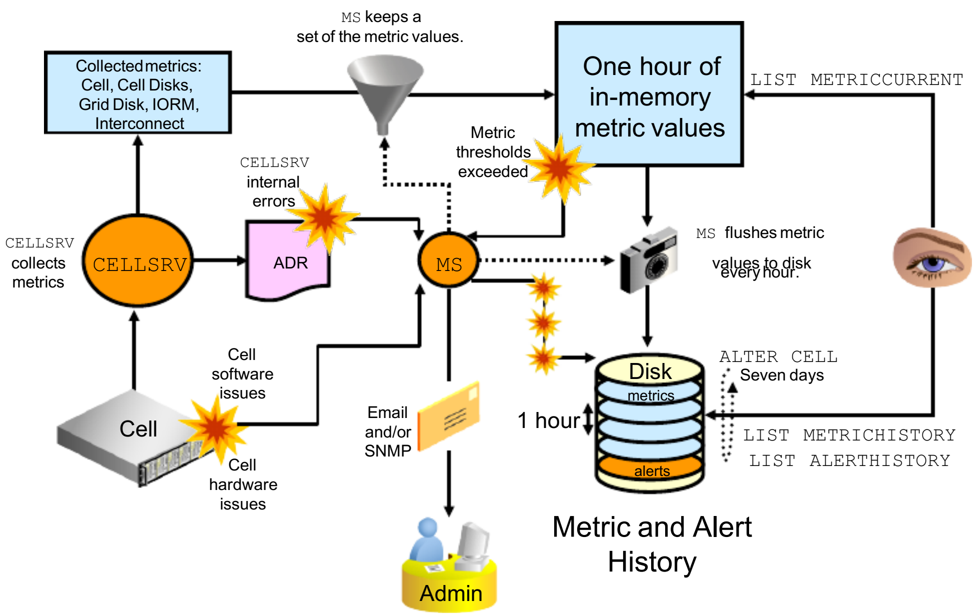
Exadata Metrics and Alerts Architecture



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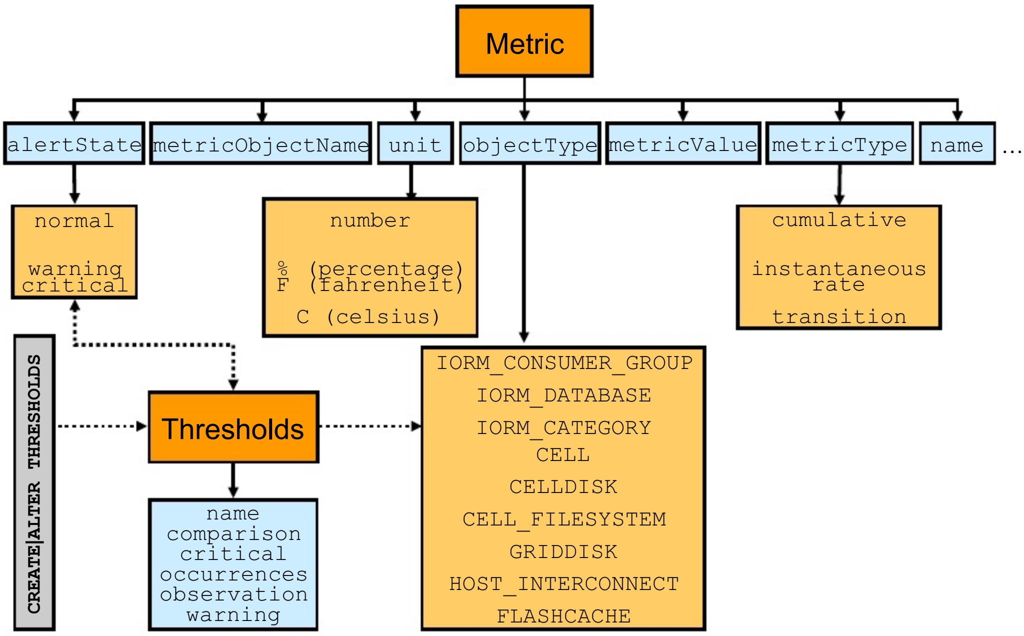
Monitoring Exadata Storage Server with Metrics



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Monitoring Exadata Cell Metrics: Examples

```
CellCLI> LIST METRICDEFINITION WHERE objectType ='CELL' DETAIL
         name: CL_CPUT
         description: "Cell CPU Utilization is the percentage of time over
                       the previous minute that the system CPUs were not
                       idle (from /proc/stat). "
         metricType: Instantaneous objectType: CELL
         unit: %
         ...
```

```
CellCLI> LIST METRICHISTORY WHERE name like 'CL_.*' -
         AND collectionTime > '2009-10-11T15:28:36-07:00'
         CL_RUNQ    cell03_2    6.0        2009-10-11T15:28:37-07:00
         CL_CPUT    cell03_2    47.6 %     2009-10-11T15:29:36-07:00
         CL_FANS    cell03_2    1          2009-10-11T15:29:36-07:00
         CL_TEMP    cell03_2    0.0 C      2009-10-11T15:29:36-07:00
         CL_RUNQ    cell03_2    5.2        2009-10-11T15:29:37-07:00
         ...
```

```
CellCLI> LIST METRICCURRENT WHERE objectType =  'CELLDISK'
         CD_IO_TM_W_SM_RQ CD_1_cell03 205.5 us/request
         CD_IO_TM_W_SM_RQ CD_2_cell03  93.3 us/request
         CD_IO_TM_W_SM_RQ CD_3_cell03   0.0 us/request
         ...
```

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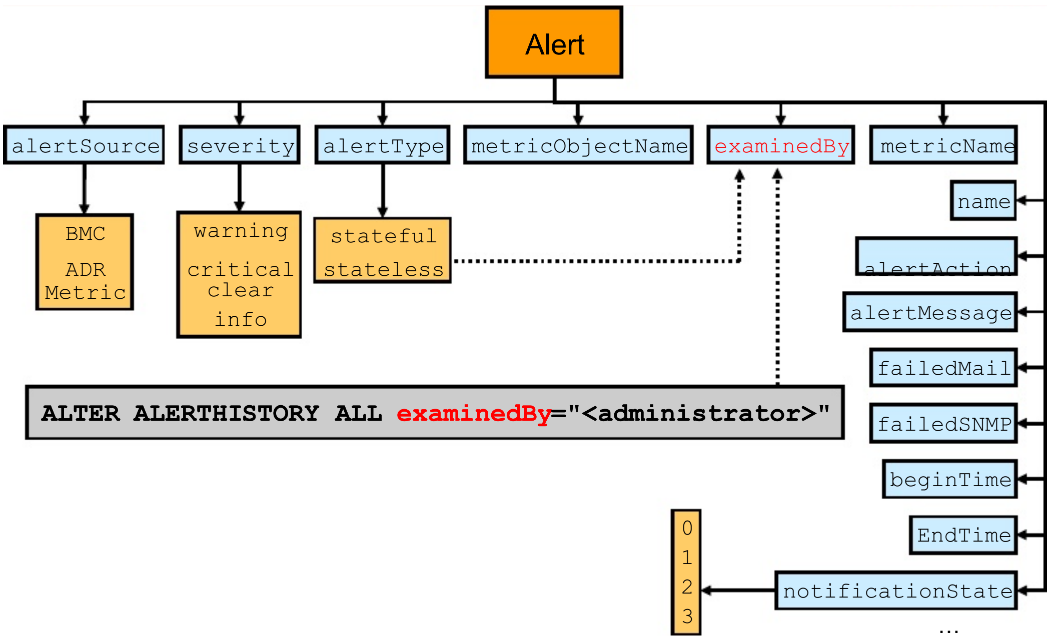
Monitoring Exadata Storage Server with Alerts



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Monitoring Cell Alerts and Creating Thresholds: Examples

```
CellCLI> LIST ALERTDEFINITION ATTRIBUTES name, metricName, description
    ADRAlert "CELL Incident Error"
    HardwareAlert "Hardware Alert"
    StatefulAlert_CG_IO_RQ_LG CG_IO_RQ_LG "Threshold Based Stateful Alert"
    StatefulAlert_CG_IO_RQ_LG_SEC CG_IO_RQ_LG_SEC "Threshold Based …Alert"
    StatefulAlert_CG_IO_RQ_SM CG_IO_RQ_SM "Threshold Based Stateful Alert"
    ...
```

```
CellCLI> LIST ALERTHISTORY WHERE severity = 'critical' -
         AND examinedBy = '' DETAIL
```

```
CellCLI> ALTER ALERTHISTORY 1671443814 examinedBy="JFV"
```

```
CellCLI> CREATE THRESHOLD ct_io_wt_lg_rq.interactive -
         warning=1000, critical=2000, comparison='>', -
         occurrences=2, observation=5
```


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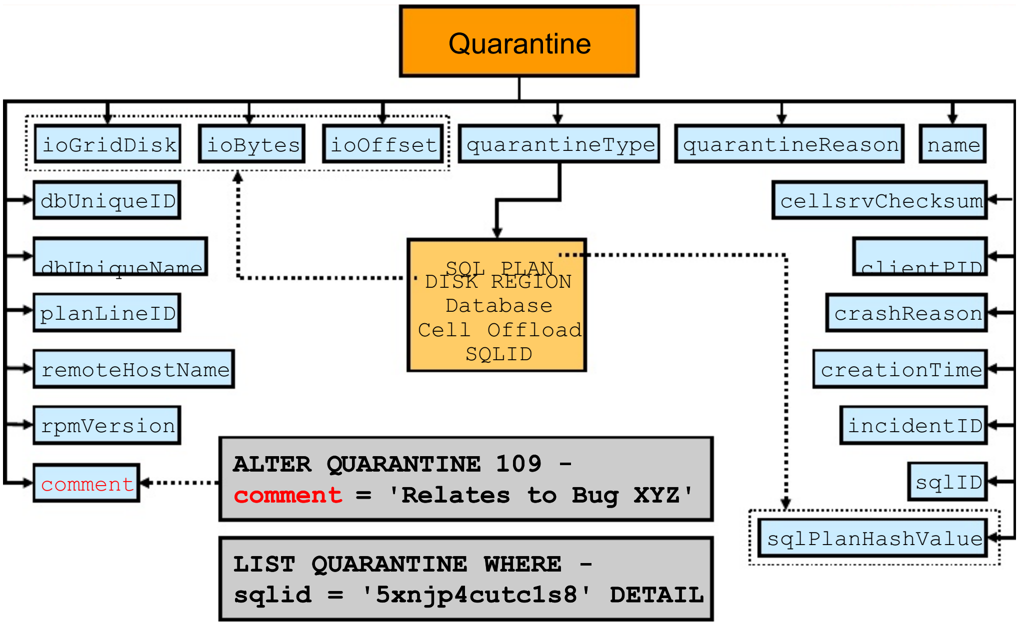
Isolating Faults with Exadata Storage Server Quarantine



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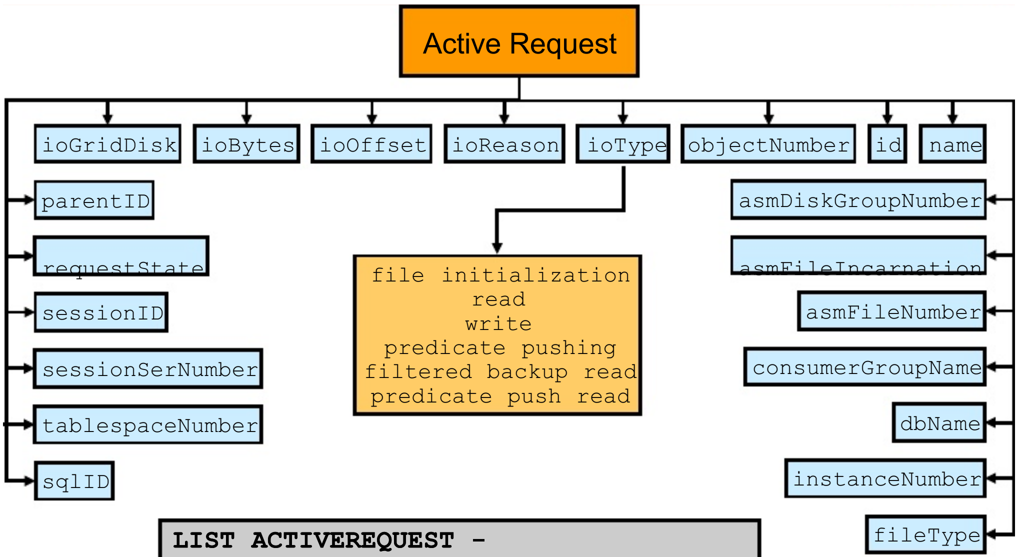
Monitoring Exadata Storage Server with Active Requests




```
LIST ACTIVEREQUEST -
WHERE IoType = 'predicate pushing' -
DETAIL
```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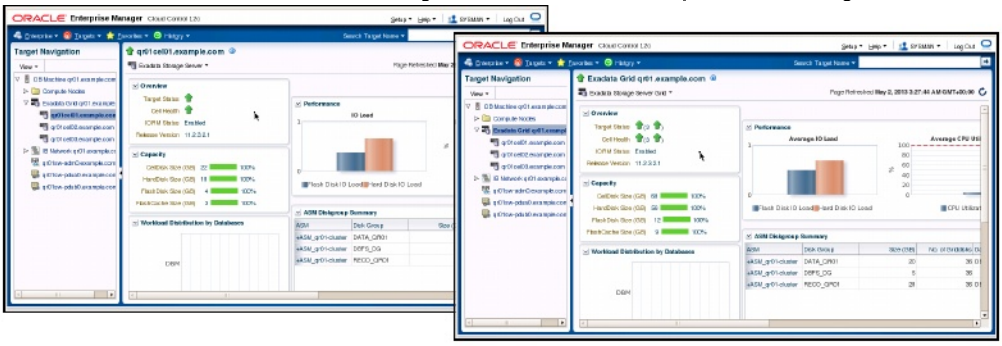
Monitoring Exadata Storage Server with Enterprise Manager: Overview

- Each storage server is a separate target in Enterprise Manager.
  - Storage servers in a Database Machine are grouped together.
- Metrics in Enterprise Manager are mostly based on cell metrics.
- Additional thresholds can be set in Enterprise Manager.
- Alerts generated in the cell are displayed in Enterprise Manager.
- Additional alerts can be generated in Enterprise Manager.



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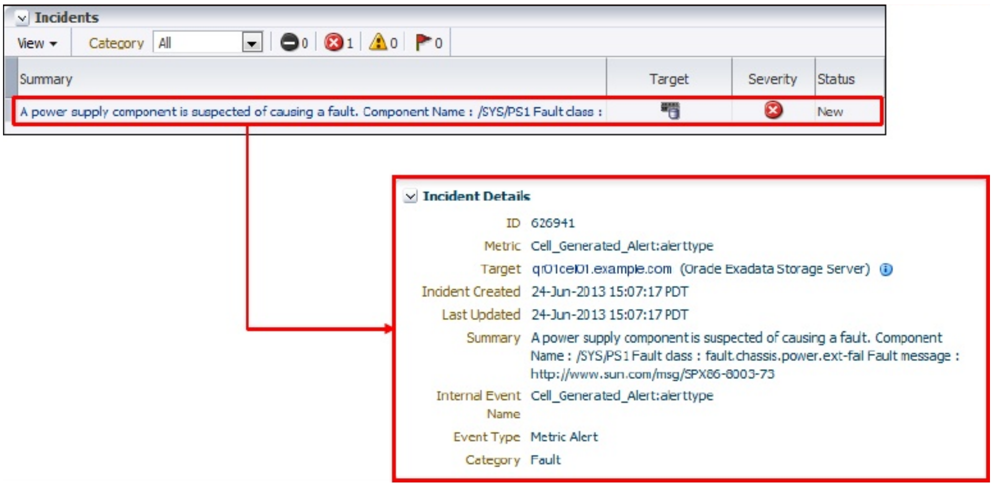
Monitoring Hardware Failure and Sensor State




```
CellCLI> list alerthistory
```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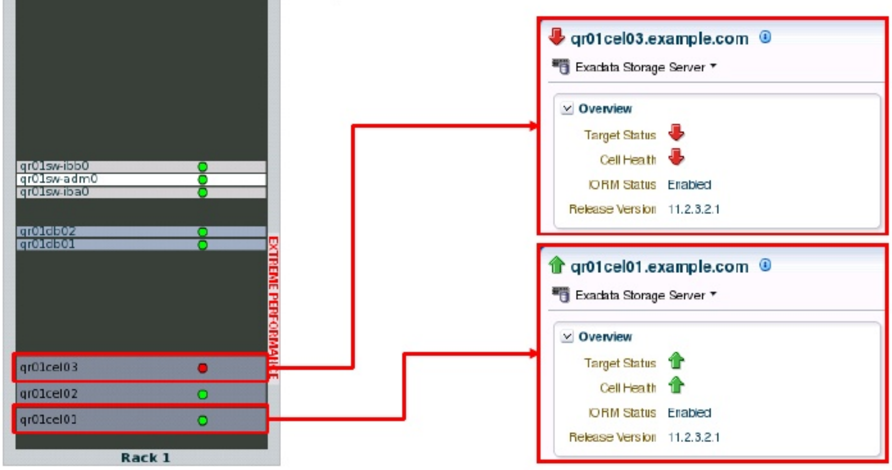
Monitoring Exadata Storage Server Availability

```
CellCLI> list cell detail
         <Output Truncated>
         cellsrvStatus:          running
         msStatus:                running
         rsStatus:               running
```



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Checking for Undelivered Alerts

- Periodically check for undelivered alerts.
  - CellCLI example that checks one cell:

```
CellCLI> list alerthistory where notificationState != 1 and examinedBy = ''
         1_1      2011-04-25T12:09:22-07:00       warning         "The warning
     threshold for the following metric has been crossed. Metric Name        :
     CL_MEMUT  Metric Description : Percentage of total physical memory on the cell
     that is currently used. Object Name      : exa1cel01  Current Value      :
     51.0 %  Threshold Value   : 50.0 %  "

CellCLI>
```

  - dcli example that checks all the cells listed in the cell_group file:

```
$ dcli -g cell_group cellcli -e "list alerthistory where notificationState != 1
  and examinedBy = \'\'"
```

- If undelivered alerts exist, check cell-to-agent network connectivity, agent availability, and cell configuration.

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Checking for Disk I/O Errors

On each cell, create a warning threshold by using the following CellCLI `CREATE THRESHOLD` command:

```
CellCLI> create threshold CD_IO_ERRS_MIN comparison='>', warning=0, -
> occurrences=1, observation=1
Threshold CD_IO_ERRS_MIN successfully created

CellCLI> list threshold CD_IO_ERRS_MIN detail

         name:                        CD_IO_ERRS_MIN
         comparison:                  >
         observation:                 1
         occurrences:                 1
         warning:                     0.0

CellCLI>
```


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Checking for Network Errors

Monitor the storage network for dropped packets.

- Using Enterprise Manager
  - For the following storage server target metrics:
    - Host MB Dropped Per Sec
    - Host RDMA MB Dropped Per Sec
  - Apply the following settings:
    - Set the warning threshold to Zero.
    - Set the Collection Frequency to Repeat Every 5 Minutes.
    - Set the Upload Interval to 3 Collections.
- Directly on the cell:

```
CellCLI> create threshold N_MB_DROP_SEC comparison='>', warning=0, -
> occurrences=1, observation=1
```

```
CellCLI> create threshold N_MB_RDMA_DROP_SEC comparison='>', warning=0, -
> occurrences=1, observation=1
```


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Monitoring File System Free Space

File system free space on Exadata Storage Servers is monitored automatically by MS:

- No direct administrator action is required.
- MS generates an alert if free space becomes low.
- MS automatically reclaims used space by purging old log files, trace files, crash dumps, and other unnecessary files.

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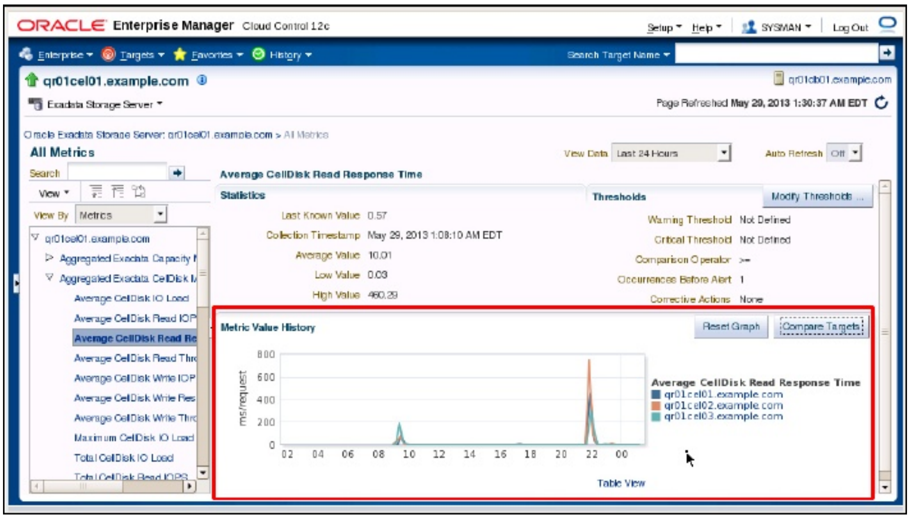
Comparing Metrics Across Multiple Storage Servers

- Enterprise Manager can compare metrics across storage servers.
- Large imbalances may indicate a problem.



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Monitoring Metrics in a Storage Server

- There are no default metric thresholds for CPU, memory, or I/O utilization.
- 100% utilization may be normal in certain cases.
- Metric observations are useful and relevant when compared with previously captured baselines.
- Suggested methodology:
  1. Determine key metrics based on your applications and service requirements.
  2. Record baseline metric observations based on normal and peak system usage.
  3. Implement thresholds to generate alerts for observations outside expected ranges.
     - Warning thresholds to indicate slightly abnormal observations
     - Critical thresholds to indicate situations that could affect service levels

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Third-Party Monitoring Tools

- Installing additional software, including any third-party monitoring agent, is not supported on Exadata Storage Server.
- Exadata Storage Server can be configured to send alerts to any SNMP subscriber.

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Quiz

Where should you define thresholds when using Enterprise Manager to monitor Exadata Storage Servers?

a. In Enterprise Manager only
b. Inside the Exadata cell only
c. Inside the Exadata cell if possible; otherwise, in Enterprise Manager
d. Either in Enterprise Manager or inside the Exadata cell; it does not matter

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Quiz

Assuming that Enterprise Manager is properly configured to monitor Exadata Storage Server, which of the following can occur?

a. A metric observation generates an alert in the cell, but no alert is seen in Enterprise Manager.
b. A metric observation generates an alert in the cell and an alert is seen in Enterprise Manager.
c. A metric observation generates no cell alert, but an alert is seen in Enterprise Manager.
d. A metric observation results in two alerts in Enterprise Manager.

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Summary

In this lesson, you should have learned how to:

- Describe Exadata Storage Server metrics, alerts, and active requests
- Identify the recommended focus areas for Exadata Storage Server monitoring
- Describe how to monitor the recommended Exadata Storage Server focus areas

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Practice 15 Overview: Monitoring Exadata Storage Server

In these practices, you will:

- Monitor Exadata Storage Server using metrics, alerts, and active requests
- Perform Exadata Storage Server monitoring by using Enterprise Manager

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Monitoring Exadata Database Machine Database Servers

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Objectives

After completing this lesson, you should be able to describe the monitoring recommendations for Exadata Database Machine database servers.

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Monitoring Database Servers: Overview

- Exadata Database Machine database server monitoring is essentially the same as monitoring any clustered Oracle Database server.
  - Skills and practices are readily transferrable.
- This lesson covers Database Machine–specific differences and recommendations with a focus on using Enterprise Manager to monitor:
  - Database server hardware
  - Database server operating system
  - Oracle Grid Infrastructure
  - Oracle Database
  - Oracle Management Agent

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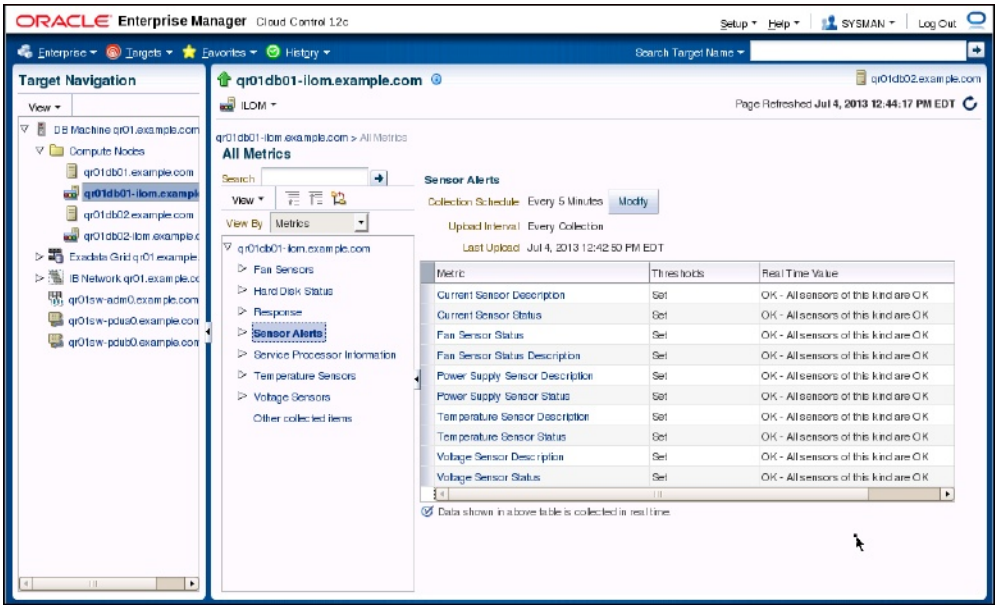
Monitoring Hardware



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Monitoring the Operating System

- Operating system monitoring is built into Enterprise Manager by using the Host target type:
  - There are no Exadata-specific configuration requirements for general monitoring.
  - Thresholds can be set or changed to accommodate site-specific requirements.
  - Remember to monitor disk I/O in the storage servers and not on the database servers.
  - Essential operating system alerts are generated by Enterprise Manager based on default metric thresholds.

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Monitoring Oracle Grid Infrastructure

- Grid Infrastructure monitoring is built intoEnterprise Manager.
  - There are no Exadata-specific configuration requirements for general monitoring.
  - Thresholds can be set or changed to accommodate site-specific requirements.
  - Essential alerts are generated by Enterprise Manager based on default metric thresholds.
- Monitoring of the ASM log file for cell connectivity issues is not provided by Enterprise Manager:
  - Check the ASM alert log file for messages such as:

```
connect: ossnet: connection failed to server <ipaddr>,
   result=5 (login: sosstcpreadtry failed)
```


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Monitoring Oracle Database

- Monitoring of Oracle databases is built into Enterprise Manager by using Cluster Database and Database Instance targets.
  - There are no Exadata-specific configuration requirements for general monitoring.
  - Thresholds can be set or changed to accommodate site-specific requirements.
  - Essential alerts are generated by Enterprise Manager based on default metric thresholds.
- Monitoring of the database instance log file for cell connectivity issues is not provided by Enterprise Manager:

```
connect: ossnet: connection failed to server <ipaddr>,
   result=5 (login: sosstcpreadtry failed)
```


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Monitoring Oracle Management Agent

- Oracle Management Agent monitoring is built in to Enterprise Manager by using the Agent target type.
  - There are no Exadata-specific configuration requirements for general monitoring.
  - Thresholds can be set or changed to accommodate site-specific requirements.
  - Essential alerts are generated by Enterprise Manager based on default metric thresholds.
- Remember that agent availability is especially important for the agents monitoring the Exadata Database Machine targets.

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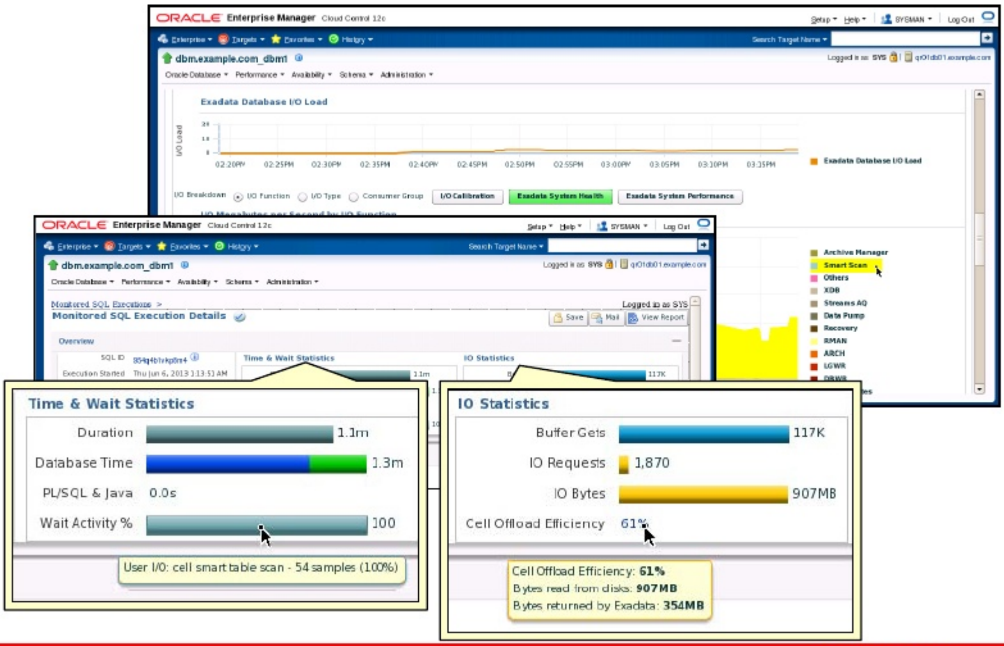
Database Monitoring with Enterprise Manager Cloud Control 12*c*



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Quiz

Extensive retraining is required for existing Oracle database administrators to monitor and maintain Oracle databases on Exadata Database Machine.

a. True
b. False

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Summary

In this lesson, you should have learned how to describe the monitoring recommendations for Exadata Database Machine database servers.

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Practice 16 Overview: Oracle Database Monitoring

In this practice, you examine the Exadata-specific database monitoring capabilities provided by Enterprise Manager.

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Monitoring the InfiniBand Network

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Objectives

After completing this lesson, you should be able to describe:

- The InfiniBand network monitoring capabilities provided by Enterprise Manager Cloud Control 12*c*
- How to monitor the Exadata Database Machine InfiniBand network without Enterprise Manager

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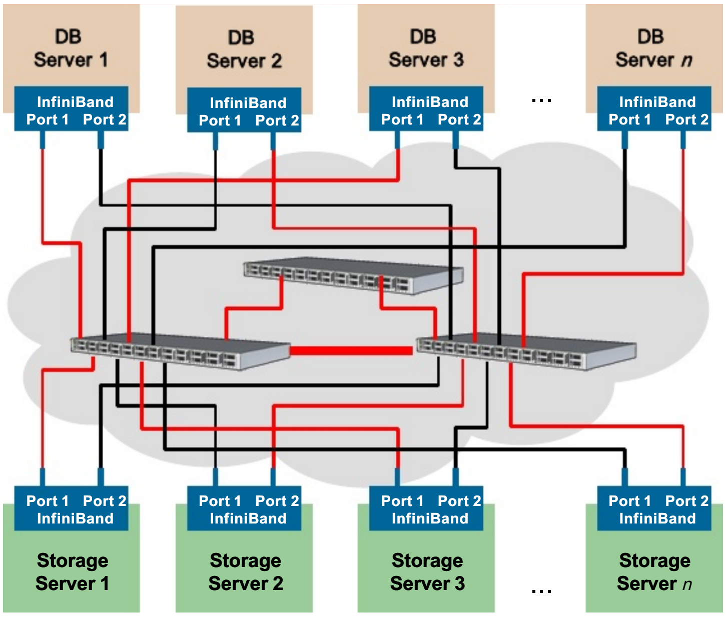
InfiniBand Network Monitoring: Overview



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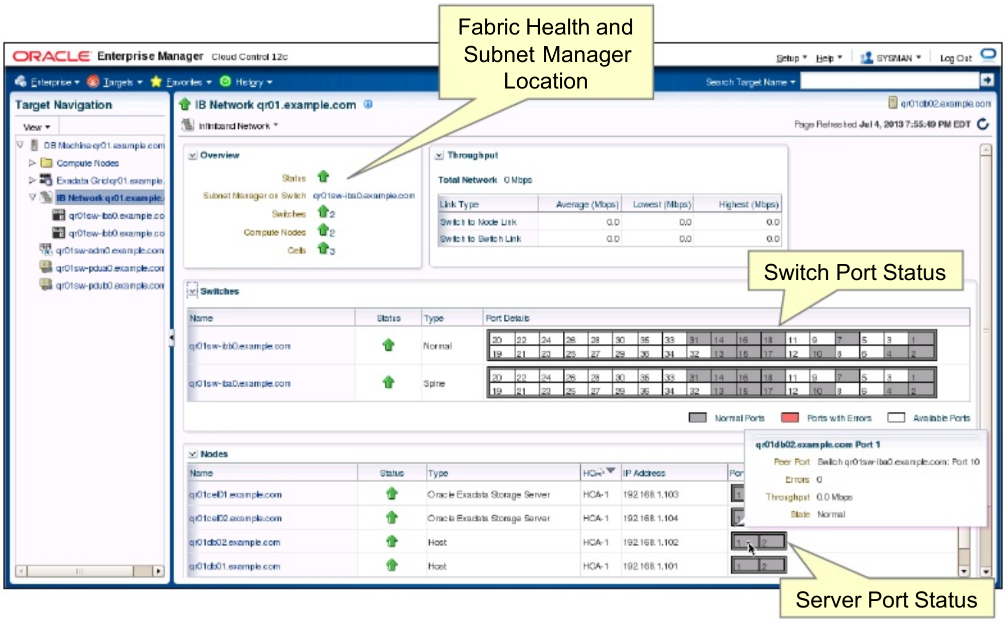
InfiniBand Network Monitoring with Enterprise Manager Cloud Control 12*c*



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Monitoring the InfiniBand Switches

InfiniBand switch monitoring checks for failed switch hardware and sensors that exceed preset thresholds.

- Example of commands and expected normal output:

```
# ssh root@dm01sw-ibb0
root@dm01sw-ibb0's password:
[root@dm01sw-ibb0 ~]# showunhealthy
OK - No unhealthy sensors
[root@dm01sw-ibb0 ~]# checkpower
PSU 0 present OK
PSU 1 present OK
All PSUs OK
```

- Checks should be performed every 60 to 120 seconds.
- Use `env_test` to gather more information if required.

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Monitoring the InfiniBand Switch Ports

Check for switch port errors with the following command:

```
# ibqueryerrors.pl -s RcvSwRelayErrors,RcvRemotePhysErrors,XmtDiscards,
XmtConstraintErrors,RcvConstraintErrors,ExcBufOverrunErrors,VL15Dropped
```

- Compare output with previous results:
  - `SymbolErrors`, `RcvErrors`, or `LinkIntegrityErrors` should not increase without `LinkDowned` increasing.
- Checks can be executed from any database server or InfiniBand switch.
- Checks should be performed every 60 to 120 seconds.

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Monitoring the InfiniBand Ports on Database Machine Servers

- InfiniBand port monitoring is automatically performed on Exadata Storage Servers.
- Manually monitor database server ports with the following commands:

```
# ibstatus
# perfquery
# ifconfig
# ping <Remote InfiniBand Hostname>
# rds-ping <Remote InfiniBand Hostname>
```


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Monitoring the InfiniBand Fabric: Subnet Manager Master Location

The following checks are recommended once per day:

- Check that the InfiniBand Subnet Manager (SM) master is located on one of the InfiniBand switches.
  - Example:

```
# sminfo
sminfo: sm lid 1 sm guid 0x21283a8516a0a0, activity count 933330
priority 5 state 3 SMINFO_MASTER
# ibswitches
Switch : 0x0021283a8516a0a0 ports 36 "Sun DCS 36 QDR switch dm01sw-ibs0"
enhanced port 0 lid 1 lmc 0
Switch : 0x0021283a8983a0a0 ports 36 "Sun DCS 36 QDR switch dm01sw-iba0"
enhanced port 0 lid 4 lmc 0
Switch : 0x0021283a89bda0a0 ports 36 "Sun DCS 36 QDR switch dm01sw-ibb0"
enhanced port 0 lid 3 lmc 0
```

- For networks containing spine switches, check that the SM master is running on a spine switch.

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Monitoring the InfiniBand Fabric: Network Topology and Link Status

- Use `verify-topology` to check the InfiniBand fabric.
  – Example of expected output:

```
# /opt/oracle.SupportTools/ibdiagtools/verify-topology
[ DB Machine Infiniband Cabling Topology Verification Tool ]
                [Version IBD VER 2.c ]
Spine switch found: dm01sw-ibs0 (21283a8516a0a0)
Leaf switch found: dm01sw-iba0 (21283a8983a0a0)
Leaf switch found: dm01sw-ibb0 (21283a89bda0a0)
Found 2 leaf, 1 spine, 0 top spine switches
Check if all hosts have 2 CAs to different switches...............[SUCCESS]
Leaf switch check: cardinality and even distribution..............[SUCCESS]
Spine switch check: Are any Exadata nodes connected ..............[SUCCESS]
Spine switch check: Any inter spine switch links..................[SUCCESS]
Spine switch check: Any inter top-spine switch links..............[SUCCESS]
Spine switch check: Correct number of spine-leaf links............[SUCCESS]
Leaf switch check: Inter-leaf link check..........................[SUCCESS]
Leaf switch check: Correct number of leaf-spine links.............[SUCCESS]
```

- Use `iblinkinfo.pl -Rl` to monitor the link status.
  – Compare output with previously gathered output.

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Quiz

Enterprise Manager Cloud Control 12*c* provides a comprehensive set of Database Machine InfiniBand network monitoring capabilities.

a. True

b. False

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Summary

In this lesson, you should have learned to describe:

- The InfiniBand network monitoring capabilities provided by Enterprise Manager Cloud Control 12*c*.
- How to monitor the Exadata Database Machine InfiniBand network without Enterprise Manager.

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Practice 17 Overview: InfiniBand Monitoring

In this practice, you will examine the InfiniBand network monitoring capabilities provided by Enterprise Manager.

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Monitoring Other Exadata Database Machine Components

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Objectives

After completing this lesson, you should be able to monitor the following additional Exadata Database Machine components:

- Cisco Ethernet Switch
- Sun Power Distribution Units
- KVM Switch

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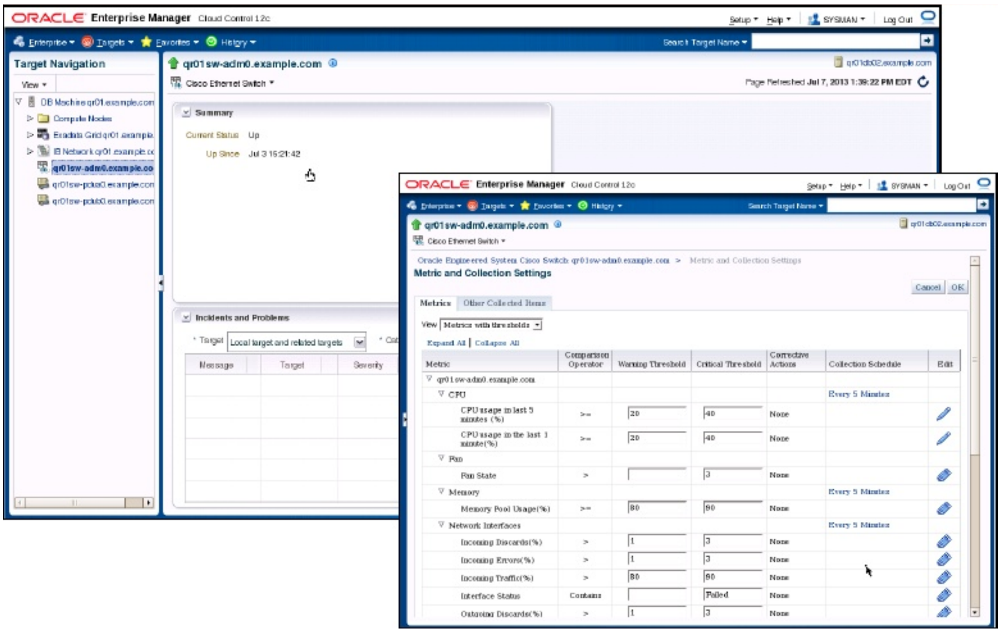
Monitoring the Cisco Ethernet Switch



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Monitoring the Sun Power Distribution Units

- Each rack contains two PDUs.
- Monitor PDUs to:
  - Ensure continuous power supply
  - Measure power consumption
- Monitoring options:
  - Physical inspection of the PDUs
  - Remote monitoring by using Enterprise Manager or other SNMP manager
    - Appropriate threshold settings inside each PDU are required to facilitate remote monitoring.

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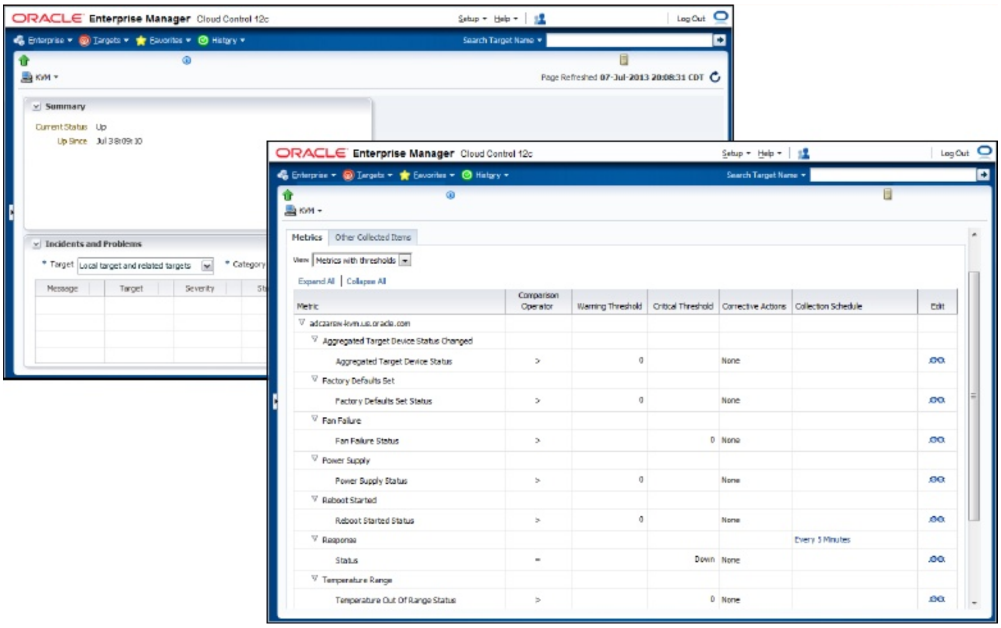
Monitoring the KVM Switch



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Quiz

Identify the component that is most important to monitor to maintain the overall availability of Database Machine.

a. Cisco Ethernet Switch
b. Sun Power Distribution Units
c. KVM Switch

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Summary

In this lesson, you should have learned how to monitor the following additional Exadata Database Machine components:

- Cisco Ethernet Switch
- Sun Power Distribution Units
- KVM Switch

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Other Useful Monitoring Tools

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Objectives

After completing this lesson, you should be able to describe the following tools:

- Exachk
- DiagTools
- ADRCI
- Imageinfo and Imagehistory
- OSWatcher

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Exachk: Overview

- Exachk is a utility that:
  - Collects data regarding Database Machine component versions and best practices
  - Enables administrators to check their environment against supported version levels and best practices
  - Is pre-installed on new Exadata Database Machines
  - Is available from My Oracle Support note 1070954.1
  - Should be executed periodically as a regular part of Database Machine monitoring and maintenance
  - Does not alter any Database Machine configuration settings
  - Is lightweight and has minimal impact on the system
- Exachk is NOT:
  - A continuous monitoring tool
  - A replacement for Enterprise Manager

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Running Exachk

As the Oracle Database software owner (`oracle` OS user):

1. Download `exachk.zip` to a database server.
2. Unzip `exachk.zip`:

```
$ unzip exachk.zip
```

   – Leave the `exachk` script and driver files (`collections.dat` and `rules.dat`) together in the same directory.

3. Ensure that the `exachk` script is executable:

```
$ chmod +x exachk
```

4. Run `exachk`:
   – Follow the prompts, and read and understand all the messages.
   – Supply the requested passwords; otherwise, some checks are skipped.
5. Review the report:
   – Review the summary to identify areas for further investigation.
   – Review the details for recommendations and further information.

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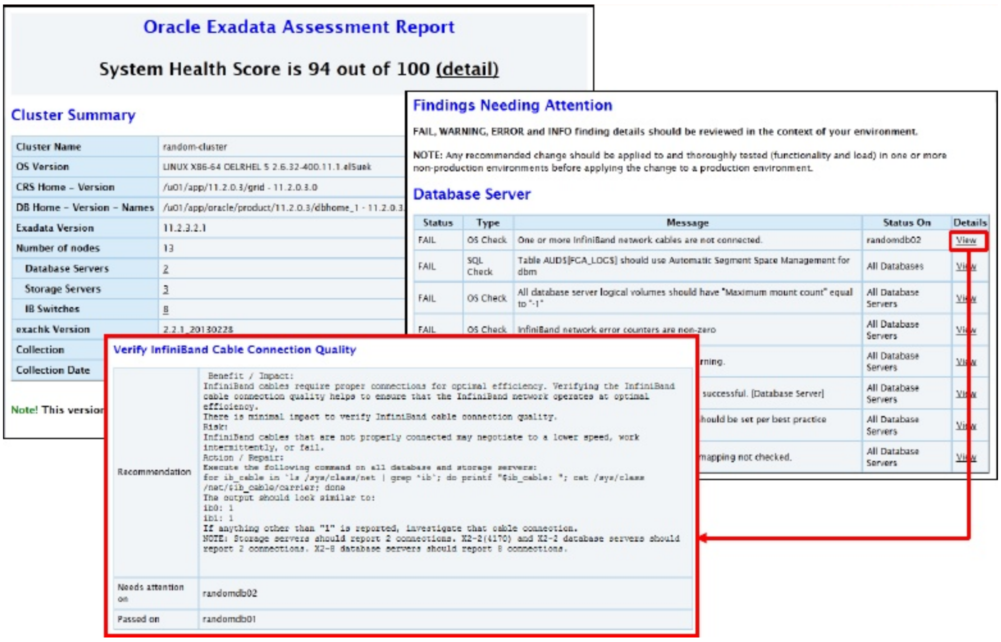
Exachk Output



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Exachk Daemon

Exachk version 2.2.2 introduces a daemon process to permit non-interactive execution at regular intervals.

- Configuration example:

```
$ ./exachk -set "AUTORUN_INTERVAL=1d;AUTORUN_FLAGS= -o -v
;NOTIFICATION_EMAIL=name@company.com;PASSWORD_CHECK_INTERVAL=1"
```

- Checking the configuration:

```
$ ./exachk -get all
```

- Starting and stopping the daemon:

```
$ ./exachk -d [ start | stop ]
```

- Checking the daemon status and the next scheduled run:

```
$ ./exachk -d [ status | nextautorun ]
```


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DiagTools: Overview

- `DiagTools.zip` contains two scripts, which collect trace, log, and configuration information:
  - `DbmCheck.sh` collects general configuration information about all the Exadata Storage Servers.
  - `diagget.sh` collects Oracle software log and trace files plus operating system information from all the servers.
- The scripts are designed to provide a consolidated package of information for use by Oracle Support.
- `DiagTools.zip` is available from My Oracle Support note 735323.1.
- See the demonstration Using DiagTools.

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Using ADRCI on Exadata Storage Servers

- The Exadata Storage Server software uses the Automatic Diagnostic Repository (ADR) structure to manage diagnostic data.
- Using ADRCI on an Exadata Storage Server is essentially the same as using it on a database server.
- The default ADR home location is:

```
/opt/oracle/cell<cell_version>/log/diag/asm/cell/<hostname>
```

- See the demonstration Using ADRCI on an Exadata Storage Cell.

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`imageinfo`: Overview

```
[root@exa1cel01 ~]# imageinfo

Kernel version: 2.6.18-194.3.1.0.3.el5 #1 SMP Tue Aug 31 22:41:13 EDT 2010 x86_64
Cell version: OSS_11.2.0.3.0_LINUX.X64_101206.2
Cell rpm version: cell-11.2.2.2.0_LINUX.X64_101206.2-1

Active image version: 11.2.2.2.0.101206.2
Active image activated: 2011-02-24 12:22:44 -0800
Active image status: success

Active system partition on device: /dev/md5
Active software partition on device: /dev/md7

In partition rollback: Impossible

Cell boot usb partition: /dev/sdac1
Cell boot usb version: 11.2.2.2.0.101206.2

Inactive image version: 11.2.2.2.1.110131
Inactive image activated: 2011-02-23 18:30:44 -0800
Inactive image status: success
Inactive system partition on device: /dev/md6
Inactive software partition on device: /dev/md8

Boot area has rollback archive for the version: undefined
Rollback to the inactive partitions: Impossible
```


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`imagehistory`: Overview

```
[root@exa1cel01 ~]# imagehistory
Version                              : 11.2.2.2.0.101206.2
Image activation date                : 2011-01-12 14:56:44 -0800
Imaging mode                         : fresh
Imaging status                       : success

Version                              : 11.2.2.2.1.110131
Image activation date                : 2011-02-23 18:30:44 -0800
Imaging mode                         : out of partition upgrade
Upgrade logs                         : /var/log/cellos/patch/rollback_20
1102242002_11.2.2.2.0.101206.2_11.2.2.2.1.110131.tar.gz
Imaging status                       : success

Version                              : 11.2.2.2.0.101206.2
Image activation date                : 2011-02-24 12:22:44 -0800
Imaging mode                         : out of partition rollback
Imaging status                       : success
```


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OSWatcher: Overview

- OSWatcher collects and archives operating system and network metrics to aid in diagnosing performance issues.
- OSWatcher gathers OS data on a regular basis, invoking utilities such as `vmstat`, `netstat`, and `iostat`.
- OSWatcher runs on all Exadata Database Machine servers with the following default settings:
  - Metric snapshots are recorded every 15 seconds.
  - 168 hours (7 days) of archived metric observations are maintained.
  - Installation location: `/opt/oracle.oswatcher/osw`
  - Archive location: `/opt/oracle.oswatcher/osw/archive`
- The *OSWatcher User Guide* is available from My Oracle Support note 301137.1.

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Quiz

Exachk is an alternative to using Enterprise Manager.

a. True
b. False

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Quiz

Which utility should you use to provide Oracle Support with a consolidated package of information about a Database Machine environment?

a. Exachk
b. DiagTools
c. ADRCI
d. Imageinfo
e. Imagehistory
f. OSWatcher

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Summary

In this lesson, you should have learned how to describe the following tools:

- Exachk
- DiagTools
- ADRCI
- Imageinfo and Imagehistory
- OSWatcher

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Additional Resources

- Lesson demonstrations
  - Using DiagTools
  - Using ADRCI on an Exadata Storage Server
- My Oracle Support notes
  - Oracle Exadata Database Machine exachk or HealthCheck
  - Exadata Storage Server Diagnostic Collection Guide
  - OS Watcher User Guide

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Backup and Recovery

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Objectives

After completing this lesson, you should be able to describe:

- How Recovery Manager (RMAN) backups are optimized using Exadata Storage Server
- The recommended approaches for disk- and tape-based backups of databases on Database Machine
- The recommended best practices for backup and recovery on Database Machine

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Backup and Recovery: Overview

- Backup and recovery of databases on Database Machine:
  - Use RMAN
  - Typical strategies:
    - Disk-based backups
    - Tape-based backups
    - Hybrid strategy
- Backup and recovery of Database Machine software:
  - Database server software
  - Exadata Storage Server software

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Using RMAN with Database Machine

- Using RMAN on Database Machine is essentially the same as using RMAN elsewhere:
  - Same concepts
  - Same commands
- Incremental backup performance is improved.
  - Block filtering is offloaded to Exadata Storage Server.
  - Fewer blocks need to be processed by RMAN.
  - Offload processing is automatic and transparent.
- Exadata Hybrid Columnar Compression can assist to further improve backup performance.
  - Reduced data size results in smaller, quicker backups.

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General Recommendations for RMAN

Use RMAN to back up and recover databases on Database Machine.

- Use RMAN incremental backups and block change tracking.
- Use an external RMAN recovery catalog repository.
- Set `DB_RECOVERY_FILE_DEST_SIZE` to bound the space used in the Fast Recovery Area.

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Disk-Based Backup Strategy

For disk-based database backups, Oracle recommends:

- Using a Fast Recovery Area
- Performing an initial level 0 (full) backup
- Performing periodic incremental level 1 backups
- Updating your level 0 backup by applying the second to last level 1 backup

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Disk-Based Backup Recommendations

- Fast Recovery Area (FRA) configuration:
  - Default: FRA disk group striped across all available Exadata Storage Servers, along with data disk groups
    - High availability with the best throughput
  - Alternative: FRA disk group and data disk groups on separate Exadata Storage Servers
    - Separation of data and backups
    - Possibility of reduced throughput
- Additional RMAN recommendations:
  - Instances and channels:
    - Initially, run RMAN across all database instances with two RMAN channels per instance.
    - Configure up to eight RMAN channels per instance if required.
  - Configure an Oracle Service to use as the RMAN target.

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Disk-Based Backup on Non-Exadata Storage

- Backup to Exadata storage provides optimal performance.
- Oracle Sun ZFS Backup Appliance provides a high-performance and cost-effective alternative that:
  – Is tested and validated with Exadata Database Machine
  – Can connect directly to the Exadata InfiniBand network
- Other NAS- and NFS-based options are feasible.
  – Thorough testing is required to ensure acceptable performance.
- Connection to a SAN requires an intermediate server.
  – Database Machine does not support direct SAN connection.
  – Performance will likely be limited by the intermediate server.

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Tape-Based Backup Strategy

For tape-based database backups, Oracle recommends:

- Using media management software that is integrated with RMAN, such as Oracle Secure Backup
- Performing periodic level 0 (full) database backups
- Performing more frequent cumulative level 1 backups and also backing up the Oracle Secure Backup catalog

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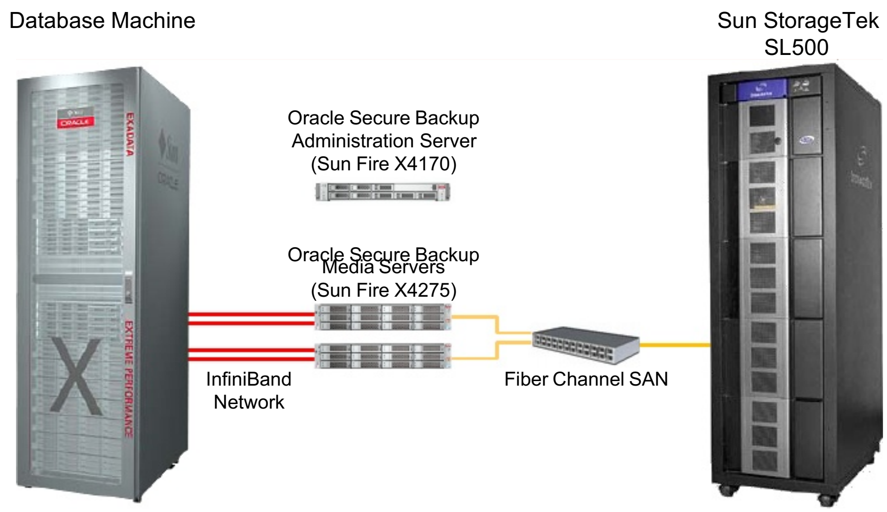
Tape-Based Backup Architecture



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Tape-Based Backup Recommendations

- Media server to Database Machine network configuration recommendation:
  - Use InfiniBand for the best backup rates:
    - Configure bonding for the media server InfiniBand interfaces.
    - Update OpenFabrics Enterprise Distribution on the media server.
    - Configure IP over InfiniBand connected mode for best performance.
    - Set the message transfer unit (MTU) size to 65520 for the InfiniBand interface.
    - Configure the media management software to use the InfiniBand network.
- Media server SAN configuration recommendation:
  - Configure persistent bindings for tape devices.

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Connecting the Media Server by Using Ethernet

- Ethernet can be used if throughput is sufficient:
  - GigE: Expect up to 120 MB/sec from each interface.
  - 10*g*igE: Expect up to 1 GB/sec from each interface.
- Recommendations:
  - Use a dedicated backup network:
    - Configure dedicated network interfaces on each Database Machine database server.
  - Use bonded network interfaces:
    - Configure LACP for maximum throughput:
      - Availability still maintained if one link is lost
      - Configuration required on media server, network switch, and database servers
    - Use Active-Passive bonding for high availability; otherwise:
      - Configure database servers and media server
      - No specific switch configuration required

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Tape-Based Backup Recommendations

- Run RMAN across all the available database instances.
  - Create a Database Service that runs across the cluster:

```
$ srvctl add service -d <dbname> -s <service name>
  -r <instance1>, ... ,<instancen>
```

  - Use the service name and SCAN address to connect RMAN:

```
$ rman target sys/<passwd>@<scan_address>/<service_name>
  catalog ...
```

- Allocate one RMAN channel per tape drive.
- Configure IORM and DBRM to control resource allocation between backups and application workloads.

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Hybrid Backup Strategy

- A hybrid backup strategy combines the disk-based and tape-based backup approaches.
  - Level 0 (full) database backups are stored on tape:
    - Relatively cheap backup media that can be stored off site
  - Level 1 incremental backups are stored on disk in the FRA:
    - Readily available with high-performance access
- Follow recommendations for both approaches.

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Restore and Recovery Recommendations

- Restore into existing data files if possible.
  - Restore performance is better.
- Restore using all database instances.
- Recommended number of RMAN channels:
  - For disk-based restoration, use two to eight RMAN channels per database instance.
  - For tape-based restoration, set the number of RMAN channels based on the total number of tape drives.

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Backup and Recovery of Database Machine Software

- Database Server software
  - Perform file system–level backup and recovery:
    - Use your chosen file system backup management software or Oracle Secure Backup can be used.
    - Copies of the Oracle Cluster Registry are automatically maintained on the Database Server file system and should be included in Database Server file system backups.
- Exadata Storage Server software
  - File system level–backups are not recommended:
    - System areas are mirrored.
      - Use CellCLI commands to recover if one system disk fails.
    - Use the Exadata Software Rescue Procedure if both system disks fail simultaneously.
      - The rescue procedure uses a built-in USB flash drive.

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Quiz

How many RMAN channels should you use for tape-based backups?

a. Two per database instance
b. Four per database instance
c. One per tape drive

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Summary

In this lesson, you should have learned to describe:

- How RMAN backups are optimized using Exadata Storage Server
- The recommended approaches for disk- and tape-based backups of databases on Database Machine
- The recommended best practices for backup and recovery on Database Machine

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Additional Resources

- Lesson demonstrations
  - Backup Optimization Using RMAN and Exadata Storage Server
  - Recovery Optimization Using RMAN and Exadata Storage Server
- My Oracle Support notes
  - Database Machine and Exadata Storage Server 11*g* Release 2 (11.2) Supported Versions
  - OSB - Create persistent bindings for device attachments on OEL
- Documentation and white papers
  - Backup and Recovery Performance and Best Practices for Exadata Database Machine - Oracle Database 11.2.0.2 and later

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Practice 20 Overview: Using RMAN Optimizations for Database Machine

In these practices, you will examine the backup and recovery optimizations that are enabled when Oracle Recovery Manager (RMAN) is used in conjunction with Exadata storage.

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Exadata Database Machine Maintenance Tasks

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Objectives

After completing this lesson, you should be able to perform the following Database Machine maintenance tasks:

- Powering Database Machine on and off
- Safely shutting down a single Exadata Storage Server
- Replacing a damaged physical disk on a cell
- Replacing a damaged flash card on a cell
- Moving all disks from one cell to another
- Using the Exadata cell software rescue procedure

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Database Machine Maintenance: Overview

- Maintaining Database Machine is similar to maintaining any other clustered Oracle Database environment.
- Database Machine–specific tasks outlined in this lesson:
  - Powering Database Machine on and off
  - Safely shutting down a single Exadata Storage Server
  - Replacing a damaged physical disk on a cell
  - Replacing a damaged flash card on a cell
  - Moving all disks from one cell to another
  - Using the Exadata cell software rescue procedure
- Additional references:
  - *Oracle Exadata Database Machine Owner's Guide*
  - My Oracle Support

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Powering Database Machine Off and On

- Power-off sequence:
  1. Database servers
     ```
     # <Grid_Home>/bin/crsctl stop cluster
     # shutdown -h -y now
     ```
     – Ensure that all database servers are shut down before proceeding.
  2. Exadata Storage Servers
     ```
     # shutdown -h -y now
     ```
     – Ensure that all storage servers are shut down before proceeding.
  3. Rack, including network switches
- Power-on sequence:
  1. Rack, including network switches
     – Apply power for a few minutes before proceeding.
  2. Exadata Storage Servers
     – Check that all cells are running before proceeding.
  3. Database servers

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Safely Shutting Down a Single Exadata Storage Server

- Safe shutdown sequence:
  1. Check to ensure that shutting down the storage server will not take any ASM disk group offline:

     ```
     CellCLI > LIST GRIDDISK WHERE  asmdeactivationoutcome != 'Yes'
     ```

  2. Make all the grid disks inactive:

     ```
     CellCLI> ALTER GRIDDISK ALL INACTIVE
     ```

  3. Verify that all the grid disks are inactive:

     ```
     CellCLI> LIST GRIDDISK WHERE STATUS !=  'inactive'
     ```

  4. Power off the storage server.
- Startup sequence:
  1. Start the storage server.
     - Cell services start automatically.
  2. Make all the grid disks active:

     ```
     CellCLI> ALTER GRIDDISK ALL ACTIVE
     ```

  3. Verify that all the grid disks are active:

     ```
     CellCLI> LIST GRIDDISK ATTRIBUTES name, asmmodestatus
     ```


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Replacing a Damaged Physical Disk

1. Determine the damaged disk.

```
CellCLI> LIST ALERTHISTORY -
WHERE ALERTMESSAGE LIKE "Logical drive lost.*" DETAIL
Logical drive lost. Lun: 0_5. Status: normal. Physdisk: 20:5.
Celldisk on it: CD_05_cell01. Griddisks on it: data_CD_05_cell01.
The suggested action is: Refer to section Maintaining Physical Disks in
the User Guide.
```

2. Replace the physical disk.

```
ALTER PHYSICALDISK 20:5 SERVICELED ON
```

```
LIST PHYSICALDISK
```

→ NORMAL

3. Monitor ASM to confirm the re-addition of the disk.

```
SQL> SELECT NAME, STATE FROM V$ASM_DISK
SQL> SELECT * FROM GV$ASM_OPERATION
```


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Replacing a Damaged Flash Card

1 Determine the damaged flash card.

```
CellCLI> LIST PHYSICALDISK DETAIL
         name: [9:0:2:0]
         diskType: FlashDisk
         ...
         slotNumber: "PCI Slot: 1; FDOM: 2"
         status: critical
```

2 Power off the cell.

3 Replace the flash card.

4 Power on the cell.

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Moving All Disks from One Cell to Another

1. Make the grid disks inactive:

```
CellCLI> ALTER GRIDDISK ALL INACTIVE
```

2. Back up the operating system configuration files that may change when the new cell is booted.
3. Move the disks, flash cards, disk controller, and CELLBOOT USB flash drive from the srcinal cell to the new cell.
   – Ensure that the system disks occupy the first two slots.
   – Ensure that the flash cards occupy the same PCI slots.
4. Boot the new cell.
5. Restart Exadata cell services:

```
CellCLI> ALTER CELL RESTART SERVICES ALL
```

6. Activate the grid disks:

```
CellCLI> ALTER GRIDDISK ALL ACTIVE
```


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Using the Exadata Cell Software Rescue Procedure

- Every Exadata Storage Server is equipped with a CELLBOOT USB flash drive to facilitate cell rescue:
  - Required if both system disks fail simultaneously or are corrupt
  - Should be used with extreme caution
- To perform cell rescue:
  1. Connect to the Exadata Storage Server by using the console.
  2. Boot the cell, and as soon as you see the Oracle Exadata splash screen, press any key on the keyboard.
  3. From the boot options list, select the last option, `CELL_USB_BOOT_CELLBOOT_usb_in_rescue_mode`. Then press Enter.
  4. Select the rescue option, and proceed with the rescue.
  5. At the end of the rescue process, ensure that the cell boots from the system disks.
  6. Reconfigure the cell.

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Quiz

When shutting down an Exadata Database Machine, the Exadata Storage Servers must be shut down first.

a. True
b. False

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Quiz

An Exadata Storage Server should be shut down to replace failed hardware components other than hard disk drives.

a. True

b. False

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Quiz

Which of the following statements are true about an Exadata Storage Server disk failure?

a. The associated ASM grid disks are automatically dropped and an ASM rebalance occurs to quickly restore redundancy.
b. The disk may be replaced without shutting down the storage server.
c. The storage server must be shut down to replace the disk.
d. Multiple ASM instances can participate in the rebalance operation of a single disk group.

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Summary

In this lesson, you should have learned how to perform the following Database Machine maintenance tasks:

- Powering Database Machine on and off
- Safely shutting down a single Exadata Storage Server
- Replacing a damaged physical disk on a cell
- Replacing a damaged flash card on a cell
- Moving all disks from one cell to another
- Using the Exadata cell software rescue procedure

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Patching Exadata Database Machine

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Objectives

After completing this lesson, you should be able to:

- Describe how software is maintained on different Database Machine components
- Locate the recommended patches for Database Machine
- Describe the recommended patching process for Database Machine
- Describe the characteristics of an effective test system

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Patching and Updating: Overview

- There are three categories of software that must be maintained in Database Machine:
  – Software and firmware on the Exadata Storage Servers
  – Software and firmware on the database servers
  – Software and firmware for other components
- Compatibility between the different software needs to be maintained.
- Patches and updates are rolling in nature wherever possible.
- Key information is maintained in My Oracle Support note 888828.1.

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Maintaining Exadata Storage Server Software

- Exadata Storage Server patches:
  - Are complete software images
  - Maintain consistency across all cell components
  - Are released independently from Oracle Database patches
  - Have dependencies on other software and firmware versions
- Most Exadata Storage Server patches can be applied while databases remain up and running.
- Firmware levels in Exadata Storage Server are maintained automatically.
- No additional software, RPMs or otherwise, should be installed on Exadata Storage Server.

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Maintaining Database Server Software

- You can patch and update the database server software as you would for an Oracle Database server outside of Database Machine.
  - Oracle Database patches applied by OPatch:
    - Double-check compatibility of patches with Database Machine.
    - Oracle supplies Bundle Patches for Database Machine:
      - Periodic bundling of database patches recommended for Database Machine
  - Operating system and firmware updated using regular channels:
    - Must maintain consistency with InfiniBand (OFED) software
- Check Exadata Storage Server patches for database server firmware and operating system updates.

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Assisted Patching Using OPlan

- OPlan is a utility that provides step-by-step patching instructions that are specific to the target environment:
  - Can create instructions for Apply and Rollback
- OPlan works in conjunction with Exadata Database Machine–recommended Bundle Patches:
  - Starting with 11.2.0.2 Bundle Patch 2
- Using OPlan:
  - As the Oracle software owner:
    - Download the Bundle Patch to a local directory
    - Set the `$ORACLE_HOME` environment variable and execute:

```
$ORACLE_HOME/oplan/oplan generateApplySteps <bundle patch location>
```

    - Locate the customized patch installation instructions at:

```
$ORACLE_HOME/cfgtoollogs/oplan/<TimeStamp>/InstallInstructions.txt
```


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Assisted Patching Using the DB Node Update Utility

- The DB Node Update Utility automates all the steps and checks to upgrade Database Machine database servers to a new Exadata software release:
  - Updates the database server operating system
  - Can perform upgrades and rollbacks
  - Compliments the Exadata Storage Server patching procedure and Oracle Database patching procedures
- The DB Node Update Utility supports the following:
  - Database servers with Oracle Linux 5.5 and later
  - Upgrades from release 11.2.2.4.2 and later
  - Rollbacks to release 11.2.2.4.2 and later
  - “Known issues” for upgrades to release 11.2.3.2.1 and later
- See My Oracle Support note 1553103.1 for details.

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Maintaining Other Software

- Other components in Database Machine that have software or firmware:
  - InfiniBand switches
  - Power Distribution Units (PDUs)
  - Keyboard, Video and Mouse (KVM) switch
  - Cisco Ethernet switch
- Always refer to My Oracle Support note 888828.1 for Exadata-specific requirements.

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Recommended Patching Process

1. Review the patch documentation (README file).
   - Read and understand it before proceeding.
2. Validate the patch installation on a test system.
   - Run exachk before and after patch application.
   - Automate the patch application steps where possible.
   - Test the fallback procedure.
3. Validate the patch functionality on a test system.
   - Verify that the patch provides the desired functionality.
   - Evaluate system performance.
4. Apply the patch in production.
   - Run exachk before and after patch application.
   - Make sure all cells are healthy before applying the patch.
   - Evaluate system performance.

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Test System Recommendations

An effective test system:

- Is an exact replica of the production Database Machine
- Is not used for any other purpose during testing
- Contains a full copy of the production data set with identical statistics
- Is able to mimic production transaction volumes and concurrency
- Is able to compare workload and performance metrics on the test system with metrics collected from the production system
- Includes the operational and availability test suites used in production

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Quiz

Which of the following statements is a broad overview of the recommended approach for patching and updating Database Machine?

a. All updates for Database Machine are specific to Database Machine, and these are the only updates that should be applied to Database Machine.
b. Use Unbreakable Linux Network (ULN) to update Linux on database servers and Exadata Storage Servers, and apply specific database and Exadata cell updates for the remaining software.
c. Use Exadata-specific update bundles for the Exadata Storage Servers, and use normal database updating practices for the database servers.

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Summary

In this lesson, you should have learned how to:

- Describe how software is maintained on different Database Machine components
- Locate the recommended patches for Database Machine
- Describe the recommended patching process for Database Machine
- Describe the characteristics of an effective test system

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Additional Resources

- Lesson demonstrations
  - Exadata Storage Server Rolling Patch Application
  - Exadata Storage Server Patch Rollback
- My Oracle Support notes
  - Database Machine and Exadata Storage Server 11*g* Release 2 (11.2) Supported Versions
  - Oracle Software Patching with OPLAN
  - Exadata Database Server Patching using the DB Node Update Utility
  - Oracle Exadata Database Machine exachk or HealthCheck

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Exadata Database Machine Automated Support Ecosystem

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Objectives

After completing this lesson, you should be able to describe:

- The Auto Service Request (ASR) function and how it relates to Exadata Database Machine
- The implementation requirements for ASR
- The ASR configuration process
- Oracle Configuration Manager (OCM) and how it relates to Exadata Database Machine

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Auto Service Request: Overview

- Automatically and securely opens service requests with Oracle for common server hardware faults
  - Minimal data is collected and transmitted.
  - No IP addresses are communicated.
  - One-way (customer to Oracle) SSL encrypted communications are used.
- Enables fast and accurate resolution of hardware faults
  - Improved availability, less down time
- Can be integrated with existing monitoring tools
  - The ASR Manager can send SR notifications via SNMP traps to existing monitoring tools.
- Is included with hardware warranty and Oracle Premier Support for Systems

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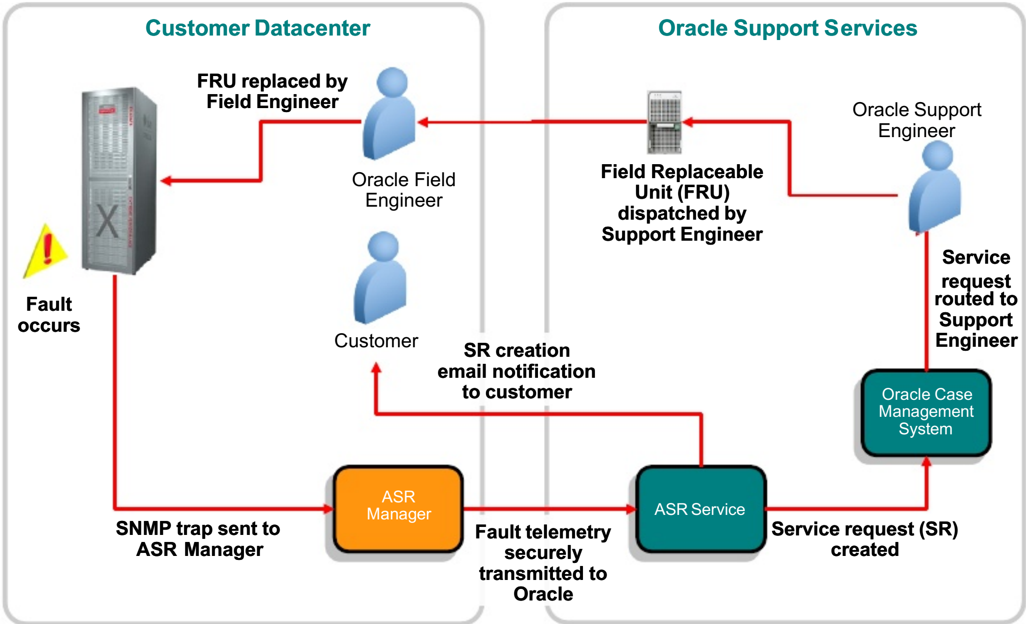
ASR Process



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ASR Requirements

- A server capable of running the ASR Manager:
  - An existing ASR Manager (version 2.7 or greater) can be used to monitor Database Machine.
  - A Database Machine database server can be used as ASR Manager (not recommended).
- Connectivity between the ASR Manager and the Database Machine management network
- HTTPS connectivity (either directly or via a proxy) from the ASR Manager to Oracle Support
- My Oracle Support account with current contact information for all Database Machine assets
- Exadata software version 11.2.1.3.1 or later on the database servers and Exadata Storage Servers

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Configuring the ASR Manager

1. Install the ASR Manager components:
   - Oracle Automated Service Manager (OASM) Package
   - Service Tools Bundle (STB) for Solaris
   - Oracle Auto Service Request (ASR) Package
2. Register the ASR Manager:
   - As `root` on the ASM Manager server, run:

     ```
     # asr register
     ```

     - Follow the prompts and provide the requested information.
   - To check the registration status, run:

     ```
     # asr show_reg_status
     ```

   - To test the network connectivity, run:

     ```
     # asr test_connection
     ```


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Configuring Exadata Database Machine for ASR

1. Configure SNMP trap destinations:
   – As `root` on each database server, run:

```
# /opt/oracle.cellos/compmon/exadata_mon_hw_asr.pl -set_snmp_subscribers \
> "(type=asr,host=<ASR Manager>,port=162,community=public,fromip=<eth0 IP>)"
```

   – As `root` or `celladmin` on each Exadata Storage Server, run:

```
CellCLI> alter cell snmpsubscriber = -
> ((host='<ASR Manager>', port=162, community=public, type=ASR))
```

   – Remember to preserve existing SNMP registrations.
2. Verify ASR SNMP subscribers:
   – As `root` on each database server, run:

```
# /opt/oracle.cellos/compmon/exadata_mon_hw_asr.pl -get_snmp_subscribers \
> -type asr
```

   – As `root` or `celladmin` on each Exadata Storage Server, run:

```
CellCLI> list cell attributes snmpsubscriber
```


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Activating ASR Assets

- As `root` on the ASR Manager server:
  - Activate the ASR Manager host:

```
# asr activate_asset -i <ASR Manager IP>
```

  - Activate each Database Machine database server ILOM and each Exadata Storage Server ILOM:

```
# asr activate_asset -i <Asset ILOM IP>
```

  - Activate each Database Machine database server and each Exadata Storage Server:

```
# asr activate_exadata -i <Asset IP> \
>  -h <Asset hostname> -l <Asset ILOM IP>
```

  - Verify that all the nodes are visible on the ASR Manager:

```
# asr list_asset
```

- Activate ASR assets in My Oracle Support
  - Follow the procedure in My Oracle Support note 1329200.1.

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Verifying the ASR Configuration

- Verify the ASR configuration:
  - As `root` on each database server, run:

```
# /opt/oracle.cellos/compmon/exadata_mon_hw_asr.pl \
> -validate_snmp_subscriber -type asr
```

  - As `root` or `celladmin` on each Exadata Storage Server, run:

```
CellCLI> alter cell validate snmp type=ASR
```


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Oracle Configuration Manager: Overview

Oracle Configuration Manager collects configuration information for propagation to Oracle Support.

- Benefits include:
  - More efficient problem diagnosis
  - Easier service request reporting
- Configuration information can be uploaded to Oracle either automatically or manually.
- Configuration information remains confidential.
- Oracle recommends the use of OCM in conjunction with Exadata Database Machine.

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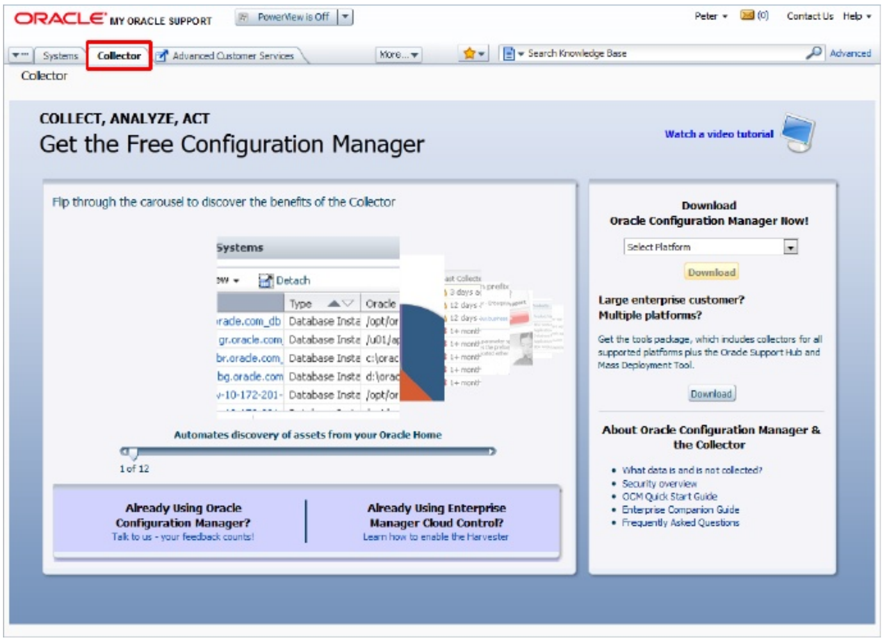
Configuring Oracle Configuration Manager



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Quiz

Oracle recommends that the ASR Manager is configured on one of the Exadata Database Machine servers.

a. True

b. False

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Quiz

ASR will create a service request with Oracle Support when which of the following occur?

a. A disk fault in a storage server
b. An ORA-600 error in a database server
c. A power supply in a server fails
d. A hardware fault in a server fan
e. All of the above

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Quiz

The Enterprise Manager Configuration Management Pack is required to use Oracle Configuration Manager.

a. True

b. False

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Summary

In this lesson, you should have learned to describe:

- The Auto Service Request (ASR) function and how it relates to Exadata Database Machine
- The implementation requirements for ASR
- The ASR configuration process
- Oracle Configuration Manager (OCM) and how it relates to Exadata Database Machine

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Additional Resources

- Documentation and recommendations:
  - Oracle Auto Service Request User Documentation and Product Qualification Information
  - Hardware and Network Configuration Recommendations for ASR

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A

Exadata Database Machine and Oracle Database 12c

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Objectives

After completing this lesson, you should be able to describe the support for Oracle Database 12*c* on Exadata Database Machine.

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Introducing Oracle Database 12*c*: The Database for Cloud Computing

- Builds on 30+ years of Oracle Database innovation
- Focuses on cloud computing enabling:
  - **Agility** through rapid provisioning and cloning along with capacity on demand
  - **Security** using isolated data containers
  - **Control** using global and local resource management
  - **Transparency** so that applications do not change
  - **Low cost** through efficient use of hardware resources and the ability to manage many as one
- Provides enhancement of core capabilities for improved **performance**, **scalability**, **availability**, **security**, and **manageability**
- Benefits for all Oracle Database users:
  - Including users of Oracle Exadata Database Machine

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Oracle Database 12*c* on Exadata Database Machine

- Exadata Database Machine supports Oracle Database 12*c* Release 1.
  - Database Machine can run a mixture of 11.2 and 12.1 databases.
- All new features of Oracle Database 12*c* Release 1 are supported.
  - Exadata Storage Server version 11.2.3.2.1 (or later) required
  - Initial restrictions for Smart Scan and IORM
  - Details in My Oracle Support note 1537407.1

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Summary

In this lesson, you should have learned how to describe the support for Oracle Database 12*c* on Exadata Database Machine.

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Exadata Release 11.2.3.3.0 New Features

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Objectives

After completing this lesson, you should be able to describe the new features introduced in Exadata release 11.2.3.3.0.

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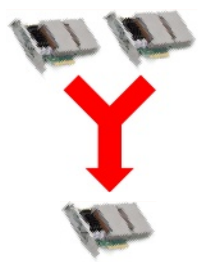
Flash Cache Compression

Modern Exadata Storage Server flash cards (Sun Flash Accelerator F40 and F80) can perform compression.

- Exadata release 11.2.3.3.0 exposes this capability
- Compression is available regardless of the cache write setting
  - Write-through and write-back modes are both supported
- Compression and decompression happens dynamically inside the flash modules
  - No performance overhead
- Exadata Smart Flash Cache capacity effectively doubles



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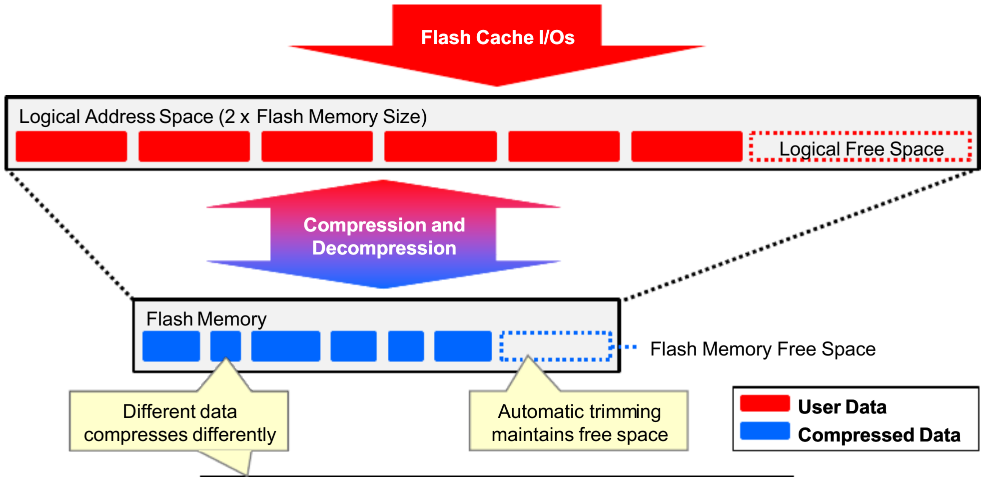
How Flash Cache Compression Works



Typical Compression with Flash Cache Compression	
Uncompressed Tables and Indexes	1.3 to 4 times
OLTP Compressed Tables	1.2 to 2 times
HCC Compressed Tables	Minimal

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Enabling Flash Cache Compression

- Flash cache compression is enabled by setting the `flashCacheCompress` cell attribute:

```
CellCLI> ALTER CELL flashCacheCompress = TRUE
```

  – Additional configuration for X3 cells running 11.2.3.3.0:

```
CellCLI> ALTER CELL flashCacheCompX3Support = TRUE
```

  – Flash cell disks must be dropped to change the `flashCacheCompress` cell attribute

- Example:

```
CellCLI> alter flashcache all flush
CellCLI> drop flashcache all
CellCLI> drop flashlog all
CellCLI> drop celldisk all flashdisk
CellCLI> alter cell flashCacheCompress = TRUE
CellCLI> create celldisk all flashdisk
CellCLI> create flashlog all
CellCLI> create flashcache all
```


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Monitoring Flash Cache Compression

- Verify that flash cache and flash disks are approximately double in size after flash cache compression is enabled:

```
CellCLI> LIST CELL ATTRIBUTES flashCacheCompress
         TRUE

CellCLI> LIST FLASHCACHE ATTRIBUTES name, size
         qr01cel01_FLASHCACHE   5959G

CellCLI> LIST PHYSICALDISK ATTRIBUTES name, physicalSize
WHERE diskType=flashdisk
         FLASH_1_0       372.52903032302856G
         FLASH_1_1       372.52903032302856G
         FLASH_1_2       372.52903032302856G
         ...
```

Exadata Storage Server	X3-2 (F40 Flash Module)		X4-2 (F80 Flash Module)	
Flash Cache Compression	**Disabled**	**Enabled**	**Disabled**	**Enabled**
Flash PHYSICALDISK size	93.13 GB	186.26 GB	186.26 GB	372.53 GB
Cell FLASHCACHE size	1489 GB	2978.75 GB	2978.75 GB	5959 GB

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Monitoring Flash Cache Compression

- Monitor the amount of data cached in Smart Flash Cache:

```
CellCLI> LIST METRICCURRENT FC_BY_USED
         FC_BY_USED       FLASHCACHE       4,617,195 MB
```

Larger than flash size without compression

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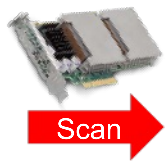
Automatic Flash Caching for Table Scan Workloads

In previous versions, large sequential scan reads are not cached in Smart Flash Cache by default:

- Exception: scans on keep objects
- Administrators must manually configure keep objects

With Exadata release 11.2.3.3.0, scan I/Os can be automatically cached for repeatedly scanned data:

- Better query performance and less administration
- Caching algorithm factors in object size, frequency of access, and other factors:
  - Ensures efficient cache utilization without flooding or thrashing the cache



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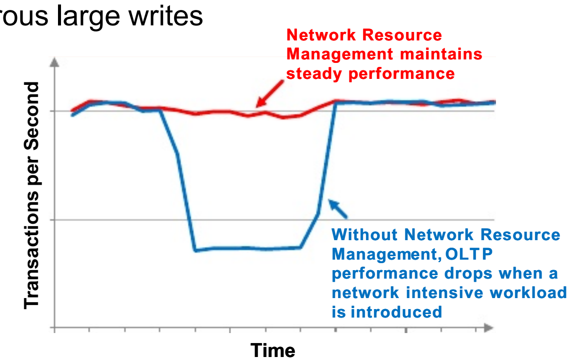
Exadata Network Resource Management

- Automatically and transparently prioritizes latency-sensitive messages:
  - Log writes:
    - Compliments Exadata Smart Flash log
    - Avoids issues caused when log writes are queued behind numerous large writes
  - Cache fusion:
    - Ensures consistent high performance for Oracle RAC



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Automatic Hard Disk Scrubbing and Repair

- Disks are periodically scanned to detect latent corruptions
  – Scrubbing I/Os are issued when the disk is idle
- If a corruption is detected, and repair is required:
  – Data in the local Smart Flash Cache is used if possible
  – Otherwise, ASM is requested to read an available mirror
- Configuration options:
  – Setting the next start time:

```
CellCLI> ALTER CELL hardDiskScrubStartTime="<Timestamp>"
```

  – Setting the scrubbing interval:

```
CellCLI> ALTER CELL hardDiskScrubInterval = [ daily | weekly |
         biweekly | none ]
```


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Cell Alert Summary

A periodic alert email summarizes the existing open alerts:

- Contains the most important information about open alerts
- Provides users with a concise summary of open issues without requiring cell access
- Makes it easier for users to identify open alerts
- Produced weekly, at 8am on Monday, by default
- Configuration options:
  – Setting the next delivery time:

```
CellCLI> ALTER CELL alertSummaryStartTime="<Timestamp>"
```

  – Setting the delivery interval:

```
CellCLI> ALTER CELL alertSummaryInterval = [ daily | weekly |
         biweekly | none ]
```


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Active-Active InfiniBand Connectivity

Each Exadata server has at least one dual-port QDR (40 Gb/s) InfiniBand HCA.

- Previously, active-passive bonding was used to deliver high availability.
  - Bandwidth was limited by the underlying PCIe architecture
- Starting with Exadata release 11.2.3.3.0, both HCA ports can be simultaneously active:
  - Effectively doubles the InfiniBand network bandwidth
  - Latest InfiniBand HCAs can exploit the full bandwidth
  - Each InfiniBand port is configured with a separate IP address
  - No bonded network interface is configured
  - Requires Oracle Linux on database servers

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Simplified Disk Controller BBU Replacement Procedure

New procedure:

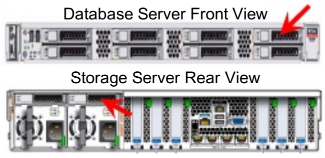
1. Prepare the BBU for replacement
   – On Exadata Storage Servers:

```
CellCLI> ALTER CELL BBU DROP FOR REPLACEMENT
```

   – On database servers:

```
# /opt/oracle.cellos/common/exadata_mon_hw_asr.pl -drop_bbu_for_replacement
```

2. Physically replace the BBU
   – Located in spare HDD slot



3. Re-enable the BBU
   – On Exadata Storage Servers:

```
CellCLI> ALTER CELL BBU REENABLE
```

   – On database servers:

```
# /opt/oracle.cellos/common/exadata_mon_hw_asr.pl -reenable_bbu
```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Safer Disk Removal

Sometimes a disk needs to be removed even though the system detects no fault with it.

- Previously, administrators had to perform numerous checks to ensure that the disk could be removed safely.
- With Exadata 11.2.3.3.0, administrators have a simple way of ensuring safe disk removal:

```
CellCLI> ALTER PHYSICALDISK { disk_1 [ , disk_n ] } DROP FOR REPLACEMENT
```

  - Disables the disk and switches on the blue ready-to-remove LED only if it is safe to remove the disk
  - Simplifies disk replacement and avoids problems

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Fast File Initialization

- Without Exadata:
  - Creating a new file requires the entire file to be formatted and written
    - ✗ Consumes significant CPU and I/O resources
- With Exadata fast file creation:
  - The database sends a file creation request to the cells
    - ✓ Very few resources are consumed on the database servers
    - ✓ Only metadata is transmitted to the cells
  - The cells format and write the file
    - ✗ Significant CPU and I/O resources are consumed on the cells
- With Exadata release 11.2.3.3.0 fast file initialization:
  - The database sends a file creation request to the cells
  - At file creation time, the cells only persist the metadata
  - The cells dynamically construct blocks as they are used
    - ✓ The I/Os to initially format and write the data blocks are avoided
    - ✓ File creation is much faster, especially for large files

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Fast File Initialization Requirements

- Exadata Smart Flash Cache must be in write-back mode:
  - Cell attribute `flashCacheMode=WriteBack`
- Smart Scan must be enabled:
  - Database parameter `CELL_OFFLOAD_PROCESSING=TRUE`
- The ASM AU size must be 4MB or larger:
  - ASM disk group attribute `au_size=4M`
- The file size must be 4MB or larger

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Faster Disk Rebalance Operations

- New ASM disk group attribute, `appliance.mode`:
  - Improves disk rebalance times
    - Redundancy is restored faster after a failure
  - Can only be enabled on disk groups where:
    - `compatible.asm` is set to `11.2.0.4`, or later
    - `cell.smart_scan_capable` is set to `TRUE`
    - All disks are the same type and size
    - All failure groups have an equal number of disks
    - No disk in the disk group is offline
  - Enabled by default on new disk groups
  - Can be enable or disable manually:

```
SQL> ALTER DISKGROUP <disk_group> SET ATTRIBUTE
     'appliance.mode' = ['TRUE'|'FALSE'];
```


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Summary

In this lesson, you should have learned how to describe the new features introduced in Exadata release 11.2.3.3.0.

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Exadata Release 12.1.1.1.0 New Features

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Objectives

After completing this lesson, you should be able to describe the new features introduced in Exadata release 12.1.1.1.0.

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Complete Exadata Feature Support for Oracle Database 12*c*

- Full offload support:
  - Smart scan
  - Fast file creation
  - Fast incremental backup
- Full IORM support:
  - Non-CDB
  - Multitenant architecture

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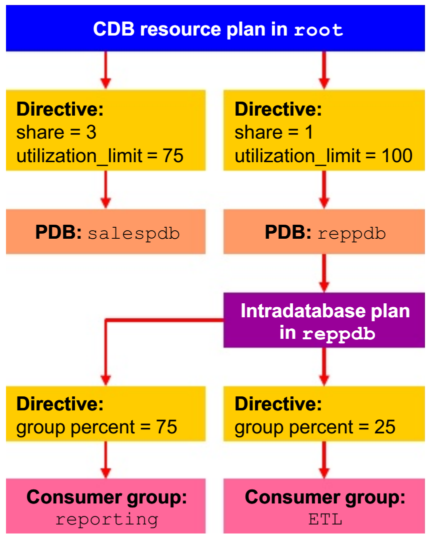
Using Exadata I/O Resource Management with Oracle Database 12*c*

- Non-CDB databases use IORM in the same way as version 11.2 databases
- To manage PDBs within a CDB:
  - New CDB resource plan:
    - Defined in the CDB root container
    - Allocates resources to PDBs based on shares
    - Can also enforce utilization limits for PDBs
    - Background resource usage is charged to the root container
      - Example: log file sync
    - Works in conjunction with other resource plans
  - Other resource plans are still available:
    - Intradatabase plan is defined inside each PDB
    - Interdatabase plan allocates resources across databases (including CDBs)
    - Category plan still allocates resources across categories



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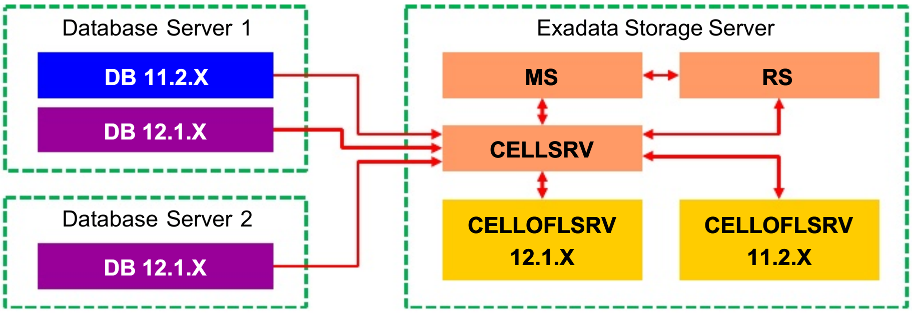
Support for Mixed Database Versions

- New CELLSRV architecture to support mixed database versions:
  - Separate offload servers for each major database release
  - Offload requests are automatically sent to the appropriate offload server
  - No additional configuration or maintenance



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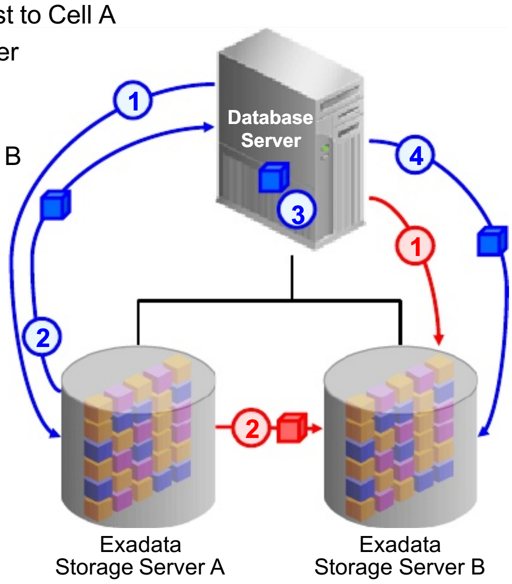
Cell to Cell Data Transfer

- Cell to Cell transfer in 11.2.X:
  1. Database server sends read request to Cell A
  2. Cell A sends data to database server
  3. Data is stored in the database server memory
  4. Database server sends data to Cell B
- Cell to Cell transfer in 12.1.X:
  1. Database server sends transfer request to Cell B
  2. Cell B reads data from Cell A
  - Lower network bandwidth consumption
  - Lower database server resource usage
  - Used by ASM resynchronization, resilver, and rebalance operations



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Summary

In this lesson, you should have learned how to describe the new features introduced in Exadata release 12.1.1.1.0.

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Exadata X4 Hardware Update

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Objectives

After completing this lesson, you should be able to describe the updates and changes associated with Exadata Database Machine X4 hardware.

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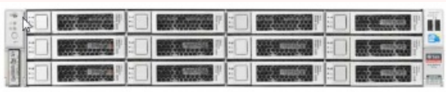
Exadata Storage Server X4-2 Hardware Overview



Processors	12 Intel CPU Cores 2 x E5-2630 v2 Processors (2.6 GHz)
System Memory	96 GB
Disk Drives	12 x 1.2 TB 10,000 RPM High Performance Disk Drives *or* 12 x 4 TB 7,200 RPM High Capacity Disk Drives
Flash	3.2 TB - 4 x 800 GB Sun Flash Accelerator F80 PCIe Cards
Disk Controller	Disk Controller Host Bus Adapter with 512 MB Battery Backed Write Cache andOnline Replaceable Battery Backup Unit
InfiniBand Network	Dual-Port QDR (40Gb/s) InfiniBand Host Channel Adapter
Remote Management	Integrated Lights Out Manager (ILOM) Ethernet Port
Power Supplies	2 x Redundant Hot-Swappable Power Supplies

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Exadata Storage Server X4-2 Configuration Options

	High Performance Disks	High Capacity Disks
Raw Disk Capacity[1]	14.4 TB	48 TB
Uncompressed Data Capacity[2]	6 TB	20 TB
Raw Disk Throughput	1.75 GB/sec	1.5 GB/sec
Flash Throughput	7.25 GB/sec	7.25 GB/sec

1 - Raw capacity calculated using 1 GB = 1000 x 1000 x 1000 bytes and 1 TB = 1000 x 1000 x 1000 x 1000 bytes.

2 - User Data: Actual space for uncompressed end-user data, computed after single mirroring (ASM normal redundancy) while also providing adequate space to re-establish the mirroring protection after a disk failure. Actual user data capacity varies by application.

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Exadata Database Machine X4-2
Database Server Hardware Overview

Processors	24 Intel CPU Cores 2 x E5-2697 v2 Processors (2.7GHz)
System Memory	256 GB (Expandable to 512 GB)
Disk Drives	4 x 600 GB 10K RPM Disk Drives
Disk Controller	Disk Controller Host Bus Adapter with 512 MB Battery Backed Write Cache andOnline Replaceable Battery Backup Unit
Network Interfaces	• Dual-Port QDR (40Gb/s) InfiniBand Host Channel Adapter • Four 1/10 Gb Ethernet Ports (copper) • Two 10Gb Ethernet Ports (optical)
Remote Management	Integrated Lights Out Manager (ILOM) Ethernet Port
Power Supplies	2 x Redundant Hot-Swappable Power Supplies

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Exadata Database Machine X3-8 Update Overview

- Now includes Exadata Storage Server X4-2
  - Increased CPU power, disk capacity, flash capacity, and so on
- Database servers remain unchanged
  - Two servers, each with 80 CPU cores and 2 TB RAM
- Name remains unchanged

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Exadata Rack-Level Changes

- Spine switches are no longer included in Database Machines:
  - They can still be purchased separately
  - They are still included in Storage Expansion Racks
- Included spare parts kit now contains:
  - 1 spare disk
  - 1 spare flash card

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Exadata Database Machine X4-2 and X3-8 Infrastructure Requirements

- Similar overall power, cooling and airflow requirements
- Unchanged infrastructure components:
  - Rack
  - Cisco switch
  - PDUs

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Summary

In this lesson, you should have learned how to describe the updates and changes associated with Exadata Database Machine X4 hardware.

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Additional Resources

Database Machine X4-2 Interactive Tour

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