ORACLE EXADATA STORAGE SERVER X4-2

KEY FEATURES AND BENEFITS

FEATURES

- 12 x 3.5 inch High Performance or High Capacity disks
- 3.2 TB of Exadata Smart Flash Cache
- 12 CPU cores dedicated to SQL processing in storage
- 96 GB memory
- Dual InfiniBand ports
- Redundant power supplies
- Oracle Exadata Storage Server software
- Oracle Linux or Solaris based Database Machines

BENEFITS

- Uncompressed usable capacity of up to 6 TB per server when using High Performance disks
- Uncompressed usable capacity of up to 20 TB per server when using High Capacity disks
- Hybrid Columnar Compression delivers 10X-15X compression ratios
- Effective data bandwidth of up to 7.25 GB/second per server with Flash and uncompressed data
- Effective data bandwidth of up to 72.5 GB/second per server with Flash and compressed data
- Software pre-installed

The Oracle Exadata Storage Server X4-2 is the storage building block of the Oracle Exadata Database Machine, Oracle SuperCluster and Oracle Exadata Storage Expansion Rack. The Exadata Storage Server is highly optimized for use with the Oracle Database and employs a massively parallel architecture and Exadata Smart Flash Cache to dramatically accelerate Oracle Database processing and speed I/O operations. It may be attached to an Exadata Database Machine to build out the Database Machine and is ideal for Online Transaction Processing (OLTP), Data Warehousing (DW) and consolidation of mixed workloads. Simple to deploy and manage, the Oracle Exadata Storage Server provides linear I/O scalability and mission-critical reliability.

Oracle Exadata Storage Server

The Oracle Exadata Storage Server is a fast, reliable, high capacity, industry-standard storage server. Each server comes preconfigured with: 2 x six-core Intel® Xeon® E5-2630 V2 Processors, 96 GB memory, 3.2 TB of Exadata Smart Flash Cache, 12 disks connected to a storage controller with 512MB battery-backed cache, and dual port InfiniBand connectivity. All software is preinstalled and comes complete with management interface for remote access, dual-redundant hot-swappable power supplies and takes up 2U in a 19-inch rack.
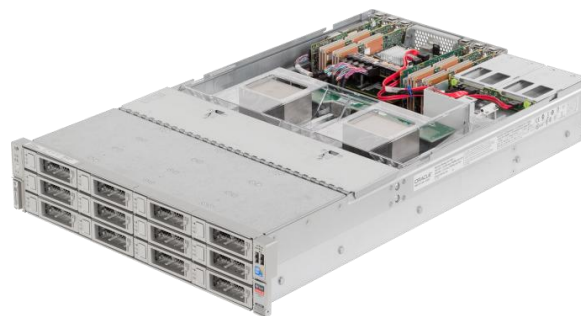
The Oracle Exadata Storage Server comes with either twelve 1.2 TB 10,000 RPM High Performance disks or twelve 4 TB 7,200 RPM High Capacity disks. The High Performance based Exadata Storage Servers provide up to 6 TB of uncompressed usable capacity, and up to 1.75 GB/second of raw data bandwidth. The High Capacity based Exadata Storage Servers provide up to 20 TB of uncompressed usable capacity, and up to 1.5 GB/second of raw data bandwidth. When stored in compressed format, the amount of user data and the amount of data bandwidth delivered by each cell increases up to 10 times.

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RELATED PRODUCTS

- Oracle Exadata Database Machine X4-2
- Oracle Exadata Database Machine X3-8
- Oracle Exadata Storage Expansion Rack X4-2
- Oracle SuperCluster
- Oracle Database 11g and 12c
- Real Application Clusters
- Partitioning
- Advanced Compression
- Advanced Security
- Active Data Guard
- Real Application Testing
- OLAP
- Advanced Analytics
- Business Intelligence
- Enterprise Manager
- Oracle Linux
- Oracle Solaris

RELATED SERVICES

The following services are available from Oracle:

- Advanced Customer Services
- Oracle Premier Support for Systems
- Oracle Platinum Services
- Consulting Services
- Oracle University courses

Extreme Performance by Offloading Data Intensive Processing

As data volumes grow exponentially, conventional storage arrays struggle to quickly transfer data from disk and flash to database servers at a rate that keeps the CPUs busy. Modern servers with many CPUs can consume data at many tens to hundreds of gigabytes a second. This is far faster than conventional architectures that use storage arrays can deliver data through their storage heads and the storage network.

The scale-out architecture of the Exadata Database Machine not only provides high performance and scalability, it also includes a unique technology that **offloads data intensive SQL operations into the Oracle Exadata Storage Servers**. By pushing SQL processing to the Exadata Storage Servers, data filtering and processing occurs immediately and in parallel across all storage servers as data is read from disk and flash. **Only the rows and columns that are directly relevant to a query are sent to the database servers**.

For example, if a query is executed to identify the customers who placed sales orders over $1000 in the month of March, an Exadata system will: offload the scanning of the table to the Exadata storage; filter out all sales orders that are less than $1000; filter out sales orders not in March; and extract just the relevant customer names. The result is that the data transferred to the database servers is reduced by orders of magnitude. This greatly accelerates query execution, eliminates bottlenecks, and significantly reduces the CPU usage of the database servers.

Each Exadata Storage Server has two Intel® Xeon® processors that are used for database offload. A full rack Exadata Database Machine has a total of 168 processor cores in the storage servers tha can be used to offload the database servers. The CPUs in Exadata Storage Servers do not replace database CPUs. Instead they accelerate data intensive workloads similar to how graphics cards accelerate image intensive workloads.

Optimizing Storage Use and I/O Through Compression

The Exadata Storage Server provides a very advanced compression capability called **Hybrid Columnar Compression (HCC) that provides dramatic reductions in storage for large databases**. Hybrid Columnar Compression enables the highest levels of data compression and provides tremendous cost-savings and performance improvements due to reduced I/O, especially for analytic workloads. Storage savings is data dependent and often ranges from 5x to 20x. Typical storage savings is an industry leading 10x. On conventional systems, enabling high data compression has the drawback of reducing performance. Because the Exadata Database Machine is able to offload decompression overhead into large numbers of processors in Exadata storage, most workloads run faster using Hybrid Columnar Compression than they do without it. Hybrid Columnar Compression delivers the compression and analytic performance benefits of column storage while avoiding the dramatic slowdown that pure columnar stores experience for drilldown operations (single row access).

Two modes of Hybrid Columnar Compression are available. **Query optimized compression** mode is suitable for read intensive workloads such as Data Warehouses and provides large storage savings while providing enhanced analytic performance. **Archive compression** mode provides the highest degree of

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compression and is targeted at seldom accessed data that is kept online.

On OLTP systems, Hybrid Columnar Compression can be used to compress older, less active data while newer, more active and update intensive data can be compressed using Advanced Row Compression. Oracle Database 12c provides the ability to change the type of compression used by individual table partitions online, even if there are global indexes on the table to ensure seamless tiering across different compression types as data ages and becomes less active.

Extreme Performance from Exadata Smart Flash Cache

Exadata systems use the latest **PCI flash technology** rather than flash disks. PCI flash delivers ultra-high performance by placing flash memory directly on the high speed PCI bus rather than behind slow disk controllers and directors. Each Exadata Storage Server includes 4 PCI flash cards with a total raw capacity of 3.2 TB of flash memory. A full rack Exadata Database Machine X4-2 includes 56 PCI flash cards providing 44.8 TB of raw physical flash memory.
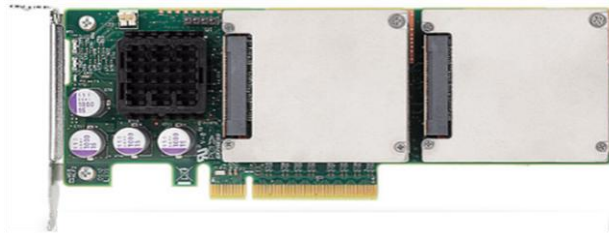
Sun Flash Accelerator F80 PCIe Card

Exadata flash can be used directly as flash disks, but it is almost always configured as a flash cache in front of disk since caching provides flash level performance for much more data than fits directly into flash.

The **Exadata Smart Flash Cache** automatically caches frequently accessed data in PCI flash while keeping infrequently accessed data on disk drives. This provides the performance of flash with the capacity and low cost of disk. The Exadata Smart Flash Cache understands database workloads and knows when to avoid caching data that the database will rarely access or is too big to fit in the cache. For example, Exadata understands when I/Os are run for backup purposes, for table scans, and for storing temporary results that will be quickly deleted. In addition to automatic caching, administrators can optionally provide SQL directives to ensure that specific tables, indexes, or partitions are always retained in flash. Tables can be retained in flash without the need to move the table to different tablespaces, files or LUNs as is often required with traditional storage.

Exadata's Smart Flash Cache is designed to deliver flash-level IO rates, throughput, and response times for data that is many times larger than the physical flash capacity in the machine by automatically moving active data that is experiencing heavy IO activity into flash, while leaving cold data that sees infrequent IO activity on disk. It is common for hit rates in the Exadata Smart Flash Cache to be over 90%, or even 98% in real-world database workloads even though flash capacity is more than 10

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times smaller than disk capacity. Such high flash cache hit rates mean that Exadata Smart Flash Cache provides an **effective flash capacity** that is often 10 times larger than the physical flash cache.   For example, a full rack Exadata Database Machine X4-2 often has an effective flash capacity of 440 TB.

On top of the capacity benefits provided by smart caching, **Exadata Smart Flash Cache Compression** dynamically increases the capacity of the flash cache by transparently compressing user data as it is loaded into the flash cache. This allows much more data to be kept in flash memory, and further decreases the need to access data on disk drives. The compression and decompression operations are completely transparent to the application and database. Exadata Smart Flash Cache Compression leverages hardware acceleration to deliver **zero performance overhead for compression and decompression**, even when running at rates of millions of I/Os per second or 100s of Gigabytes per second.

Flash Cache Compression benefits vary based on the compressibility of the user data. Tables that are uncompressed will see the largest benefits. Indexes will also typically compress very well. Exadata Smart Flash Cache Compression will also provide significant flash cache space expansion on top of the benefits already provided by Advanced Row and Basic table compression. OLTP applications will often see the overall logical size of the flash cache double even if they use Advanced Row Compression. Tables that use Hybrid Columnar Compression or LOB Compression will see minimal additional compression since these are already very highly compressed formats. With Flash Cache Compression turned on, a full rack Exadata Database Machine X4-2 provides up to 90 TB of logical flash cache capacity (before database level compression is factored in).

Flash performance is often limited and bottlenecked by traditional storage architectures. In contrast, Exadata uses a combination of scale-out storage, InfiniBand networking, database offload, and PCI flash to deliver extremely high performance rates from flash. A single full rack Exadata Database Machine X4-2 achieves up to **100 GB per second of data scan bandwidth**, and up to **2.66 Million random 8K read I/O operations per second** (IOPS) when running database workloads. This performance is orders of magnitude faster than traditional database architectures. It is important to note that these are real-world end-to-end performance figures measured running SQL workloads with realistic IO sizes inside a single rack Exadata system. They are not component level measurements based on low level IO tools.

The Exadata Smart Flash cache also caches database block writes. Write caching eliminates disk bottlenecks in large scale OLTP and batch workloads. The flash write capacity of a single full rack Exadata Database Machine X4-2 exceeds **1.96 Million 8K write I/Os per second**. The Exadata write cache is transparent, persistent, and fully redundant. The I/O performance of the Exadata Smart Flash Cache is comparable to dozens of enterprise disk arrays with thousands of disk drives.

To further accelerate OLTP workloads, the Exadata Smart Flash Cache also implements a special algorithm to reduce the latency of log write I/Os called

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Exadata Smart Flash Logging. The time to commit user transactions or perform critical updates is very sensitive to the latency of log writes. Smart Flash Logging takes advantage of the flash memory in Exadata storage combined with the high speed RAM memory in the Exadata disk controllers to greatly reduce the latency of log writes and avoid the latency spikes that frequently occur in other flash solutions. The Exadata Smart Flash Logging algorithms are unique to Exadata.

Exadata uses only enterprise grade flash that is designed by the flash manufacturer to have high endurance. Exadata is designed for mission critical workloads and therefore does not use consumer grade flash that can potentially experience performance degradations or fail unexpectedly after a few years of usage. The enterprise grade flash chips used in Exadata X4 have an expected endurance of 10 years or more for typical database workloads.

Intelligent Scalable Storage Grid

Oracle Exadata Storage Servers are installed in to a customer supplied 19-inch rack and is connected to an Exadata Database Machine or a SuperCluster via InfiniBand. Exadata Storage Servers have dual 40 Gigabit InfiniBand links that provide connectivity many times faster than traditional storage or server networks. Further, Oracle's interconnect protocol uses direct data placement to ensure very low CPU overhead by directly moving data from the wire to database buffers with no extra data copies.

Exadata Storage Servers are **architected to scale-out easily**. To achieve higher performance and greater storage capacity, additional Exadata Storage Servers can be connected to an Oracle Database Machine or a SuperCluster. This, combined with faster InfiniBand interconnect, Exadata Smart Flash Cache and the reduction of data transferred due to offload processing and Hybrid Columnar Compression, yields very large performance improvements. A 10x improvement in query performance compared to traditional database storage architectures is common, with much greater improvement possible.

An alternative to the purchase of individual Exadata Storage Servers with the requisite rack, InfiniBand switches, cables and other infrastructure built and configured by the customer, is the Exadata Storage Expansion Rack. The Exadata Storage Expansion Rack enables you to easily grow the Exadata storage capacity and bandwidth of any X4-2 and X3-8 Exadata Database Machine or SuperCluster. It is designed for database deployments that require very large amounts of data including: historical or archive data; backups and archives of Exadata Database Machine data; documents, images, file and XML data, LOBs and other large unstructured data. Available in Full Rack, Half Rack and Quarter Rack versions it connects to the Exadata Database Machine or SuperCluster using the integrated InfiniBand fabric to easily scale the system to any capacity. The expansion rack is extremely simple to configure as there are no LUNs or mount points to configure. Storage is configured and added to a database with a few simple commands, completed in minutes. ASM dynamically and automatically balances the data across Exadata Storage Servers, online, evenly spreading the I/O load across the racks fully utilizing all the hardware and easily integrating the expansion rack into the

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configuration.

Mission Critical High Availability

The Oracle Exadata Storage Server has **complete redundancy built in** to support the demands of mission critical applications. Each Exadata Storage Server has dual port InfiniBand connections and dual-redundant, hot-swappable power supplies for high availability. Automatic Storage Management, a feature of the Oracle Database, provides disk mirroring. Hot swappable Exadata disks ensure the database can tolerate disk drive failures. In addition, data is mirrored across storage servers to ensure that storage server failure will not cause loss of data, or inhibit data accessibility.

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Oracle Exadata Storage Server X4-2 Hardware	
The Oracle Exadata Storage Server comes preconfigured with:	
Processors	2 x Six-Core Intel® Xeon® E5-2630 v2 (2.6 GHz) Processors
Exadata Smart Flash Cache	3.2 TB
System Memory	96 GB
Disk Controller	Disk Controller HBA with 512MB Battery Backed Write Cache
InfiniBand Connectivity	Dual-Port QDR (40Gb/s) InfiniBand Host Channel Adapter
Power Supplies	Dual-redundant, hot-swappable power supply
Disk Drives	12 x 1.2 TB 10,000 RPM High Performance Or 12 x 4 TB 7,200 RPM High Capacity For raw disk capacity, 1 GB = 1 billion bytes. Actual formatted capacity is less.
Remote Management	Integrated Lights Out Manager (ILOM) Ethernet port

Oracle Exadata Storage Server X4-2 Key Capacity and Performance Metrics	
High Capacity disks	• Up to 7.25 GB/second of SQL Flash data bandwidth, assuming no database compression, per cell • Up to 1.5 GB/second of SQL disk bandwidth, assuming no database compression, per cell • 3.2 TB of raw flash capacity • 48 TB of raw disk data capacity • Up to 20 TB of uncompressed usable capacity per cell
High Performance disks	• Up to 7.25 GB/second of SQL Flash data bandwidth, assuming no database compression, per cell • Up to 1.75 GB/second of SQL disk bandwidth, assuming no database compression, per cell • 3.2 TB of raw flash capacity • 14.4 TB of raw disk data capacity • Up to 6 TB of uncompressed usable capacity per cell

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Oracle Exadata Storage Server X4-2 Environmental Specifications	
Dimensions and Weight	• Height: 3.5 in. (87.6 mm) • Width: 17.5 in. (445.0 mm) • Depth: 29.0 in. (737.0 mm) • Weight: 63 lbs. (28.5 kg)
Environment	• Operating temperature: 5 ℃ to 35 ℃ (41 ℉ to 95 ℉) • Non-operating temperature: -40 ℃ to 70 ℃ (-40 ℉ to 158 ℉) • Operating relative humidity 10% to 90% non-condensing • Non-operating relative humidity: up to 93%, non-condensing • Operating altitude: Up to 3,000 m, maximum ambient temperature is derated by 1° C per 300 m above 900 m • Non-operating altitude: Up to 12,000 m • Acoustic noise: 7.61 B operating
Power	• Dual-redundant, hot-swappable power supply • Maximum output power: 1000 W • Maximum AC input current at 100 V AC and 1,000 W output: 12.0 A • Specified power supply efficiency at 1,000 W (100%) load: 91%
Regulations [1]	• Safety: UL/CSA-60950-1, 2nd Edition, EN60950-1-2006 + A11:2009 + A1:2010 + A12:2011, IEC60950-1:2005 + A1:2009 CB scheme with all country deviations, CNSI4336-1, GB4943.1-2012 • EMI: EN55022:2010 , CISPR22:2008 Class A, 47 CFR 15B Class A, ICES-003 Class A, VCCI Class A, AS/NZS CISPR 22:2009/A1:2010 Class A, CNS 13438 Class A, GB9254 Class A, EN61000-3-2, GB17625.1, EN61000-3-3 • Immunity: EN 55024:2010
Certifications [1]	• Safety: UL/cUL Listing, CE, BSMI, GOST R, CCC. • EMC: CCC, CE, FCC, VCCI, ICES, C-Tick, KCC, GOST R, BSMI, Class A • Other: Complies with WEEE Directive (2012/19/EC), RoHS Directive (2011/65/EC)

[1] In some cases, as applicable, regulatory and certification compliance were obtained at the component level.

Oracle Exadata Storage Server X4-2 Software
• Oracle Exadata Storage Server Software 11g Release 2 (release 11.2.3.3 or later)

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- Oracle Linux 5 Update 9 with the Unbreakable Enterprise Kernel 2
- Requires Oracle Database 11g Release 2 Enterprise Edition or Oracle Database 12c Enterprise Edition for the database accessing Exadata storage

High-Availability Features

- Redundant power supplies
- Redundant InfiniBand ports
- Hot swappable disk drives
- Oracle Automatic Storage Management: All database files either double or triple mirrored; Disk failures do not abort queries or transactions
- Oracle Exadata Storage Server Software: Storage server failure can be tolerated without data loss or aborting queries or transactions

Manageability Features

- Oracle Embedded Integrated Lights Out Manager (ILOM)
- Oracle Enterprise Manager Cloud Control 12c

Support Services Provided By Oracle

- Hardware Warranty: 1 year with a 4 hour web/phone response during normal business hours (Mon-Fri 8AM-5PM), with 2 business day on-site response/Parts Exchange
- Oracle Premier Support for Systems: Oracle Linux and Solaris support and 24x7 with 2 hour on-site hardware service response (subject to proximity to service center)
- Oracle Premier Support for Operating Systems
- Oracle Customer Data and Device Retention
- System Installation Services
- Software Configuration Services
- Oracle Platinum Services
- Oracle Exadata Start-Up Pack
- System Upgrade Support Services including hardware installation and software configuration
- Oracle Auto Service Request (ASR)

Contact Us

For more information about the Oracle Exadata Storage Server, please visit

oracle.com or call +1.800.ORACLE1 to speak to an Oracle representative.

Oracle is committed to developing practices and products that help protect the environment

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