

# ORACLE EXADATA DATABASE MACHINE X6-2



The Oracle Exadata Database Machine is engineered to deliver dramatically better performance, cost effectiveness, and availability for Oracle databases. Exadata features a modern cloud-based architecture with scale-out high-performance database servers, scale-out intelligent storage servers with state-of-the-art PCI flash, and an ultra-fast InfiniBand internal fabric that connects all servers and storage. Unique software algorithms in Exadata implement database intelligence in storage, compute, and InfiniBand networking to deliver higher performance and capacity at lower costs than other platforms. Exadata runs all types of database workloads including Online Transaction Processing (OLTP), Data Warehousing (DW), In-Memory Analytics as well as consolidation of mixed workloads. Simple and fast to implement, the Exadata Database Machine powers and protects your most important databases. Exadata can be deployed on premises as the ideal foundation for a private database cloud, or can be used on the Oracle Public Cloud for rapid and elastic deployment with no infrastructure management or Capex.



## Engineered System for Fast and Reliable Deployment

The Exadata Database Machine is an easy to deploy system that includes all the hardware needed for running Oracle Database. The database servers, storage servers and network are pre-configured, pre-tuned and pre-tested by Oracle experts, eliminating weeks or months of effort typically required to deploy a mission critical high performance system. Extensive end-to-end testing ensures all components including database software, OS, firmware, drivers, etc. work seamlessly together and there are no performance bottlenecks or single points of failure that can affect the complete system.

Because all Exadata Database Machines are identically configured, customers benefit from the experience of thousands of other users that have deployed the Exadata Database Machine for their mission critical applications including most of the top Banks, Telcos, and Retailers in the world. Customer machines are also identical to the machines Oracle Support uses for problem identification and resolution, the machines Oracle Engineering uses for development and testing of Oracle Database, and the machines Oracle uses to implement its own SaaS and PaaS public cloud. Hence, **Exadata is the most thoroughly tested and tuned platform for running Oracle Database and is also the most supportable platform.**

**KEY FEATURES**

- Up to 836 CPU cores and 28.5TB memory per rack for database processing
- Up to 360 CPU cores per rack dedicated to SQL processing in storage
- From 2 to 19 Database Servers per rack
- From 3 to 18 Storage Servers per rack
- Up to 460 TB of flash capacity (raw) per rack
- Up to 1.7 PB of disk capacity (raw) per rack
- Hybrid Columnar Compression often delivers 10X-15X compression ratios
- 40 Gb/second (QDR) InfiniBand Network
- Complete redundancy for high availability

**KEY BENEFITS**

- Uncompressed I/O bandwidth of up to 350 GB/second per full rack from SQL
- Ability to perform up to 5.6M database 8K read I/O operations or 5.2M database 8K write I/O operations per second
- Easily upgrade to meet the needs of any size application
- Scale by connecting multiple Exadata Database Machine X6-2 racks or Exadata Storage Expansion Racks. Up to 18 racks can be connected by simply connecting via InfiniBand cables and using internal switches. Larger configurations can be built with external InfiniBand switches
- Pre-configured system optimized for all database applications

*"I would recommend Exadata as a platform for performance, reliability and ease of support. Those three things mean very much to me in my daily life."*

- Richard Ewald  
Senior Technical Architect  
Sprint

The Oracle Exadata Database Machine runs the standard Oracle Database. Therefore, **any application that uses the Oracle Database today can be easily and seamlessly migrated to use the Exadata Database Machine with no changes to the application.** Databases can also be easily migrated off of Exadata eliminating any fear of "lock-in".

Customers thinking of deploying databases on the Public Cloud, now or in the future, can be confident that **Exadata provides 100% compatibility between on-premises and public cloud** enabling easy migration to the public cloud and simple hybrid cloud deployments.

## Extreme System Scalability and Growth with Elastic Configurations

The Exadata Database Machine uses a **scale-out architecture for both database servers and storage servers**. As an Exadata Database Machine grows, database CPUs, storage, and networking can be added in a balanced fashion ensuring scalability without bottlenecks.

The scale-out architecture accommodates any size workload and allows seamless expansion from small to extremely large configurations while avoiding performance bottlenecks and single points of failure.

A high-bandwidth low-latency 40 Gb/second **InfiniBand network** connects all the components inside an Exadata Database Machine. Specialized database networking protocols run over the InfiniBand network and provide **much lower latency and higher bandwidth** communication than is possible using generic communication protocols. This enables both faster response time for OLTP operations, and higher throughput for analytic workloads. External connectivity to the Exadata Database Machine is provided using standard 10 Gigabit Ethernet.

**Exadata Database Machine is the most versatile database platform.** The Exadata X6-2 Database Machine uses powerful database servers each with two 22-core x86 processors and 256 GB of memory (expandable up to 1.5 TB). Exadata also uses scale-out, intelligent storage servers that appear in two configurations – High Capacity (HC) or Extreme Flash (EF). HC Storage Servers have four PCI Flash cards each with 3.2 TB (raw) Exadata Smart Flash Cache and twelve 8 TB 7,200 RPM disks. EF Storage Servers have an all-Flash configuration with eight PCI Flash drives, each with 3.2 TB (raw) storage capacity. The starting configuration of an Exadata Database Machine consists of two database servers and three storage servers, which can be elastically expanded by adding more database and/or storage servers as requirements grow. Elastic configurations provide an extremely flexible and efficient mechanism to expand computing power and/or storage capacity to meet any business need.

In addition to upgrading within a rack, **multiple racks can be connected using the integrated InfiniBand fabric** to form even larger configurations. For example, a system composed of four racks is simply four times as powerful as a single rack system - providing quadruple the I/O throughput, quadruple the storage capacity, and quadruple the processing power. It can be configured as a large single system or logically partitioned for consolidation of multiple databases. Scaling out is easy with Exadata Database Machine. Oracle Real Application Clusters (RAC) can dynamically add more processing power, and Automatic Storage Management (ASM) can dynamically add more storage capacity.

**RELATED PRODUCTS**

- Oracle Database Exadata Cloud Service
- Oracle Exadata Database Machine X6-8
- Oracle Exadata Storage Expansion Rack X6-2
- Oracle Exadata Storage Server X6-2 Plus InfiniBand Infrastructure
- Oracle Exadata Database Server X6-2 Plus InfiniBand Infrastructure
- Oracle SuperCluster
- Oracle Database 11g and 12c
- Real Application Clusters
- Partitioning
- Multitenant
- Database In-Memory
- Advanced Compression
- Advanced Security
- Active Data Guard
- GoldenGate
- Real Application Testing
- OLAP
- Advanced Analytics
- Business Intelligence
- Enterprise Manager
- Oracle Linux
- Oracle Virtual Machine

**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

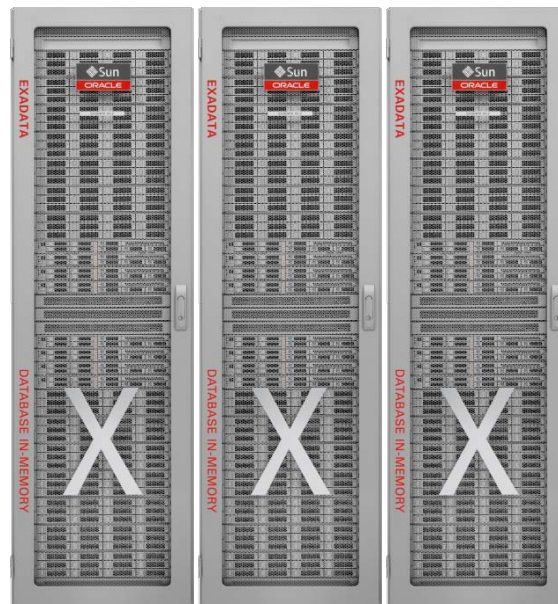


Fig 1: Elastic Scale-out to Multi-rack Exadata

When even larger storage capacity is required, the **Oracle Exadata Storage Expansion Rack** is available. The Exadata Storage Expansion Rack enables you to grow the storage capacity and bandwidth of any Exadata Database Machine. It is designed for database deployments that require very large amounts of data including: historical or archive data, backups, documents, images, XML, JSON and LOBs. The storage expansion rack connects to the Exadata Database Machine using the integrated InfiniBand fabric and is extremely simple to configure, as there are no LUNs or mount points. Storage is configured and added to a database online with a few simple commands. The starting configuration of the Oracle Exadata Storage Expansion Rack consists of four storage servers and can be further expanded by adding additional storage servers.

Exadata Database Machines protect your investment by allowing **newer generation servers and storage to be deployed seamlessly into existing Exadata Database Machines**. Similarly, new software releases are compatible with previous generation Exadata Database Machines. All currently supported Exadata platforms can be combined in a single configuration and can run the latest Exadata software.

### Extreme Flash Storage Server: Record-breaking I/O Performance

Exadata **Extreme Flash (EF) Storage Server**, first introduced with Exadata X5, is the foundation of a database-optimized all-flash Exadata Database Machine. Exadata X6-2 enhances previous generation EF Storage Servers, by doubling the flash capacity. Each EF Storage Server contains eight 3.2 TB state-of-the-art Flash Accelerator F320 PCI flash drives, offering 25.6TB raw flash capacity per EF Storage Server. Exadata X6 uses state-of-the-art 3D V-NAND flash technology for improved speed, power efficiency, and

*“Oracle Exadata enabled seamless and rapid migration of our cloud-based, integrated business applications, required no major modifications, and helped us reduce costs. With Oracle, we dramatically improved our batch processing speed by 241x and overall system performance by 3x, enabling us to improve operating efficiency for our daily, critical tasks and to enhance customer service.”*

- Kyoji Kato  
Executive Officer and GM  
Daiwa House

*“Oracle Exadata Database Machine is helping to transform our business. Our SAP environment, one of the world’s largest, can now support twice as much throughput with improved stability.”*

- Milt Simonds  
Director, Enterprise Platform Delivery  
AmerisourceBergen Corporation

endurance compared to previous generations of Flash. The enterprise grade flash used in Exadata X6 have an expected endurance of 8 years or more for typical database workloads. This is very different from consumer grade flash that can potentially experience performance degradations or fail unexpectedly after a few years of usage. In addition, Exadata delivers ultra-high performance by placing the flash devices directly on the high speed PCI bus rather than behind slow disk controllers and directors. Finally, Exadata flash uses the latest NVMe (Non-Volatile Memory Express) flash protocol to achieve extremely low latency and CPU overhead.

Flash performance is often limited and bottlenecked by traditional storage architecture. 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 traditional full rack Exadata Database Machine X6-2, with 8 database servers and 14 Extreme Flash storage servers, can achieve up to **350 GB per second of analytic scan bandwidth from SQL**, and **0.25 ms Database I/O latency at 2.4 Million Flash IOPS** when running database workloads. A slightly different full rack combination, with 10 database servers and 12 Extreme Flash storage servers, can achieve up to **5.6 Million random 8K read and 5.2 Million random 8K write I/O operations per second (IOPS) from SQL**, which is an industry record for database workloads.

This performance is orders of magnitude faster than traditional storage array architectures, and is also much faster than current all-flash storage arrays. It is important to note that these are real-world end-to-end performance figures measured running SQL workloads with realistic I/O sizes inside a single rack Exadata system. They are not component-level measurements based on low-level I/O tools.



Fig 2: Flash Accelerator F320 PCIe Card

## High Capacity Storage Server: Tiered Disk and Flash Deliver Cost of Disk with Performance of Flash

The second Exadata storage option is the Exadata X6-2 **High Capacity (HC) Storage Server**. This server includes twelve 8 TB SAS disk drives with 96 TB total raw disk capacity. It also has four Flash Accelerator F320 NVMe PCIe cards with a total raw capacity of 12.8 TB of flash memory. These flash cards are also based on innovative 3D V-NAND technology. Exadata flash in a High Capacity Storage Server can be used directly as flash disks, but is almost always configured as a flash cache (**Exadata Smart**

**Flash Cache**) in front of disk storage since caching provides flash level performance for much more data than fits directly into flash.

Exadata Smart Flash Cache automatically caches frequently accessed data while keeping infrequently accessed data on disk. 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 doesn't cache I/Os caused by backups, table scans, or 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 the flash cache. Tables can be retained in flash cache without the need to move the table to different tablespaces, files or LUNs as is often required with traditional storage. A single full rack Exadata Database Machine X6-2, with 8 database servers and 14 High Capacity storage servers can achieve up to **301 GB per second of analytic scan bandwidth from SQL**, and up to **4.5 Million random 8K read I/O operations per second (IOPS) from SQL**, and **0.25 ms I/O latency at 2 Million flash IOPS** when running database workloads.

Exadata's Smart Flash Cache is designed to deliver flash-level I/O rates and response times for data that is many times larger than the physical flash capacity in the machine by moving active data into flash, while leaving cold data 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 7 times smaller than disk capacity. Such high flash cache hit rates mean that Exadata Smart Flash Cache provides an **effective flash capacity** that is many times larger than the physical flash cache. For example, a full rack Exadata Database Machine X6-2 with 8 database servers and 14 High Capacity Storage Servers often has an effective flash capacity equal to the usable disk capacity of 508 TB.

The Exadata Smart Flash cache also caches database block writes using Exadata Write Back Flash Cache technology. Write caching eliminates disk bottlenecks in large scale OLTP and batch workloads. The flash write capacity of a single full rack Exadata Database Machine X6-2 with 8 database servers and 14 High Capacity Storage Servers exceeds **4.144 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.

The automatic data tiering between RAM, flash and disk implemented in Exadata provides tremendous advantages over other flash-based solutions. Many storage vendors have recognized that the architecture of their traditional storage arrays inherently bottleneck the performance of flash and therefore have developed new flash-only arrays. These flash-only arrays deliver higher performance than traditional arrays but give up the cost advantages of smart tiering of data between disk and flash. Therefore the overall size of data that benefits from flash is limited to the size of expensive flash. These flash arrays also do not benefit from any of Exadata's unique storage optimization technologies. Data deduplication provided by some flash arrays is very effective for VDI (Virtual Desktop Infrastructure) environments but is ineffective for databases.

Exadata not only delivers much more capacity than generic all-flash arrays, it also

*"We chose Oracle Exadata because it offered a complete solution ... we've created daily financial reports 4x faster and liquidity risk reports 7x faster to consistently meet our service-level agreement, improved credit risk management, and reduced our data center footprint."*

- Vaibhav Samant  
Senior Vice President, IT  
HDFC Bank Ltd.

*"None of the reports takes more than 10 minutes. It was taking 3-4 hours before, now it completes in 3 minutes. It sounds like unreal but it is real."*

- Finance User  
Turkcell

delivers better performance. Flash-only storage arrays cannot match the throughput of Exadata's integrated and optimized architecture with full InfiniBand based scale-out, fast PCI flash, offload of data intensive operations to storage, and algorithms that are specifically optimized for databases.

## Accelerating Database Processing with Smart System Software

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 dozens of CPU cores can consume data at many tens to hundreds of gigabytes a second. This is far faster than conventional storage arrays can deliver through their storage controllers and the storage network.

The technology that enables Exadata's unparalleled performance without any of the bottlenecks of traditional storage arrays is **Exadata Storage Server Software**. This software powers the Exadata storage servers, providing a highly efficient database-optimized storage infrastructure. Each Exadata Storage Server has two 10-core x86 processors that are used to offload database processing. A rack of Exadata Database Machine can have a total of up to 360 processor cores in the storage servers that can be used to offload the database servers. The CPUs in the storage servers do not replace database CPUs. Instead they accelerate data intensive workloads similar to how graphics cards accelerate image intensive workloads.

One of the many unique features of Exadata Storage Server software is **Smart Scan** technology, which **offloads data intensive SQL operations from the database servers directly into the storage servers**. By pushing SQL processing to the storage servers, data filtering and processing occur 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.

**Storage Index** is another powerful capability of Oracle Exadata Storage Server software that helps avoid unnecessary I/O operations and improves overall performance. The storage index, maintained in-memory, tracks the minimum and maximum values of columns per storage region for tables stored on that cell. When a query specifies a WHERE clause, Exadata Storage Server software examines the storage index to determine if rows with the specified column value exist in a region of disk in the cell by comparing the column value to the minimum and maximum values maintained in the storage index. If the column value is outside the minimum and maximum range, then scan I/O in that region for that query is avoided. Storage Index makes many SQL operations run dramatically faster because large numbers of I/O operations are automatically replaced by a few in-memory lookups.

Besides the intrinsic capabilities of Exadata Storage Server software, the combination of

*"The heart and soul of our stack right now is Oracle Exadata Database Machine. With Oracle Exadata, we've been able to reduce queries from days to minutes, and those that used to take minutes to seconds."*

- Chris Wones  
Enterprise Architect  
dunhumby

*"[With Exadata] We can more quickly process 65 billion daily transactions for data charging, while providing real-time information for customer inquiries, increasing customer satisfaction, and reducing costs."*

- Jin Hyung Lee  
ICT Team Manager, Networking  
Engineering  
SK Telecom

Oracle Database software, Exadata Storage Server software and Exadata infrastructure enables several additional capabilities that offer unparalleled performance levels for today's complex enterprise databases. For example, **Exafusion Direct-to-Wire Protocol** allows database processes to read and send Oracle Real Applications Cluster (Oracle RAC) messages directly over the InfiniBand network, bypassing the OS kernel and networking software overhead. This improves the response time and scalability of Oracle RAC configurations on Oracle Exadata Database Machine.

The **Smart Fusion Block Transfer** capability improves performance of a RAC configuration further by eliminating the impact of redo log write latency, especially when hot blocks need to be transferred between sending and receiving nodes. The block is transferred as soon as the I/O to the redo log is issued at the sending node, without waiting for it to complete. Based on internal tests, it has been observed that Smart Block Transfer increases throughput (about 40% higher) and decreases response times (about 33% less) for certain workloads.

To further accelerate OLTP workloads, the Exadata Smart Flash Cache implements a special algorithm to ensure low latency of database log writes called **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 reduce the average 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.

## Optimizing Storage Use and I/O Through Compression

The Exadata Storage Server provides a very advanced compression capability called **Hybrid Columnar Compression (HCC) that enables dramatic reductions in storage for large databases**. Hybrid Columnar Compression technology is an innovative method of organizing data within a database table. As the name implies, this technology utilizes a combination of both row and columnar methods for storing data. This hybrid approach achieves the compression benefits of columnar storage, while avoiding the performance shortfalls of a pure columnar format.

With Hybrid Columnar Compression, Exadata enables the highest levels of data compression possible with Oracle databases, 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. Average storage savings is an industry leading 10x. On conventional systems, enabling high data compression has the drawback of reducing performance by consuming CPU for decompression. Because the Exadata Database Machine is able to offload decompression overhead into large numbers of processors in Exadata storage, and in addition there is reduced I/O need because of the high compression achieved, most analytic workloads run faster using Hybrid Columnar Compression than they do without it. Hybrid Columnar Compression delivers the compression and analytic performance benefits of columnar storage while avoiding the dramatic slowdown that columnar-only data stores experience for drilldown operations that often involve single row access.

Two modes of Hybrid Columnar Compression are available. **Warehouse compression** mode is suitable for read intensive workloads such as Data Warehouses and provides

*"Exadata is the heart of the booking engine, and we cannot operate as a business, we cannot sell tickets without it."*

- James Callaghan  
Chief Technologist  
Westjet

*"Exadata delivers an amazing 20x compression for our Data Warehouse."*

- Jonathan Walsh  
Head of BI & DW  
Morrisons, Plc.

large storage savings while providing enhanced analytic performance. **Archive compression** mode provides the highest degree of compression and is targeted at data that is seldom accessed but still must be 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.

For data analytics which benefits from a pure columnar access, Exadata Smart Flash Cache implements a unique algorithm to accelerate reporting and analytical queries called **Exadata Columnar Flash Cache**. Columnar Flash Caching implements a dual format architecture in Exadata flash by automatically transforming frequently scanned Hybrid Columnar Compressed data into a pure columnar format as it is loaded into the flash cache. Smart scans on pure columnar data in flash run faster because they read only the selected columns, reducing flash I/Os and storage server CPU consumption. This accelerates reporting and analytic queries while maintaining excellent performance for OLTP style single row lookups.

## Fault Tolerant and Fastest Database In-Memory Machine

Exadata is the ideal platform for running Oracle Database In-Memory. Oracle Database In-Memory on Exadata does not require all data to reside in memory. Data can be stored across multiple tiers of storage, with the hottest data in memory providing extremely high query performance, active data on flash providing very high I/O throughput, and less active or older data on disk at a very low cost. **A single query can access data from all three tiers: memory, flash and disk, completely transparently.** This allows Exadata to run faster, support higher capacities and deliver lower costs than competing products.

Elastic configurations enable users to configure systems with very large system memory. An X6-2 system can have up to 28.5 TB system memory and 19 database servers in each rack. In addition, the 40Gb per second InfiniBand network provides extremely high throughput and very low latencies for in-memory queries that are distributed across the database servers.

Exadata **implements Fault Tolerant memory duplication for Oracle Database In-Memory.** Memory Fault Tolerance is unique to Oracle Engineered Systems. On a generic cluster configuration, when a server node fails, the in-memory data on that node is lost, and it takes many minutes to repopulate the in-memory data on a surviving node. During this time analytic queries will run orders of magnitude slower. This means generic platforms will fail to meet business SLAs. However, on Exadata, Fault-Tolerant memory duplication can eliminate this slowdown by duplicating any subset of the in-memory data across the clustered database servers. If a database server fails, queries will transparently access the duplicate copy of data on a surviving database server and processing will continue without interruption.



## Enhanced Consolidation using Oracle Virtual Machines

Consolidated environments running on Exadata can use Xen based Oracle Virtual Machine (OVM) to deliver a high degree of isolation between workloads. This is a very desirable feature for cloud, hosted, shared, service provider, and test/dev environments. Using OVM, multiple RAC clusters can be deployed on the same set of database servers of the Exadata Database Machine, which enables consolidation of applications that have specific Clusterware version needs.

### **Exadata Database Machine is the world's fastest virtualized database platform.**

Exadata virtual machines use high speed InfiniBand networking with Single Root I/O Virtualization (SR-IOV) to ensure that performance within a virtual machine is similar to Exadata's famous raw hardware performance. Exadata Smart Scans greatly decrease virtualization overhead compared to other platforms by dramatically reducing message traffic to virtual machines. Exadata virtual machines can dynamically expand or shrink the use of CPUs based on the workload requirement of the applications running in that virtual machine.

Virtual machines on Exadata are considered Trusted Partitions and therefore software can be licensed at the virtual machine level instead of the physical processor level. Without Trusted Partitions, database options and other Oracle software must be licensed at a server or cluster level even though all databases running on that server or cluster may not require a particular option.

## Enterprise-Class Security with Extreme Performance

Exadata Database Machine is the world's most secure database machine. Building on the high security capabilities in the Oracle Database, **Exadata moves decryption processing from database server software into the Exadata Storage Server hardware.** Exadata storage leverages hardware decryption and compression together to provide the highest performance secure databases. **Encryption occurs after the data is compressed so that the cost of decryption is decreased by the degree of compression.** By leveraging both technologies, Exadata is able to query fully encrypted and compressed databases with near zero overhead at hundreds of gigabytes of user data per second.

The Exadata system is designed and delivered as an integrated whole, and not a collection of components. In traditional database deployments, the customer takes on all the integration tasks for the system – including the task of ensuring the security of each individual software and hardware component, and ensuring that security is maintained across the full product stack. **Oracle delivers full stack security in the Exadata Database Machine.** Exadata virtual machines provide an added layer of isolation at the operating system level. Additionally, on both physical and virtual deployments, Exadata systems use minimal Linux distributions to ensure that just the RPMs needed to run Oracle Database are installed and enabled. With this approach, system security is stronger than default installations and common security vulnerabilities are avoided.

Exadata security has been probed and evaluated by hundreds of leading banks, telcos, and government organizations worldwide. The security findings of all these evaluations have been incorporated into the Exadata standard configuration, making it a highly secure database platform.

## Mission Critical High Availability

The Exadata Database Machine is engineered to provide the highest levels of availability. **All types of failures are protected against** including simple failures such as disk, server, or network, as well as complex site failures and human errors. Each Exadata Database Machine has **completely redundant hardware**, including redundant InfiniBand networking, redundant Power Distribution Units (PDU), redundant power supplies, and redundant database and storage servers. Oracle RAC protects against database server failure. Oracle ASM provides data mirroring to protect against disk or storage server failures. Oracle RMAN provides extremely fast and efficient backups to disk or tape. Oracle's Flashback technology allows backing out user errors at the database, table or even row level. Using Oracle Data Guard, a second Exadata Database Machine can be configured in a Maximum Availability Architecture (MAA) configuration to transparently maintain a real-time copy of the database at a remote site and provide full protection against primary database failures and site disasters. Exadata in an MAA configuration is recognized by the analyst firm IDC as a system that **delivers at least 5-nines availability** and is categorized in the IDC AL4 fault-tolerant market segment, along with HP Integrity NonStop and IBM z Systems<sup>1</sup>.

*"I don't get the calls in the middle of the night anymore that we have a system down. Exadata is taken as always being available."*

- James Callaghan  
Chief Technologist  
Westjet

The Exadata principle of deep hardware and software integration is also evident in the many ways Exadata uniquely assures high availability across several different failure conditions. One such capability is **Instant Detection of Compute and Storage Server Failures**. On non-Exadata platforms, detecting a server failure requires waiting for a long timeout, leading to extended application brownouts. Exadata leverages InfiniBand integration to very quickly determine that the suspect server is not reachable through any network path and can immediately initiate eviction of the failed server from the cluster. This entire operation can be completed in less than 2 seconds, leading to virtual elimination of application brownout conditions.

Disk and flash devices occasionally exhibit very long latency IO operations due to internal recovery of failed sectors, internal firmware reboots, or wear leveling. These long IO operations can cause stalls in mission critical OLTP databases. With Exadata **I/O Latency Capping**, Oracle Exadata Storage Server software automatically redirects read I/O operations to an ASM-mirrored copy of the data when the latency of a read I/O is much longer than expected. Similarly, it automatically redirects high latency write I/O operations to a healthy flash device, eliminating write outliers. If disks do fail, ASM performs a rebalance operation for the data that was resident on the disk. Exadata Storage Server software takes rebalance one step further by preserving the flash cache population and storage indexes when moving data between storage servers to maintain consistent application performance.

Because of its industry leading availability, the Exadata Database Machine has been deployed by leading companies for their most critical applications including interbank fund transfers, online securities trading, real-time call tracking, and web-based retailing. Exadata's Mission Critical availability capabilities are not restricted to OLTP workloads; they also apply to warehousing and analytics.

<sup>1</sup> Worldwide Fault-Tolerant Servers Market Shares, 2014: *Vendors Are Hearing the Customer — More Bold Moves Needed to Grow the Segment*, IDC, Peter Ruten, Lloyd Cohen, October 2015

## Ideal Platform for Database as a Service

*“By consolidating 350 database servers and storage systems onto Oracle Exadata, we gained a high-performance, reliable, and scalable mobile billing platform, enabling us to calculate billings data 10x faster, and halve maintenance costs.”*

- Tomoki Shimamura  
Senior Manager Billing Systems Group  
NTT DoCoMo, Inc.

*“By integrating 20 legacy database servers for our investment trust sales system into four Oracle Exadata Database Machines, we can provide information to customers 136x faster, enhance our competitive advantage, and support transaction growth for the next 10 years at lower costs.”*

- Tomoshiro Takemoto  
Senior Managing Director  
Cloud Computing Service Division  
Nomura Research Institute Ltd.

The Exadata Database Machine can host many databases, enabling massive database consolidation or a sophisticated Database as a Service private cloud. Multi-database environments inherently have diverse, complex, and unpredictable workloads mixing OLTP, analytics, and batch operations with sequential and random access patterns. Exadata’s ability to **run any type or mix of database workloads with industry leading scalability and performance** makes it an ideal consolidation platform – whether for multi-database workloads, or for pluggable databases with Oracle Multitenant in Oracle Database 12c.

Multi-database environments create an inherent risk that one database will consume too many resources and therefore impact the quality of service of other databases. The Exadata Database Machine provides unique **end-to-end prioritization** from the application to database CPUs, network, and storage. Priorities and resource limits can be specified at the physical database, pluggable database, connection, application, user, or even job level to ensure that each of the consolidated databases or SQL operations receives the necessary resources and achieves the target response times.

Exadata implements unique **database and I/O resource management**. Fine-grained priorities specified for operations at the database level are automatically communicated to Exadata Storage Servers and applied to each I/O operation to ensure that prioritization of database operations applies to both CPU operations and I/O operations. The same resource management principles can also be applied when multiple databases are deployed on one Exadata rack, as is typical in a consolidated private cloud.

Exadata also implements unique **database network resource management** to ensure that network intensive workloads such as reporting, batch, and backups don’t stall response time sensitive interactive workloads. Latency sensitive network operations such as RAC Cache Fusion communication and log file writes are automatically moved to the head of the message queue in server and storage network cards as well as InfiniBand network switches, bypassing any non-latency sensitive messages. Latency critical messages even jump ahead of non-latency critical messages that have already been partially sent across the network, ensuring low response times even in the presence of large network DMA (Direct Memory Access) operations.

## Fast Deployment of Development and Test Databases with Exadata Snapshots

Space-efficient database snapshots can be quickly created for test and development purposes directly on Exadata. Exadata database snapshots are integrated with Oracle Multitenant to provide an extremely simple interface for creating new pluggable database (PDB) snapshots.

Snapshots start with a shared read-only copy of the production database (or PDB) that has been cleansed of any sensitive information. As changes are made, each snapshot writes the changed blocks to a sparse disk group. Since multiple users can create independent snapshots from the same base database, multiple test and development environments can share space while maintaining independent databases for each task.

All Exadata specific features such as Smart Scan, resource management and Smart

Flash Cache work seamlessly on database instances created via Exadata snapshots hence providing an exact test and development environment while using a fraction of valuable storage resources.

## Comprehensive System Management

Oracle Enterprise Manager uses a holistic approach to manage the Exadata Database Machine and provides comprehensive capabilities from monitoring and reporting to active lifecycle management. It enables:

- **Unified Monitoring:** The latest version of Enterprise Manager, Oracle Enterprise Manager 13c, supports a single pane of glass view of all the hardware and software components such as database servers, storage servers, InfiniBand switches, and monitors the operations running on them and their resource utilization. DBAs can drill down from database monitoring screens to the Exadata storage layer to quickly determine root causes of any performance bottlenecks. Lights-out monitoring within Enterprise Manager is optimized for Exadata with predefined metrics and thresholds so that administrators receive timely notifications when issues arise, and manage those exceptions. In addition, hardware incidents are automatically detected and service requests logged to reduce problem resolution time.
- **Intelligent Consolidation Planning:** Oracle Enterprise Manager's Database Consolidation Workbench provides optimal placement strategy for source databases for an effective Database as a Service deployment, using Enterprise Manager's rich provisioning and deployment procedure capabilities. Further, it can validate the chosen consolidation platform using Real Application Testing's SQL Performance Analyzer to make sure there are no SQL execution plan regressions in the post-consolidated environment.
- **Lifecycle Management:** Enterprise Manager automates manual, time-consuming activities such as provisioning, patching, managing snapshots, etc. The patching feature supports upfront pre-flight checks and then automates application of rolling patches on databases, Grid Infrastructure and Exadata hardware. The Exachk tool, which is integrated with Enterprise Manager's powerful compliance framework, provides functionality for system administrators to automate the assessment of Engineered Systems for known configuration problems and best practices. Administrators can leverage the Consistency Check functionality to check for deviations in configuration across the racks or among the database servers of a rack.

## Highest Level of Service

Oracle offers a complete set of support services for the Exadata family of products including: 24x7 hardware service, system monitoring, software installation and configuration among other standard and custom offerings.

Of particular value is **Oracle Platinum Services** that is available exclusively for Oracle's Engineered Systems. Platinum Services provides fault monitoring, faster response times, and expedited escalation to development. With Platinum Services, Oracle support engineers perform software maintenance and patching remotely. Platinum Services provides a higher level of support than has ever been available before for all software and hardware within an Engineered System including the Oracle Database. Platinum Services is provided at no extra charge to Exadata customers.

## IT Agility

Exadata is a complete system for running databases including storage, servers, and internal networks. Management of a traditional database system is typically spread

*"With Oracle Platinum Services, we achieved a 40% increase in operational efficiency - virtually eliminating the need for dedicated resources to perform updates, monitor systems, and resolve incidents."*

- Roland Schiller  
Architect  
Swiss Re

across the management teams of each of the components such as the database team, the storage team, and the system administration team. In contrast, an **Exadata system is typically managed by a unified Database Machine Administration team.**

Database Machine Administrators have full control of all resources in the Exadata Database Machine including storage resources. New database deployments and configuration changes can be implemented by the Database Machine Administrators without coordination across different component management teams that are often overloaded and have differing priorities. Database Machine Administrators can focus on application and business specific enhancements rather than coordinating across component teams, or tuning and triaging of low level configuration issues.

## Dramatically Lower Costs

Because of the extreme performance, high storage capacity, and unique compression capabilities delivered by the Exadata Database Machine, workloads that would require very large traditional hardware systems can be run on much smaller Exadata systems. The hardware needed for an application deployed on an Exadata system is often reduced 2-4X compared to a traditional system.

Exadata provides a huge RAM, flash, and disk footprint for large data sets. Raw disk storage on an Exadata full rack can exceed 1.7 Petabytes while raw flash storage can be up to 460 TB. In addition, Hybrid Columnar Compression often expands storage and memory capacity 10X. By intelligently moving active data across disk, flash, and memory tiers, Exadata simultaneously delivers the highest performance and the lowest cost.

Exadata has the unique ability to consolidate many databases supporting multiple workloads in a single cloud platform. High-end OLTP, analytics, batch, reporting, and backups can all run simultaneously within and across databases with extreme performance. **The extreme performance and capacity of Exadata enables very large numbers of databases and workloads to be consolidated on Exadata.** Consolidating databases on Exadata reduces system hardware cost, software cost, and greatly reduces ongoing operations cost.

The uniformity of Exadata Database Machine configurations results in large cost savings. **Exadata standardizes not just technologies, but also integration, testing, hardening, tuning, and support.** Customers deploy Exadata systems much faster and with a lot less labor than traditional systems. Low level tuning, integration, and maintenance is reduced or eliminated. Because all Exadata users run a configuration that is identical to thousands of other users, and is identical to Oracle's internal configurations, it is far less likely that issues will be encountered, and issue resolution is quicker and simpler reducing both operations cost and downtime cost.

## Capacity-on-Demand Software Licensing

An X6-2 database server has a substantial amount of compute capacity with two 22-core x86 processors (44 cores in total). The Capacity-on-Demand feature allows a number of cores per database server to be turned off during the hardware installation, leaving at least 14 cores enabled. As your workload grows and more cores are needed, Capacity-on-Demand can be used to re-enable cores and license software 2 cores at a time. This pay-as-you-grow approach to software licensing is another way in which Exadata helps to align costs with business growth.

*"We've seen system performance increase 4x and the total cost of storage ownership fall by 30%, even as our data volumes have surged."*

- Holger Haun  
Managing Director  
IDS GmbH – Analysis and Reporting  
Service

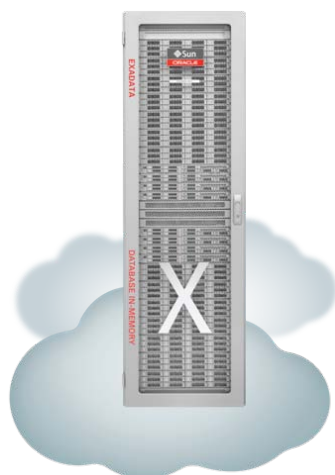
*"On an annual basis Exadata provides at least half a million dollars in savings in operating costs."*

- James Callaghan  
Chief Technologist  
Westjet

## Exadata in Oracle Public Cloud

With Oracle Database Exadata Cloud Service, customers can now run Oracle databases in the cloud on Exadata, with the same extreme performance and availability experienced by thousands of organizations deploying Exadata on-premises. Exadata Cloud Service combines the world's #1 database – Oracle, and the most powerful database platform – Exadata, with all the simplicity and cost effectiveness of the public cloud.

Oracle databases deployed in the cloud as part of this service include **all Oracle Database options and features** – such as Oracle Multitenant, In-Memory Database, Real Application Clusters (RAC), Active Data Guard, Partitioning, Advanced Compression, Advanced Security, etc. It also includes all Oracle Enterprise Manager packs. Oracle databases deployed in the Exadata Cloud Service are **100% compatible** with those deployed on-premises, ensuring a smooth transition to the cloud, and an efficient hybrid cloud strategy. With pay-as-you-grow dedicated Exadata configurations, and infrastructure managed by Oracle experts, Exadata Cloud Service enables business agility and operational flexibility with **zero CapEx**.



To commence an Exadata Cloud Service, customers log in through **Oracle Cloud Portal** (<https://cloud.oracle.com>) and activate the Exadata configuration allocated and dedicated for them. They can start with a Quarter Rack with 2 database servers and 3 storage servers. The database servers have a minimum and maximum number of compute cores (OCPUs) that can be enabled for the chosen configuration, and customers can specify their desired number of compute cores within these limits. Customers subscribe to the Exadata service for a specified term, and the pricing is based on the number of enabled compute cores for that term. As business grows, customers can enable additional compute cores, or opt for larger Exadata configurations, thus paying only for the processing power that is required.

Once the Exadata Service is activated, customers can start creating databases on the allocated Exadata system. Customers have root privilege for the Exadata database server VMs and DBA password on the Oracle Databases, so they can configure the system and create/deploy databases as they like, and load additional agent software on the Exadata database servers to conform to business standards or security monitoring requirements. They can connect to the configured databases using standard Oracle Net Services clients such as JDBC and OCI. Customers can also deploy their applications within Oracle Public Cloud infrastructure, using cloud offerings such as Oracle Dedicated Compute Service or Oracle Java Cloud Service.

Customers perform their own database administration tasks, using the familiar Oracle Enterprise Manager interface. All supporting infrastructure for Exadata Cloud Service is deployed, maintained and managed by Oracle, including datacenter networking, private Exadata InfiniBand networks, physical Exadata database and storage servers, firmware, and Exadata storage software. This allows customers to focus on their business needs and application requirements, and not IT infrastructure management.

Exadata Cloud Service is an ideal fit for:

- Running business-critical production OLTP or analytic databases at almost any scale without incurring the capital expenditure and complexity of maintaining the underlying IT infrastructure.

- Consolidating a variety of workloads in the Cloud using multiple Oracle Databases or Oracle Multitenant.
- Maintaining synchronized Oracle standby or replica databases for disaster recovery in the Cloud and/or query offloading using Oracle Active Data Guard or Oracle GoldenGate.
- Quickly provisioning high-performance Oracle databases for ad-hoc business reasons such as feature development, functionality testing, application certification, proof-of-concept, try-before-buy, Database 12c sandbox testing, etc.
- Executing time-sensitive business applications such as launching a web-based marketing campaign, running loyalty programs, rolling out new business initiatives, etc.

An attractive aspect of all these use cases for existing Oracle Database customers is that their applications and data models **do not have to change**. Their data center simply expands to include the elasticity and flexibility of the Oracle Cloud. They also do not have to invest in multiple cloud platforms for multiple workloads since Exadata provides a unified platform for all workloads – analytics, data warehousing, OLTP, consolidation, in-memory and mixed-workloads.

With a database platform uniquely engineered for extreme performance for all workloads, along with fast deployment, simplified management, low operating costs and reduced risks, Exadata Service is the best Cloud Database platform available today.

## Exadata Business Benefits

Beyond the operational benefits of extreme performance, availability, and security, and deployment flexibilities across on-premises and Cloud, Exadata also directly benefits the business.

**Exadata accelerates time to market** for new business applications since the time needed for system configuration, tuning, and testing is largely eliminated. Deployment times are reduced from months to days, and the risk of unexpected system level issues after go-live is greatly reduced. When a new application is deployed, it is common for unanticipated application usage patterns to create performance issues. Exadata's huge I/O, network, and compute throughput can absorb spikes created by unanticipated workloads without slowing response times of mission critical workloads. Overall Exadata speeds application deployment and reduces risk, allowing businesses to innovate faster.

Exadata's extreme performance and large memory and flash capacity enhance employee productivity and customer satisfaction by greatly improving user response times. **Users spend more time doing useful work, and less time waiting** for the system to respond.

Exadata's extreme performance does not just improve business efficiency, it also **enables business users to make smarter decisions, discover growth opportunities, and reduce costs**. Users can analyze data in real-time, explore different possibilities, and perform rapid iteration to find better solutions. Exadata enables:

- Real-time business data analysis
- Faster financial closes
- Better planning and budgeting
- More effective and faster projections

## Conclusion

Exadata delivers a fully integrated database platform with the latest hardware technologies and unique software to deliver extreme performance, availability, and security. This coupled with cost savings, ease of management, and enhanced supportability result in greater business agility and efficiency. Given what can be achieved with Exadata, it is no surprise it is the new global standard for running Oracle Databases – **whether on-premises, or in the Oracle Public Cloud.**



EXADATA SERVER HARDWARE<sup>1</sup>

Server Type	CPU	Memory	Disk	Flash	Network
Database Server	2x 22-core Xeon E5-2699 v4 processors	256 GB (default) to 1.5 TB (max)	4x 600 GB 10,000 RPM disks (Hot-Swappable) – Expandable to 8	None	3x 1/10 Gb copper Ethernet ports (client) 1x 1/10 Gb copper Ethernet port (mgmt) 2x 10 Gb optical Ethernet ports (client) 2x QDR (40 Gb) InfiniBand ports 1x ILOM Ethernet port
Storage Server HC	2x 10-core Xeon E5-2630 v4 processors	128 GB	12x 8 TB 7,200 RPM disks	4x 3.2 TB NVMe PCIe 3.0 flash cards	2x QDR (40 Gb) InfiniBand ports 1x ILOM Ethernet port
Storage Server EF		128 GB	None	8x 3.2 TB NVMe PCIe 3.0 flash drives	

<sup>1</sup> All servers include redundant hot swappable fans and power supplies

EXADATA TYPICAL RACK CONFIGURATIONS<sup>2</sup>

Rack Size	Database Servers and Cores	Storage Servers and Cores	HC Storage Capacity (raw)	EF Storage Capacity (raw)
Eighth Rack <sup>3</sup>	2x servers, 44 cores	3x servers, 30 cores for SQL offload	144 TB disk, 19.2 TB flash	38.4 TB flash
Quarter Rack	2x servers, 88 cores	3x servers, 60 cores for SQL offload	288 TB disk, 38.4 TB flash	76.8 TB flash
Half Rack	4x servers, 176 cores	7x servers, 140 cores for SQL offload	672 TB disk, 89.6 TB flash	179.2 TB flash
Full Rack	8x servers, 352 cores	14x servers, 280 cores for SQL offload	1,344 TB disk, 179.2 TB flash	358.4 TB flash

<sup>2</sup> Each rack is 42 RU (Rack Units) in height, has 2x redundant Power Distribution Units (PDUs), 2x 36-port QDR (40 Gb/s) InfiniBand switches and 1x 48-port Cisco Ethernet switch for administration. Included Spare Parts Kit Contains:

- 1 x 3.2 TB NVMe PCI Flash card and 1 x 8 TB High Capacity disk, or
- 1 x 3.2 TB NVMe PCI flash drive

<sup>3</sup> Eighth Rack is the minimum Exadata configuration. Eighth Rack compute servers have half the cores enabled. Eighth Rack EF storage servers have half the cores and flash drives enabled. Eighth Rack HC storage servers have half the cores enabled and half the disks and flash cards removed.

EXADATA ELASTIC CONFIGURATIONS<sup>4</sup>

Rack Size	Database Servers and Cores	Storage Servers and Cores	HC Storage Capacity (raw)	EF Storage Capacity (raw)
Base Rack (Quarter Rack)	2x servers, 88 cores	3x servers, 60 cores for SQL offload	288 TB disk, 38.4 TB flash	76.8 TB flash
+ Database Servers	Up to 19x servers <sup>5</sup> , 836 cores max per rack	n/a	n/a	n/a
+ Storage Servers	n/a	Up to 18x servers <sup>5</sup> , 360 cores max per rack	1,728 TB disk, 230.4 TB flash max per rack	460.8 TB flash max per rack

<sup>4</sup> A full rack elastic configuration cannot exceed 22 servers and 39 RU (Rack Units). Database Servers = 1 RU, Storage Servers = 2 RU

<sup>5</sup> Maximum number of database servers allowed in an elastic configuration is 19. Maximum number of storage servers allowed in an elastic configuration is 18.

## OTHER ELASTIC EXPANSION OPTIONS

Multi-Rack Connection	Connect any combination of up to 18 Exadata Database Machine racks or Exadata Storage Expansion Racks via the InfiniBand fabric. Larger configurations can be built with external InfiniBand switches. Connected racks can be any combination of V2, X2, X3, X4, X5 or X6 hardware.
Eighth Rack to Quarter Rack Upgrade	Upgradability: Field upgrade from Eighth Rack to Quarter Rack. Expand just compute or just storage or both. Additional Hardware Components are enabled/installed with the Upgrade: <ul style="list-style-type: none"> <li>• For each Database Server: Twenty two additional cores are enabled,</li> <li>• For each EF Storage Server: Ten additional cores and four PCI Flash drives are enabled</li> <li>• For each HC Storage Server: Ten additional cores are enabled, six disks and two PCI Flash Cache cards are installed.</li> </ul>

## EXADATA X6-2 CAPACITY AND PERFORMANCE METRICS: INDIVIDUAL SERVERS

Server Type	Maximum SQL Flash Bandwidth <sup>2</sup>	Maximum SQL Read IOPS <sup>3</sup>	Maximum SQL Write IOPS <sup>4</sup>	PCI Flash Capacity (raw) <sup>5</sup>	Disk Data Capacity(raw)
Database Server	NA	562,500	518,000	NA	2.4 TB
Storage Server HC <sup>1</sup>	21 GB/s	475,000	410,000	12.8 TB	96 TB
Storage Server EF <sup>1</sup>	25 GB/s	495,000	450,000	25.6 TB	N/A

## EXADATA TYPICAL RACK CONFIGURATIONS: FLASH METRICS (HC &amp; EF)

Flash Metrics		Maximum SQL Flash Bandwidth	Maximum SQL Flash Read IOPS	Maximum SQL Flash Write IOPS	PCI Flash Capacity (raw)
Full Rack	HC	301 GB/s	4,500,000	4,144,000	179.2 TB
	EF	350 GB/s	4,500,000	4,144,000	358.4 TB
Half Rack	HC	150 GB/s	2,250,000	2,072,000	89.6 TB
	EF	175 GB/s	2,250,000	2,072,000	179.2 TB
Quarter Rack	HC	64 GB/s	1,125,000	1,036,000	38.4 TB
	EF	75 GB/s	1,125,000	1,036,000	76.8 TB
Eighth Rack	HC	32 GB/s	562,500	518,000	19.2 TB
	EF	38 GB/s	562,500	518,000	38.4 TB

## EXADATA TYPICAL RACK CONFIGURATIONS: DISK METRICS (HC)

Disk Metrics	Maximum SQL Disk Bandwidth	Maximum SQL Disk IOPS	Data Capacity (raw)
Full Rack	25 GB/s	36,000	1,344 TB
Half Rack	12.5 GB/s	18,000	672 TB
Quarter Rack	5.4 GB/s	7,800	288 TB
Eighth Rack	2.7 GB/s	3,900	144 TB

## EXADATA TYPICAL RACK CONFIGURATIONS: COMBINED METRICS (HC &amp; EF)

Combined Metrics		Data Capacity (Usable) – Normal Redundancy <sup>6</sup>	Data Capacity (Usable) – High Redundancy <sup>6</sup>	Maximum Data Load Rate <sup>7</sup>
Full Rack	HC	508 TB	399 TB	21 TB/hour
	EF	130 TB	102 TB	21 TB/hour
Half Rack	HC	254 TB	199 TB	11 TB/hour
	EF	65 TB	51 TB	11 TB/hour
Quarter Rack	HC	109 TB	85 TB	5 TB/hour
	EF	28 TB	22 TB	5 TB/hour
Eighth Rack	HC	54 TB	43 TB	2.5 TB/hour
	EF	14 TB	11 TB	3 TB/hour

<sup>1</sup>HC = High Capacity' EF = Extreme Flash. Actual system performance varies by application.

<sup>2</sup> Bandwidth is peak physical scan bandwidth achieved running SQL, assuming no database compression. Effective user data bandwidth is higher when database compression is used.

<sup>3</sup> Based on 8K I/O requests running SQL. Note that the I/O size greatly affects Flash IOPS. Other products quote IOPS based on smaller IOs that are not relevant for databases.

<sup>4</sup> Based on 8K I/O requests running SQL. Flash write I/Os measured at the storage servers after ASM mirroring, which usually issues multiple storage IOs to maintain redundancy.

<sup>5</sup> Raw capacity is measured in standard disk drive terminology with 1 GB = 1 billion bytes.

<sup>6</sup> Usable capacity is measured using normal powers of 2 space terminology with 1 TB = 1024 \* 1024 \* 1024 bytes. It is the actual space available to create a database after taking into account space needed for ASM redundancy, recovering from a drive failure, DBFS disk group, and OS images and binaries.

<sup>7</sup> Load rates are typically limited by database server CPU, not IO. Rates vary based on load method, indexes, data types, compression, and partitioning.

## EXADATA DATABASE MACHINE X6-2 COMPONENT ENVIRONMENTAL SPECIFICATIONS

Metric	X6-2 Database Server Plus InfiniBand Infrastructure	X6-2 High Capacity Storage Server Plus InfiniBand Infrastructure	X6-2 Extreme Flash Storage Server Plus InfiniBand Infrastructure
Height	1.7 in. (42.6 mm)	3.5 in. (87.6 mm)	
Width	17.2 in. (436.5 mm)	17.5 in. (445.0 mm)	
Depth	29.0 in. (737.0 mm)	29.0 in. (737.0 mm)	
Acoustic noise (operating)	7.8 B	7.8 B	7.8 B
Weight	45.0 lbs (20.4 kgs)	73.0 lbs (33.1 kgs)	62.0 lbs (28.1 kgs)
Maximum power usage	0.665 kW (0.678 kVA)	0.588 kW (0.600 kVA)	0.547 kW (0.558 kVA)
Typical power usage <sup>1</sup>	0.466 kW (0.475 kVA)	0.412 kW (0.420 kVA)	0.383 kW (0.391 kVA)
Cooling at maximum usage	2,269 BTU/hour (2,394 kJ/hour)	2,006 BTU/hour (2,117 kJ/hour)	1,866 BTU/hour (1,969 kJ/hour)
Cooling at typical usage	1,588 BTU/hour (1,676 kJ/hour)	1,404 BTU/hour (1,482 kJ/hour)	1,307 BTU/hour (1,378 kJ/hour)
Airflow at maximum usage <sup>2</sup>	105 CFM	93 CFM	86 CFM
Airflow at typical usage <sup>2</sup>	74 CFM	65 CFM	60 CFM

Operating temperature/humidity: 5 °C to 32 °C (41 °F to 89.6 °F), 10% to 90% relative humidity, non-condensing

Altitude Operating: Up to 3,048 m, max. ambient temperature is de-rated by 1° C per 300 m above 900 m

<sup>1</sup> Typical power usage varies by application load

<sup>2</sup> Airflow must be front-to-back.

## EXADATA DATABASE MACHINE X6-2 ENVIRONMENTAL SPECIFICATIONS

Metric	Full Rack	Half Rack	Quarter Rack	Eighth Rack
Height	<ul style="list-style-type: none"> <li>• 78.66" - 1998 mm</li> <li>• 23.62" - 600 mm</li> <li>• 47.24" - 1200 mm</li> </ul>			
Width				
Depth				
Acoustic noise (operating)	8.6 B	8.5 B	8.3 B	8.3 B
<b>Environmentals With High Capacity Disks</b>				
Weight	1928.5 lbs (874.8 kg)	1236.5 lb (560.9 kg)	840.5 lbs (381.2 kg)	810.3 lbs (367.6 kg)
Maximum power usage	14.8 kW (15.1 kVA)	8.0 kW (8.2 kVA)	4.0 kW (4.1 kVA)	3.3 kW (3.4 kVA)
Typical power usage <sup>1</sup>	10.4 kW (10.6 kVA)	5.6 kW (5.7 kVA)	2.8 kW (2.9 kVA)	2.3 kW (2.3 kVA)
Cooling at maximum usage	50,455 BTU/hour	27,335 BTU/hour	13,679 BTU/hour	11,207 BTU/hour
	53,230 kJ/hour	28,838 kJ/hour	14,432 kJ/hour	11,823 kJ/hour
Cooling at typical usage	35,319 BTU/hour	19,134 BTU/hour	9,575 BTU/hour	7,845 BTU/hour
	37,261 kJ/hour	20,187 kJ/hour	10,102 kJ/hour	8,276 kJ/hour
Airflow at maximum usage <sup>2</sup>	2336 CFM	1265 CFM	633 CFM	519 CFM
Airflow at typical usage <sup>2</sup>	1635 CFM	886 CFM	443 CFM	363 CFM

## Environmentals With Extreme Flash Drives

Weight	1774.5 lbs (804.9 kg)	1159.5 lbs (525.9 kg)	807.5 lbs (366.3 kg)	807.5 lbs (366.3 kg)
Maximum power usage	14.2 kW (14.5 kVA)	7.7 kW (7.9 kVA)	3.9 kW (4.0 kVA)	3.2 kW (3.3 kVA)
Typical power usage <sup>1</sup>	9.9 kW (10.1 kVA)	5.4 kW (5.5 kVA)	2.7 kW (2.8 kVA)	2.2 kW (2.3 kVA)
Cooling at maximum usage	48,497 BTU/hour	26,355 BTU/hour	13,260 BTU/hour	10,952 BTU/hour
	51,164 kJ/hour	27,805 kJ/hour	13,989 kJ/hour	11,554 kJ/hour
Cooling at typical usage	33,948 BTU/hour	18,449 BTU/hour	9,282 BTU/hour	7,666 BTU/hour
	35,815 kJ/hour	19,463 kJ/hour	9,792 kJ/hour	8,0888 kJ/hour
Airflow at maximum usage <sup>2</sup>	2245 CFM	1220 CFM	614 CFM	507 CFM
Airflow at typical usage <sup>2</sup>	1572 CFM	854 CFM	430 CFM	355 CFM

Operating temperature/humidity: 5 °C to 32 °C (41 °F to 89.6 °F), 10% to 90% relative humidity, non-condensing

Altitude Operating: Up to 3,048 m, max. ambient temperature is de-rated by 1° C per 300 m above 900 m

<sup>1</sup> Typical power usage varies by application load.

<sup>2</sup> Airflow must be front-to-back.

## EXADATA DATABASE MACHINE X6-2 REGULATIONS AND CERTIFICATIONS

Regulations <sup>1</sup>	<b>Safety:</b>	UL/CSA 60950-1, EN 60950-1, IEC 60950-1 CB Scheme with all country differences
	<b>RFI/EMI:</b>	EN55022, EN61000-3-11, EN61000-3-12
	<b>Immunity:</b>	EN 55024
	<b>Emissions and Immunity:</b>	EN300 386
Certifications <sup>1</sup>	North America (NRTL), European Union (EU), International CB Scheme, BSMI (Taiwan), C-Tick (Australia), CCC (PRC), MSIP (Korea), CU EAC (Customs Union), VCCI (Japan)	
European Union Directives <sup>1</sup>	2006/95/EC Low Voltage Directive, 2004/108/EC EMC Directive, 2011/65/EU RoHS Directive, 2012/19/EU WEEE Directive	

<sup>1</sup>All standards and certifications referenced are to the latest official version at the time the data sheet was written. Other country regulations/certifications may apply. In some cases, as applicable, regulatory and certification compliance were obtained at the component level.

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## EXADATA DATABASE MACHINE X6-2 SUPPORT SERVICES

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- *Hardware Warranty: 1 year with a 4 hr 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 includes Oracle Linux 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*
  - *Business Critical Service for Systems*
  - *Oracle Exadata Start-Up Pack*
  - *System Upgrade Support Services including hardware installation and software configuration*
  - *Oracle Auto Service Request (ASR)*
- 

## OPTIONAL CUSTOMER SUPPLIED ETHERNET SWITCH INSTALLATION IN EXADATA DATABASE MACHINE X6-2

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- *Each Exadata Database Machine X6-2 rack has 2U available at the top of the rack that can be used by customers to optionally install their own client network Ethernet switches in the Exadata rack instead of in a separate rack. Some space, power, and cooling restrictions apply.*
-

## KEY FEATURES &amp; FUNCTIONALITY

**Exadata and Database Software Features - Analytics**

- *Automatically Parallelize and Offload Data Scans to storage*
- *Filter Rows in Storage based on 'where' clause*
- *Filter Rows in Storage based on columns selected*
- *JSON and XML Offload*
- *Filter rows in Storage based on Join with other Table*
- *Hybrid Columnar Compression*
- *Storage Index data skipping*
- *I/O Resource Management by User, Query, Service, DB, etc.*
- *Automatic Transformation to Columnar Format in Flash Cache*
- *Smart Flash Caching for Table Scans*
- *Offload Index Fast Full Scans*
- *Offloads Scans on Encrypted Data, with FIPS compliance*
- *Storage offload for LOBs and CLOBs*
- *Storage offload for min/max operations*
- *Data Mining Offload*
- *All Ports Active InfiniBand Messaging*
- *Reverse Offload to DB servers if Storage CPUs are Busy*
- *Automatic Data Compression in Flash Cache*
- *Offload JSON and XML analytic queries*

**Exadata and Database Software Features - OLTP**

- *Database Aware PCI Flash*
- *Exadata Smart Flash Caching*
- *Exadata Smart Flash Logging*
- *Write-back Flash Cache*
- *I/O Prioritization by DB, User, or workload to ensure QOS*
- *Exafusion Direct-to-Wire Protocol*
- *Network Resource Management*
- *Exachk full-stack validation*
- *Full-stack security scanning*
- *NVMe flash interface for lowest latency IO*
- *Database scoped security*
- *Cell-to-Cell Rebalance preserving Flash Cache*
- *Secure disk and flash erase*
- *Oracle VM with SRIOV*
- *InfiniBand Partitioning*
- *Instant data file creation*
- *Active Bonding of InfiniBand*
- *Smart Fusion Block Transfer*
- *Automatic VLAN creation*
- *Set Minimum or Maximum Flash Cache Size per Database*

**Exadata and Database Software Features - High Availability**

- *Instant Detection of Node or Cell Failure*
- *In-Memory Fault Tolerance*
- *Sub-second Failover of I/O on stuck disk or flash*
- *Offload backups to storage servers*
- *Exadata Data Validation (H.A.R.D.)*
- *Prioritize rebalance of critical files*
- *Automatic Hard Disk scrub and repair*
- *Power cycle failed drives to Eliminate false drive failures*
- *Avoid reading Predictive failed disks*
- *Cell software transparent restart*
- *Flash and disk life cycle management alert*
- *Confinement of temporarily poor performing drives*
- *Prevent shutdown if mirror server is down*
- *Detection and disabling of unreliable network links*
- *Preserve Storage Index on Rebalance*
- *Automatic disk scrub and repair*

**Manageability Features**

- *Oracle Embedded Integrated Lights Out Manager (ILOM)*
  - *Oracle Enterprise Manager Exadata Plug-in*
  - *Active AWR includes storage stats for end to end monitoring*
  - *IPv6 Support for Ethernet Connections*
  - *Capacity on Demand*
  - *Trusted Partitions for Oracle Virtual Machine*
  - *Automated VLAN Creation*
  - *Oracle Exadata Deployment Assistant*
  - *Separate Management Switch and Connectivity*
  - *Exaccli command line management from remote servers*
  - *Cellcli command line management of Storage Servers*
  - *DCLI distributed command line automation tool*
- 

**Oracle Database Software (available separately):**

**For database servers:** Oracle Database 11g Release 2 Enterprise Edition and Oracle Database 12c Enterprise Edition. Oracle Database Options such as Oracle Real Application Clusters, Oracle Partitioning, Oracle Multitenant, Oracle Active Data Guard. See the release specific documentation for feature support.

**For storage servers:** Oracle Exadata Storage Server Software. Licenses are transferable from one system to another, or to a new system

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**Oracle Software (included):**

**For database servers:** Oracle Linux 6 Update 7 with the Unbreakable Enterprise Kernel 2. Zero-loss Zero-copy Datagram Protocol (ZDP) InfiniBand protocol used to communicate between the Exadata Storage Servers and the Oracle Database which is based on the Reliable Datagram Sockets (RDS) OpenFabrics Enterprise Distribution (OFED)





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#### CONTACT US

For more information about Oracle Exadata, visit [oracle.com/exadata](http://oracle.com/exadata) or call +1.800.ORACLE1 to speak to an Oracle representative.

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