

# ORACLE EXADATA STORAGE EXPANSION RACK X8-2

**ORACLE®**  
Exadata

Oracle Exadata and Oracle SuperCluster deliver extreme performance and scalability for all your database applications including Online Transaction Processing (OLTP), Data Warehousing (DW) and consolidation of mixed workloads. The Oracle Exadata Storage Expansion Rack is engineered to be the simplest, fastest and most robust way to add additional storage capacity to an Exadata Database Machine or a SuperCluster. A natural extension of the Exadata Database Machine and the SuperCluster, the Exadata Storage Expansion Rack can be used to satisfy the Big Data requirements of the largest mission critical databases.



## Engineered System for Fast and Reliable Deployment

The Exadata Database Machine is an easy to deploy system that integrates 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 mission critical systems. Extensive end-to-end testing ensures that all components including database software, operating system, firmware, drivers, etc., work seamlessly together and that there are no performance bottlenecks or single points of failure that can affect the complete system. The Exadata Storage Expansion Rack takes this to the next level.

## Extreme Performance and Capacity

The Exadata Storage Expansion Rack enables you to grow the Exadata storage capacity and bandwidth of any Exadata Database Machine or SuperCluster. It is designed for database deployments that require very large amounts of data including: historical or archive data, backups, documents, images, XML, LOBs, etc. The expansion rack is extremely simple to configure as there are no LUNs or mount points to set up. It connects to the Exadata Database Machine or SuperCluster using the integrated InfiniBand fabric. Storage is configured and added to a database online with a few simple commands.

## Extreme System Scalability and Growth with Elastic Configurations

The Exadata Storage Expansion Rack offers you more flexibility than ever to grow. With the introduction of Elastic Configurations starting with X5, Exadata Storage Expansion Rack can be configured and purchased as small as a Quarter Rack with four storage servers, additional storage servers can be added one at a time or as many as needed up

**KEY FEATURES**

- Grow the storage capacity of Oracle Exadata Database Machines and Oracle SuperCluster
- Includes from 4 to 19 Oracle Exadata Storage Servers
- Mirrored usable capacity of up to 1,294TB per rack before compression
- Up to 608 CPU cores dedicated to SQL processing in storage
- Up to 486.4TB of Smart Flash Cache
- Connected directly to Exadata X8-2 and X8-8 and SuperCluster via 40 Gbps InfiniBand
- Hybrid Columnar Compression often delivers 10X-15X compression ratios
- Complete redundancy for high availability

**KEY BENEFITS**

- Uncompressed I/O bandwidth of up to 475 GB/second per rack from SQL
- Engineered scale-out storage architecture pre-configured to easily expand system capacity and performance, online
- Simple upgrade to meet the needs of any size application
- Over 12 Petabytes of user data can be stored in a rack using the included Hybrid Columnar Compression
- Scale the configuration by connecting up to 18 Exadata Database Machines and Exadata Storage Expansion Racks without external switches. Larger configurations can be built with additional InfiniBand switches

to a maximum of 19. With the flexibility of adding between 4 and 19 storage servers, there is a configuration that fits any application. In addition to upgrading from a small to large Exadata Storage Expansion Rack, Oracle continues to use a building-block approach to connect the Exadata Storage Expansion Rack to the Exadata Database Machine and SuperCluster using the integrated InfiniBand fabric to easily scale the system to any size. Exadata Storage Expansion Quarter or Elastic Racks can be coupled to Exadata Database Machine Full, Half and Quarter or Elastic Rack systems in almost any combination. Up to 18 Exadata Database Machine racks and Exadata Storage Expansion Racks can be easily connected via InfiniBand cables and internal switches. An Exadata X8-2 "Full Rack" with 17 Exadata X8 Storage Expansion Racks, each with 19 High Capacity Storage Servers, has a raw disk capacity of 65 Petabytes (65,243 TB) and 10,784 CPU cores dedicated to SQL processing. Larger configurations can be built with additional InfiniBand switches.

As new Exadata Storage Expansion Racks are connected to an Exadata Database Machine or a SuperCluster, the storage capacity and performance of the system grows. The system can be run in single system image mode or logically partitioned for consolidation of multiple databases. Scaling out is easy with Exadata Database Machine, SuperCluster and Exadata Storage Expansion Racks. Automatic Storage Management (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 configuration. The I/O Resource Manager can also be used to apportion I/O bandwidth to different databases and users of the system to deliver on business service level targets.

**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 and the SuperCluster 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.

**RELATED PRODUCTS**

- Oracle Exadata Database Machine X8-2
- Oracle Exadata Database Machine X8-8
- Oracle Exadata Storage Server X8-2
- Oracle Exadata Database Server X8-2
- Oracle SuperCluster
- Oracle Database 11g, 12c, 18c and 19c
- 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

Each Exadata Storage Expansion Rack Storage Server has two Xeon® x86 processors that are used for database offload. A Max Configuration Exadata Storage Expansion Rack with 19 Storage Servers has a total of 608 processor cores that 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 unique 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 that uses 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 substantial 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 as it adds the load of decompression to the CPU. Because the Exadata Database Machine is able to offload decompression to 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 without it.

Two modes of Hybrid Columnar Compression are available. **Warehouse compression** mode is suitable for read-intensive workloads and provides large storage savings and 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. In addition, this data can now be seamlessly stored on the XT storage server for further cost reduction.

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 Release 18c and above 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, 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.

## 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. Each EF Storage Server contains eight 6.4 TB state-of-the-art Flash Accelerator F640 NVMe PCI Flash drives, offering 51.2TB raw Flash capacity per EF Storage Server. Exadata X8 uses state-of-the-art Flash memory technology for improved speed, power efficiency, and endurance compared to previous generations of Flash. The enterprise grade Flash used in Exadata X8 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 state-of-the-art **NVMe** (Non-Volatile Memory Express) Flash to achieve extremely low latency and CPU overhead.

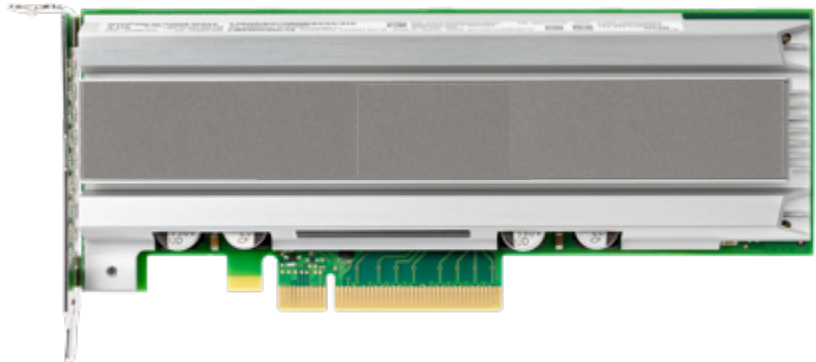


Fig. 1: Flash Accelerator F640 PCIe Card

Flash performance is often limited and bottlenecked in 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 from Flash. A configuration of Exadata Storage Expansion Rack X8-2, with 19 Extreme Flash storage servers, can achieve up to **475 GB per second of analytic scan bandwidth from SQL**, and up to 11.3 Million random 8K read I/O operations per second (IOPS) and 9.88 Million random 8K write I/O operations per second (IOPS) when running database workloads.

This performance is orders of magnitude faster than traditional storage array architectures, and it is also much faster than current all-Flash storage arrays. These are real-world end-to-end performance figures measured running SQL workloads with standard 8K database I/O sizes inside a single rack Exadata system, unlike storage vendor performance quotes that are usually based on small I/O sizes and low-level I/O tools and therefore are many times higher than can be achieved from SQL workloads.

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

The second Exadata storage option for Exadata Storage Expansion Rack is the Exadata X8-2 **High Capacity (HC) Storage Server**. This server includes twelve 14 TB SAS disk drives with 168 TB total raw disk capacity. It also has four Flash Accelerator F640 NVMe PCIe cards with a total raw capacity of 25.6 TB of Flash memory. 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 to deliver the best performance.

Exadata Smart Flash Cache automatically caches frequently accessed data while keeping infrequently accessed data on disk, delivering the high I/O rates and fast response times of Flash with the large capacity and low cost of disk. The Exadata Smart Flash Cache uniquely 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, large 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 preferentially retained in the Flash cache.

It is common for hit rates in the Exadata Smart Flash Cache to be over 95%, or even 99% in real-world database workloads. 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.

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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 Storage Expansion Rack X8-2 with 19 High Capacity Storage Servers exceeds **9.8 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 bottlenecks 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, as the overall size of data that can benefit from Flash is limited to the size of expensive Flash. And these Flash arrays are unable to benefit from Exadata's unique storage optimization technologies. Data deduplication provided by some Flash arrays is very effective for Virtual Desktop Infrastructure (VDI) environments, but not for databases.

Exadata not only delivers much more capacity than generic all-Flash arrays, it also 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 throughout that are specifically optimized for databases.

### Extended Capacity Storage Server: Much Lower Cost Exadata Storage for Low Use Data

New for Exadata X8, a third Exadata storage option has been introduced - the Exadata X8-2 **Extended (XT) Storage Server**.

Each Exadata XT Storage Server includes twelve 14 TB SAS disk drives with 168 TB total raw disk capacity. To achieve a lower cost, Flash is not included, and storage software is optional.

This new storage option enables customers to extend the operational and management benefits of Exadata to rarely accessed data that must be kept online. This lower-cost addition to the Exadata Storage Server lineup delivers Exadata class benefits:

- Efficient – The XT server offers the same high capacity as the HC Storage server, including Hybrid Columnar Compression
- Simple – The XT server adds capacity to Exadata while remaining transparent to applications, transparent to SQL, and retains the same operational model
- Secure – The XT server enables customers to extend the same security model and encryption used for online data to low-use data, because it is integrated within the same Exadata
- Fast and Scalable – Unlike other low-access data storage solutions, the XT server is integrated to the Exadata fabric, for fast access and easy scale-out
- Compatible – The XT server is just another flavor of Exadata Storage server – you can just add XT servers to any Exadata rack

With Exadata X8-2 Extended (XT) Storage Server enterprises particularly in Finance, Insurance, and Telecommunications can meet their long-term data retention compliance requirements with the same trusted and continually validated Exadata solution, avoiding the operational risks and costs of managing information lifecycle on two or more platforms.

## Extreme Backup & Recovery Performance

One example of the Big Data strengths of the Exadata Storage Expansion Rack is when used as a destination for Exadata Database Machine or SuperCluster backups. A full database backup can be created at up to 48 TB/hour when backing up uncompressed data that is being written to mirrored disk in an Exadata Storage Expansion Rack. It is capable of backing up hundreds of terabytes per hour when doing incremental database backups and petabytes per hour with incremental backups of Hybrid Columnar Compressed data. A disk backup on an Exadata Storage Expansion Rack is usable directly without loss of performance and without having to do a restore. This is a unique backup capability only available when backing up to an Exadata Storage Expansion Rack. It is by far the fastest and simplest way to backup and recover your Oracle Exadata Database Machine or SuperCluster.

## Mission Critical High Availability

The Exadata Database Machine is engineered to provide the highest levels of availability. **All types of failures are protected against** from simple failures such as disk, server, or network, to 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 deployed 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>.

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 **unique** 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 quickly determine that a server is not reachable through any network path enabling Exadata to 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 I/O operations due to internal recovery of failed sectors, internal firmware reboots, or wear leveling. These long I/O operations can cause stalls in mission critical OLTP databases. With Exadata's

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<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 Rutten, Lloyd Cohen, October 2015

**unique I/O Latency Capping**, Oracle Exadata System 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. Exadata System Software uses Machine Learning techniques to predict components susceptible to failure and takes proactive action to gracefully take such components out of service. If disks do fail, ASM performs a rebalance operation for the data that was resident on the disk. Exadata allows hot swapping of disks, fans, power supplies, and PCIe Flash cards to avoid downtime. Exadata System 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. On rare occasions when there are outliers within the networking subsystem, Exadata redirects the I/O issued by the database server to another storage server.

Exadata automates monitoring of CPU, memory, Input/Output, file system, and network. This automation combines machine learning techniques with the deep lessons learned from thousands of mission critical real-world deployments. For example, Exadata can detect that anomalous use of system resources is affecting database performance, identify the process responsible, and issue an alert, without any pre-existing set-up.

Because of its industry leading availability, the Exadata Database Machine and Exadata Storage Expansion Rack 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.

## 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 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 (DMA) 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 Storage Expansion Rack High Capacity can exceed 3 Petabytes while raw Flash storage can be up to 970 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, security, 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.

## 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 STORAGE EXPANSION RACK X8-2 KEY CAPACITY AND PERFORMANCE METRICS

Metric	Quarter Rack HC <sup>1</sup>	Quarter Rack EF <sup>1</sup>	Single Server HC	Single Server EF	Single Server XT <sup>1</sup>	Max Config HC	Max Config EF
Number of Storage Servers	4	4	1	1	1	19	19
<b>Flash Metrics</b>							
Maximum SQL flash bandwidth <sup>2</sup>	100 GB/sec	160 GB/sec	25 GB/sec	40 GB/sec	N/A	475 GB/sec	760 GB/sec
Maximum SQL flash read IOPS <sup>3</sup>	2,388,000	2,388,000	597,000	597,000	N/A	11,343,000	11,343,000
Maximum SQL flash write IOPS <sup>4</sup>	2,080,000	2,080,000	520,000	520,000	N/A	9,880,000	9,880,000
PCI Flash capacity (raw) <sup>5</sup>	102.4 TB	204.8 TB	25.6 TB	51.2 TB	0.0 TB	486.4 TB	972.8 TB
<b>Disk Metrics</b>							
Maximum SQL disk bandwidth <sup>2</sup>	7.2 GB/s	N/A	1.8 GB/s	N/A	1.8GB/s	34 GB/s	N/A
Maximum SQL disk IOPS <sup>3</sup>	10,000	N/A	2,600	N/A	2,600	49,000	N/A
Data capacity (raw) <sup>5</sup>	672 TB	205 TB	168 TB	51 TB	168 TB	3192 TB	973 TB
<b>Combined Metrics</b>							
Data Capacity (usable) – Normal Redundancy <sup>6</sup>	254 TB	75 TB	64 TB	18.8 TB	64 TB	1294 TB	382 TB
Data Capacity (usable) – High Redundancy <sup>6</sup>	199.6 TB	59.0 TB	49.9 TB	14.7 TB	49.9 TB	948.0 TB	280.2 TB
Maximum data load rate <sup>7</sup>	10 TB/hour	10 TB/hour	2.5 TB/hour	2.5 TB/hour	2.5 TB/hour	48 TB/hour	48 TB/hour

Actual system performance varies by application.

<sup>1</sup> EF = Extreme Flash; HC = High Capacity; XT = Extended. 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 IO requests running SQL. Note that the IO size greatly affects Flash IOPS. Others quote IOPS based on smaller IOs and are not relevant for databases.

<sup>4</sup> Based on 8K IO requests running SQL. Flash write IOs 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. Usable capacity is measured using normal powers of 2 space terminology with 1 TB = 1024 \* 1024 \* 1024 \* 1024 bytes.

<sup>6</sup> Actual space available for a database after mirroring (ASM normal redundancy) while also providing adequate space (one disk on Quarter and Half Racks and two disks on a Full Rack) to reestablish the mirroring protection after a disk failure in the normal redundancy case.

<sup>8</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 STORAGE EXPANSION RACK X8-2 HARDWARE

### Quarter Rack

4 x Exadata Storage Server X8-2:

- 128 CPU cores for SQL processing
- 48 x 14 TB High Capacity Drive and 16 x 6.4 TB NVMe PCI Flash Cards for HC Quarter Rack, or, 32 x 6.4 TB NVMe PCI Flash Drives for EF Quarter Rack
- 3 x 36 port QDR (40 Gb/sec) Infiniband Switches

Additional Hardware Components:

- 42U Rack
- Ethernet switch for administrative connectivity. To servers in the Database Machine
- 2x Redundant Power Distribution Units (PDUs)

Included Spare Parts Kit Contains:

- 1 x 6.4 TB NVMe PCI Flash Card and 1 x 14 TB High Capacity disk, or
- 1 x 6.4 TB NVMe PCI Flash drive, or

## EXADATA STORAGE EXPANSION RACK X8-2 CONNECTIVITY AND UPGRADES

### Connection to Exadata Database Machine

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 X4, X5, X6, X7 or X8 generation hardware.

### Upgradability

After the initial quarter rack, additional HC, EF, XT or combination of HC, EF and XT storage servers can be added one at a time or as many as needed up to a maximum configuration (19 storage servers).

Hardware Components included with the upgrade:

- InfiniBand and Ethernet cables and adapters to connect all the components
- 12 x 14 TB High Capacity Drives and 4 x 6.4 TB NVMe PCI Flash Cards for each additional HC storage server, or
- 8 x 6.4 TB NVMe PCI Flash Drives for each additional EF storage server, or
- 12 x 14 TB High Capacity Drives for each additional XT storage server

Upgrade Support Services:

- Hardware Installation and Software Configuration

## EXADATA STORAGE EXPANSION RACK X8-2 SUPPORT SERVICES

Components:

- 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 includes 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
- 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)

**EXADATA STORAGE EXPANSION RACK X8-2 ENVIRONMENTAL SPECIFICATIONS**

Metric	Quarter Rack	Maximum Configuration	Single Server
Height	78.74" (2000 mm)		3.42 in. (86.9 mm)
Width	23.66" (601 mm)		17.52 in. (445.0 mm)
Depth	47.13" (1197 mm)		29.88 in. (759.0 mm)
Acoustic Noise (Operating)	8.9 B	9.5 B	8.2 B

**Environmentals with High Capacity Disks**

Weight	919.3 lb ( 417.0 kg)	2064.8 lb ( 936.6 kg)	76.7 lb ( 34.8 kg)
Maximum Power Usage	3.9 kW ( 3.9 kVA)	14.0 kW ( 14.3 kVA)	0.7 kW ( 0.7 kVA)
Typical Power Usage <sup>1</sup>	2.7 kW ( 2.8 kVA)	9.8 kW ( 10.0 kVA)	0.5 kW ( 0.5 kVA)
Cooling at Maximum Usage	13,150 BTU/hour	47,903 BTU/hour	2,317 BTU/hour
	13,874 kJ/hour	50,538 kJ/hour	2,444 kJ/hour
Cooling at Typical Usage	9,205 BTU/hour	33,532 BTU/hour	1,622 BTU/hour
	9,712 kJ/hour	35,376 kJ/hour	1,711 kJ/hour
Airflow at Maximum Usage <sup>2</sup>	609 CFM	2218 CFM	107 CFM
Airflow at Typical Usage <sup>2</sup>	426 CFM	1552 CFM	75 CFM

**Environmentals with Extreme Flash Drives**

Weight	854.9 lb ( 387.8 kg)	1758.9 lb ( 797.8 kg)	60.6 lb ( 27.5 kg)
Maximum Power Usage	3.8 kW ( 3.9 kVA)	13.8 kW ( 14.1 kVA)	0.7 kW ( 0.7 kVA)
Typical Power Usage <sup>1</sup>	2.7 kW ( 2.7 kVA)	9.7 kW ( 9.9 kVA)	0.5 kW ( 0.5 kVA)
Cooling at Maximum Usage	13,014 BTU/hour	47,255 BTU/hour	2,283 BTU/hour
	13,730 kJ/hour	49,854 kJ/hour	2,408 kJ/hour
Cooling at Typical Usage	9,110 BTU/hour	33,078 BTU/hour	1,598 BTU/hour
	9,611 kJ/hour	34,898 kJ/hour	1,686 kJ/hour
Airflow at Maximum Usage <sup>2</sup>	602 CFM	2188 CFM	106 CFM
Airflow at Typical Usage <sup>2</sup>	422 CFM	1531 CFM	74 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 STORAGE EXPANSION RACK X8-2 REGULATIONS AND CERTIFICATIONS**

Regulations <sup>1,2,3</sup>	<b>Product Safety:</b>	UL/CSA 60950-1, EN 60950-1, IEC 60950-1 CB Scheme with all country differences
	<b>EMC</b>	
	<b>Emissions:</b>	FCC CFR 47 Part 15, ICES-003, EN55032, EN61000-3-11, EN61000-3-12
	<b>Immunity:</b>	EN55024
Certifications <sup>2,3</sup>	North America (NRTL), European Union (EU), International CB Scheme, HSE Exemption (India), BSMI (Taiwan), CCC (PRC), EAC (EAEU including Russia), RCM (Australia), VCCI (Japan)	
European Union Directives <sup>3</sup>	2014/35/EU Low Voltage Directive, 2014/30/EU 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. For additional detail, please contact your sales representative.

<sup>2</sup> Other country regulations/certifications may apply.

<sup>3</sup> In some cases, as applicable, regulatory and certification compliance were obtained at the shelf-level systems only.

## KEY FEATURES & FUNCTIONALITY

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### **Exadata and Database Software Features - Analytics**

- *Unique Automatic Parallelization and Offload of Data Scans to storage*
  - *Unique Filtering of Rows in Storage based on 'where' clause*
  - *Unique Filtering of Rows in Storage based on columns selected*
  - *Unique Storage Offload of JSON and XML Analytic Queries*
  - *Unique Filtering of rows in Storage based on Join with other Table*
  - *Unique Hybrid Columnar Compression*
  - *Unique Storage Index Data Skipping*
  - *Unique I/O Resource Management by User, Query, Service, DB, etc.*
  - *Unique Automatic Transformation to Columnar Format in Flash Cache*
  - *Unique Smart Flash Caching for Table Scans*
  - *Unique Storage Offload of Index Fast Full Scans*
  - *Unique Storage Offloads of Scans on Encrypted Data, with FIPS compliance*
  - *Unique Storage offload for LOBs and CLOBs*
  - *Unique Storage offload for min/max operations*
  - *Unique Data Mining Offload to Storage*
  - *Unique Intelligent Routing Across All InfiniBand Ports and Links to Minimize Congestion*
  - *Unique Reverse Offload to DB servers if Storage CPUs are Busy*
  - *Unique Automatic Data Columnarization in Flash Cache*
  - *Unique Automatic Conversion of Data to In-Memory Formats when Loading into Flash Cache*
- 

### **Exadata and Database Software Features - OLTP**

- *Unique Database Aware PCI Flash*
  - *Unique Exadata Smart Flash Caching*
  - *Unique Exadata Smart Flash Logging*
  - *Unique Smart Write-back Flash Cache*
  - *Unique I/O Prioritization by DB, User, or workload to ensure QOS*
  - *Unique Exafusion Direct-to-Wire Protocol*
  - *Unique Database Intelligent Network Resource Management*
  - *Unique Exachk full-stack validation*
  - *Unique Full-stack security scanning*
  - *Unique Database scoped security*
  - *Unique Cell-to-Cell Rebalance preserving Flash Cache and Storage Index*
  - *Unique Full-Stack Secure Erase*
  - *Unique Oracle VM with InfiniBand SRIOV*
  - *Unique Automated InfiniBand Partitioning for Workload Isolation*
  - *Unique Instant Data File Creation*
  - *Unique Smart Fusion Block Transfer*
  - *Unique Control of Flash Cache Size per Database*
  - *Unique In-Memory OLTP Acceleration*
  - *Unique Undo-Block Remote RDMA Read*
  - *Unique Support for More Than 252 Pluggable Databases with Multitenant Option*
- 

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

- *Unique Instant Detection of Node or Cell Failure*
  - *Unique In-Memory Fault Tolerance*
  - *Unique Sub-second Failover of I/O on stuck disk or Flash*
  - *Unique Offload backups to storage servers*
  - *Unique Exadata Data Validation (extended H.A.R.D.)*
  - *Unique Prioritize Recovery of Critical Database Files*
  - *Unique Automatic Repair of Corrupt Disk Data By Reading Other Storage Servers*
  - *Unique Avoidance of Read I/Os on Predictive failed disks*
  - *Unique Confinement and power cycle of temporarily poor performing drives*
  - *Unique Shutdown Prevention If Mirror Storage Server is Down*
  - *Unique Detection and Disabling of Unreliable Network Links*
  - *Unique Preservation of Storage Index on Rebalance*
-

## **Manageability Features**

- *Oracle Embedded Integrated Lights Out Manager (ILOM)*
- *Oracle Enterprise Manager Exadata Plug-in*
- *Unique Active AWR includes storage stats for end to end monitoring*
- *IPv6 Support for Ethernet Connections*
- *Capacity on Demand*
- **Cell software transparent restart**
- **Flash and disk life cycle management alert**
- **Automatic Disk Scrub and Repair**
- *Trusted Partitions for Oracle Virtual Machine*
- *Automated VLAN Creation*
- *Oracle Exadata Deployment Assistant*
- *Separate Management Switch and Connectivity*
- *Exacli command line management from remote servers*
- *Cellcli command line management of Storage Servers*
- *DCLI distributed command line automation tool*

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

**For database servers:** Oracle Database 11g Release 2 Enterprise Edition, Oracle Database 12c Enterprise Edition Release 1 and 2, Oracle Database 18c Enterprise Edition Release 1, and Oracle Database 19c. 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 System 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 7 Update 5 with the Unbreakable Enterprise Kernel 4. 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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## Integrated Cloud Applications & Platform Services

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