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Oracle Exadata Statement of Direction

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Introduction

Oracle's Exadata Database Machine is engineered to deliver maximum performance, highest levels of availability, combined with the highest levels of security for Oracle Database infrastructure. Exadata is a modern architecture featuring scale-out industry-standard database servers, scale-out intelligent storage servers, state-of-the-art persistent memory, NVMe flash, and an extremely high-speed RDMA (Remote Direct Memory Access) network fabric that connects all database and storage servers.

Exadata takes advantage of Oracle's decades of database experience and builds on Oracle's leadership position as the #1 database for Online Transaction Processing (OLTP), Data Warehousing (DW), Database Consolidation, and In-Memory Analytics. Current Exadata offerings are the outcome of fifteen years of dedicated development and thousands of engineer years of effort. Exadata is a strategic platform for Oracle, both on-premises as well as in Oracle Cloud, where Exadata is used to power Autonomous Database, Oracle SaaS applications, and Exadata Cloud Service and Exadata Cloud@Customer offerings.

With thousands of Exadata deployments globally, that include the top banks, telecoms, eCommerce portals, healthcare providers and retailers, one common question for customers invested and interested in Exadata is where the Exadata technology is headed in the near future. The following is intended to outline the general product direction for Oracle Exadata so that customers can feel reassured that they will continue to get significant returns on their Exadata investment into the future.

Exadata's Scale-out Flexible Architecture

The Exadata architecture moves beyond the legacy idea that customers should assemble database systems from silos of compute and generic storage connected with legacy networks. Exadata was designed from the ground up to seamlessly integrate modern scale-out principles at both compute and storage layers, unified connectivity based on optimized network protocols, tightly integrated flash and in-memory technologies, as well as application-aware intelligence within the storage. As workloads grow, database CPUs, storage, and networking can be added without scalability bottlenecks. This 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.

Key to the success of the Exadata architecture is software that makes many scale-out servers look like a single system to an application. Applications do not need to be changed to take advantage of databases running on Exadata or take advantage of additional database and storage servers as they are added.

Exadata's Hardware Update Strategy

The Exadata hardware update strategy is very logical and easy to understand. Oracle has successfully followed the same strategy for many generations and intends to continue to follow it going forward.

Exadata leverages state-of-the-art components to build the fastest, most highly available, and cost-effective Oracle Database platform in the market. Each generation of Exadata adopts leading-edge processors, memory, flash, disk, and networking technologies. Since Exadata is built using industry-standard servers for both compute and storage, it stays abreast of innovations in the processor, memory, flash, networking, and I/O technologies, delivering the best performance and highest price-performance.

The following table outlines how successive Exadata generations have evolved, along with corresponding enhancements in leading-edge hardware components.

Database Platform Leadership Since 2008

	V1	V2	X2	X3	X4	X5	X6	X7	X8	X8M	X9M	
	Sep 2008 Xeon E5430 Harpertown	Sep 2009 Xeon E5540 Nehalem	Sep 2010 Xeon X5670 Westmere	Sep 2012 Xeon E5-2690 Sandy Bridge	Nov 2013 E5-2697 v2 Ivy Bridge	Dec 2014 E5-2699 v3 Haswell	Apr 2016 E5-2699 v4 Broadwell	Oct 2017 Xeon 8160 Skylake	Apr 2019 Xeon 8260 Cascade Lake	Sep 2019 Xeon 8260 Cascade Lake	Mar 2021 Xeon 8358 Ice Lake	V1 – X9M Growth
CPU (cores)	64	64	96	128	192	288	352	384	384	384	512	8 X
Max Memory (GB)	256	576	1152	2048	4096	6144	12 TB	12 TB	12 TB	12 TB	16 TB	64 X
Flash Cache (TB)	0	5.3	5.3	22.4	44.8	89.6	179.2	358	358	358	358	67 X
Disk Storage (TB)	168	336	504	504	672	1344	1344	1680	2.35 PB	2.35 PB	3 PB	17 X
Network Fabric (Gb/s)	20	40	40	40	40	40	40	40	40	100	100	5 X
Ethernet (Gb/s)	8	24	184	400	400	400	400	800	800	800	800	100 X
Max Scan Rate (GB/s)	14	50	75	100	100	263	301	350	560	560	1050	75 X
Max Read IOPS (M)	.05	1	1.5	1.5	2.66	4.14	5.6	5.97	6.57	16	27.6	552 X

Figure 1 Exadata Hardware Generational Advances

As can be seen in the above table, Exadata Database Machine generations closely follow processor update cycles. This model maintains an innovation cadence that ensures the adoption of the latest microprocessor technologies, with new advancements approximately every eighteen months. In addition to adopting new processors, every new generation of Exadata adopts state-of-the-art memory, flash, disks, and networking. For example, Exadata X7 doubled the flash capacity compared to the previous version. Exadata X9M introduced 18TB disk drives compared to 14TB disk drives in X8. Exadata X8M introduced Intel® Optane™ persistent memory and 100 Gigabit remote direct memory access (RDMA) over Converged Ethernet (RoCE) network fabric to dramatically improve price/performance for a wide variety of workloads, including the most demanding ones. Exadata hardware updates bundle changes to many components together into a single generational update which embodies Oracle's expertise in selecting and configuring all components into an architecture that is more than the sum of its parts. This approach also avoids cumbersome and risky changes to individual components. When releasing a new Exadata generation, the goal is to be timely enough to maintain leading performance and price-performance while being conservative enough to ensure the highest quality.

Exadata's Software Update Strategy

Oracle will continue to develop unique new and unique Exadata software capabilities to optimize compute, storage, and networking, enabling even higher levels of performance, availability, security, and scalability for the Oracle Database.

Exadata software is released at periodic intervals, with each release incorporating customer feedback and additional enhancements and updates (e.g., security updates) since the previous releases. Exadata software is compatible with

previous Exadata hardware generations. Similarly, each major Database software release is followed by the release of a major Exadata software version that is fully compatible with that release of the Database software.

Exadata software is developed by Oracle's core Database development team. Many of its capabilities require algorithmic enhancements at several layers of the software stack, including core database, operating system, virtual machine, and storage. Such enhancements are provided by various Oracle product development teams working together in a tightly integrated manner. Oracle is thus uniquely positioned in the industry to innovate across all software and hardware layers for all types of database workloads, realizing immense value to customers.

The unique innovations that Oracle has created in Exadata software over the last several years have not only enabled unparalleled levels of performance, availability, scalability, security, and capacity for the Oracle Database when deployed on Exadata, they also differentiate Exadata from generic integrated infrastructure platforms available from other vendors. While many of these infrastructure platforms are also based on recent processors, network, flash, disk, and other hardware, they trail Exadata in the adoption of hardware advances such as 18TB disk drives, NVMe flash, memory-level performance with shared flash, RDMA-based data access, persistent memory, 100 Gigabit remote direct memory access (RDMA) over Converged Ethernet (RoCE) network fabric, etc. They also lack the deep database integration and unique optimizations between Exadata software, hardware and Oracle Database, such as Smart Scan, Storage Indexes, Hybrid Columnar Compression, Database-aware flash, In-Memory fault tolerance, Persistent Memory Data and Commit Accelerators, etc. These innovative software features create a fundamental gap in performance, capacity, price-performance, and availability between Oracle Database on Exadata vs. Oracle Database on generic integrated platforms. This gap is extremely large today and is growing at a very rapid pace, as shown in the diagram below.

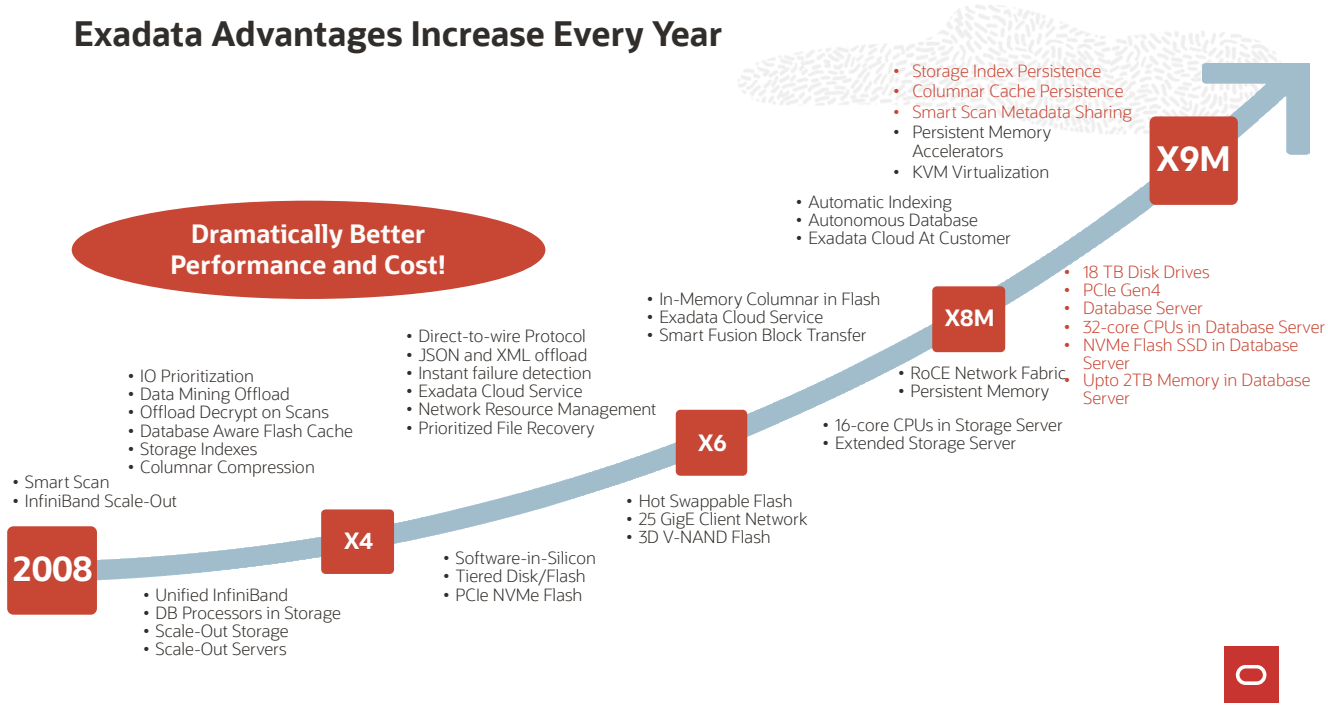

Figure 2 Exadata: Continuous Innovation

Oracle will continue to develop software capabilities that are unique to Exadata. Some of the new software capabilities may be tied to specific hardware advances, however many of these capabilities are pure software optimizations that will benefit both new Exadata systems and previous Exadata generations. Therefore, Exadata customers benefit from a constant stream of software improvements that increase the performance and ROI of their existing and new Exadata platforms.

Investment Protection and Compatibility Guidelines

Exadata's hardware and software update methodology is consistent with the following compatibility guidelines that have been established over several generations of Exadata systems.

- Exadata protects customer investment by allowing newer generation compatible servers (i.e. X9M) to be deployed seamlessly into customers' existing Exadata Database Machines (i.e. X8M). Newer generation Exadata servers can be added to a compatible Exadata systems for a period of up to five years after the system was purchased. To support business growth, Exadata X8M and X9M systems may be scaled out by elastically expanding with other Exadata database and storage components, or by inter-racking with other X8M or X9M systems using the integrated RoCE network fabric.
- Exadata also protects customer investment in previous generations by allowing compatible servers (i.e. X8) to be deployed seamlessly into customers' existing Exadata Database Machines (e.g. X4, X5, X6, X7, or X8). Customers can elastically expand their existing systems to meet their business growth.
- New Exadata software releases are compatible with the prior generation Exadata Servers and Systems released in the past five years.
- Oracle will continue to support future versions of the Oracle Database on current Exadata Database Machines that are still under Premier Support.
- Beginning with Exadata X8M, Oracle has continued innovating on Exadata by combining persistent memory, 100 Gbps RDMA over Converged Ethernet (RoCE) network fabric, KVM-based virtualization, and unique software algorithms to enable dramatic improvements in database read IOPS and database I/O latency. Reducing response times by an order of magnitude using direct database access to shared persistent memory accelerates every OLTP application, and is a game-changer for applications that need real-time access to large amounts of data such as fraud detection and personalized shopping.
- Due to the native integration with RoCE, Exadata X8M and X9M database and storage servers cannot be used to elastically expand previous generations of Exadata systems such as X7 or X8, which are based on InfiniBand network fabric. Exadata X8M or X9M systems cannot be inter-connected or multi-racked with a previous-generation Exadata system using the internal RoCE network fabric. However, an Exadata X8M or X9M system may be connected with a previous generation Exadata system using Oracle Data Guard, and this configuration may also be used for migrating databases into the newer system.
- Exadata X8 InfiniBand-based Database and Storage Servers are currently available for customers to expand existing InfiniBand-based Exadata Systems. Oracle may choose to discontinue sale of new X8 Database and Storage Servers at its sole discretion. Oracle will continue to support InfiniBand-based Exadata systems by following the hardware support guidelines mentioned above.
- Oracle will continue to support both virtualized and bare-metal database deployments on Exadata Database Machines.
- Exadata is based on x86-based database servers and storage servers. The underlying operating system is Oracle Linux. Oracle has no current plans to remove the currently offered options
- As customer workloads change, Oracle will continue to evolve the Exadata architecture in the most non-disruptive manner to accommodate changing workload patterns. For example, with the advent of workloads such as In-Memory Data Analytics and all-flash OLTP, Oracle introduced the concept of Elastic Configurations, enabling an Exadata Database Machine to be configured with different ratios of database and storage servers, to meet specific needs of those workloads. Exadata's scale-out network fabric architecture and use of standard servers for both compute and storage is instrumental to this flexibility, allowing Exadata to innovate much more rapidly and effectively than traditional server + SAN + storage array architecture.
- To enable consolidated database environments on Exadata, multiple Oracle database versions can be deployed within a single Exadata Database Machine. Exadata uniquely includes software algorithms that aid in managing the

complexity of several databases sharing the same physical infrastructure. Future Exadata Software releases will be compatible with supported database releases.

The following example highlights how it is possible to perform highly flexible upgrades and expansions across generations of Exadata Database Machine, with no impact to existing production applications.

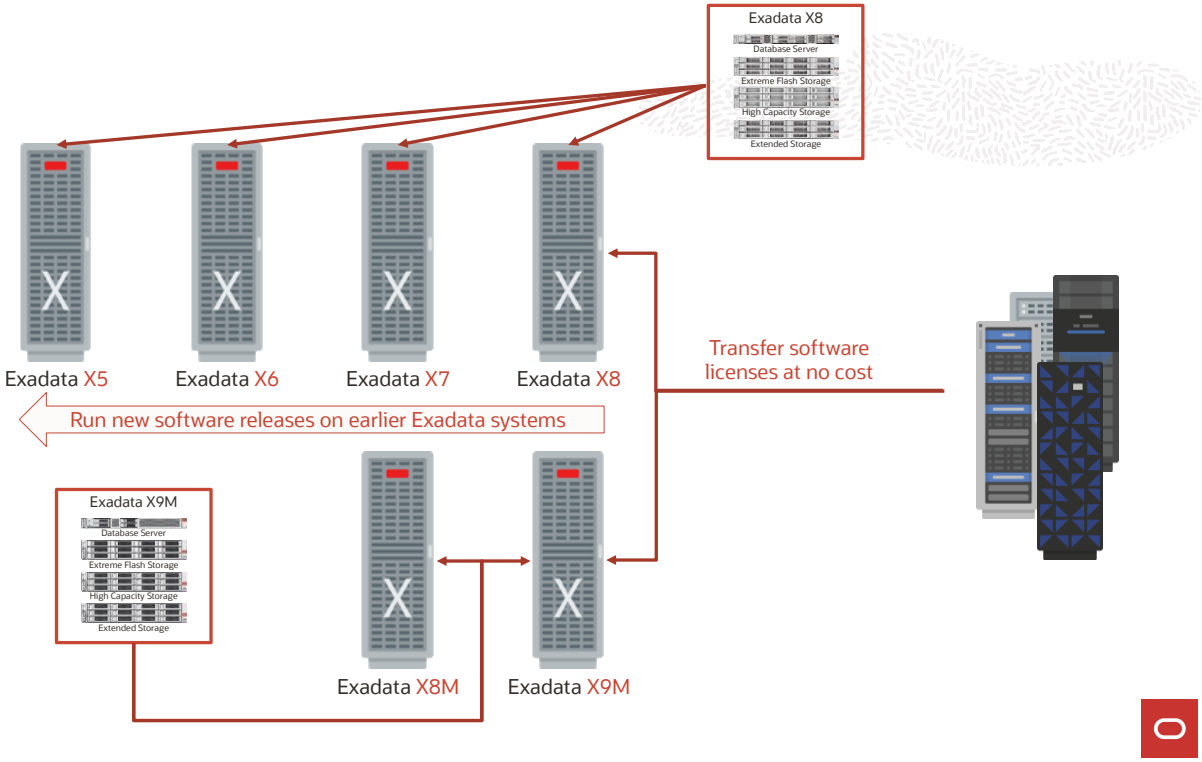

Figure 3 Seamless Upgrades and Expansions across multiple Exadata Hardware Generations by adding newer generation servers to compatible systems

Investment Protection with Exadata and Oracle Cloud

While Exadata on-premises will continue to be a major focus for Oracle, Oracle also delivers Exadata technology in the cloud to offer customers more deployment options. As seen in the diagram below, the investment protection that Oracle has provided through multiple Exadata generations continues with Oracle Autonomous Database, Oracle Database Exadata Cloud Service, and with Oracle Database Exadata Cloud@Customer.

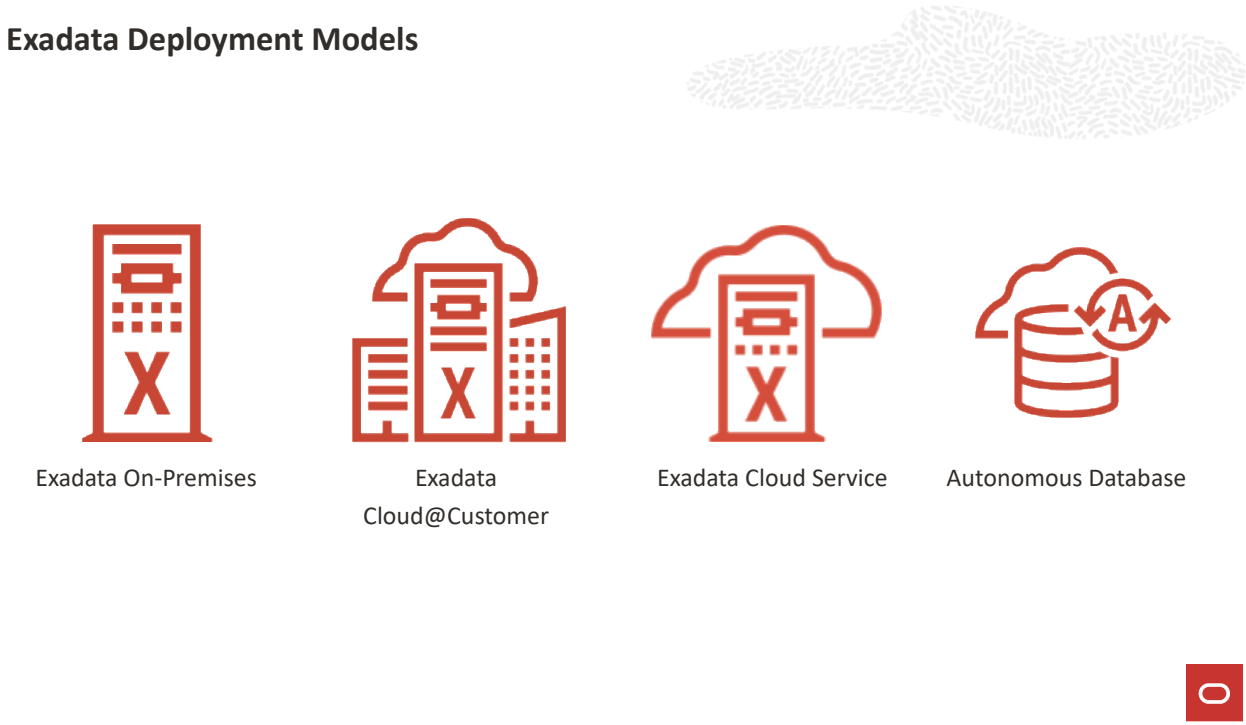

Figure 4 Exadata Deployment Models

With Exadata Cloud Service, customers run Oracle databases in the cloud on Exadata, with the same extreme performance and availability enjoyed 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 operational flexibility of the public cloud.

An Oracle database deployed in the cloud as part of this service can 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 Database Enterprise Manager (EM) packs. Customers can also bring their on-premises database licenses to their Exadata Cloud deployments in a Bring Your Own License (BYOL) model.

A core principle of Exadata Cloud Service is that Oracle databases deployed in this Cloud Service are 100% compatible with those deployed on-premises. This means that customers' applications and data models do not have to change, ensuring a smooth transition to the cloud, and an efficient hybrid cloud strategy. Customers also need not invest in multiple cloud services for multiple workloads since Exadata provides a unified platform for all workloads – analytics, data warehousing, OLTP, consolidation, in-memory, IoT, and mixed workloads.

Exadata Cloud@Customer takes this investment protection one step further by enabling a cloud-based Oracle Database subscription service available on Oracle Exadata, either with all Database options and EM Packs included, or in the BYOL model, but deployed in the customer data center behind their firewall. Customers enjoy the benefits of agile cloud-based provisioning in-house, while the associated Exadata infrastructure is maintained by Oracle.

Finally, Exadata is the underlying platform for the Oracle Autonomous Database Cloud Service. An Autonomous Database is a cloud database that uses machine learning to eliminate the human labor associated with database tuning, security, backups, updates, and other routine management tasks traditionally performed by database administrators (DBAs). With Autonomous Database, Oracle is responsible and accountable for the health and administrative lifecycle of the database providing the customer with a simple to use service level API. Oracle Autonomous Database brings together decades of database automation, decades of automating database infrastructure, and new cloud technology to deliver a fully autonomous database that is self-driving, self-securing, and self-repairing. In addition to providing a fully Autonomous Database, Oracle will make many of the Oracle Database features that are used to implement Autonomous Database available on the Exadata on-premises and Exadata Cloud platforms.

Oracle will continue to enhance the Autonomous Database and Exadata Cloud platforms with exciting capabilities to meet the demanding requirements of enterprise customers. Along with the Exadata Cloud platforms, Oracle will also continue to enhance and support the on-premises Exadata platform for the foreseeable future.

Conclusion

Exadata is Oracle's strategic database platform and Oracle will continue investing heavily in the technology – for on-premises, cloud, and Autonomous Database deployments. It is a fundamental cornerstone of Oracle's database strategy that addresses the ever-increasing need to process large volumes of data in the most optimal manner, seeking to leverage the newest trends in proven hardware and software technology. Exadata will continue to provide full investment protection for existing Oracle Database customers while also evolving and innovating, with hardware and software engineered together, delivering a complete solution for enterprise data management.

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