

INSIDE THE WORLD'S FASTEST DATABASE MACHINE—ORACLE EXADATA X9M

DELIVERING WORLD'S FASTEST OLTP AND ANALYTICAL PERFORMANCE TO THE ENTERPRISE

It may seem obvious to state that a database that supports a business-critical application should run on a platform tuned to exploit the full capabilities of that database. Yet time and again, IT organizations host their critical database applications on general-purpose servers, hoping that the performance is good enough to keep those business-critical applications running.

The truth is that a general-purpose server often isn't the best choice for a business-critical database application, no matter how fast that machine might operate. Oracle's philosophy behind the Exadata line is to design a machine purpose-built to deliver the full potential of Oracle Database — and provide net incremental capabilities in the process. Oracle Exadata, deployed by 87% of the Fortune Global 100 and thousands of smaller companies, has supported critical applications for more than 13 years.

Extracting every ounce of performance from the hardware while simultaneously delivering extreme reliability, scalability, and security from a database machine such as Oracle Exadata requires thinking about system architecture from the ground up. Oracle Exadata X9M is designed with an understanding and appreciation of the intricacies of dataflows and deep knowledge of Oracle Database, which Oracle engineers have at the source-code level. It stands to reason, therefore, that there is nobody better to take on that job than Oracle.

Of course, you could run Oracle Database on a general-purpose server. Still, you would find it nearly impossible to achieve the peak performance, cost efficiencies, or automation offered by the newest Exadata, the X9M generation. Nor could you achieve the linear scalability and infrastructure stability when dealing with complex applications requiring near multiple concurrent real-time responses from the database tier.

THE ORACLE EXADATA X9M

Oracle's vision for Exadata X9M is simple: combine a scale-out platform optimized for Oracle Database with intelligent system software tuned for the highest level of database processing. Coupled with the automated management capabilities demanded by modern IT administrators, Exadata X9M promises an ideal database machine.

Oracle Exadata X9M is the ultimate expression of the Exadata vision to date. The X9M generation combines Oracle Database technology with reliable ultra-high-performance technologies for compute, storage, and networking. The capabilities of this system continue the long-held tradition of evolving generational innovations that Oracle has delivered with every release of Exadata. Including significant improvements over the previous generation for Online Transaction Processing (OLTP) and analytics, Exadata X9M is ideal for consolidating multiple databases on a single system. While the Oracle Exadata X8M broke new ground with persistent memory and remote direct memory access (RDMA) over converged Ethernet (RoCE) innovations, the X9M generation builds upon these technologies to provide more bandwidth and throughput for the most demanding OLTP and analytics workloads.

UPDATED PROCESSING & I/O CAPABILITIES ACCELERATE OLTP PERFORMANCE

The Oracle Exadata X9M is built around Intel's third-generation Intel® Xeon® Scalable processor, Ice Lake. The new processors allow Oracle to deliver both increased processing capabilities and unprecedented levels of I/O performance.

The updated Intel Xeon processors combined with faster networking components and intelligent system software in Exadata X9M accelerate OLTP performance, improve analytic throughput, and increase workload consolidation. Exadata X9M utilizes 32-core Intel processors, which yields 33% more cores for all workloads than the previous generation of Oracle Exadata.

To fully take advantage of the dramatically increased processing capabilities requires an updated I/O subsystem. The Intel Xeon Ice Lake processor used in the X9M supports peripheral component interconnect express (PCIe) 4.0, which doubles the raw performance of the system's PCI Express subsystem.

Exadata takes advantage of the high bandwidth delivered by PCIe 4.0 using dual-port, active-active network interface cards supporting 100Gb RDMA over Converged Ethernet (RoCE) internal networking that connects database and storage servers. The extensive use of RDMA bypasses the overhead inherent in the system's operating system (OS), networking, and Input/Output (I/O) software stacks. This allows the CPUs to remain available to service OLTP transactions while the networking subsystem manages the details of moving data between Exadata's database and storage servers.

The Oracle Exadata X9M also allows for up to 2 TB of dynamic random-access memory (DRAM) for each database server. The additional memory in the compute tier, combined with a large Intel Optane Persistent Memory pool, enables ultra-low latency communication critical for OLTP workloads.

Oracle Exadata X9M leverages ultra-fast persistent memory (PMem) in the storage servers for log writes to achieve less than 19 microseconds of OLTP I/O latency from database to PMem in storage—ten times faster than directly accessing flash storage¹.

The I/O performance of the Exadata X9M scales rapidly and linearly as racks are added (up to 12). Each rack within an X9M system has up to:

- 1,216 Database Cores
- 38 TB of DRAM
- 3.8 PB of raw disk capacity
- 920 TB of non-volatile memory (NVMe) flash storage
- 27 TB of PMem
- A 100 Gb/s RoCE internal fabric that eliminates operating system and network stack overhead for low-latency and high-throughput operations

These capabilities together can deliver 27.6 million real-world 8K Read input/output operations per second (IOPS). Compared to the previous generation Exadata X8M, the new X9M provides 72% more IOPS, thereby providing a 42% reduction in the cost per transaction. This enables new transactional and hybrid cloud database use cases while making the solution more affordable for more organizations. According to Oracle, this is up to 50x more IOPs than any on-premises storage system—and when you include the separate costs for servers and networking in a typical DIY configuration, the cost comparison becomes a moot point.

IMPROVED ANALYTIC THROUGHPUT

The Oracle Exadata X9M can perform analytic scans at up to 1 Terabyte per second — meaning it can scan a exabyte in just over 16 minutes; try doing that on a general-purpose cloud compute instance or on-premises server. Oracle achieves this throughput level by bringing the X9M's new high-performance architecture together with Smart Scan query offloading, along with enhanced automatic columnarization of data using vector processing in the flash cache.

¹ Source: Oracle Corporation. Performance measured using 8K block I/O directly from SQL.

Oracle's Smart Scan technology offloads data-intensive structured query language (SQL) operations from the database servers directly into the storage servers.

Compared to the previous generation Exadata X8M, Exadata X9M delivers 87% higher throughput, enabling new data-intensive use cases at 47% lower scan costs, bringing Exadata capabilities to a broader range of customers.

INCREASED CONSOLIDATION & AFFORDABILITY

Beyond changes to the compute and I/O capabilities, the Oracle Exadata X9M also implements several changes that increase its ability to scale while also improving its consolidation and cost characteristics. For example, Oracle increased the hard disk drive size from 14 TB to 18 TB drives for the storage tier, while also replacing the hard disk drives in the database servers with faster and more reliable NVMe drives, increasing capacity and performance for virtualized Exadata systems.

The increased overall processor core count, coupled with the changes in memory and disk size, allows the system to provide more capacity without increasing cost, as Oracle has not changed the list price from the prior generation. It also enables higher levels of consolidation, allowing more virtual machines per database server. With fewer systems to manage, customers significantly reduce operational costs.

UPDATED EXADATA SOFTWARE

Oracle updated the system software for the Exadata X9M, with significant changes designed to improve system performance further:

- Optimized Smart Scan improves scalability for complex queries and better supports parallelism.
- Automatic Indexing continuously learns and tunes the database as the underlying data model or usage patterns change.
- Faster decryption and decompression algorithms allow data to be stored securely with no performance penalty.
- Storage index and columnar cache persistence ensure consistent performance for analytic workloads after storage server maintenance.
- Smarter overall management with enhanced database alerting and faster software updates.
- New support for enhanced Oracle Database algorithms for Oracle Machine Learning, Graph, Spatial, In-Memory, and Blockchain Tables.

EXADATA CLOUD@CUSTOMER X9M

Exadata Cloud@Customer X9M offers IT shops the benefits of an on-premises database cloud deployment in their data centers with a complete cloud experience and economics, enabling customers to meet data sovereignty, security, or latency requirements.

BUSINESS BENEFITS OF THE CLOUD@CUSTOMER MODEL

Exadata Cloud@Customer X9M provides several benefits to enterprise IT organizations:

- **Cloud Operating Model:** Oracles owns, manages, and maintains the physical infrastructure allowing customers to eliminate capital and management expenses.
- **Painless Adoption and Operation:** Exadata Cloud@Customer X9M runs Oracle Database Enterprise Edition or Oracle Autonomous Database, using the same APIs and cloud control plane as public cloud deployments. With Autonomous Database, customers further automate operations and reduce costs, and benefit from automatic threat detection and threat remediation.
- **Consumption-based Subscription Model:** Enterprises pay only for resources used, allowing for predictable, controlled costs. Dynamic up-and-down scaling of vCPU consumption enables customers to further control costs and meet peak requirements without interrupting operations.

CLOUD AUTOMATION ENHANCEMENTS

Oracle has implemented several enhancements to its cloud automation capabilities in Exadata Cloud@Customer X9M. These enhancements are also available for older generations of the platform and include:

- Elastic Storage Expansion lowers the cost of storage-centric configurations.
- Operator Access Control allows IT organizations to control access to their infrastructure by Oracle Cloud Operations teams.
- Oracle Active Data Guard allows administrators to quickly set up both synchronized standby and replica Oracle databases used in the cloud or in customers' data centers.
- Automated Multi-VM Support increases workload isolation, enabling better consolidation.

- VM Clusters on a Subset of DB Servers improves the utilization of resources by providing more flexible isolation.
- Maintenance Scheduling allows IT administrators to flexibly customize maintenance windows through either APIs or the Cloud UI.

These enhancements are designed to give an IT administrator increased control without sacrificing the cloud operating model enabled by Exadata Cloud@Customer X9M. This is a critical set of capabilities that, Oracle claims and Moor Insights & Strategy agrees, provide it with a significant competitive advantage.

Exadata Cloud@Customer has been in the market since 2016, providing Oracle with extensive real-world experience in deploying hybrid, fully managed database cloud services. For some cloud providers, a cloud that's deployed on a customer site is an afterthought, analogous to a check box for a diesel manufacturer who happens to offer a hybrid model.

For Oracle, it's a core strategic direction, and Oracle demonstrates this by enabling customers to run either Oracle Database Enterprise Edition or its flagship Autonomous Database in customer data centers. In contrast, with other cloud on-premises offerings, customers often must make do with their second- and third-tier database offerings and assemble a series of mismatched hardware components that may not run in their public cloud services.

COMPETITIVE POSITIONING FOR EXADATA CLOUD@CUSTOMER X9M

There are many ways to compare a database service like Oracle Exadata Cloud@Customer X9M to cloud-based offerings, which provide a similar operating model, but with remote resources.

One could look at raw performance, the service's cost, or how the solution might reduce the overall complexity of database and application deployment and management. Oracle Exadata Cloud@Customer X9M is one of those rare offerings that succeeds in nearly every metric that it's measured against.

Oracle Exadata Cloud@Customer X9M most closely compares to the on-premises database-as-a-service/hybrid offerings from the leading public cloud providers. For their

hybrid cloud deployments, it's possible to compare a leading cloud service provider's capabilities against those offered by the Oracle Exadata Cloud@Customer X9M.² .

The following table summarizes the key differences in both performance and scalability between the two offerings.

TABLE 1: ORACLE EXADATA CLOUD@CUSTOMER X9M VS. TOP CSP ON-PREMISES DATABASE-AS-A-SERVICE/HYBRID DBAAS CLOUD

	CSP Database-as-a-Service	Oracle Exadata Cloud@Customer X9M	Oracle Advantage
Minimum SQL Read Latency	1,000 microseconds	<19 microseconds	50x Faster
Maximum SQL Read IOPS	0.96 M	22.4M	23x Faster
Maximum SQL Throughput	28.5 GB/s	540 GB/s	18x Faster
Maximum Database Size (uncompressed)	64 TB	615 TB	9x Larger
Maximum Data Warehouse Size (Compressed)	656 TB	6 PB	24x Larger

(Source: Moor Insights & Strategy)

This comparison reflects Oracle's distinct advantages in each of these categories. Oracle Exadata Cloud@Customer X9M can deliver nine times the database size and 24 times the data warehouse size compared to the leading public cloud on-premises database-as-a-service offering.

Exadata Cloud@Customer X9M is 50 times faster than the leading public cloud on-premises database-as-a-service offering. Oracle achieves this by leveraging the secure RoCE fabric to read directly from persistent memory. It then provides up to 25 times the processing capabilities (with an even higher amount when factoring in Oracle's dedicated SQL offload processing cores—a technology that cloud service providers do not currently offer). It is also important to point out Oracle's architectural equivalency based on Exadata and Oracle Database across on-premises and the cloud. In contrast, other vendors' on-premises database-as-a-service offerings use different hardware

² The source for the comparison metrics in this section are from Oracle Corporation.

infrastructure or provide a subset of their databases across on-premises and in the cloud.

THE ANALYST'S VIEW

An enterprise's ability to derive value from its data directly ties to its ability to compete. Thus, strategically utilized data is a competitive advantage. Conversely, inefficiently managed data can strip an enterprise of its competitiveness.

Few technology providers understand the value of data to an enterprise better than Oracle. The company was founded to redefine enterprise database technology and, in the process, triggered a wave of customer adoption of Oracle Database technology that continues to this day. As a result, Oracle's Exadata X9M is the optimum platform for running Oracle Database.

The availability of the new machine as both a stand-alone offering and in a hybrid Cloud@Customer model makes it affordable to most enterprises and Oracle Database customers.

Even mid-sized companies that have never considered an Exadata should consider it now because the consumption-based pricing and Oracle-managed infrastructure dramatically reduce the upfront and ongoing costs.

Oracle's portfolio of architecturally identical offerings, both on-premises and in the cloud, uniquely position the company to help enterprises find success. As a result, Oracle can help improve your on-premises delivered database services, streamline your transition to the cloud, and even help provide you with a fully self-driving and intelligent database infrastructure.

It's not an accident that Exadata powers 87% of the Fortune Global 100 as well as thousands of smaller organizations. Oracle's time-proven technology is at the heart of the databases that underlie business-critical applications across industries worldwide. This is true from your favorite coffee chain to your favorite airline, and even your favorite financial services and telecom companies — Exadata powers their most critical business operations.

The Oracle Exadata X9M sits in the top tier of available database services from any vendor. Its scalable and elastic consumption model deserves thorough evaluation as the vehicle for any organization's cloud journey. IT organizations looking for the best platform to run Oracle Database are well-served by the performance, scalability,

security, and redundancy offered by the Oracle X9M. The X9M is a game changer and in a whole different league from any other platform running critical databases today.

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