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Autonomous Database on Exadata Cloud@Customer X11M

Oracle Autonomous Database uniquely combines automation, machine learning, and cloud agility to deliver the world's first autonomous database management system.

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Service overview

Oracle Autonomous Database

The Oracle Autonomous Database is a Cloud Database Management System for organizations that require enterprise-grade Oracle Database support and desire a fully-managed offering with the administrative simplicity and automation of cloud services.

Autonomous Database uses machine learning and automation to eliminate human labor, human error, and manual tuning, thereby reducing cost and complexity while ensuring higher reliability, security, and operational efficiency. Built on Oracle's Exadata Database Machine, Autonomous Database delivers the highest performance and cost-effective operation customers require for their most demanding and mission-critical applications.

The underlying converged database capabilities of the Oracle Database enable the Autonomous Database to support a broad spectrum of modern workloads with a common operational model. Modern application architectures using combinations of relational data modeling for transaction processing and data warehousing, plus JSON document, graph, key-value, and blockchain data models are greatly simplified by common maintenance, high availability, and security processes.

Autonomous Transaction Processing (ATP) is tailored to online transaction processing, JSON document management, batch, reporting, IoT, machine learning, and mixed workload applications. Autonomous Data Warehouse (ADW) is tailored to data warehousing, data marts, data lakes, and machine learning workloads. Autonomous Database when used for JSON document, graph, key-value and blockchain storage comes with developer-oriented APIs and works seamlessly with the latest SQL standards.

Dedicated Exadata Infrastructure

Autonomous Database supports two Exadata deployment choices, serverless and dedicated. In a serverless environment, multiple customers may share the resources of a single Exadata infrastructure; the focus is on simplicity and elasticity with a standardized configuration and lifecycle. In a dedicated environment, the Exadata infrastructure is wholly dedicated to the subscribing customer, isolated from other cloud tenants, with no shared processor, storage, and memory resource.

Autonomous Database on Dedicated Exadata Infrastructure has all the simplicity of autonomous operation while adding governance and isolation controls for overall performance, health, availability, and security best practices. Customers can customize operational policies to meet their corporate governance requirements and use a clean separation of roles between fleet administrators who setup operating environments and database consumers (developers and application DBAs) who self-service Autonomous Database in their assigned environments. Autonomous Database on Dedicated Exadata Infrastructure provides customers with a

Autonomous Key Benefits

- Most powerful Oracle Database
- All Exadata capabilities, ensuring extremely high levels of performance, availability, and security
- Easy and rapid Infrastructure and database provisioning in a few clicks or an API call
- Lower total cost of ownership from pay-per-use, elimination of manual labor
- Lower risk thru automated updates, built in security features and no human error
- Increased pace of innovation thru skilled DBAs focusing on business change instead of administration
- Win-win for IT and Development. IT governance and best practices with self-service agility for developers

Autonomous Key Features

- Self-service database cloud running on dedicated Exadata infrastructure
- Available in the Oracle Public Cloud and in the customer's data centers via Oracle Cloud@Customer
- Dynamic online auto-scaling of CPU triggered by real-time workload
- Online scaling of storage
- Customizable operational policies supporting mission-critical requirements
- Multi-level workload isolation
- Managed backup and recovery
- Autonomous configuration management
- Autonomous performance management with real-time stats capture and auto-indexing
- Secure, external encryption key management

simple, complete, and private Database as a Service to enable developers of new database applications.

Autonomous Database on Dedicated Exadata Infrastructure is available in the Oracle Public Cloud and in the customer's data centers via Oracle Cloud@Customer*.

Subscription overview

Autonomous Database on Dedicated Exadata Infrastructure is available through two flexible subscription offerings:

- License Included
- Bring Your Own License (BYOL)

License included

This subscription model includes all the features of Oracle Database Enterprise Edition, plus all the Oracle Database Enterprise Manager Packs and all Oracle Database Enterprise Edition Options. These industry-leading capabilities include Database In-Memory, Real Application Clusters (Oracle RAC), Automatic Storage Management (ASM), Active Data Guard, Partitioning, Advanced Compression, Advanced Security, Label Security, Database Vault, Real Application Testing, OLAP, Advanced Analytics, and Spatial and Graph. Also included in an Autonomous Database Dedicated PaaS subscription is Oracle Multitenant, enabling high consolidation density, rapid provisioning, and cloning. This subscription model is ideal for customers without existing Oracle database licenses, customers seeking to use Oracle database features beyond those currently licensed, and customers with variable workloads who can reduce their costs by paying for only what they use.

Bring your own license (BYOL)

Autonomous Database on Dedicated Exadata Infrastructure Bring Your Own License (BYOL) is designed to minimize costs when migrating to the cloud. In a BYOL model, customers can deploy their existing Oracle Database and Database Option licenses. When a customer brings an Oracle Database license entitlement, they are additionally granted the rights to use Oracle Transparent Data Encryption (TDE), Diagnostics Pack, Tuning Pack, Data Masking and Subsetting Pack, and Real Application Testing without bringing license entitlements for those Database Options and Management Packs. The Exadata System software is also included in a BYOL subscription, so BYOL customers do not have to bring a license entitlement for the Exadata System Software. Users of BYOL are required to have Oracle Database Enterprise Edition licenses and the Real Application Cluster (RAC) Option for databases with more than 16 OCPUs; they must also have Oracle Active Data Guard if Autonomous Data Guard will be used.

Oracle Cloud controls and customization

Oracle Cloud Control Plane

Customers perform life cycle operations for Autonomous Databases running on Exadata Infrastructure using an Oracle Cloud Control Plane, a sophisticated software suite that runs in the Oracle Public Cloud on Oracle Cloud Infrastructure (OCI). Customers can connect to the Cloud Control Plane through a secure link using a web browser, command line interface (CLI), REST APIs, or language-specific SDKs. Autonomous Database life cycle operations such as create, delete, clone, backup, restore, audit, and scaling are examples of operations customers can perform using the Cloud Control Plane. Another key function of the Control Plane is to track a customer's usage and bill only for what they use.

The Cloud Control Plane includes a sophisticated Identity Access Management (IAM) system, which allows multiple departments or groups to share an Oracle Cloud Infrastructure (OCI) tenancy. IAM compartments are used as a logical resource grouping construct within OCI that enables access control across resources and provides an effective mechanism to organize and control access to resources within a single tenancy. Policies can be used to grant fine-grain permissions on resources within a compartment for separation of duty and privileged access to specific resources. For example, users can be isolated to only specific databases, and within a given database, one user could be responsible for create/scale and another for restore/audit.

Oracle Cloud Operations

Oracle Cloud Operations monitors and maintains the Database, Virtualization Stack, and infrastructure components of the Autonomous Database on Dedicated Exadata Infrastructure service. Key components and activities include:

- Components managed include:
  - Exadata storage servers and physical database servers
  - Power distribution units (PDUs)
  - RoCE network and switches
  - Management switch
  - Control plane servers
  - Oracle KVM (hypervisor)
  - Exadata system software and all firmware
  - VM Clusters
  - Database Homes
  - Grid Infrastructure
  - Operating System
- Monitoring activities include:
  - Autonomous infrastructure layer incident monitoring, management, and root cause analysis
  - Threshold performance analysis
- Maintenance activities include:
  - Bug and security fixes inside hypervisor
  - Exadata System Software updates and upgrades
  - Firmware updates and upgrades to any of the hardware components including networking components and RoCE switches
  - Proactive infrastructure upgrades to update software and firmware as required
  - Grid Infrastructure and Database updates
  - Operating System updates

Customizable operational policies

Autonomous Database on Dedicated Exadata Infrastructure provides the customer customizations over operational policies, including software and hardware isolation for the highest levels of performance and security governance; it is well suited for customers wanting to deploy Oracle Database in cloud with common enterprise lifecycle controls. Users can configure one or more virtual machines and container databases on their dedicated infrastructure, each of which can have one or more autonomous databases (a mixture of ADW and ATP) within it. Customers can customize the policies used to control the provisioning of new databases, the timing of updates, the availability configuration, the backup retention period, and the density of databases that can run on the infrastructure. Having control over database versions and the timing of updates is essential for critical applications that require a version validation check against pre-production environments before a new software version is applied to production deployments. Although customers can customize these operational policies, all operations are still fully automated by Oracle autonomous software.

Administrative role separation

Autonomous Database on Dedicated Exadata Infrastructure allows a clean separation of roles between IT and database consumers. An IT group of Fleet Administrators would oversee capacity of Exadata Infrastructure, governance policies, and resource quotas. Database consumers, project team developers and application DBAs consume Autonomous Database without visibility into the underlying infrastructure. This separation of fleet versus database consumer allows simple budgeting controls and resource isolation without getting in the way of the line of business execution. A dedicated database deployment will support the entire spectrum of needs, from

simple apps to those that require the highest governance, consistent performance, and operational controls.

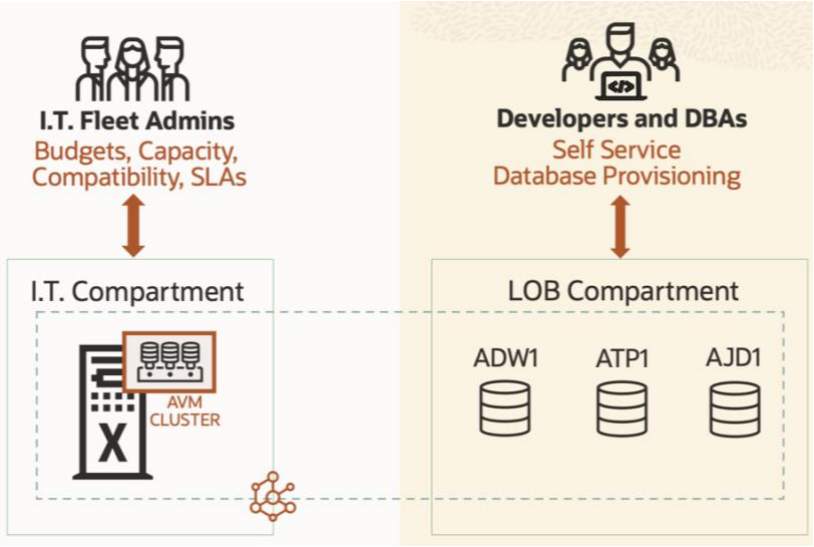

Figure 1. Dedicated fleet and database consumer roles

Enterprise class security with the simplicity of cloud

Autonomous Database on Dedicated Exadata Infrastructure benefits from scrutiny by Oracle Security experts and by hundreds of industry experts around the world. Autonomous Database delivers Exadata as an Oracle Cloud Service based on comprehensive security measures deployed in the hardware infrastructure, network, Exadata platform, and Oracle database. The security features of Autonomous Database segregate customer data access and Oracle Cloud Operations and secure data that enters, leaves, and resides on the system, authenticate access to the system, and validate Oracle provided software that runs on the system. Oracle Cloud automation further enhances security by enforcing strong passwords and data encryption on all databases and making it fast and easy to keep databases updated with the latest security updates from Oracle.

Autonomous Database subscriptions includes all Oracle Advanced Security features, such as Transparent Data Encryption (TDE), Database Vault, Label Security, Redaction, Subsetting, and Masking. BYOL customers are also entitled to use Transparent Data Encryption (TDE) and the Data Masking and Subsetting pack on any Oracle Database license they move to Autonomous Database.

The list of important Autonomous Database deployment security features include:

- Customer controlled encryption key management
- Bring Your Own Certificates for SSL encryption of both TCP (TLS/mTLS) and REST API access
- Kerberos with Centrally Managed Users (CMU) control for password less authentication
- Customizable listener ports for both non-TLS and TLS based connections
- Operator Access Control extended to include the Autonomous VM Cluster resource
- Active Directory integrated user management and OCI Identity and Access Management (IAM) controlled database users
- Digitally Signed Binaries integrated with change management workflow: hashed, encrypted and cryptographically signed to ensure deployment is tamper-proof
- Data Safe ready, for centralized user auditing, and automated configuration management, compliance scans, data masking of sensitive data
- Database level access control lists, to ensure only traffic from specific hosts can reach Autonomous Database

Exadata Infrastructure security protects the physical servers and components that are the building blocks of the system. Infrastructure security features include:

- Vendor signed firmware on hardware components to ensure hardware components will only run valid code from the vendor that supplied that component
- Hardware acceleration that delivers near-native encryption and decryption speed so that encryption can always be used for all Oracle database data
- Infrastructure optimizations that uniquely move decryption processing to Exadata Storage Server infrastructure
- Virtual machines that provide secure isolation between the customers different workloads
- Database Vault Operations Control, isolating Cloud Operations from customer data in Autonomous Databases. Customer data cannot be accessed by Oracle Cloud operators.

Autonomous Database customers can also use Oracle Database Vault to isolate their own ADMIN database users, further ensuring data in the Oracle database can only be accessed by customer users with explicit rights to access that data.

Exadata network security is implemented with isolated networks, and each network is equipped with additional security measures to secure critical data processing tasks. Network security features include:

- Internal RoCE network: RoCE Secure Fabric isolates and protects storage and Oracle RAC interconnect traffic
- Customer client network: Application traffic is SSL encrypted using TLS/mTLS with customer-controlled certificates or applications can use native Oracle Net Encryption
- Customer backup network: Oracle Net Encryption secures traffic for high-bandwidth backup activities
- Customer controlled VLANs mapped directly to the database VMs

Exadata platform security leverages virtual machine isolation. The operating system deployment for the Exadata platform includes:

- A minimal Linux distro so just the packages needed to run Oracle Database are installed and enabled
- Minimal open ports and running services that minimize attack surfaces
- Comprehensive logging and auditing that tracks access and modification

Oracle Operator Access Control

Oracle Operator Access Control (OpCtl) is an Oracle Cloud Infrastructure access management service for Autonomous Database on Dedicated Exadata Infrastructure. OpCtl provides the customer interfaces to:

- Control access to Exadata infrastructure and Autonomous VM Clusters by Oracle staff, limiting when they have access, components they can access, and commands they can execute
- Observe and record Oracle operator commands and keystrokes Oracle staff execute
- Terminate Oracle operator connections at the customer's discretion

OpCtl is ideal for regulated industries such as banking and financial services, energy utilities, and defense, and any industry where risk management is a key pillar of application success. These controls are a standard part of Autonomous Dedicated on Exadata Infrastructure and are available at no extra cost to Oracle customers.

Backup and recovery

Autonomous Database on Dedicated Exadata Infrastructure provides automatic built-in database backup facilities, with weekly full backups and daily incremental backups that are available for a selectable timeframe up to 95 days or from 90 days to 10 years for long-term backups. Manual backups can be taken at any time and recovery can be done from a backup or any point in time in the backup retention window. Additionally, you can create new Autonomous Database instances from backups.

What's new in Exadata Cloud@Customer X11M

Exadata Cloud@Customer X11M is built on Exadata X11M hardware, offering faster processor cores, faster DDR5 memory, faster flash and faster Exadata RDMA Memory (XRMEM), compared to the previous Exadata X10M generation. The XRMEM Data Accelerator with Remote Direct Memory Access

Exadata Compute

- 5th Generation AMD EPYC™ Processors
- Up to 6,080 Usable Database Server Cores Available to VMs

(RDMA) accessible memory boosts overall system performance, reducing storage latency to as low as 14µs.

Exadata X11M accelerates AI Vector Search with AI Smart Scan by transparently offloading parallelized scans of massive volumes of vector data. Vector search on database servers is up to 43% faster and vector search on storage servers is up to 55% faster than the previous Exadata X10M generation.

Exadata Hardware

Exadata Cloud@Customer X11M features powerful database servers, scale-out intelligent storage servers, XRMEM, PCIe NVMe flash, and high-capacity disk drives. Connectivity between database and storage servers is enabled by the low-latency RoCE internal network fabric. External network connectivity to the Exadata Cloud@Customer infrastructure is provided using standard 10 or 25 Gigabit Ethernet.

The database-optimized data tiering between XRMEM, PCIe NVMe flash, and disk implemented in Exadata storage provides lower latency, higher capacity, and faster performance than other flash-based solutions. All-flash storage arrays cannot match the throughput of Exadata's integrated and optimized architecture with full RoCE-based scale-out, XRMEM, PCIe NVMe flash, offload of data intensive operations to storage, and algorithms optimized for databases.

Exadata Cloud@Customer X11M elastic infrastructure shapes provide database compute and storage resources for any workload and scale for any database size. Flexible shapes start with 2 database and 3 storage servers, and can be expanded up to 16 total servers in a single rack and up to 32 database and 64 storage servers across multiple racks to meet a variety of processing and storage requirements. There are 4 database server options: three with either standard, large, or extra large memory capacities, and a base server with fewer processor cores and less memory. There are 2 storage server options with different storage capacities: base and high capacity. Any database server can be combined with either base or standard storage servers. All database and storage servers in a system must be the same type.

Exadata Software

The technology that enables Exadata's unparalleled performance without any of the bottlenecks of traditional storage arrays is the Exadata Storage Server Software. This software powers the storage servers, providing an extremely efficient and database-optimized storage infrastructure. All Exadata Storage Server Software features are included in Exadata Cloud@Customer.

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 to the storage servers, data filtering and processing for databases of any size occurs immediately and in parallel across all storage servers, as data is read from XRMEM, flash, and disk. Only the rows and columns that are directly relevant to a query are sent to the database servers. This greatly accelerates analytic queries, eliminates bottlenecks, and significantly reduces the processor usage of the database servers.

- Up to 87.5 TB of DDR5 DRAM

Scalable Storage

- Up to 4.0 PB Database Size (High Redundancy, Without Compression)
- Up to 1.7 PB NVMe Flash
- Up 80 TB Exadata RDMA Memory (XRMEM)
- 5th Generation AMD EPYC™ Processors
- Up to 4,096 Storage Server Cores

Fastest Networking

- 100 Gbps RoCE Internal Fabric
- 2 x 25 Gbps bonded Ethernet for client connections
- 2 x 25 Gbps bonded Ethernet for backup connections

Exadata Software

- Smart Scan
- AI Smart Scan
- JSON/XML Smart Scan
- Exadata RDMA Memory Data Accelerator
- Storage Indexes
- Data Mining Offload
- Hybrid Columnar Compression
- Smart Flash Cache
- Smart Flash Logging
- In-Memory Fault Tolerance
- I/O Resource Management
- Network Resource Management
- Instant Failure Detection
- Sub-second I/O Latency Capping
- Columnar Flash Cache
- Direct-to-Wire OLTP protocol
- Test/Dev Thin Clones
- Fastest Oracle RAC Node Failure Recovery
- Fastest Data Guard Redo Apply

Related Products

- Oracle Database 23ai
- Oracle Autonomous Database
- Real Application Clusters

AI Smart Scan, another Exadata unique feature, greatly accelerates AI Vector Search with optimizations that deliver extremely low-latency, high-throughput, and parallelized scans across massive volumes of vector data. AI vector data is processed at memory speed, leveraging XRMEM and flash in the storage servers, avoiding unnecessary network data transfer and database server processing.

In addition to Smart Scan, Exadata includes a vast array of software capabilities that enables its unparalleled scalability, performance and availability. Some of these Exadata software features are:

- Exadata RDMA Memory Data Accelerator uses RDMA to read data from XRMEM in the storage servers with unprecedented low latency
- Smart Flash Log Write-Back eliminates storage disks as a potential log write throughput bottleneck and provides consistent log write latency
- Storage Indexes avoid unnecessary I/O operations by replacing them with a few in-memory lookups
- Exafusion Direct-to-Wire Protocol allows database processes to read and send Oracle RAC messages directly over the RoCE network, which considerably improves OLTP response time and scalability in Exadata
- Hybrid Columnar Compression utilizes a combination of row and columnar methods to greatly compress data, enabling tremendous cost-savings and performance improvements due to reduced storage capacity and reduced I/O, especially for analytic workloads
- In-Memory columnar formats in Flash Cache extend the Exadata Columnar Flash Cache by automatically transforming data into In-Memory columnar formats as it's loaded into Flash Cache. Smart Scans then leverage ultra-fast Single Instruction Multiple Data (SIMD) Vector instructions, thus processing multiple column values with a single instruction

- Active Data Guard
- Multitenant
- Database In-Memory
- Partitioning
- Advanced Compression
- Advanced Security
- Real Application Testing
- Advanced Analytics
- Enterprise Manager

Exadata Cloud@Customer systems can be used to deploy a large number of databases, enabling high database consolidation. To ensure consistent performance in a highly consolidated environment, Exadata provides unique end-to-end prioritization and resource management capabilities spanning database servers, network and storage.

Maximum Availability Architecture (MAA)

Exadata is engineered to provide the highest levels of availability with completely redundant hardware and software. It has been designed around Oracle Maximum Availability Architecture (MAA), a set of tiered best practices and blueprints for the use of Oracle's High Availability (HA) and Disaster Recovery (DR) technologies. These technologies include Real Application Clusters (Oracle RAC), ASM, RMAN, Flashback, Active Data Guard, and Application Continuity and optimize availability to meet the business continuity requirements of critical applications. Exadata Database Service on Cloud@Customer is deployed with MAA best practices enabling customers to take immediate advantage of key HA and DR features including Oracle RAC and Autonomous Data Guard.

Multiple Virtual Machine Clusters

Database services run securely in Virtual Machine (VM) Clusters running on the Exadata Cloud@Customer infrastructure. Multiple VM Clusters can be provisioned to increase value through greater consolidation. They provide isolated operating environments for different database workloads through separate access rules and network configurations as well as customizable compute, memory, and storage resources. Each VM Cluster can run Autonomous Database or Exadata Database Service, which allows Autonomous Database to be deployed alongside Exadata Database Service on the same infrastructure, eliminating the need to deploy separate systems for these services. VM Clusters can span a subset of database servers in the infrastructure with two database

server minimum to better align resources to workload requirements. VM Clusters are provisioned through the Cloud Control Plane.

In Oracle public cloud or your data centers

Many companies cannot simply move to the public cloud due to challenges involving the regulatory nature of their data, data residency laws requiring data to stay in the country of origin, and the complexities of systems entanglement present in enterprise architectures. Systems entanglement happens because individual applications are coupled to others in such a way that changes to one impact the others, thereby complicating a move to the public cloud. To mitigate these challenges while providing customers the benefits of cloud self-service and a pay-per-use financial model, Oracle introduced its Cloud@Customer offerings bringing the cloud to customers who cannot simply transform to public cloud.

Oracle Dedicated Region Cloud@Customer delivers an entire stack of Oracle Cloud Infrastructure (OCI) and its portfolio of Platform as a Service offerings to the customer data center, including Autonomous Database on Dedicated Exadata Infrastructure.

Oracle Exadata Cloud@Customer is a slice of Oracle Cloud delivered to the customer data center that is specific to Exadata based database Platform as a Service offerings and includes Autonomous Database. Autonomous Database on Exadata Cloud@Customer is a low-cost entry point for on-premises users providing all the feature functionality found in Autonomous Database on public cloud, but users also have the option of backing up their Autonomous Database to a local Zero Data Loss Recovery Appliance or local network-attached storage. The minimum term for an Autonomous Cloud@Customer infrastructure subscription is four years, and the same BYOL or license included (billed per second) models exist.

The Cloud Control Plane used by Autonomous Database in the public cloud is also used by the Autonomous Database on Exadata Cloud@Customer. This allows customers to work with both Public Cloud and Cloud@Customer, using the exact same UX and REST APIs. Any investments in automated scripting developed for a Cloud@Customer environment will be preserved should a customer eventually choose to migrate to the Oracle Public Cloud.

Secure access to Exadata Cloud@Customer

Platform control plane commands are sent to the Exadata Cloud@Customer system through a dedicated WebSocket secure tunnel between the Cloud Control Plane and the Exadata Cloud@Customer platform. Oracle Cloud Operations staff use the same tunnel to monitor Autonomous Database on Exadata Cloud@Customer for maintenance and troubleshooting. Two remote Control Plane Servers installed in the Exadata Cloud@Customer rack host the secure tunnel endpoint and act as a gateway for access to the infrastructure. They also host components that orchestrate the cloud automation, aggregate and route telemetry messages from the Exadata Cloud@Customer platform to the Oracle Support Services infrastructure, and host images for service patching. The minimum network bandwidth from the Control Plane Server to the Cloud Control Plane is 50 Mbps.

The following diagram shows a typical access configuration of Autonomous Database on Exadata Cloud@Customer.

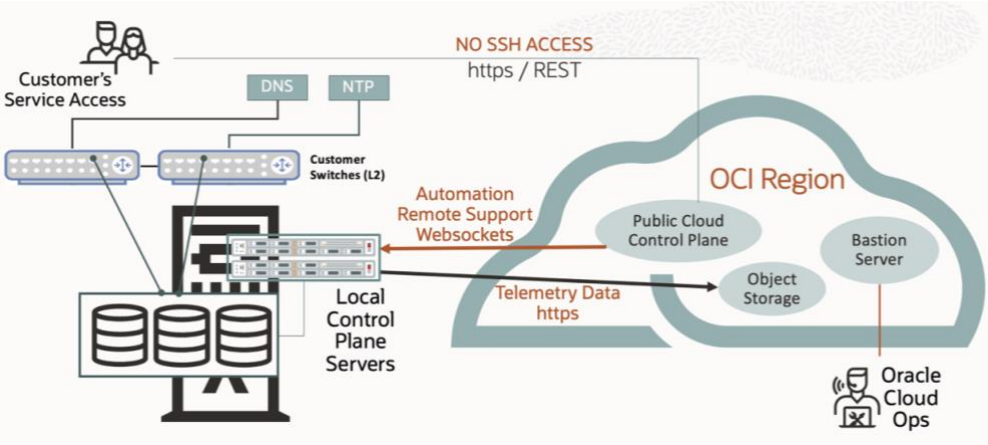

Figure 2. Access architecture for Exadata Cloud@Customer

Conclusion

Autonomous Database on Dedicated Exadata Infrastructure is an ideal solution for customers looking to leverage cloud-based database service to modernize the use of database for all database deployments, including for their most demanding and mission critical solutions. Autonomous Database will help to lower costs, reduce security risks, and enable customers to focus on adding business value instead of worrying about technology.

Table 1: Exadata Cloud@Customer X11M: Technical Specifications

Typical Hardware Configuration Examples

Service item	Base System Example[1]	Elastic Config. Example 1[1]	Elastic Config. - Example 2[1,2]	Elastic Config. - Example 3[1,2]
Number of Database (DB) Servers per System	2 (Base)	2 (Std, L, XL)	8 (Std, L, XL)	2 (Std, L, XL)
Number of Storage Servers per System	3 (Base)	3 (HC)	8 (HC)	14 (HC)
Total ECPUs in DB Servers per System	240	1,520	6,080	1,520
Min # of ECPUs per VM	20	20	20	20
Total Memory Available for VMs - Std (GB)	1,320	2,780	11,120	2,780
Total Memory Available for VMs - L (GB)	n/a	4,180	16,720	4,180
Total Memory Available for VMs - XL (GB)	n/a	5,600	22,400	5,600
Max # of VMs per DB Server[3]	2	6	6	6
Max # of VM Clusters per System[3]	2	6	6	6
Max Usable Local Storage Per DB Server[4] (GB)	1,084	2,243	2,243	2,243
Max Usable Local Storage Per VM[4] (GB)	900	900	900	900
VM Image Size Minimum and Default[4] (GB)	184	184	184	184
Total Cores in Storage Servers per System	96	192	512	896
Total XRMEM Capacity[5] (TB)	n/a	3.75	10	17.5
Total Flash Capacity (TB)	38.4	81.6	217.6	380.8
Total Usable Disk Capacity[6] (TB)	106	240	640	1,120
Max DB Size – No Local Backup[6] (TB)	85	192	512	896
Max DB Size – Local Backup[6] (TB)	42	96	256	448
Max SQL Flash Bandwidth[7] (GB/s)	37.5	300	800	1400
Max SQL XRMEM Bandwidth[7] (GB/s)	n/a	1500	4,000	7,000
Max SQL Read IOPS[5,8]	597,000	5,600,000	22,400,000	5,600,000
Max SQL Write IOPS[9]	544,000	3,000,000	8,000,000	5,000,000
Max SQL Disk Bandwidth[7] (GB/s)	2.7	5.4	14.4	25.0
Max SQL Disk IOPS[8]	3,900	7,800	20,800	36,000
Max Data Load Rate[10] (TB/hr)	3.8	7.5	20.0	7.5

Network Connectivity	Per Database Server: • 4 x 10/25 Gb SFP28 Ethernet ports (2 client, 2 backup), or • 4 x 10 Gb RJ45 Ethernet ports (2 client, 2 backup) Per Control Plane Server: • 2 x 10/25 Gb SFP28 Ethernet ports or 2 x 10Gb RJ45 Ethernet ports (Minimum internet connectivity of 50Mbps down and 10Mbps up required) Transceiver support for Base Database server: • With SFP28 client network, backup network can be RJ45, SFP28, or backup/client on shared SFP28 • With RJ45 client network, backup network can be SFP28, RJ45, or backup/client on shared RJ45 Transceiver support for Standard, Large, Extra Large Database Servers: • With SFP28 client network, backup network can be SFP28 • With RJ45 client network, backup network can be RJ45

Individual Server Specifications

Database Server Type	Total ECPUs	Total Memory Available for VMs (GB)
Base	120	660
Standard (Std)	760	1,390
Large (L)	760	2,090
Extra Large (XL)	760	2,800

Storage Server Type	Total Storage Cores	XRMEM Capacity (TB)	Total Flash Capacity (TB)	Total Usable Disk Capacity[6] (TB)
Base	32	0	12.8	35.6
Standard (Std)	64	1.25	27.2	80.0

Individual Server Performance Metrics

Database Server Type	Maximum SQL Flash Bandwidth (GB/s)[7]	Maximum SQL Read IOPS[5,8]	Maximum SQL Write IOPS[9]
Base	n/a	298,500	272,000
Standard (Std), Large (L), Extra Large (XL)	n/a	2,800,000	2,500,000

Storage Server Type	Maximum SQL Flash Bandwidth (GB/s)[7]	Maximum SQL XRMEM Bandwidth (GB/s)[7]	Maximum SQL Read IOPS[5,8]	Maximum SQL Write IOPS[9]
Base	12.5	n/a	298,500	260,000
High Capacity (HC)	100	500	2,800,000	1,000,000

Notes on Technical Specifications:

[1] *Elastic configurations allow adding database and storage servers to achieve the exact ratio of compute to storage that the application needs. Elastic configurations range from 2 database and 3 storage servers, up to a total of 16 servers in the initial rack and up to a total of 32 database and 64 storage servers across multiple racks. Any database server (Base, Standard, Large, or Extra Large) can be combined with either Base or High Capacity storage servers. All database and storage servers in a system must be the same type.*

[2] *Elastic configuration example 2 and elastic configuration example 3 are examples of typical elastic configurations that provide the highest Flash Read IOPS and Flash Bandwidth in a single rack, respectively.*

[3] *The maximum number of VM Clusters is 6 for systems with 2 or more database servers. The maximum number of VMs per database server is 6 regardless of the number of database servers in the system. The maximum number of VM Clusters and VMs per database server for systems containing Base database servers is 2 regardless of the number of database servers in the system.*

[4] *The maximum usable local storage is 2,243 GB per database server and 1,084 GB per Base System database server. Each VM requires a VM image size 184 GB. The file system used for Oracle homes can be up to 900 GB per VM. The maximum size may be less than 900 GB as it is limited by the amount of local storage used by file systems of all VMs.*

[5] *Exadata RDMA Memory (XRMEM) is included with Standard, Large, and Extra Large database servers. Read I/Os use XRMEM.*

[6] *Usable capacity is measured using normal powers of 2 space terminology with 1 TB = 1024 * 1024 * 1024 * 1024 bytes. It is the actual space available to create a database after taking into account space needed for ASM high redundancy and recovering from a drive failure, but before database compression.*

[7] *Bandwidth is peak physical scan bandwidth achieved running SQL, assuming no database compression. Effective user data bandwidth is higher when database compression is used.*

[8] *Based on 8K I/O requests running SQL.*

[9] *Based on 8K I/O requests running SQL. Flash write I/Os measured at the storage servers after ASM mirroring, which issues multiple storage I/Os to maintain redundancy.*

[10] *Load rates are typically limited by database server CPU, not I/O. Rates vary based on load method, indexes, data types, compression and partitioning.*

Additional Notes on Technical Specifications:

1) Each rack is 42 RU (Rack Units) in height, has 2x redundant Power Distribution Units (PDUs), 2x 36-port QSFP28 (100 Gb/s) RoCE switches and 1x 48-port Cisco Ethernet switch for infrastructure administration by Oracle Cloud Operations. Multiple rack configurations also include an additional 36-port QSFP28 (100 Gb/s) RoCE switch.

2) Refer to the product documentation for the latest information on product features.

Table 2: Exadata Cloud@Customer X11M: Environmental Specifications

Metric	Base System Example	Elastic Config. Example 1 – Std	Elastic Config. Example 1 – L	Elastic Config. Example 1 – XL
Number of Database (DB) Servers per System	2 (Base)	2 (Std)	2 (L)	2 (XL)
Number of Storage Servers per System	3 (Base)	3 (HC)	3 (HC)	3 (HC)
Height	78.74" (2000 mm)			
Width	23.62" (600 mm)			
Depth	47.12" (1197 mm)			
Acoustic noise (operating)	9.4 B	9.4 B	9.5 B	9.6 B
Weight	999.4 lb (453.3 kg)	1,035.8 lb (469.8 kg)	1,035.8 lb (469.8 kg)	1,035.8 lb (469.8 kg)
Maximum power usage	6.2 kW (6.3 kVA)	7.5 kW (7.7 kVA)	7.5 kW (7.7 kVA)	7.5 kW (7.7 kVA)
Typical power usage[1]	4.3 kW (4.4 kVA)	5.3 kW (5.4 kVA)	5.3 kW (5.4 kVA)	5.3 kW (5.4 kVA)
Cooling at maximum usage	21,072 BTU/hr	25,666 BTU/hr	25,673 BTU/hr	25,625 BTU/hr
	22,231 kJ/hr	27,078 kJ/hr	27,085 kJ/hr	27,035 kJ/hr
Cooling at typical usage	14,750 BTU/hr	17,966 BTU/hr	17,971 BTU/hr	17,938 BTU/hr
	15,562 kJ/hr	18,954 kJ/hr	18,959 kJ/hr	18,924 kJ/hr
Airflow at maximum usage[2]	976 CFM	1,188 CFM	1,189 CFM	1,186 CFM
Airflow at typical usage[2]	683 CFM	832 CFM	832 CFM	830 CFM

Individual Server Metric	Database - Base	Database - Standard	Database - Large	Database - Extra Large	Storage - Base	Storage – High Capacity
Height	3.42" (86.9 mm)					
Width	17.52" (445.0 mm)					
Depth	30.51" (775.0 mm)					
Acoustic noise (operating)	8.5 B	8.5 B	8.8 B	9.0 B	8.6 B	8.6 B
Weight	51.8 lb (23.5 kg)	53.0 lb (24.0 kg)	53.0 lb (24.0 kg)	53.0 lb (24.0 kg)	62.7 lb (28.4 kg)	74.0 lb (33.6 kg)
Maximum power usage	1.1 kW (1.1 kVA)	1.4 kW (1.4 kVA)	1.4 kW (1.4 kVA)	1.4 kW (1.4 kVA)	0.8 kW (0.8 kVA)	1.0 kW (1.0 kVA)
Typical power usage[1]	0.8 kW (0.8 kVA)	1.0 kW (1.0 kVA)	1 .0 kW (1.0 kVA)	1.0 kW (1.0 kVA)	0.5 kW (0.5 kVA)	0.7 kW (0.7 kVA)
Cooling at maximum usage	3,783 BTU/hr	4,726 BTU/hr	4,729 BTU/hr	4,705 BTU/hr	2,570 BTU/hr	3,474 BTU/hr
	3,991 kJ/hr	4,986 kJ/hr	4,989 kJ/hr	4,964 kJ/hr	2,712 kJ/hr	3,665 kJ/hr
Cooling at typical usage	2,648 BTU/hr	3,308 BTU/hr	3,310 BTU/hr	3,294 BTU/hr	1,799 BTU/hr	2,431 BTU/hr
	2,794 kJ/hr	3,490 kJ/hr	3,493 kJ/hr	3,475 kJ/hr	1,898 kJ/hr	2,565 kJ/hr
Airflow at maximum usage[2]	175 CFM	219 CFM	219 CFM	218 CFM	119 CFM	161 CFM
Airflow at typical usage[2]	123 CFM	153 CFM	153 CFM	152 CFM	83 CFM	113 CFM

1) Operating temperature/humidity: 5 ºC to 32 ºC (41 ºF to 89.6 ºF), as measured by an industry grade temperature measurement device directed at the front bezel of the servers, 10% to 90% relative humidity, non-condensing

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

[1] Typical power usage varies by application load.

[2] Airflow must be front-to-back.

Table 3: Exadata Cloud@Customer X11M: Regulations and Certifications

Regulations [1,2,3]	**Product Safety:**	UL/CSA 60950-1, EN 60950-1, IEC 60950-1 CB Scheme with all country differences UL/CSA 62368-1, EN 62368-1, IEC 62368-1 CB Scheme with all country differences
	Emissions:	FCC CFR 47 Part 15, ICES-003, EN55032, KS C 9835, EN61000-3-11, EN61000-3-12
	Immunity:	EN55024, KS C 9835
Certifications [2,3]	North America (NRTL), CE (European Union), International CB Scheme, HSE Exemption (India), BSMI (Taiwan), KC (Korea), RCM (Australia), VCCI (Japan), UKCA (United Kingdom)	
European Union Directives[3]	2014/35/EU Low Voltage Directive, 2014/30/EU EMC Directive, 2011/65/EU RoHS Directive, 2012/19/EU WEEE Directive	

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

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