Exadata Cloud@Customer X9M

Exadata Cloud Performance, Availability, and Security in Customer Data Centers

Customers want to move database workloads to the cloud

- Pay-as-you-go economics

- Simplified management

- Rapid business & technology innovation

- With high performance, availability, scalability and security

Not every organization or workload can use the public cloud

Data Sovereignty and Security

- Regulations or policies require data to be local
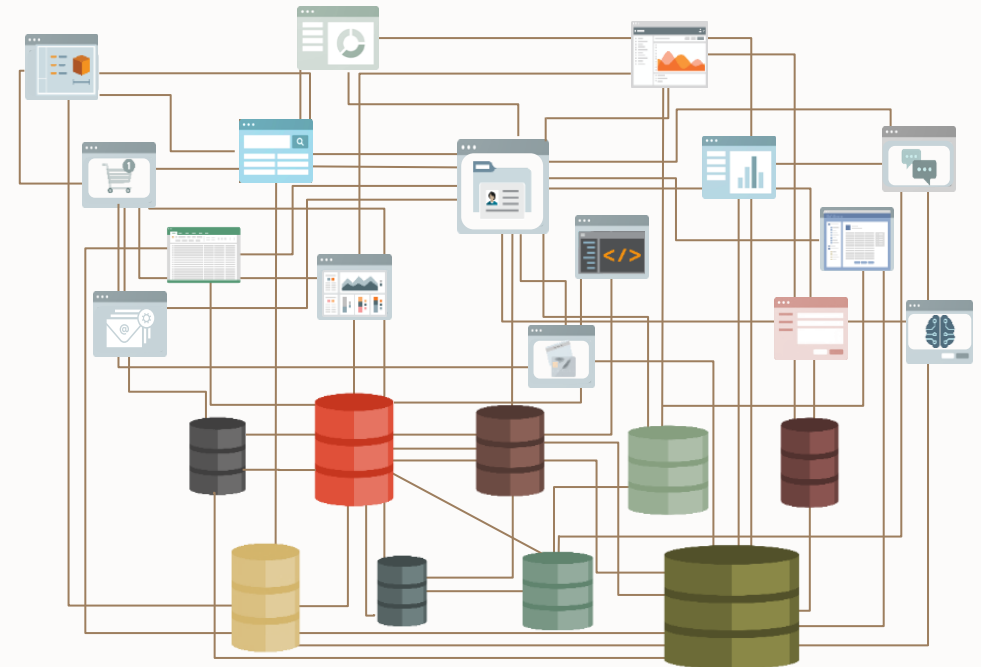- Requirements to protect data in specific ways

Response Time

- Real-world systems require low latency
- Hard to disentangle one system from others

Perceived Risk

- Concerns about multi-tenant cloud
- Concerns about cloud provider access to data

Database cloud services in customer data centers address critical needs

- High security and full data sovereignty behind customer-controlled firewalls

- Low latency connectivity with existing applications and data center resources

- Single-tenant environments

- Reduced management via cloud automation

- The same consumption model and economics as the public cloud

The Exadata Vision

Deliver Maximum Performance, Availability, and Cost-Effectiveness Everywhere
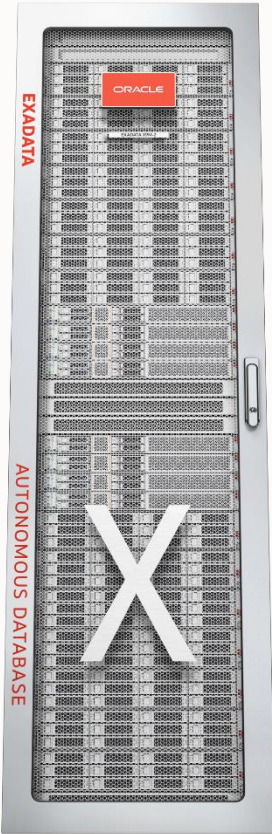
Ideal Database Hardware

Scale-out, database optimized compute, networking, and storage

Database Aware System Software

Unique algorithms vastly improve OLTP, Analytics, and Consolidation

Automated Management

Fully automated and optimized end-to-end

Available

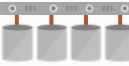On Premises

Cloud@Customer

Oracle Cloud

Exadata Platform and Database Innovations

Multitenant

In-Memory DB

Real Application Clusters

Active Data Guard

Partitioning

Advanced Compression

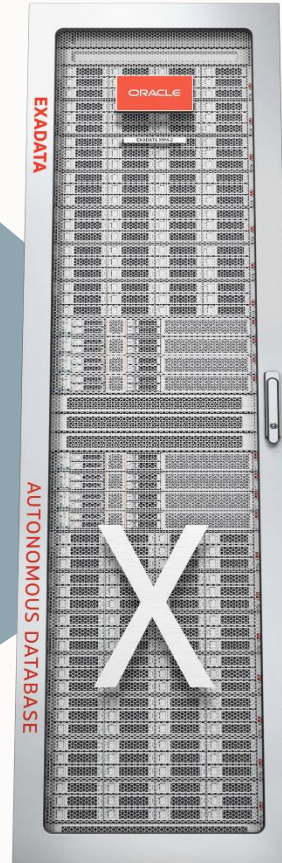**Advanced Security, Label Security, DB Vault**

Real Application Testing

Advanced Analytics, Spatial and Graph

Management Packs for Oracle Database

All Oracle Database Innovations

EXADATA

AUTONOMOUS DATABASE

ORACLE

All Exadata DB Machine Innovations

Offload SQL to Storage

RoCE Fabric

100 Gbs
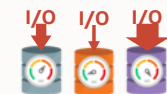
PMEM Commit and Data Accelerators

Smart Flash Cache

PCI Flash

Storage Indexes

Columnar Flash Cache

Hybrid Columnar Compression
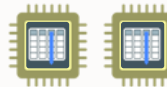
10:1

I/O Resource Management
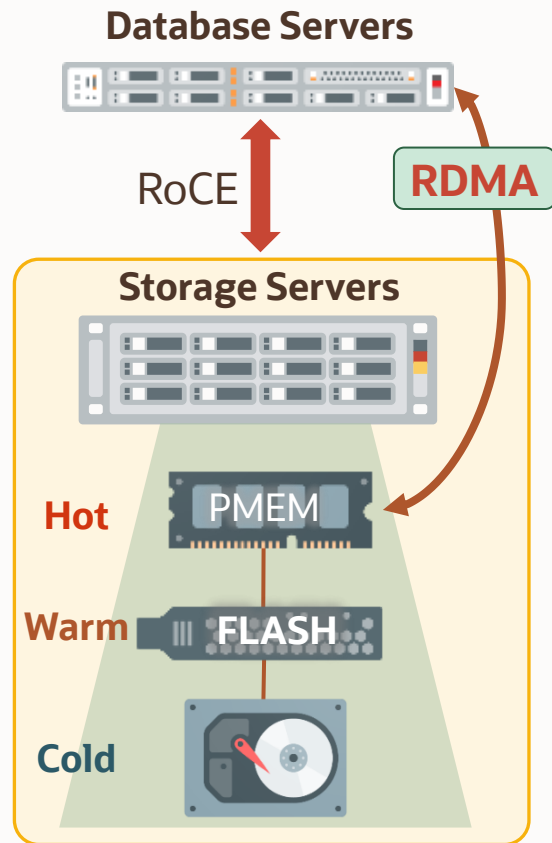
I/O I/O I/O

Network Resource Management

PRIORITY LANE

In-Memory Fault Tolerance

Exafusion Direct-to-Wire Protocol

Exadata Architecture – Scale out design with persistent memory

Database Servers

RoCE

RDMA

Storage Servers

Hot PMEM

Warm FLASH

Cold

Scale-out system architecture and software

- Oracle RAC across multiple database servers for scaling and high availability
- Smart Scan offload of SQL to parallel intelligent storage servers
- Speeds up queries and scans with local access to data

Database uses RDMA instead of I/O to read PMEM in Smart Storage

- Bypasses network and I/O software, interrupts, context switches
- Hottest data transparently managed in PMEM
- Automatic redundancy across multiple storage servers
- Speeds up both database reads and commits

Results - 19µs IO latency from Database to PMEM in Storage

- 10X faster than flash for OLTP

World's Only Shared Persistent Memory Optimized for Database

The Best for All Database Workloads
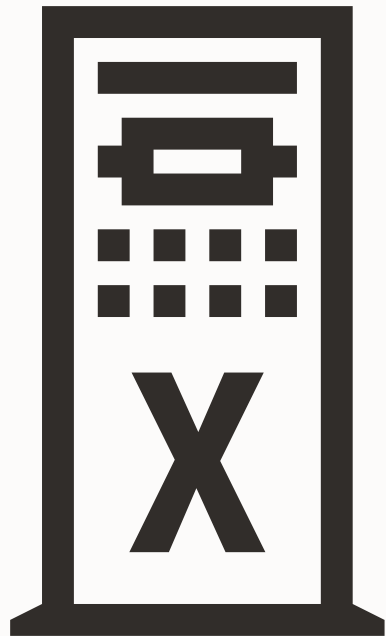
Oracle Exadata

Best for OLTP

Database transparent PMEM and RoCE, automated data tuning, performance scaling with Real Application Clusters, built-in high availability, and easy-to-use disaster recovery

Best for Analytics

Smart Scan query offload to intelligent storage servers, in-database machine learning, Smart Flash Cache, and in-memory columunarization
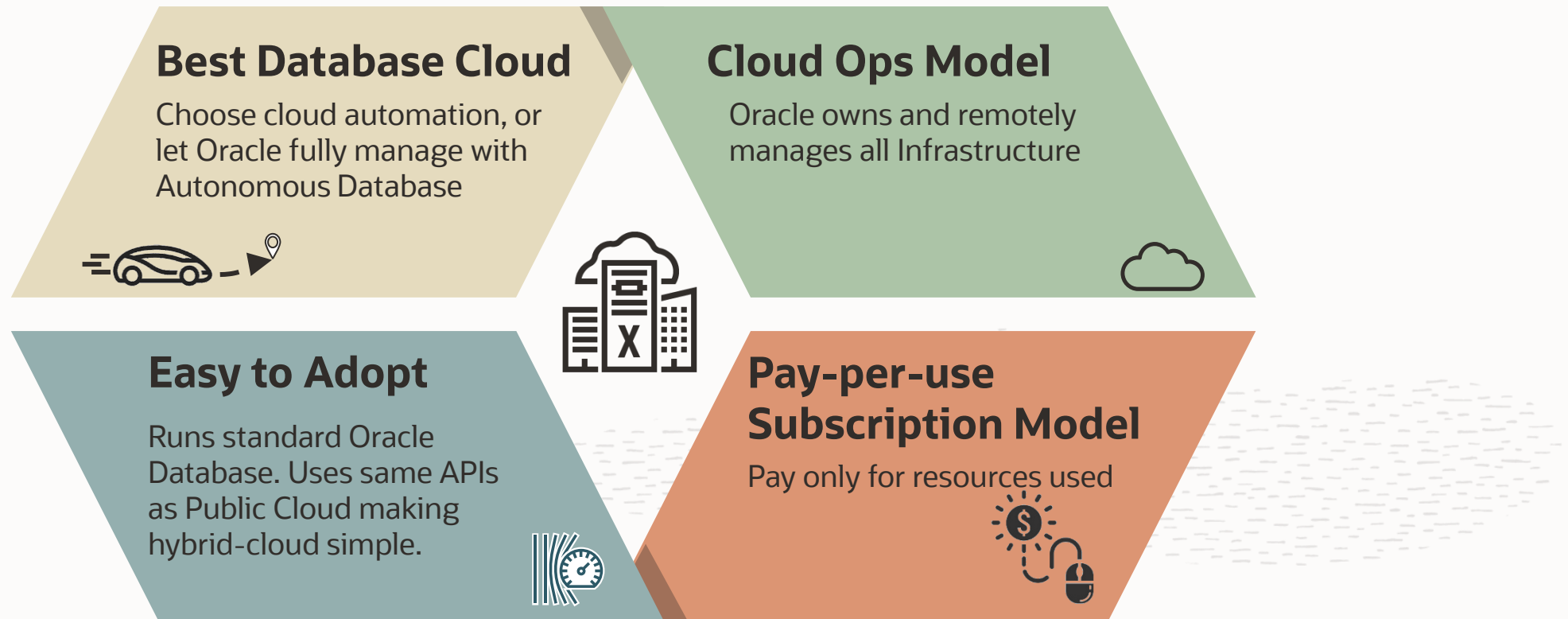
Best for Consolidation

Converged database supports all workloads, prioritization of latency-sensitive tasks, workload isolation, and large amounts of pooled resources

Exadata Cloud@Customer

Delivers Oracle Database and Autonomous Database on Exadata infrastructure as a cloud service in customer data centers

Eliminates the need to move application stacks to the public cloud

Best Database Cloud
Choose cloud automation, or let Oracle fully manage with Autonomous Database

Cloud Ops Model
Oracle owns and remotely manages all Infrastructure

Easy to Adopt
Runs standard Oracle Database. Uses same APIs as Public Cloud making hybrid-cloud simple.

Pay-per-use Subscription Model
Pay only for resources used

Same Exadata Cloud Advantages in OCI and Customer Data Centers

Easy migration and seamless coexistence: The best database platform for any deployment
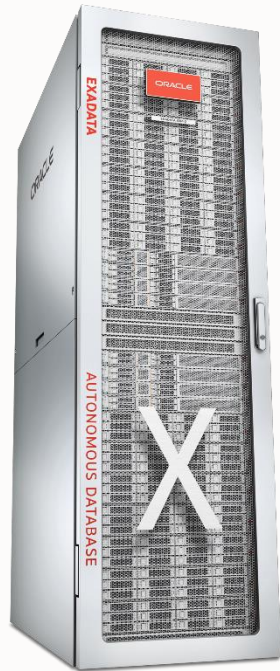
Exadata Platform

+

- Flexible Subscription Model
- Cloud Automation
- Unified Control Plane
- Cloud Security and Hardening
- Oracle-Managed Exadata Infrastructure

Can use Public Cloud →

Can't use Public Cloud →

Exadata Cloud Service
In Oracle Cloud Infrastructure Data Centers

| Exadata Cloud Service | PaaS | IaaS | SaaS |

Exadata Cloud@Customer
In Customer Data Centers

| Exadata Cloud@Customer | Servers | Storage | Apps |

Thousands of Critical Deployments, On-Premises & Cloud
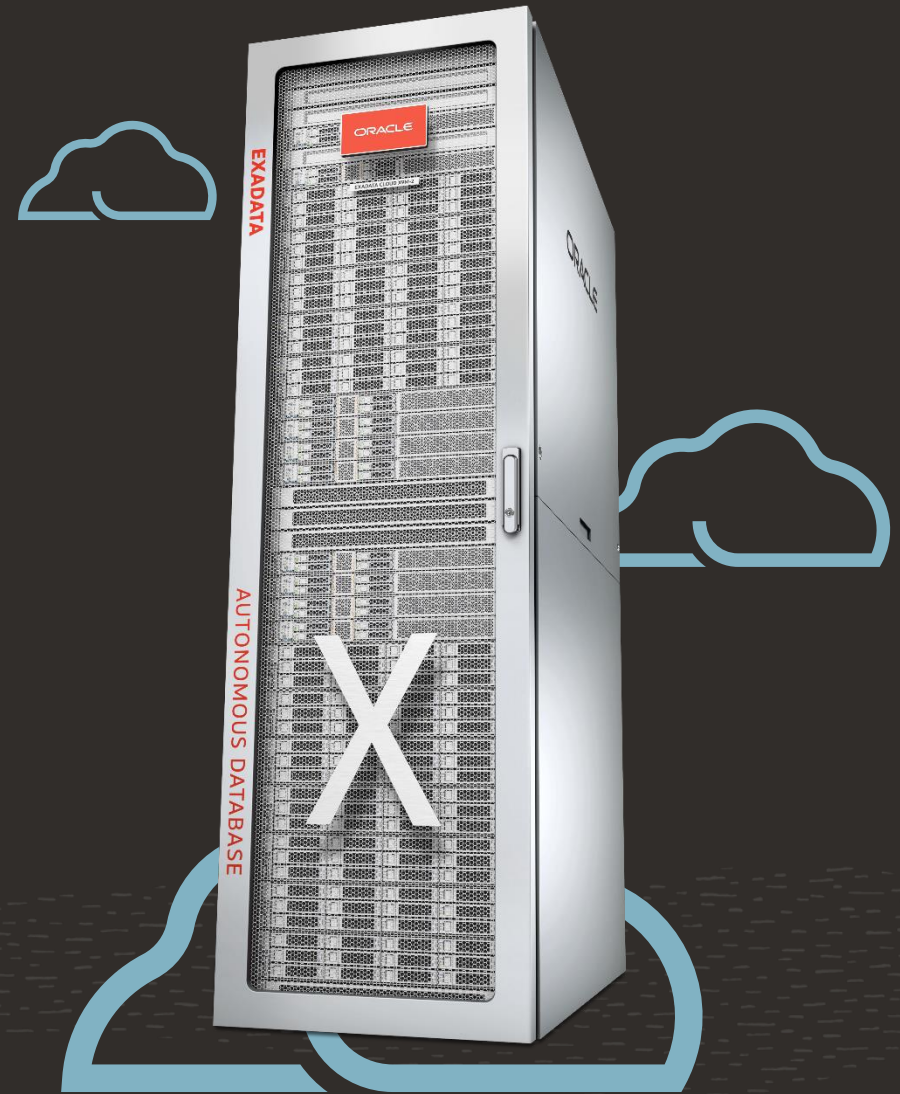**87%** of Fortune Global 100 Run Exadata | **45%** Run Exadata Cloud

Superior Architecture for ALL Workloads

- **Petabyte Warehouses**
- **Super Critical Systems**
  - Financial Trading
  - Process manufacturing
  - E-commerce
- **Packaged Applications**
  - SAP, Oracle, Siebel, PSFT, …
- **Database Consolidation**

Exadata Cloud@Customer

Exadata Cloud@Customer X9M

The World's fastest on-premises cloud database system

Large pools of sharable database compute and storage

- Up to 992 vCPUs in database servers

- Up to 576 processor cores for SQL offload in intelligent storage servers

- Up to 18 TB of database-transparent PMEM and 300 TB of smart flash cache

- Up to 769 TB of usable storage capacity

Faster internal networking and flash with PCIe 4.0

Enables Autonomous Database in customer data centers
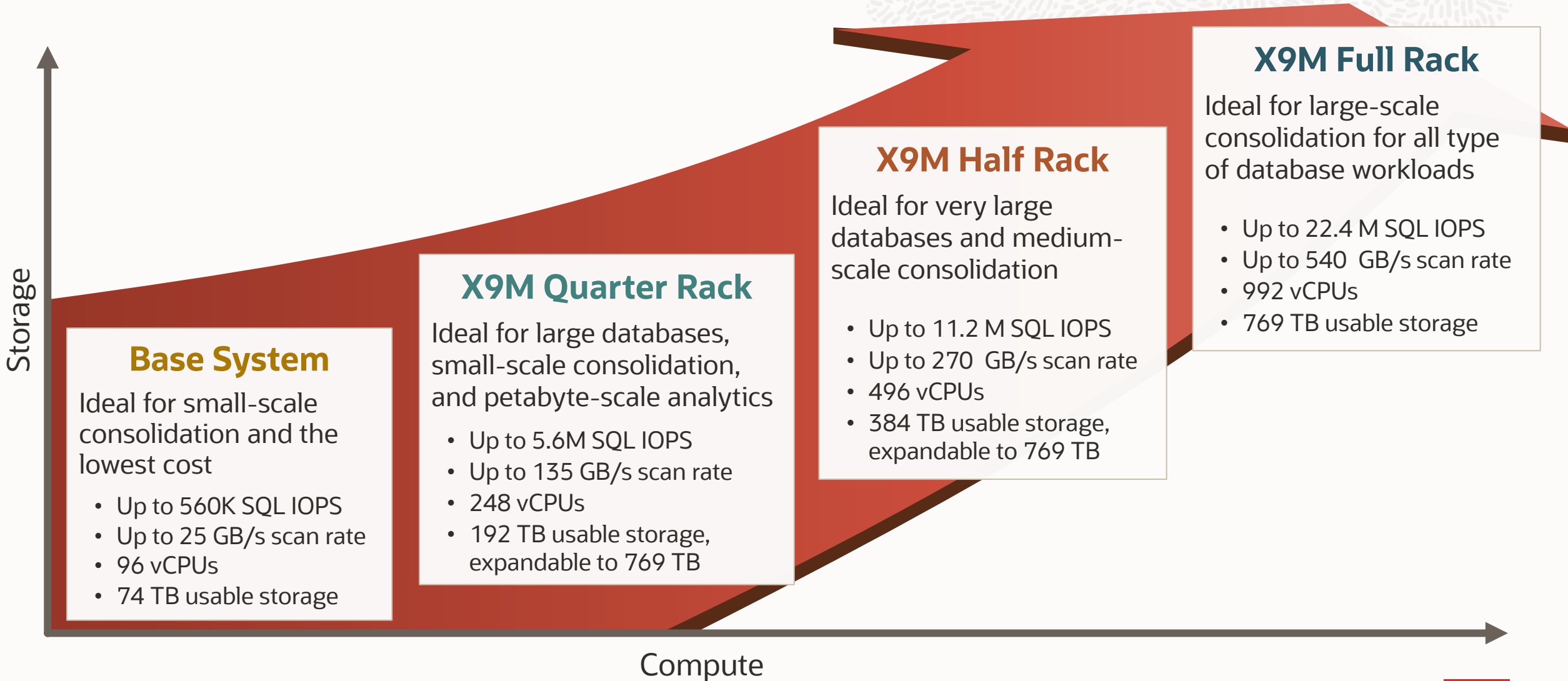
No Change in Price from X8M

22.4M SQL IOPS

<19 µs Latency
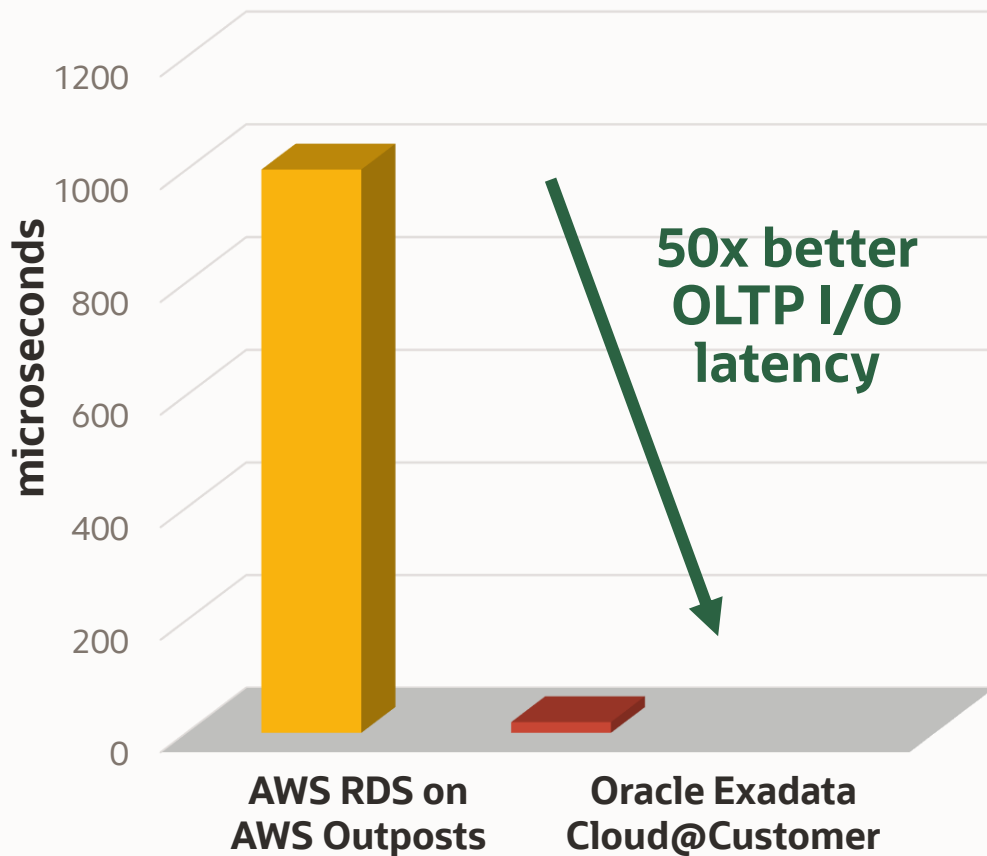
540 GB/sec Scan Throughput

Exadata Cloud@Customer Flexible Shapes

Available in high-performance, cost-effective shapes to match enterprise needs

X9M Full Rack

Ideal for large-scale consolidation for all type of database workloads

- Up to 22.4 M SQL IOPS
- Up to 540 GB/s scan rate
- 992 vCPUs
- 769 TB usable storage

X9M Half Rack

Ideal for very large databases and medium-scale consolidation

- Up to 11.2 M SQL IOPS
- Up to 270 GB/s scan rate
- 496 vCPUs
- 384 TB usable storage, expandable to 769 TB

X9M Quarter Rack

Ideal for large databases, small-scale consolidation, and petabyte-scale analytics

- Up to 5.6M SQL IOPS
- Up to 135 GB/s scan rate
- 248 vCPUs
- 192 TB usable storage, expandable to 769 TB

Base System

Ideal for small-scale consolidation and the lowest cost

- Up to 560K SQL IOPS
- Up to 25 GB/s scan rate
- 96 vCPUs
- 74 TB usable storage

Storage

Compute

Exadata X9M Cloud@Customer Compared to AWS RDS on AWS Outposts

Minimum Read IO Latency

50x better OLTP I/O latency

microseconds (y-axis: 0, 200, 400, 600, 800, 1000, 1200)

- AWS RDS on AWS Outposts
- Oracle Exadata Cloud@Customer

Maximum single-database scan throughput
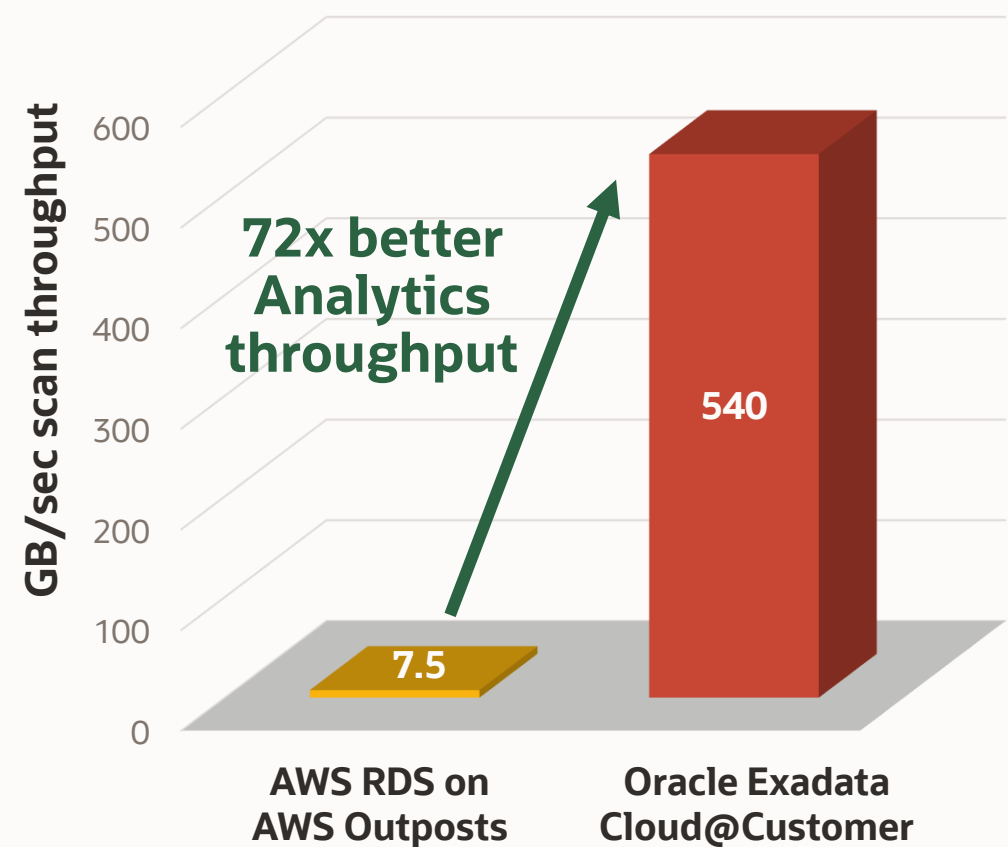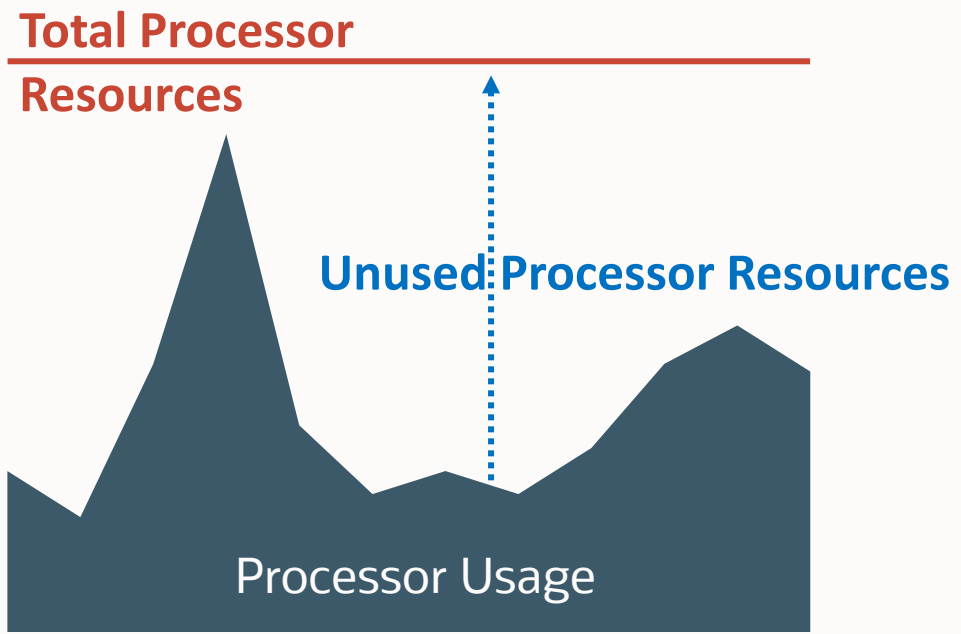
72x better Analytics throughput

GB/sec scan throughput (y-axis: 0, 100, 200, 300, 400, 500, 600)

- AWS RDS on AWS Outposts: **7.5**
- Oracle Exadata Cloud@Customer: **540**

Elastic Scaling - Pay Only for What You Use

Total Processor Resources

Unused Processor Resources

Processor Usage

Enabled OCPUs

Processor Usage

On-Premises – Static

Purchase server processors and software licenses for highest projected peak load
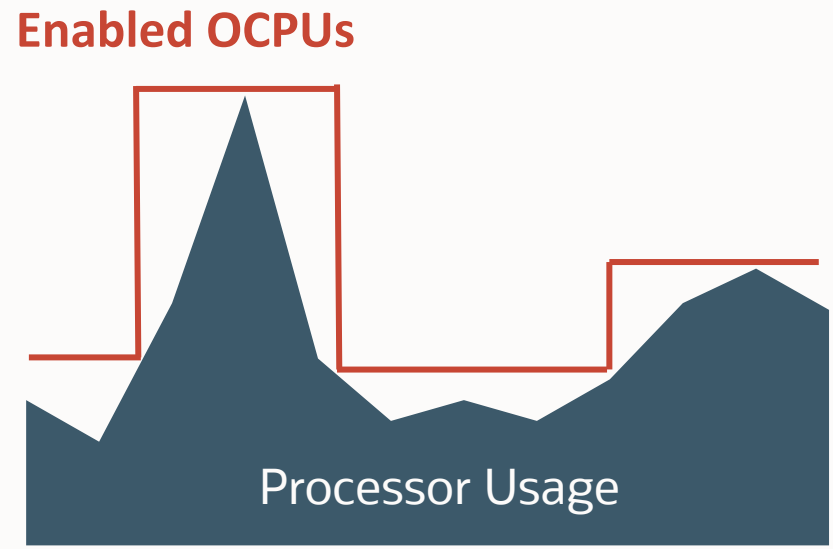
Exadata Cloud – Elastic

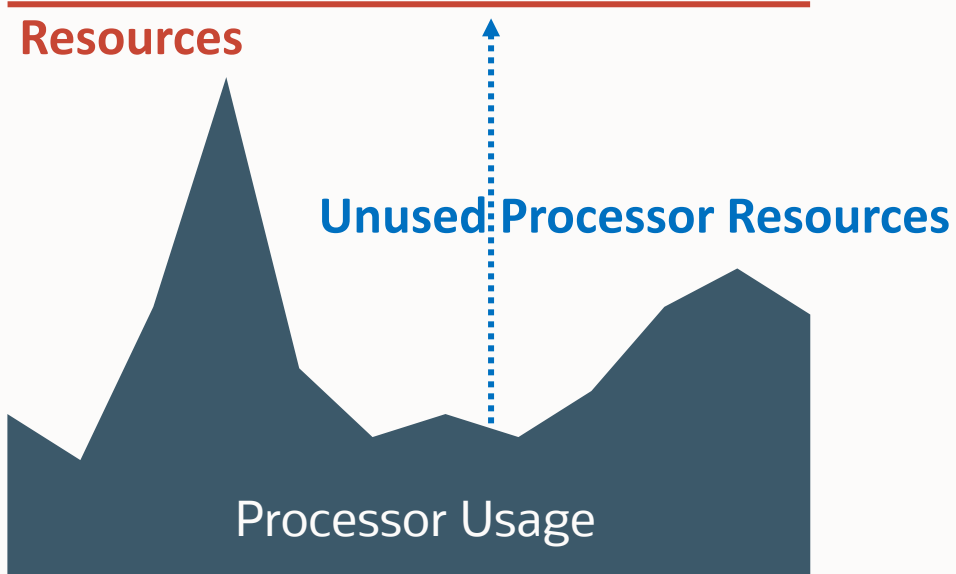Adjust enabled vCPUs to match actual workload via APIs and web UI - vCPUs are charged per second

Elastic Scaling - Pay Only for What You Use
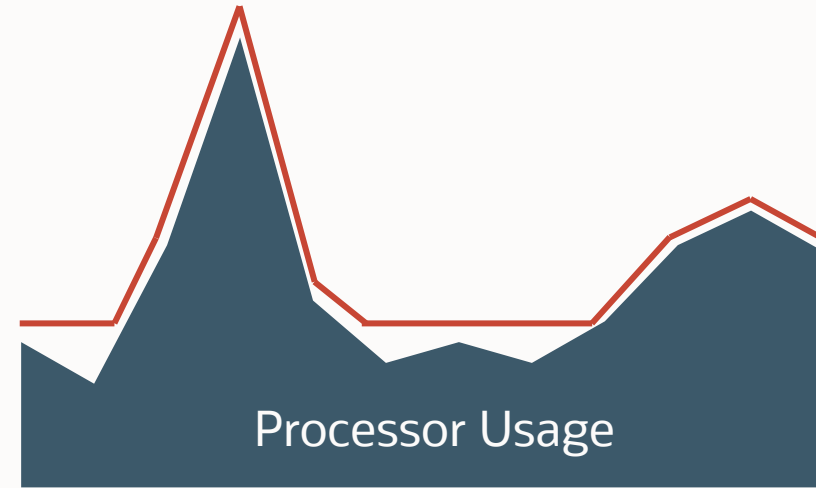## Even better with Autonomous Database

Total Processor Resources

Unused Processor Resources

Processor Usage

Autonomously Enabled OCPUs

Processor Usage

On-Premises – Static
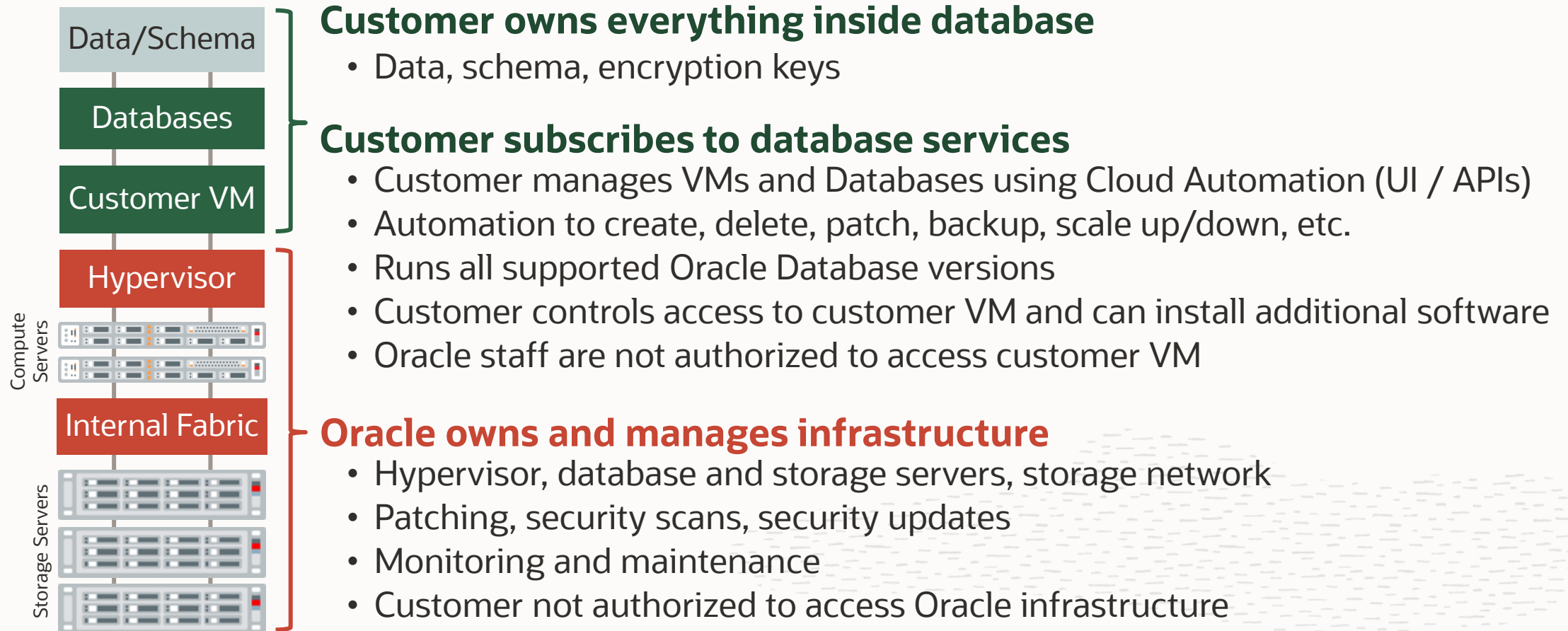Purchase server processors and software licenses for highest projected peak load

Autonomous Cloud – Self-scaling
Automatically scales vCPU consumption based on dynamic workload demands, in real-time

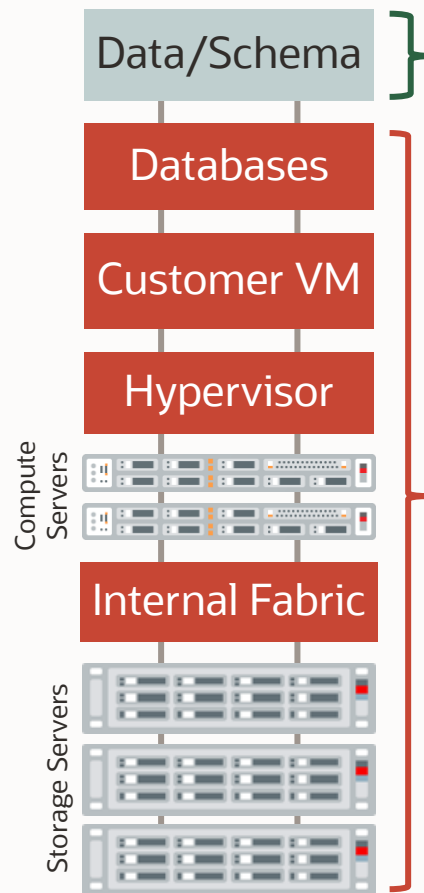# Simple Cloud Management Model in Customer Data Centers

Data/Schema

Databases

Customer VM

Hypervisor

Compute Servers

Internal Fabric

Storage Servers

Customer owns everything inside database
- Data, schema, encryption keys

Customer subscribes to database services
- Customer manages VMs and Databases using Cloud Automation (UI / APIs)
- Automation to create, delete, patch, backup, scale up/down, etc.
- Runs all supported Oracle Database versions
- Customer controls access to customer VM and can install additional software
- Oracle staff are not authorized to access customer VM

Oracle owns and manages infrastructure
- Hypervisor, database and storage servers, storage network
- Patching, security scans, security updates
- Monitoring and maintenance
- Customer not authorized to access Oracle infrastructure

Simple Cloud Management Model in Customer Data Centers

Even simpler with Autonomous Database

| Data/Schema |

} **Customer controls**
- DB users, data, schema, encryption keys (Oracle Database 19c or later)

| Databases |

| Customer VM |

| Hypervisor |

Compute Servers

| Internal Fabric |

Storage Servers

Oracle owns, manages, and controls
- Hypervisor, database and storage servers, storage network
- DomU, Container Databases
- No customer access
- Oracle owns ALL issues

Exadata Database Cloud@Customer is Easy to Adopt

The simplest and fastest transition to a cloud database

Lift-and-shift existing on-premises databases

- Existing applications simply connect and run
- No application or database changes needed
- Built-in integration with Oracle Cloud and Recovery Appliance

Data never leaves customer data centers

High solution identicality with on-premises Oracle Exadata Database Machine and Exadata Cloud Service in OCI

Accelerate time to value, convert CapEx to OpEx, and reduce TCO

- Pay-per-use vCPU consumption
- No infrastructure administration
- Less database administration with Autonomous Database

OCI interface and operations

Customer Data Center

Existing Applications and Servers

Users and Developers
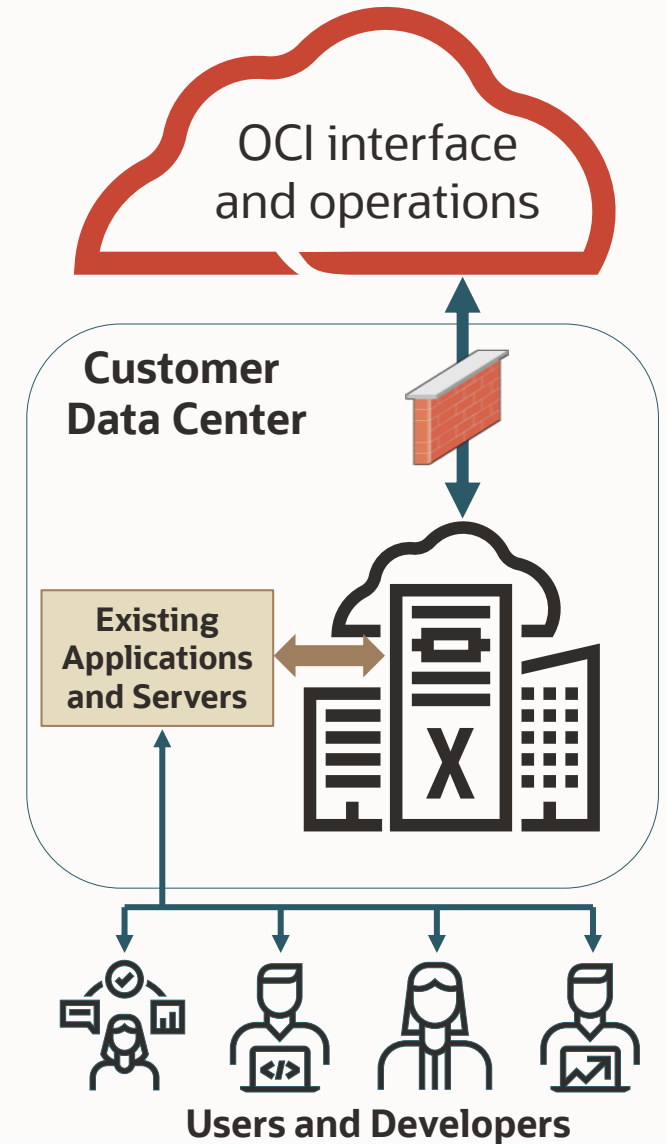
Cloud Automation for Common Lifecycle Tasks

Oracle Cloud Web base UI, REST APIs, SDK, CLI, Terraform

- Scale OCPUs
- Create Database Homes and Databases
- Schedule Infrastructure Maintenance
- Update Operating System, Grid Infrastructure, and Databases
- Backup and recovery
- Enable Data Guard

Operator Access Control (OpCtl)

Enhanced security for regulated industries

OpCtl enables customers to grant, audit, and revoke access to Exadata Cloud@Customer infrastructure managed by Oracle

Customers control access to infrastructure by Oracle operators to limit:

- when they have access

- components they can access

- commands they can execute

Observe and record Oracle operator commands and keystrokes that Oracle staff execute

Terminate Oracle operator connections at discretion

Oracle

Requests Access

Customer

Approves, Logs, Terminates Access
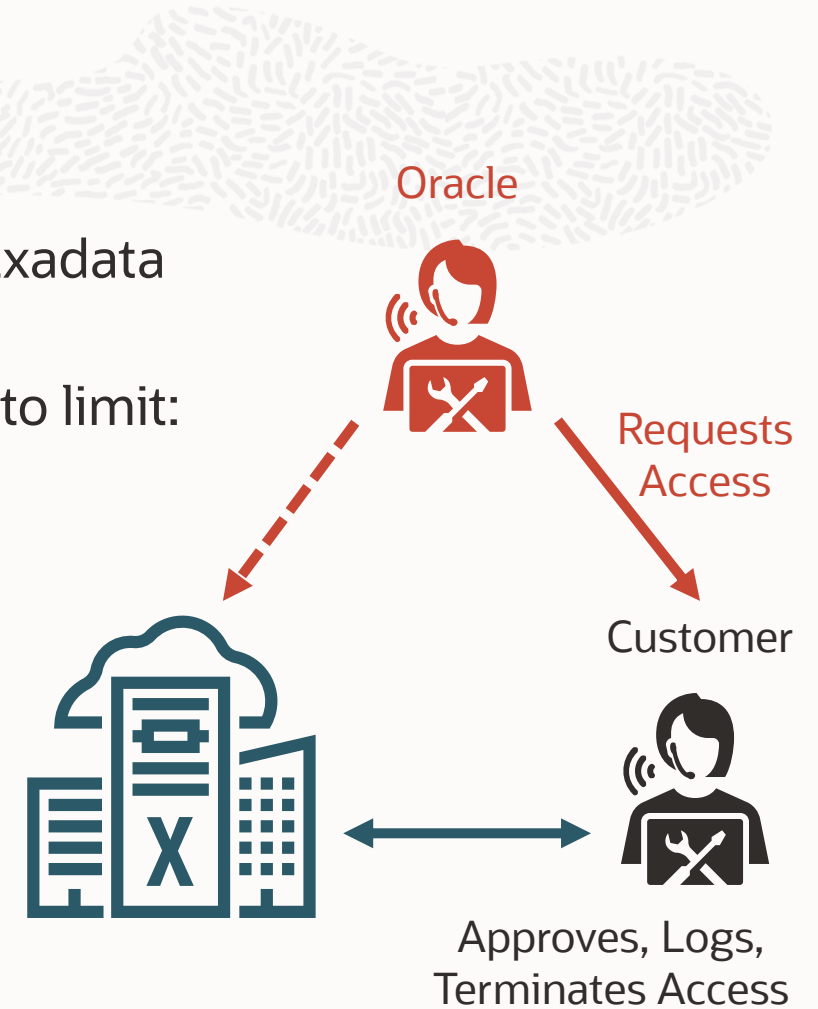
Significantly more control than other cloud vendors

Cost-Effective Software Licensing Models

Subscribe to infrastructure and choose License Included or Bring Your Own License (BYOL)

License Included Pricing

Ideal for organizations with new workloads and dynamic utilization

- Includes Oracle Database Enterprise Edition with all options and management packs at one low price

- Consumption-based pricing for software and vCPUs, includes software support and paid for with Universal Credits

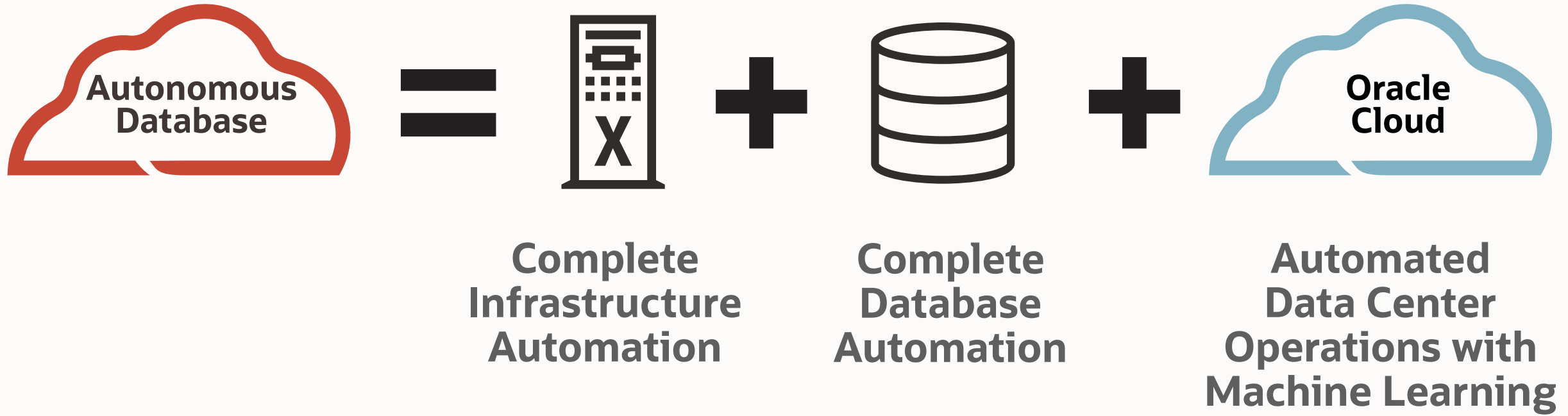## Bring Your Own License Pricing

Ideal for organizations moving existing workloads with consistent usage to the cloud

- Utilize existing on-premises licenses and pay software support for them

- Very-low, compute-only consumption pricing, paid for with Universal Credits

- Includes Transparent Data Encryption, Data Safe, Oracle Machine Learning, and select management packs at no additional cost

Oracle Autonomous Database on Exadata Cloud@Customer
Automates the entire database stack

Autonomous Database = **Complete Infrastructure Automation** + **Complete Database Automation** + Oracle Cloud **Automated Data Center Operations with Machine Learning**

Oracle Autonomous Database

Self-Driving | Self-Securing | Self-Repairing

Provision

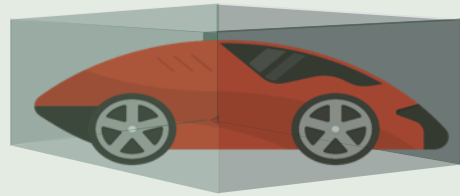Rapidly and easily creates **mission critical** databases

Secure

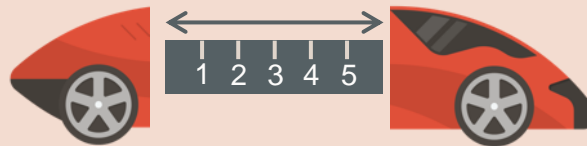Protects data from all external and internal threats

Manage

Automates all infrastructure and database maintenance

Protect

Recovers from any failure without application downtime

Scale

Scales online for highest performance and lowest cost

Optimize

Optimally runs workloads without human direction

Autonomous Database

Provides a Database Cloud running on dedicated Exadata infrastructure
- Runs all databases - any type, size, scale, or criticality

Highest Availability
- Out of the Box configurations with 99.995 availability targets

Highest Security
- Isolated network, externally managed encryption keys, ACLs, Operator Access Control, Oracle Database and OCI security

Highest Consolidation
- Many large databases sharing a pool of resources
- 1,000's of small databases with fractional-core allocations

Customizable Operational Policies
- Control of provisioning, patch schedules, availability, density
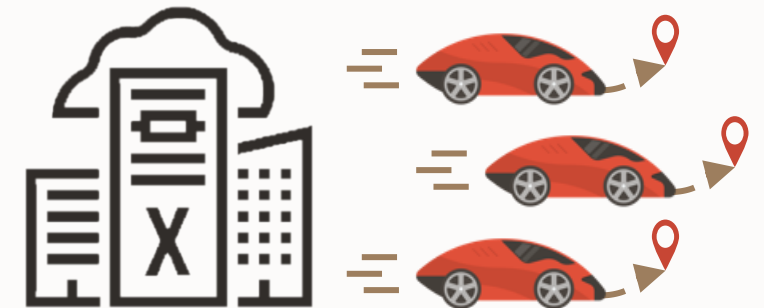
Deutsche Bank's Moves to Oracle Exadata Cloud@Customer

"Oracle fits into [our] strategy and complements our existing journey. There will be applications staying in the on-premises world, and we need to invest in simplifying them. It fully supports our cloud strategy, supports consuming technology as a service, and comes with significant financial benefits."

Bernd Leukert
Head of Technology, Data and Innovation, Deutsche Bank

Business Challenge:

As a turnaround effort by Germany's Deutsche Bank to gain momentum, its work with Oracle to modernize the data handling software behind key trading, risk management, and capital planning underlines technology's importance in helping banks gain a competitive edge.

Results:

The Oracle migration, to unfold over the next three to five years, is expected to save the bank triple-digit millions of euros in costs.

- ✓ In-house database service provides near real-time responses to market events
- ✓ Maintains control of customer data, while Oracle handles encryption and software updates
- ✓ Lower network latency for critical banking applications
- ✓ Migrating over 40 PB of Oracle Database data

Products Used:

Oracle Exadata Cloud@Customer

Oracle Cloud Infrastructure

Oracle Database

A Move to Cloud while Maintaining Data Sovereignty

"We were dealing with Solvency 2, Cloud Guidelines IT Governance, GDPR, and more. Staying compliant with these rules consume an important part of the budget and workload at the expense of innovation projects. However, a generation of new technology, especially around data represents to Lalux a huge opportunity as an innovation enabler."

Vincent Arnal

Head of IT Department, Lalux

Business Challenge:

Lalux needed the best performance and efficiency for its 40-plus Oracle databases which were originally running at 19% compute utilization. The insurer needed to improve their cybersecurity capabilities and meet industry-standard regulations. Staying compliant with these rules was consuming money and DBA time, slowing innovation.

Results:

The Luxembourg-based insurance company turns to Oracle Exadata Cloud@Customer to maintain data sovereignty while modernizing its IT infrastructure.

- ✓ Up to 2X better OLTP performance
- ✓ Up to 3X faster batch jobs
- ✓ 6X more on-demand processing capacity to handle peak workloads
- ✓ Control of data security and locality for data sovereignty
- ✓ Availability of Partitioning, Advanced Compression, and other features at no additional cost enables the creation of new applications

Products Used:

Oracle Exadata Cloud@Customer
Oracle Consulting

Lalux logo provided courtesy of Lalux, https://www.lalux.lu/en/customers

Analysts Agree – Exadata Cloud@Customer Delivers Significant Advantages

FUTURUM.	*"**Exadata Cloud@Customer X9M delivers and is unrivaled** through lower costs, and blended OLTP/OLAP workload optimization that AWS and Azure are unable to counter."* – *Futurum*
WIKIBON	*"Compared to Oracle Autonomous Database on Exadata Cloud@Customer, **the cost of running the same large mission-critical Oracle-based workloads in a traditional IT datacenter is 96% higher and on AWS RDS on Outposts is 90% higher.**"* – *Wikibon*
IDC	*"IDC quantifies the value that study participants are achieving through their use of Oracle **Exadata Cloud@Customer** at an average of **$1.93 million per organization per year over five years**."* – *IDC*

40% lower IT infrastructure costs

69% more efficient IT infrastructure staff

47% lower total operating costs

73% less unplanned downtime

40% faster time to market

Based on the IDC Business Value study

Superior Performance, Cloud Automation, and Agility in Customer Data Centers

1 **World's best database cloud in customer data centers**
- Faster, easier, and more cost effective
- Deploy Oracle Database or Autonomous Database on cloud resources in cloud resources

2 **Cloud benefits without compromising compliance**
- Consumption economics and simplified management
- Data residency and security

3 **The simplest and fastest transition to the cloud**
- Existing applications just connect and run
- Accelerate time to value, convert CapEx to OpEx, and reduce TCO

Backup Slides

Exadata Cloud@Customer Customers

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University keeps up with student demand

"We need to make sure our students are successful and provide them with the best experience possible. Keeping up with student requirements from a technology perspective is challenging as it is constantly changing. We had to become more agile and responsive, and Exadata Cloud@Customer has allowed us to become that – by using cloud features."

Kevin de Kock

Director of Enterprise Solutions and Applications, McMaster University

Business Challenge:

McMaster University is a public research university in Hamilton, Ontario, Canada with six academic faculties and more than 31,000 students. Whenever the university needed to fire up a database or a virtual machine, it took 5 and 10 days.

Results:

The ability to scale consumption up or down during the university's open registration period was key to anticipating spikes and adding resources when required.

- ✓ Consolidated 175 databases down to only 75
- ✓ 80% time-savings in database provisioning
- ✓ End-to-end IT refresh dropped from 6 hours to 1.5 hours
- ✓ HR backup from 1 hour to 7 minutes
- ✓ 10x faster ETLs
- ✓ 70% improvement in scheduled query runtimes

Products Used:

Oracle Exadata Cloud@Customer

Oracle Cloud Infrastructure

Norwegian Public Roads Administration enhances security and cuts costs

"We have significant potential for increased operational efficiency and cost-cutting with Oracle Exadata Cloud@Customer. We don't need to focus on hardware maintenance or software licensing and can dedicate ourselves to our primary business."

Rikard Thorbjørnsen
Head of IT platform services, Norwegian Public Roads Administration

Business Challenge:

Statens Vegvesen needed to eliminate the costs of periodic hardware refreshes and reduce growing maintenance expenses. As a long-term Exadata user, they wanted to maintain its capabilities but wanted to move to the cloud. Maintaining data sovereignty, security, and adherence to European Union GDPR requirements prevented them from moving to a public cloud.

Results:

After migrating 90 critical systems with 395 databases to Exadata Cloud@Customer in 2 months, Statens Vegvesen was able to:

- ✓ Reduce maintenance costs by 30%
- ✓ Implement disaster recovery across two locations
- ✓ Strengthened security and compliance with always-on encryption and automatic security patching
- ✓ Reduce operational costs during spikes in usage by using consumption-based pricing with Universal Credits

Products Used:

Oracle Exadata Cloud@Customer