ORACLE
Data Deep Dive
at AI World

Ascend to the Diamond Tier

Next-Gen Oracle Maximum Availability Architecture

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Safe harbor statement

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What is Oracle Maximum Availability Architecture?

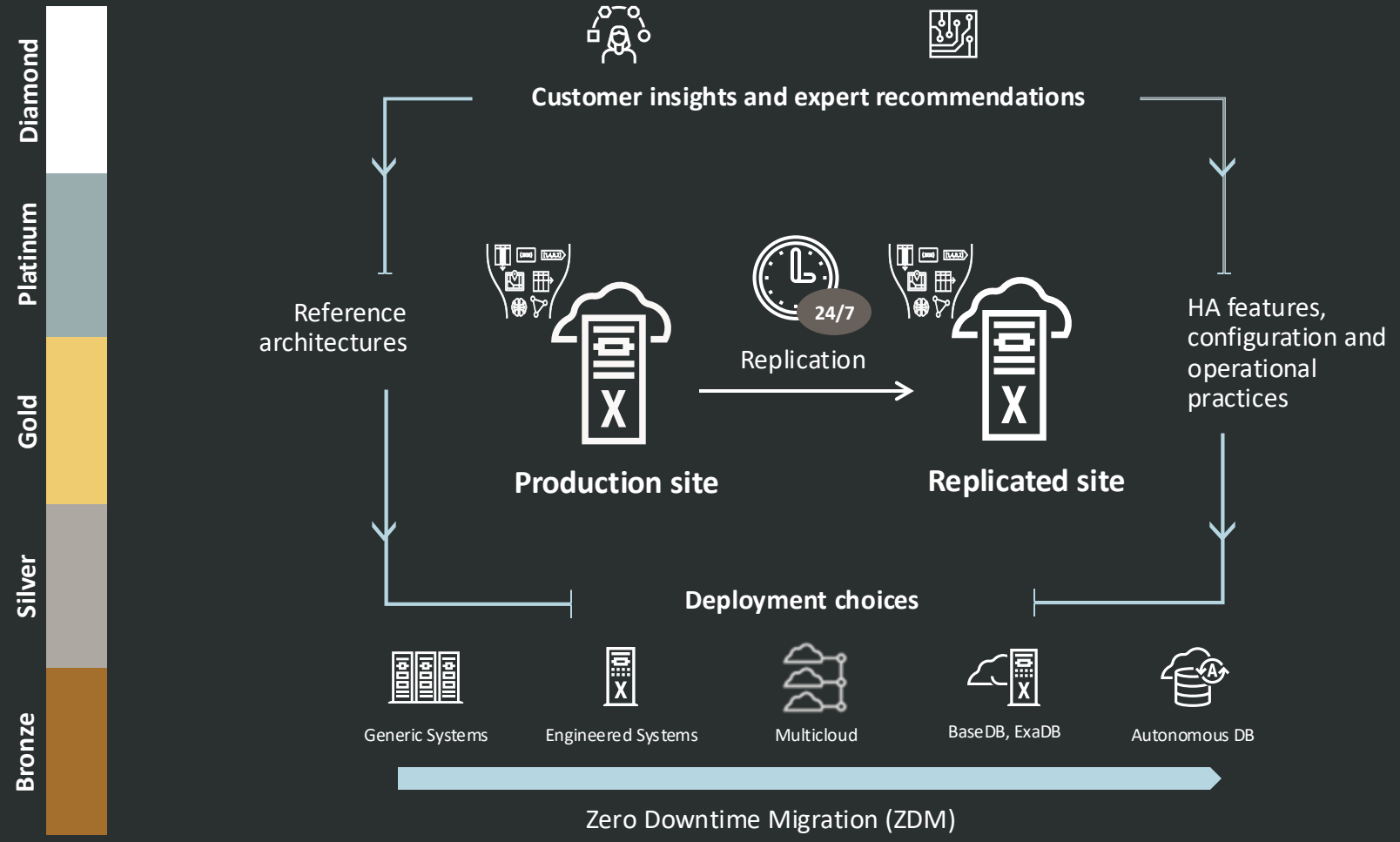
- **Four Tiers of Oracle High Availability and Disaster Recovery Protection**
  - Historically offers a tiered architecture (Bronze, Silver, Gold, Platinum) to match different business availability requirements.
- **Comprehensive Outage Prevention and Service Restoration**
  - Provides a blueprint to protect from all outages including software maintenance, corruptions, human errors, gray failures, and disasters.
- **Integrated Oracle Technologies**
  - Leverages a combination of proven Oracle products like RAC for high availability and Data Guard for disaster recovery.
- **Validated Best Practices and Solution**
  - Developed and continuously tested by MAA engineers to ensure the architecture, configuration and life cycle operations are up-to-date

Original MAA reference architectures

Availability service levels

Bronze	Silver	Gold	Platinum
Dev, test, prod	**Prod/departmental**	**Business critical**	**Mission critical**
Single instance DB Restartable Flashback Technologies Backup/restore	**Bronze +** Database HA with RAC Application Failover Zero Downtime Software Update	**Silver +** DB replication with Active Data Guard or Data Guard Comprehensive Data Corruption	**Gold +** GoldenGate and Active/Active Edition-based redefinition
Instance Failure: Minutes to an hour Disasters – Hours to days	Instance Failure: Less than 60 secs (brown out) Disasters – Hours to days	Instance Failure: Less than 60 secs (brown out) Disasters – < 5 min	Instance Failure :Zero or single-digit secs Disasters – Zero or near-zero

Next Gen Maximum Availability Architecture (MAA)



High performance

Resource Management | Database In-Memory | True Cache

Continuous availability

Application Continuity | Online Redefinition | Edition-based Redefinition

Data protection

Flashback | RMAN | ZDLRA+ ZRCV

Active replication

Active Data Guard | Full Stack DR | GoldenGate

Scale out & Lifecycle

RAC | Globally Distributed Database | FPP | Real Application Testing

Why are we introducing the next generation of MAA?

Evolving one of the most successful architectures for database resiliency

- Thousands of customers rely on MAA reference architecture
- Customers are demanding more flexibility regarding where they can deploy and more variety regarding RTO and RPO in the MAA tiers to accommodate their evolving SLA requirements.
- The goal regarding the next-gen MAA tiers is to meet the flexibility demand and accommodate a variety of RTO and RPO tiers.

The four primary strategies behind the MAA next-gen updates include:

1. The inclusion of Exadata as a key component in the MAA tiers at the high levels
2. Account for Oracle AI Database 26ai enhancements that improve the MAA solution
3. Expand definitions for tiers to accommodate RTO/RPO with a 5th tier
4. Introduce MAA best practices focused on applications making use of Distributed Databases with Globally Distributed Database RAFT

Next-Gen MAA Reference Architectures

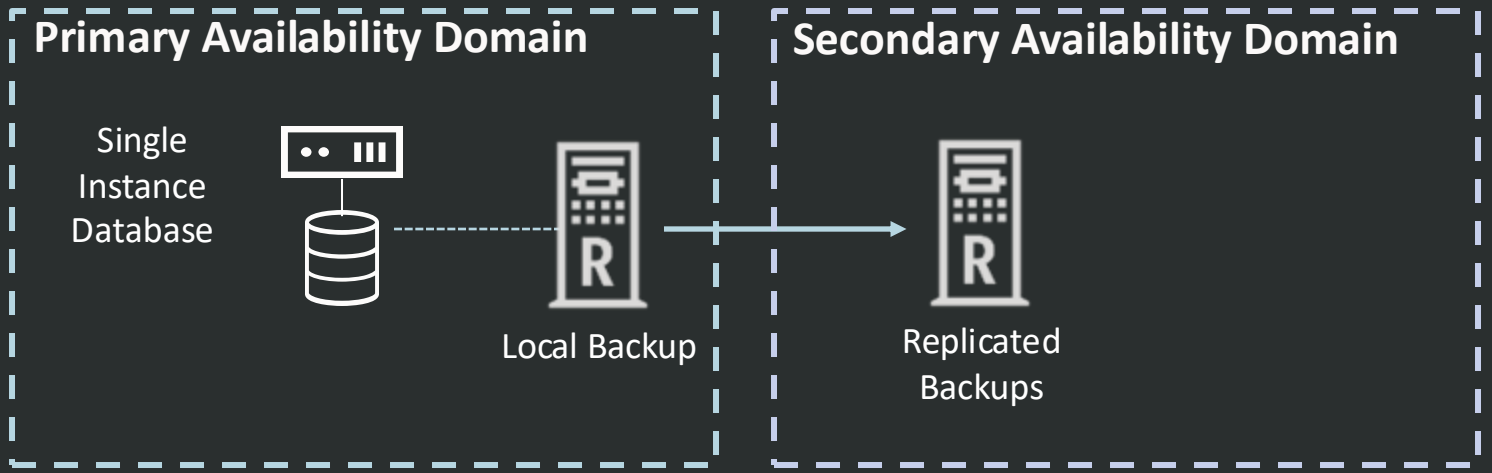
Availability service levels for the next generation of Oracle Database

Bronze	Silver	Gold	Platinum	Diamond (NEW)
Dev, test, prod	**Prod/departmental**	**Business critical**	**Mission critical**	**Extreme availability**
Single instance DB Restartable Backup/restore	**Bronze +** Database HA with RAC or Local Data Guard Client failover HA best practices Application Continuity (optional)	**Silver with RAC +** DB replication with (Active) Data Guard with automatic failover Client failover DR best practices	**Gold with** Exadata *and either option:* Option 1: GoldenGate with Oracle Database 19c ***OR*** Option 2: (Active) Data Guard with Oracle AI Database 26ai	**Configuration** GoldenGate 26ai replicas, *each running*: Oracle AI Database 26ai + RAC on Exadata + (Active) Data Guard
Recoverable local failure: Minutes to hour Disasters: Hours to days RPO < 15 min	Recoverable local failure: seconds to minutes Disasters: Hours to days RPO < 15 min	Recoverable local failure: Less than 60 seconds Disasters: < 5 min RPO = zero or near zero	Recoverable local failure: Less than 20 seconds Disasters: < 30 secs RPO = zero or near zero	Recoverable local failures: Less than 10 seconds Disasters zero to 10 secs RPO = zero or near zero

BRONZE

Dev, Test, & Non-critical Production

- Single Instance or Multitenant Database with Clusterware Restart
- Advanced backup/restore with RMAN
  - Optional ZDLRA with incremental forever and near-zero RPO
- Storage redundancy and validation with ASM
- Management with PDB features
- Online Maintenance
- Some corruption protection
- Flashback technologies



Availability Matrix

Unplanned Outage	RTO / RPO Service Level Objectives (f1)
Recoverable node or instance failure	Minutes to hour
Disasters: corruptions and site failures	Hours to days. RPO since last backup or near zero with ZDLRA
Planned Maintenance	
Software/hardware updates	Minutes to hour (f1)
Major database upgrade	Minutes to hour

f1 : RPO=0 unless explicitly specified

Expanding Zero Data Loss Autonomous Recovery Service (ZRCV)

Intelligent data protection for Oracle databases in OCI, Multicloud and On-premises

Zero Data Loss Recovery

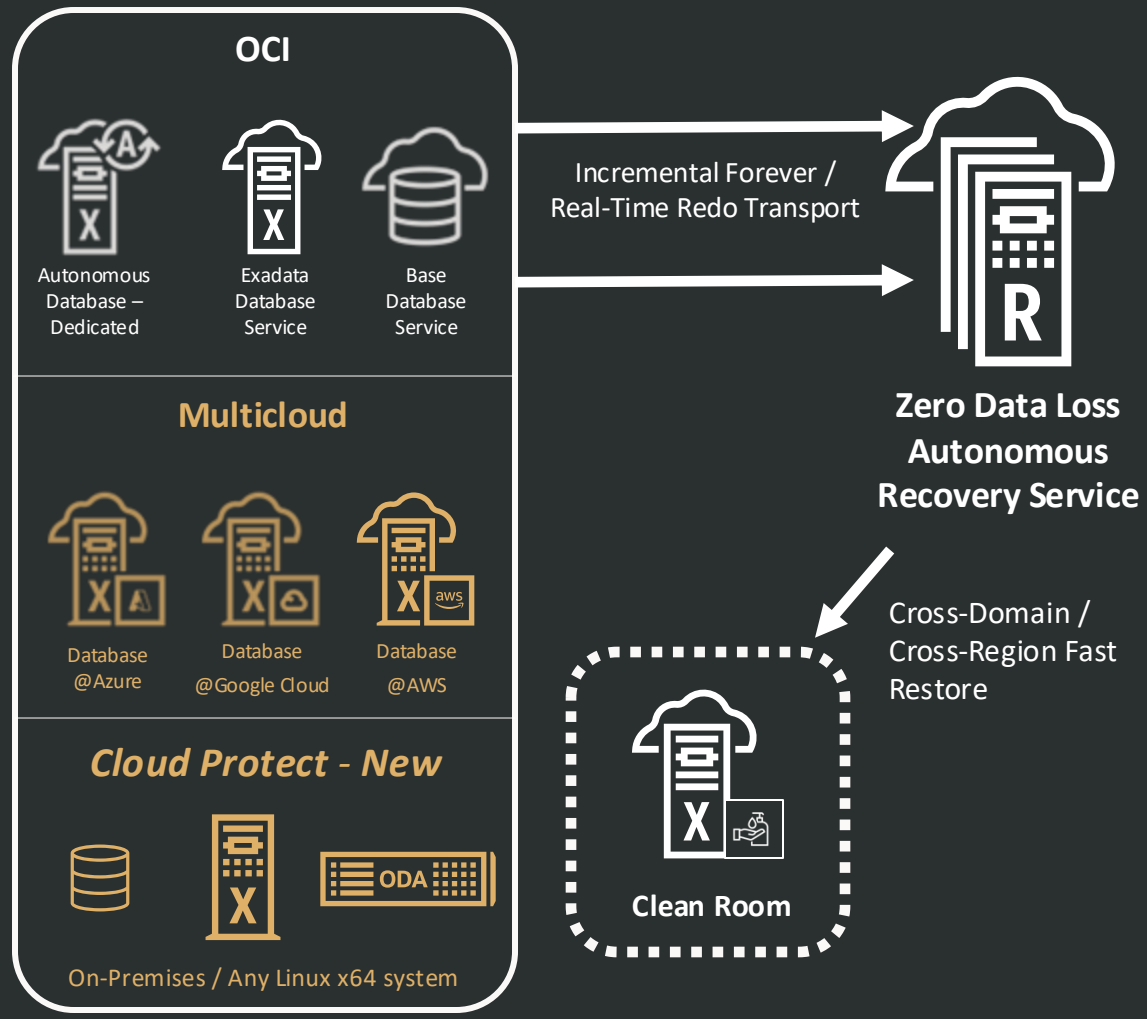
- Real-time transaction protection
- Continuous recovery validation

Fast, Low-Impact Backup and Recovery

- Space-efficient incremental forever
- One-step recovery without needing incremental apply

Database-aware Ransomware Resiliency

- Immutable backups with retention lock
- Separation of duties and granular access control
- Logical airgap between the customer and Oracle Cloud Operations tenancies
- Cross-domain and cross-region clean room support



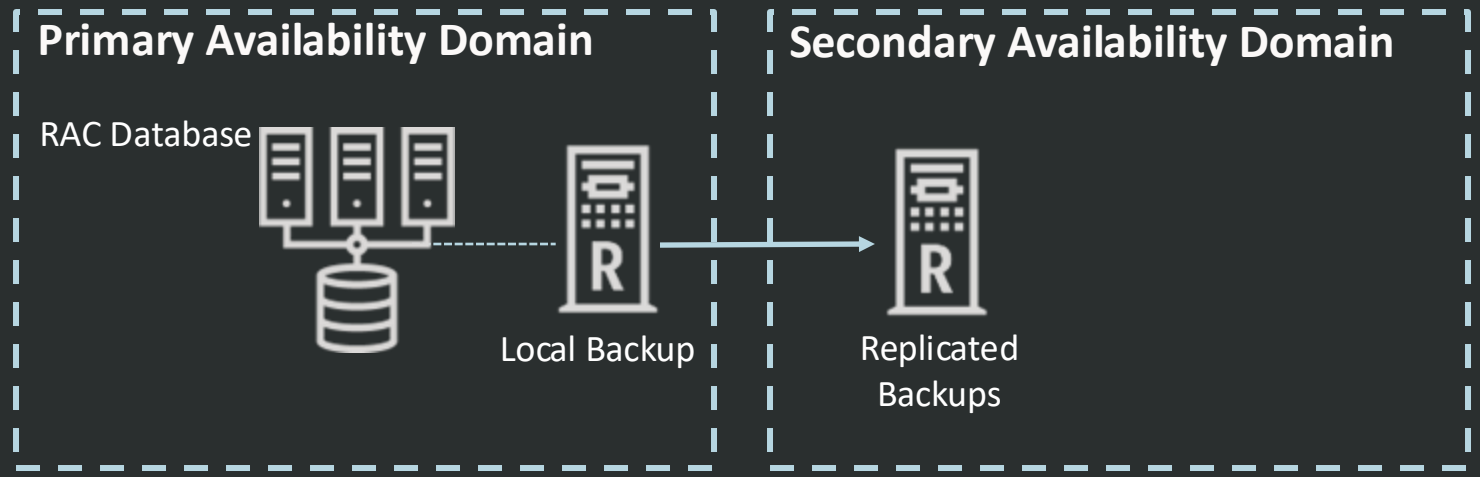
SILVER (Option 1)

Prod/Departmental

Bronze +

- Real Application Clustering (RAC)
- Scale Out and Elastic Shapes
- Zero Downtime Software Updates
- Client Failover HA Best Practices

Client connectivity best practices:
https://docs.oracle.com/en/database/oracle/oracle-database/23/haovw/continuous-availability-applications.html



Availability Matrix

Unplanned Outage	RTO/RPO Service Level Objectives (f1)
Recoverable node or instance failure	Seconds to minutes for non-Exadata <20 seconds with Exadata ~~(f2)~~
Disasters: corruptions and site failures	Hours to days. RPO since last backup or near zero with ZDLRA
Planned Maintenance	
Software/Hardware updates	**Zero** (f1)
Major database upgrade	Minutes to hour

f1: RPO=0 unless explicitly specified. To achieve minimal downtime or lowest impact, apply application client best practices; Batch jobs should be deferred outside planned maintenance window.

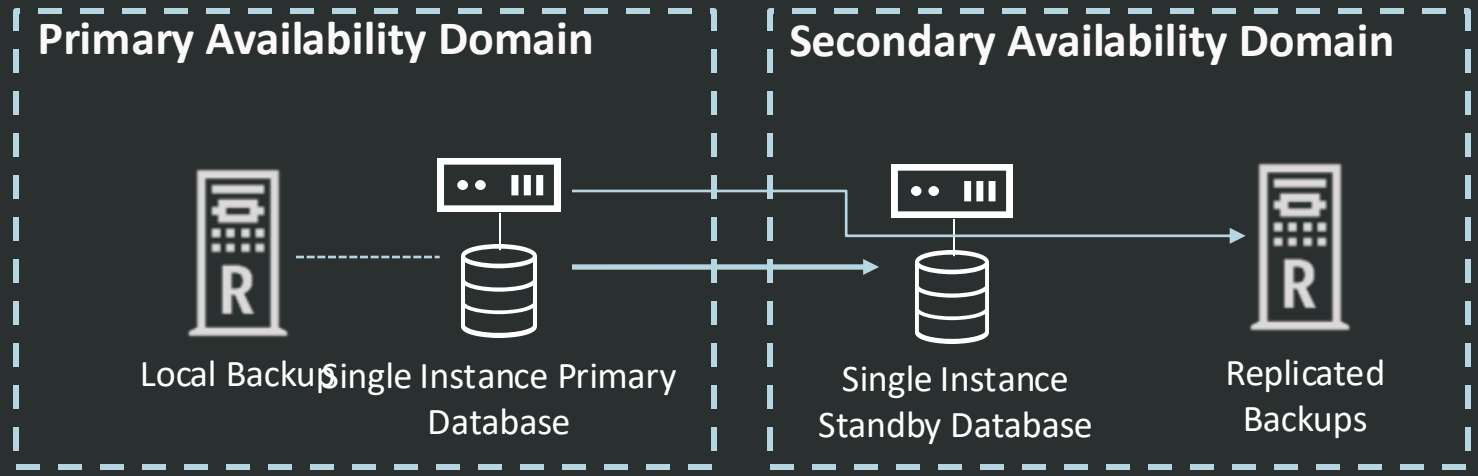
SILVER (Option 2)

Prod/Departmental

Bronze +

- Local Standby Database using Data Guard Automatic Failover
  - More Fault Isolation
  - Comprehensive Corruption Protection
  - Standby-first updates for planned maintenance
  - Client Failover HA Best Practices

Client connectivity best practices:
https://docs.oracle.com/en/database/oracle/oracle-database/23/haovw/continuous-availability-applications.html



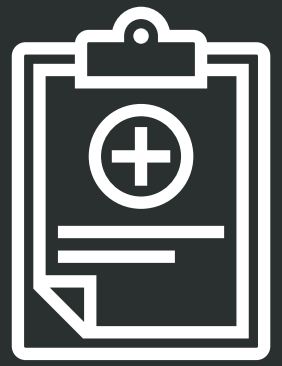
Availability Matrix

Unplanned Outage	RTO/RPO Service Level Objectives (f1)
Recoverable local failure, corruptions and possible AD/AZ failures	Zero for data corruptions Seconds to minutes for local failures
Disasters: regional failures	Hours to days. RPO since last backup or near zero with ZDLRA
Planned Maintenance	
Software/Hardware updates	Seconds to minutes (f1)
Major database upgrade	Minutes to 1 hour

f1: RPO=0 unless explicitly specified. To achieve minimal downtime or lowest impact, apply application client best practices; Batch jobs should be deferred outside planned maintenance window.

Oracle Update Advisor

Taking the guesswork out of updates and MAA software lifecycle



Accurate Software Health Status

Software health is assessed and reported according to customer's software inventory and policies.

Up-to-Date Version **Guidance**

Delivers both critical and required additional fixes.

Streamlined Access to Updates

Customized gold images enable convenient out-of-place updates.

Fully integrated in FPP & DBCA

Completely automated software update flow.

GOLD

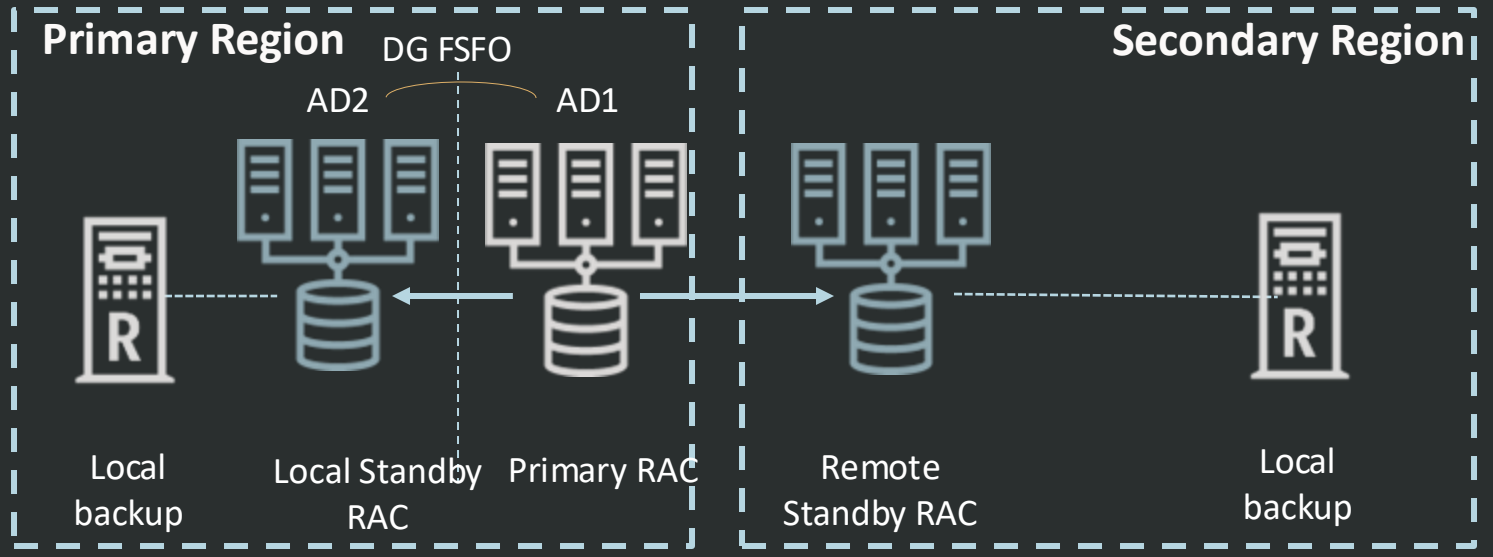
Business Critical

Silver (Option 1 with RAC) +

- Active Data Guard
  - Comprehensive disaster recovery and corruption protection

MAA Architecture:

- At least one standby is required preferable across AD or region.
- Data Guard Fast-Start Failover (FSFO)
- Local backups on both primary and standby



Availability Matrix

Unplanned Outage	RTO/RPO Service Level Objectives (f1)
Recoverable node or instance failure	Singles to minutes for non-Exadata <20 seconds with Exadata
Disasters: corruptions and site failures	**< 5 minutes. RPO zero or seconds**
Planned Maintenance	
Software/Hardware updates	Zero (f1)
Major database upgrade	**< 30 seconds**

f1: RPO=0 unless explicitly specified To achieve zero downtime or lowest impact, apply application checklist best practices; Batch jobs should be deferred outside planned maintenance window.

It’s Official - Oracle MAA Gold for all Oracle Database@Hyperscalers

Exadata Database Service on Dedicated Infrastructure

Oracle Database@Azure

- ✓ MAA Silver
- ✓ MAA Gold cross-regions
- ✓ MAA Gold cross-zones

Oracle Database@Google Cloud

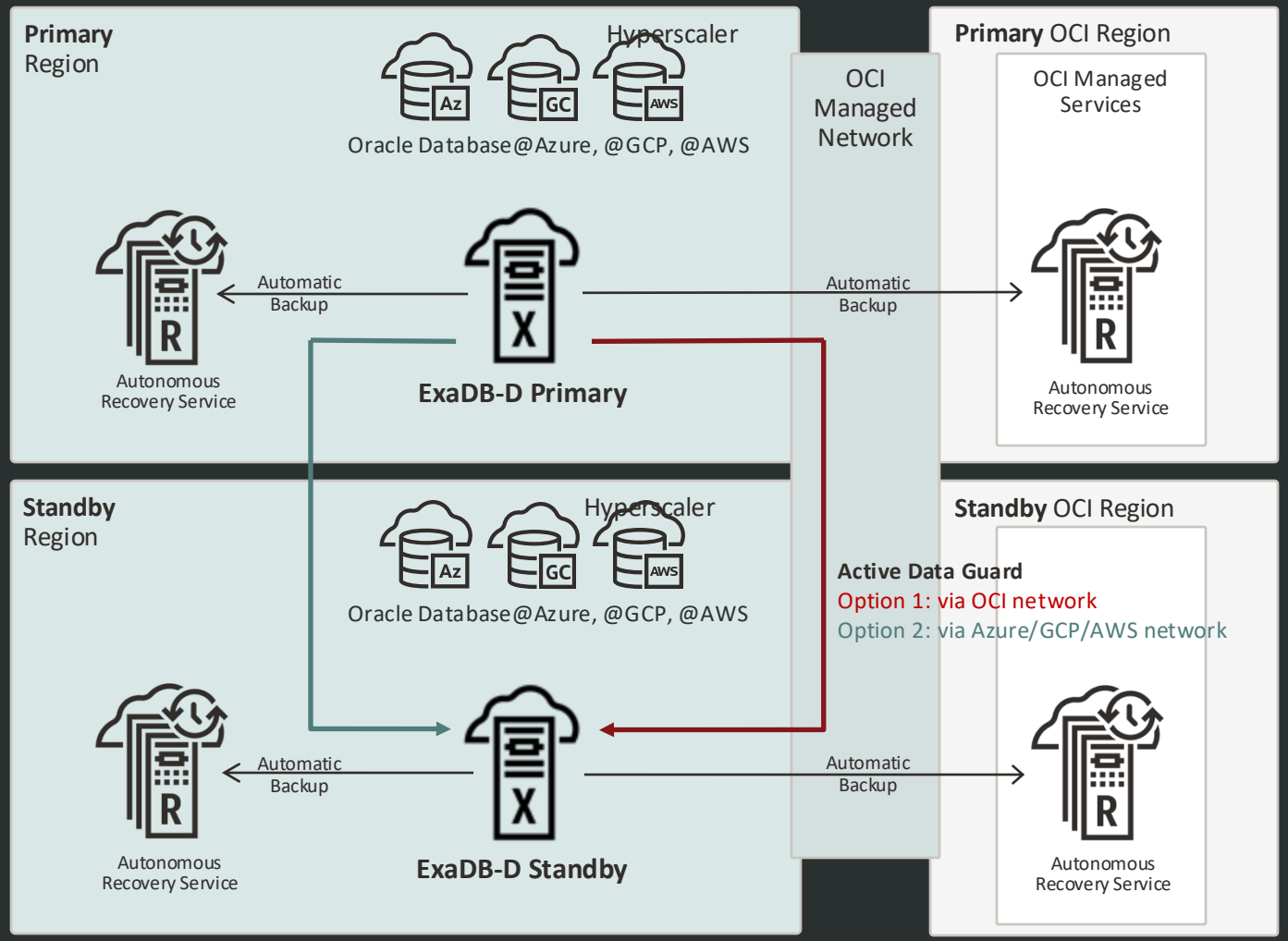
- ✓ MAA Silver
- ✓ MAA Gold cross-regions
- – MAA Gold cross-zones (planned)

Oracle Database@AWS

- ✓ MAA Silver
- ✓ MAA Gold cross-regions
- ✓ MAA Gold cross-zones

Exadata Database Service | MAA Gold Level - Cross-regions

Mission-Critical Deployments with Disaster Recovery



- ✓ Fully Automated Oracle Active Data Guard setup
  - ✓ **Regional disaster recovery protection**
  - ✓ Comprehensive data corruption prevention
  - ✓ Defense from ransomware attacks
  - ✓ Online upgrades and migrations
  - ✓ Offload backup and workload to standby with read-mostly scale-out
  - ✓ Network traffic through OCI network (**recommended**) or Azure/GCP/AWS Network

PLATINUM

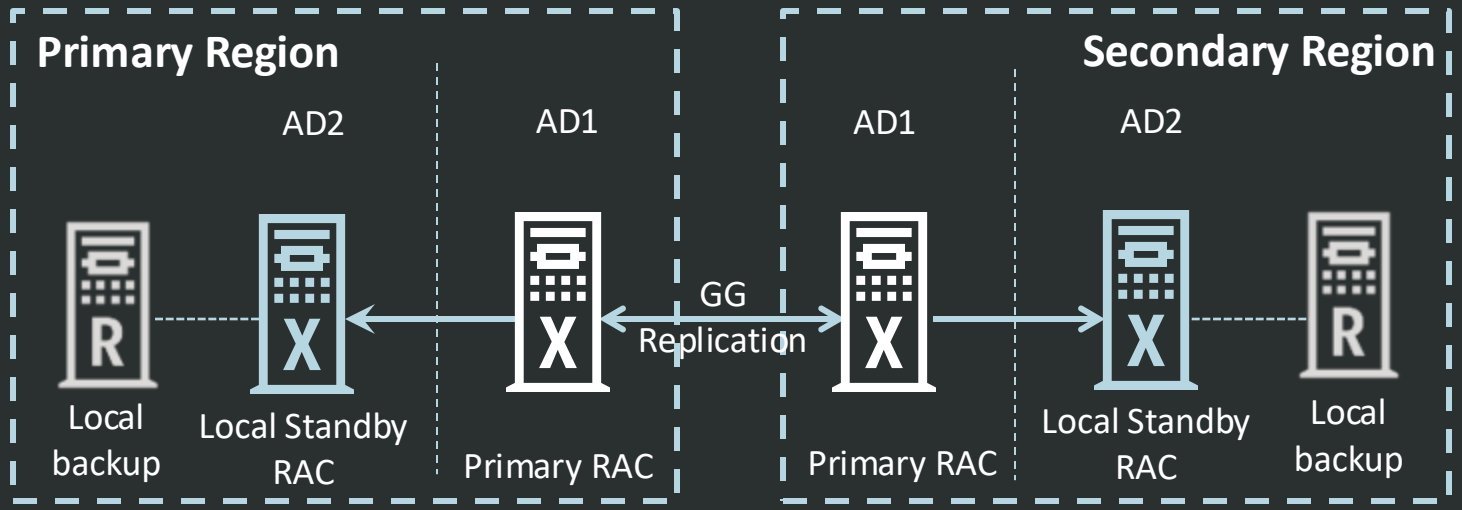
Mission Critical (Option 1)

Gold +

- GoldenGate Active/Active Replication
- Exadata
- Edition-based Redefinition (Optional)

MAA Architecture:

- Each GoldenGate "primary" replica protected by Exadata, RAC and Active Data Guard
- Primary in one data center (or AD) replicated to another Primary in remote data center (or AD)
- Oracle GG & Edition-based Redefinition for zero downtime application upgrade
- Achieve zero downtime through custom failover to GG replica



Availability Matrix

Unplanned Outage	RTO/RPO Service Level Objectives (f1)
Recoverable node or instance failure	< 20 secs
Disasters including corruptions and site failures	< 30 secs. RPO zero or seconds
Planned Maintenance	
Most common software/hardware updates	Zero
Major database upgrade, application upgrade	Zero

PLATINUM

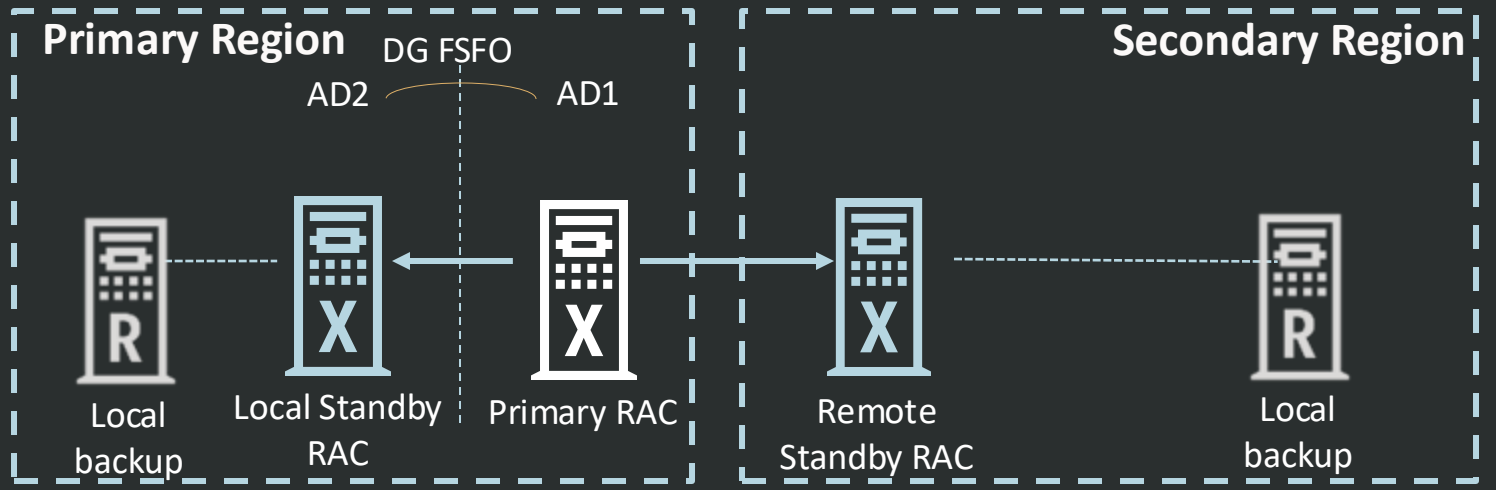
Mission Critical (Option 2)

Gold +

- Oracle AI Database 26ai
- Exadata
- Active Data Guard
  - Comprehensive Data Protection

MAA Architecture:

- At least one standby is required across AD or region.
- Primary in one data center(or AD) replicated to a Standby in another data center
- Data Guard Fast-Start Failover (FSFO)
- Local backups on both primary and standby



Availability Matrix

Unplanned Outage	RTO/RPO Service Level Objectives (f1)
Recoverable node or instance failure	< 20 secs
Disasters: corruptions and site failures	**Seconds to 2 minutes. RPO zero or seconds**
Planned Maintenance	
Software/Hardware updates	Zero (f2)
Major database upgrade	**Less than 30 seconds**

Why is Exadata extraordinary and unique for resiliency & scalability?

Exadata and RAC – The Foundation for Platinum MAA

Highest Application Availability

Engineered for zero-downtime software updates for standard outages and near-zero downtime for outages, with mitigation for severe gray failures

Proactive Data Protection

Exadata actively detects and repairs data corruption, ensuring data integrity.

Quality of Service

Application maintains extreme performance and low latency, adjusting dynamically when changes or issues occur

Ongoing Health Checks

Exadata is deployed by default with integrated MAA. Exachk and health checks maintain extreme stability and availability

Exadata is extraordinary and unique for resiliency & scalability

HA Use Case	Application Impact
Database Node Rolling software Update (Exadata, Grid Infrastructure and Database)	No application delay
Storage Server Rolling Software Update	No application delay
RDMA Network Fabric Switch Rolling Upgrade	10 seconds or less application delay
Hard Disk and Flash Failure	No application delay
Database Node and Instance Failure	10 seconds or less application delay
RDMA Network Fabric Switch or Port Failure	10 seconds or less application delay

Near Zero Application Impact for Most Common Planned and Unplanned Outages

Striving for Much Better!!!

Mitigation Solutions for Toughest “Gray Failures”

Gray Failure HA Use Case	Exadata Feature and Handling
Oversubscribed Resources	Exadata leverages MS alerting, Exadata AWR Support, and Real Time Insight to proactively notify and report on resource oversubscription so it can be addressed.
RoCE network port dropped packets	Exadata leverages the Exaportmon feature to detect sick network ports and take them down if traffic is not flowing correctly
Exadata Storage Cell slow / sick flash disk and hard disk	Exadata leverages the cell side IO latency capping features to cancel IO and route to secondary partners when primary partners are very slow
I/O hang	Exadata leverages the I/O hang detection to reboot a cell when the I/O are not being serviced due to, for example a sick controller.

Exadata extraordinary examples

Highest Application Availability

- 15 X Faster for Node Failure
- Only Exadata HA enables the lowest brownout

Data Guard Redo Apply Performance

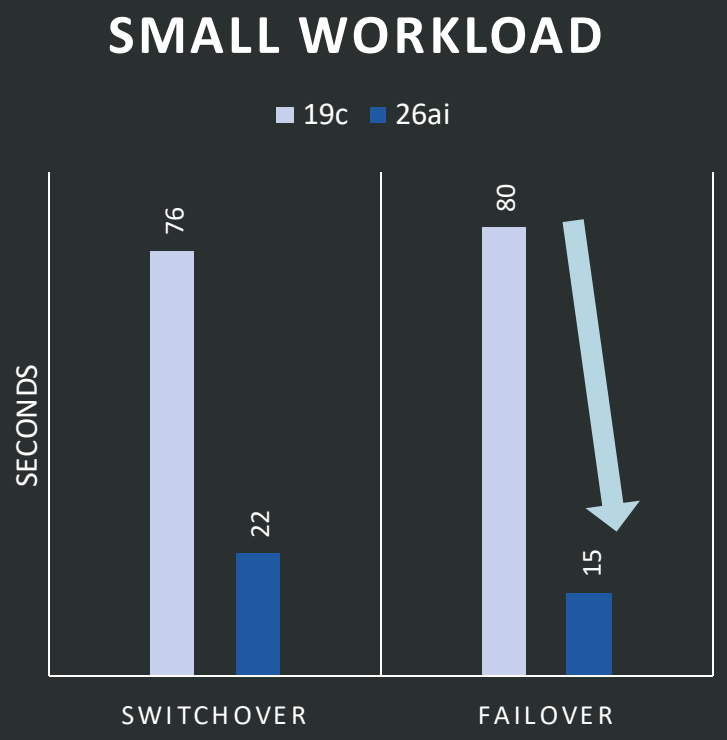
- 5-10 X Faster due to scale-out network and storage

Exadata Performance and Scalability

- 33 X better performance
- 4-10 X better OLTP latency

Oracle Data Guard 26ai Provides Lower RTO

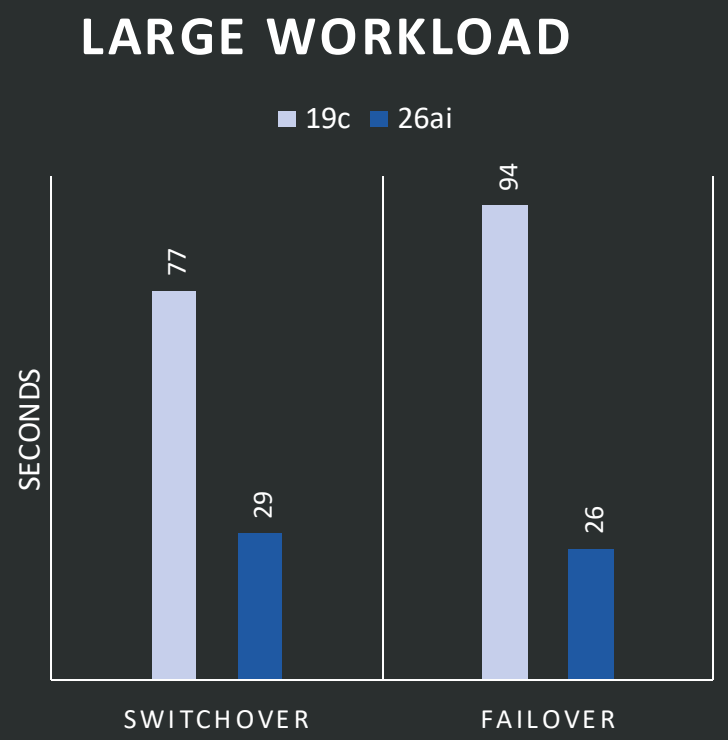
Faster role transitions regardless of the size of the workload



UP TO

400%

FASTER



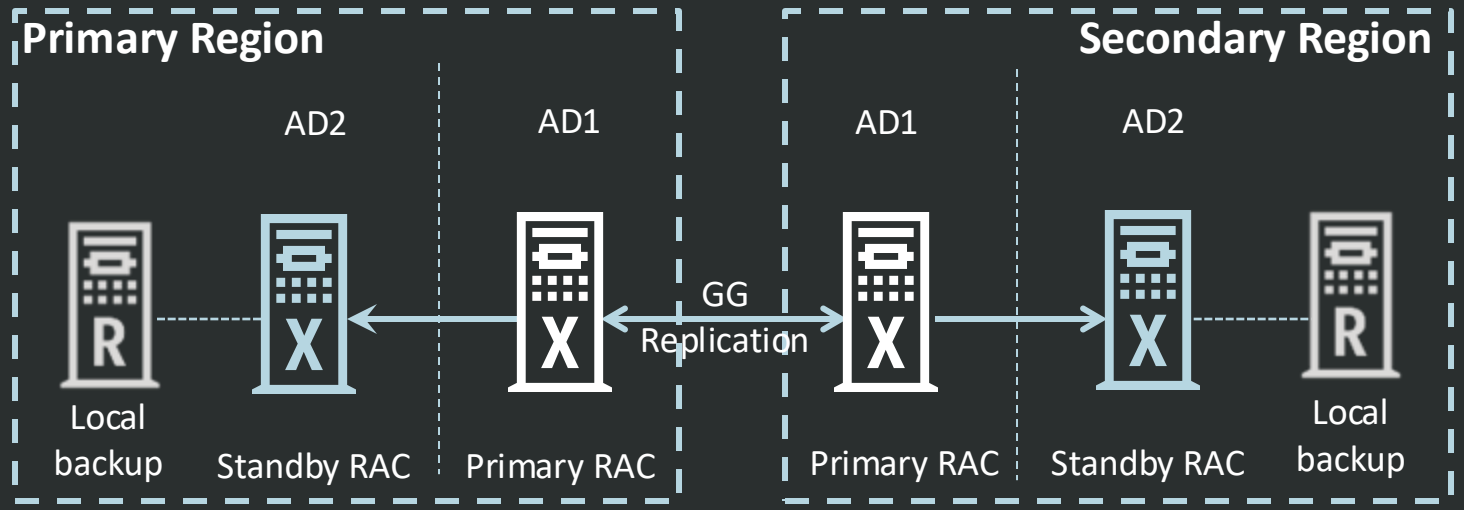
Workload	System	PDBs	Data Files	Services	Redo Rate
SMALL	2-node Exadata RAC	5	50	10	60 MB/s
LARGE	4-node Exadata RAC	12	500	12	100 MB/s

DIAMOND

Extreme Availability

Platinum (Option 1 with GoldenGate) +

- GoldenGate 26ai Active/Active Replication
- Oracle AI Database 26ai on Exadata
- Edition-Based Redefinition compatible (optional) with GG
- MAA GGHub with Automation
  - Deployment and configuration best practices
  - ACFS failover/switchover automation
  - More Planned



Availability Matrix

Unplanned Outage	RTO/RPO Service Level Objectives (f1)
Recoverable node or instance failure	< 10 secs
Disasters including corruptions and site failures	Zero. RPO zero or seconds
Planned Maintenance	
Most common software/hardware updates	Zero (f2)
Major database upgrade, application upgrade	Zero (f3)

f1: RPO=0 unless explicitly specified
f2: To achieve zero downtime or lowest impact, apply application checklist best practices
f3: Application failover is custom or with Global Data Services

Diamond MAA Tier – Ideal for Extremely Mission Critical Systems

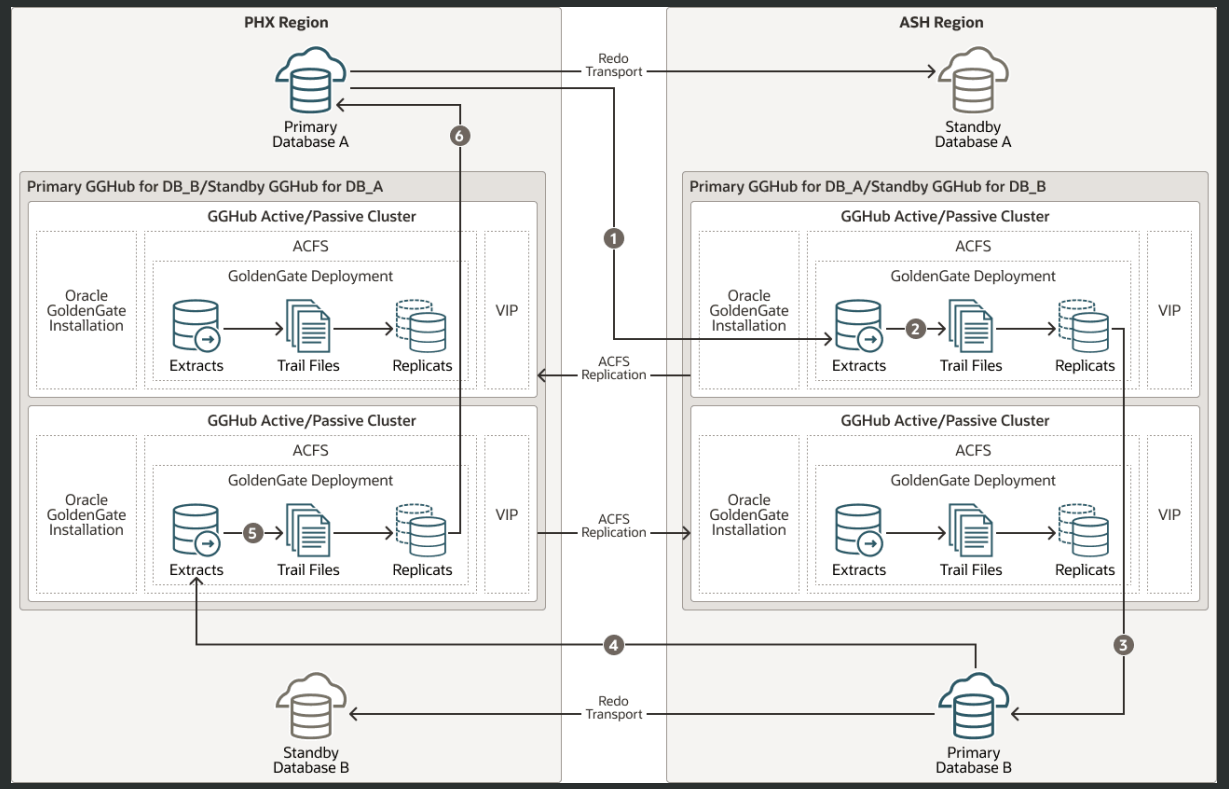
Bringing it all together

- Maximizing uptime and data protection simultaneously for both planned maintenance and unexpected outages
  - Oracle GoldenGate 26ai is required to provide an active-active platform for HA, where a simple load balancer switch allows administrators to switch workloads.
  - Oracle Active Data Guard in Oracle AI Database 26ai is providing data protection simultaneously to both primary databases, either with local or remote standby databases, depending on the data center configuration
  - Oracle Real Application Clusters provides the high availability foundation with Oracle Exadata, providing the infrastructure that maximizes highest application availability, data protection, quality of service and stability.
  - MAA GoldenGate Hub provides deployment and life cycle automation to ensure best practices are incorporated for streamline replication and failover and HA and DR for the GoldenGate Hub

Diamond MAA: Redundancy Throughout the Architecture

Extreme Availability Goal: Provides near-zero downtime and near-zero data loss

- **Core Components**: Architecture relies on Oracle Active Data Guard with Fast-Start Failover (FSFO) for database redundancy and MAA OGG Hub for data replication.
- **Cross-Region Placement**: The primary/active OGG Hub is co-located in the same OCI region as its target database to ensure optimal Replicat performance (≤4 ms latency).
- **Zero Data Loss**: Achieved by configuring Data Guard with SYNC redo transport and GoldenGate resynchronization after any Data Guard failover.
- **GGHub High Availability**: Both the Primary and Standby GGHubs are configured as Active/Passive clusters, using ACFS replication to preserve all GoldenGate trail files and metadata between regions.



The Next-Gen MAA Tiers in Summary

- **Five Tiers of MAA:** Architecture expanded to five tiers (Bronze to Platinum), culminating in the new Diamond tier. More MAA architectural options cater to specific local HA and DR RTO and RPO.
- **Multicloud expansion:** This accounts for the rapid Hyperscaling MAA expansion and its variables that impact RTO and RPO.
- **Enhanced DR:** Benefits from 400% faster Data Guard role transitions enabled by Oracle AI Database 26ai.
- **Exadata HA:** Benefits from and differentiates lower application brownouts, proactive data protection, performance quality of service, and ongoing health checks that enable Platinum local HA
- **Technology Foundation:** Incorporates existing and new HA, data protection, and DR foundations of Real Application Clusters, Active Data Guard, GoldenGate, Oracle Update Advisor, and AI to MAA

Maximum Availability Architecture and Distributed Databases

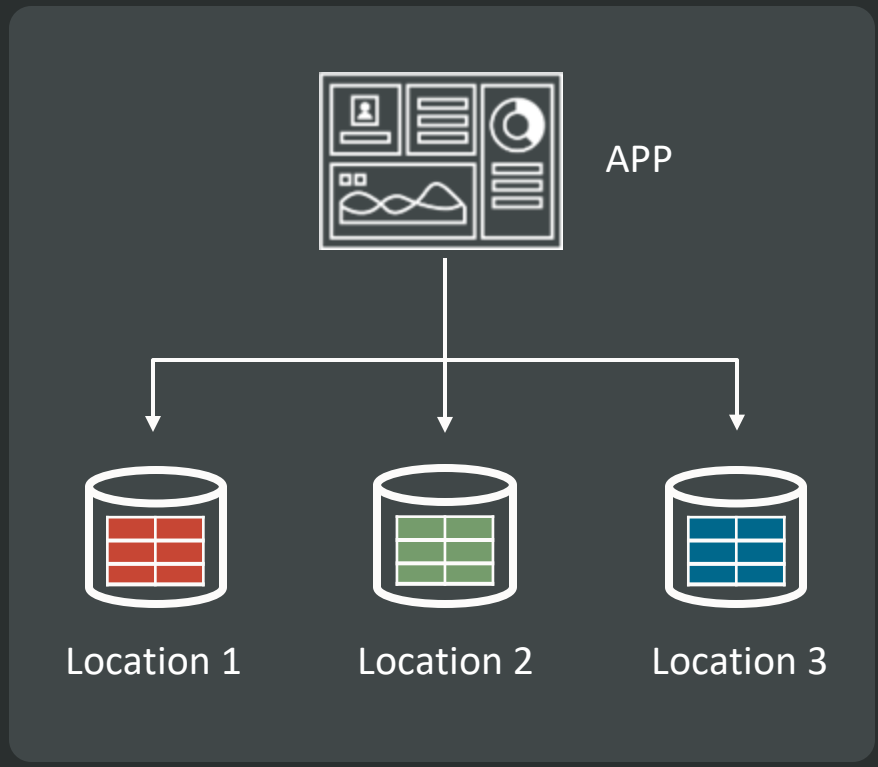
Oracle Globally Distributed Database and RAFT

What is a Distributed Database?

It is a database that stores data across multiple physical locations instead of one location

- Each location stores a subset of the data

The physical distribution of data is hidden from applications

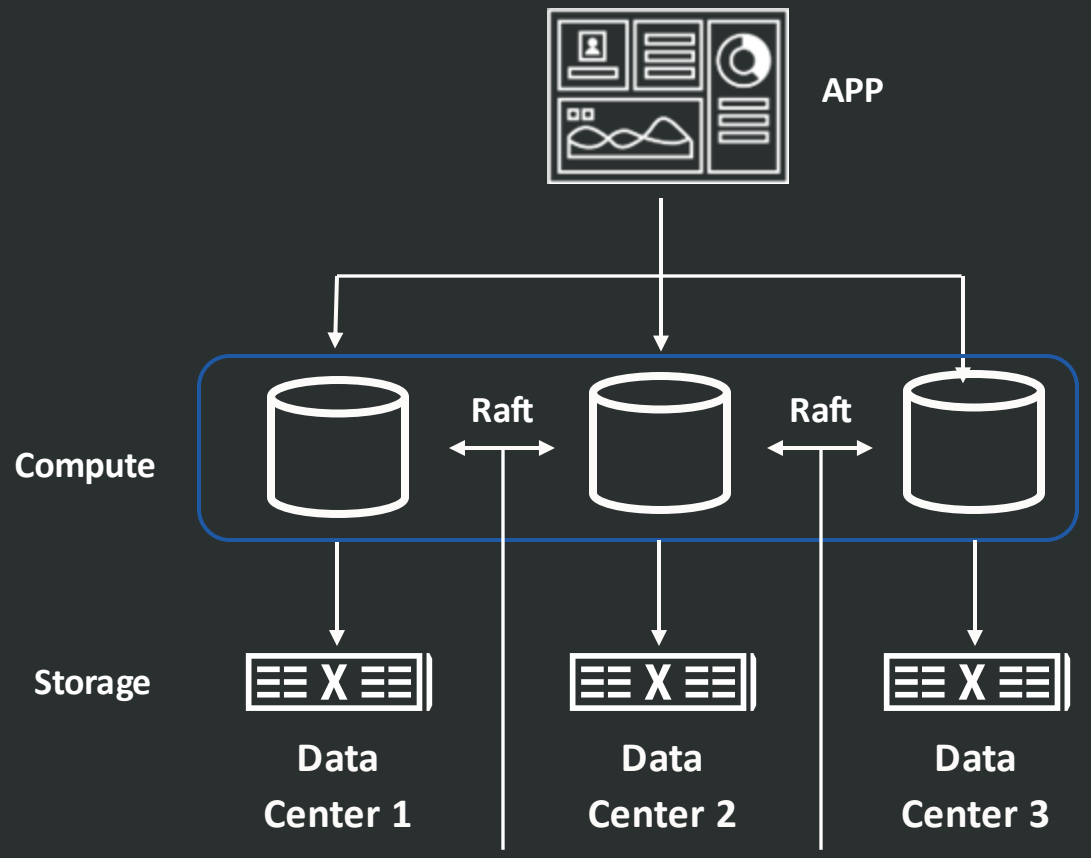


Always-on Distributed Databases

A single Distributed Database can span multiple nodes, availability domains and zones, and regions

Shards deployed across multiple locations

Raft replication provides instant protection from a node failure, an availability zone failure, and a region failure without any data loss



Raft-Based Replication for Extreme Survivability

New In 23ai

New replication method that uses the popular Raft quorum-based replication protocol

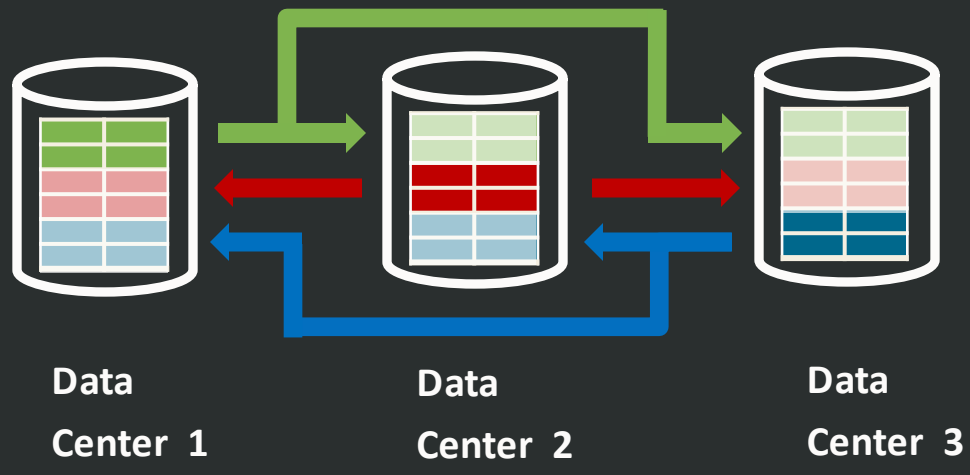
- Provides automatic failover to a replica in under 3 seconds

Implements an active-active symmetric configuration

- Each shard accepts writes and reads for a subset of data

Delivers zero data loss

- Using high-performance synchronous replication across shards



Quorum Based Consensus

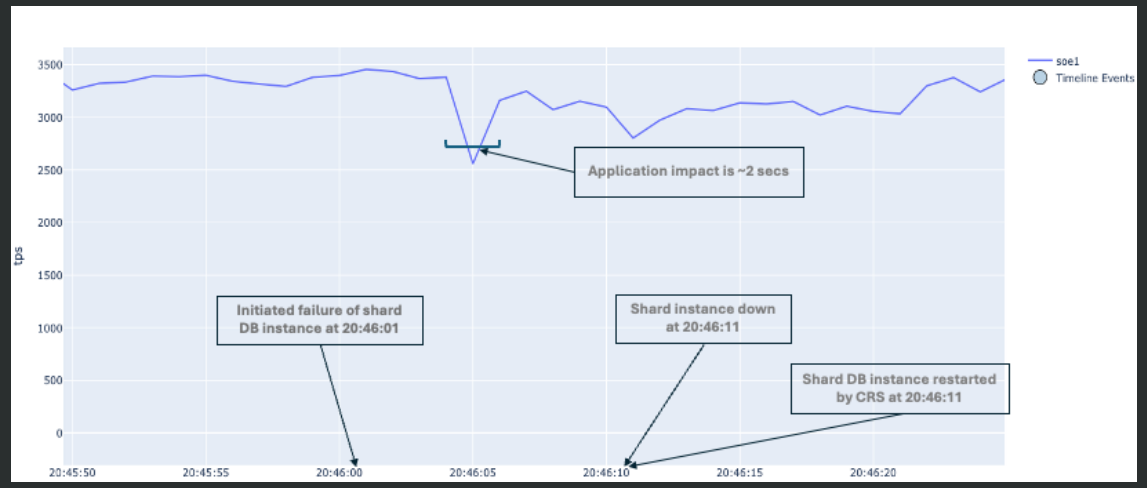
Globally Distributed Database with RAFT & MAA Distributed Database Class

Adheres to MAA Best Practices for the Distributed Database Class

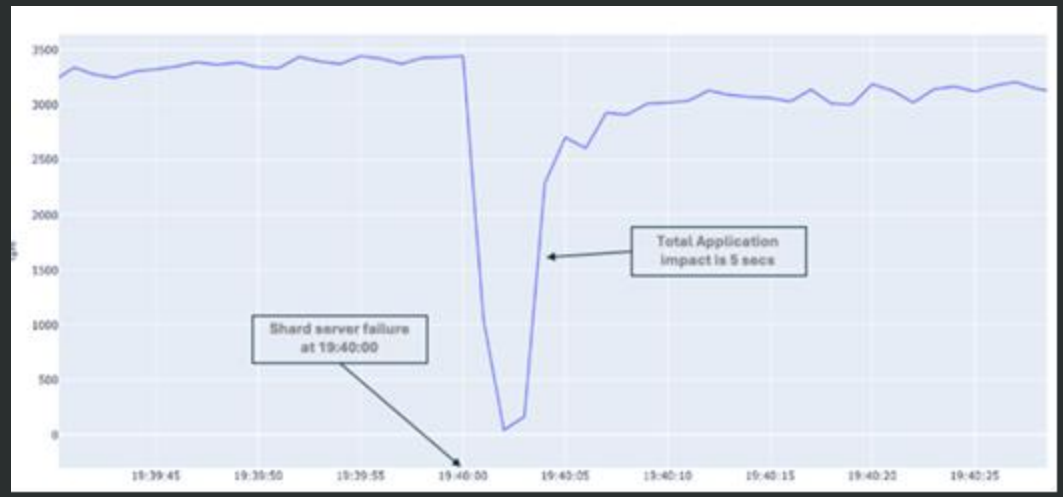
1. Superior Scalability & Agility:
   - Horizontal scaling achieved by adding/dropping shards.
   - Scaling is transparent to applications; no code changes required (one logical database view).
2. Always-on Continuous Database Availability
   - Fault-tolerant shards isolated across separate hardware/zones/data centers.
   - Automatic failover with observed application brownouts <5 seconds and zero data loss.
3. Seamless Distributed Application Integration
   - No application changes are required while scaling (one logical database transparency)
4. External Consistency & Transaction Support:
   - Supports required levels of consistent data reads/writes and transactional guarantees across shards.
   - Guaranteed external consistency

Unprecedented High Availability

Application TPS* during shard database instance failure



Application TPS* during shard node failure



* TPS = Transactions Per Second

MAA Best Practices for Globally Distributed Database with RAFT

- Architecture Planning:
  - Application Tier: Use the latest optimized Oracle AI Database 26ai UCP and JDBC drivers, direct routing with shard keys.
  - Routing Tier: Use Global Data Services with HA Catalog Database and HA listeners per data center
  - Database and Data Replication Tier: Location of shards depends on acceptable fault isolation and acceptable performance with SYNC latency. Sufficient bandwidth for data transfer.
- Latency is Key: Aggressively minimize inter-shard network latency (validate with iperf); tune network parameters (TCP buffers, MTU, and SDU) for Raft throughput and latency.
- Fast Failover Tuning: Configure UCP/JDBC with recommended timeouts, application-level retry logic with error exception handling, and validated settings
- Robust Configuration: Use Clusterware for automatic shard restart; incorporate HA for Catalog DB and listeners, and configure Raft logs with 24-hour retention.
- Configure for Performance: Configure Raft for High IOPS, Acceptable latency for performance, Sufficient system resources for workload growth, and to tolerate at least one shard down for maintenance or failure
- Minimize Application Impact: Recommend a low-activity planned maintenance window for scaling and planned maintenance operations due to high data movements or higher activity per shard

Summary and Takeaways

- Five-Tier Next Gen MAA provides more flexibility, resilience, and zero data loss options than ever before.
- The new Diamond Tier now provides the highest level of resilience and zero data loss, taking advantage of Exadata and Oracle AI Database 26ai
- Multicloud MAA is available, expanding the Oracle MAA solution footprint to AWS, Azure, and Google Cloud.
- Oracle Globally Distributed Database in 26ai provides a best-of-class MAA-certified, never-down solution for horizontal scaling using sharding and RAFT technology

Thank you


ORACLE