



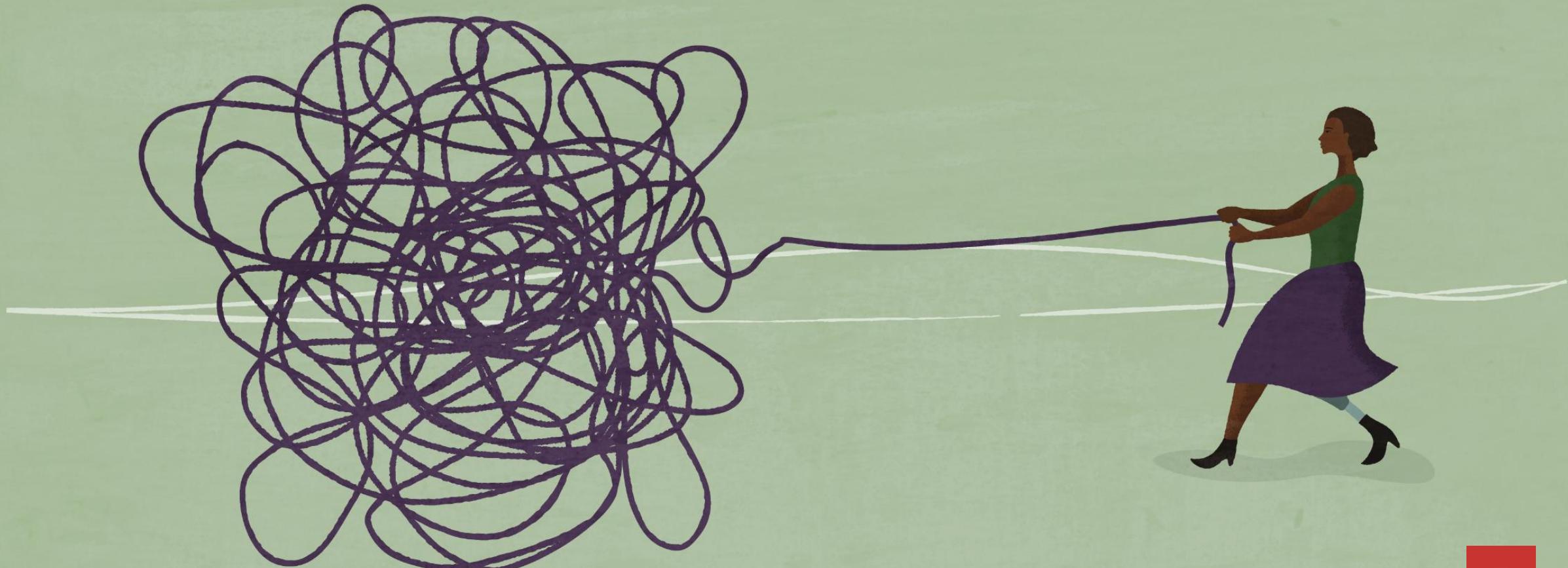
Oracle Maximum Availability Architecture (MAA)

Blueprints for reduced planned and unplanned downtime for
the On-Premises, Exadata-based or Cloud-based Oracle AI Database

February 2026



Why is Availability so important?



Impact of downtime



\$350K

average cost of
downtime per hour



87 hours

average amount of
downtime per year



\$10M

average cost of
unplanned data
center outage or
disaster



91%

percentage of
companies that
have experienced
an unplanned data
center outage in the
last 24 months

Key terminology



High availability

A system type with redundant components and enabling software that provides consistent and uninterrupted service, even in the event of hardware or software failures.



Disaster Recovery

A method of protecting computer systems from failure, in which standby equipment automatically takes over when the main system fails.



Recovery Time Objective (RTO)

Time to resume application service after failure. The shorter the Recovery Time Objective (RTO) the quicker you get back to business.



Recovery Point Objective (RPO)

Tolerance for data loss (sec's, hours, days); impacted by frequency of backups and replication approaches.

Protect systems during planned and unplanned downtime



Downtime type	Typical causes	Examples
 Planned	System changes Data changes	<ul style="list-style-type: none">• Server changes• Database changes• Data changes• Application changes
 Unplanned	Server failures Data failures	<ul style="list-style-type: none">• Computer failure• Storage failure• Human error• Data corruption• Lost writes• Hang or slow down• Site failure

MAA & Chaos Engineering – Breaking things to ensure your peace of mind



Chaos Engineering is the art form of experimenting (i.e. proactively breaking things) on a system in order to build confidence in a system's resilience to withstand turbulent events in production

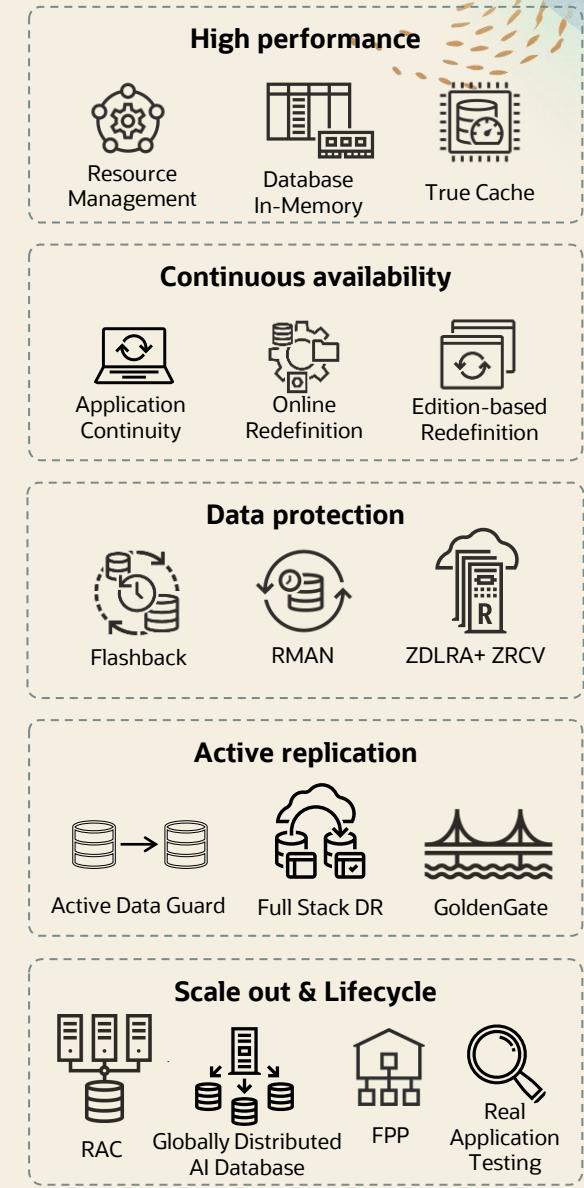
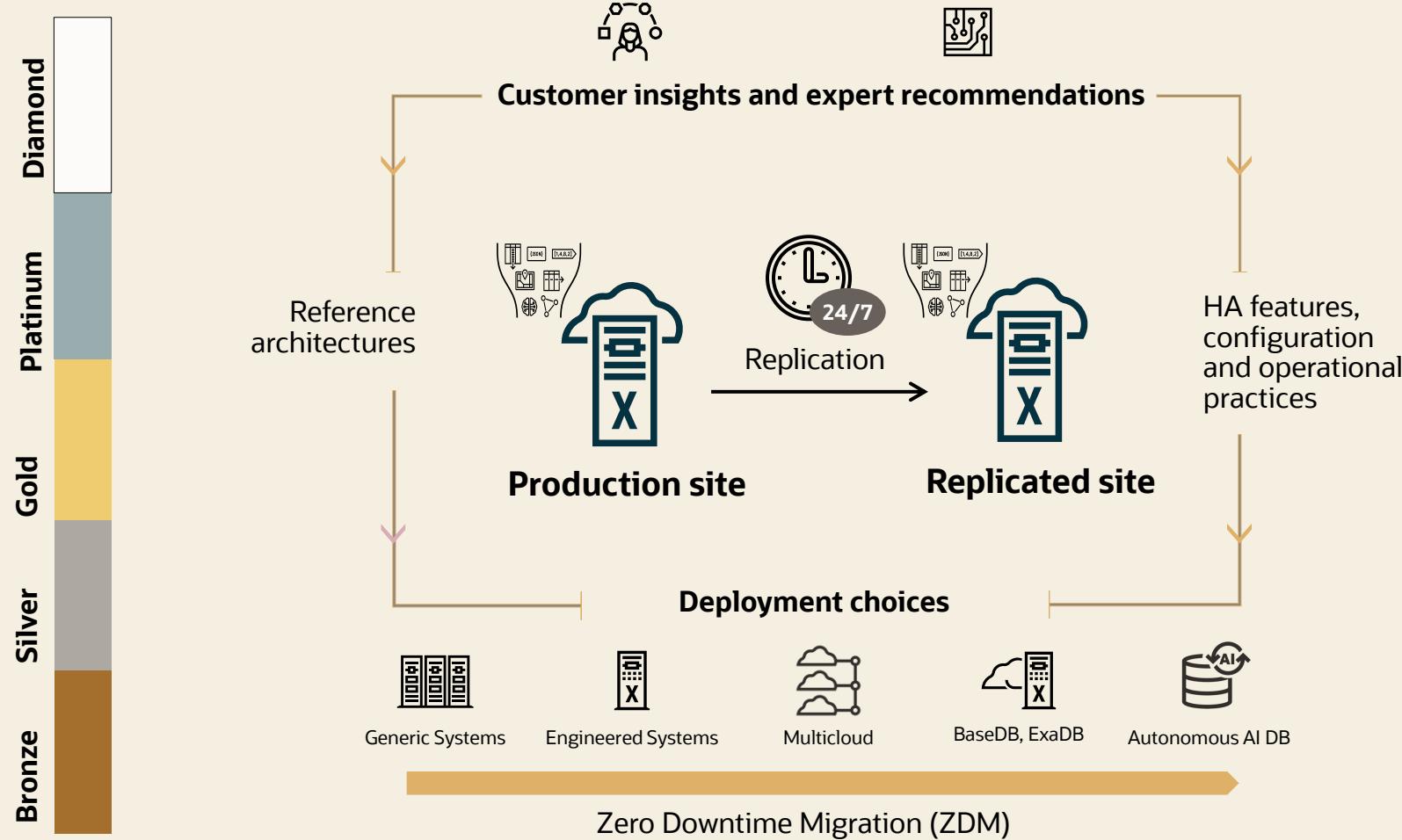
In today's digital age, this may include but is not limited to:

- Network, server & storage failures
- Human errors & data corruption
- Data corruption
- Power failures or site failure (i.e. *Godzilla attack or hurricane*)
- Application, database & server software updates
- Data reorganization or changes
- Application changes and optimizations

Oracle Solutions for High Availability and Disaster Recovery

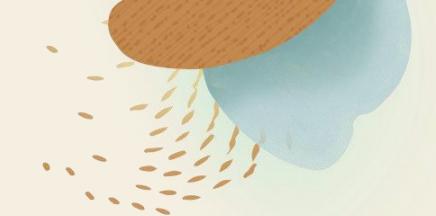
Maximum Availability Architecture

Next Gen Maximum Availability Architecture (MAA)



Next-Gen MAA Reference Architectures

Availability service levels for the next generation of Oracle AI Database



Bronze

Dev, test, prod

Single instance DB

Restartable

Backup/restore



Recoverable local failure:
Minutes to hour

Disasters: Hours to days

RPO < 15 min

Silver

Prod/departmental

Bronze +

Database HA with RAC
or Local Data Guard

Client failover HA best
practices

Application Continuity
(optional)



Gold

Business critical

Silver with RAC +

DB replication with
(Active) Data Guard
with automatic
failover

Client failover DR
best practices



Platinum

Mission critical

Gold with Exadata and either:

Option 1 - GoldenGate
with Oracle Database
19c

OR

Option 2- (Active) Data
Guard with Oracle AI
Database 26ai



Diamond (NEW)

Extreme availability

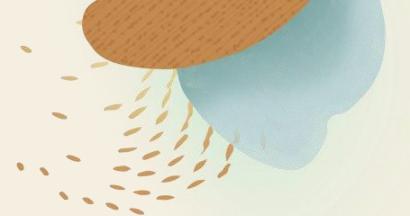
Configuration

GoldenGate 26ai
replicas, *each running*:

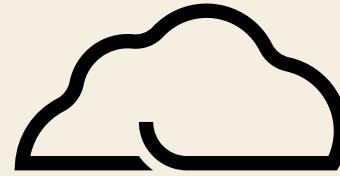
Oracle AI Database
26ai
+ RAC on Exadata
+ (Active) Data Guard



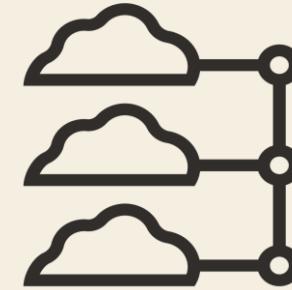
MAA, has you covered, no matter where your apps reside



On-premises, on commodity hardware, or on engineered systems like Exadata



In Oracle Cloud Infrastructure, using services such as the Autonomous AI Database or Exadata Database Cloud



In hybrid and multicloud environments; e.g. Oracle AI Database@Azure, Oracle AI Database@Google Cloud, or Oracle AI Database@AWS

Examples and benefits of MAA everywhere and anywhere....



Generic Systems:

- MAA Reference architectures (bronze through platinum)
- MAA configuration and operational best practices for all tiers
- MAA database compliance and health checks (i.e. Orachk)



Engineered Systems:

- Fully integrated end-to-end MAA best practices including DB, OS, network, storage
- Designed for lowest brownout, best performance, QoS, and highest data protection, agility, and availability
- Specialized hardware designed for the highest availability, resiliency and performance
- Fully MAA compliant OOTB with Exachk for full stack compliance and health checks



Exadata Database Cloud in OCI or Multicloud

- Cloud automation deploys and manages the database architecture
- MAA operational and configuration best practices are automated and built-in
- Collaboration with Azure, Google, AWS providing MAA in multicloud
- Multi-cloud MAA evaluations



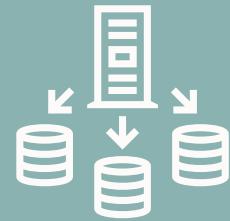
Autonomous AI Database in OCI or Multicloud

- Fully managed MAA-compliant architecture and configuration
- Simplified deployment, operations, and Oracle-managed maintenance

Oracle AI Database MAA Availability Recent Features



Rolling Patching for Complex Changes



Globally Distributed DB with RAFT



Single Server Rolling Database Maintenance



DBMS_ROLLING with Application Continuity



FPP Local Mode



Exadata Fleet Update



In-Database Firewall

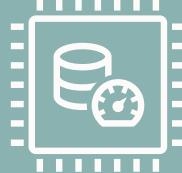


Data Guard Redo Decryption for Hybrid DR Configurations

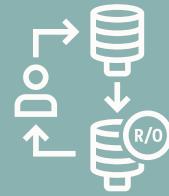
Oracle AI Database 26ai MAA Scalability Recent Features



RAC Smart Connection Load Balancing



True Cache



Real-time Query for PDB Standby



Clusterware Resiliency



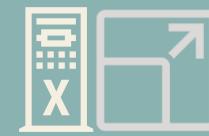
Ordered Sequences with Oracle RAC



Automatic tempfile creation on the standby database



Oracle RAC Fast Start Reconfiguration



RDMA-based Exadata RAC Scaling

Thousands of Oracle customers making use of MAA

Maximum Availability Architecture

Thousands of critical deployments use MAA, on-premises and cloud

76% of Fortune Global 100 run Exadata | **53%** 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



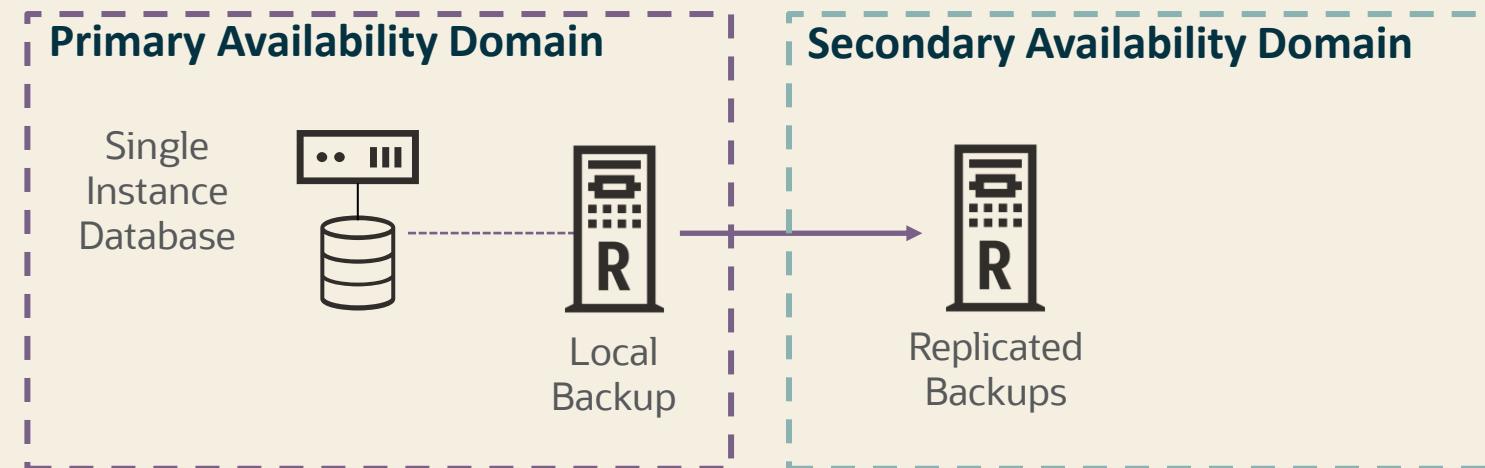
Diving into the MAA tiers

Maximum Availability Architecture

BRONZE

Dev, Test, Prod - Single Instance or Multitenant Database with Backups

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



Outage 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

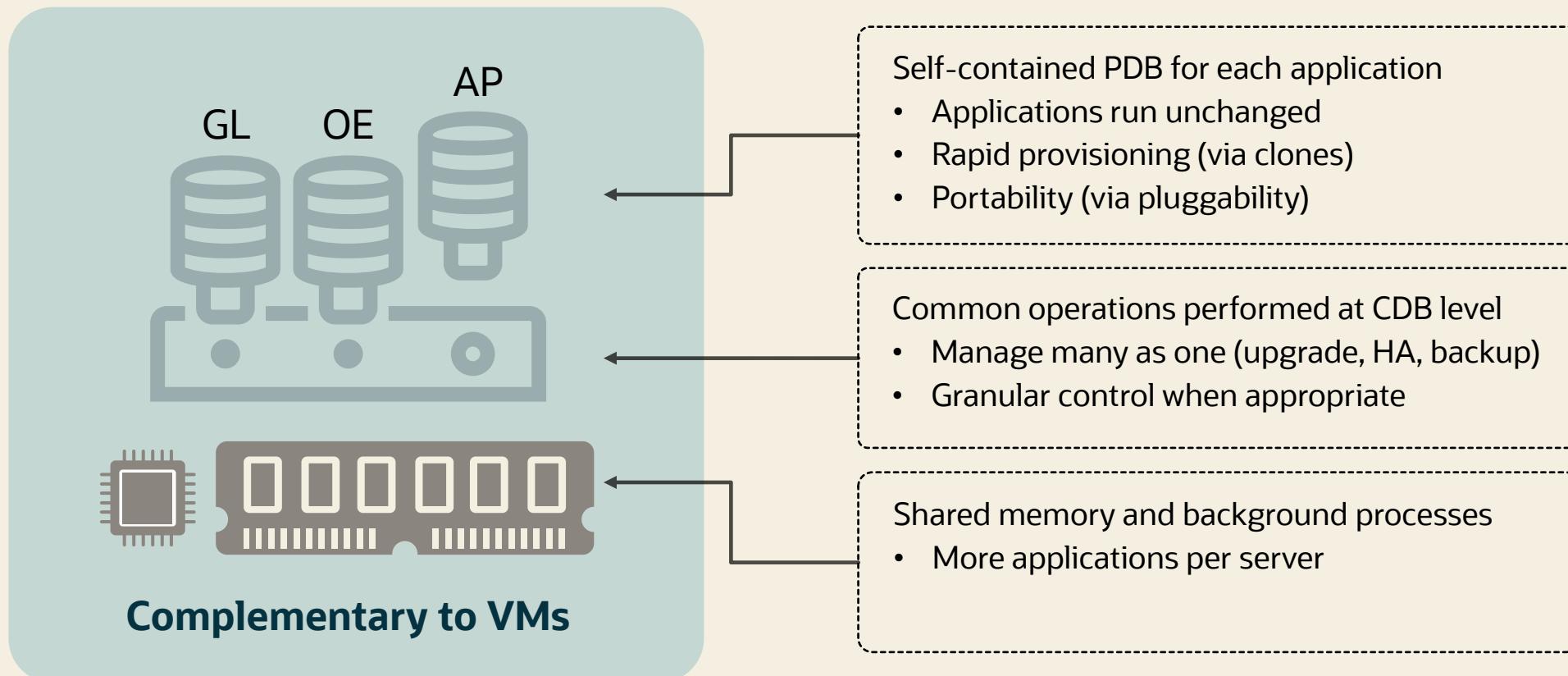


Oracle Clusterware for Automatic Restart

1. Oracle Clusterware is available for all Oracle AI Databases
2. Enables HA capabilities and resource management:
 - Automatic Restart of database instances, listeners, and other resources
 - Fleet patching
 - Service management, including restarting service after failure
 - Automatic Storage Management (ASM) for HA, data protection and ease of use
- Trade off: additional software maintenance for Grid Infrastructure

Advantages of Multitenant Architecture

Isolation and agility with economies of scale



Oracle Multitenant Features



Rapid cloning and provisioning

- Local clones and remote clones
- Snapshot clones
- Refreshable PDBs



Manage many as one

- Database consolidation
- Improve productivity
- Maintain granular control



Improve agility for development teams

- Pre-configured service level agreement
- Compatibility
- Interface



Enhance security

- Separation of duties
- Data security
- Resource isolation



Integration with Oracle RAC

- High availability
- Scalability
- Flexibility



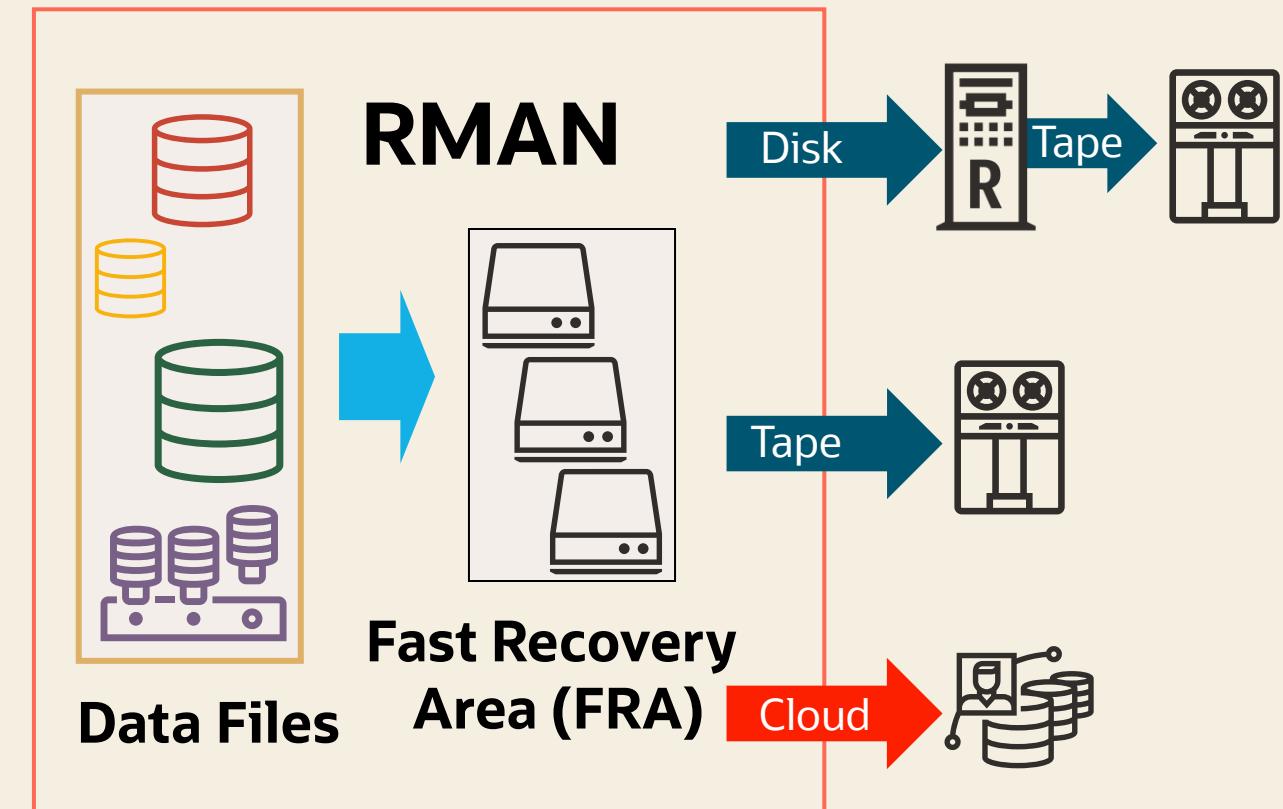
Pluggable Database Backup, Restore and Recovery

- Backup and restore pluggable database ...
- Create Restore Point 'before_event' for pluggable database...
 - Normal or Guaranteed Restore Point
 - Clean Restore Point
- Flashback Pluggable Database
- Complete ZDLRA support

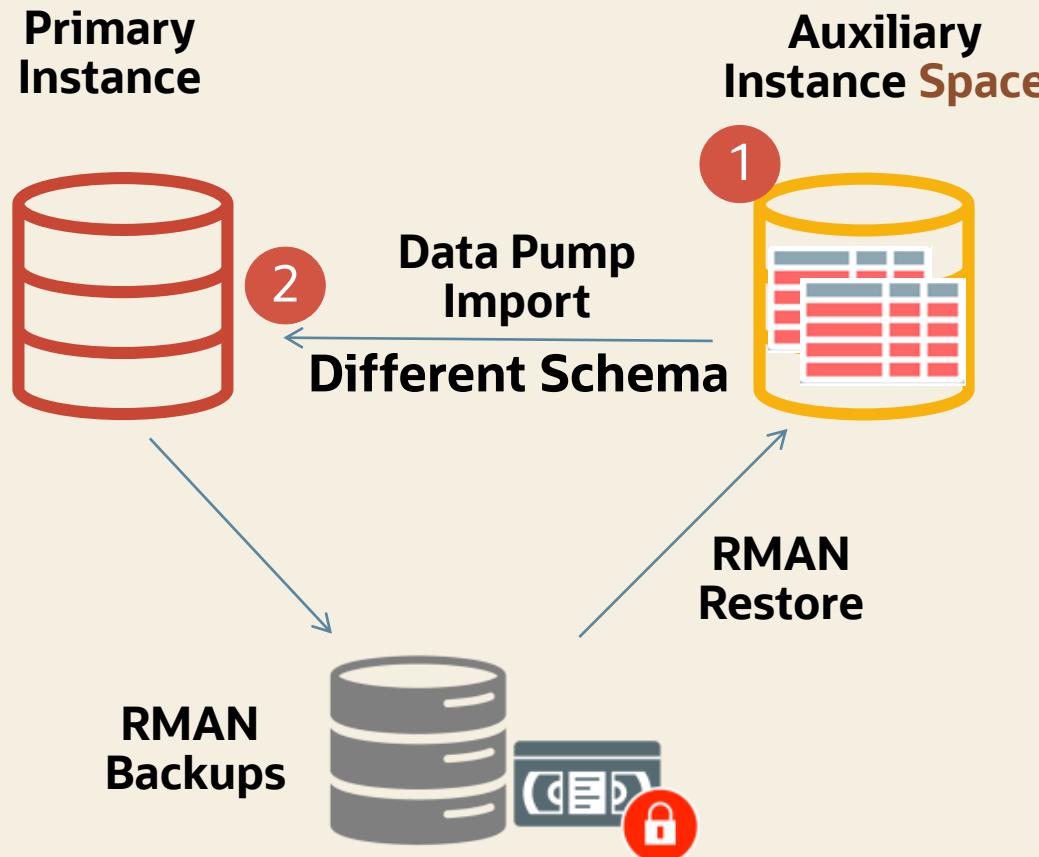
Oracle Recovery Manager - RMAN

Database Integrated Backup and Recovery

- Unique knowledge of database file formats and recovery procedures
 - Oracle block validation
 - Online block-level recovery
 - Native encryption, compression
 - Table/partition-level recovery
 - Oracle Multitenant support
- Tape and cloud backups
- Unified Management



RMAN Enhancements for Table Recovery

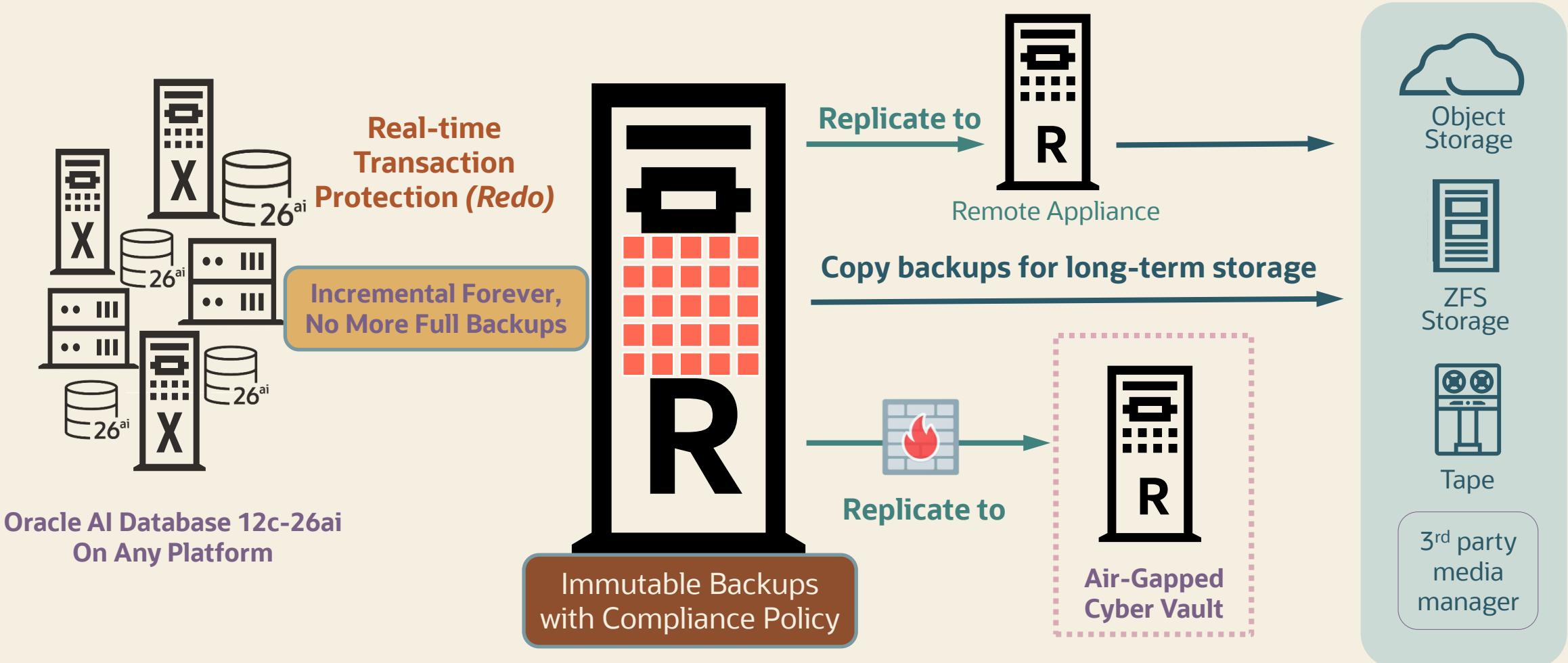


- 1) Check Auxiliary Instance Disk Space
 - Automated Table Recovery requires disk space for SYSTEM, SYSAUX, UNDO and User Tablespace(s)
 - Pre-check for space in the Auxiliary Instance disk space to avoid failures in the middle of the process
- 2) Recovery Across Schema
 - Enables Table level recovery under different schema
 - Provide **OLD: NEW Schema(s)** under **REMAP TABLE**

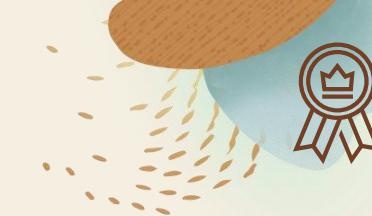
```
RECOVER TABLE hr.department, sales.product
UNTIL SCN 1234 AUXILIARY DESTINATION
' /tmp/' REMAP TABLE
hr.department:dev.testdepartment,
sales.product:mkt.newproduct;
```

Recovery Appliance Recommended

Continuous data protection and multi-tiered backup addressing compliance requirements



Database and Exadata Health Checks



Assessment Report

- Health Score, Summary Findings

Findings & Recommendations

• How to Solve the problem?

MAA Score Card

- MAA architectural readiness and configuration practices

Oracle Exadata Assessment Report

Maximum Availability Architecture (MAA) Scorecard							
Outage Type	Status	Type	Message	Status On	Details		
		<p>Description Proactive hardware and software maintenance helps avoid critical issues and helps maintain the highest stability and availability of your system. By running the latest version of exachk, automatic detection occurs for the following:</p> <ol style="list-style-type: none"> 1. Software version mismatches on the system. 2. Known critical issue exposure for your specific environment. 3. Software releases that are older than recommended versions. <p>Furthermore, the suggested "Recommended Versions" can be leveraged when planning for your next planned maintenance window. Note that not all Exadata Software components need to be upgraded during one planned maintenance window; however, it is advised to maintain a regular maintenance schedule. The recommended frequency is 3 to 12 months depending on business requirements. Oracle recommends patching and upgrading in the following order:</p> <ol style="list-style-type: none"> 1. Grid Infrastructure Software and Oracle Database Software. Grid Infrastructure should always be equal to or higher than the highest Oracle Database Software version. 2. Exadata Database Server Software. For Exadata Database Server Software upgrades, run and evaluate exachk and dbnodeupdate precheck outputs. 3. Exadata Storage Server Software. For Exadata Storage Server Software upgrades, run and evaluate exachk and patchmgr precheck outputs. 4. InfiniBand Switch Software. For InfiniBand Switch Software upgrades, run and evaluate exachk and patchmgr precheck outputs. 					
SOFTWARE MAINTENANCE BEST PRACTICES		FAIL	<p>Best Practices</p> <ol style="list-style-type: none"> 1. Note 1652019.1 - Oracle Sun Database Machine Cross Node Consistency Best Practice Checks 2. MAA Best Practices for Database Consolidation and Oracle Multitenant with Oracle 12c 3. Oracle Exadata Software Planned Maintenance 4. Note 5938228 - Oracle Exadata Software and Hardware Maintenance Planning Guide 5. Best Practices For Database Consolidation On Exadata Database Machine 6. Note 5938228 - Oracle Database Machine and Exadata Storage Server Supported Versions 7. Note 1270924.1 - Exadata Critical Issues 				
FAIL	OS Check	System is exposed to Exadata critical issue DB24		All Database Servers	View		
FAIL	Patch Check	System is exposed to Exadata critical issue DB28		All Homes	View		
FAIL	Storage Server Check	System is exposed to Exadata Critical issue EX19		All Storage Servers	View		
Component		Host/Location	Found version	Recommended versions	Status		
DATABASE SERVER	Database Home	/u01/app/oracle/product/11.2.0.4/dbhome_1	11.2.0.4.1	11.2.0.4.160119	11.2.0.4.8P is older than recommended		
	Grid Infrastructure	/u01/app/11.2.0.4/grid	11.2.0.4.1	11.2.0.4.160119	11.2.0.4.8P is older than recommended		
	Exadata	randomclm07,randomdm08	11.2.3.3.0	12.1.2.1.3 or 12.1.2.2.1	Older than recommended version		
STORAGE SERVER	Exadata	randomclm01,randomclm03,randomclm04,randomclm05,randomclm06,randomclm07,randomclm08	11.2.3.3.1	11.2.3.3.1	Older than recommended version		
IB SWITCH	Firmware	randommse-ib01	2.1.8-1	2.1.5-1 or higher	Version within recommended range. Exception: Version is different from peers.		
		randommsw-ib02,randommsw-ib03,randommsw-ib04	2.1.3-4	2.1.5-1 or higher	Version within recommended range. Exception: Version is different from peers.		

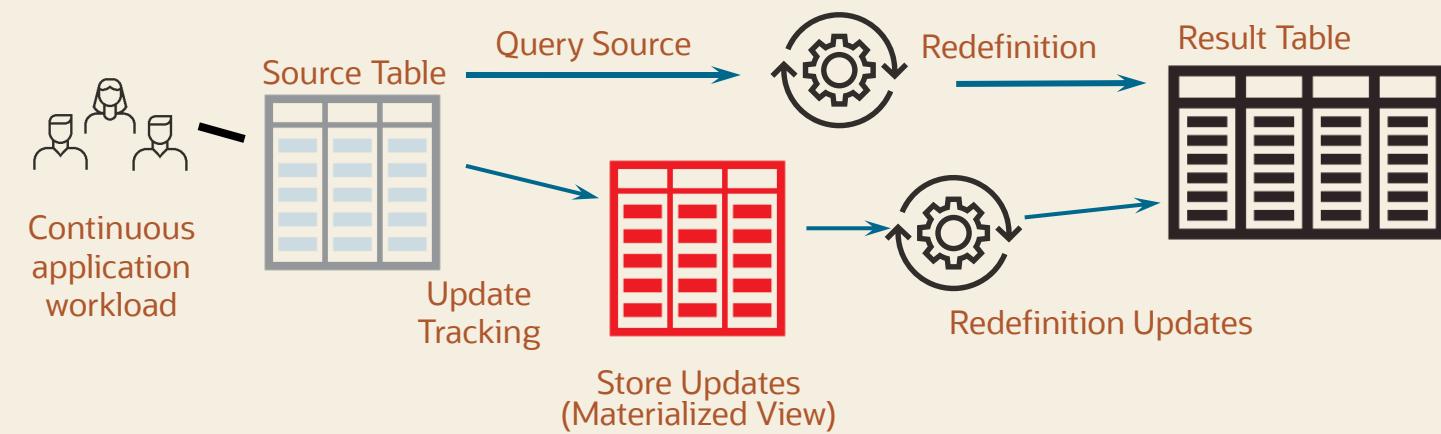
Note: Automated Orachk/Exachk Healthcheck MOS 107954.1 updated frequently



Online Operations

Redefine your data structures without taking tables offline

- Online Redefinition: reorganize and redefine tables online
 - Examples:
 - add/drop/rename/reorder columns
 - change physical storage structures
- Updates / queries not interrupted
- Resumes at point of any failure
- Ability to enable fast rollback to prior definition if needed
- Ability to monitor progress throughout redefinition operation

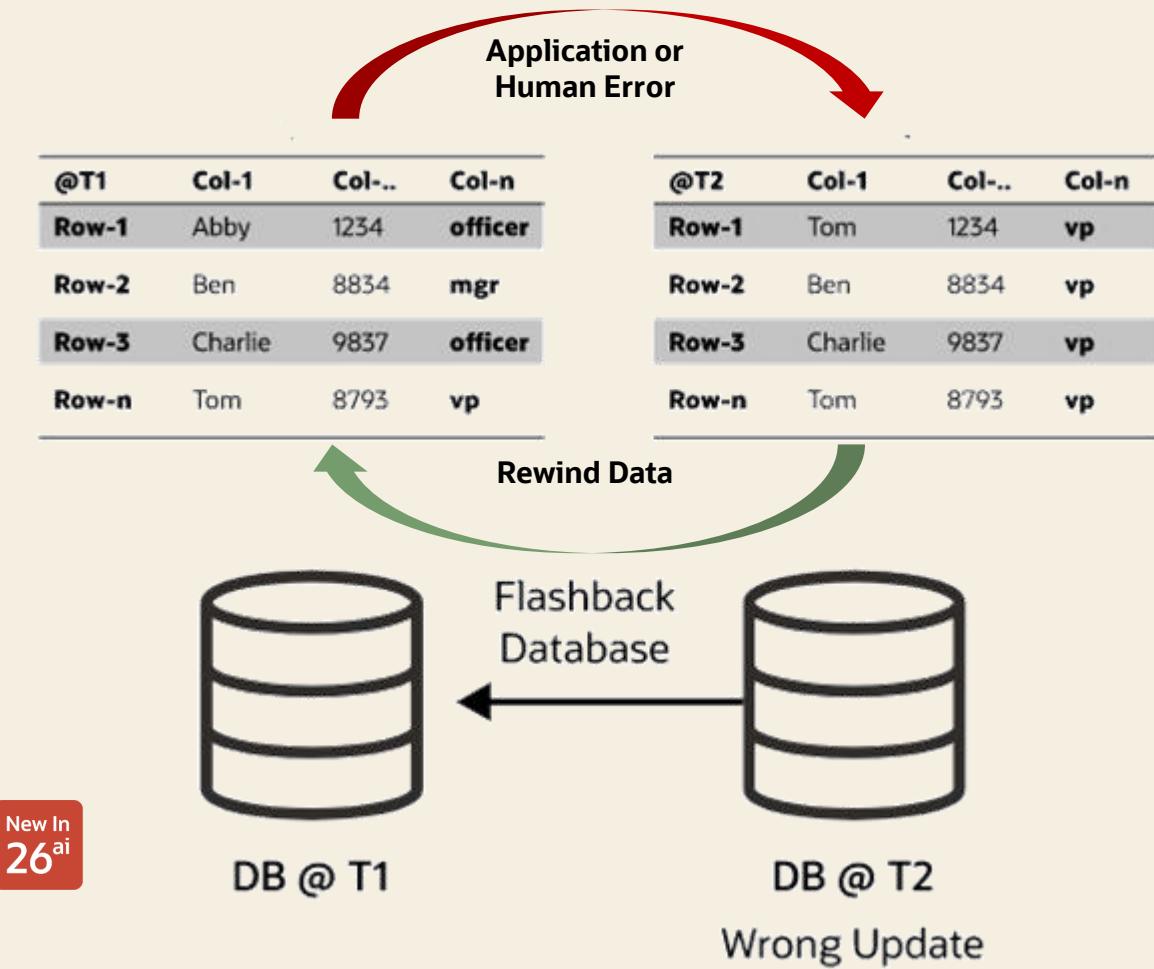


Flashback Technologies

Rewind Button for Oracle AI Databases



- Fast point-in-time recovery (PITR) without expensive restore operation
- Error investigation
 - View data as of previous point in time
- Error correction
 - Back-out a transaction
 - Incorrect table updates
 - Rewind the entire database
- *New in Oracle AI Database 26ai:*
 - Flashback Time Travel operates at the transactional level tracking and archiving transactional changes to tables



SILVER (Option 1)

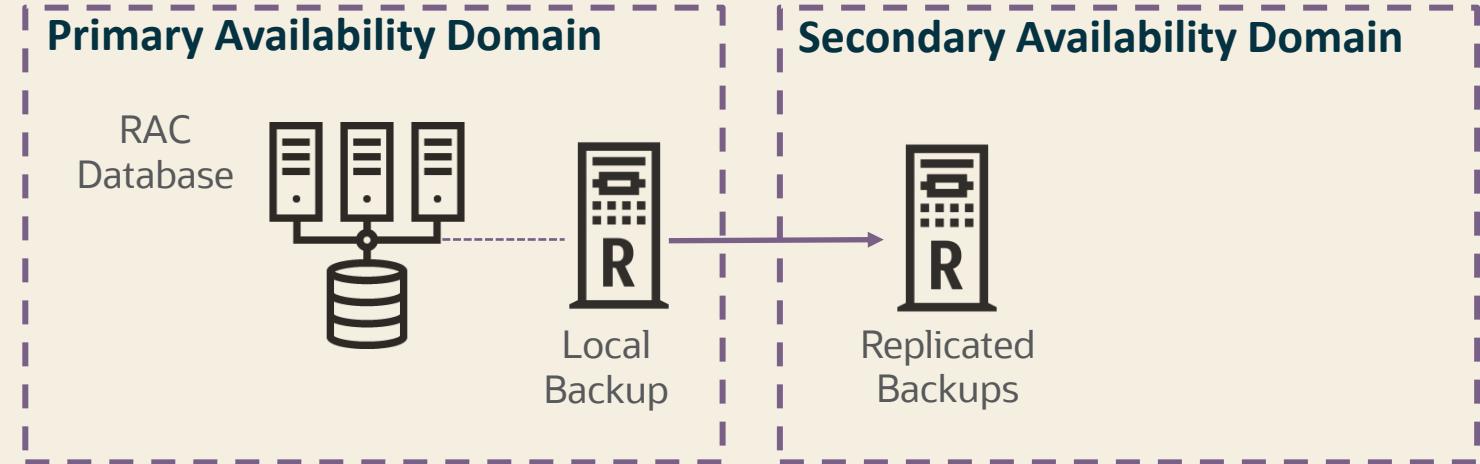
Prod/Departmental

Bronze +

- Real Application Clustering (RAC)
- Application Continuity
- Globally Distributed Database (Optional)
 - Provides fault isolation, scalability, and geographical distribution

Client connectivity best practices:

<https://docs.oracle.com/en/database/oracle/oracle-database/26/haovw/continuous-availability-applications.html>



Outage Matrix

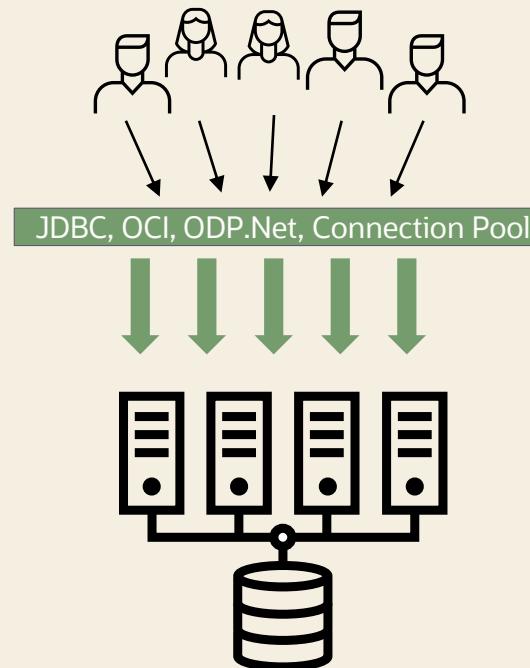
Unplanned Outage	RTO/RPO Service Level Objectives(f1)
Recoverable node or instance failure	<30 seconds (f2); single-digit minutes on non-Exadata
Disasters: corruptions and site failures	Hours to days. RPO since last backup or near zero with ZDLRA
Planned Maintenance	
Software/Hardware updates	Zero (f1)
Major database upgrade	Minutes to hour

f1: RPO=0 unless explicitly specified

f2: Fast sub-30 seconds role transition is on Exadata; near-zero with Application Continuity enabled.

Oracle RAC (Real Application Clusters)

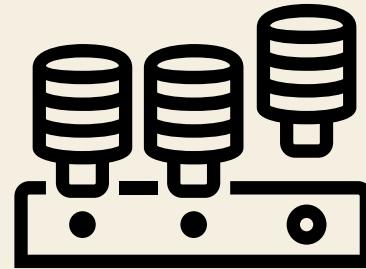
Active-active instances provide unmatched scalability, performance and availability



-  Unique scale-everything, highly available database architecture with concurrent active active instances
-  Scales OLTP, OLAP, and Hybrid Workloads and minimizes downtime with rolling patching
-  Applications supported on single instance runs without any changes on Oracle RAC
-  Applications scale by simply adding nodes to the cluster without incurring downtime

Oracle RAC 26ai Improvements

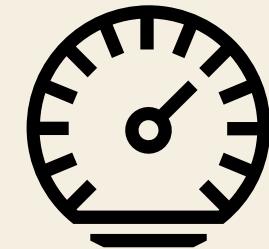
Parallel operations result in consistent performance



2X faster Pluggable Database Open
Parallel Distributed Lock Manager operations during PDB open



8X faster to create 10k services
14X faster to create, **23X** faster to delete individual services with 10k services

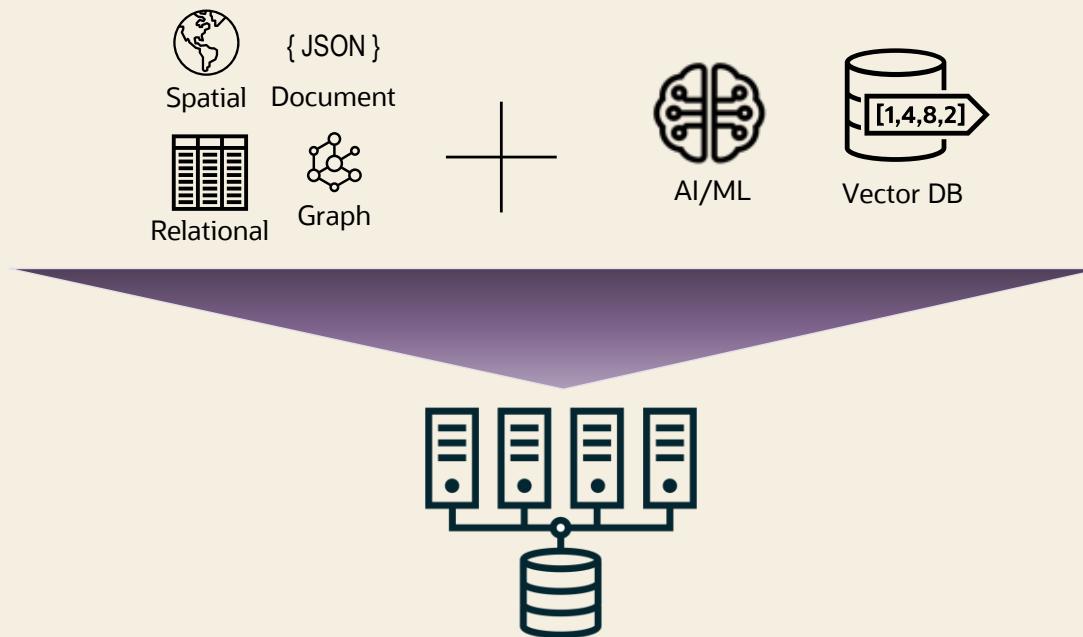


10X Faster start of work on instance crash or restart
Buddy Instance, Parallel operations on dirty buffers list and other features

Distribute Vector AI and OLTP workloads on Oracle RAC Instances

Realtime insights without interrupting or slowing business operations

Integrate AI Vector Search with Business Data

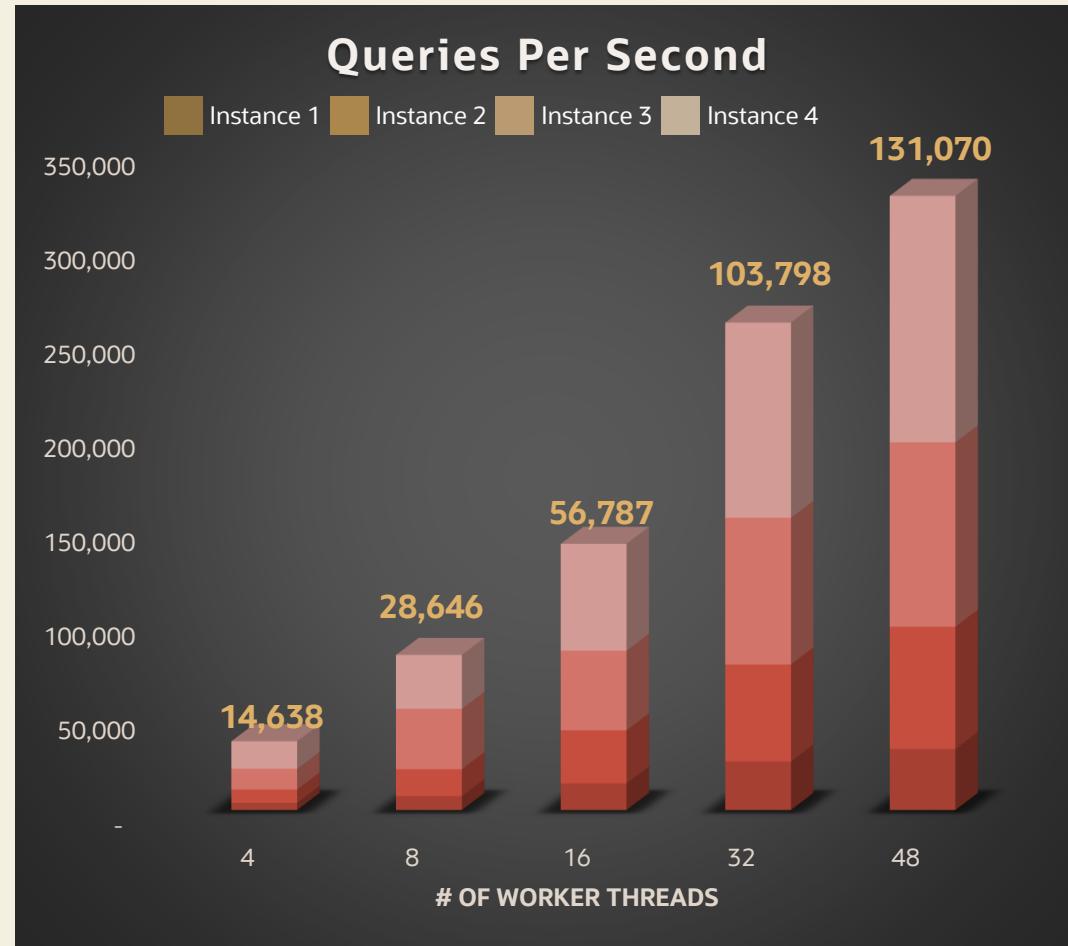


Best of both: Isolate ongoing Business operations on one set of instances while running RAG workloads on another

- Integrate AI Vector search on business-critical data with simple-to-use SQL that can benefit from both inter-node and intra-node parallel operations.
- Active-Active Oracle RAC
 - Protects against outages due to hardware failures
 - Scales performance as workloads can run concurrently on different Oracle RAC instances
- Even better performance, scalability and high availability on Engineered Systems such as Exadata

Performance of sample AI Vector Search workload on Oracle RAC

Data Set: GloVe-25 | ~1.2 million rows (VECTOR(25, FLOAT32))



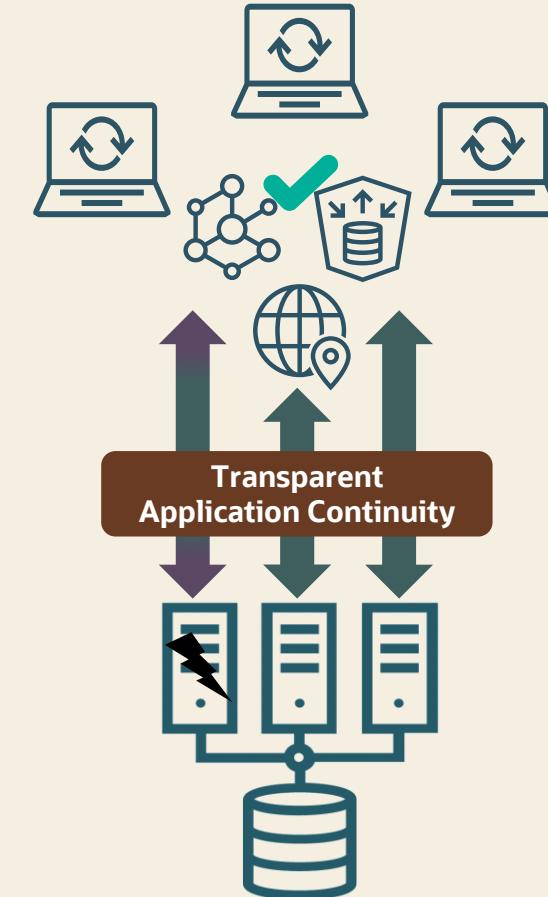
- Oracle RAC scales the GloVe-25 workload linearly across all the instances
 - The GloVe-25 dataset contains pre-trained, 25-dimensional word vectors generated using the GloVe (Global Vectors for Word Representation) algorithm
 - Each entry maps a single English word to a compact numerical representation based on semantic similarity
 - ~99% of the query elapsed time was CPU time

Transparent Application Continuity (TAC)

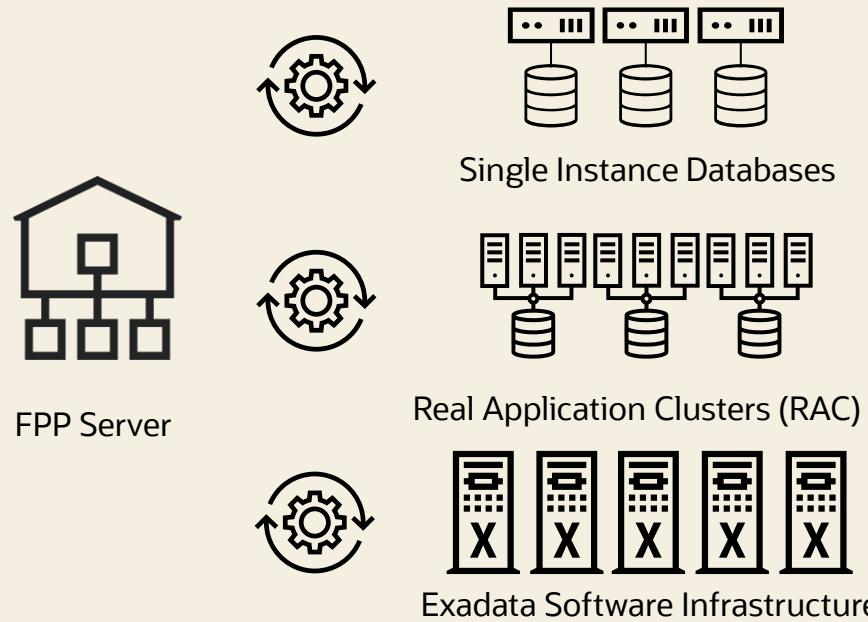
Keeps applications online during outages without requiring any custom error handling

- Hide downtime from end-users
 - TAC rebuilds the session state and replays in-flight transactions as part of automated session failover
- Eliminate errors unless unrecoverable
 - For both planned maintenance and unplanned outages
- Fast Application Notification (FAN) and session draining
 - FAN notifies clients of database status changes - helps break applications out of TCP timeouts
 - Draining causes sessions to complete their work on a given instance to prepare the node or the database for maintenance - no application changes required
- Best used with an Oracle (compatible) connection pool
- Oracle AI Database 26ai provides Application Continuity through DBMS_ROLLING operations.

New In
26^{ai}

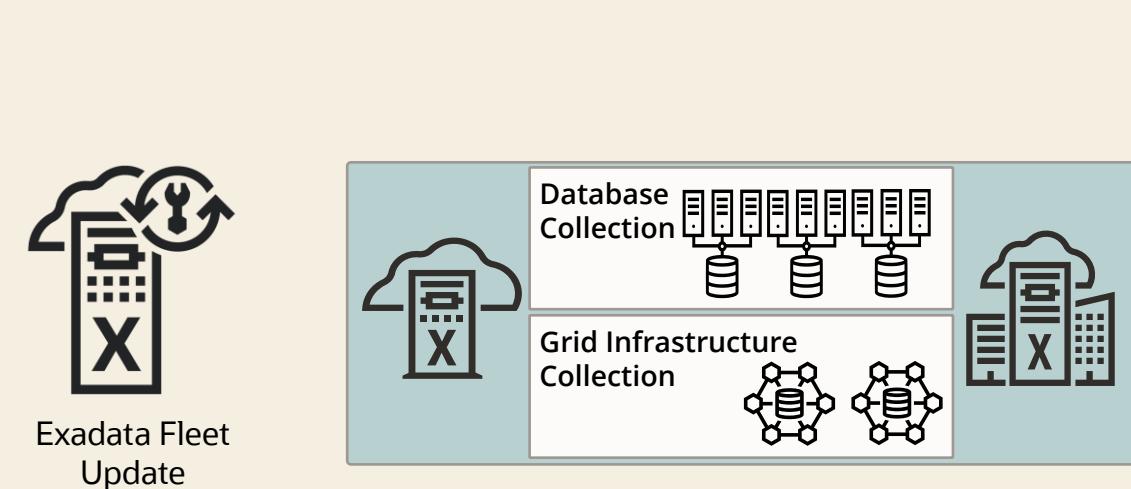


Fleetwide maintenance on-premises and for ExaDB in OCI



Fleet Patching & Provisioning:

- Gold image-based drift detection
- Integrated job scheduling
- User actions for extensibility
- Comprehensive Exadata Patching
- Full-stack Exadata patching



Exadata Fleet Update:

- Group multiple Oracle AI Databases and Oracle Grid Infrastructures into collections
- Rolling and non-rolling, session draining, scheduling of pre-check, staging, and patch operations
- Less complexity with out-of-place patching mechanism
- Available for ExaDB-D and ExaDB-C@C deployments

SILVER (Option 2)

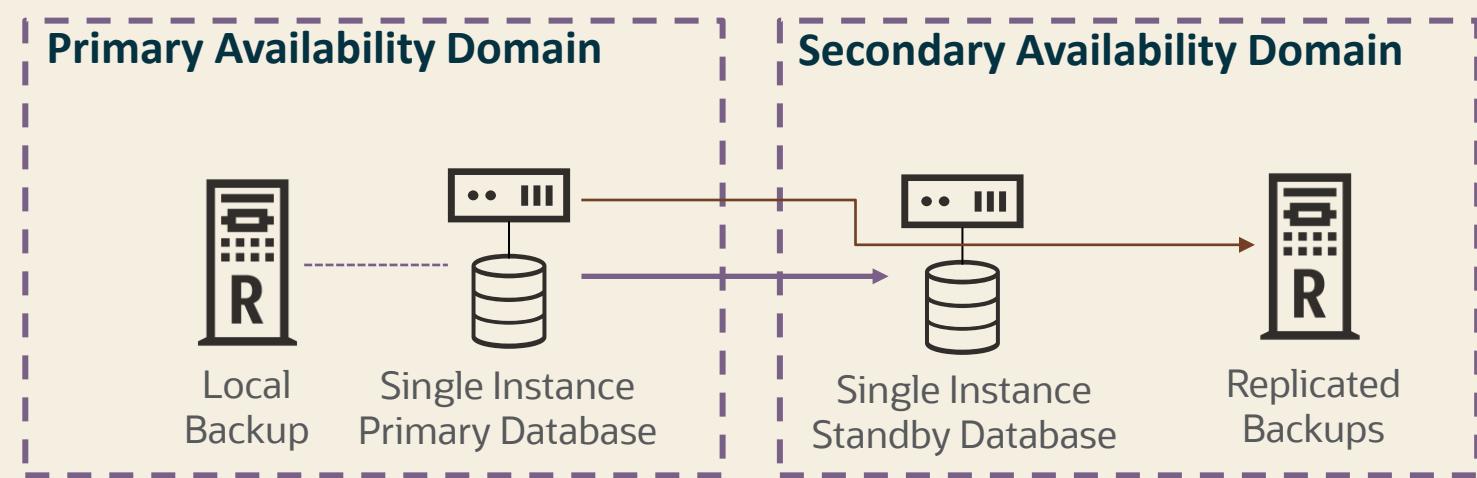
Prod/Departmental

Bronze +

- Local Standby Database using Data Guard
 - Protects from local failures but minimal benefits for planned maintenance
- Globally Distributed Database (Optional)
 - Provides fault isolation, scalability, and geographical distribution

Client connectivity best practices:

<https://docs.oracle.com/en/database/oracle/oracle-database/23/haovw/continuous-availability-applications.html>

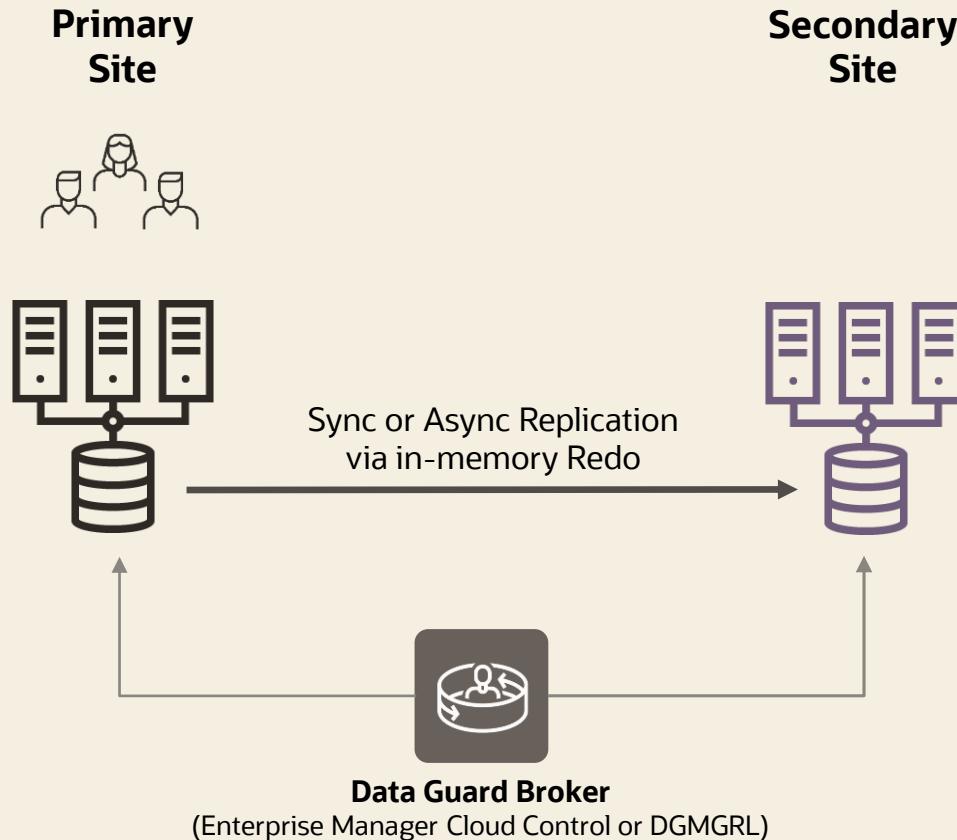
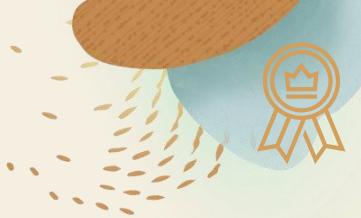


Outage Matrix

Unplanned Outage	RTO/RPO Service Level Objectives(f1)
Recoverable local failure	< 1 min
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: To achieve minimal downtime or lowest impact, apply application client best practices; Batch jobs should be deferred outside planned maintenance window.

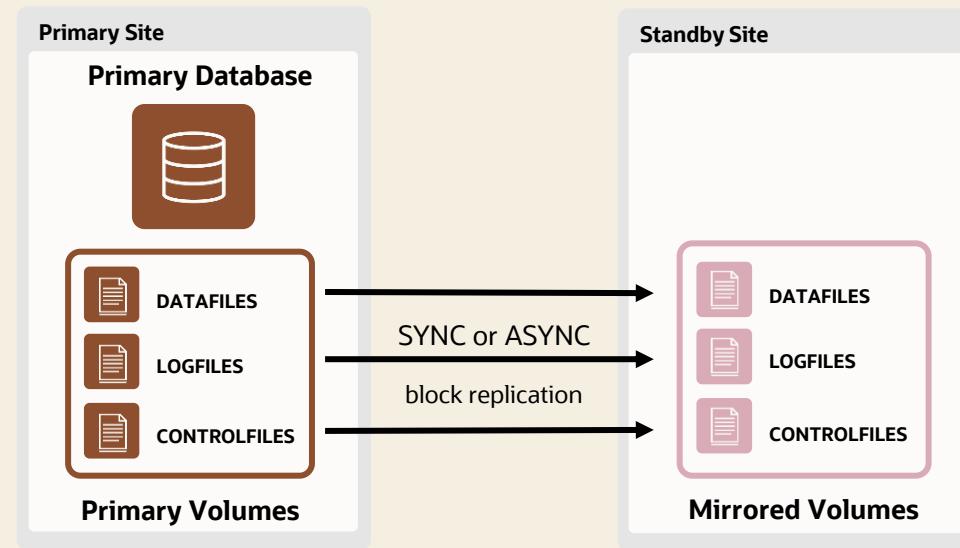
Oracle Data Guard



- **Basic in-memory redo replication (included with DB EE)**
 - License primary and secondary sites
- **Active-passive**
 - Standby is used only for failovers
- **Automatic failover to Standby site**
- **Zero / near-zero data loss**
- **Continuous data validation**
- **Simple migrations and upgrades**

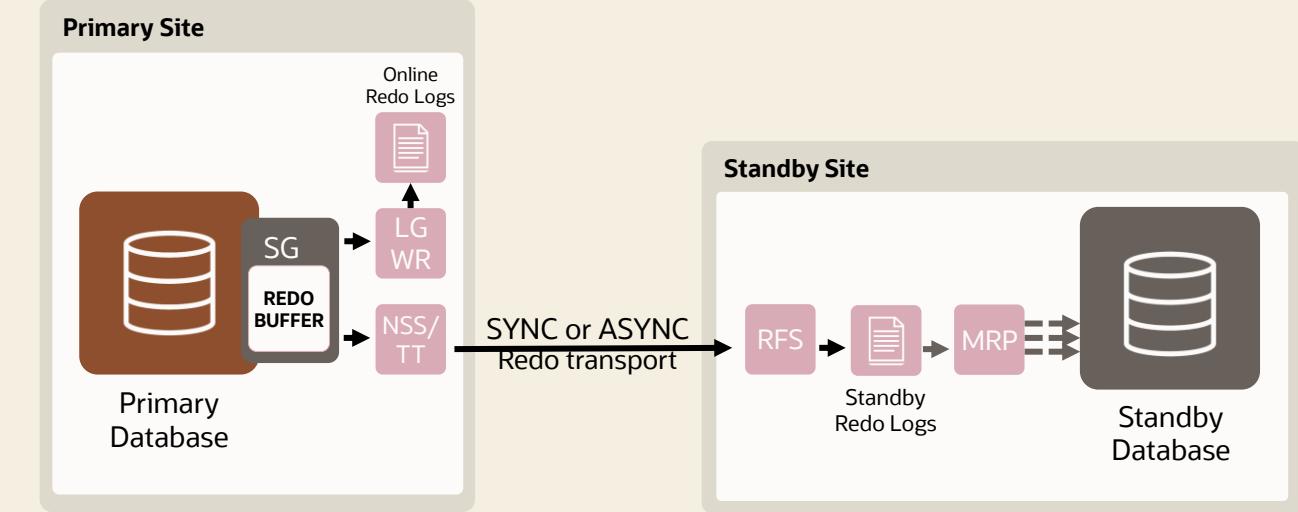
Data Guard is Optimized for the Database

Better than storage mirroring or 3rd party solutions



Traditional replication

- Corruptions are replicated
- Unusable destination
- 7x network volume
- 27x network I/O
- Standby needs warm-up

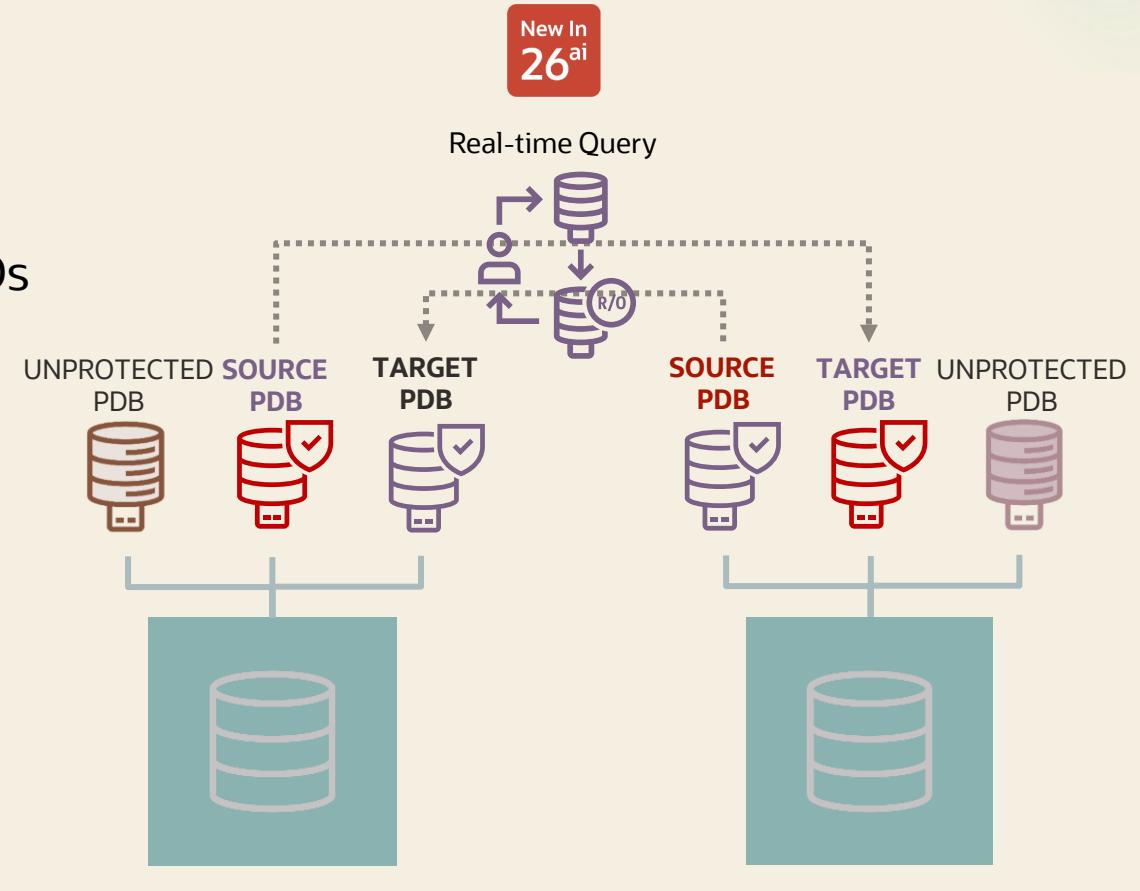


Data Guard replication

- **Validation end to end**
- **Ransomware Protection**
- Only the essential information is replicated
- Efficient and performant
- **Implicit Integrity**

Data Guard per Pluggable Database

- Two Container Databases (CDB) actively running workload
 - Both open read-write with different database IDs
- Disaster Protection at the PDB level
 - No need to fail over a full Container Database
 - Role transition on a single PDB with Data Guard Broker
 - Automatic gap fetching from the source
 - ASYNC support
- Real-Time Query for DGPDB configurations now available in Oracle AI Database 26ai



Global scale with Globally Distributed Database

Horizontal partitioning of data across independent databases (shards)

- Each shard holds a subset of the data
- Replicated for high availability

Shared-nothing architecture

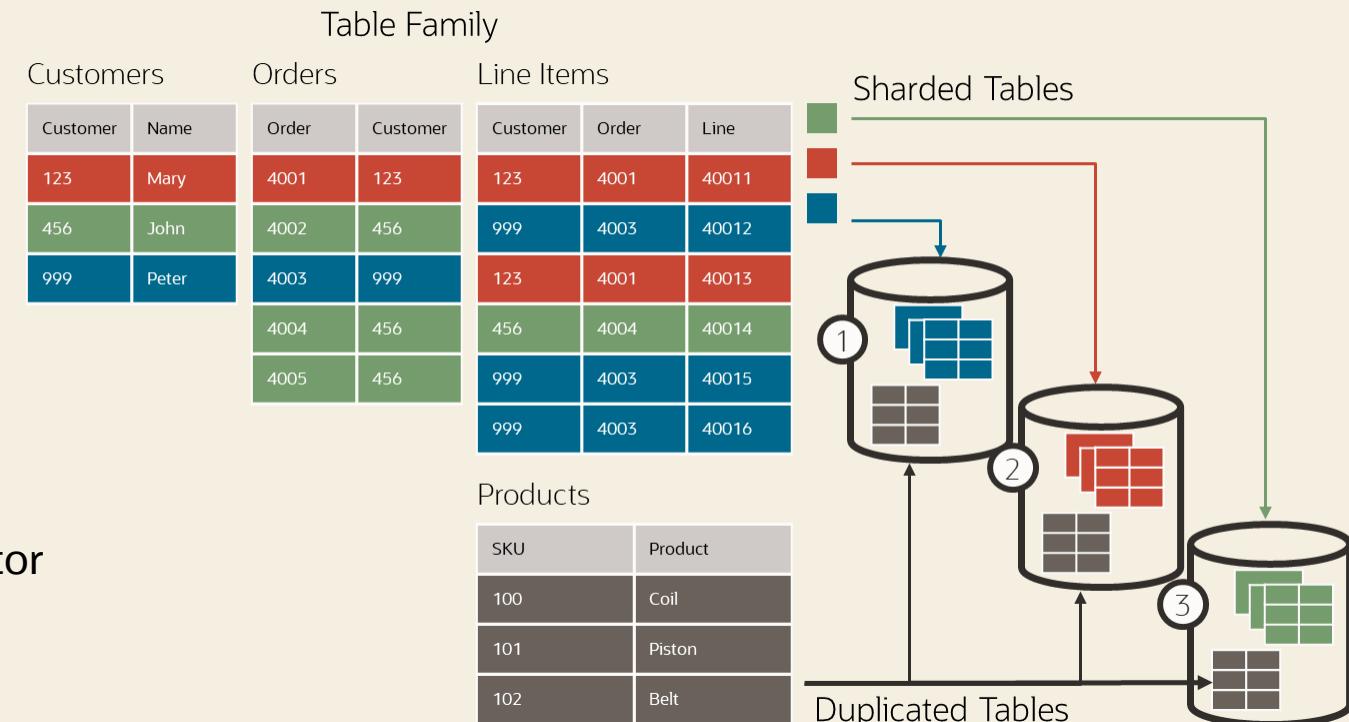
- Shards don't share any hardware (CPU, memory, disk), or software (Clusterware)

Massively Parallel Processing

- Application connects directly to a shard
- Multi-Shard queries go through the coordinator

Ideal for data sovereignty

- User-defined data placement for complying with regulatory requirements
- New in Oracle AI Database 26ai:
 - RAFT replication option for Globally Distributed Database



Active-active Globally Distributed Database

Raft Replication

Built-in replication, integrated with transaction execution

Fast and automatic sub-3-second failover with zero data loss

Active-active, symmetric configuration

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

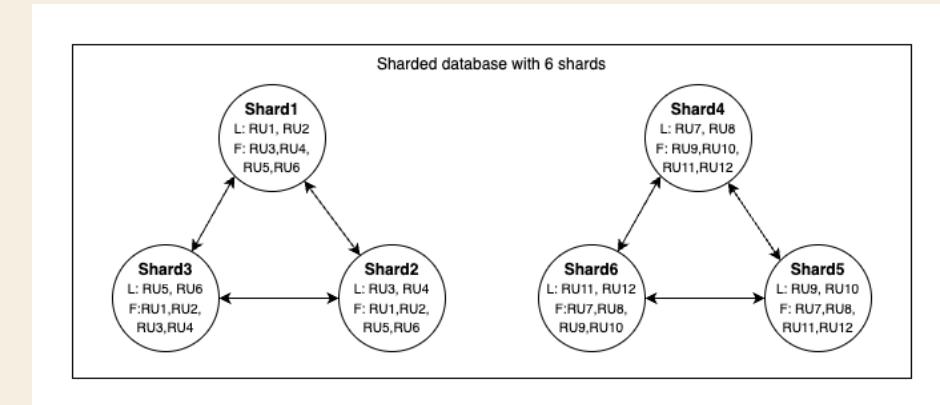
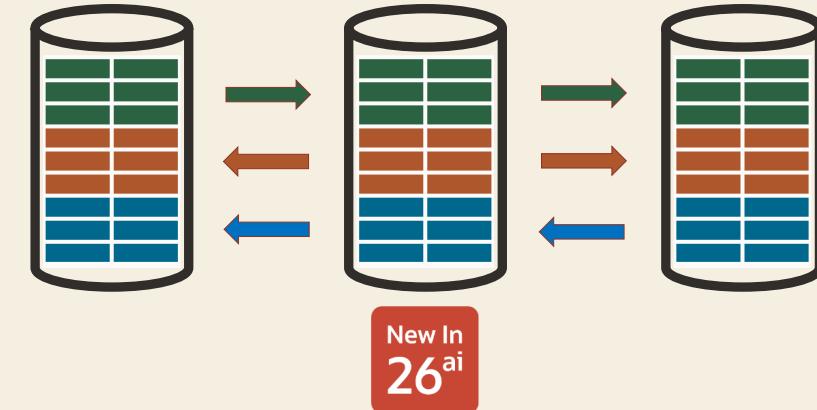
Easy: no need to configure Data Guard or GoldenGate for shards

Globally Distributed Database is divided into multiple replication units

- Replication unit replicas are spread evenly across 3 (or more) shards
- Each shard is both a primary (leader) for some replication units and a follower (replica) for other replication units

Builds on popular Raft distributed consensus protocol

- Guarantees consistency among replicas in case of failures, network partition, message loss, or delay
- Automatic reconfiguration after failure, or when the number of shards changes



GOLD

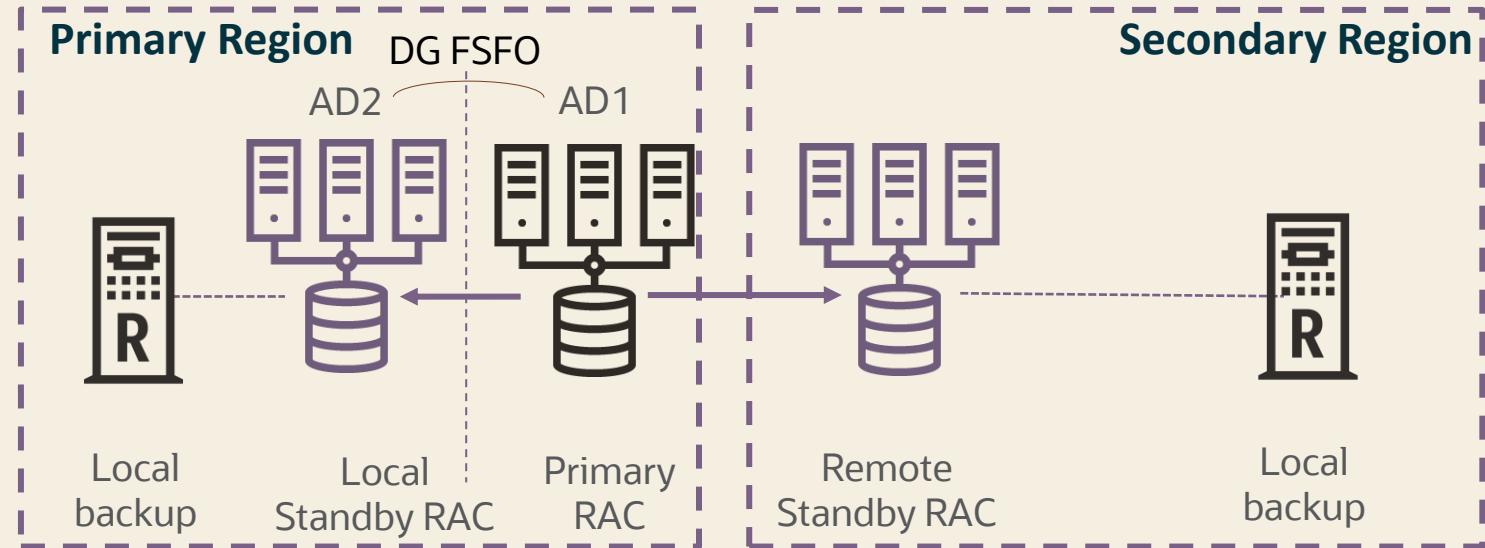
Business Critical

Silver (Option 1 with RAC) +

- 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



Outage Matrix

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

f1: RPO=0 unless explicitly specified

f2: To achieve zero downtime or lowest impact, apply application checklist best practices; Batch jobs should be deferred outside planned maintenance window.

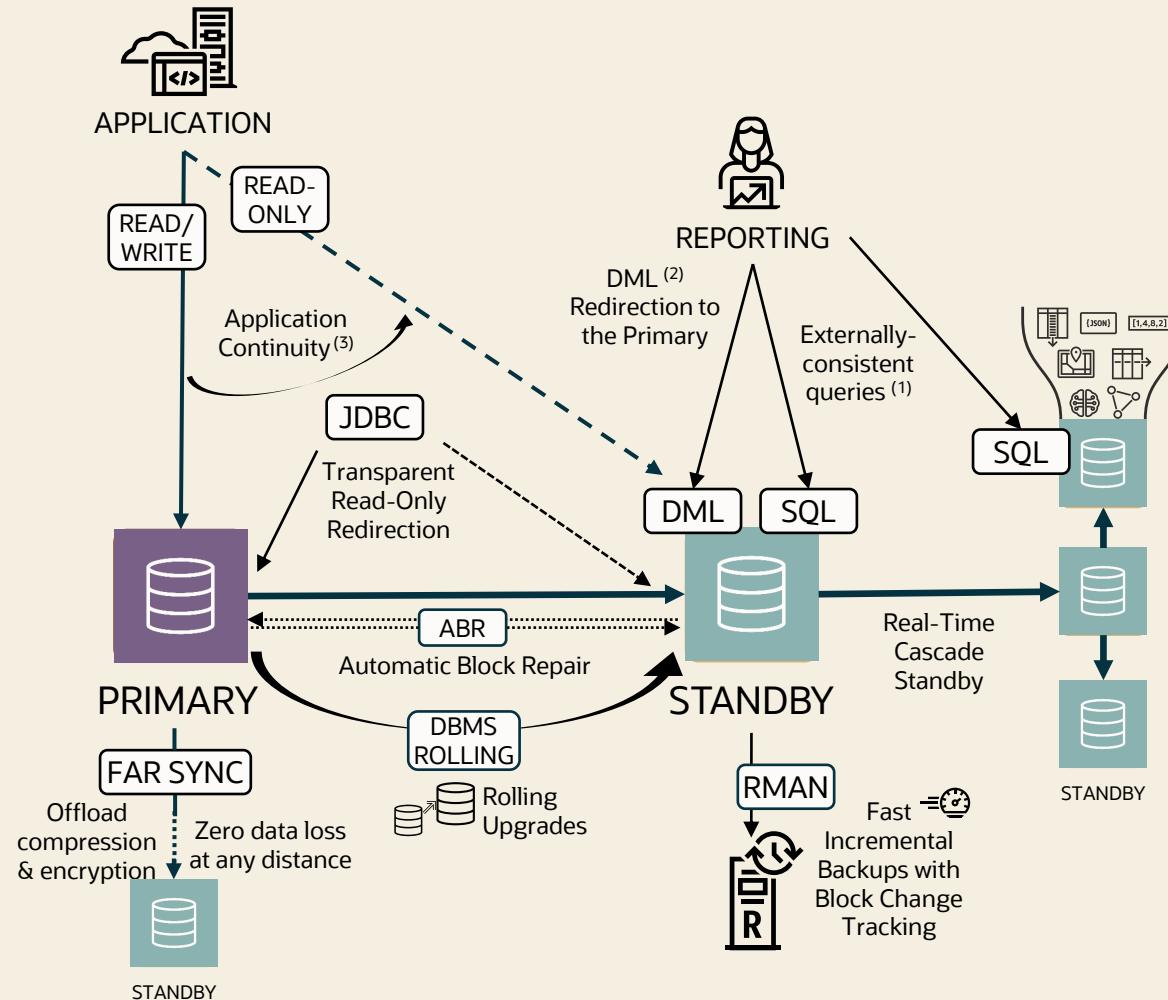
Oracle Data Protection

Gold – Comprehensive Data Protection



	Physical Block Corruption	Logical Block Corruption
Manual	Dbverify, Analyze	Physical block checks Logical checks for intra-block and inter-object consistency
	RMAN, ASM	Physical block checks Intra-block logical checks
Runtime	Active Data Guard	<ul style="list-style-type: none">Continuous physical block checking at standbyStrong isolation to prevent single point of failureAutomatic repair of physical corruptionsAutomatic database failover (option for lost writes) <ul style="list-style-type: none">Detect lost write corruption, auto shutdown and failoverIntra-block logical checks at standby
	Database	In-memory block and redo checksum In-memory intra-block checks, shadow lost write protection
	ASM	Automatic corruption detection and repair using extent pairs
	Exadata	HARD checks on write, automatic disk scrub and repair HARD checks on write

Oracle Active Data Guard



Offload & scale

Don't leave your standby infrastructure idle:

- **Offload** queries, reports, and backups
- **Linearly scale** the application's read-only activity
- **Increase** read/write **throughput** by freeing important resources
- Transparently load balance across replicas

Enhanced protection

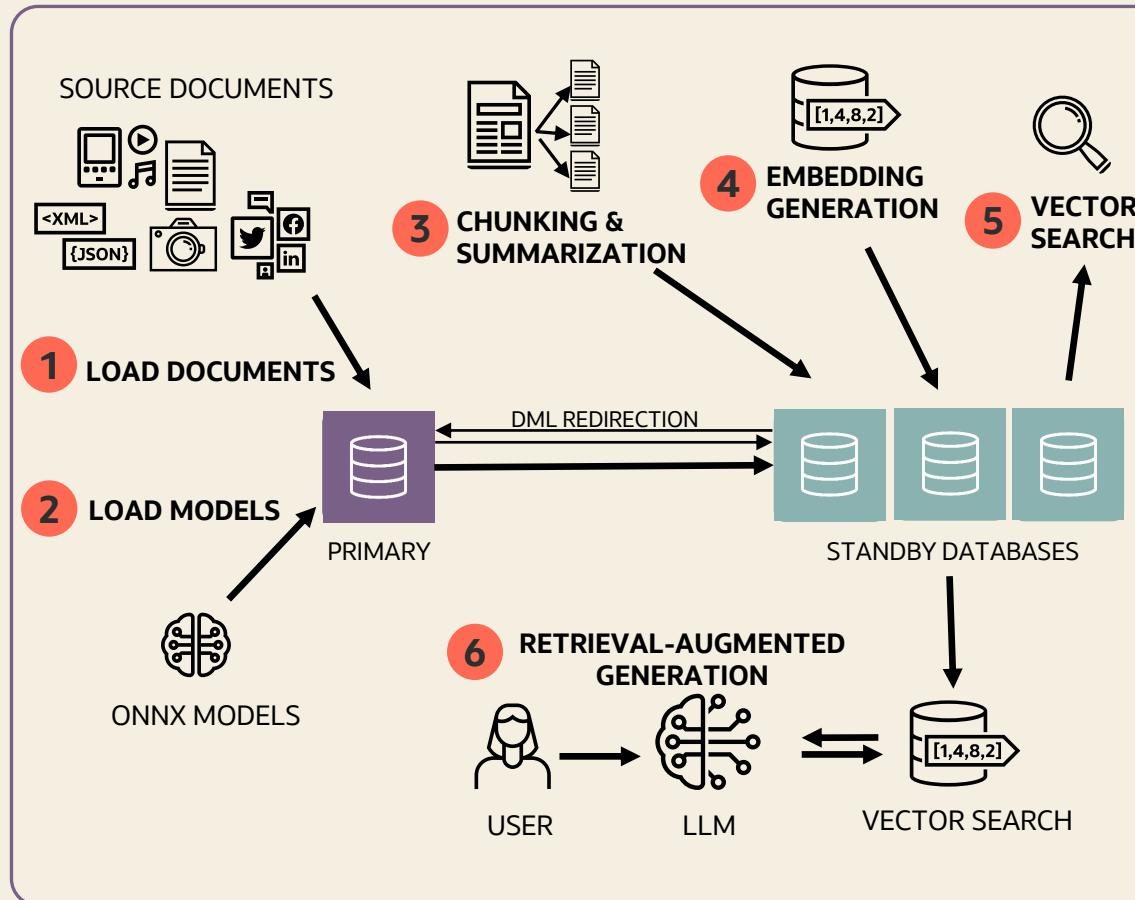
- All your transactions are **protected regardless of the distance**
- Block corruptions are **fixed on the fly without application errors**
- Cascaded standbys protect your transactions without delay
- Backups are **incredibly fast**, also on the standby database

Higher availability

- Major **upgrades** are **transparent** or require minimal downtime
- **Mask failovers** to the application **without additional coding**

Offload Inferencing and AI Vector Search to Oracle Active Data Guard

Leverage the standby for AI workloads, keeping the primary free for mission-critical transactions



- Offload CPU-intensive workloads
 - Inferencing
 - Chunking and summarization
 - AI Vector Search
- Embeddings are created on the standby database
- Vectors are inserted via DML Redirection
- Standby resources are fully utilized

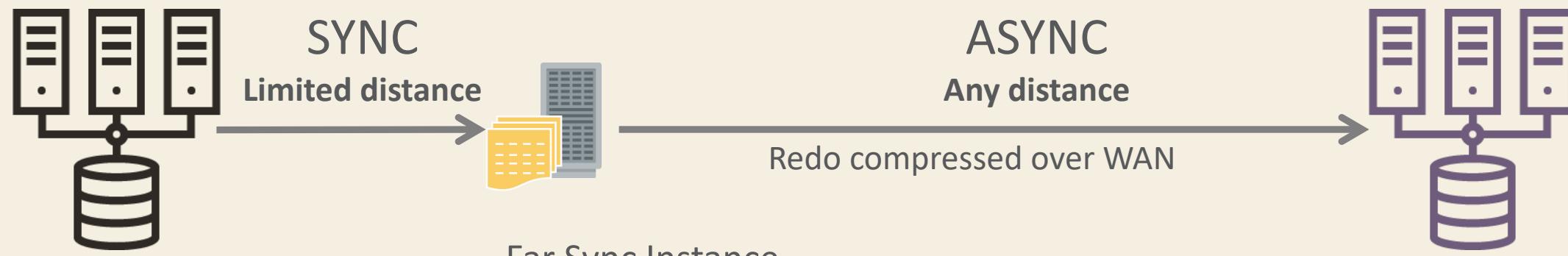
Primary database performance is unaffected



<https://blogs.oracle.com/maa/onnx-on-active-data-guard>

Active Data Guard Far Sync

Zero Data Loss Protection at Any Distance



Primary Database

- Production copy

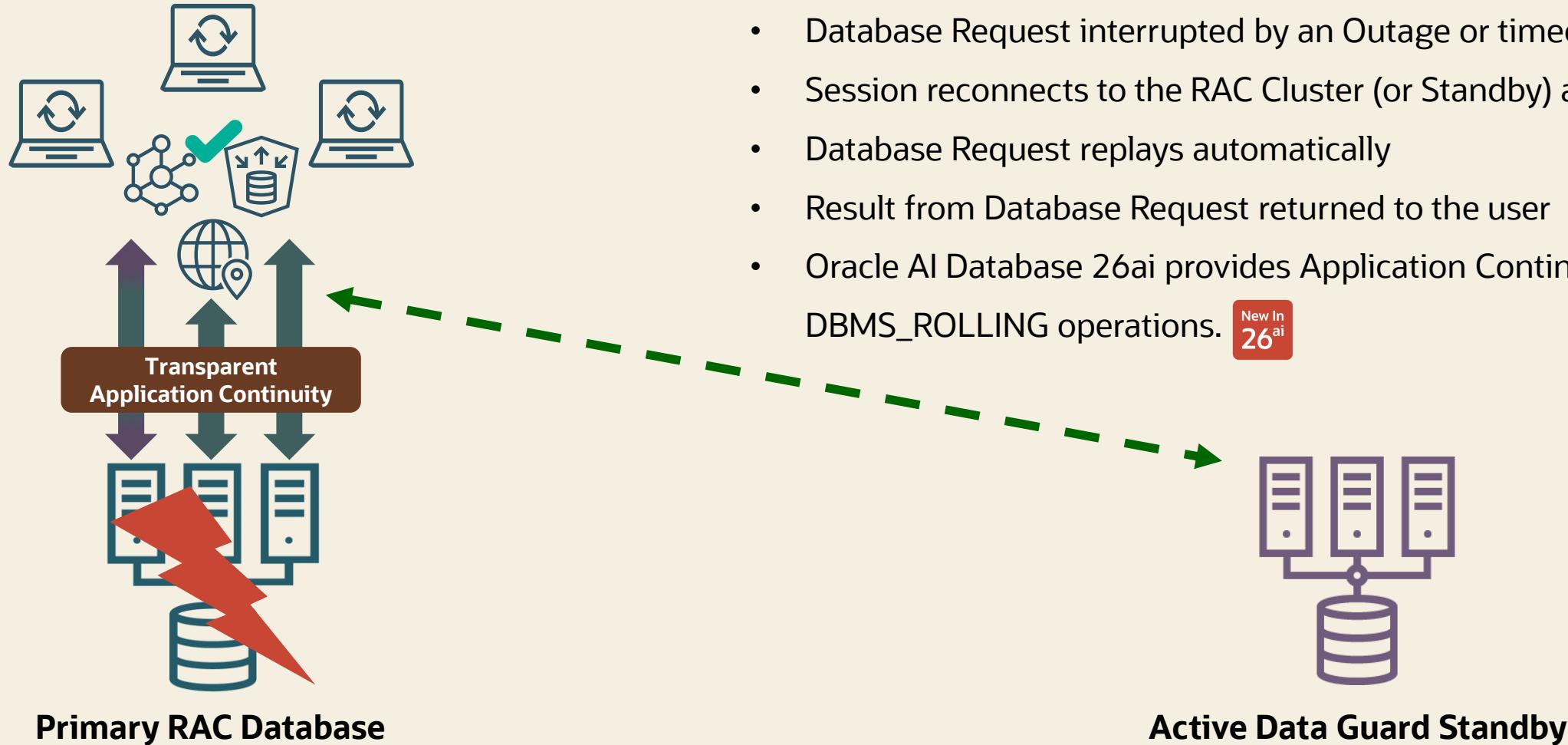
Far Sync Instance

- Oracle control file and log files
- No database files
- No media recovery
- Offload transport compression and/or encryption

Active Standby Database

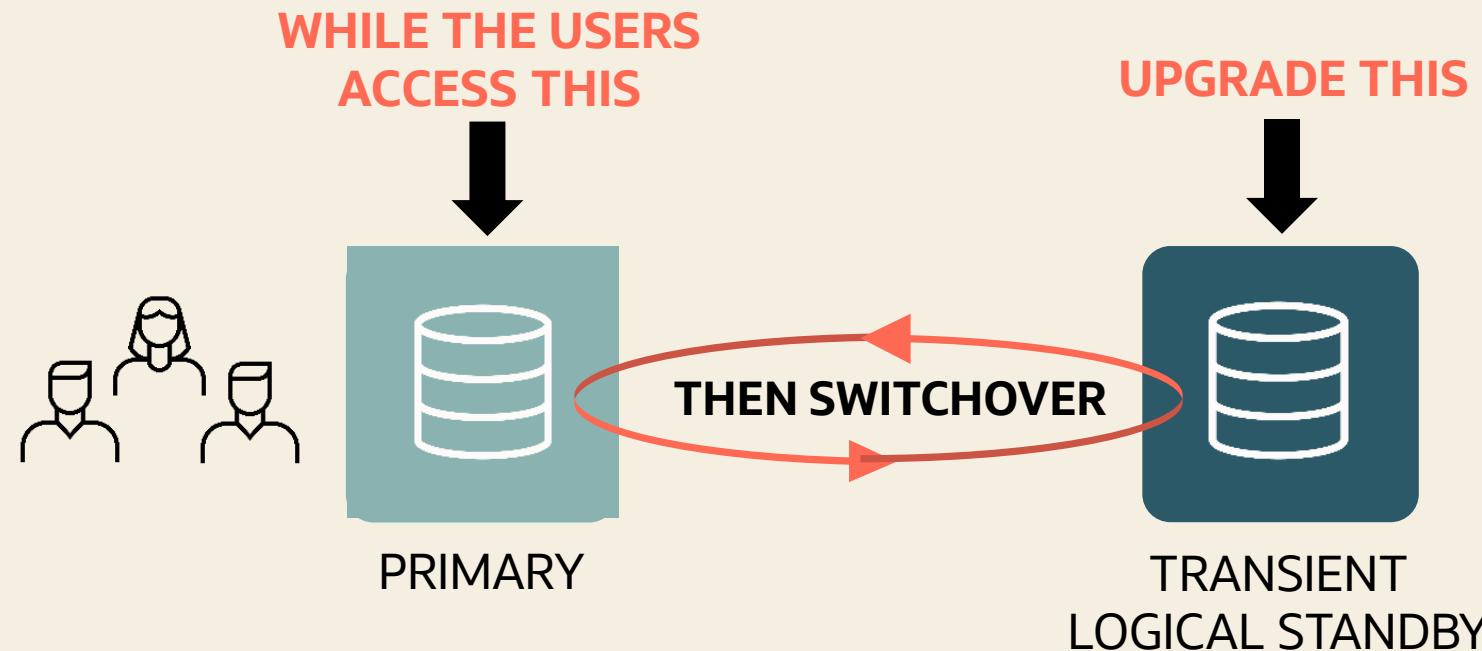
- Zero data loss failover target
- Database open read-only
- Continuous Oracle validation
- Manual or automatic failover

Unplanned Outages, Application Continuity expanded to the Standby



Active Data Guard Rolling Maintenance and Upgrades

Using DBMS_ROLLING package

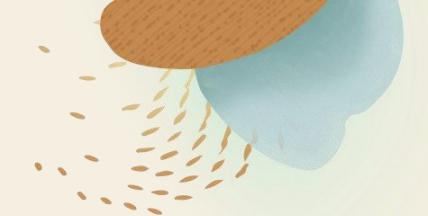


- Use a transient logical standby database to upgrade with very little downtime.
- The only downtime is as little as it takes to perform a switchover.
- Oracle AI Database 26ai provides Application Continuity Support

New In
26^{ai}

Different Ways to Configure Oracle Data Guard

For easy integration with DevOps and configuration pipelines



```
DGMGRL> create configuration mydb  
> as primary database is mydb  
> connect identifier is 'clu-scan:1521/mydb'
```



```
SQL> DG create configuration mydb as primary database is  
mydb connect identifier is 'clu-scan:1521/mydb'
```



```
DECLARE  
  severity BINARY_INTEGER;  
  retcode  BINARY_INTEGER;  
BEGIN  
  retcode := DBMS_DG.CREATE_CONFIGURATION (  
    config_name      => 'mydb'  
    primary_ci       => 'clu-scan:1521/mydb'  
    severity         => severity  
  );  
END;
```



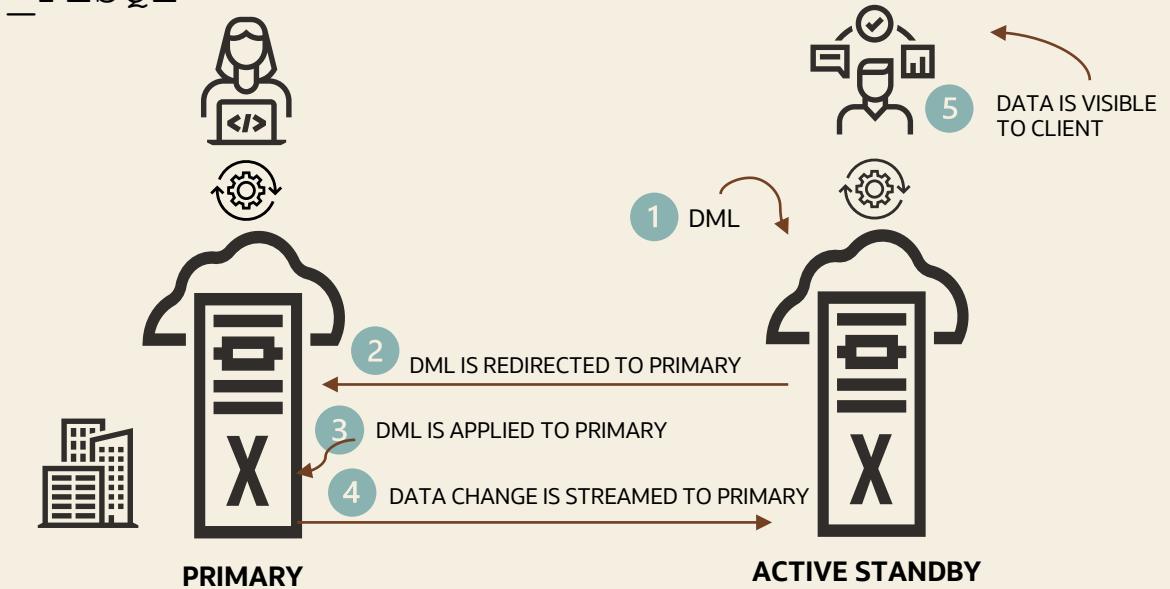
```
POST /database/dataguard/configuration/  
{  
  "primary_connection_identifier": "clu-scan:1521/mydb",  
  "primary_database": "mydb_site1"  
}
```



Extend Footprint of Active Data Guard Applications

Support for DML Re-direction

- DML Re-direction is automatically performed from an Active Data Guard standby to the primary (**ACID uncompromised**)
- New parameter `ADG_REDIRECT_DML` controls DML Redirection
- New `ADG_REDIRECT_DML` and `ADG_REDIRECT_PLSQL`
- “Read-Mostly, **Occasional Updates**” applications supported for Oracle AI Database 19c and above





Tunable Automatic Outage Resolution

Data Guard maintains internal mechanisms that detect and correct issues with its redo transport and gap resolution processes

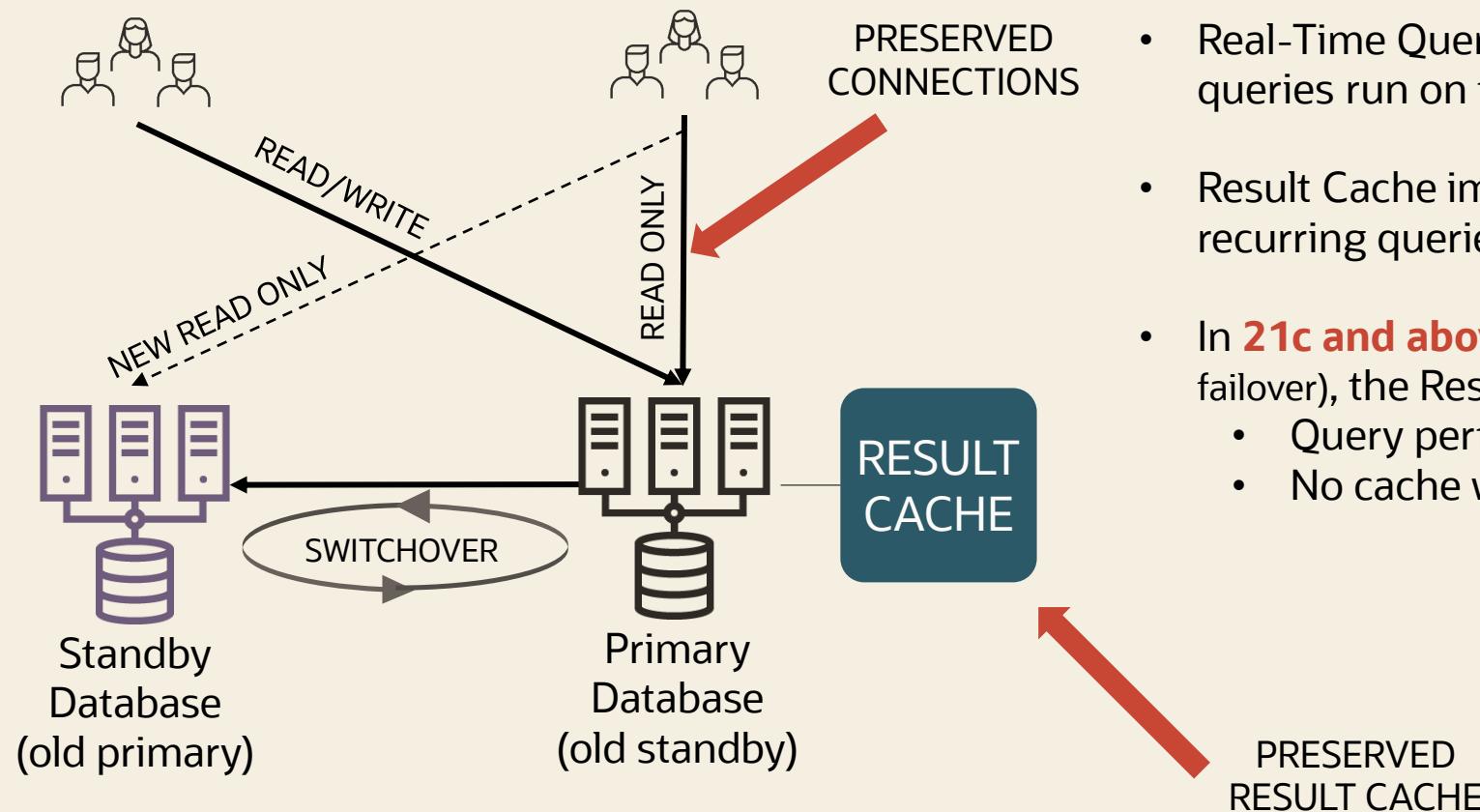
- In case of network or disk I/O problems, these mechanisms prevent those processes from hanging and causing unnecessarily *long gaps (or is it hangs?)*

Use the following parameters to influence the outage resolution:

- **DATA_GUARD_MAX_IO_TIME**
 - Sets the maximum number of seconds that can elapse before a process is considered hung while performing reads, writes, and status operations.
- **DATA_GUARD_MAX_LONGIO_TIME**
 - Sets the maximum number of seconds as above, but for operations such as open and close

Standby Result Cache Preservation

Keep the Result Cache warm after a role transition



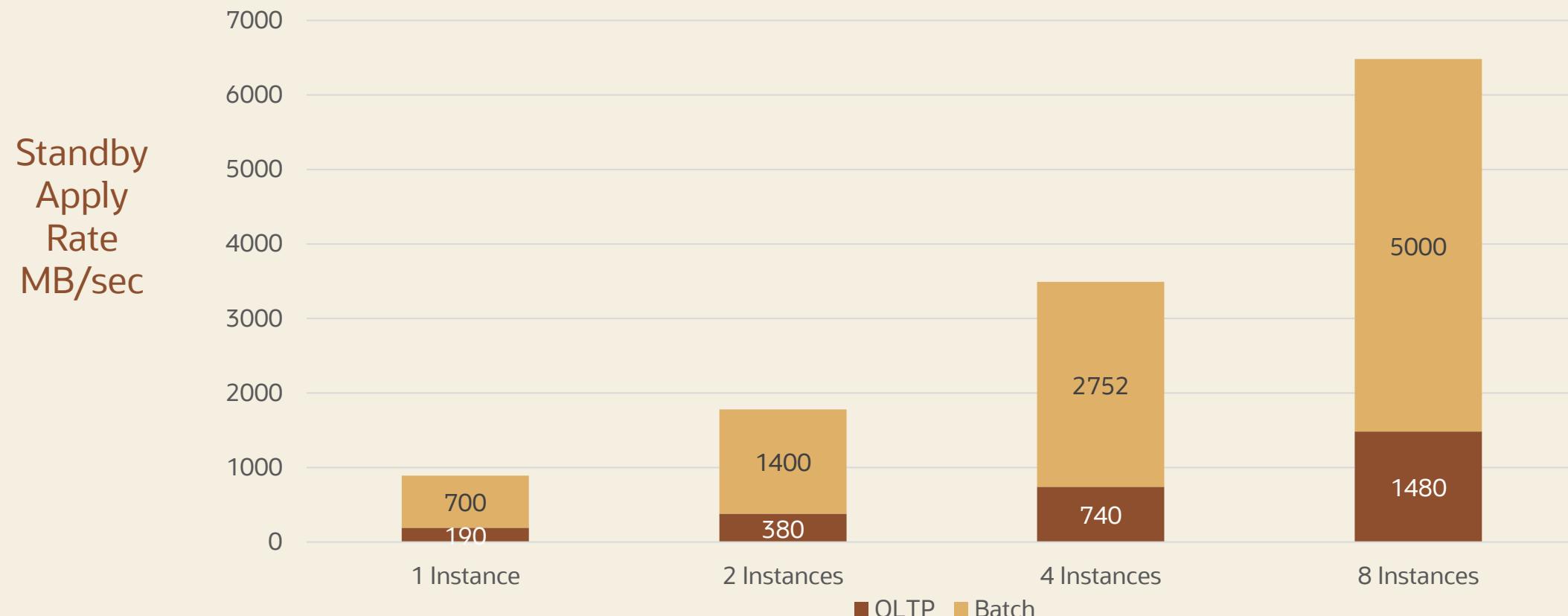
- Real-Time Query supports the Result Cache for queries run on the standby database (tables only)
- Result Cache improves query performance for recurring queries and reduces resource usage (CPU, I/O)
- In **21c and above**, after a role transition (switchover or failover), the Result Cache is preserved
 - Query performance not impacted
 - No cache warm-up required

Multi-Instance Redo Apply Performance

Lower Latency Active Data Guard Standby Databases



- Utilizes all RAC nodes on the Standby database to parallelize recovery
- OLTP workloads on Exadata show great scalability



PLATINUM

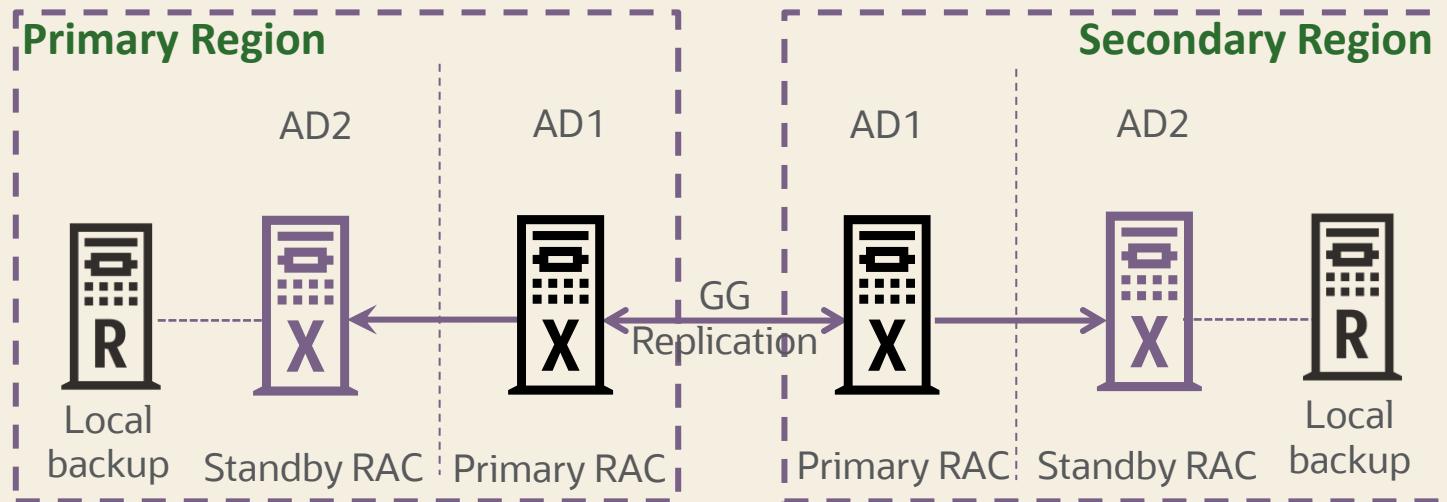
Mission Critical (Option 1)

Gold +

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

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



Outage Matrix

Unplanned Outage

RTO/RPO Service Level Objectives (f1)

Recoverable node or instance failure

Zero or single-digit seconds (f2/f3)

Disasters including corruptions and site failures

< 30 secs (f3)

Planned Maintenance

Most common software/hardware updates

Zero (f2)

Major database upgrade, **application upgrade**

Zero (f3)

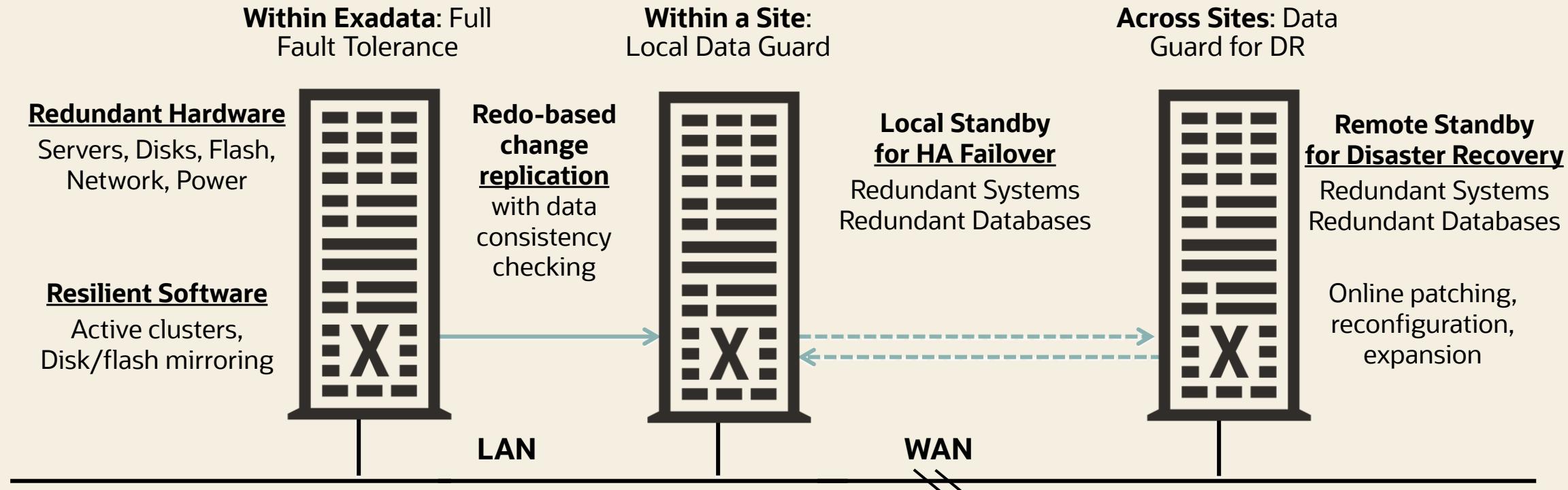
f1: RPO=0 unless explicitly specified

f2: To achieve zero downtime or lowest impact, apply application checklist best practices

f3: Application failover is custom or with Global Data Services

Exadata Maximum Availability Architecture (MAA)

Optimized on-premises blueprint for HA: designed/tested against failure scenarios

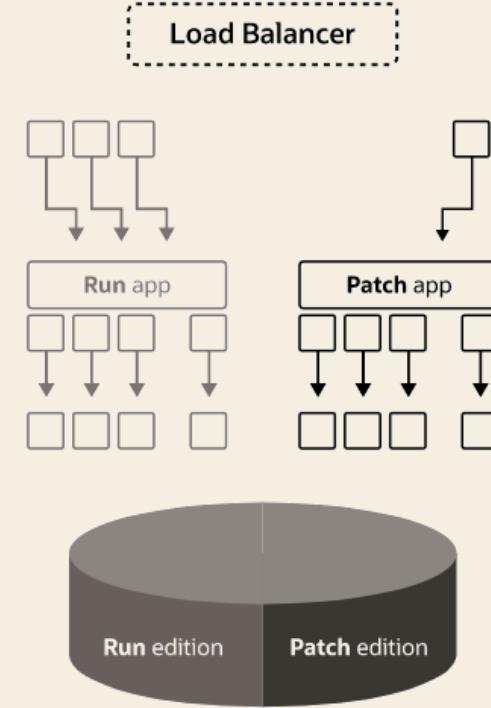


Fastest RAC recovery after node or instance failure | Fastest Backup - RMAN Offloads to Storage
Seamless ASM Integration | Fastest Data Guard Redo Apply | Automated Chaos Engineering injection testing

GoldenGate or Alternatively Edition-based Redefinition to Further Protect Your Applications



Use Oracle Golden Gate
Standard Approach

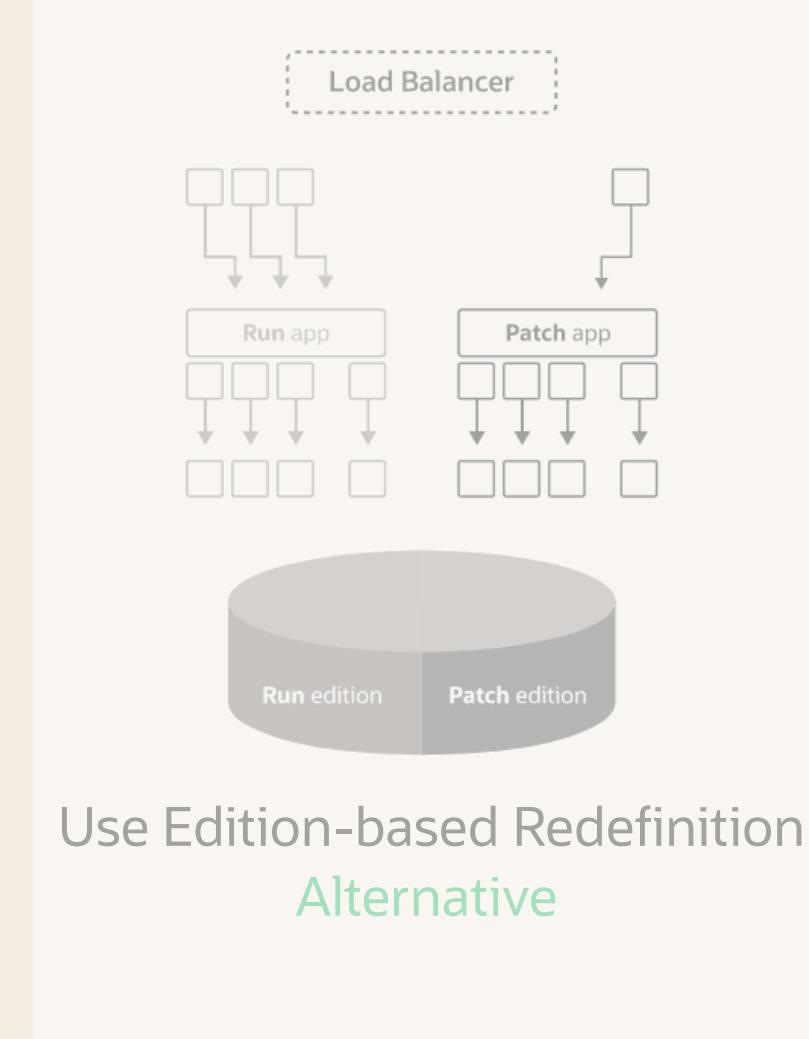


Use Edition-based Redefinition
Alternative

GoldenGate or Alternatively Edition-based Redefinition to Further Protect Your Applications



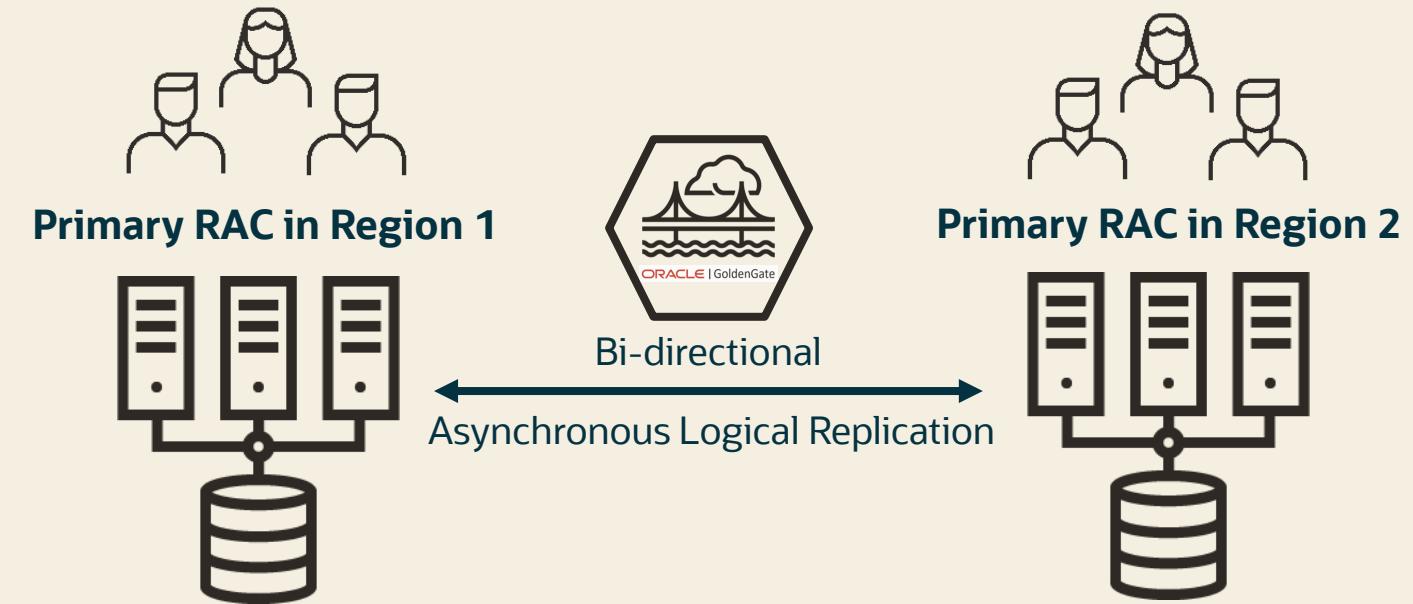
Use Oracle Golden Gate
Standard Approach



Oracle GoldenGate Architecture

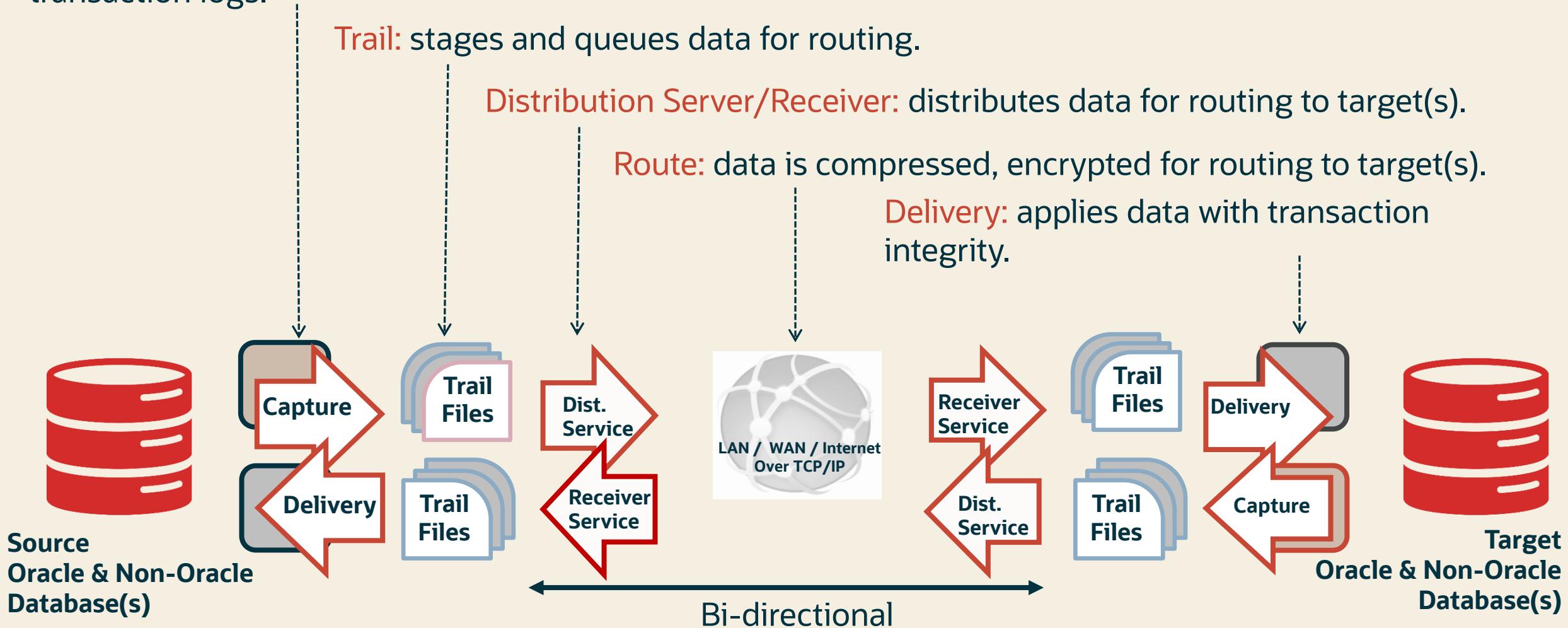
Multiple primaries ensure maximum availability even during maintenance periods

- Eliminates downtime with Bi-directional full active-active replication between regions
- Asynchronous logical replication provides flexibility for maintenance activities
- Different hardware supported
- Regional affinity supports geographical distribution
- Combine with synchronous local standby databases or remote standby databases using Active Data Guard to eliminate data loss



Oracle GoldenGate Architecture

Capture: committed transactions are captured (and can be filtered) as they occur by reading the transaction logs.





Key GoldenGate Improvements Simplify Platinum

1. GoldenGate Hub simplifies migration and administration by offloading work from source and target
 - New GoldenGate cloud marketplace automates GG hub deployment
 - Cross endianness capture enables cross platform migration
 - Zero Downtime Migration integration with GoldenGate
2. GoldenGate Microservices simplifies administration and management

Zero Downtime Migration
www.oracle.com/goto/zdm

[Resource Link: Oracle Database Migration with an Oracle GoldenGate Hub Configuration](#)

[Resource Link: Oracle Maximum Availability Architecture \(MAA\) GoldenGate Hub](#)



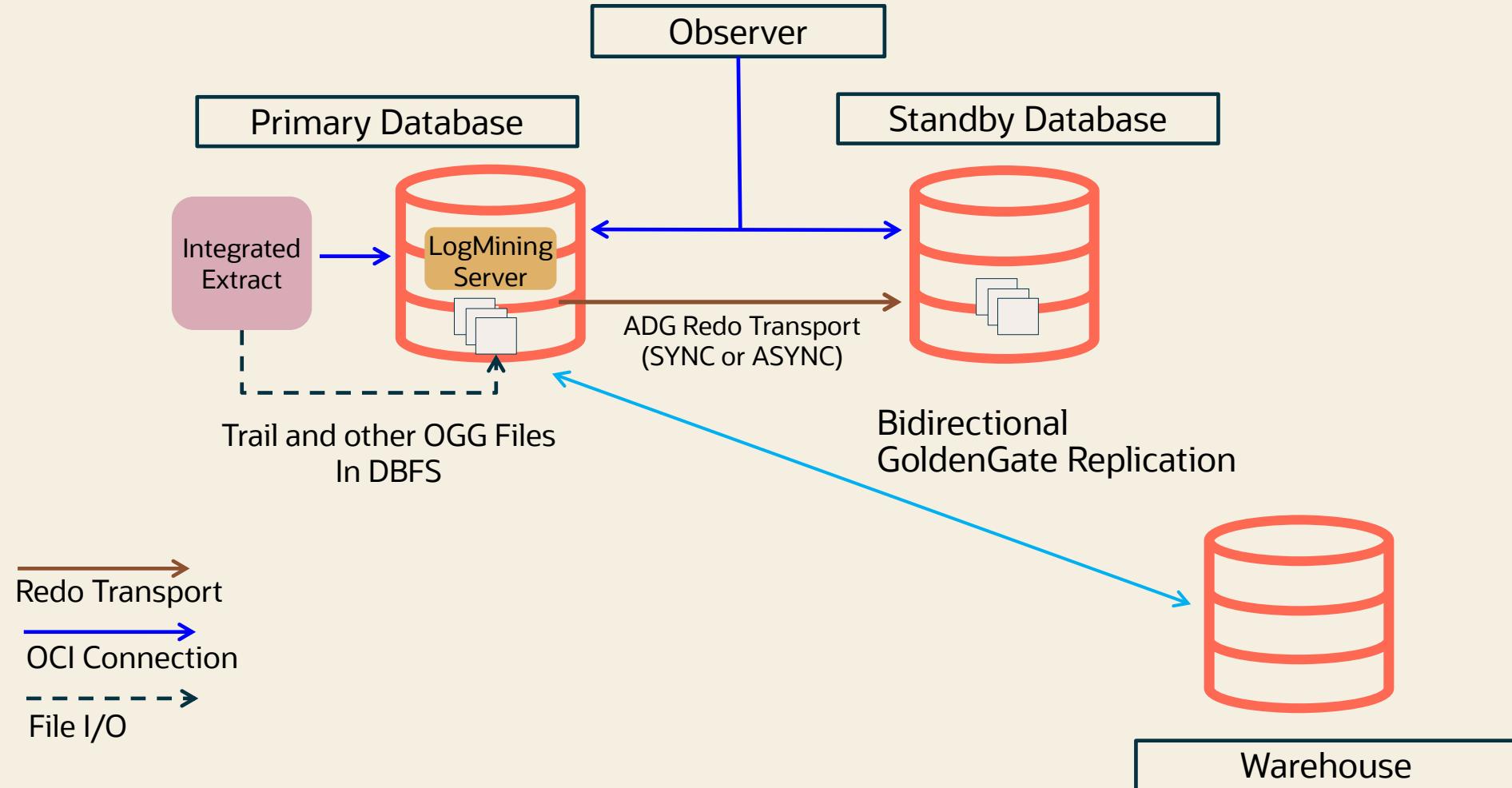
Oracle GoldenGate

MAA Best Practices

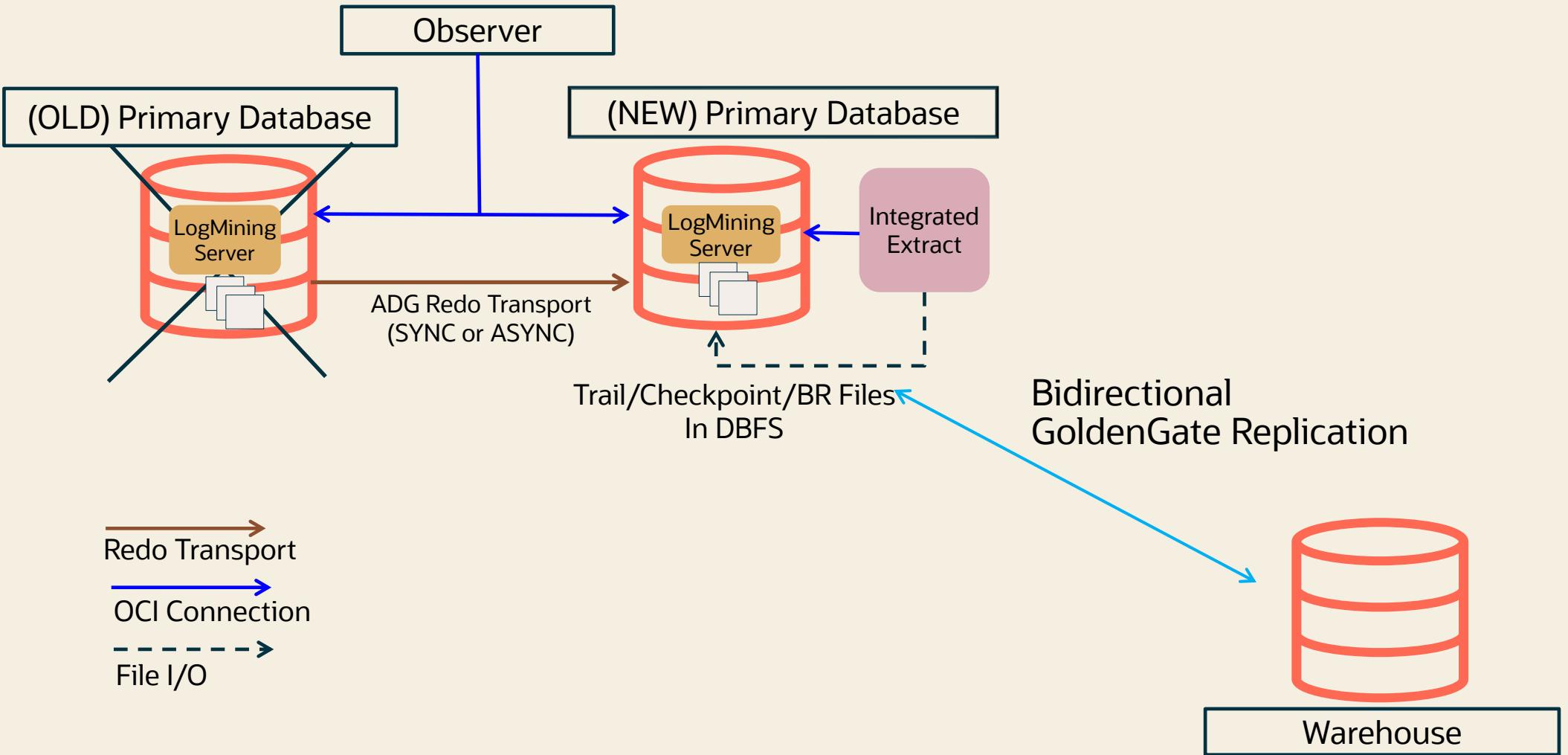
- Transparent Role Transitions in Data Guard Configurations
 - No manual intervention required with FSFO and DG Broker
- Configuration makes use of:
 - Oracle Grid Infrastructure Bundled Agent (XAG)
 - DBFS or ACFS for shared GoldenGate files (trails and checkpoint files)
 - Role based services
 - Integrated Extract (with HANDLEDLFAILOVER option for ASYNC DG)
 - Microservices Architecture for simpler administration

[Resource Link: Transparent Role Transitions with Data Guard and Oracle GoldenGate](#)

Sample GoldenGate MAA Deployment



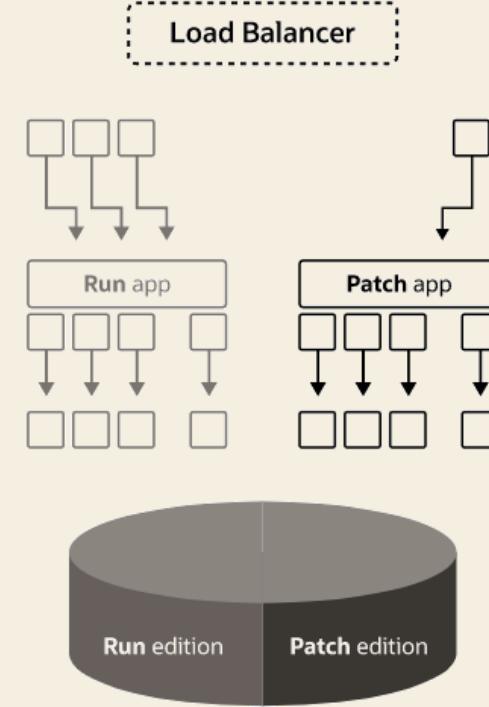
Sample GoldenGate MAA Deployment – Post Role Transition



GoldenGate or Alternatively Edition-based Redefinition to Further Protect Your Applications



Use Oracle Golden Gate
Standard Approach

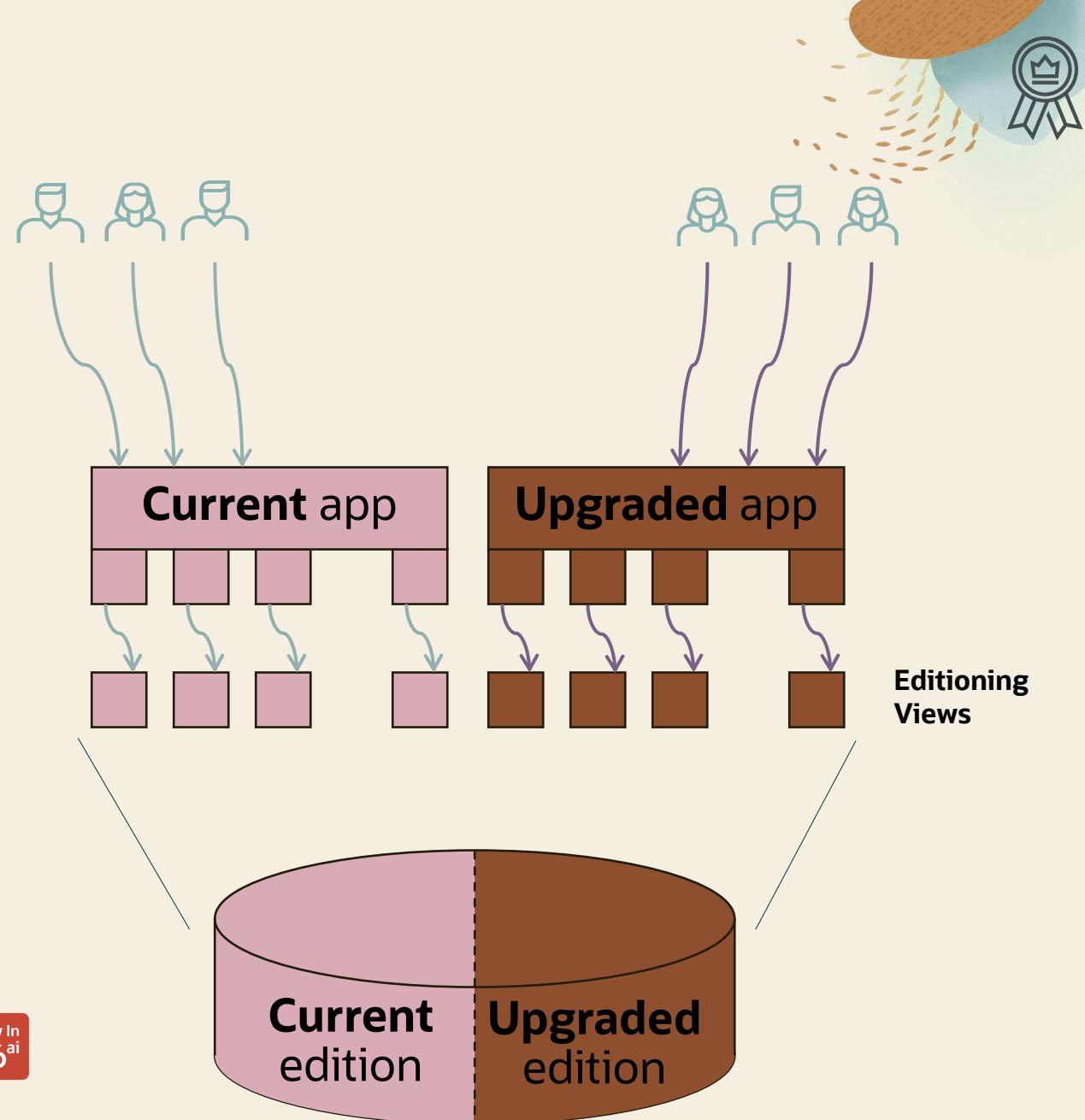


Use Edition-based Redefinition
Alternative

Edition-Based Redefinition

Online Application Upgrade

- Enables application upgrades to be performed online
- Code changes installed in the privacy of a new ***edition***
- Data changes are made safely by writing only to new columns or new tables not seen in the old edition
- An ***editioning view*** exposes a different projection of a table into each edition to allow each to see just its own columns
- A ***cross-edition trigger*** propagates data changes made by the old edition into the new edition's columns, or (in hot-rollover) vice-versa
- With Oracle AI Database 26ai, EBR is now compatible with Oracle GoldenGate thanks to New In
26ai supplemental logging enhancements



PLATINUM

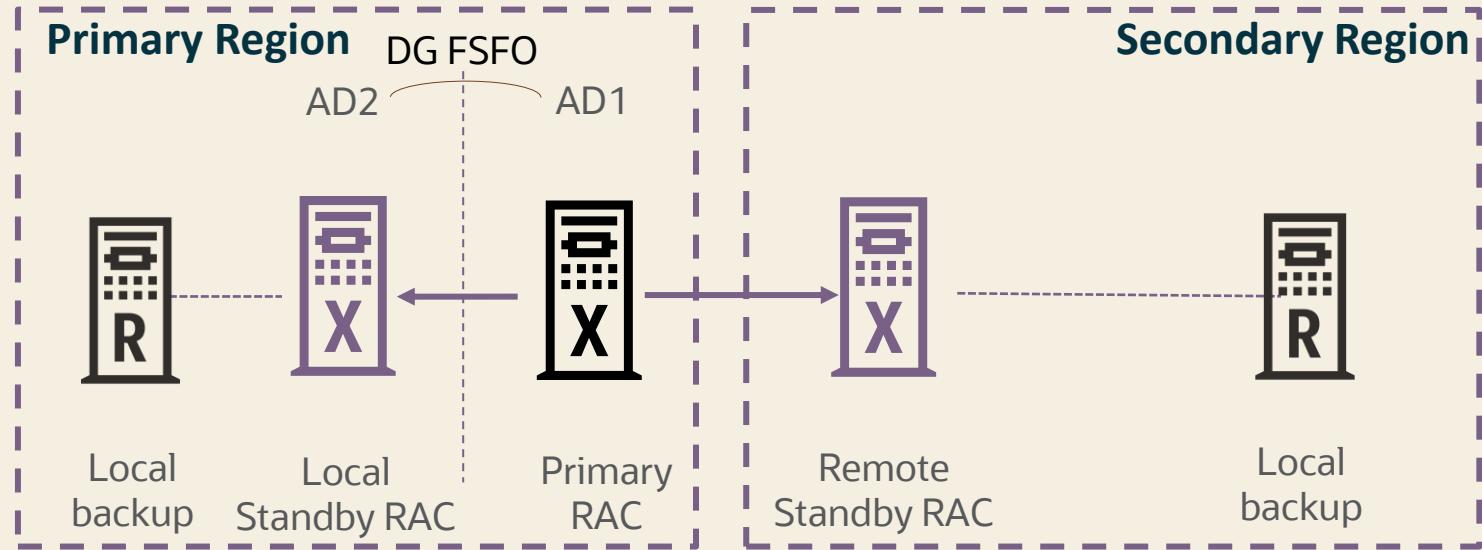
Mission Critical (Option 2)

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



Outage Matrix

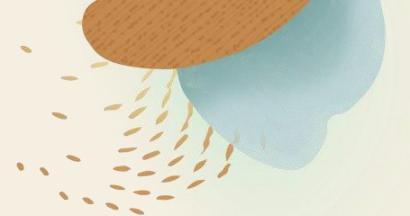
Unplanned Outage	RTO/RPO Service Level Objectives (f1)
Recoverable node or instance failure	Single digit seconds (f2)
Disasters: corruptions and site failures	Seconds to 1 min. RPO zero or seconds
Planned Maintenance	
Software/Hardware updates	Zero (f2)
Major database upgrade	Less than 30 seconds

f1: RPO=0 unless explicitly specified

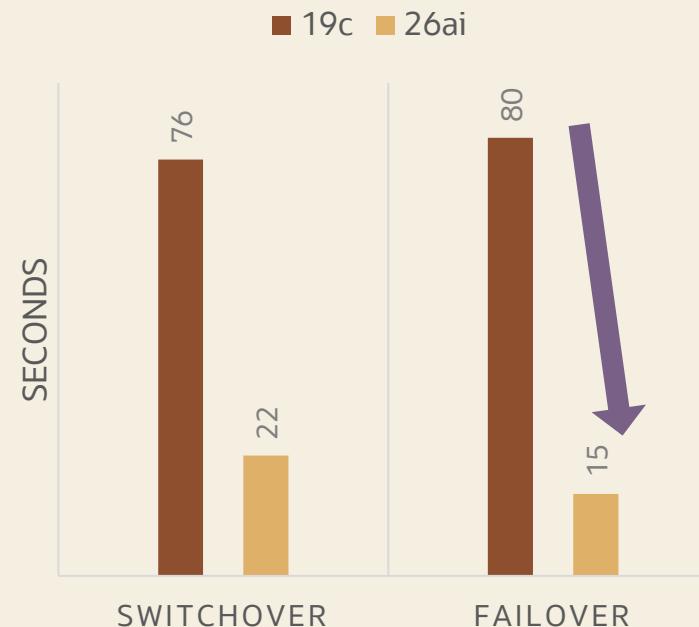
f2: To achieve zero downtime or lowest impact, apply application checklist best practices; Batch jobs should be deferred outside planned maintenance window.

Oracle Data Guard 26ai Provides Lower RTO

Faster role transitions regardless of the size of the workload

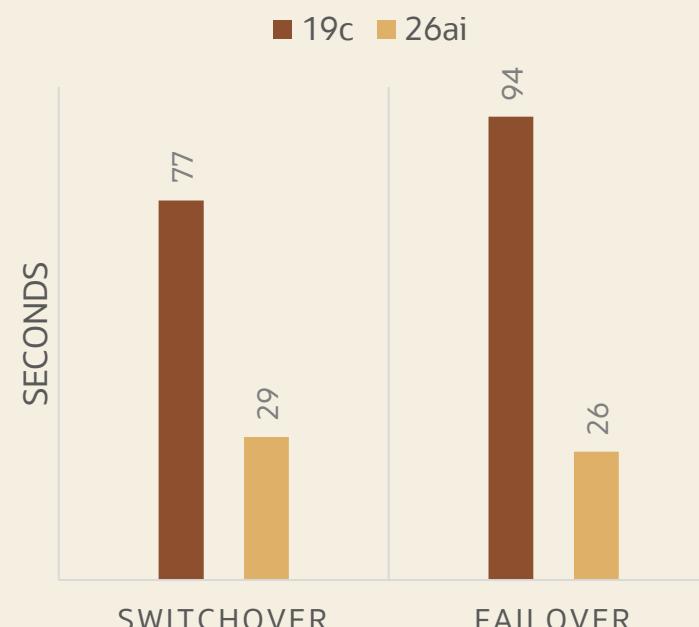


SMALL WORKLOAD



UP TO
400%
FASTER

LARGE WORKLOAD



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

Why is Exadata extraordinary and unique for resiliency & scalability?

Exadata and RAC – The Foundation for Platinum MAA



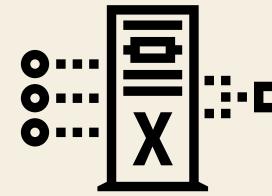
Highest Availability

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

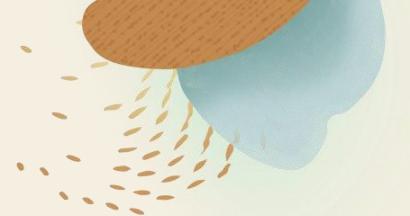
Application maintains extreme performance and low latency, adjusting dynamically when changes or issues occur



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

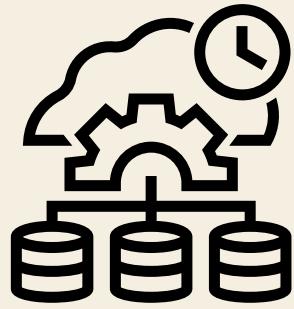
Near Zero Application Impact for Most Common Planned and Unplanned Outages

Striving for Much Better!!!

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.

Mitigation Solutions for Toughest “Gray Failures”

Exadata extraordinary examples



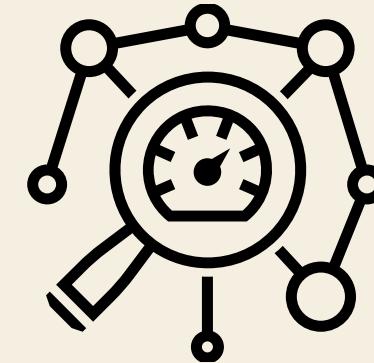
Highest Application Availability

- 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

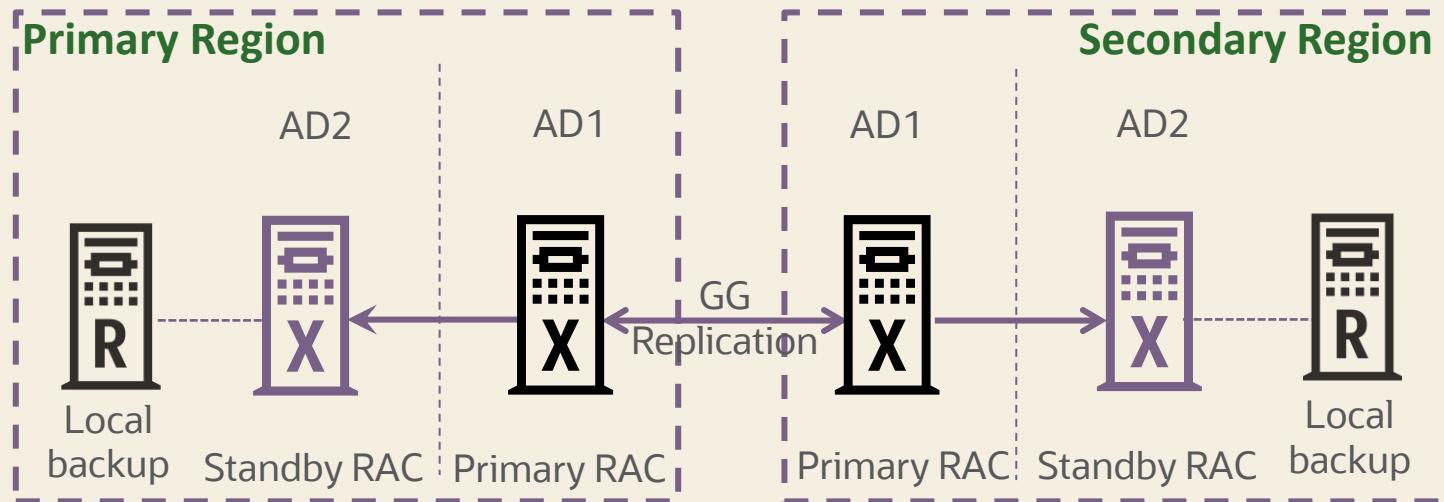
- 33 X better performance
- 4-10 X better OLTP latency

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



Outage 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
Major database upgrade, application upgrade	Zero

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

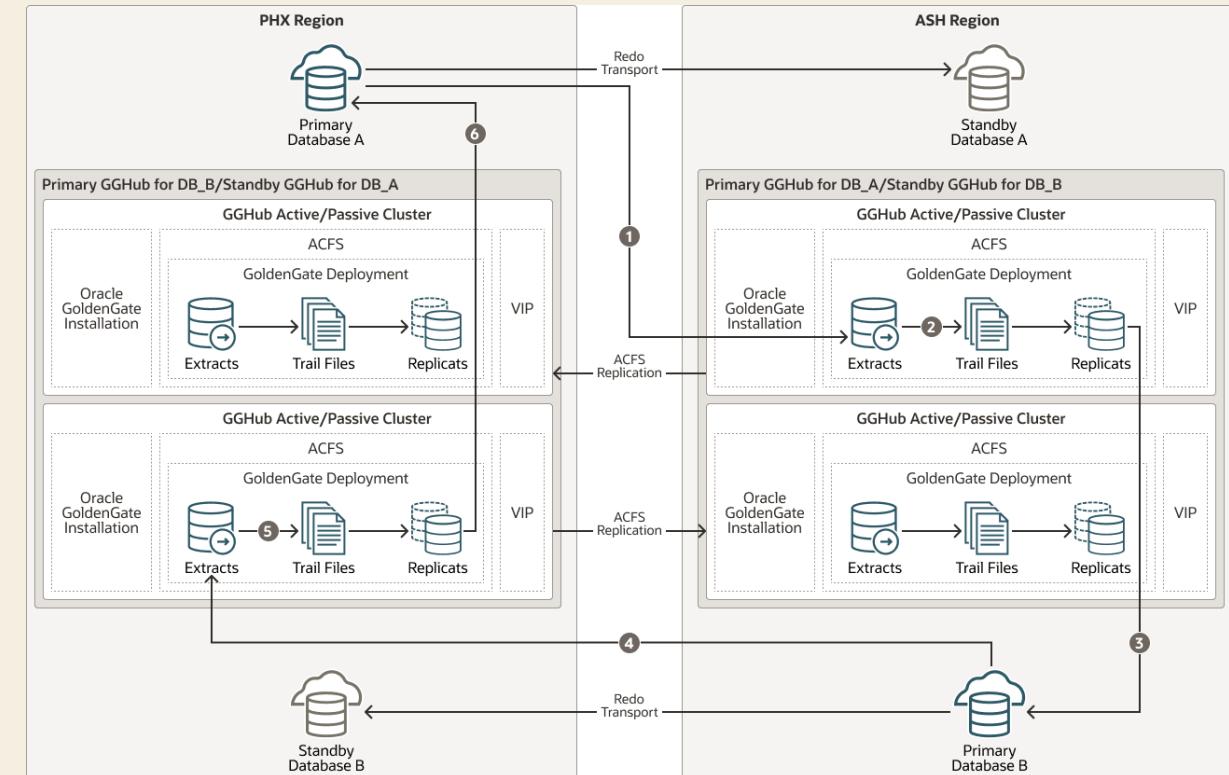
Bringing it all together

- 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 the 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 streamlined 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

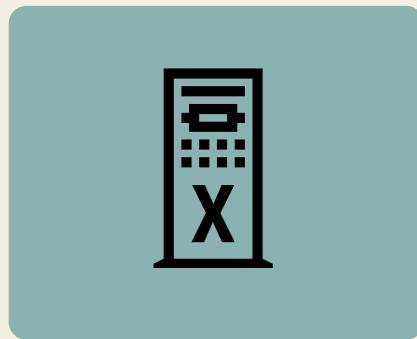
- **Core Components:** Architecture relies on Oracle Active Data Guard with Fast-Start Failover (FSFO) for database redundancy and MAA OGG Hub for data replication.
- **Cross-Region Placement:** The primary/active OGG Hub is co-located in the same OCI region as its target database to ensure optimal Replicat 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.



MAA in the Cloud

Maximum Availability Architecture

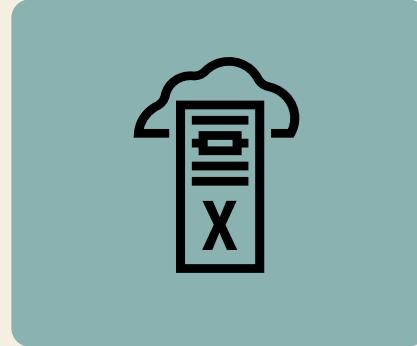
Unique: Consistent Database Experience Across Deployments



Exadata Database Machine
(on-premises)

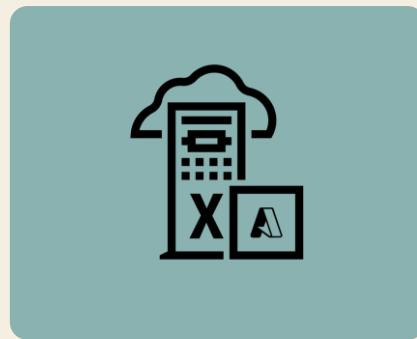


Exadata Cloud@Customer
(hybrid cloud)



Exadata Cloud Infrastructure
(Oracle public cloud)

Same Oracle Database | 100% compatible | No app changes | Zero downtime migration



Oracle AI Database@Azure
(multicloud)



Oracle AI Database@Google Cloud
(multicloud)



Oracle AI Database@AWS
(multicloud)

Oracle MAA Gold for all Oracle AI Database@Hyperscalers

Exadata Database Service on Dedicated Infrastructure



Oracle AI Database@Azure

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



Oracle AI Database@AWS

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



Oracle AI Database@Google Cloud

- ✓ MAA Silver
- ✓ MAA Gold cross-regions
- MAA Gold cross-zones (in progress)



SILVER



GOLD



SILVER



GOLD



SILVER



GOLD

Multiple Standby Databases in Exadata Database Service

Up to 6 standby databases can now be managed by the OCI control plane



By taking advantage of multiple standbys in different regions, applications can immediately benefit from improved data protection, increased flexibility and scalability, and better ROI

Using the new Data Guard Group feature, multiple standby databases can be easily deployed and managed via the OCI console feature

Data Guard group

Add standby									
Member	VM Cluster	Role	Region	Protection mode	Transport type	Apply lag	Transport lag	Lag as of	Data Guard type
DB1200	VMCluster-A	Primary	US East (Ashburn)	Maximum Availability	Async	—	—	—	Data Guard
DB1200	VMCluster-B	Standby	US East (Ashburn)	Maximum Availability	Sync	0 seconds	0 seconds	Mon, Dec 16, 2024, 15:57:46 UTC	Data Guard
DB1200	VMCluster-202404251654	Standby	US East (Ashburn)	Maximum Availability	Async	0 seconds	0 seconds	Mon, Dec 16, 2024, 15:58:01 UTC	Active Data Guard
DB1200	CGBCK	Standby	US East (Ashburn)	Maximum Availability	Async	0 seconds	0 seconds	Mon, Dec 16, 2024, 15:58:07 UTC	Active Data Guard
DB1200	VMCluster-202411184690	Standby	US East (Ashburn)	Maximum Availability	Async	0 seconds	0 seconds	Mon, Dec 16, 2024, 15:58:12 UTC	Active Data Guard
DB1200	VMCluster-202411184300	Standby	US West (Phoenix)	Maximum Availability	Async	0 seconds	0 seconds	Mon, Dec 16, 2024, 15:58:18 UTC	Active Data Guard
DB1200	VMCluster-202411184311	Standby	US West (Phoenix)	Maximum Availability	Async	0 seconds	0 seconds	Mon, Dec 16, 2024, 15:58:23 UTC	Active Data Guard

Eliminates Site Downtime

Oracle Autonomous Data Guard

Maintains a real-time remote copy of a production database

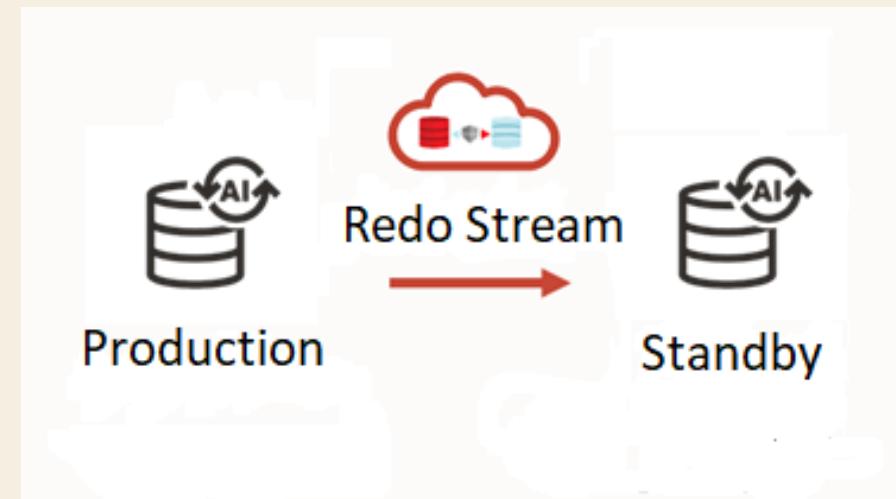
- Protects from physical disasters, network outages
- Can automatically switch from primary to remote copy

Maintains copy by applying physiological changes

- Protects against database corruption
- Validates data consistency as changes are applied

Fully Autonomous – Automates Everything

- Creation, operation, patching, and backup
- Database and Data Guard management

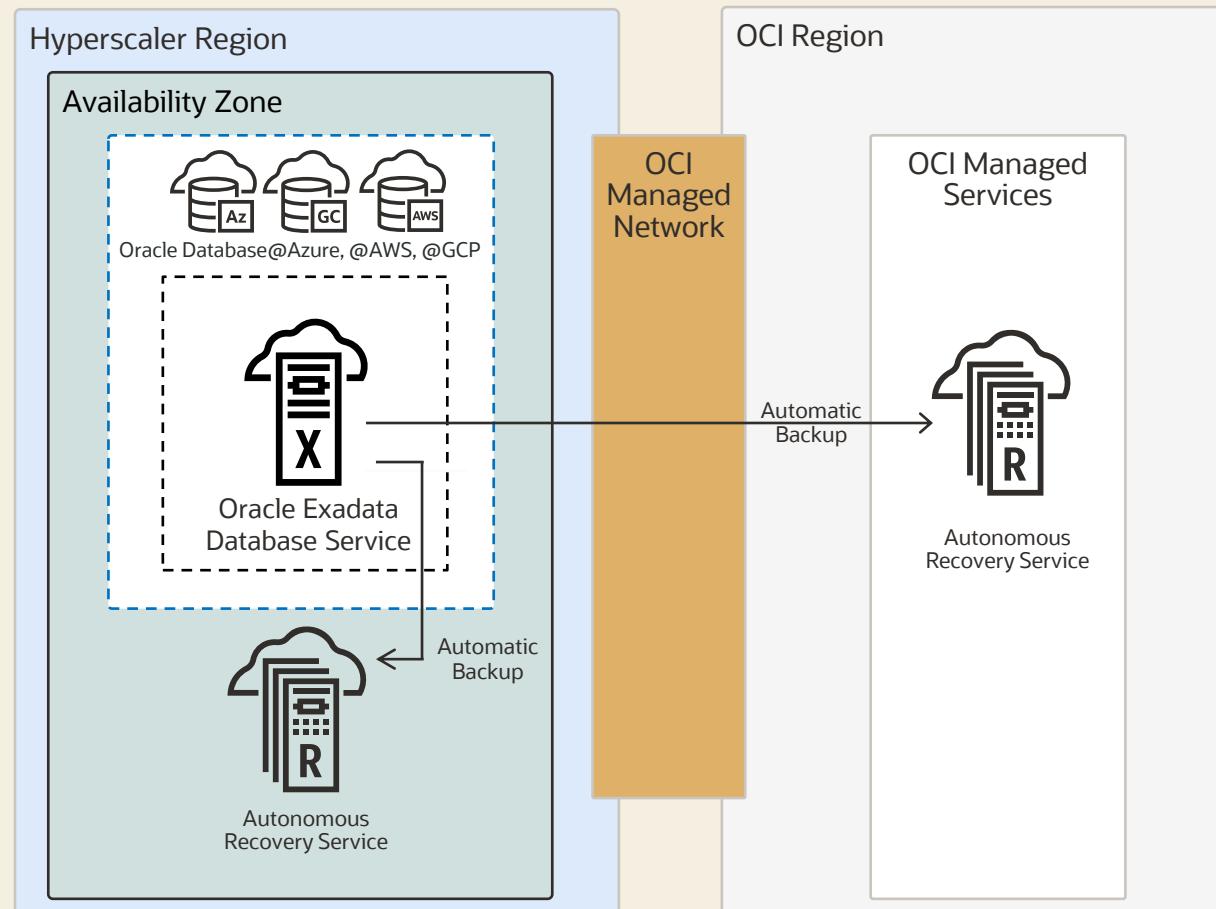




SILVER

Exadata Database Service@Hyperscaler | MAA Silver Level

High Availability and Data Protection Built-in by Default



- ✓ Oracle Exadata and Oracle RAC
 - ✓ Agility to scale storage, compute, and memory without downtime
 - ✓ Node failure protection
 - ✓ Zero downtime software maintenance
- ✓ Zero Data Loss Autonomous Recovery Service
 - ✓ Available in OCI and in multicloud hyperscaler
 - ✓ One click to choose the backup destination

Store backups in the same cloud provider as the database i

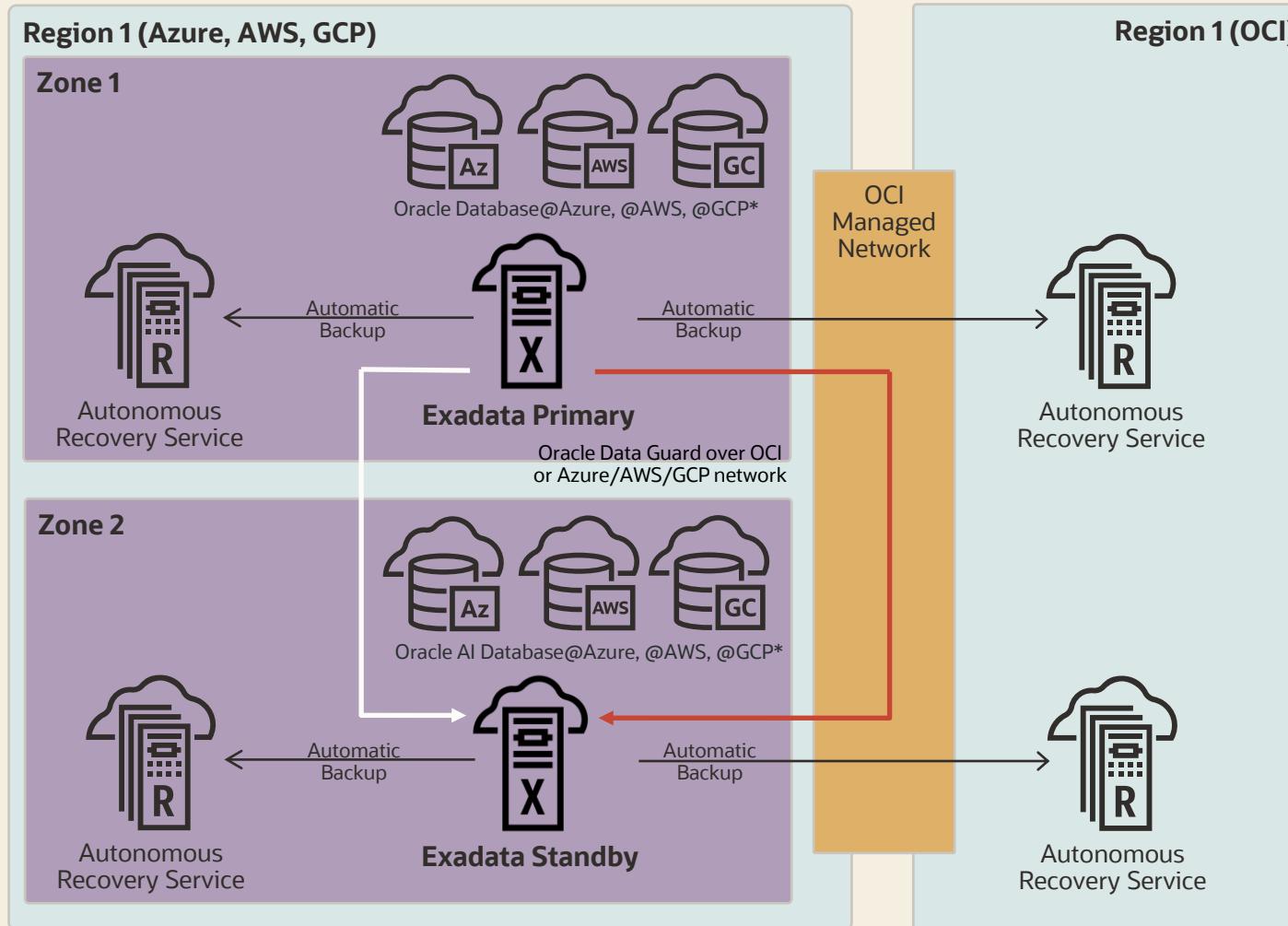




GOLD

Oracle MAA Gold level cross-zones architecture

Enhancing availability and ensuring zero data loss



MAA Silver Level +

- ✓ Site failure protection
- ✓ Oracle Data Guard's In-Memory replication with zero data loss
- ✓ Minimal performance impact

+ Active Data Guard

- ✓ Comprehensive data corruption prevention
- ✓ Offload read-mostly workloads to the standby
- ✓ Online updates

+ Multiple Standbys

- ✓ Read-mostly scale-out

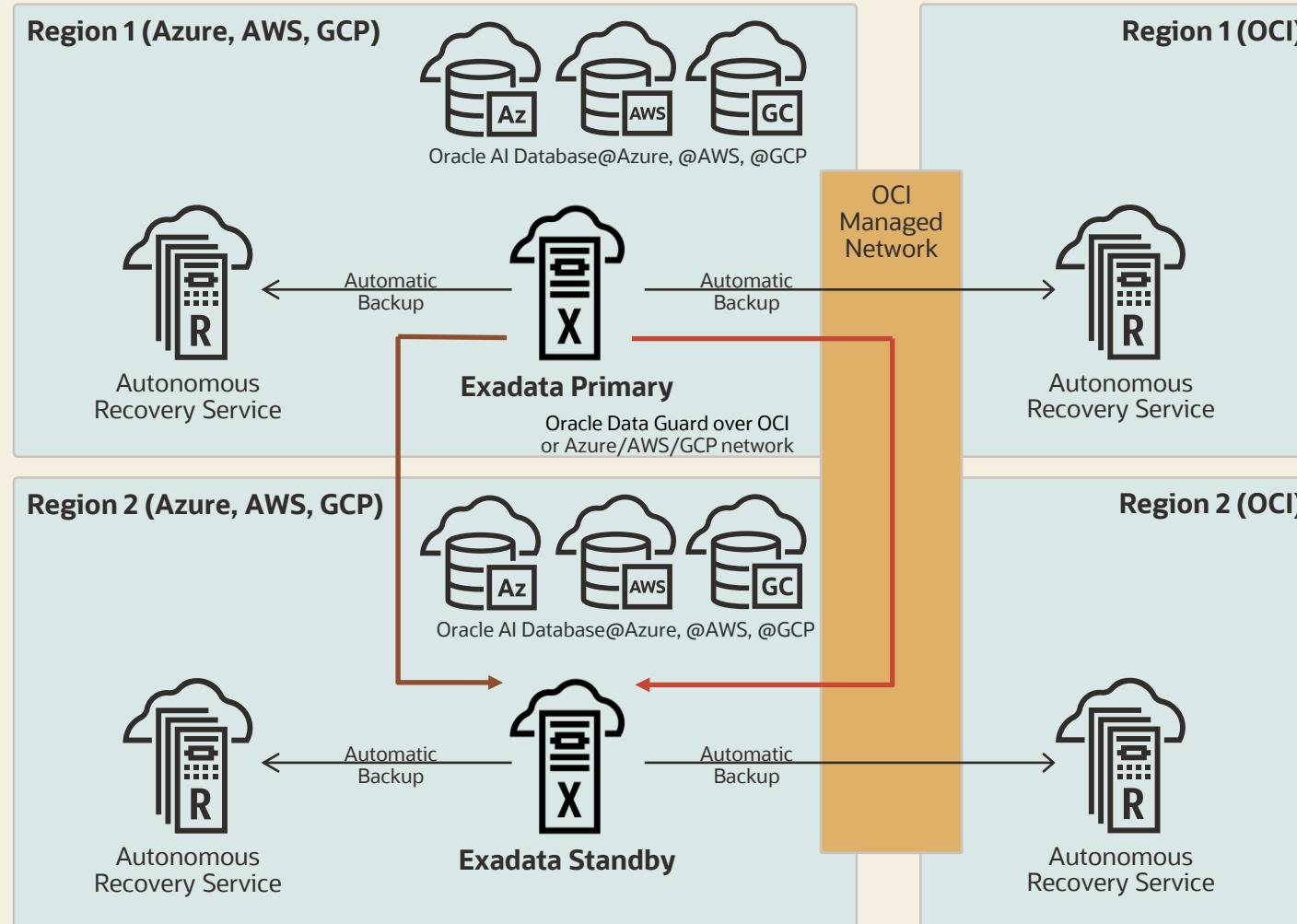
*MAA cross-zones certification for GCP in progress

Oracle MAA Gold level multi-region architecture

Safeguarding continuous availability and real-time data protection



GOLD



MAA Silver Level +

- ✓ Regional disaster recovery protection
- ✓ Oracle Data Guard's In-Memory replication with (near) zero data loss
- ✓ No performance impact

+ Active Data Guard

- ✓ Comprehensive data corruption prevention
- ✓ Offload read-mostly workloads to the standby
- ✓ Online updates

+ Multiple Standbys

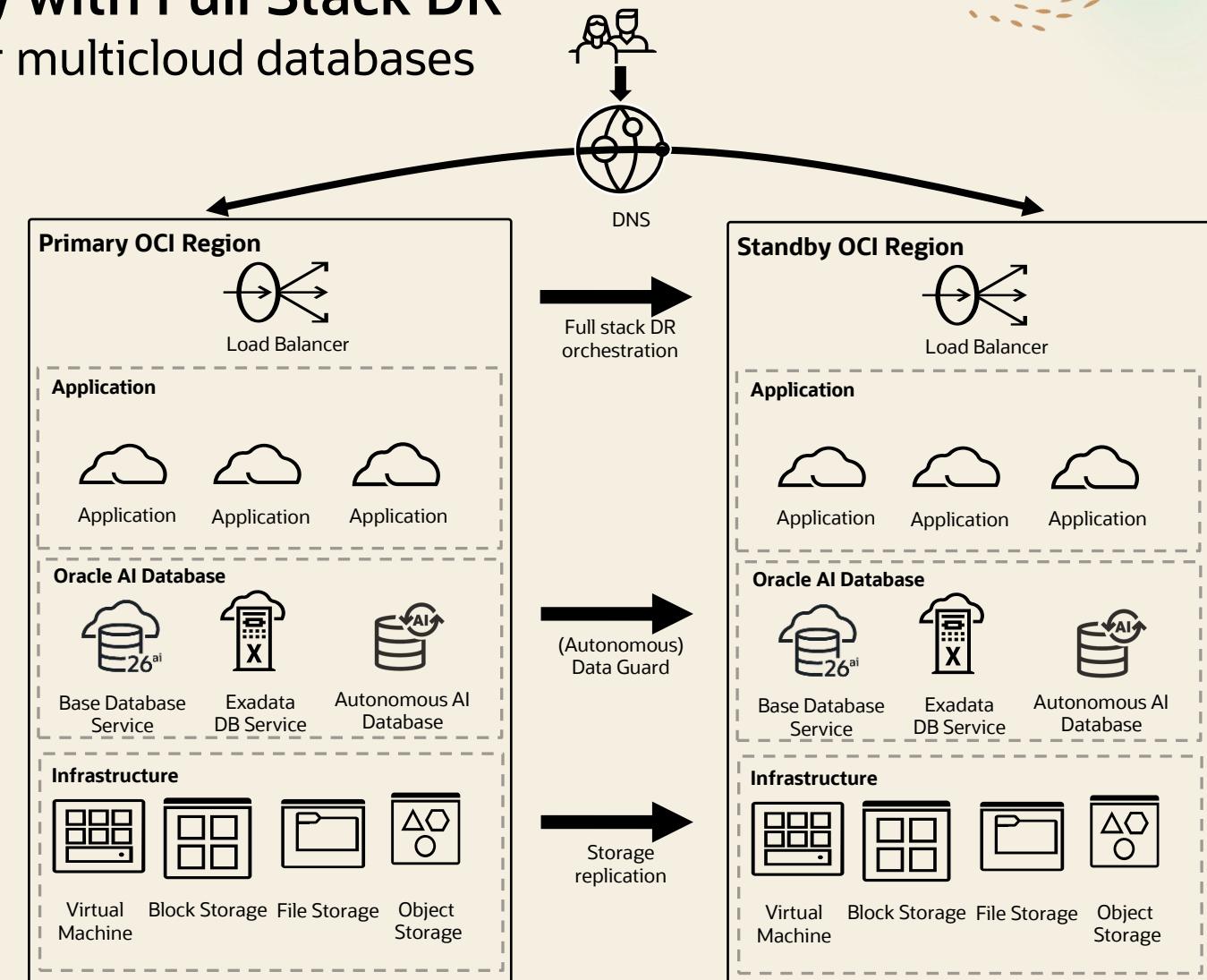
- ✓ Zero data loss across regions with minimal impact on primary performance
- ✓ Read-mostly scale-out

Orchestrate end-to-end recovery with Full Stack DR

Available for the full stack in OCI, and for multicloud databases

Fully-managed disaster recovery (DR) service providing

- **DR for the entire application stack**
 - Orchestrated single-click DR for infrastructure, applications & databases
- **Automated DR plan creation**
 - Reduced time and effort to create and manage disaster recovery plans
- **Unified management**
 - Validated and monitored execution of DR plans through an integrated UI / API



Zero Data Loss Autonomous Recovery Service (ZRCV)

Intelligent data protection for Oracle AI Databases in OCI, Multicloud, & On-premises

Zero Data Loss Recovery

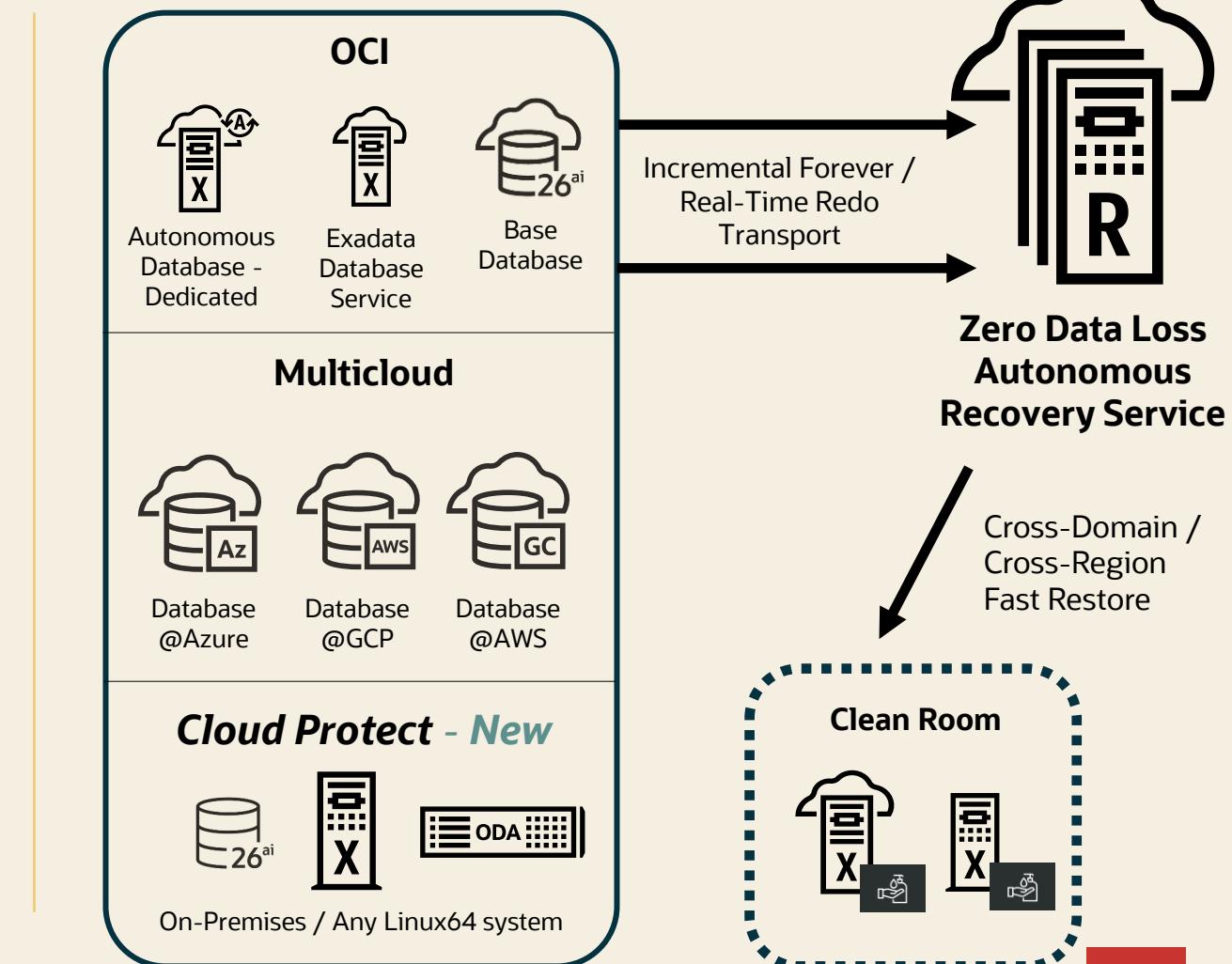
- Real-time transaction protection
- Continuous recovery validation

Fast, Low-Impact Backup and Recovery

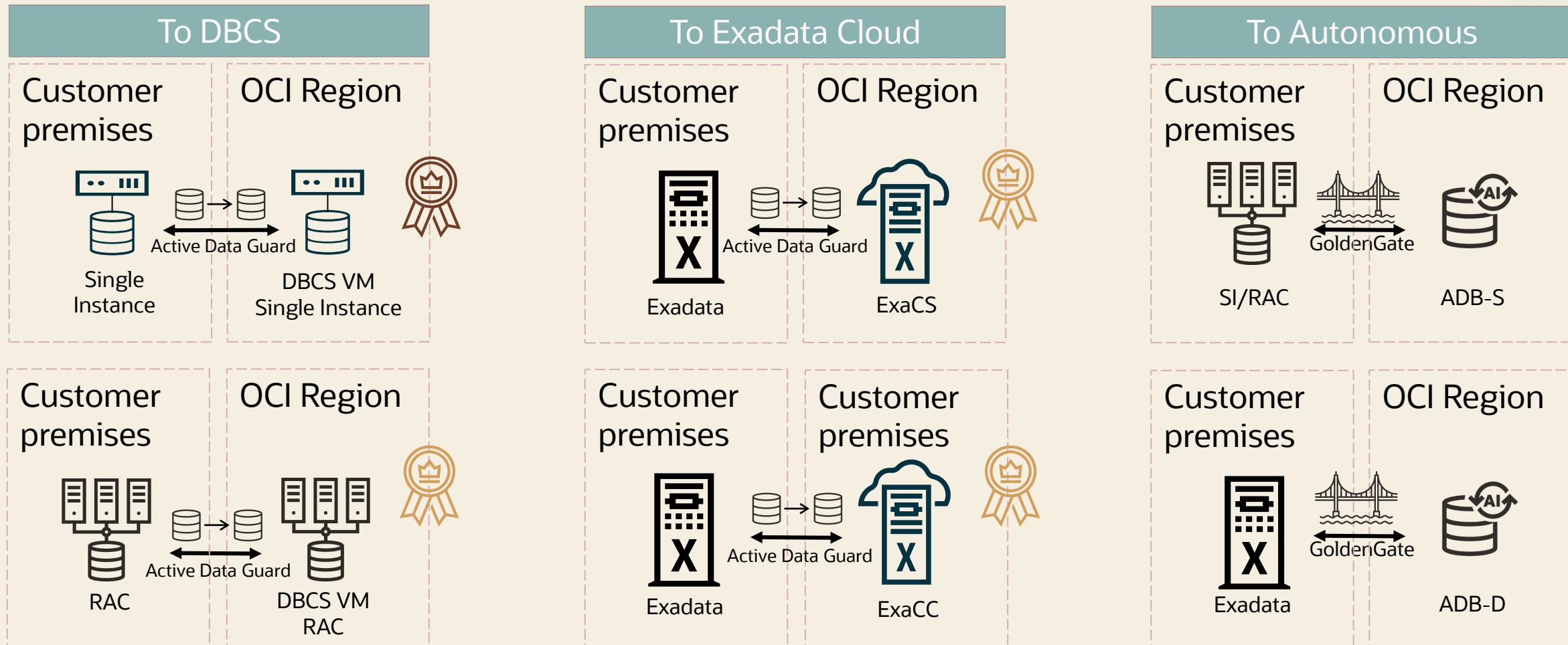
- Space-efficient incremental forever
- One-step recovery without needing incremental apply

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



Hybrid Cloud: Recommended Hybrid Sources/Destinations



- All Hybrid configurations are achieved manually: no Control Plane automation
- On-premises non-Exadata to ExaCC/ExaCS is possible but beware of exclusive features

Key Takeaways

Oracle AI Database High Availability and Disaster Recovery technology provides:

- MAA reliability that has evolved over 20 years, deployed by thousands of customers
- Flexible high availability and disaster recovery for the application with no modification
- Zero data loss is an option regardless of distance
- Rolling patching provides zero downtime during the most common planned maintenance operations
- On-demand, reliable, and fully elastic



Maximum Availability Architecture

- MAA Home:
 - <http://oracle.com/goto/maa>
- On-Premises MAA:
 - <https://www.oracle.com/database/technologies/high-availability/oracle-database-maa-best-practices.html>
- Exadata MAA:
 - <https://www.oracle.com/database/technologies/high-availability/exadata-maa-best-practices.html>
- Cloud MAA:
 - <https://www.oracle.com/database/technologies/high-availability/oracle-cloud-maa.html>

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