ORACLE

Oracle Maximum Availability Architecture (MAA)

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

November 2025

Why is Availability so important?

Impact of downtime

$350K
average cost of downtime per hour

87 hours
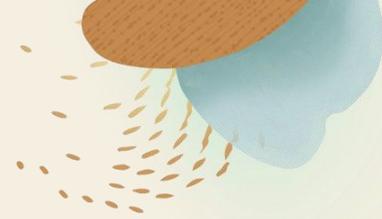average amount of downtime per year

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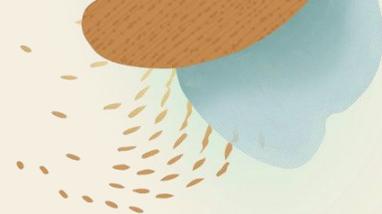
Recovery Time Objective (RTO)
Time to resume application service after failure. The shorter the Recovery Time Objective (RTO) the quicker you get back to business.

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	• Server changes • Database changes • Data changes • Application changes
Unplanned	Server failures Data failures	• 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*
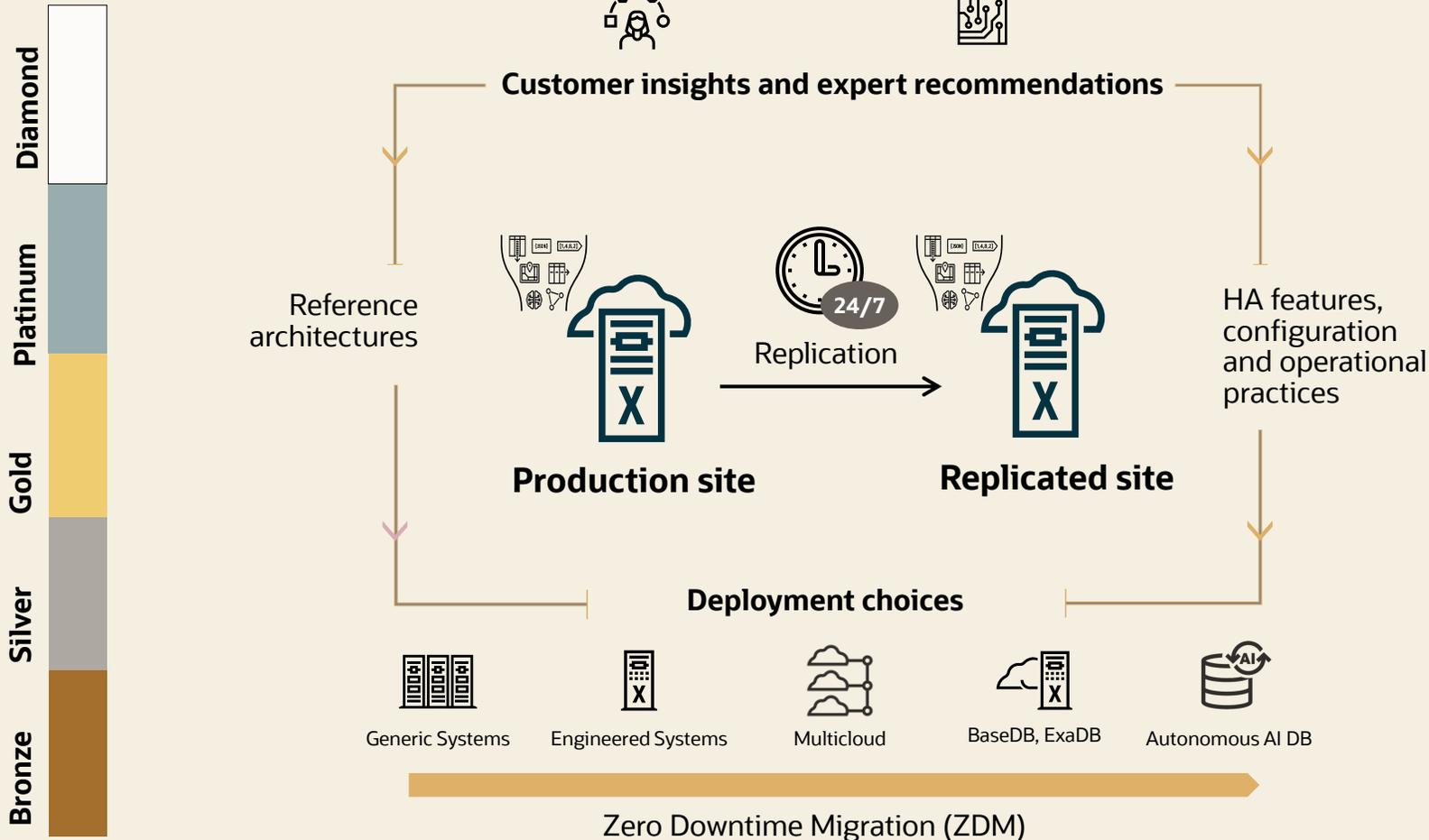
In today's digital age, this may include but is not limited to:

- 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)

Diamond
Platinum
Gold
Silver
Bronze

Customer insights and expert recommendations

Reference architectures

Production site

24/7
Replication

Replicated site

HA features, configuration and operational practices

Deployment choices

Generic Systems

Engineered Systems

Multicloud

BaseDB, ExaDB

Autonomous AI DB

Zero Downtime Migration (ZDM)

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
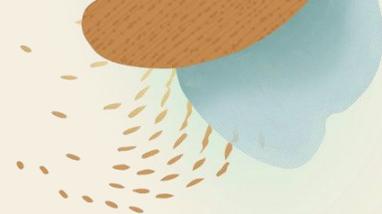
Next-Gen MAA Reference Architectures

Availability service levels for the next generation of Oracle AI 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 1 - GoldenGate with Oracle Database 19c *OR* Option 2- (Active) Data Guard with Oracle AI Database 26ai	**Configuration** GoldenGate 23ai 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

MAA, has you covered, no matter where your apps reside
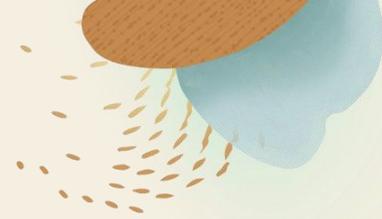
On-premises, on commodity hardware, or on engineered systems like Exadata
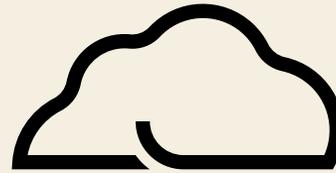
In Oracle Cloud Infrastructure, using services such as the Autonomous AI Database or Exadata Database Cloud
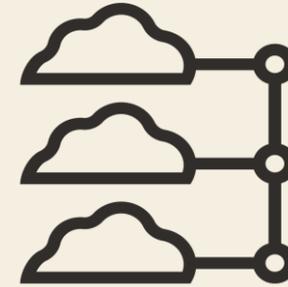
In hybrid and multicloud environments; e.g. Oracle AI Database@Azure, Oracle AI Database@Google Cloud, or Oracle AI Database@AWS

Examples and benefits of MAA everywhere and anywhere….
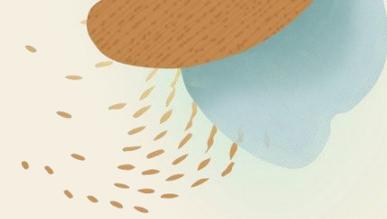
Generic Systems:

- 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

New In
26ai

Rolling Patching for Complex Changes

Globally Distributed DB with RAFT

Single Server Rolling Database Maintenance

DBMS_ROLLING with Application Continuity
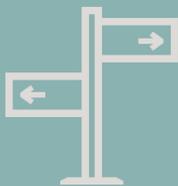
FPP Local Mode

Exadata Fleet Update

In-Database Firewall

Data Guard Redo Decryption for Hybrid DR Configurations

Oracle AI Database 26ai MAA Scalability Recent Features

New In 26ai

RAC Smart Connection Load Balancing

True Cache

Real-time Query for PDB Standby

Clusterware Resiliency

Ordered Sequences with Oracle RAC

Standby
TEMPFILE
Automatic tempfile creation on the standby database

Oracle RAC Fast Start Reconfiguration
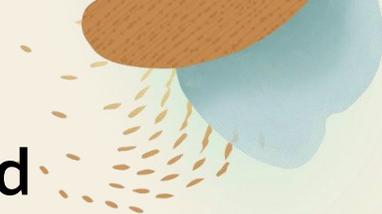
RDMA-based Exadata RAC Scaling

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**
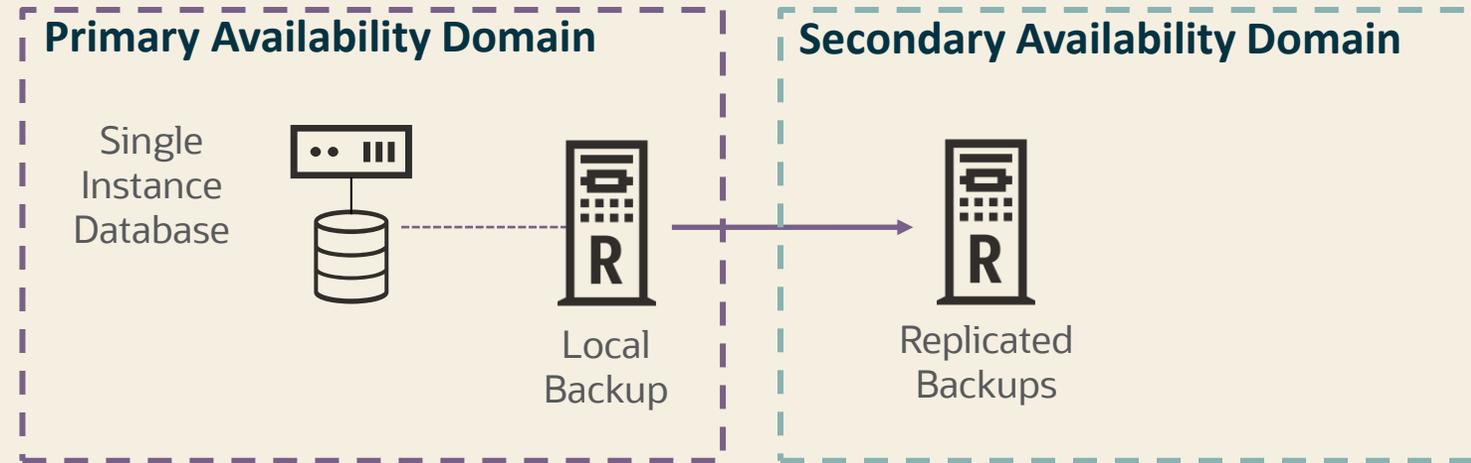
Diving into the MAA tiers

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

Primary Availability Domain

Single Instance Database

Local Backup

Secondary Availability Domain

Replicated Backups

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
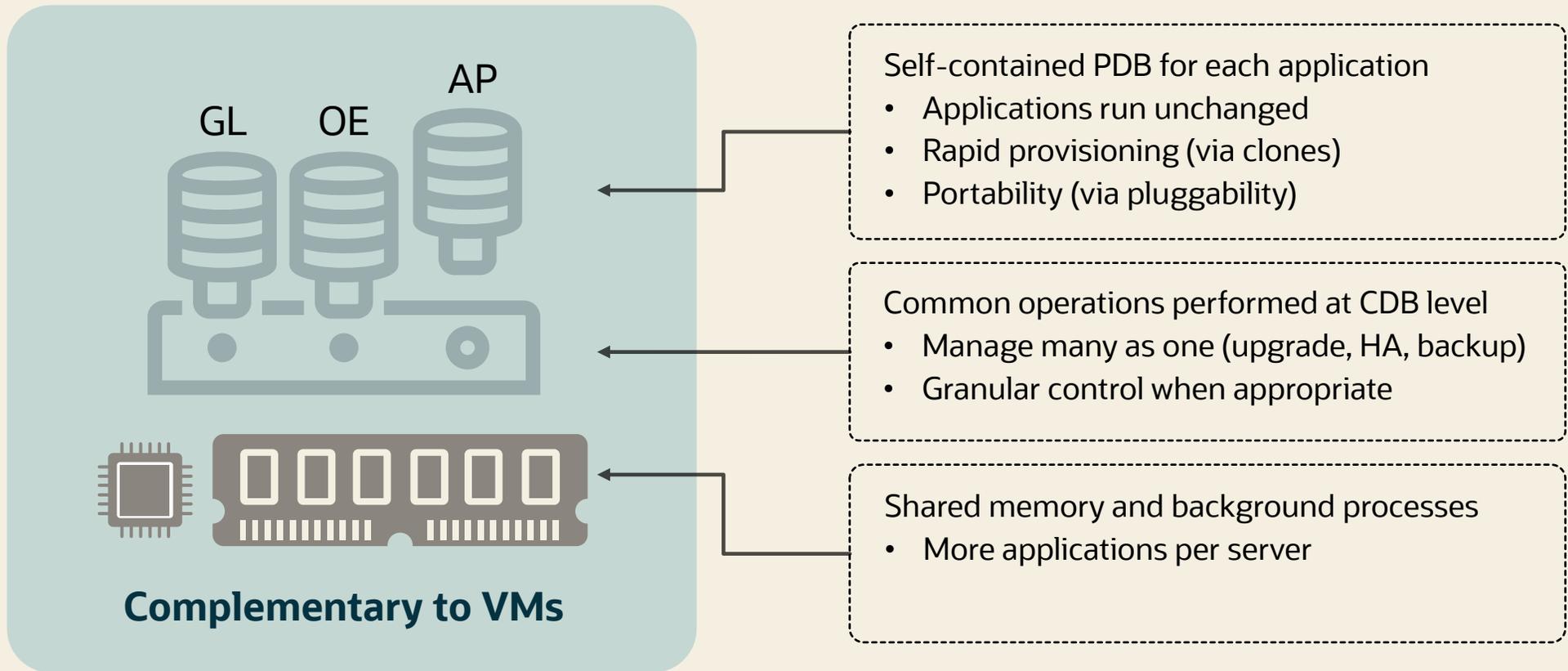2. Enables HA capabilities and resource management:
   - Automatic Restart of database instances, listeners, and other resources
   - Fleet patching
   - Service management, including restarting service after failure
   - Automatic Storage Management (ASM) for HA, data protection and ease of use

- Trade off: additional software maintenance for Grid Infrastructure

Advantages of Multitenant Architecture
Isolation and agility with economies of scale

GL OE AP

Complementary to VMs

Self-contained PDB for each application
- Applications run unchanged
- Rapid provisioning (via clones)
- Portability (via pluggability)

Common operations performed at CDB level
- Manage many as one (upgrade, HA, backup)
- Granular control when appropriate

Shared memory and background processes
- More applications per server

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
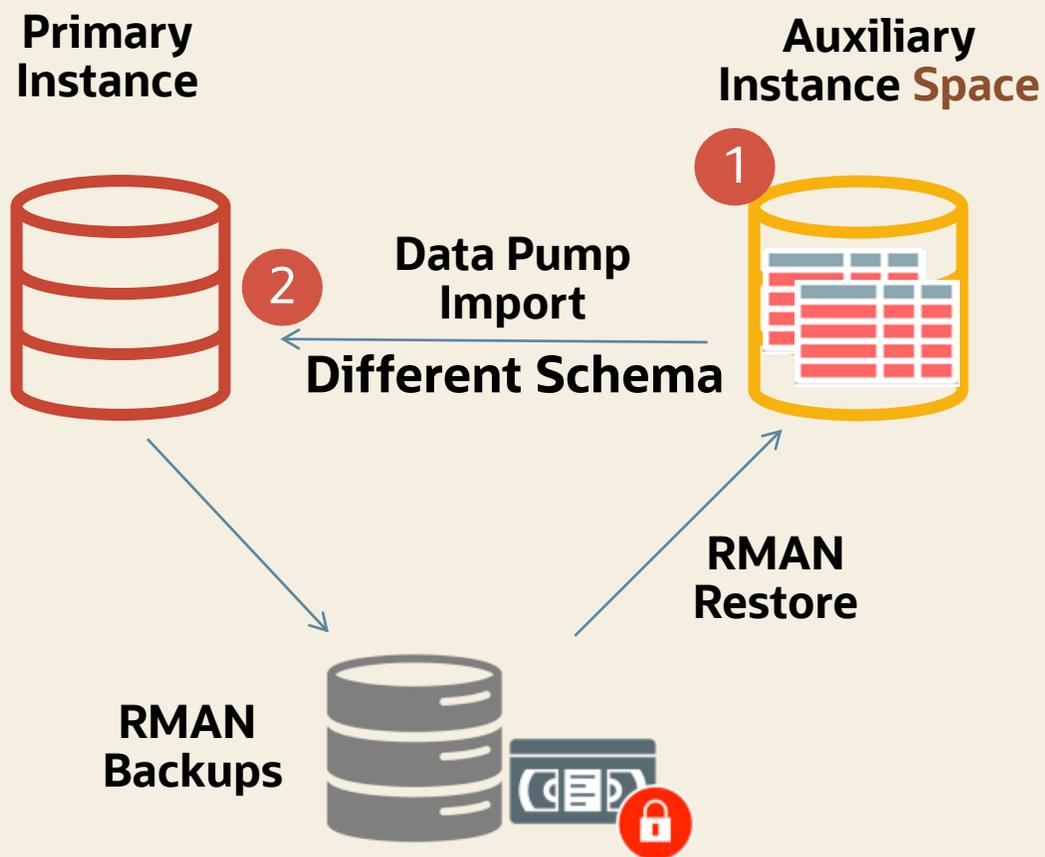
Oracle Recovery Manager - RMAN
Database Integrated Backup and Recovery

- 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

Data Files   **Fast Recovery Area (FRA)**

Disk   Tape

Tape

Cloud
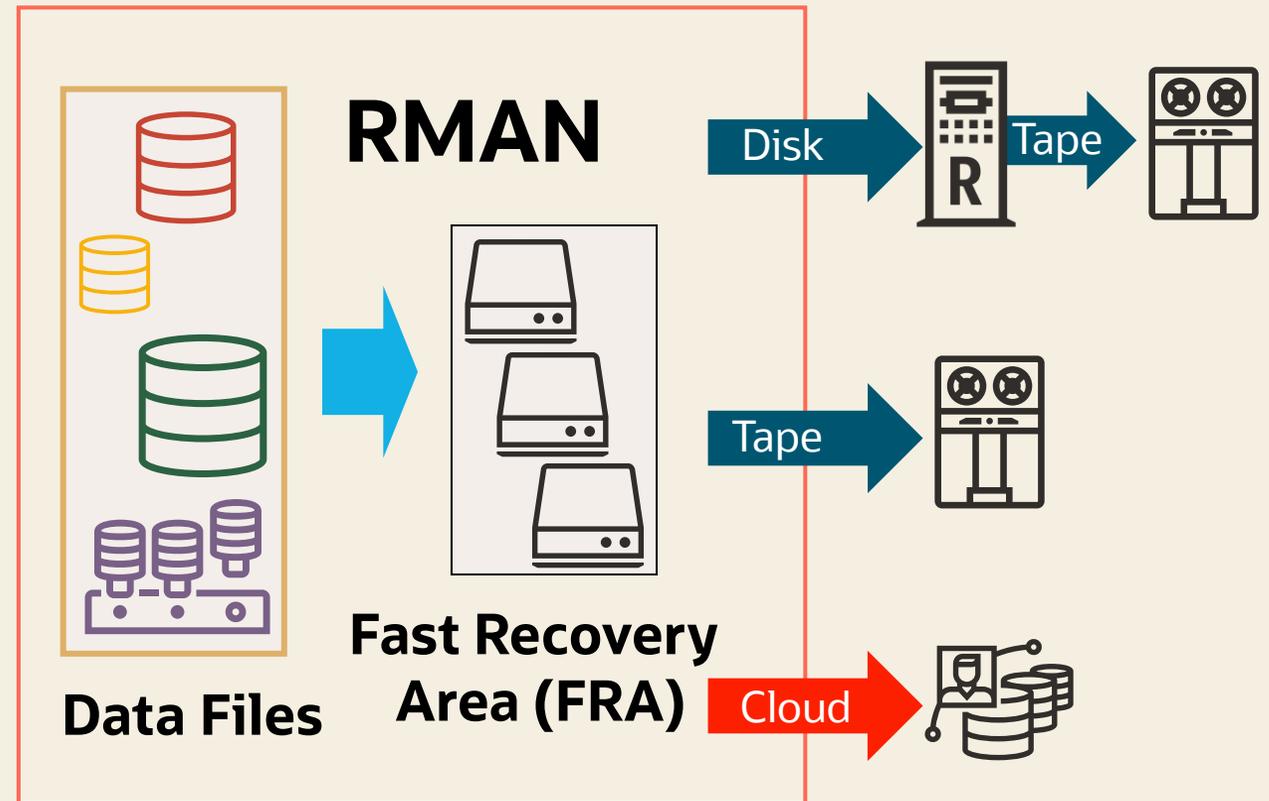
RMAN Enhancements for Table Recovery

Primary Instance

Auxiliary Instance Space

Data Pump Import

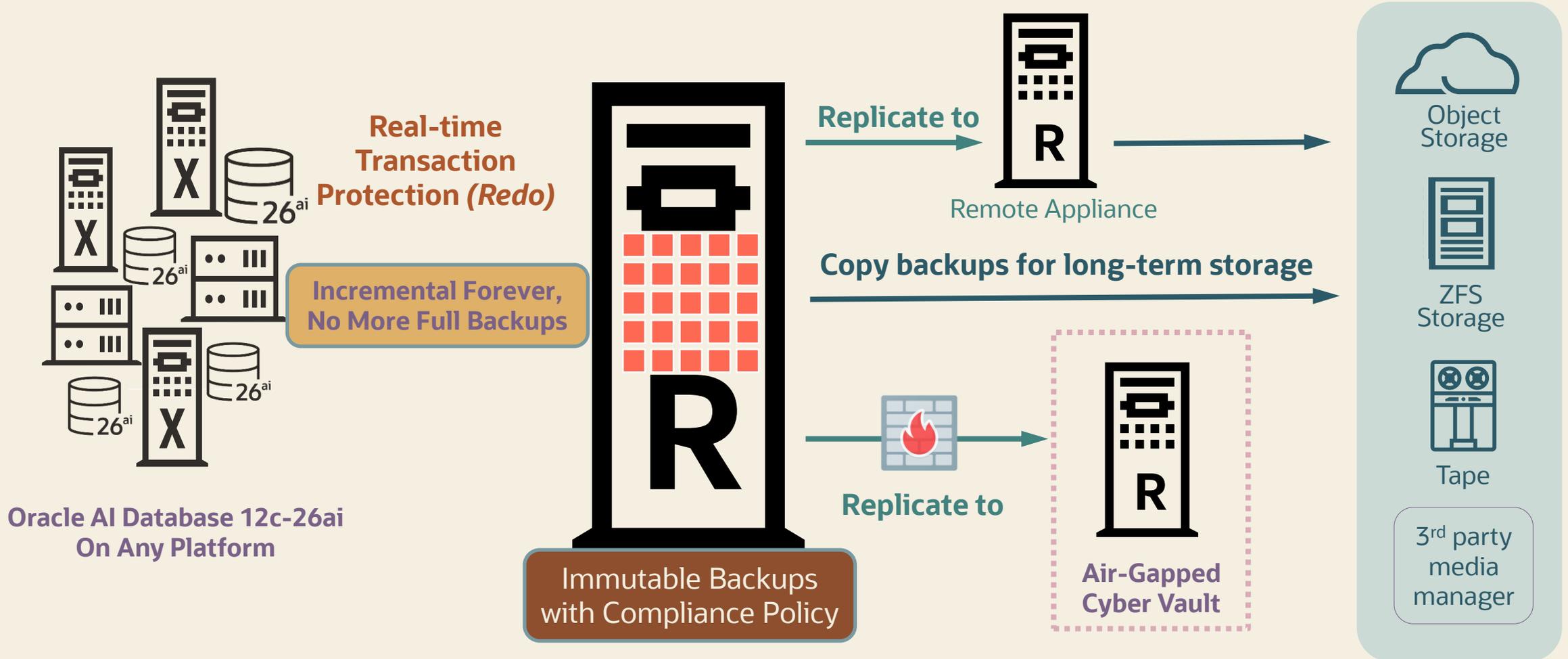**Different Schema**

RMAN Restore

RMAN Backups

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

Real-time Transaction Protection *(Redo)*

Incremental Forever, No More Full Backups

Oracle AI Database 12c-26ai On Any Platform

Immutable Backups with Compliance Policy

Replicate to

Remote Appliance

Copy backups for long-term storage

Replicate to

Air-Gapped Cyber Vault

Object Storage

ZFS Storage

Tape

3rd party media manager

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

System Health Score is 89 out of 100 (detail)

Cluster Summary

Cluster Name	cluster-clu1
OS/Kernel Version	LINUX X86-64 OELRHEL 5 2.6.39-400.124.1.el5uek
CRS Home - Version	/u01/app/11.2.0.4/grid - 11.2.0.4.1
DB Home - Version - Names	/u01/app/oracle/product/11.2.0.4/dbhome_1 - 11.2.0.4.1 - dbm
EM Agent Home	/u01/app/oracle/em/agent_haem/core/12.1.0.5.0
Exadata Version	11.2.3.3.0
Number of nodes	9
Database Servers	2
Storage Servers	3
IB Switches	4
exachk Version	12.1.0.2.6(BETA)_20160125
Collection	exachk_randomadm07_dbm_012516_141503.zip
Duration	10 mins, 49 seconds
Executed by	root
Collection Date	25-Jan-2016 14:15:39

Note! This version of exachk is considered valid for 120 days from today or until a new version is available

NOTE : exachk is only one part of the MAA Best Practices recommendation methodology. My Oracle Support "Oracle Exadata Best Practices (Doc ID757552.1)" should be reviewed thoroughly as it is the driver for exachk and contains additional operational and diagnostic guidance that is not programmed within exachk.

WARNING! The data collection activity appears to be incomplete for this exachk run. Please review the "Killed Processes" and / or "Skipped Checks" section and refer to "Appendix A - Troubleshooting Scenarios" of the "Exachk User Guide" for corrective actions.

Database Server

Status	Type	Message	Status On	Details
FAIL	SQL Parameter Check	ASM parameter SGA_TARGET is NOT set according to recommended value.	All Instances	View
WARNING	Patch Check	Patch 16618055 not is applied on RDBMS_HOME	All Homes	View
WARNING	OS Check	Database parameter _enable_NUMA_support should be set to recommended value	All Database Servers	Hide

Verify database parameter _enable_NUMA_support

Recommendation	NUMA enabled in the database on all Exadata 8 socket servers boosts overall application performance. NUMA enabled in the database on Exadata generation X5 2 socket servers boosts performance of memory scan intensive workloads, for example IMDB. As of Oracle RDBMS release 12.1.0.2.6 and above, the enabling of NUMA in the database is automatic so no action is necessary on any Exadata platform. For any Exadata platform using 12.1.0.5 or lower, please reference the recommended value. NUMA support in the database should always be off on Exadata OVM.
Needs attention on	randomadm07
Passed on	-

Status on randomadm07:
WARNING => Database parameter _enable_NUMA_support should be set to recommended value

DATA FROM RANDOMADM07 - DBM DATABASE - VERIFY DATABASE PARAMETER _ENABLE_NUMA_SUPPORT

_enable_NUMA_support = FALSE
isdefault = FALSE

INFO	SQL Check	Direct NFS Client is NOT enabled	All Databases	View

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Maximum Availability Architecture (MAA) Scorecard

Outage Type	Status	Type	Message	Status On	Details
SOFTWARE MAINTENANCE BEST PRACTICES	FAIL		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:

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.

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:

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.

Best Practices
1. Note: 1662018.1 - 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: 1461240.1 - Exadata Database Machine Software and Hardware Maintenance Planning Guide
5. Best Practices For Database Consolidation On Exadata Database Machine
6. Note: 888828.1 - Database Machine and Exadata Storage Server Supported Versions
7. Note: 1270094.1 - 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	randomadm07,randomadm08: /u01/app/oracle/product/11.2.0.4/dbhome_1	11.2.0.4.1	11.2.0.4.160119	11.2.0.4 BP is older than recommended.
	Grid Infrastructure	randomadm07,randomadm08: /u01/app/11.2.0.4/grid	11.2.0.4.1	11.2.0.4.160119	11.2.0.4 BP is older than recommended.
	Exadata	randomadm07,randomadm08	11.2.3.3.0	12.1.2.1.3 or 12.1.2.2.1	Older than recommended version.
STORAGE SERVER	Exadata	randomceladm12,randomceladm13,randomceladm14	11.2.3.3.0	11.2.3.3.1	Older than recommended version.
IB SWITCH	Firmware	randomsw-ib01	2.1.8-1	2.1.5-1 or higher	Version within recommended range. Exception: Version is different than peers.
		randomsw-iba0,randomsw-ibb0,randomsw-ibs0	2.1.3-4	2.1.5-1 or higher	Version within recommended range. Exception: Version is different than peers.

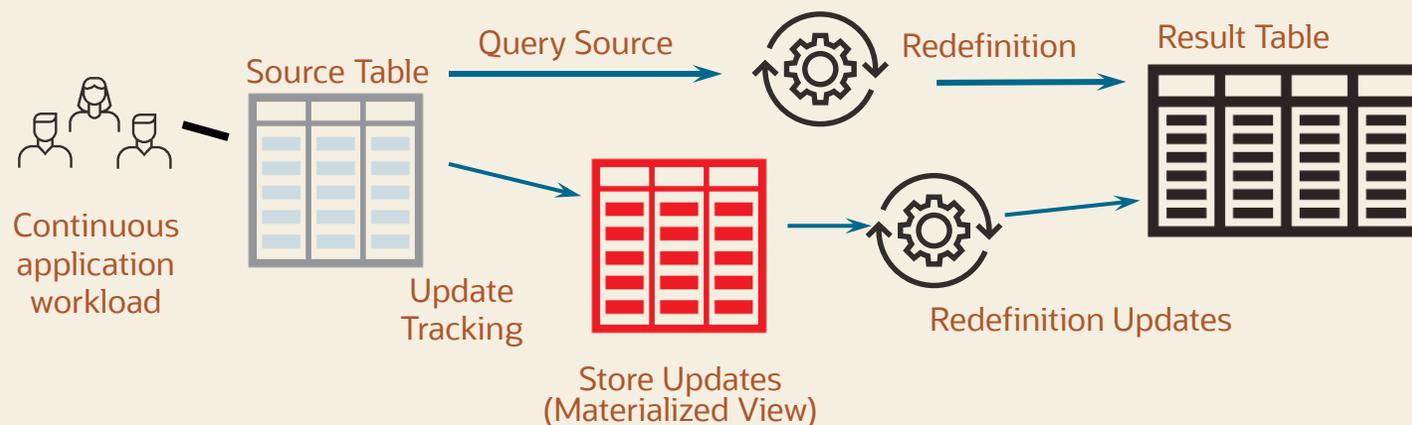Note: Automated Orachk/Exachk Healthcheck MOS 107954.1 updated frequently
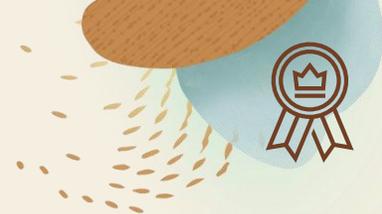
Online Operations
Redefine your data structures without taking tables offline

- 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
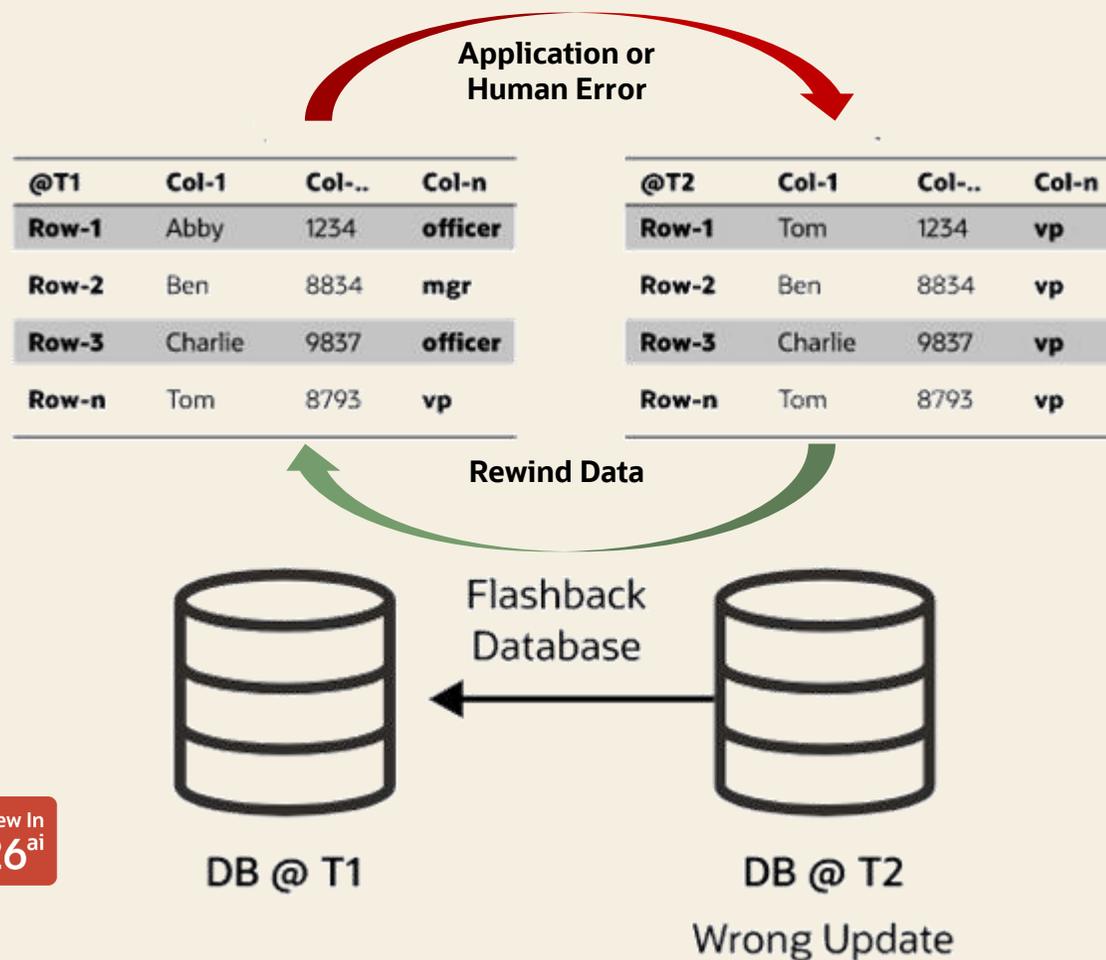- Ability to monitor progress throughout redefinition operation

Continuous application workload

Source Table

Query Source

Redefinition

Result Table

Update Tracking

Store Updates (Materialized View)

Redefinition Updates

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
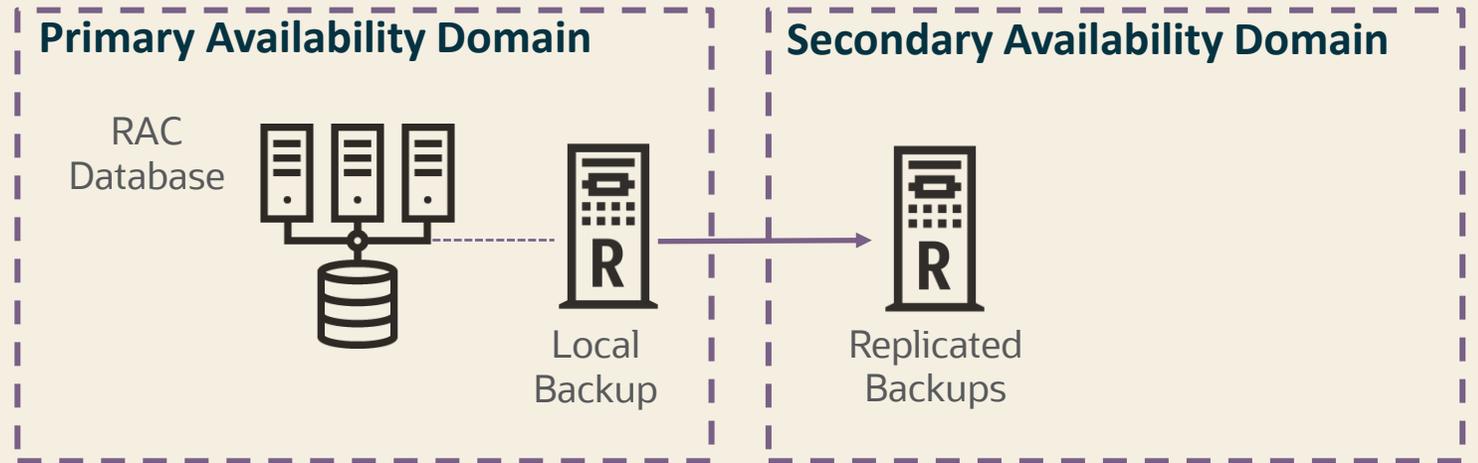
New In 26^{ai}

Application or Human Error

@T1	Col-1	Col-..	Col-n
Row-1	Abby	1234	officer
Row-2	Ben	8834	mgr
Row-3	Charlie	9837	officer
Row-n	Tom	8793	vp

@T2	Col-1	Col-..	Col-n
Row-1	Tom	1234	vp
Row-2	Ben	8834	vp
Row-3	Charlie	9837	vp
Row-n	Tom	8793	vp

Rewind Data

Flashback Database

DB @ T1

DB @ T2

Wrong Update

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

Primary Availability Domain

RAC Database

Local Backup

Secondary Availability Domain

Replicated Backups

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

JDBC, OCI, ODP.Net, Connection Pool
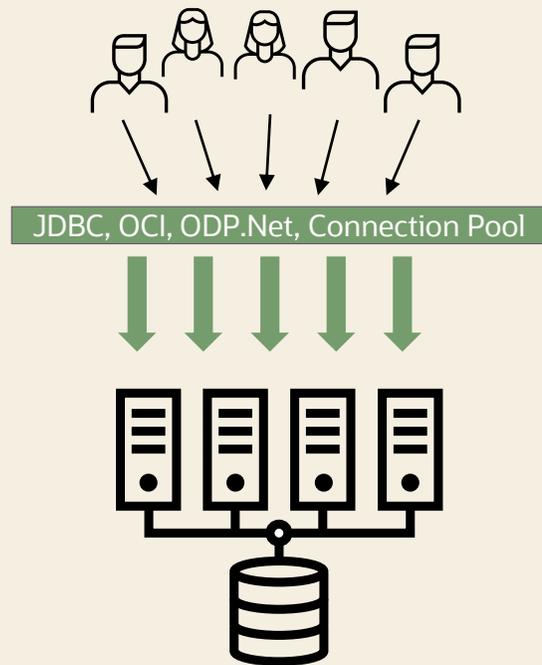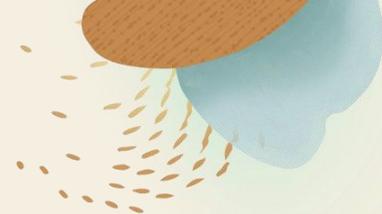
✓ Unique scale-everything, highly available database architecture with concurrent active active instances

✓ 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
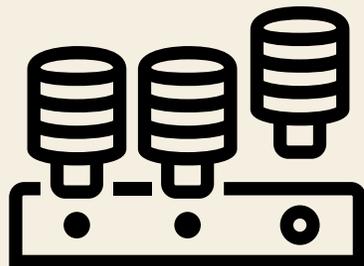
2X faster Pluggable Database Open

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
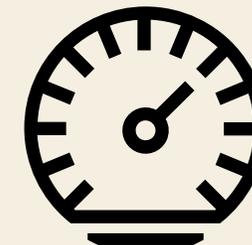
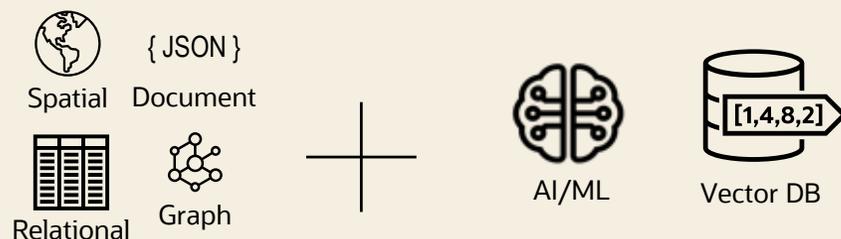**10X** Faster start of work on instance crash or restart

Buddy Instance, Parallel operations on dirty buffers list and other features

New In 26ai

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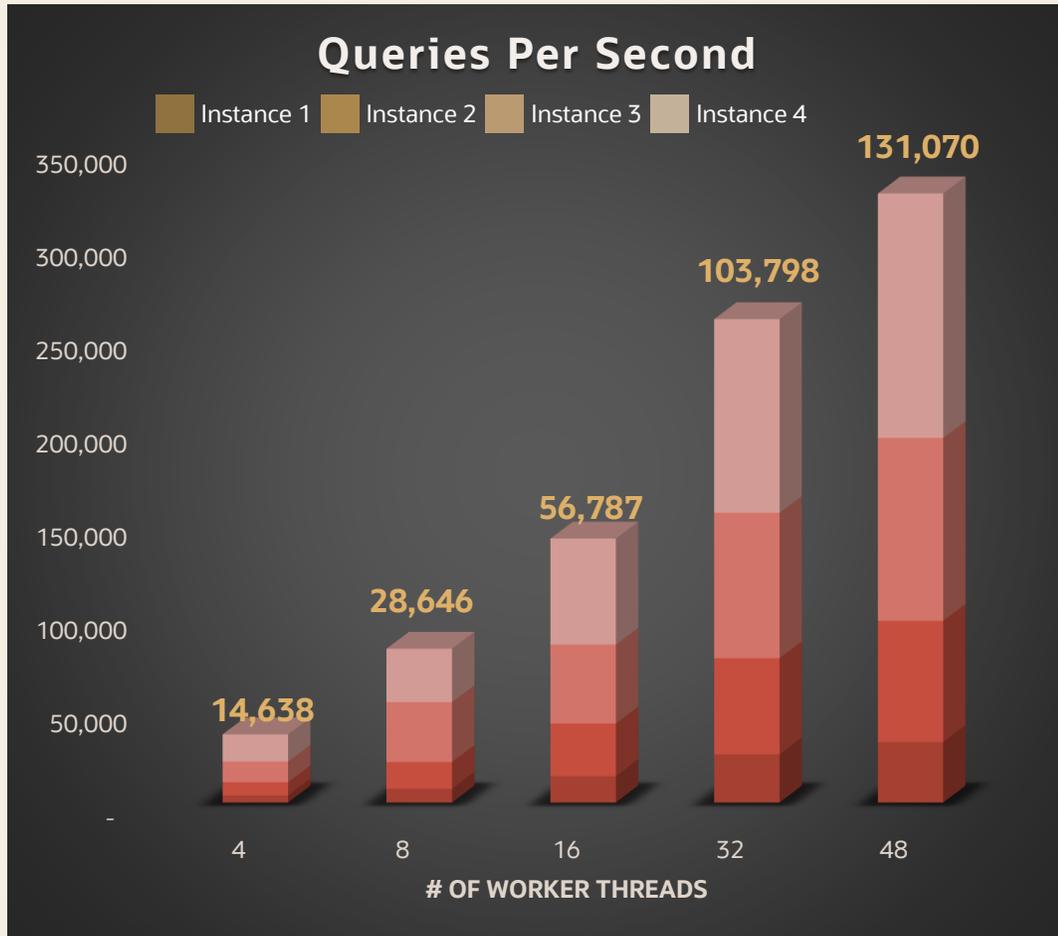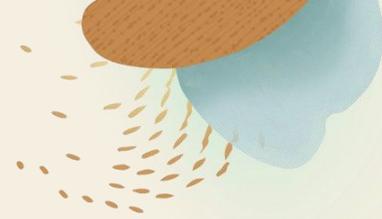
- Oracle RAC scales the GloVe-25 workload linearly across all the instances
  - The GloVe-25 dataset contains pre-trained, 25-dimensional word vectors generated using the GloVe (Global Vectors for Word Representation) algorithm
  - Each entry maps a single English word to a compact numerical representation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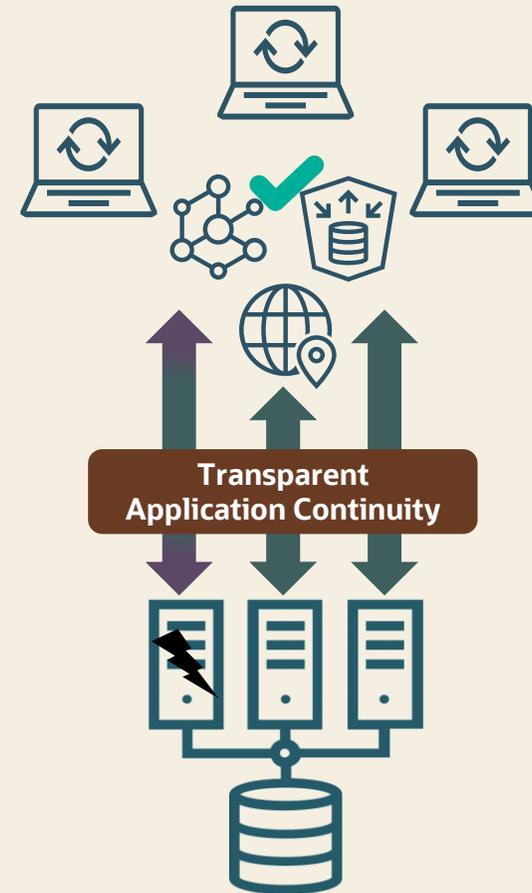 - ~99% of the query elapsed time was CPU time

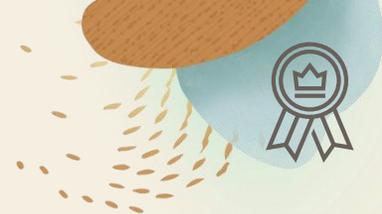# Transparent Application Continuity (TAC)

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.
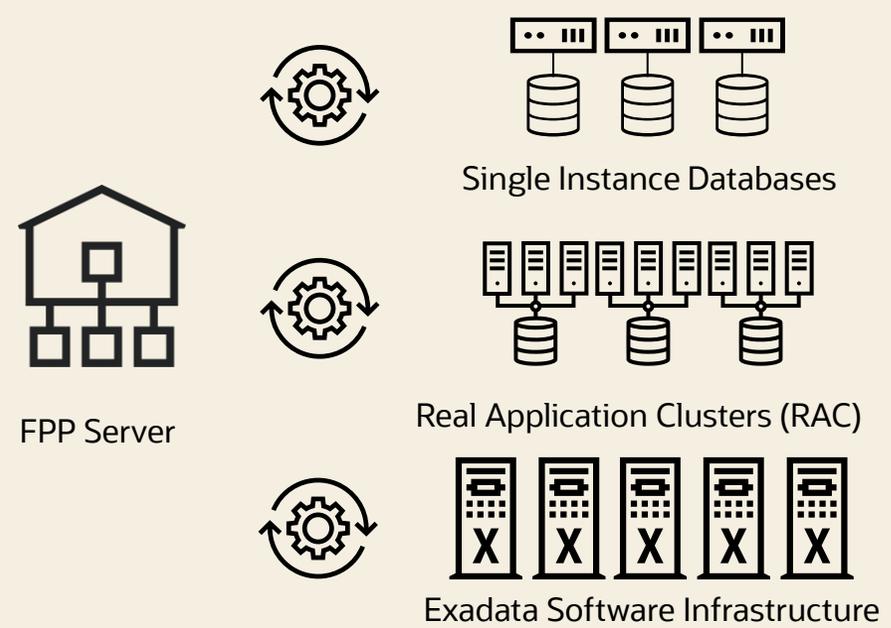
New In 26ai

Transparent Application Continuity

Fleetwide maintenance on-premises and for ExaDB in OCI

Single Instance Databases

FPP Server

Real Application Clusters (RAC)

Exadata Software Infrastructure

Exadata Fleet Update

Database Collection

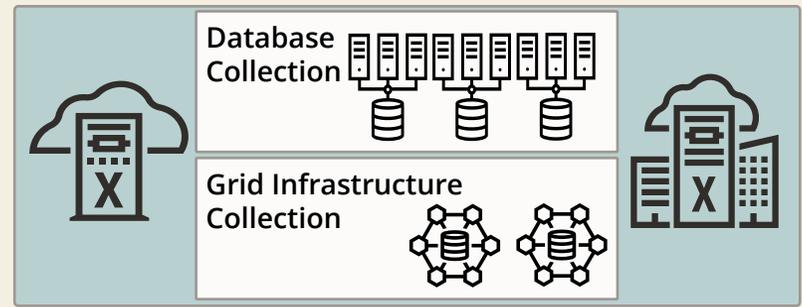Grid Infrastructure Collection

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
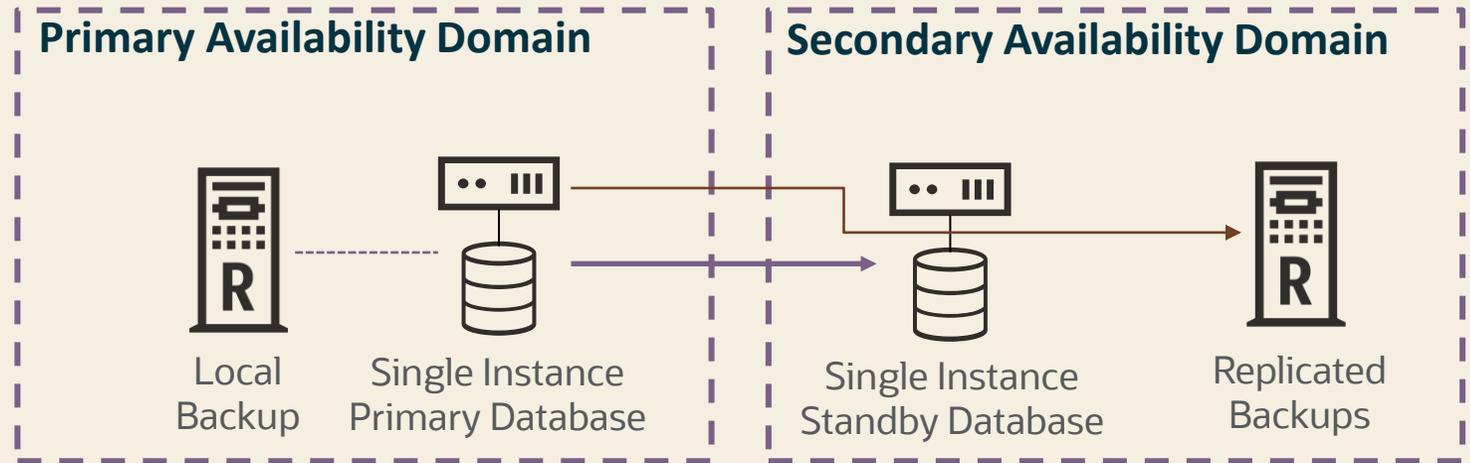
SILVER (Option 2)

Primary Availability Domain

Secondary Availability Domain

Local Backup | Single Instance Primary Database | Single Instance Standby Database | Replicated Backups

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
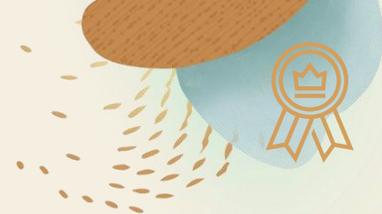-database/23/haovw/continuous-availability-
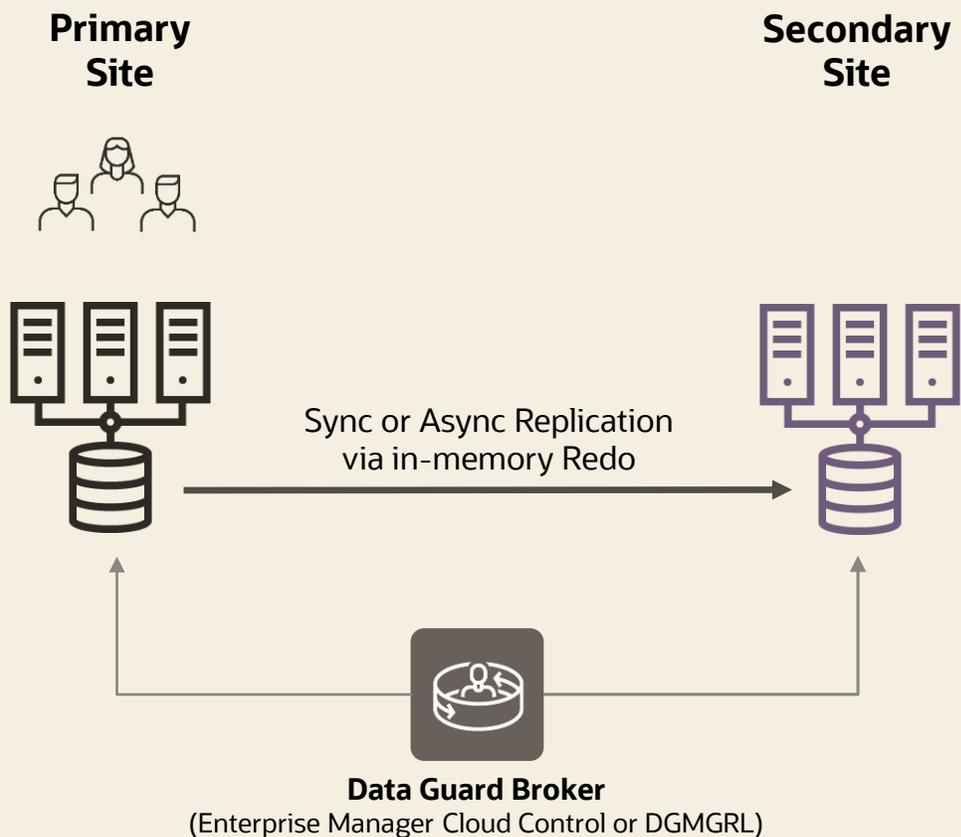applications.html

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

Primary Site

Secondary Site

Sync or Async Replication
via in-memory Redo

Data Guard Broker
(Enterprise Manager Cloud Control or DGMGRL)

- **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**
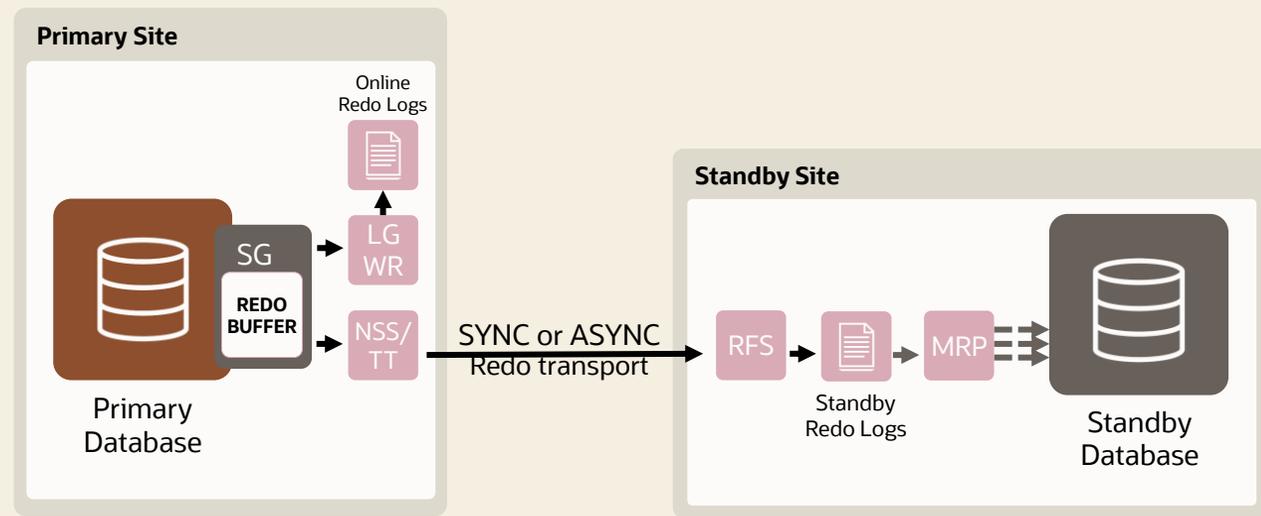
- **Simple migrations and upgrades**
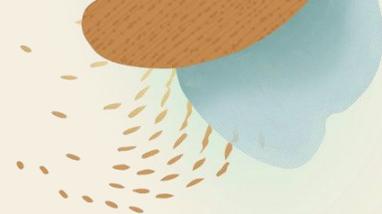
Data Guard is Optimized for the Database
Better than storage mirroring or 3rd party solutions
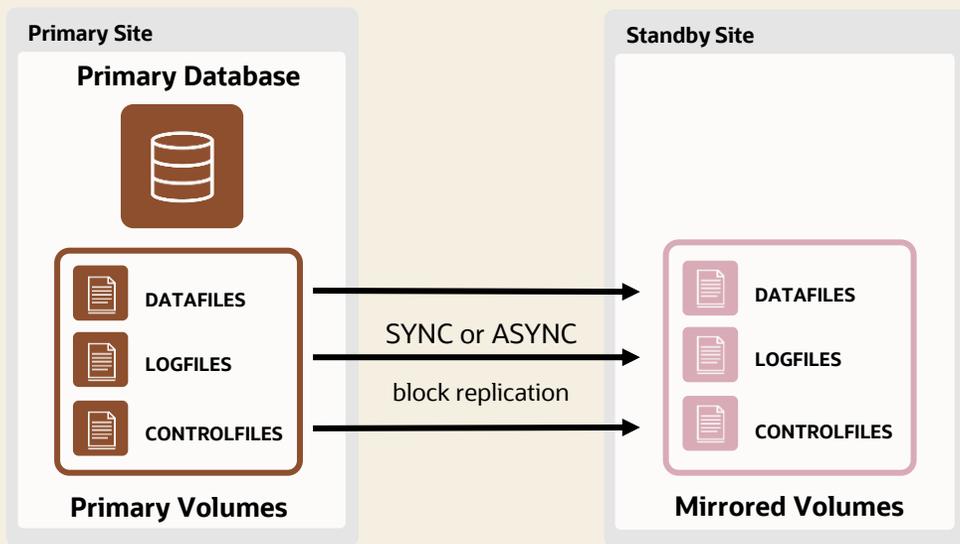
Traditional replication

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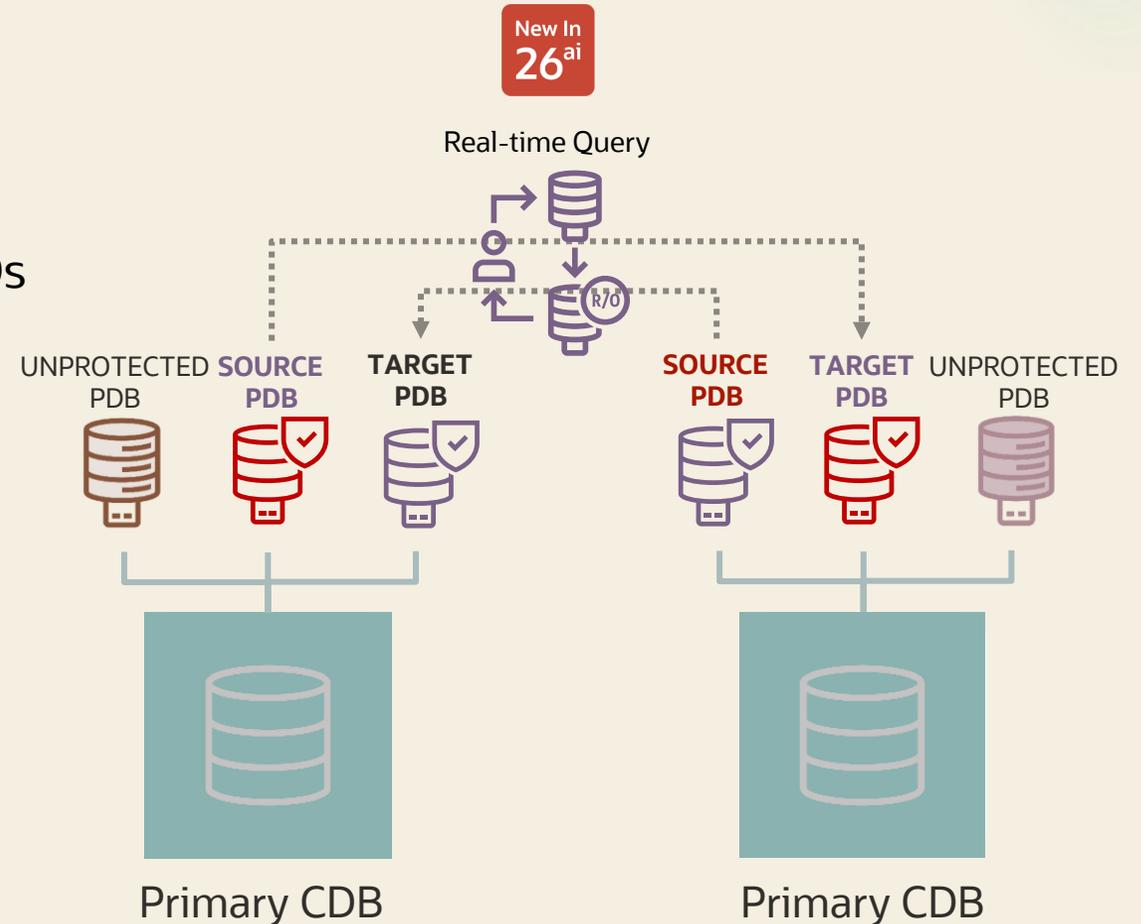- 27x network I/O
- Standby needs warm-up
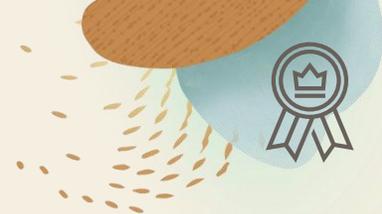
Data Guard replication

- **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

New In 26ai

Real-time Query

UNPROTECTED PDB   **SOURCE PDB**   **TARGET PDB**   **SOURCE PDB**   **TARGET PDB**   UNPROTECTED PDB

Primary CDB

Primary CDB

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

New In 26ai

Table Family

Customers

Customer	Name
123	Mary
456	John
999	Peter

Orders

Order	Customer
4001	123
4002	456
4003	999
4004	456
4005	456

Line Items

Customer	Order	Line
123	4001	40011
999	4003	40012
123	4001	40013
456	4004	40014
999	4003	40015
999	4003	40016

Products

| SKU	Product
100	Coil
101	Piston
102	Belt

Sharded Tables

Duplicated Tables
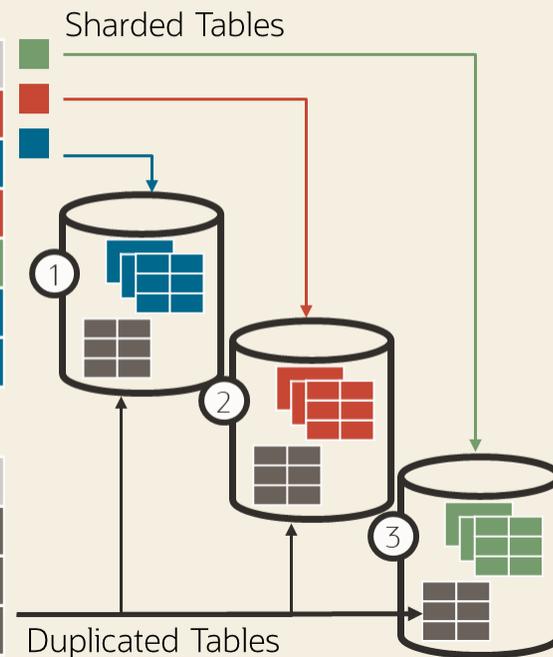
Active-active Globally Distributed Database
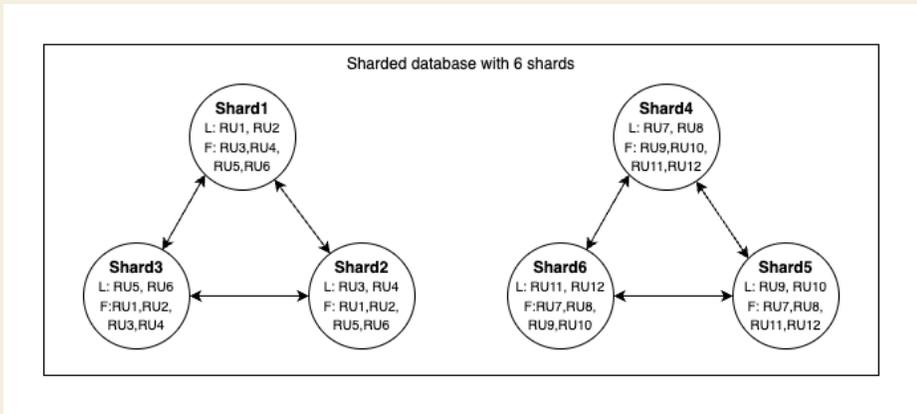## Raft Replication

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
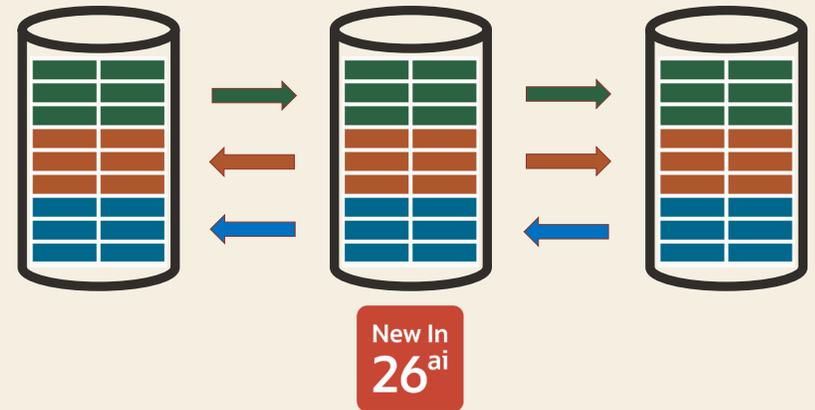
Globally Distributed Database is divided into multiple replication units

- 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

New In
26^{ai}

Sharded database with 6 shards

Shard1
L: RU1, RU2
F: RU3,RU4,
RU5,RU6

Shard4
L: RU7, RU8
F: RU9,RU10,
RU11,RU12

Shard3
L: RU5, RU6
F:RU1,RU2,
RU3,RU4

Shard2
L: RU3, RU4
F: RU1,RU2,
RU5,RU6

Shard6
L: RU11, RU12
F:RU7,RU8,
RU9,RU10

Shard5
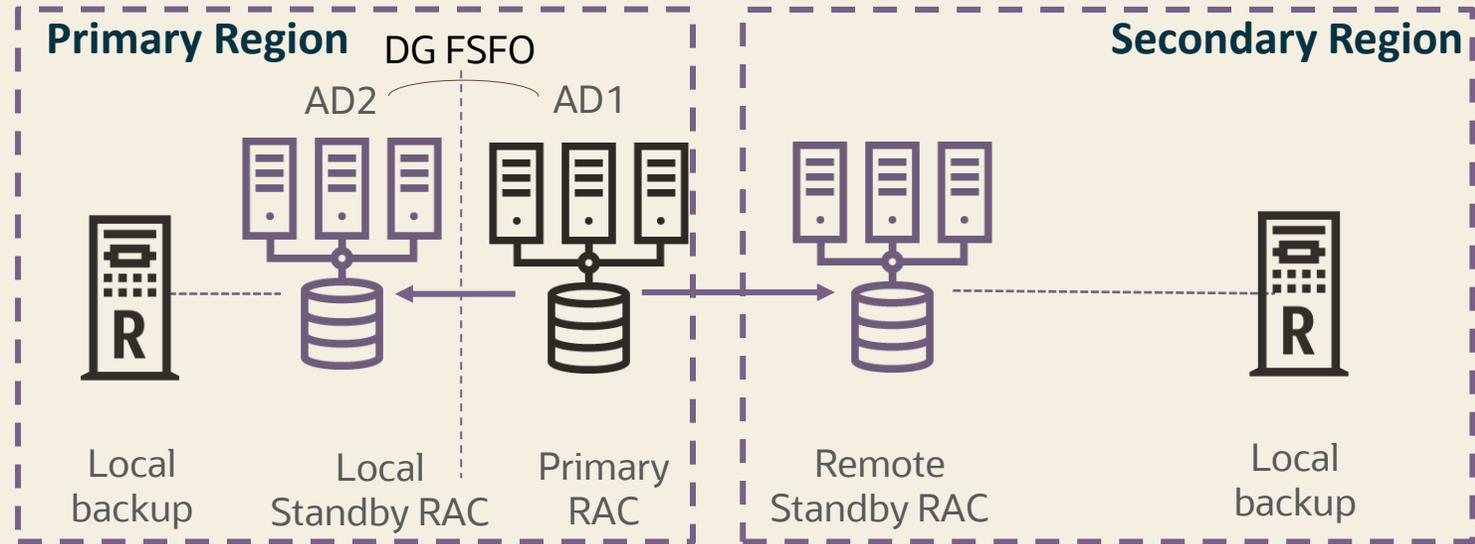L: RU9, RU10
F: RU7,RU8,
RU11,RU12

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

Primary Region DG FSFO **Secondary Region**

AD2 AD1

Local backup | Local Standby RAC | Primary RAC | Remote Standby RAC | Local backup

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.
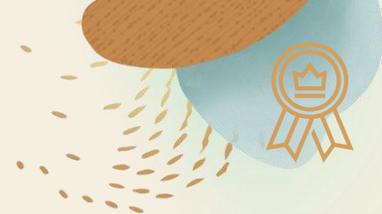
Oracle Data Protection
Gold – Comprehensive Data Protection

	Capability	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	• Continuous physical block checking at standby • Strong isolation to prevent single point of failure • Automatic repair of physical corruptions • Automatic database failover (option for lost writes)	• **Detect lost write corruption, auto shutdown and failover** • **Intra-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
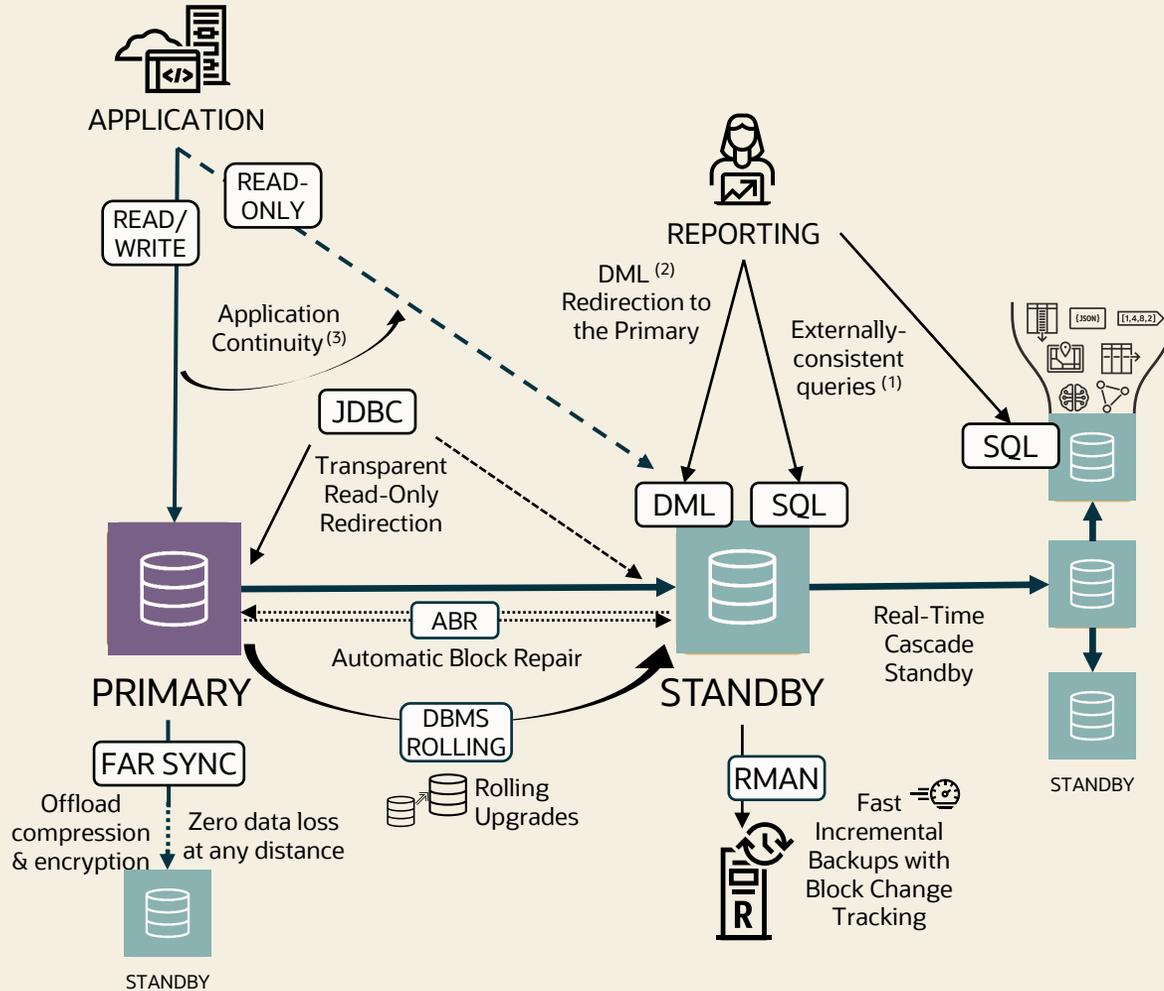
Offload & scale

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
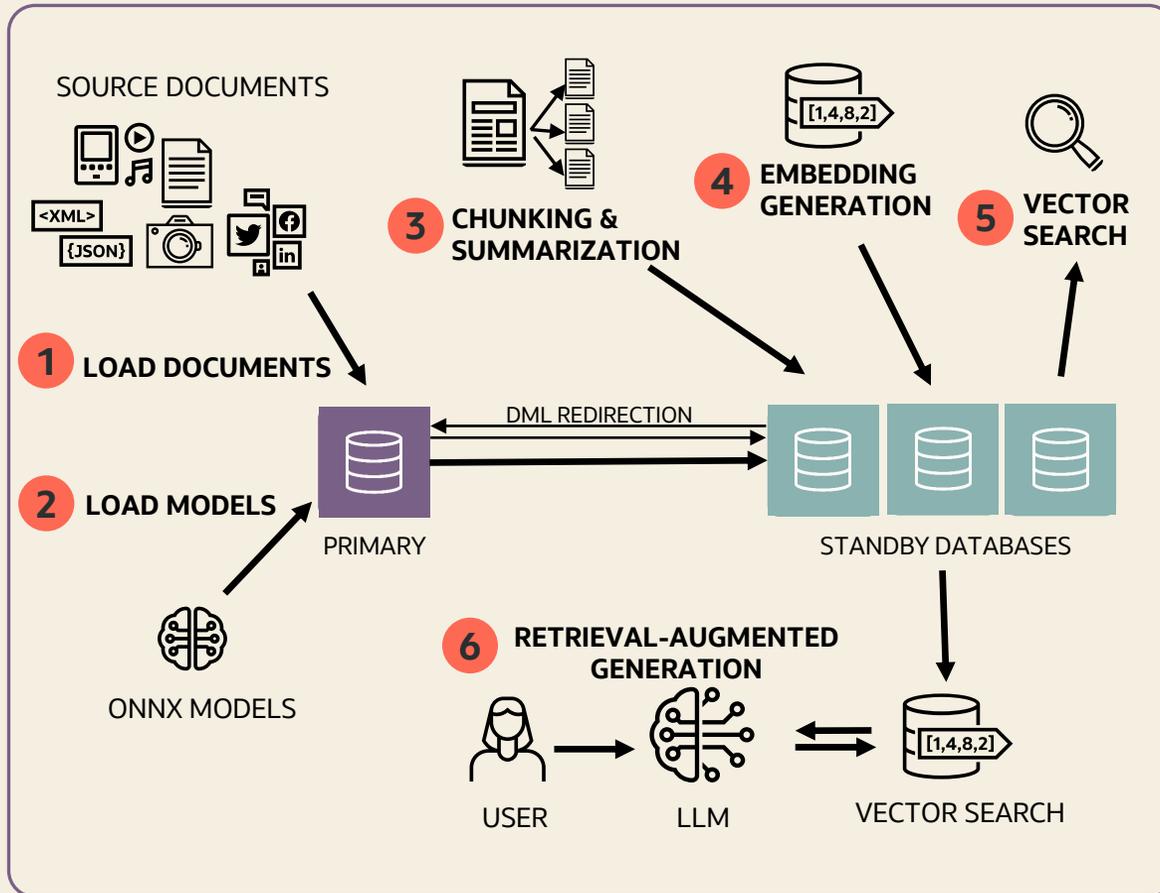
Higher availability

- 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

New In 26 ai

SOURCE DOCUMENTS

1 LOAD DOCUMENTS

2 LOAD MODELS

ONNX MODELS

3 CHUNKING & SUMMARIZATION

4 EMBEDDING GENERATION

5 VECTOR SEARCH

DML REDIRECTION

PRIMARY

STANDBY DATABASES

6 RETRIEVAL-AUGMENTED GENERATION
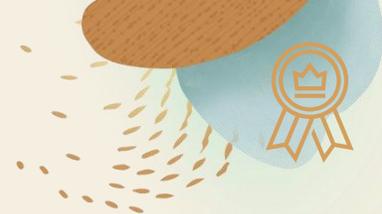
USER → LLM → VECTOR SEARCH

- 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

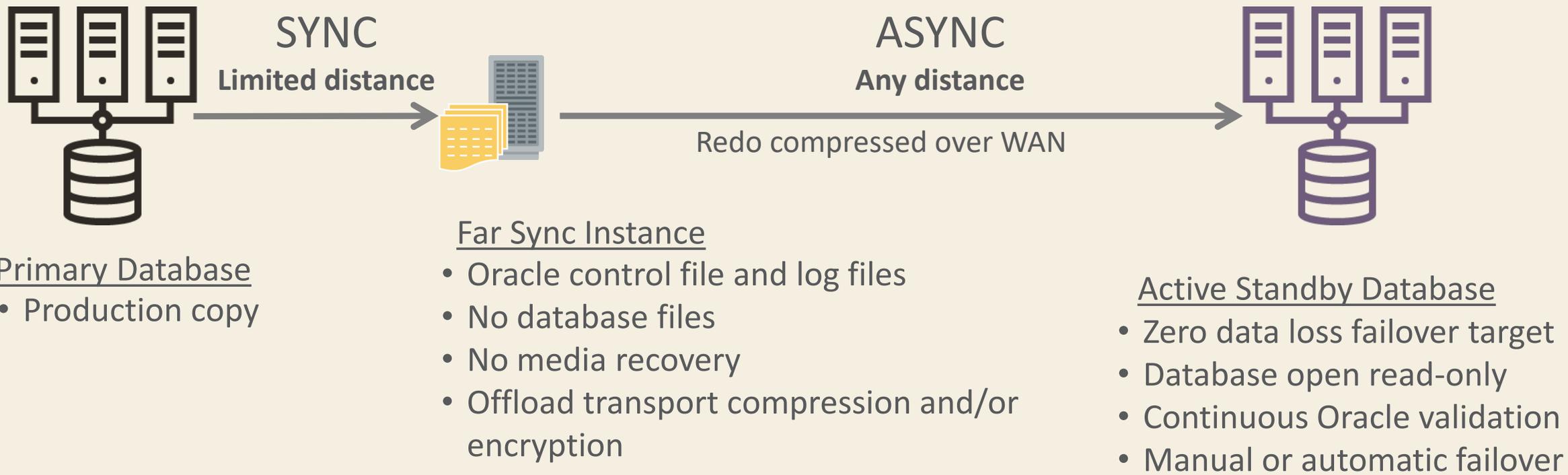**Primary database performance is unaffected**

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

Active Data Guard Far Sync
Zero Data Loss Protection at Any Distance

SYNC
Limited distance

ASYNC
Any distance

Redo compressed over WAN

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

Primary Database
- Production copy

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

Transparent Application Continuity
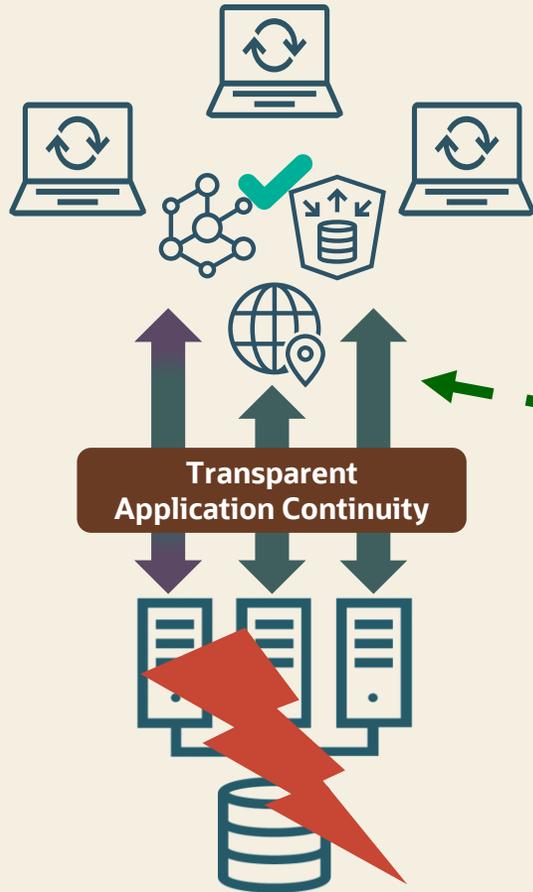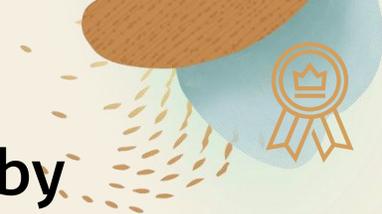
Primary RAC Database

Active Data Guard Standby

<u>Outage or Interruption at Database</u>:

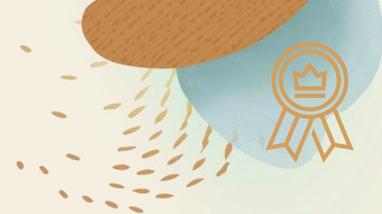- Database Request interrupted by an Outage or timeout

- Session reconnects to the RAC Cluster (or Standby) and

- Database Request replays automatically

- Result from Database Request returned to the user

- Oracle AI Database 26ai provides Application Continuity through DBMS_ROLLING operations. **New In 23ai**

Active Data Guard Rolling Maintenance and Upgrades
Using DBMS_ROLLING package

WHILE THE USERS ACCESS THIS

UPGRADE THIS

THEN SWITCHOVER

PRIMARY

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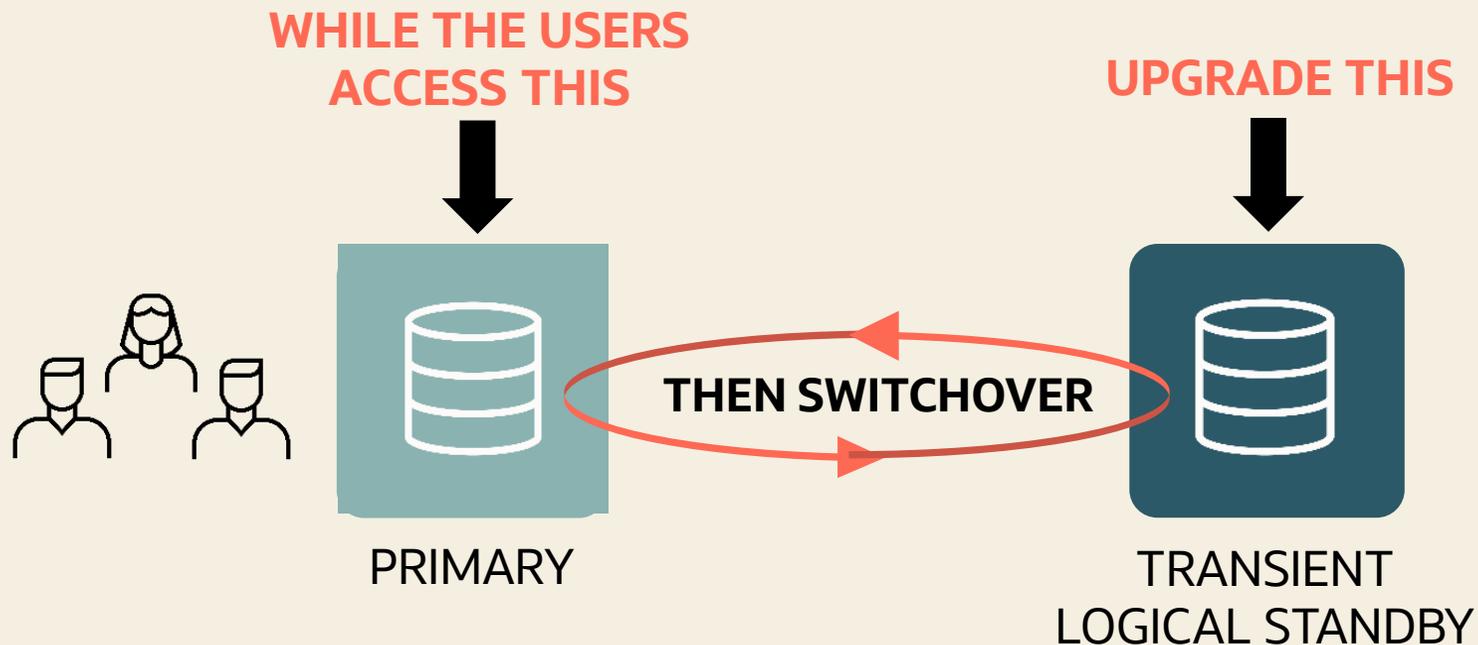
- Use a transient logical standby database to upgrade with very little downtime.
- The only downtime is as little as it takes to perform a switchover.
- Oracle AI Database 26ai provides Application Continuity Support

New In
26ai
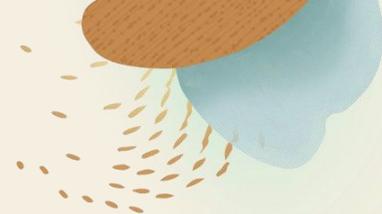
Different Ways to Configure Oracle Data Guard
For easy integration with DevOps and configuration pipelines

```
dgmgrl

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'
```

```
PL/
SQL

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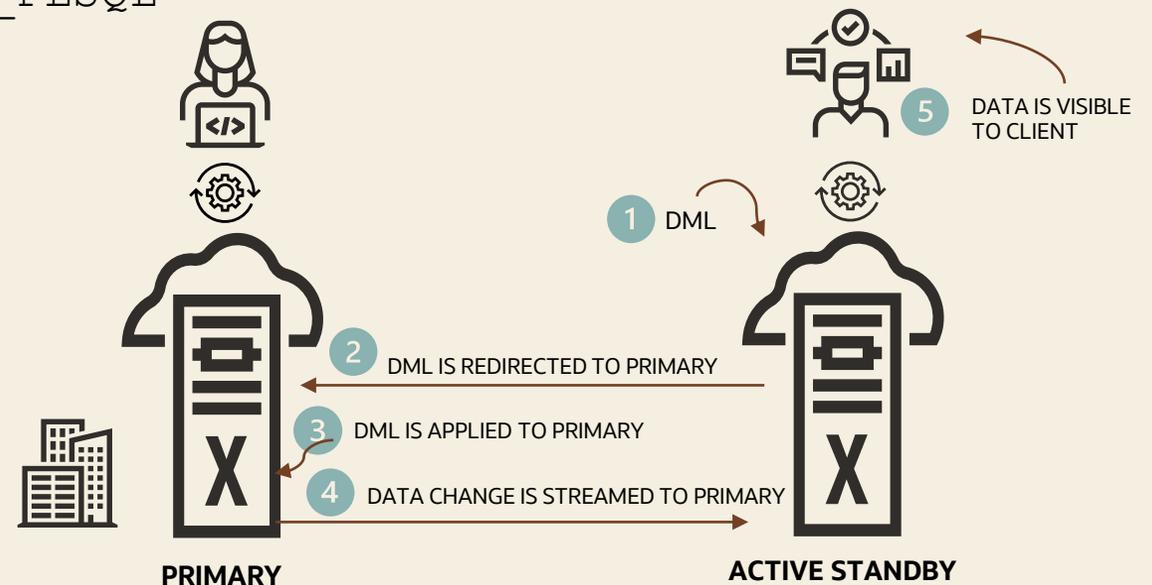
```
POST /database/dataguard/configuration/
{
  "primary_connection_identifier":"clu-scan:1521/mydb",
  "primary_database": "mydb_site1"
}
```

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

5 DATA IS VISIBLE TO CLIENT

1 DML

2 DML IS REDIRECTED TO PRIMARY

3 DML IS APPLIED TO PRIMARY

4 DATA CHANGE IS STREAMED TO PRIMARY

PRIMARY

ACTIVE STANDBY

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
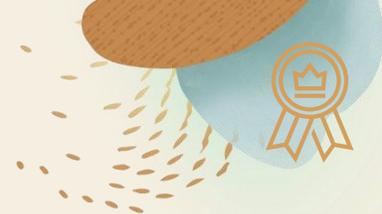
Standby Result Cache Preservation
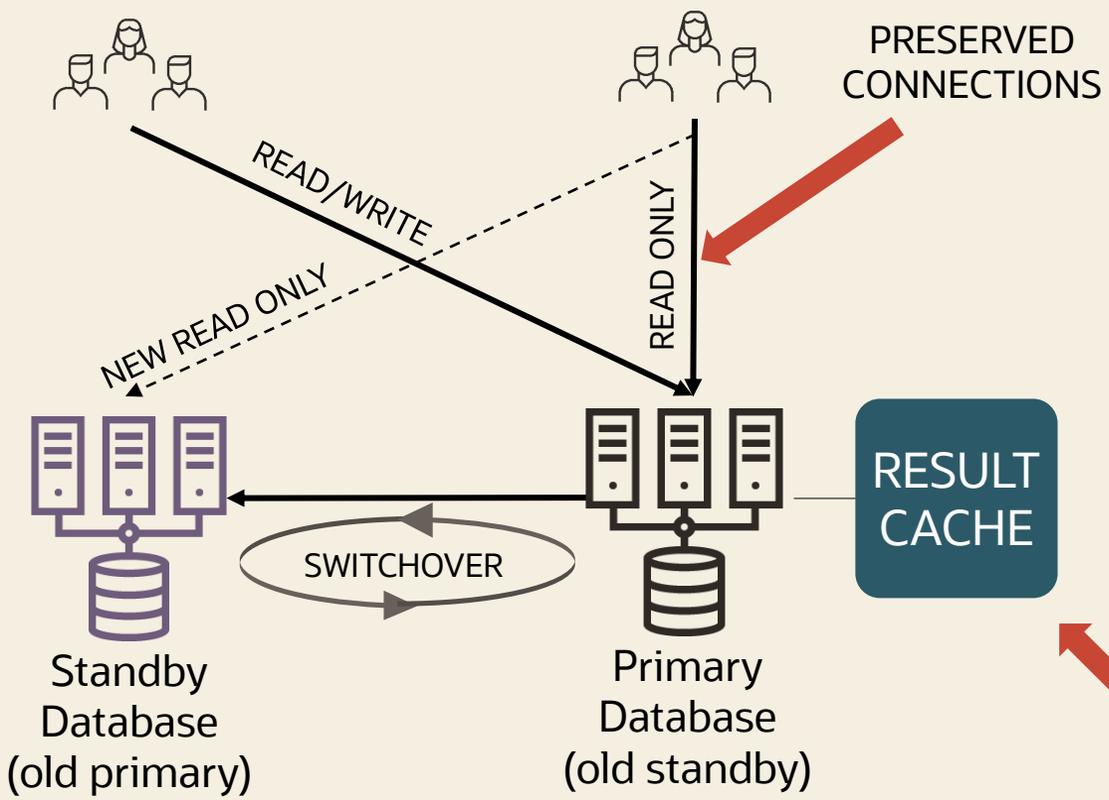## Keep the Result Cache warm after a role transition

READ/WRITE

READ ONLY

NEW READ ONLY

PRESERVED
CONNECTIONS

READ ONLY

RESULT
CACHE

SWITCHOVER

Standby
Database
(old primary)

Primary
Database
(old standby)

PRESERVED
RESULT CACHE

- 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
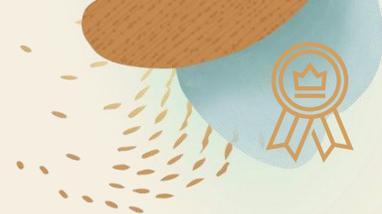
Multi-Instance Redo Apply Performance
Lower Latency Active Data Guard Standby Databases

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

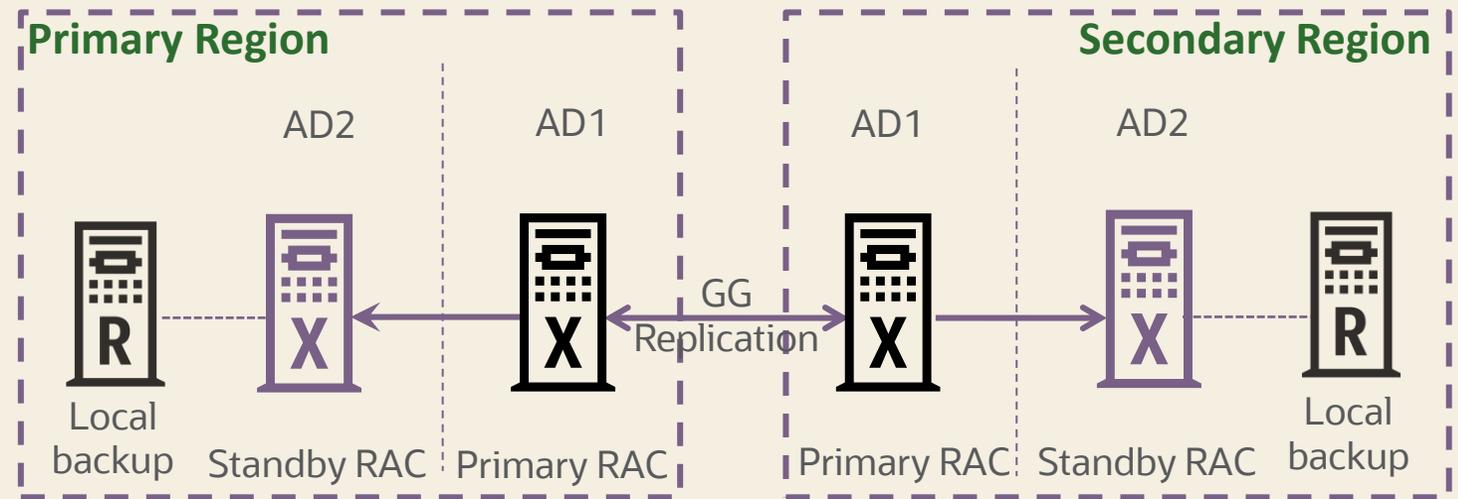**Standby Apply Rate MB/sec**

Instances	OLTP	Batch
1 Instance	190	700
2 Instances	380	1400
4 Instances	740	2752
8 Instances	1480	5000

Legend: ■ OLTP ■ Batch
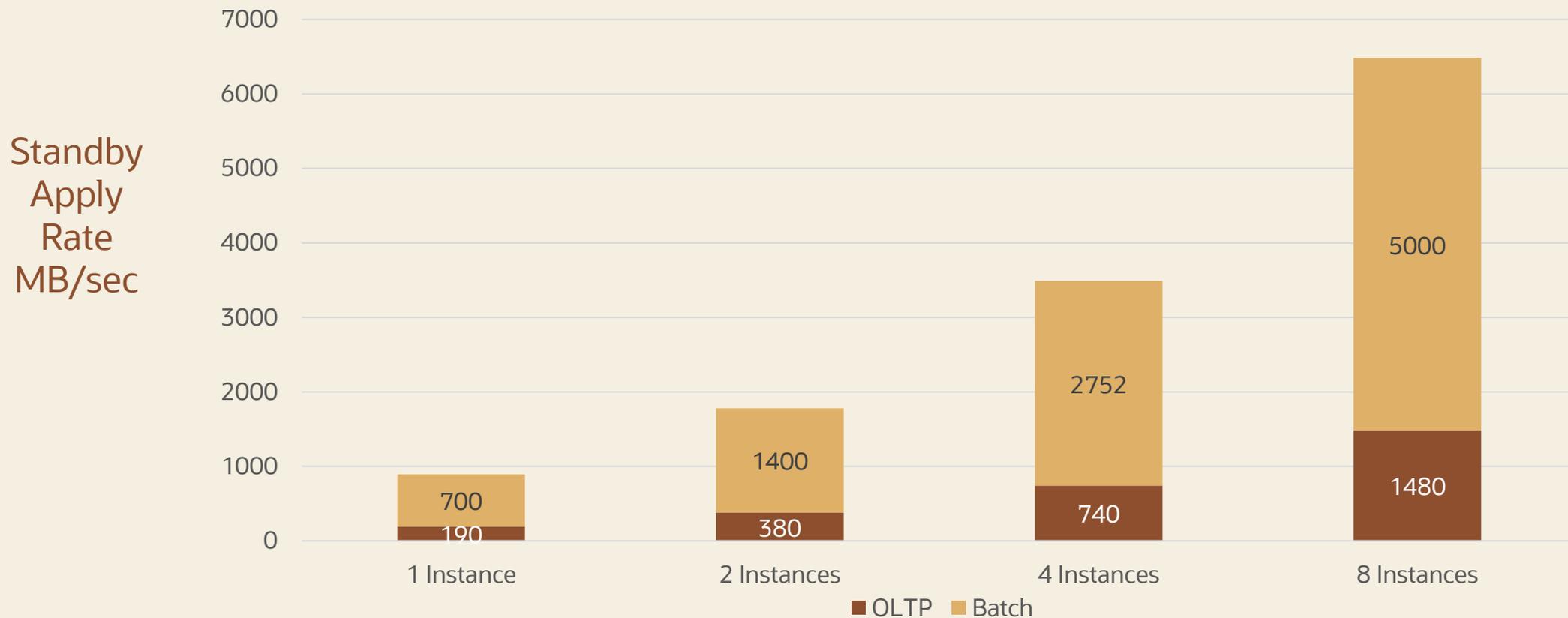
PLATINUM

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

Primary Region — AD2, AD1 — Local backup, Standby RAC, Primary RAC — GG Replication — **Secondary Region** — AD1, AD2 — Primary RAC, Standby RAC, Local backup

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	**<1 min (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
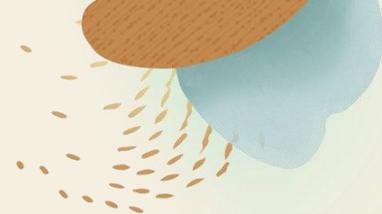
Exadata Maximum Availability Architecture (MAA)

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

Within Exadata: Full Fault Tolerance

Within a Site: Local Data Guard

Across Sites: Data Guard for DR
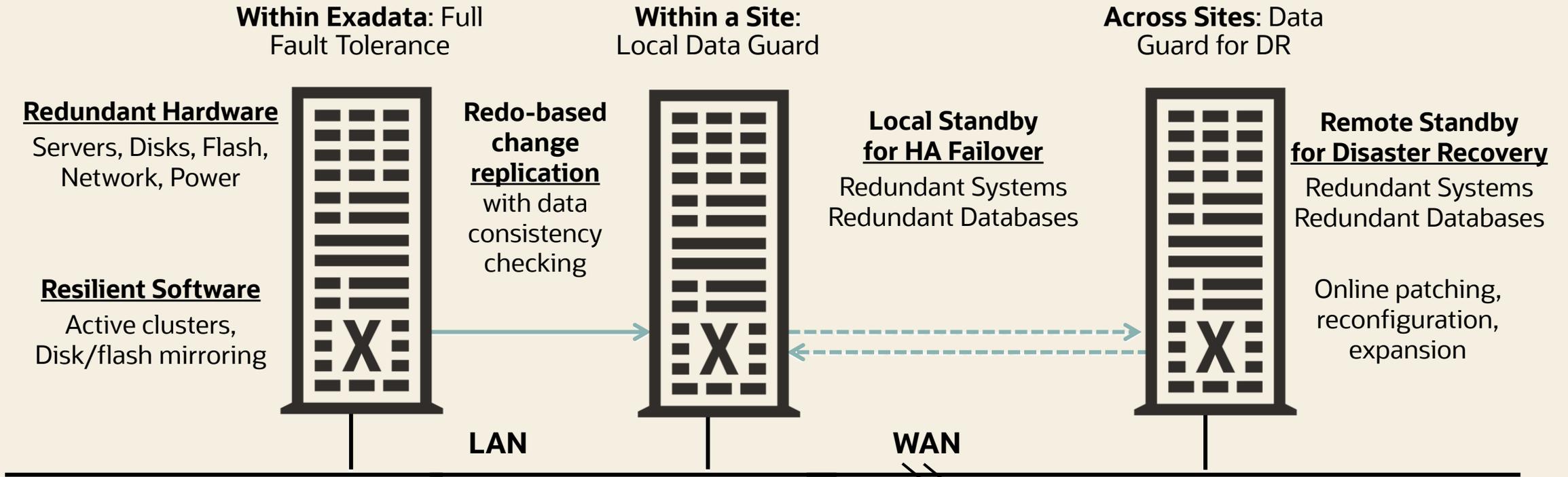
Redundant Hardware
Servers, Disks, Flash, Network, Power

Resilient Software
Active clusters, Disk/flash mirroring

Redo-based change replication
with data consistency checking

Local Standby for HA Failover
Redundant Systems
Redundant Databases

Remote Standby for Disaster Recovery
Redundant Systems
Redundant Databases

Online patching, reconfiguration, expansion

LAN

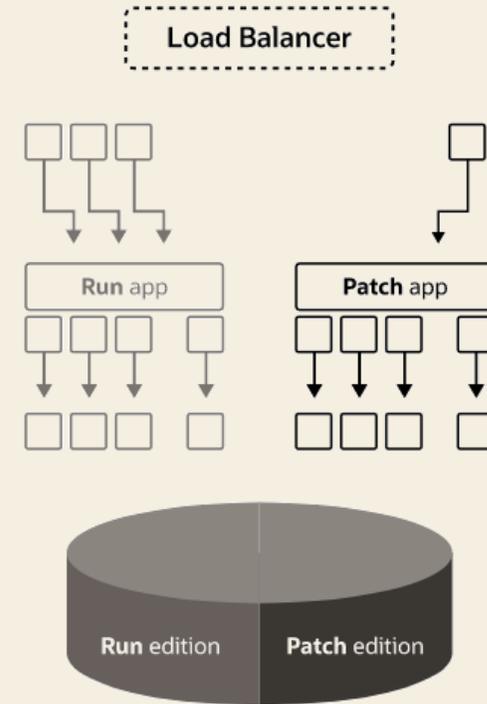**WAN**

**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
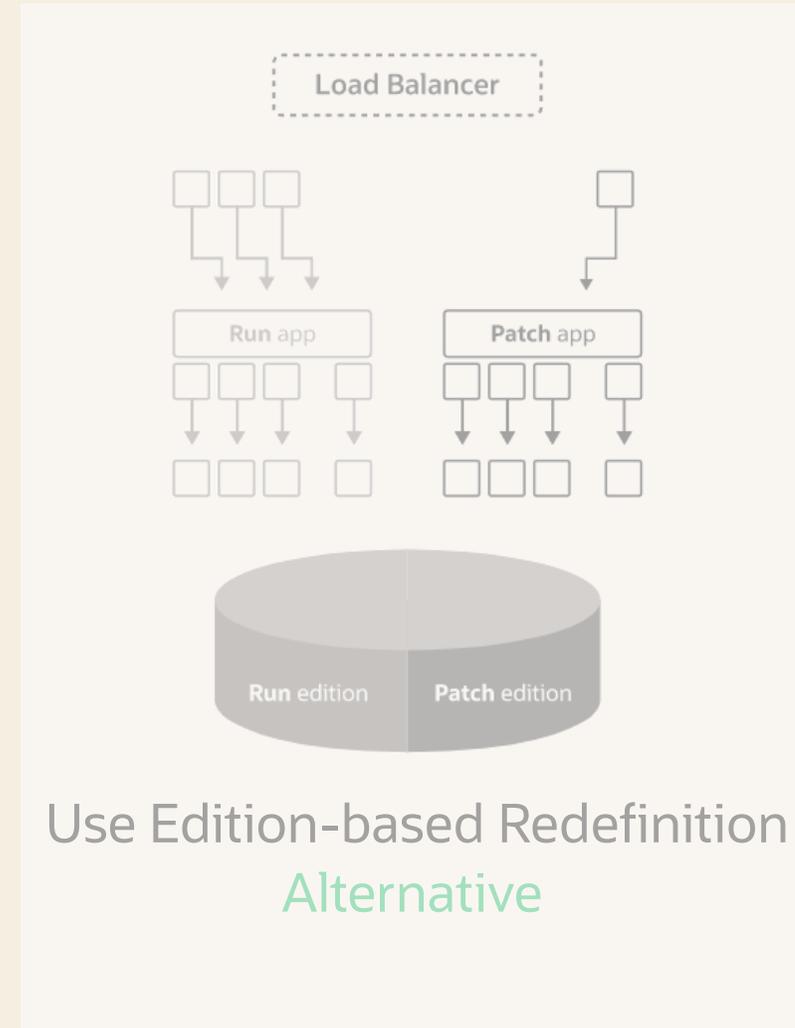

Use Oracle Golden Gate
Standard Approach

Use Edition-based Redefinition
Alternative

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

Use Oracle Golden Gate
Standard Approach

Use Edition-based Redefinition
Alternative

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

Primary RAC in Region 1

Primary RAC in Region 2

Bi-directional

Asynchronous Logical Replication
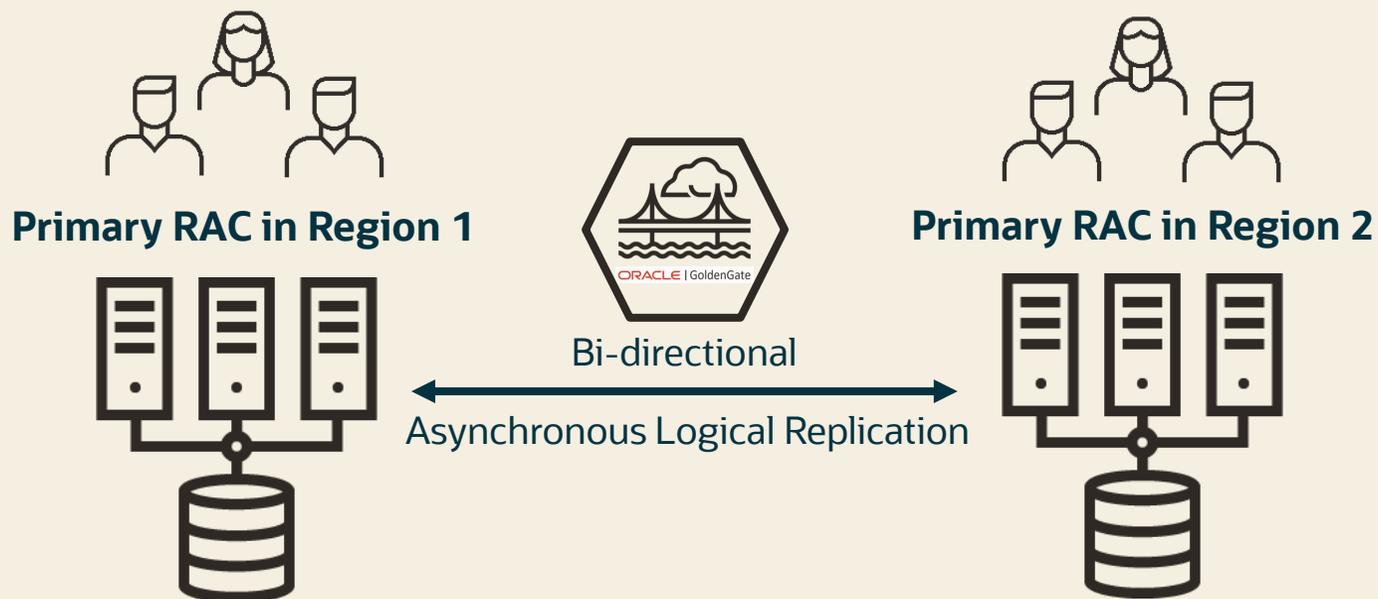
Oracle GoldenGate Architecture
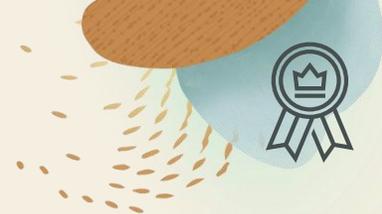
Capture: committed transactions are captured (and can be filtered) as they occur by reading the transaction logs.

Trail: stages and queues data for routing.

Distribution Server/Receiver: distributes data for routing to target(s).

Route: data is compressed, encrypted for routing to target(s).

Delivery: applies data with transaction integrity.

Source
Oracle & Non-Oracle
Database(s)

Capture

Delivery

Trail Files

Trail Files

Dist. Service

Receiver Service

LAN / WAN / Internet Over TCP/IP

Receiver Service

Dist. Service

Trail Files

Trail Files

Delivery

Capture

Target
Oracle & Non-Oracle
Database(s)

Bi-directional
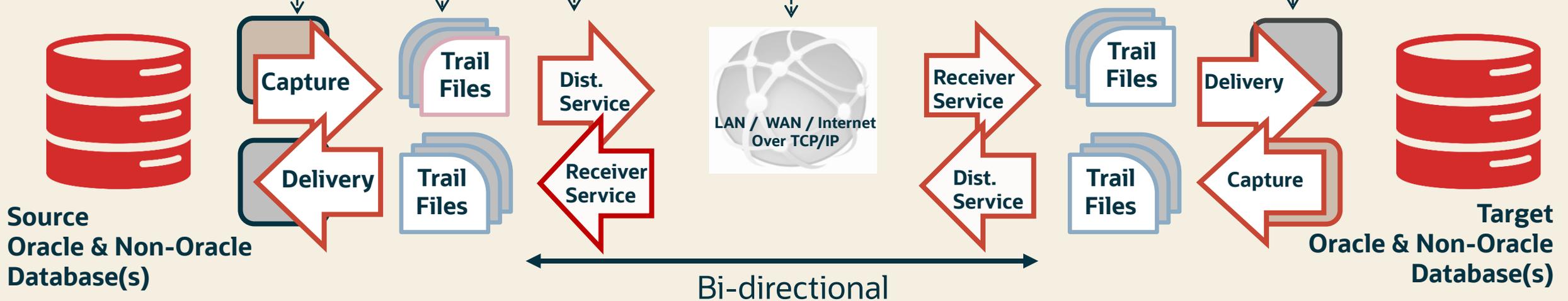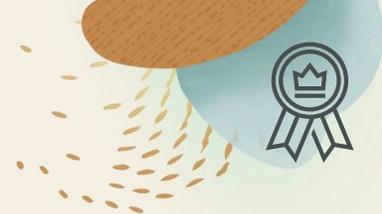
Key GoldenGate Improvements Simplify Platinum

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

Observer

Primary Database

Standby Database

Integrated
Extract

LogMining
Server

ADG Redo Transport
(SYNC or ASYNC)

Trail and other OGG Files
In DBFS

Bidirectional
GoldenGate Replication

Redo Transport

OCI Connection

File I/O

Warehouse
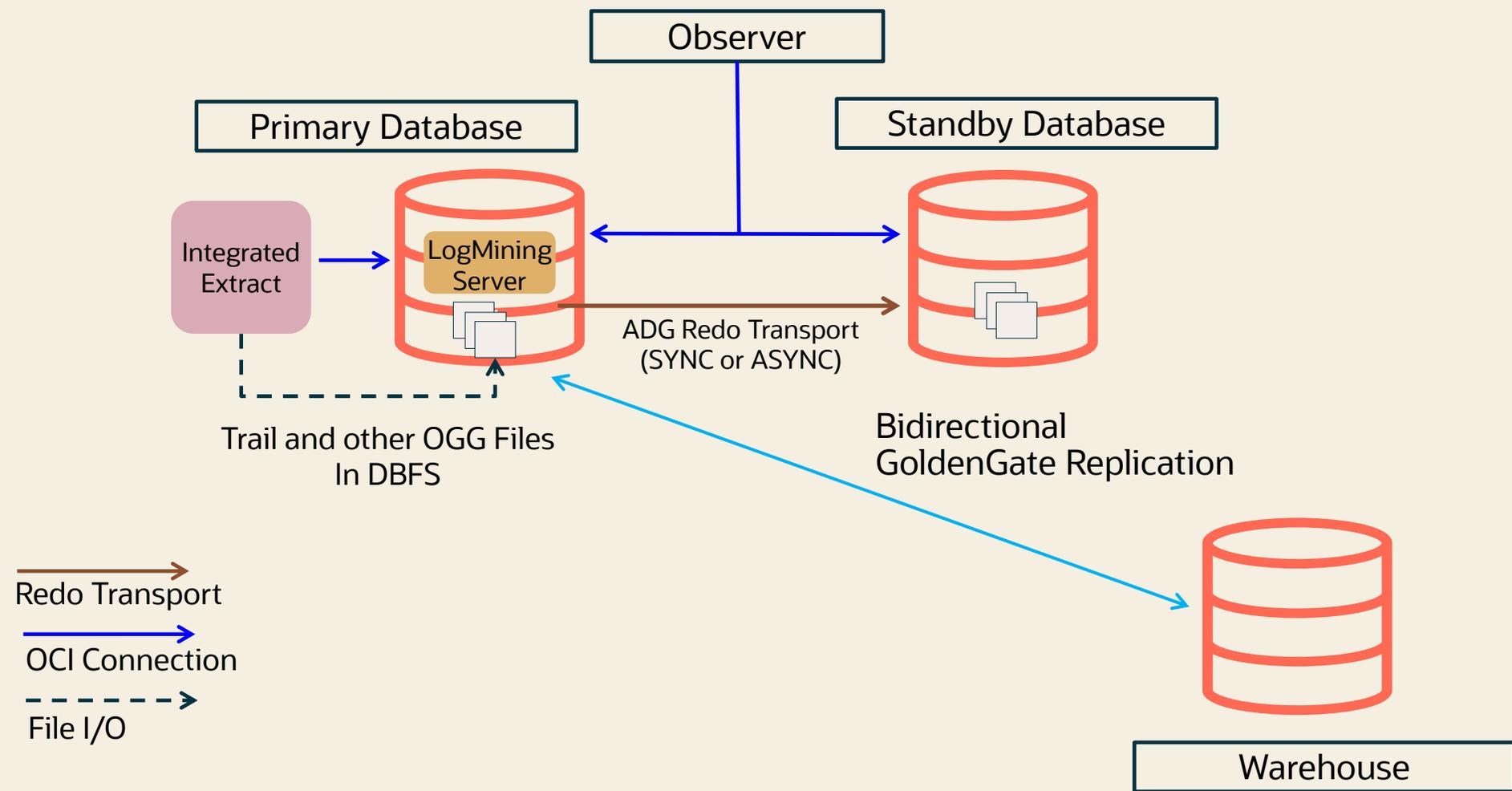
Sample GoldenGate MAA Deployment – Post Role Transition
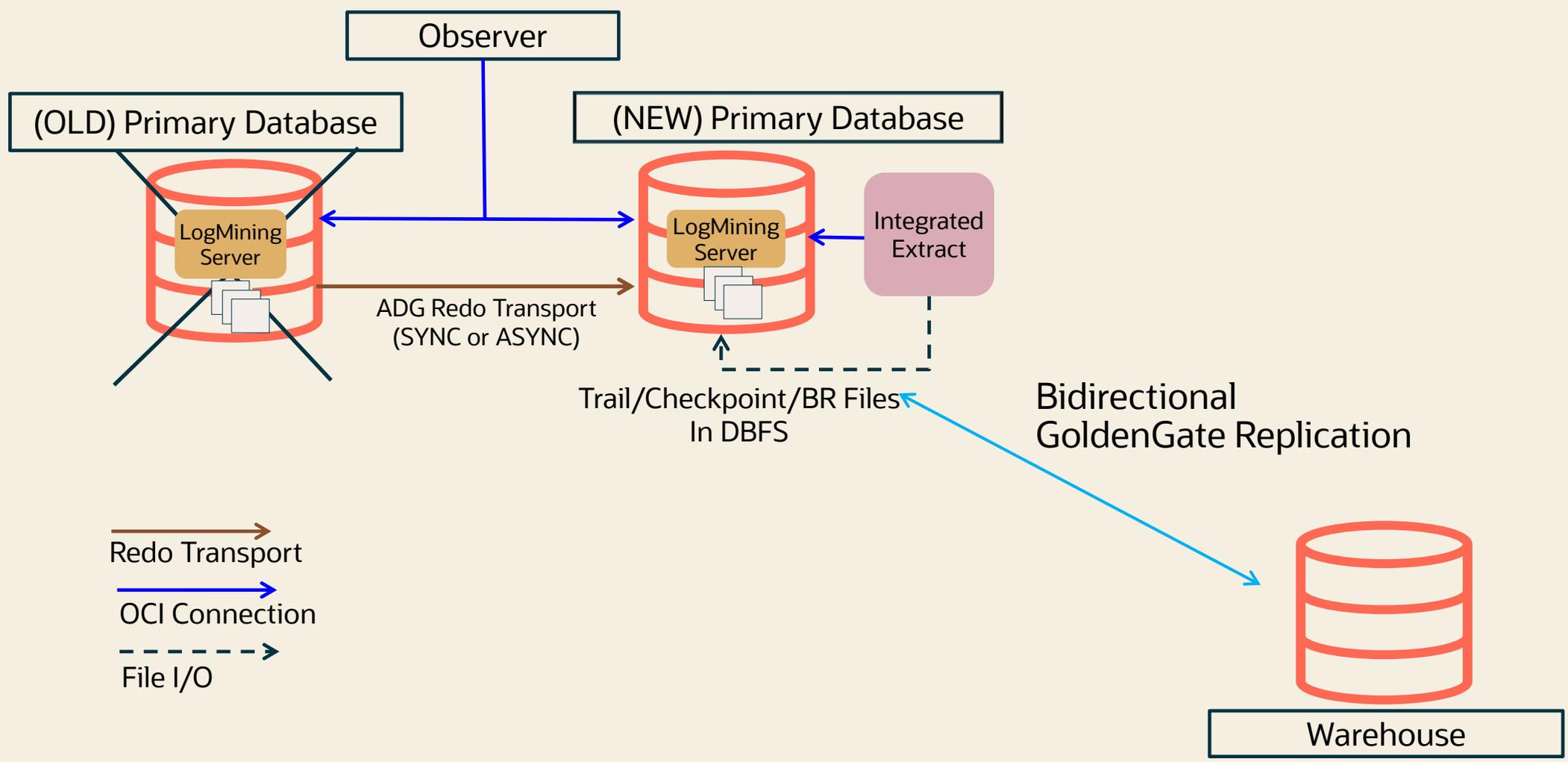
Observer

(OLD) Primary Database

LogMining
Server

(NEW) Primary Database

LogMining
Server

Integrated
Extract

ADG Redo Transport
(SYNC or ASYNC)

Trail/Checkpoint/BR Files
In DBFS

Bidirectional
GoldenGate Replication

Redo Transport

OCI Connection

File I/O

Warehouse

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

Use Oracle Golden Gate
Standard Approach
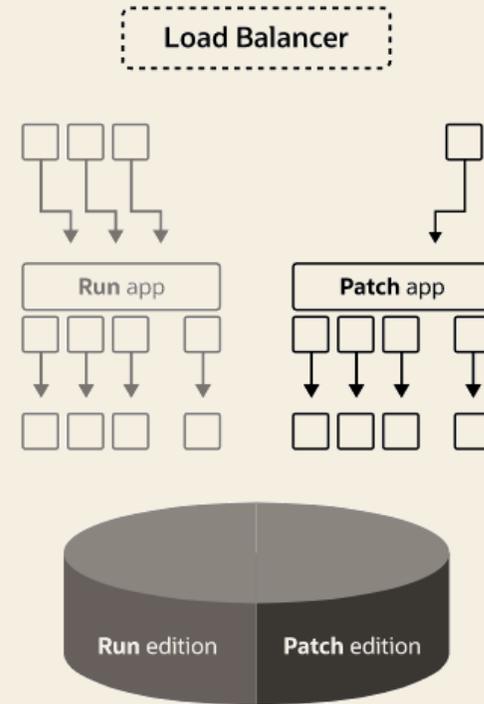
Use Edition-based Redefinition
Alternative

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 supplemental logging enhancements

New In 26ai

Current app   **Upgraded** app

Editioning Views

Current edition   **Upgraded** edition
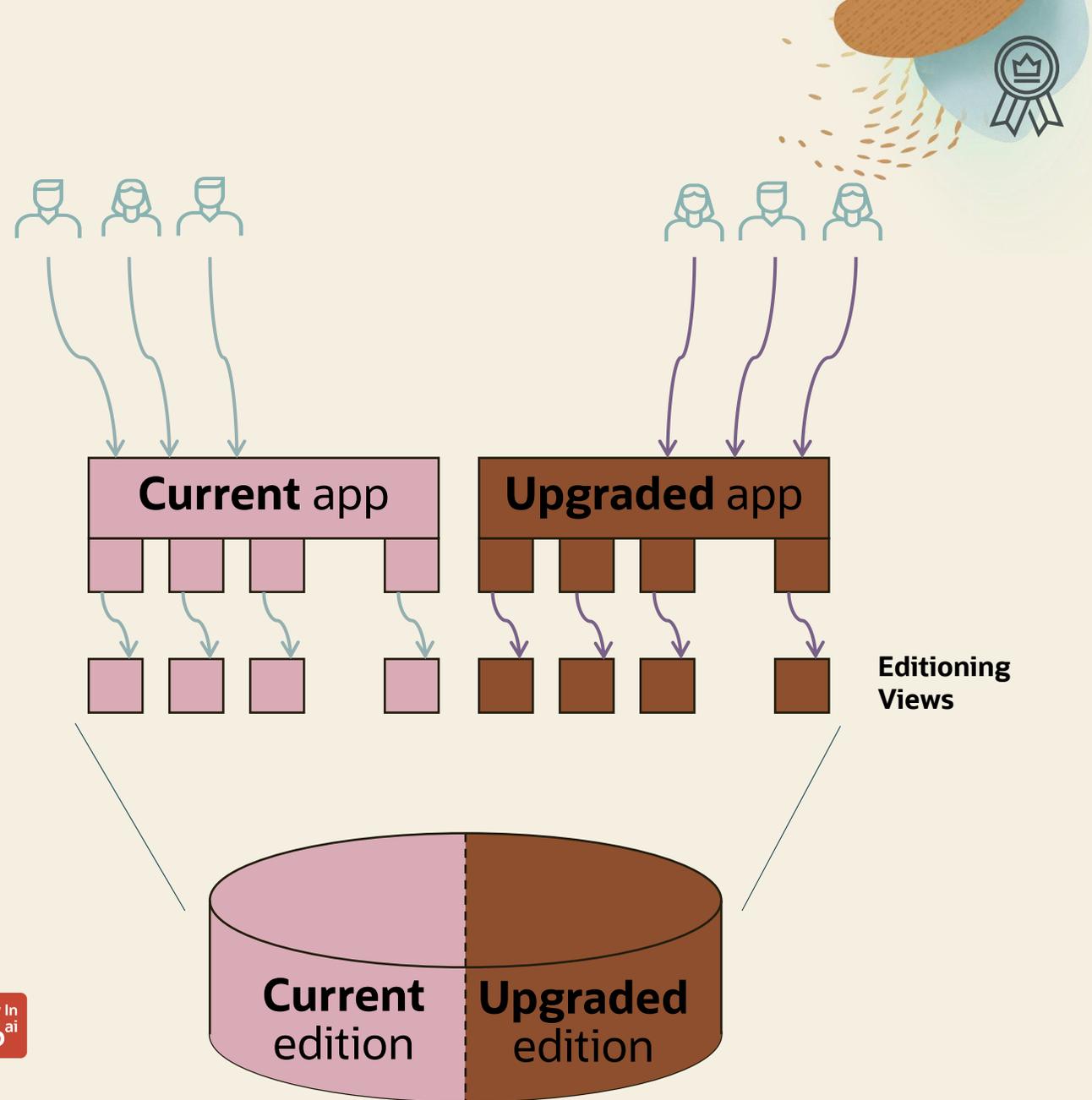
PLATINUM

Mission Critical (Option 2)

Gold +

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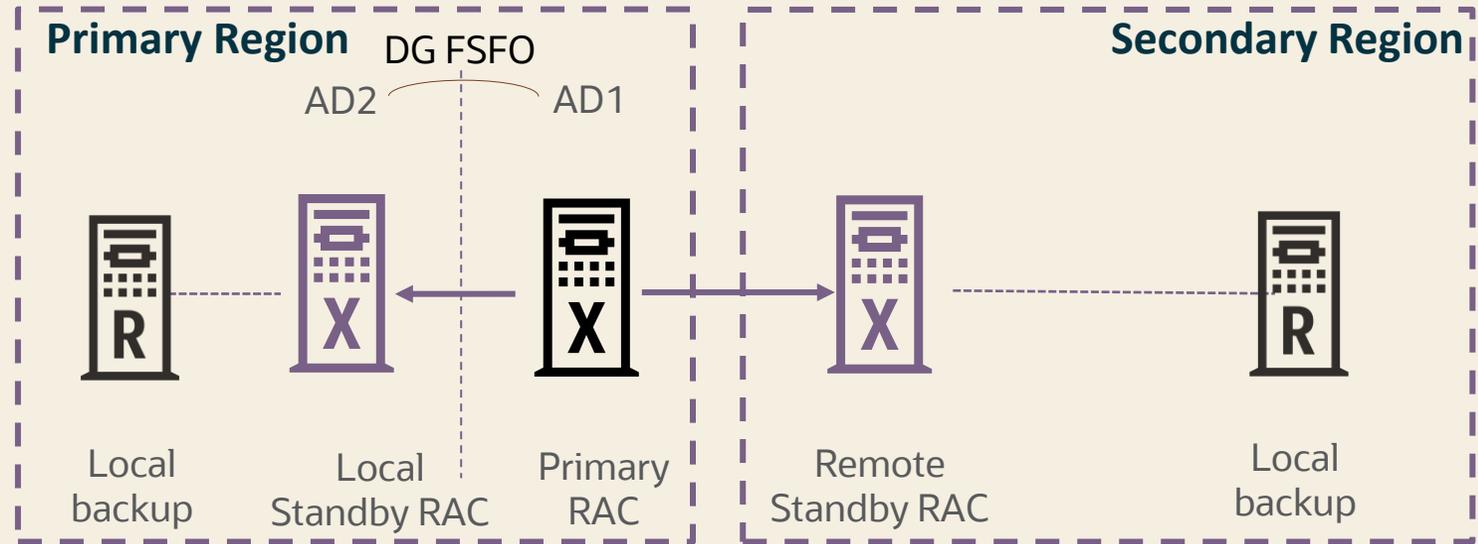- Exadata
- Active Data Guard
  - Comprehensive Data Protection

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

Primary Region   DG FSFO   **Secondary Region**

AD2   AD1

Local backup   Local Standby RAC   Primary RAC   Remote Standby RAC   Local backup

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 2 minutes. 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.
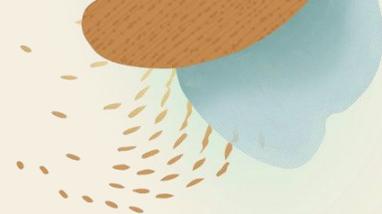
Oracle Data Guard 26ai Provides Lower RTO
Faster role transitions regardless of the size of the workload

SMALL WORKLOAD

■ 19c ■ 26ai

SECONDS

SWITCHOVER: 76 / 22
FAILOVER: 80 / 15
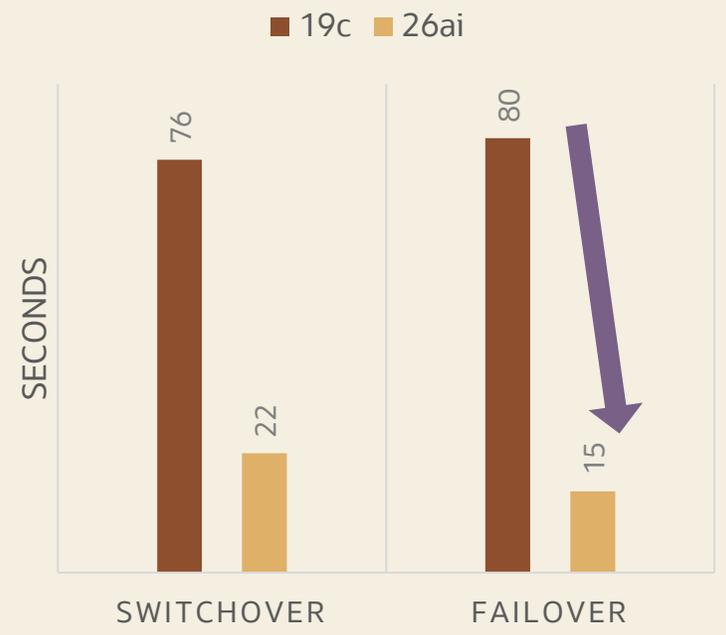
UP TO
400%
FASTER

LARGE WORKLOAD

■ 19c ■ 26ai

SECONDS

SWITCHOVER: 77 / 29
FAILOVER: 94 / 26
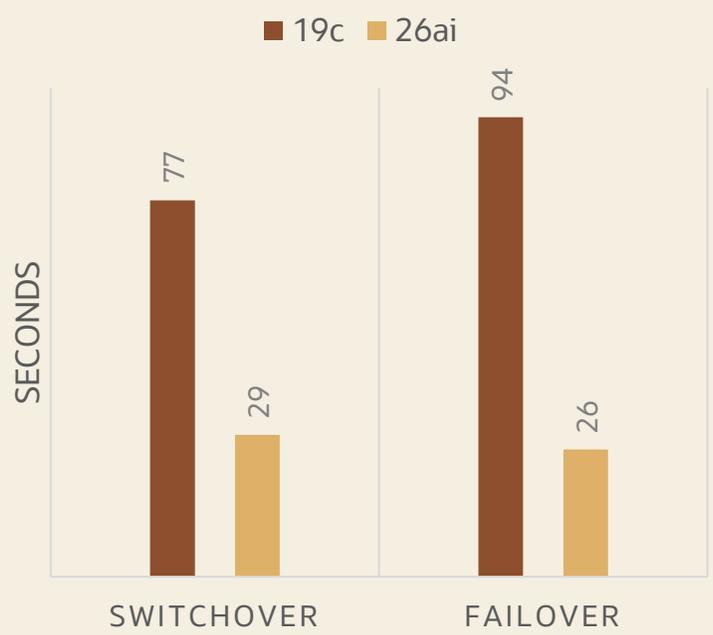
Workload	System	PDBs	Data Files	Services	Redo Rate
SMALL	2-node Exadata RAC	5	50	10	60 MB/s
LARGE	4-node Exadata RAC	12	500	12	100 MB/s

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.
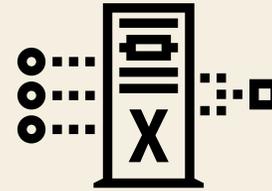
Quality of Service

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

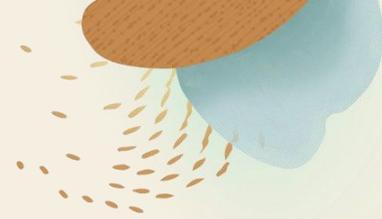| HA Use Case	Application Impact
Database Node Rolling software Update (Exadata, Grid Infrastructure and Database)	No application delay
Storage Server Rolling Software Update	No application delay
RDMA Network Fabric Switch Rolling Upgrade	10 seconds or less application delay
Hard Disk and Flash Failure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

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
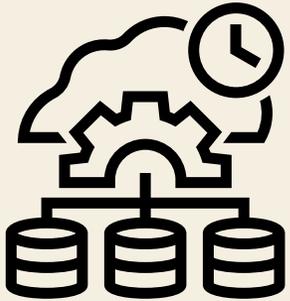
Highest Application Availability

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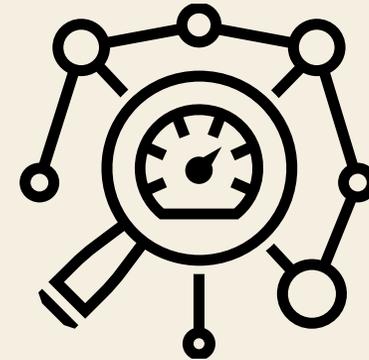
- 33 X better performance
- 4-10 X better OLTP latency

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
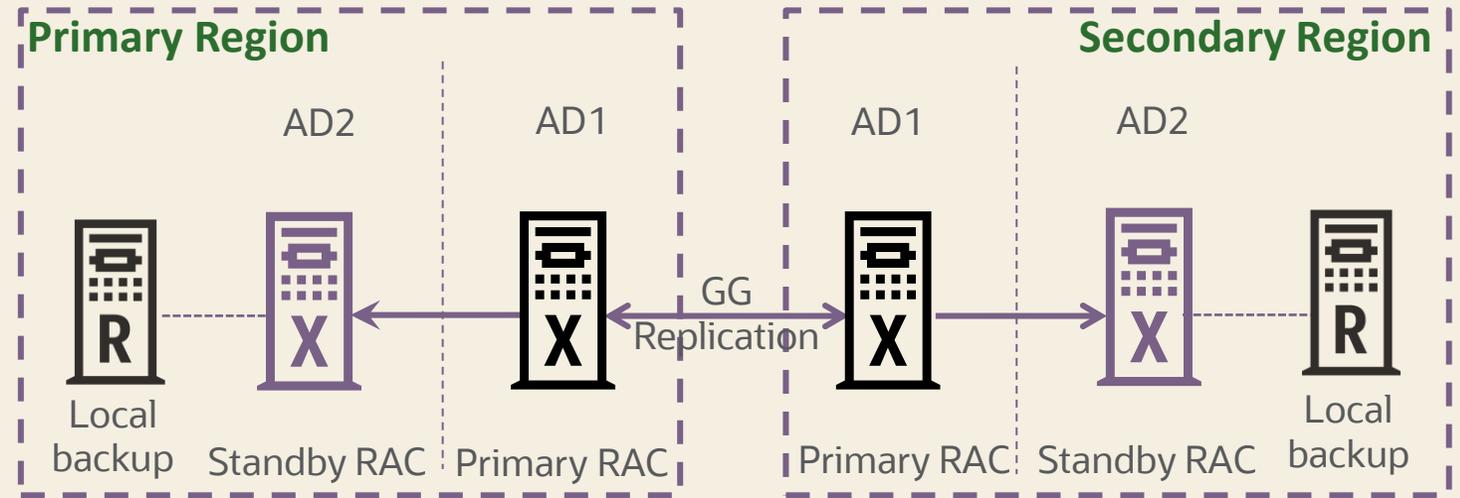
Primary Region | **Secondary Region**

AD2 | AD1 | AD1 | AD2

Local backup | Standby RAC | Primary RAC | GG Replication | Primary RAC | Standby RAC | Local backup

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
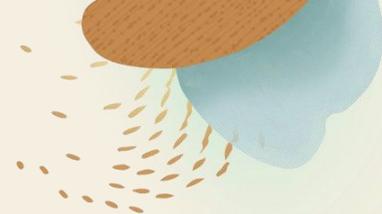
Diamond MAA: Redundancy Throughout the Architecture
Extreme Availability Goal: Provides near-zero downtime and near-zero data loss

- **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.
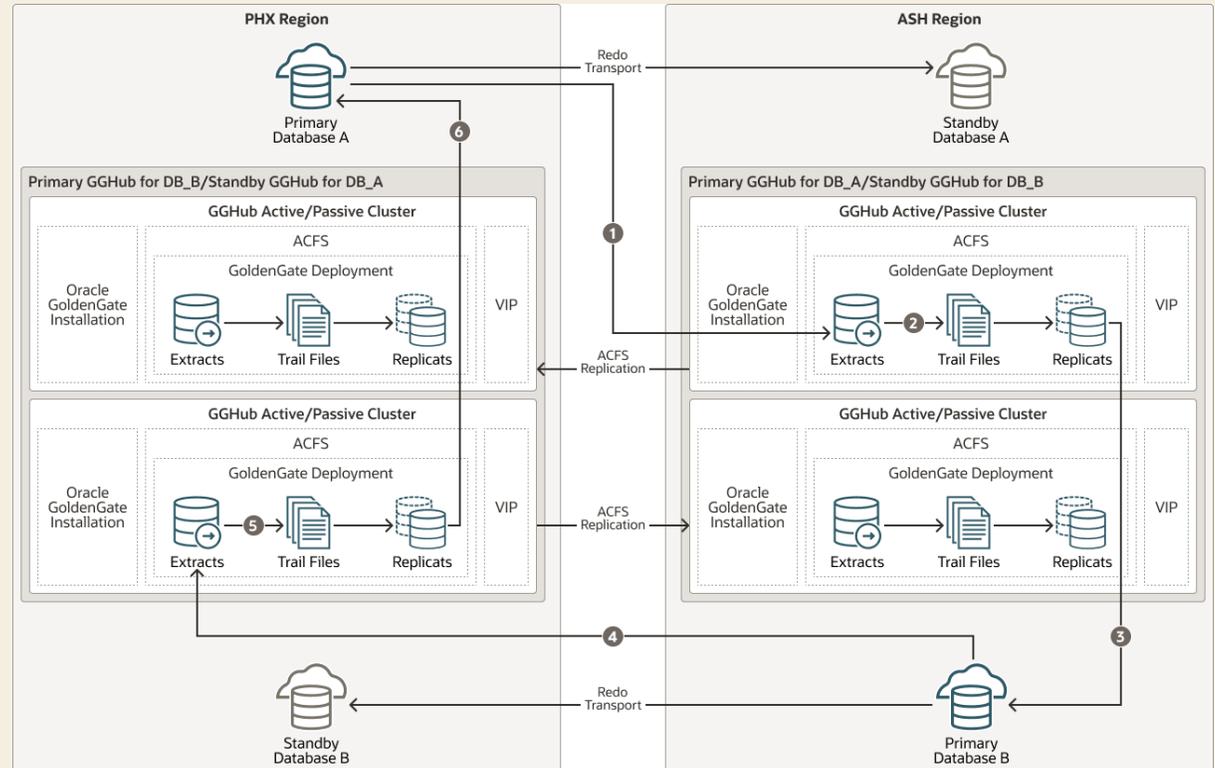
MAA in the Cloud

Maximum Availability Architecture

Unique: Consistent Database Experience Across Deployments

Exadata Database Machine
(on-premises)

Exadata Cloud@Customer
(hybrid cloud)
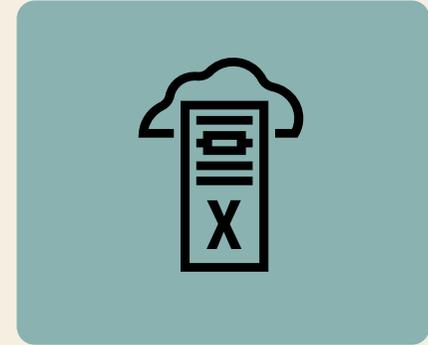
Exadata Cloud Infrastructure
(Oracle public cloud)

← 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)
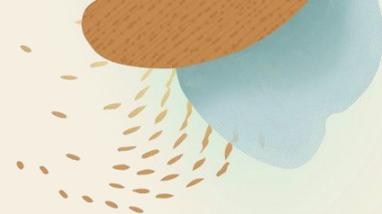
Oracle MAA Gold for all Oracle AI Database@Hyperscalers
Exadata Database Service on Dedicated Infrastructure

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

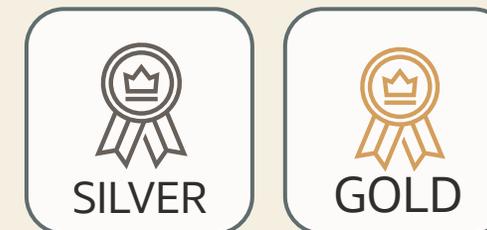| Member	VM Cluster	Role	Region	Protection mode	Transport type	Apply lag	Transport lag	Lag as of	Data Guard type
DB1200	VMCluster-A	Primary	US East (Ashburn)	Maximum Availability	Async	—	—	—	Data Guard
DB1200	VMCluster-B	Standby	US East (Ashburn)	Maximum Availability	Sync	0 seconds	0 seconds	Mon, Dec 16, 2024, 15:57:46 UTC	Data Guard
DB1200	VMCluster-20240425l654	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
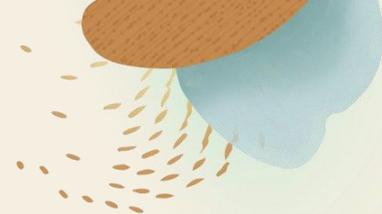
Eliminates Site Downtime
Oracle Autonomous Data Guard

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
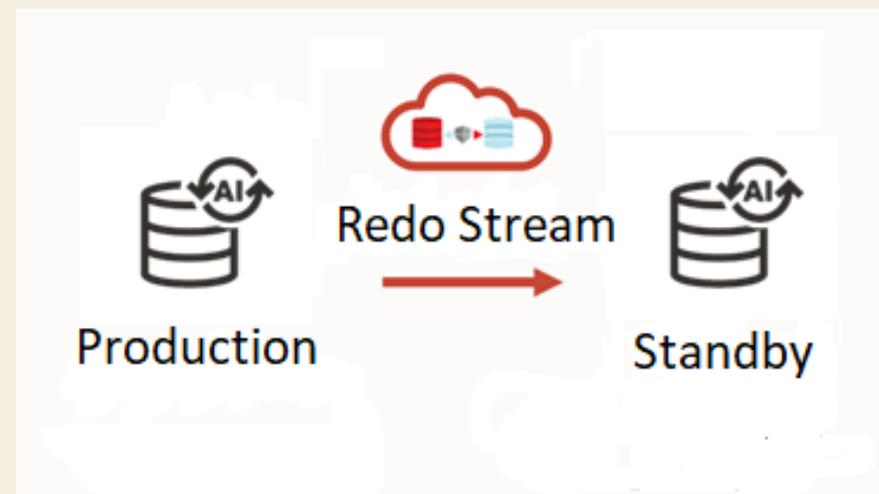
Exadata Database Service@Hyperscaler | MAA Silver Level
High Availability and Data Protection Built-in by Default

Hyperscaler Region

Availability Zone

Oracle Exadata
Database Service

Automatic
Backup

Autonomous
Recovery Service

OCI
Managed
Network

OCI Region

OCI Managed
Services

Automatic
Backup

Autonomous
Recovery Service
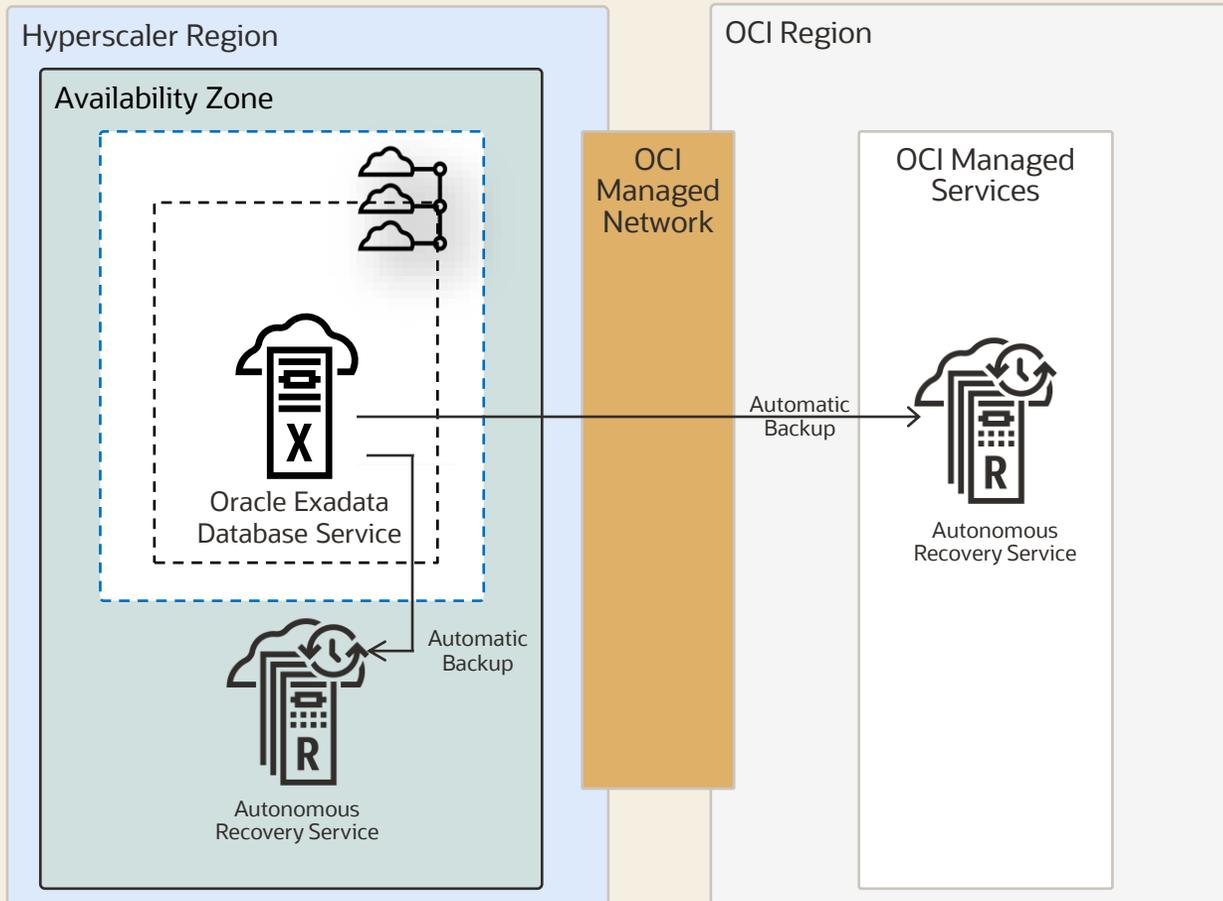
- ✓ **Oracle Exadata and Oracle RAC**
  - ✓ Agility to scale storage, compute, and memory without downtime
  - ✓ Node failure protection
  - ✓ Zero downtime software maintenance

- ✓ **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 ⓘ

Oracle MAA Gold level cross-zones architecture
Enhancing availability and ensuring zero data loss

GOLD

Region 1 (Azure, AWS, GCP)

Zone 1

Oracle Database@Azure, @AWS, @GCP*

Automatic Backup

Autonomous Recovery Service

Exadata Primary

Oracle Data Guard over OCI or Azure/AWS/GCP network

Zone 2

Oracle AI Database@Azure, @AWS, @GCP*

Automatic Backup

Autonomous Recovery Service

Exadata Standby

OCI Managed Network

Region 1 (OCI)

Automatic Backup

Autonomous Recovery Service

Automatic Backup

Autonomous Recovery Service

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

Region 1 (Azure, AWS, GCP)

Oracle AI Database@Azure, @AWS, @GCP

Autonomous Recovery Service

← Automatic Backup

Exadata Primary

Oracle Data Guard over OCI or Azure/AWS/GCP network

Automatic Backup →

Region 1 (OCI)

Autonomous Recovery Service

OCI Managed Network

Region 2 (Azure, AWS, GCP)

Oracle AI Database@Azure, @AWS, @GCP

Autonomous Recovery Service

← Automatic Backup

Exadata Standby

Automatic Backup →

Region 2 (OCI)

Autonomous Recovery Service

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
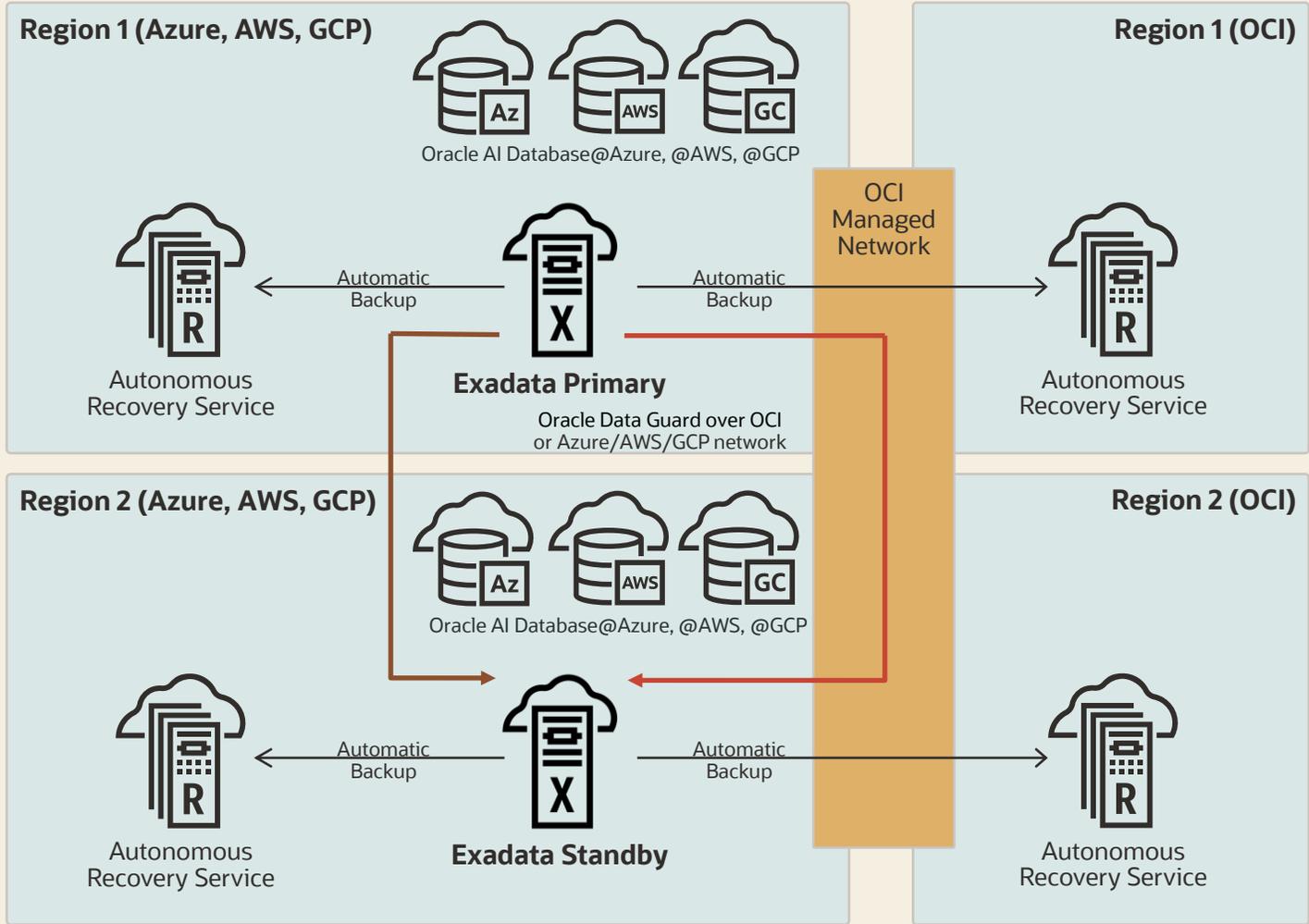- ✓ Online updates

+ Multiple Standbys

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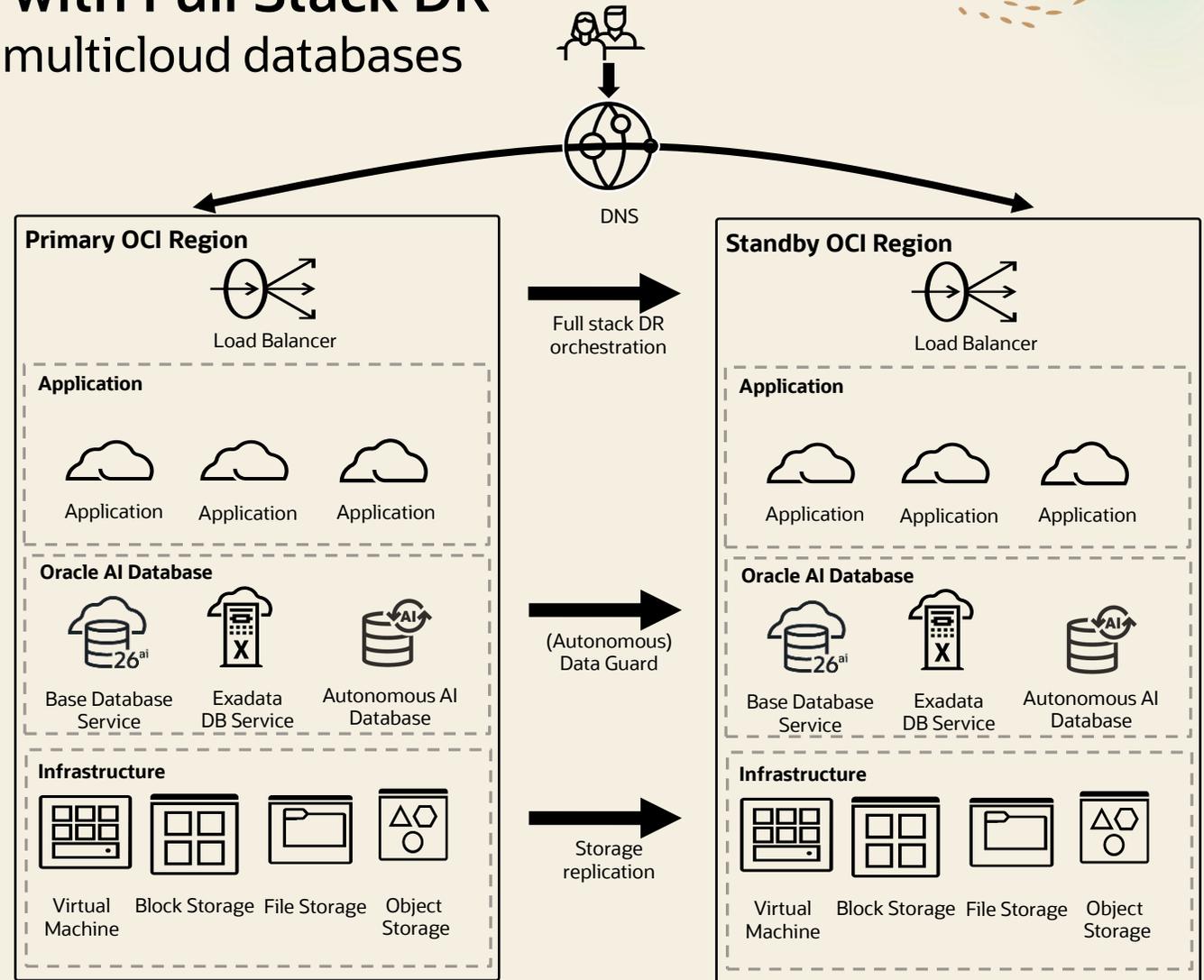- ✓ Read-mostly scale-out

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

DNS

Primary OCI Region

Load Balancer

Application

Application   Application   Application

Oracle AI Database

Base Database Service   Exadata DB Service   Autonomous AI Database

Infrastructure

Virtual Machine   Block Storage   File Storage   Object Storage

Full stack DR orchestration

(Autonomous) Data Guard

Storage replication

Standby OCI Region

Load Balancer

Application

Application   Application   Application

Oracle AI Database

Base Database Service   Exadata DB Service   Autonomous AI Database

Infrastructure

Virtual Machine   Block Storage   File Storage   Object Storage

Zero Data Loss Autonomous Recovery Service (ZRCV)

Intelligent data protection for Oracle AI Databases in OCI, Multicloud, & On-premises
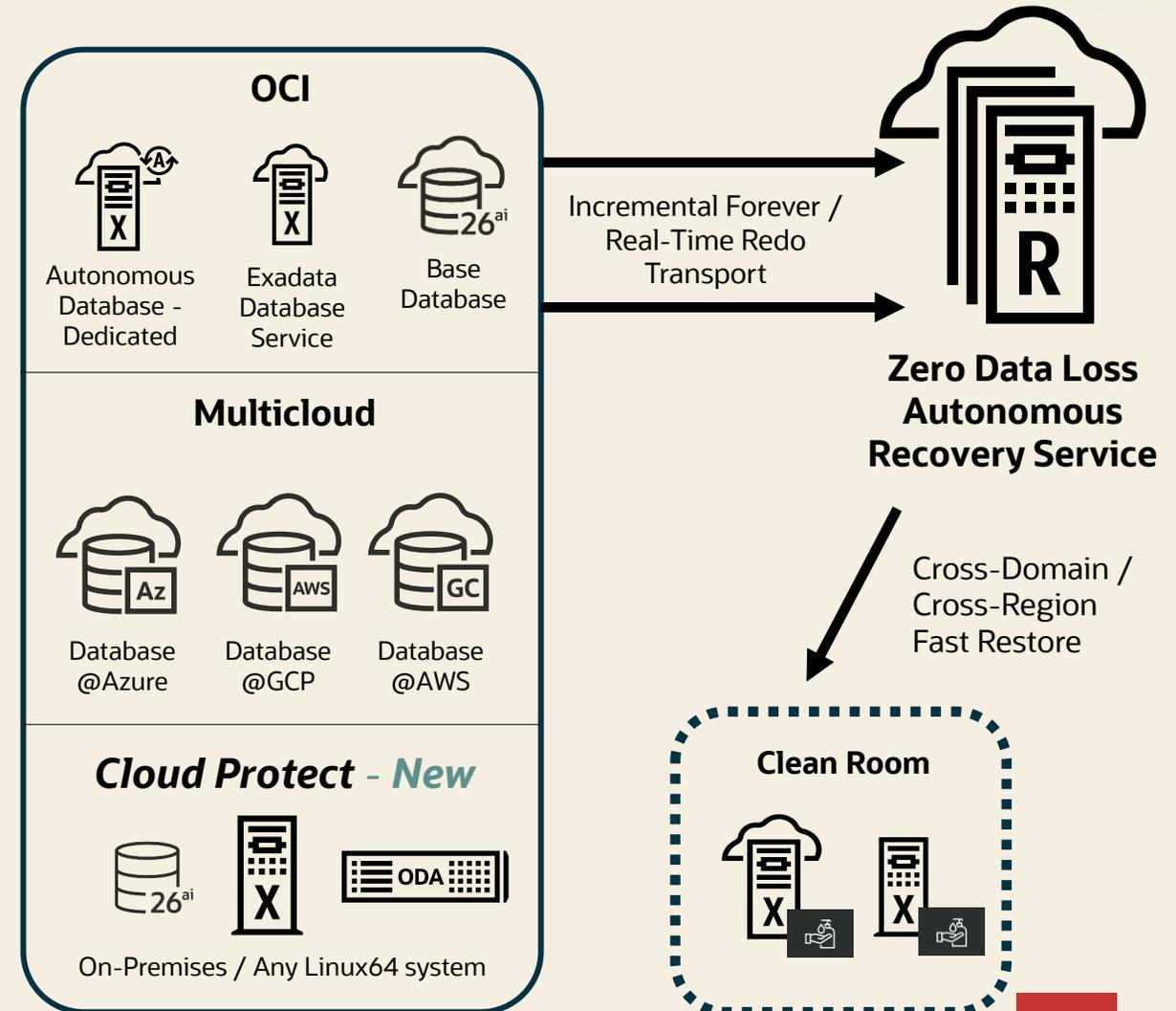
Zero Data Loss Recovery

- Real-time transaction protection
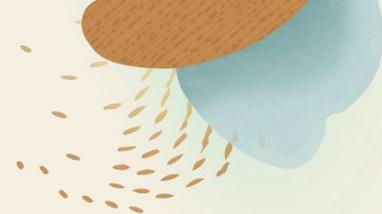- Continuous recovery validation

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

OCI

Autonomous Database - Dedicated | Exadata Database Service | Base Database

Multicloud

Database @Azure | Database @GCP | Database @AWS

Cloud Protect - *New*

On-Premises / Any Linux64 system

Incremental Forever / Real-Time Redo Transport

Zero Data Loss Autonomous Recovery Service

Cross-Domain / Cross-Region Fast Restore

Clean Room

Hybrid Cloud: Recommended Hybrid Sources/Destinations

To DBCS

Customer premises → OCI Region

Single Instance — Active Data Guard → DBCS VM Single Instance

RAC — Active Data Guard → DBCS VM RAC

To Exadata Cloud

Customer premises → OCI Region

Exadata — Active Data Guard → ExaCS

Exadata — Active Data Guard → ExaCC

To Autonomous

Customer premises → OCI Region

SI/RAC — GoldenGate → ADB-S

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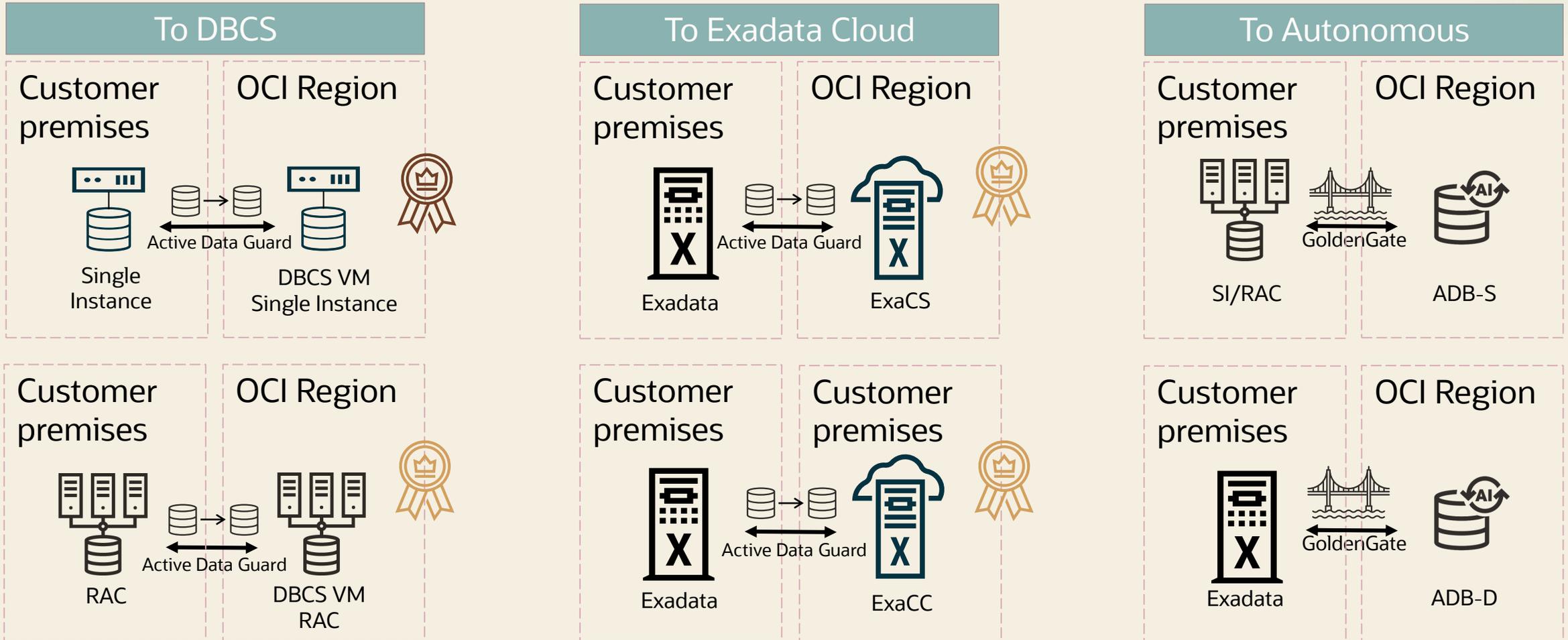
- All Hybrid configurations are achieved manually: no Control Plane automation
- On-premises non-Exadata to ExaCC/ExaCS is possible but beware of exclusive features

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