Oracle Maximum Availability Architecture (MAA)

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

August, 2022
Program Agenda

1. Why Availability is Important
2. MAA: Blueprints for Oracle Database HA & DR
3. Summary and Resources
4. How does OCI cloud automation enhance MAA in the cloud?
5. Summary
Why is Availability so important?
Impact of database 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.

**Scalability**
The ability to add system resources or additional nodes to database environments thereby achieving improved performance.

**Rolling updates/patches**
The automated process of updating software without impact to database and application availability.

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

**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.
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 Maximum Availability Architecture (MAA)
Standardized Reference Architectures for Never-Down Deployments

Customer insights and expert recommendations

Reference architectures

Production site → Replication → Replicated site

Deployment choices

Generic Systems → Engineered Systems → DBCS ExaCS/ExaCC → Autonomous DB

HA features, configurations and operational practices

Zero Downtime Migration (ZDM)

Continuous availability

- Application Continuity
- Online Redefinition
- Edition-based Redefinition

Data protection

- Flashback
- RMAN + ZDLRA

Active replication

- Active Data Guard
- GoldenGate

Scale out & Lifecycle

- RAC
- FPP
- Sharding
# MAA reference architectures

Availability service levels

<table>
<thead>
<tr>
<th>Tier</th>
<th>Dev, test, prod</th>
<th>Prod/departmental</th>
<th>Business critical</th>
<th>Mission critical</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bronze</td>
<td>Single instance DB</td>
<td>Database HA with RAC</td>
<td>DB replication with Active Data Guard</td>
<td>Gold +</td>
</tr>
<tr>
<td></td>
<td>Restartable</td>
<td>Application continuity</td>
<td></td>
<td>GoldenGate</td>
</tr>
<tr>
<td></td>
<td>Backup/restore</td>
<td>Sharding (optional)</td>
<td></td>
<td>Edition based redefinition</td>
</tr>
<tr>
<td>Silver</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gold</td>
<td></td>
<td></td>
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<td></td>
</tr>
<tr>
<td>Platinum</td>
<td></td>
<td></td>
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</tr>
</tbody>
</table>

All tiers exist with on-premises and cloud. However, platinum currently must be configured manually while bronze to gold are covered with some form of cloud automation depending on the desired MAA architecture (i.e., multiple standby databases still must be manually configured in cloud today).
Oracle MAA – Proven at Thousands of Customers
Thousands of Critical Deployments, On-Premises & Cloud
88% of Fortune Global 100 Run Exadata | 39% Run Exadata Cloud

Superior Architecture for ALL Workloads

- Petabyte Warehouses
- Super Critical Systems
  - Financial Trading
  - Process manufacturing
  - E-commerce
- Complex Applications
  - SAP, Fusion Apps, E-Business Suite, NetSuite, Siebel, PeopleSoft, ...
- Database Consolidation
- Maximum Availability Architecture

Deutsche Bank  
Telefónica  
FedEx  
Samsung  
NTT  
7 Eleven  
docomo  
dialog  
entel  
CaixaBank  
EQUINIX  
Cerner  
ANA  
AmerisourceBergen  
Swisscom  
현대Hmall  
Exelon.  
Arcor  
EDF  
Manhattan Associates  
KCB  
NHS Business Services Authority  
RNN  
Western Digital  
Halliburton  
Specialized  
Panasonic  
Swiss Re  
Algar  
Lalux  
AT&T  
Tractor Supply Co.  
Alliance Data  
Quest Diagnostics  
Beyond ORIGINAL  
Energy Transfer  
Circle K  
Fluor  
Crédit Agricole Corporate & Investment Bank
Oracle MAA
Designed to Address the Complete Range of Business Requirements

On Premises
Oracle Database
On Cloud

Common Platform – On Premises, Cloud, and Hybrid Cloud
Big Differentiator
OEM Single Pane of glass

Single pane of glass for hardware and software management across cloud and on-premise

Centralized diagnostics, tuning and lifecycle activities

Fleet-wide automation across Oracle Cloud and on-premises assets

Integrated named credentials and auditing
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

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<tr>
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<th>RTO / RPO Service Level Objectives (f1)</th>
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<td>Recoverable node or instance failure</td>
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<td>Disasters: corruptions and site failures</td>
<td>Hours to days. RPO since last backup or near zero with ZDLRA</td>
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</table>

Planned Maintenance

- Software/hardware updates
  - Minutes to hour (f2)
- Major database upgrade
  - Minutes to hour

f1: RPO=0 unless explicitly specified
f2: Exadata systems has RAC but Bronze Exadata configuration with Single Instance database running with Oracle Clusterware has highest consolidation density to reduce costs

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Oracle Clusterware for Automatic Restart

1. Oracle Clusterware is available for all Oracle 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

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

Complementary to VMs
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

```sql
RECOVER TABLE hr.department, sales.product
UNTIL SCN 1234 AUXILIARY DESTINATION '/tmp/'
REMAP TABLE
hr.department:dev.testdepartment, sales.product:mkt.newproduct;
```
End-to-End Oracle Recovery Validation
Near Zero Data Loss for DR

Databases

Oracle DB 12c-21c on Any Platform

No More Full Backups, Incremental Forever

Day 1 Full
Day 2 Changes
Day N Changes

Virtual Full Backup

Day N State

EM Real-Time Protection Status & Space Monitoring

Cloud Storage
Remote Replica
Tape

Transactional Block Changes

End-to-End Oracle Recovery Validation
Near Zero Data Loss for DR

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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

Note: Automated Orachk/Exachk Healthcheck MOS 107954.1 updated frequently
Online Operations
Online Redefinition Improvements

DBMS_REDEFINITION allows you to reorganize and redefine tables online
- Add/drop(rename/reorder columns
- Switch physical storage structures
- Reorganize & transform data while online

Additional Benefits of using DBMS_REDEFINITION
- Fault Tolerant (resume at point of failure) and track changes to enable fast rollback to prior definition
- Entire redefinition process runs without acquiring Exclusive DDL lock
- Monitor reorganization using V$online_redef
### Online Operations

All Partition Maintenance Operations are now Online

| 11.2 & Prior | Create index online, **rebuild index** online, rebuild index partition online  
| Add Column, Add Constraint enable **novalidate** |
|---|---|
| 12.1 | **Online move partition**  
**Drop index** online  
**Set unused** column online, **alter column visible/invisible**, alter index unusable online, alter index visible/invisible  
alter index parallel/no**parallel** |
| 12.2 | **Alter table move online for non-partitioned tables**  
**Alter table from non-partitioned to partitioned online**  
**Alter table split partition online**  
Create table for exchange (usable for online partition exchange)  
**Move/merge/split partition maintenance operations can now do data filtering** |
| 18.1, 19c | **Alter table modify partitioned table to a different partitioning method** (e.g., hash to range)  
**Alter table merge partition/sub-partition** online |
Flashback Technologies
Rewind Button for Oracle 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
**Prod/Departmental**

**Bronze +**
- Real Application Clustering (RAC)
- Application Continuity
- Sharding (Optional)
  - Provides fault isolation, scalability and geographical distribution

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**Planned Maintenance**

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<tr>
<th>Software/Hardware updates</th>
<th>Zero (f2)</th>
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<tr>
<td>Major database upgrade</td>
<td>Minutes to hour</td>
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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 Real Application Clusters (Oracle RAC)
Node Failure, Instance Failure, Rolling Maintenance

- Utilizes two or more instances of an Oracle Database concurrently
- Very Scalable
  - All instances active; Add capacity online; Ideal for database consolidation
- Highly Available
  - Auto-failover of services to an already running instance
  - Outage is transparent to user, in-flight transactions succeed
  - Zero downtime rolling maintenance
Planned Maintenance with Oracle Fleet Patching and Provisioning

- **MAA-compliant** for **PLANNED MAINTENANCE** (Session Draining)
- Centralized operations
- Fleet-ready: operates 1000s of nodes
- Provides Automation and Standardization

**Gold image repository**

- 11.2.0.4
- 12.1.0.2
- 12.2.0.1
- 19.3.0
- 19.11.0
- 21.1.0

**Supported targets:**

- **11.2, 12.1, 12.2, 18c, 19c, 21c**
- RAC, RAC One Node or Single Instance on **Exadata** or Commodity HW

**FPP server**

**GI and DB home management**
- Install
- Remove
- Series
- Drift detection

**Oracle Database (SI, RAC, RACON)**
- Provision
- Patch
- Upgrade
- Scale

**Oracle Grid Infrastructure**
- Provision
- Patch
- Upgrade
- Scale

**Other features**
- FPP peering
- REST APIs
- Exadata SW Updates
Transparent Application Continuity (TAC)
Application does not see errors during outages

- Uses Application Continuity and Oracle Real Application Clusters
- Transparently tracks and records session information in case there is a failure
- Built inside of the database, so it works without any application changes
- Rebuilds session state and replays in-flight transactions upon unplanned failure
- Planned maintenance can be handled by TAC to drain sessions from one or more nodes
- Adapts as applications change: protected for the future
Planned Maintenance

Planned Maintenance (without the Outages!):
1. Database Service is relocated or stopped
2. Service starts on another RAC instance
3. Sessions connected to the service are drained
4. New sessions connect to Service on another instance
5. Results from Database Request returned to user
6. Maintenance activities can start on first node (rolling)
Unplanned Outages, without Impact

Outage or Interruption at Database:
1. Database Request interrupted by an Outage or timeout
2. Session reconnects to the RAC Cluster and
3. Database Request replays automatically
4. Result from Database Request returned to user
Checklist for Achieving Zero Application Downtime

1. Use Oracle Clusterware Service (never use default service)
2. Use Recommended Connection String
3. Configure FAN for Connection Pool
4. Drain your service
5. Use Application Continuity or Transparent Application Continuity

1. MAA Whitepaper: Application Checklist for Continuous Service for MAA Solutions
2. Using RHPhelper to Minimize Downtime During Planned Maintenance on Exadata (MOS 2385790.1)
3. Fleet Patch and Provisioning (FPP) should be utilized for database fleet patching and incorporates MAA practices
Oracle Sharding – An Elastic Database Architecture

- Horizontal partitioning of data across up to 1000 independent Oracle Databases (shards)
- Shared-nothing hardware architecture
  - Each shard runs on commodity server
  - No shared storage
  - No clusterware
- Data is partitioned using a sharding key (i.e. account_id)

A single logical DB sharded into N physical Databases:
Oracle Database Sharding – Benefits

**Linear Scalability**
Add shards online to increase database size and throughput. Online split and rebalance.

**Extreme Availability**
Shared-nothing hardware architecture. Fault of one shard has no impact on others.

**Geographic Distribution**
User defined data placement for performance, availability, DR or to meet regulatory requirements.
Mission Critical

Silver +
- Active Data Guard
- Comprehensive Data Protection

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

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<tr>
<td>Recoverable node or instance failure</td>
<td>Single digit seconds</td>
</tr>
<tr>
<td>Disasters: corruptions and site failures</td>
<td>Seconds to 2 minutes. RPO zero or seconds</td>
</tr>
</tbody>
</table>

Planned Maintenance

<table>
<thead>
<tr>
<th>Software/Hardware updates</th>
<th>Zero</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major database upgrade</td>
<td>Less than 30 seconds</td>
</tr>
</tbody>
</table>

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

Generic - Must Transmit Writes to All Files

... INCLUDING CORRUPTED BLOCKS OR BAD DATA

Primary Database

Oracle Instance (in memory)

Mirrored Volumes

• Zero Oracle validation
• 7x network volume
• 27x network i/o

SYNC or ASYNC block replication
Data Guard Addresses Shortcomings of Storage Replication
Inadequate isolation, zero application-level validation

“…when something happens in the I/O stack and a database write is malformed Symmetrix A happily replicates the faulty data to site B and the corruption goes undetected”

EMC BLOG with Integrity
## Oracle Data Protection

**Gold – Comprehensive Data Protection**

<table>
<thead>
<tr>
<th>Capability</th>
<th>Physical Block Corruption</th>
<th>Logical Block Corruption</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dbverify, Analyze</td>
<td>Physical block checks</td>
<td>Logical checks for intra-block and inter-object consistency</td>
</tr>
<tr>
<td>RMAN, ASM</td>
<td>Physical block checks</td>
<td>Intra-block logical checks</td>
</tr>
<tr>
<td><strong>Active Data Guard</strong></td>
<td>• Continuous physical block checking at standby&lt;br&gt;• Strong isolation to prevent single point of failure&lt;br&gt;• Automatic repair of physical corruptions&lt;br&gt;• Automatic database failover (option for lost writes)</td>
<td>• Detect lost write corruption, auto shutdown and failover&lt;br&gt;• Intra-block logical checks at standby</td>
</tr>
<tr>
<td><strong>Database</strong></td>
<td>In-memory block and redo checksum</td>
<td>In-memory intra-block checks, shadow lost write protection</td>
</tr>
<tr>
<td><strong>ASM</strong></td>
<td>Automatic corruption detection and repair using extent pairs</td>
<td>HARD checks on write</td>
</tr>
<tr>
<td><strong>Exadata</strong></td>
<td>HARD checks on write, automatic disk scrub and repair</td>
<td>HARD checks on write</td>
</tr>
</tbody>
</table>
Oracle Data Guard (DG)

- **Basic DR (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**

Oracle Active Data Guard (ADG)

- **Advanced Disaster Recovery**
  - Queries, reports, backups
  - Occasional updates (19c)
  - Assurance of knowing system is operational

- **Active-active**

- **Automatic block repair**

- **Application Continuity**

- **Zero data loss across any distance**

- **Many other features**

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

- **SYNC** Limited distance
- **ASYNC** Any distance

**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, without Impact expanded to the Standby

Outage or Interruption at Database:
1. Database Request interrupted by an Outage or timeout
2. Session reconnects to the RAC Cluster (or Standby) and
3. Database Request replays automatically
4. Result from Database Request returned to user
Extend Footprint of ADG 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, Occasionally Updates” applications supported for Oracle Database 19c
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**, 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
Database Rolling Upgrade

Database Rolling Upgrade with DBMS_ROLLING
• Pre-checks and early problem detection
• Fault tolerant, resumable and rollback capabilities
• Three Role Transition Steps: Start, Switchover, Finish
• Potential Maintenance Window: Hours
• Potential Database and Application Downtime: Seconds

Resource Link: Automated Database Upgrades using Oracle Active Data Guard and DBMS_ROLLING
Extreme Critical

Gold +
- GoldenGate Active/Active Replication
- 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
- Local backups on both sites
- Achieve zero downtime through custom failover to GG replica

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<tr>
<td>Disasters including corruptions and site failures</td>
<td>Zero (f3)</td>
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Planned Maintenance

<p>| | |</p>
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<tr>
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<tr>
<td>Most common software/hardware updates</td>
<td>Zero (f2)</td>
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<tr>
<td>Major database upgrade, application upgrade</td>
<td>Zero (f3)</td>
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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**

**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.

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**Source**
- Oracle & Non-Oracle Database(s)

**Bi-directional**

---

**Target**
- Oracle & Non-Oracle Database(s)
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
Platinum MAA Data Center Architecture & Requirements

- A minimum of 2 Regions for Disaster Recovery Failover
  - Region is a localized geographic area
  - West Coast NAS – Primary example
  - East Coast NAS – Secondary example
- Each Region should have a minimum of 2 Availability Domains (AD)
- Availability Domain Characteristics
  - AD’s are isolated from each other & fault tolerant
  - AD’s do not share infrastructure such as power, cooling or AD Network
  - A failure of one AD does not effect other AD’s.
  - AD’s within a Region are connected via high speed network within same geographical area.

High Speed with < 1ms Latency
Sample GoldenGate MAA Deployment

- Primary Database
- Standby Database
- Observer
- Integrated Extract
- LogMining Server
- Trail and other OGG Files In DBFS
- ADG Redo Transport (SYNC or ASYNC)
- Bidirectional GoldenGate Replication
- Warehouse

Redo Transport
OCI Connection
File I/O
Sample GoldenGate MAA Deployment – Post Role Transition

Observer

(OLD) Primary Database

LogMining Server

ADG Redo Transport (SYNC or ASYNC)

(NEW) Primary Database

LogMining Server

Integrated Extract

Trail/Checkpoint/BR Files In DBFS

Bidirectional GoldenGate Replication

Warehouse

Redo Transport

OCI Connection

File I/O
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 by 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
How does OCI cloud automation enhance MAA in the cloud?
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 switches from primary to remote copy

Maintains copy by applying physio-logical changes
• Protects against database corruptions
• Validates data consistency as changes are applied

Fully Autonomous – Automates Everything
• Creation, operation, patching, and backup
• Database and Data Guard management
Hybrid Cloud – Disaster Recovery & Back-ups

### AVAILABILITY / AUTOMATION

<table>
<thead>
<tr>
<th>RMAN</th>
<th>Backup to the cloud</th>
</tr>
</thead>
<tbody>
<tr>
<td>RAC</td>
<td>Customer-specific</td>
</tr>
<tr>
<td>ACTIVE DATA GUARD</td>
<td>Instantiate &amp; operate Data Guard configuration</td>
</tr>
<tr>
<td>GOLDEN GATE</td>
<td>Manual (capture &amp; delivery)</td>
</tr>
<tr>
<td>MAA LEVEL</td>
<td>Customer responsibility</td>
</tr>
</tbody>
</table>

### Customer premises

- **Primary**
- **Backup**
- **Observer**
- **OCI Region**
- **Physical standby**

### Gold Outage Matrix

<table>
<thead>
<tr>
<th>Type</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>PLANNED MAINTENANCE</td>
<td>Zero</td>
</tr>
<tr>
<td>UPGRADE</td>
<td>Zero</td>
</tr>
<tr>
<td>RECOVERABLE FAILURE</td>
<td>Zero</td>
</tr>
<tr>
<td>UNRECOVERABLE FAILURE</td>
<td>Zero</td>
</tr>
</tbody>
</table>

**1** Customer responsibility

**2** Best case scenario (FSFO + SYNC or FAR SYNC + GoldenGate)
### Hybrid Cloud: Recommended Hybrid Sources/Destinations

#### To DBCS
- **Customer premises**
- **OCI Region**

- Single Instance
- DBCS VM Single Instance

- RAC
- DBCS VM RAC

- Active Data Guard

#### To Exadata Cloud
- **Customer premises**
- **OCI Region**

- Exadata
- ExaCS

- Active Data Guard

#### To Autonomous
- **Customer premises**
- **OCI Region**

- ADB-S

- SI/RAC

- Exadata

- ADB-D

- GoldenGate

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- All Hybrid configurations are achieved manually: no Control Plane automation
- On-premises non-Exadata to ExaCC/ExaCS is possible but beware of exclusive features
• All multicloud configurations are achieved manually: no Control Plane automation
• Azure Interconnect available in some regions
High Availability and Disaster Recovery is an absolute requirement for businesses today who require operations around the clock.

Oracle Maximum Availability Architecture (MAA) provides a tiered set of blueprints tailored to meet your RTO and RPO requirements.

Oracle MAA can be utilized to optimize business continuity for both planned maintenance and outage events across many different platforms spanning on-premises & cloud.
External Resources

Maximum Availability Architecture

• MAA Home:
  • http://oracle.com/goto/maa

• On-Premise MAA:

• Exadata MAA:

• Cloud MAA:
  • https://www.oracle.com/database/technologies/high-availability/oracle-cloud-maa.html
It’s now time for Q&A