Top Oracle Database 12c High Availability Innovations

A Technical Drilldown

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Best Innovations Make Things Easy

- Any sufficiently advanced technology is indistinguishable from magic - Arthur C. Clarke
- Any technology that is distinguishable from magic is not sufficiently advanced - Gregory Benford

- This talk will give an overview of the new high availability features introduced in Oracle Database 12c
- Then describes some of the internal innovations that make these features powerful and easy to use
Oracle Database 12c

Extreme Availability

- Oracle Database 12c introduces significant new HA capabilities that
  - Drastically cut down planned and unplanned downtime
  - Eliminate compromises between HA and Performance
  - Tremendously boost operational productivity

- These take Availability to unprecedented new levels
  - Next-generation Maximum Availability Architecture (MAA)
  - Optimized for Oracle
Oracle Maximum Availability Architecture

Production Site

RAC
- Scalability
- Server HA

Flashback
- Human error correction

Application Continuity
- Application HA

Global Data Services
- Service Failover / Load Balancing

Active Replica

Active Data Guard
- Data Protection, DR
- Query Offload

GoldenGate
- Active-active
- Heterogeneous

Edition-based Redefinition, Online Redefinition, Data Guard, GoldenGate
- Minimal downtime maintenance, upgrades, migrations

RMAN, Oracle Secure Backup
- Backup to tape / cloud

Oracle Database 12c

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Oracle Database 12c
High Availability Key* New Features

- Application Continuity
- Global Data Services
- Data Guard Enhancements
- RMAN Enhancements
- Flex ASM
- Other HA Enhancements
- GoldenGate Update
- MAA at PayPal

*Nearly a hundred new HA features in 12c
Pre-12c Situation

- Database outages can cause in-flight work to be lost, leaving users and applications in-doubt -
  - User frustration
  - Cancelled work
  - Duplicate submissions
  - Rebooting mid-tiers
  - Developer pains
Application Continuity

Masks unplanned/planned outages when successful

In-flight work continues

- Replays in-flight work on recoverable errors
- Masks many hardware, software, network, storage errors and outages
- Supports JDBC-Thin, Universal Connection Pool (UCP), WebLogic Server, 3rd Party Java apps/mid-tiers
- RAC, RAC One, & Active Data Guard
- Better end user experience
Application Continuity Subtleties

The hardest part of replay is deciding when NOT to replay

- Application Continuity minimizes divergence by re-executing SQL at original SCN (when possible) and rebuilding original environment
  - Stops replay (and returns error) if replayed request returns different result than original (e.g., two users concurrently updating same row)

- Application Continuity does not attempt replay (and returns error) if
  - Error is not recoverable – e.g., constraint violation
  - DDLs such as SHUTDOWN ABORT, DROP TABLESPACE are executed
  - Request has been explicitly disabled for replay – e.g., disbursing money
  - Failure occurred too long ago – don’t automatically replay a request from yesterday

- Application Continuity is safe; only replays incomplete requests – Will not pay for the same item twice
Transaction Guard
Preserve & Retrieve COMMIT Outcome

Reliable outcome for every TX after outages

- Tracks outcome of the last transaction
- Without Transaction Guard, retry can cause logical corruption
- Transaction Guard allows applications to deal correctly with failures
- Application Continuity uses Transaction Guard
- Transaction Guard also available for applications that do not use Application Continuity
## Application Continuity

### Internals

<table>
<thead>
<tr>
<th>Runtime</th>
<th>Reconnect</th>
<th>Replay</th>
</tr>
</thead>
</table>
| • Keep track of database requests  
• Decides what can / cannot be replayed  
• Holds on to original calls with validation for use during replay | • Ensures request has replay enabled  
• Handles timeouts  
• Creates a new connection  
• Validates target database  
• Uses Transaction Guard to determine & enforce last outcome | • Replays held calls  
• During replay, ensures that application-visible results match original  
• Continues request if replay successful |

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**Application Continuity & Transaction Guard:**  
Intelligent, application-centric fault tolerance
Oracle Database 12c
High Availability Key New Features

- Application Continuity
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Databases in Replicated Environments

Challenges

- Maximum Availability Architecture
  Active Data Guard and GoldenGate with RAC
- Want to optimize utilization of
  Active Data Guard and GoldenGate databases
  - Efficiently use all available databases
  - Automated load balancing and fault tolerance
Global Data Services

Load Balancing and Service Failover for Replicated Databases

- Extends RAC-style service _failover, load balancing_ (within and across data centers), and _management_ capabilities to a set of replicated databases
- Takes into account network latency, replication lag, and service placement policies
- Achieve higher availability, improved manageability and maximize performance
Global Data Services

Active Data Guard Example

- Reporting client routed to ‘best’ database
  - Based on location, response time, data, acceptable data lag
  - Reports will automatically run on least loaded server

- Reporting client failover
  - If preferred database not available, will route to another database in same region or a remote database

- Global service migration
  - Automatically migrates services based on failover/switchover - if primary database is down, start Call Center service on the new primary
Global Data Services

GoldenGate Example

- Call Center Client connections and requests transparently routed to the closest / best database
  - Runtime load balancing metrics give client real-time information on which database to issue next request
- If a database fails, its global services are restarted on another replica
Load Balancing is Very Complicated

Global Data Service (GDS) Load Balancing

- Supports connect-time and run-time (per-request) load balancing
- Load balancing is easy if all your machines and workload are uniform
  - GDS supports heterogeneous environment – RAC + non-RAC, powerful and less powerful machines (important since some customers have less powerful machines for DR)
- Load balancing is **NOT** equal load on all machines
  - Instead, GDS minimizes *average response time* across all requests
  - If database 1 much faster than database 2, then 100% of requests might go to machine database 1
  - Sometimes, request to lightly-loaded database in remote region might complete faster than request to heavily loaded database in local region
  - Equalization of average response time done for all clients in *each* region (remote requests expected to be longer)
- Load balancing must balance responding rapidly to changing workloads and avoiding oscillations
- Uses internal database metrics, does not blindly rely on external metrics
  - More accurate (factors out network variability), handles workload generated external to global services, & handles planned shutdown case
Global Data Services: Summary
Globally Replicated, High Availability Architecture

- GDS Framework dynamically balances user requests across multiple replicated sites
  - Based on location, load, and availability
- Provides global availability
  - Supports automatic service failover
- GDS integrates disparate databases into a unified data cloud

GSM - Global Service Manager

SALES POOL (sales_reporting_srvc, sales_entry_srvc)

Data Center #1
APAC

Local
Standby

Active
Data Guard

Primary

Global Service Managers

GDS Catalog
Primary

GDSCTL

Local
Standby

Oracle
GoldenGate

Master

SALES POOL (sales_reporting_srvc, sales_entry_srvc)

Active
Data Guard

Remote
Standby

Reader Farm

Data Center #2
EMEA

Local
Standby

Active
Data Guard

Primary

Global Service Managers

GDS Catalog
Standby

GDSCTL

Local
Standby

Active
Data Guard

Master

HR POOL (hr_apac_srvc, hr_emea_srvc)

All GDS client databases connected to all GSMs

SALES POOL (sales_reporting_srvc, sales_entry_srvc)

Active
Data Guard

Remote
Standby

Reader Farm

Data Center #2
EMEA

Local
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HR POOL (hr_apac_srvc, hr_emea_srvc)

All GDS client databases connected to all GSMs
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Zero Data Loss Challenge

Synchronous Communication Leads To Performance Trade-Offs

The longer the distance, the larger the performance impact
Data Guard Async – Today
Some Data Loss Exposure Upon Disaster
Active Data Guard Far Sync

Zero Data Loss For Async Deployments

- Far Sync: light-weight Oracle instance: standby control file, standby redo logs, archived redo logs, no data files

- Receives redo synchronously from primary, forwards redo asynchronously in real-time to standby

- Upon Failover: Async standby transparently obtains last committed redo from Far Sync and applies: zero data loss failover

- Second Far Sync Instance can be pre-configured to transmit in reverse direction after failover/switchover

- Terminal standbys required to be Active Data Guard Standbys
Active Data Guard Far Sync

Operational Flow

Primary → SYNC → Far Sync Instance → ASYNC → Standby
Active Data Guard Far Sync

Operational Flow (contd.)

No Compromise Between Availability and Performance!

Zero Data Loss

Primary

Standby

Far Sync Instance

ASYNC
Active Data Guard Far Sync

Much work done to make things work ‘like magic’

- Looks just like SYNC. So Fast Start Failover (FSFO) works – automatic, zero data loss failover to far destination
- If Far Sync instance fails, can failover to another Far Sync (recommended), or go into async mode directly to standby (using remote alternate log_archive_dest_x)
- Sophisticated logic to make failovers seamless
  - When primary dies, Far Sync keeps track of state of async connections to terminal standby to ship the exact redo needed for zero data loss
  - Works with RAC (multiple threads of redo)
- Smart gap resolution – if the primary is missing redo, it can fetch from Far Sync instance. Far Sync instance will transparently fetch from primary & forward to standby
Active Data Guard Far Sync

Summary of Benefits

- Best data protection, least performance impact
- Low cost and complexity
- Best way to implement a near DR + Far DR model
- Relevant to existing Data Guard ASYNC configurations
- Data Guard Failover? No Problem! Just do it – No Data Loss!
Active Data Guard Real-Time Cascading

Eliminates Propagation Delay

- In 11.2, Standby 1 waits till log switch before forwarding redo from archived logs to Standby 2

- In 12.1, Standby 1 forwards redo to Standby 2 in real-time, as it is received: no propagation delay for a log switch

- Standby 2 (Active Data Guard Standby) is up-to-date for offloading read-only queries and reports
Data Guard Fast Sync
Reduced Primary Database Impact for Maximum Availability

- For SYNC transport: remote site acknowledges received redo before writing it to standby redo logs
- Reduces latency of commit on primary
- Better DR – increased SYNC distance
- If network round-trip latency less than time for local online redo log write, synchronous transport will not impact primary database performance
- Can use Fast Sync from Primary to Far Sync, and Fast Sync works with FSFO
# Data Guard

## Other New Features in Oracle Database 12c

### Rolling Upgrade With Active Data Guard
- Automate complexity through simple PL/SQL Package: `DBMS_ROLLING` (12.1.0.1 onwards), with simple Init, Build, Start, Switchover, Finish procedures
- Additional Data Type Support: XML OR, Binary XML, Spatial, Image, Oracle Text, DICOM, ADTs (simple types, varrays), …

### DML on Global Temporary Tables
- Temporary undo is not logged in redo logs
- Enables DML on global temporary tables on Active Data Guard: more reporting support
- Set by default on Active Data Guard standby

### Validate Role Change Readiness
- Ensure Data Guard configuration ready for switchover with automated health checks – verify no log gaps, perform log switch, detects any inconsistencies, ensures online log files cleared on standby, …

### Unique Sequences
- Primary allocates a unique range of sequence numbers to each Standby
- Enables more flexible reporting choices for Active Data Guard
Oracle Database 12c
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Fine-grained Table Recovery From Backup

- Simple `RECOVER TABLE` command to recover one or more tables (most recent or older version) from an RMAN backup
- Eliminates time and complexity associated with manual restore, recover & export
  - Enables fine-grained point-in-time recovery of individual tables instead of the contents of the entire tablespace
Cross-Platform Backup & Restore
Simplified Platform Migration

- Simplifies procedure for platform migration
- Minimize read-only impact with multiple incremental backups
Pluggable Database Backup & Restore
Fine-Grained Backup & Recovery to Support Consolidation

- Backup and recover specific pluggable databases with new PLUGGABLE DATABASE keywords:
  \texttt{RMAN> BACKUP PLUGGABLE DATABASE <PDB1>, <PDB2>};

- Familiar \texttt{BACKUP DATABASE} command backs up CDB, including all PDBs

- PDB Complete Recovery
  - \texttt{RESTORE PLUGGABLE DATABASE <PDB>};
  - \texttt{RECOVER PLUGGABLE DATABASE <PDB>};

- PDB Point-in-Time Recovery
  - \texttt{RMAN> RUN \{}
  - \texttt{SET UNTIL TIME 'SYSDATE-3';}
  - \texttt{RESTORE PLUGGABLE DATABASE <PDB>};
  - \texttt{RECOVER PLUGGABLE DATABASE <PDB>};
  - \texttt{ALTER PLUGGABLE DATABASE <PDB> OPEN RESETLOGS; \}}

- Familiar \texttt{RECOVER DATABASE} command recovers CDB, including all PDBs
Oracle Database 12c
High Availability Key New Features

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- **Flex ASM**
- Other HA Enhancements
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Automatic Storage Management (ASM) Overview

Current State

One to One Mapping of ASM Instances to Servers

Shared Disk Groups

Wide File Striping

RAC Cluster

Database Instance

ASM Instance

Node 1

ASM

Node 2

ASM

Node 3

ASM

Node 4

ASM

Node 5

ASM

ASM Cluster Pool of Storage

Disk Group A

Disk Group B

ASM Disk

DB_A

DB_A

DB_B

DB_B

DB_B

DB_C
Flex ASM: Eliminate 1:1 Server Mapping

New: ASM Storage Consolidation in Oracle Database 12c

Databases share ASM instances

Node1 runs as ASM Client to Node2
Node2 runs as ASM Client to Node3
Node3 runs as ASM Client to Node5
Node4 runs as ASM Client to Node5
Node5 runs as ASM Client to Node4

Shared Disk Groups
Wide File Striping
Flex ASM: Supporting Oracle Database 11g

Previous Database Versions Will Host Local ASM Instance

Databases share ASM instances

Shared Disk Groups

Wide File Striping

RAC Cluster

Node1

Node2

Node3

Node4

Node5

DB_A

11.2 DB

DB_B

ASM

ASM

ASM

ASM

ASM

DB_A

DB_B

DB_B

DB_B

11.2 DB

DB_C

ASM Cluster Pool of Storage

Disk Group A

Disk Group B

ASM Disk
Oracle Database 12c
High Availability Key New Features

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- **Other HA Enhancements**
- GoldenGate Update
Other HA Enhancements

1. **Online Datafile Move**
   - Relocate a datafile while users are actively accessing data: `ALTER DATABASE MOVE DATAFILE ...`
   - Maintains data availability during storage migration

2. **Online Redefinition Enhancements**
   - Improved `sync_interim_table` performance
   - Ability to redefine table with VPD policies
   - Improved resilience of `finish_redef_table`
   - Better handling of multi-partition redefinition

3. **Separation of Duties**
   - `SYSDG / SYSBACKUP`: Data Guard & RMAN specific administrative privileges
   - No access to user data: enforce security standards throughout the enterprise

4. **Additional Online Operations**
   - Drop index online / Alter index unusable online / Alter index visible / invisible online
   - Drop constraint online / Set unused column online
   - Online move partition: `ALTER TABLE ... MOVE PARTITION ... ONLINE`
Oracle Database 12c
High Availability Key New Features

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Data Guard
Redo Transport
SYNC or ASYNC

Oracle Active Data Guard
Real-Time Data Protection and Availability

Note: A single DR copy may be multi-purposed for any combination of the use cases described.
Log-based Changed Data

Oracle & Non-Oracle Database(s)

Message Bus

Oracle Database 12c

Oracle GoldenGate 12c*

Low-Impact, Real-Time Data Integration & Transactional Replication

New DB/ HW/OS/APP

Fully Active Distributed DB

Logical Copy of Primary Reporting Database

Data Warehouse

Global Data Centers

Message Bus

ODS

Data Integrator

*: GoldenGate 12c for Oracle Database 12c will be available in CY2013

Zero Downtime Upgrade & Migration

Active-Active High Availability

Disaster Recovery for Non-Oracle Databases

Query & Report Offloading

Real-time BI, Operational Reporting, MDM

Data Synchronization within the Enterprise

Event Driven Architecture, SOA
GoldenGate Zero Downtime Migration/Upgrade
Seamless Migration and Upgrades to Oracle Database 12c*

- Consolidate/migrate/maintain systems without downtime
- Minimize risk with failback option
- Validate data before switchover
- Use Active-Active replication for phased user migration

*: GoldenGate 12c for Oracle Database 12c will be available in CY2013
Oracle GoldenGate for Active-Active Databases

Increase ROI on Existing Servers & Synchronize Data

- Utilize secondary systems for transactions
- Enable continuous availability during unplanned & planned outages
- Synchronize data across global data centers
- Use intelligent conflict detection & resolution

*: GoldenGate 12c for Oracle Database 12c will be available in CY2013
Oracle Database 12c
Extreme Availability: Summary

Oracle Database 12c offers a tremendously sophisticated set of high availability (HA) capabilities

These capabilities
  – Further reduce downtime
  – Significantly improve productivity
  – Eliminate traditional compromises
Resources

- OTN HA Portal:
  http://www.oracle.com/goto/availability

- Maximum Availability Architecture (MAA):
  http://www.oracle.com/goto/maa

- MAA Blogs:
  http://blogs.oracle.com/maa

- Exadata on OTN:

- Oracle HA Customer Success Stories on OTN:
Key HA Sessions and Demos by Oracle Development

**Monday, 23 September  Moscone South**

10:45a Oracle DB 12c—Eng’d for Clouds and Big Data, North D  
1:45p Oracle Exadata—What’s New and What’s Coming, 103  
3:15p Top Oracle DB 12c HA Innovations - A Technical Drill-down, 103  
4:45p RMAN in Oracle DB 12c: New Features and Best Practices, 102  
4:45p Compression and Performance in Oracle Database 12c, 104

**Tuesday, 24 September  Moscone South**

10:30a Always Available: Oracle Exadata and Oracle MAA, 102  
10:30a Oracle RAC 12c Best Practices, 104  
12:00p A Revolutionary New Way to Do DB Backup and Recovery, 102  
12:00p Oracle Flex Cluster: Optimized Resource Mgmt. for Cloud, 104  
12:00p Storage Optimization with Oracle Database 12c, 301  
3:45p Oracle DB 12c Best Practices for Data Availability and Disaster Protection, 102  
5:15p Optimize Oracle Active Data Guard and Oracle GoldenGate: Oracle DB12c Global Data Services, 200

**Demos – Mon & Tue 9:45a-6:00p - Wed 9:45a-4:00p**

Oracle Maximum Availability Architecture, SL-025  
Data Protection Made Simple, Moscone South, Center  
Oracle Database 12c: Global Data Services, SL-030

**Wednesday, 25 September  Moscone South**

10:15a Best Practices for Integrating GoldenGate w/ Act. Data Guard, 104  
11:45a The Next Big Thing!, 103  
11:45a Best Practices for Oracle Exadata Backup and Recovery, 200  
11:45a Cloning and Snapshots with Oracle Database 12c, 102  
1:15p Redefining Backup and Recovery with Oracle Eng’d Systems, 200  
3:30p Oracle Active Data Guard: Next-Generation Data Protection, 103  
5:00p Oracle Exadata Storage Availability Best Practices, 200  
5:00p Integrated Apply: Scalable Replication with GoldenGate, North 131  
5:00p Exadata Planned Maintenance for Zero Downtime, Westin Metro. I

**Thursday, 26 September  Moscone South**

11:00a Oracle Database-Aware Flash: Maximizing Performance and Availability for Your Database, 236  
2:00p Oracle MAA Best Practices for the Oracle Multitenant Option, 102  
2:00p Maximize Availability by Using DB Services with Oracle RAC, 103  

Oracle Active Data Guard, SL-026  
Oracle Recovery Manager and Oracle Flashback, SL-031  
Meeting Service Objectives with Oracle RAC, SL-021  
GoldenGate 11gR2: Real-Time, Transactional DB Replication, SL-027  
Continuous Database Services, SL-029