Deploying Active-Active Data Centers Using Oracle Database Solutions

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Agenda

• Active-Active Data Centers
  • Introduction
  • Characteristics
  • Requirements

• Solutions for the Oracle Database
  • Oracle RAC Extended Clusters
  • Oracle Data Guard
  • Oracle Streams

• Summary
  • Summarizing Oracle Active-Active Solutions
Active-Active Systems

**Definition**

• Network of independent processing systems, connected to databases kept synchronized in a geographically distributed configuration, and managed through a unified interface

• Benefits:
  ✓ High Utilization
  ✓ High Availability
  ✓ High Flexibility
Active-Active

Data Centers and Databases

- Active-active data centers – ones which host copies of the same database that are actively accessed by various apps
- The copies are kept synchronized through some means

Not active-active databases

Data Center A
- DB-a
- DB-b-copy

Data Center B
- DB-a-copy

Active-active databases

Data Center A
- DB-a
- DB-b

Data Center B
- DB-a-copy
- DB-b-copy

- Database copies not accessed
- Some utilization of data center assets

- Database copies actively accessed
- Full utilization of data center assets
From a Data Perspective …

- Globally deployed data-synchronized active data centers
Active-Active Deployment

**Key Decision Metrics**

1. How far apart could the sites be?
2. How is the data kept synchronized?
3. How is high availability maintained?
4. How easily can the configuration be managed?
Active-Active Deployment

Decision Metric – Site Distance

- Issues to consider:
  1. How far apart could the data centers be located?
  2. What replication technology should be used?
Active-Active Deployment

Site Distance Issues

• Benefits of geographically separated data centers
  • 24x7 work cycle – follow-the-sun model
  • Local access – better performance
  • High Availability – protection from regional disasters
  • Utilization – leverage data centers after M&A

✓ Design decisions
  ➢ Choosing right network – latency, bandwidth implications
  ➢ Choosing right replication protocol – distance limitations
Active-Active Deployment

Replication Technologies

• **Host-based Replication**
  1. Specialized for a specific data source – e.g. a database
  2. Target storage can be open – fits active-active requirement
  3. Better / optimized protection from data corruptions
  4. Selected data changes transferred – better network utilization
  5. No distance limitation

• **Storage Array-based Mirroring**
  1. Works for all data – e.g. both database and file systems
  2. No access to target storage – doesn’t work well for active-active
  3. Data corruptions will propagate between storage systems
  4. All data changes transferred – worse network utilization
  5. Some distance limitation

Host-Based Replication – External or Internal to the Database?

• External replication: database integration lagging, separate process / admin overhead, synchronous replication not possible, may also support other databases
• Internal replication: built-in integration, unified admin interface, zero data loss through synchronous replication, typically supports the host database only
Active-Active Deployment

*Decision Metric – Data Synchronization*

- Issues to consider:
  1. Could all databases be available read/write?
  2. If reads occur anywhere, how to handle data latency?
  3. If writes occur anywhere, how to handle data conflicts?
Active-Active Deployment

Data Synchronization Issues – Database Utilization

- Bi-Directional Multi-Master Configuration
  - Both reads & writes directed to any system

- Hub & Spoke Configuration
  - All writes to hub, local reads & writes to spokes

✓ Design decision

  Keeping the distributed systems in sync with each other

- Master-Slave Configuration
  - Writes directed to a designated Master system
  - Any system can perform Reads

✓ Design decision

  Keeping the reader systems in sync with the master
Active-Active Deployment

Data Synchronization Issues – Data Latency

• If writes and reads occur at two different systems – by how much should “readers” lag the “writers”?
  • Some reader-applications need latest data – e.g. real-time reporting
  • Some applications can work with stale data – e.g. workflow apps
  • Hybrid: work with stale data, but only till a specified limit on the staleness

• Synchronous Replication
  1. Primary I/O gated till data transfer + secondary I/O are complete
  2. Impact of network latency on primary processing
  3. In disasters: zero data loss
  4. Assurance: data freshness

• Asynchronous Replication
  1. Data transfer to secondary systems detached from primary I/O
  2. Minimal impact of network latency on primary processing
  3. In disasters: some data loss
  4. Assurance: performance

Smarter synchronous replication: optimize data transfer such that not all primary I/O-s are blocked – minimize impact on performance
Active-Active Deployment

Data Synchronization Issues – Data Conflicts

Concurrent updates of same data at different locations

- Application Design Considerations – How to Prevent Data Conflicts?
  - Is the schema too complex? Is this a packaged app and can’t be customized?
- Technology Considerations – How to Detect and Resolve Conflicts?
  - Does the technology provide the required capabilities?
Active-Active Deployment

*Data Synchronization – Preventing Data Conflicts*

- Use logical partitioning to designate “master” dataset
  - Localized Partitioning
    - Data specific to a region gets updated only at the local database (e.g. APAC data for a global financial company)
  - Application Partitioning
    - Data specific to an application gets updated at a specified database (e.g. shopping cart app vs. inventory app)
  - Data Partitioning
    - Designated data gets updated only at a designated database (e.g. a hash-based mechanism to route data to a designated database)
- Application must be able to deal with “eventual consistency”
  - Application accessing the APAC database will have the latest APAC data but not necessarily the latest EMEA data
Active-Active Deployment

Data Synchronization – Detecting & Resolving Data Conflicts

• Detection Requirements
  • An efficient logical replication mechanism based on primary/unique keys
  • While applying changes from a remote database, a way to compare before-image of the changes with existing data of the local database
  • Note: avoid system-generated primary keys – will cause unnecessary conflicts
  • An efficient comparison tool to validate data consistency on-demand

• Resolution Requirements
  • Flexible means to resolve conflicts - some could be built-in – e.g. higher value wins, lower value wins, overwrite local data, discard incoming data
  • Should be extensible with specialized “handler” code to satisfy complex business requirements
Active-Active Deployment

Decision Metric – High Availability

• Issues to consider:
  1. How to maintain uptime despite unplanned outages?
  2. How to maintain uptime despite planned maintenance?
  3. How to protect from data corruptions?

✓ Design decisions
  ➢ Determine the HA metrics:
    ▪ Recovery Point Objective (RPO) – how much data loss can be afforded?
    ▪ Recovery Time Objective (RTO) – how fast should you be back online?
Active-Active Deployment

High Availability Issues – System Failures

- Individual system failures should not impact the rest of the configuration
  - E.g. site / network / server …

- Required:
  - Loosely-coupled configuration
  - Fault isolation
  - Ability to reconnect users to surviving systems
  - Ability to resynchronize after system reinstated

- What if zero data loss is required?
  - Consider using a separate disaster recovery (DR) solution in synchronous replication mode
  - Users could reconnect to that system after DR failover
Active-Active Deployment

*High Availability Issues – Scheduled Maintenance*

- Similar principle: individual system maintenance should not impact rest of the configuration
  - HW & SW upgrades / patching
  - Platform migration
  - Data Center migration

- Required:
  - Loosely-coupled configuration
  - Ability to reconnect users to other systems while master system unavailable
  - Seamless resynchronization once maintenance complete
Active-Active Deployment

*Decision Metric – Manageability*

- Is the configuration
  - *Simple* to set up, operate and administer?
  - *Flexible* to adapt to new business requirements?
  - *Scalable* to meet business growth?
  - *Integrated* out-of-the-box?

 ✓ *Design decisions*

  - Determine operational Service Level Objectives:
    - Automatic management with minimal manual intervention
    - Capability of alerts / fine-grained monitoring
    - Extensibility and integration with minimal impact

<table>
<thead>
<tr>
<th>Creating</th>
<th>Monitoring</th>
<th>Extending</th>
</tr>
</thead>
</table>

Manageability

*ORACLE*
Active-Active Deployment

*Manageability Issues – Create, Monitor, Extend*

- Creating the initial configuration
  - What methods are available to create initial setup?
  - What’s used – replica of existing database / subset / transformed?
  - Is any downtime incurred during the creation?

- Monitoring the configuration
  - Is fine-grained monitoring available?
  - How easy it is to identify bottlenecks?
  - How does one measure latency, esp. if it is tied to SLAs?
  - How are suitable alerts raised and handled?

- Extending the configuration globally?
  - Is there any impact on existing systems while creating new sites?
  - Is there any limit on the number of sites supported?
  - Does the configuration scale as new sites are added?
  - Does the configuration allow appropriate heterogeneity?
Next … Oracle Active-Active Solutions

• Evaluating
  • Oracle RAC Extended Clusters
  • Oracle Data Guard
  • Oracle Streams

• with respect to …
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Oracle RAC Extended Clusters
RAC Extended Cluster

*What Is It?*

- An Oracle Real Application Clusters (RAC) configuration deployed over two sites separated within metro distance (~25 Km)
- Both sites are fully active (read / write), but tightly coupled to access the same clustered database
- If one site goes down, users at the other site are unaffected
- Easy way to extend the High Availability benefits of a traditional RAC configuration
Traditional RAC Configuration

Application Access

N1

N2

N3

N4

Application Access

Same Data Center
RAC Extended Cluster Configuration

Data Center A

Application Access

N1

Extended Cluster

N2

N3

N4

Data Center B

Cluster Interconnect

Remote Mirroring

One Database

Application Access

One Database
RAC Extended Cluster

*Distance & Data Synchronization*

- Ideal for metro distances (25 Km or less)
  - RAC Cache Fusion message traffic and Disk I/O traffic now have to traverse the inter-site network => additional network latency
  - Redundant, high bandwidth network required
  - <10 KM, direct cables; >10 KM, need Dark fibre / DWDM
  - Performance impact analysis is required

- Both sites could be fully active (read/write)
  - One database => no data conflicts, no data latency
  - ASM mirroring recommended
  - Can’t use storage-array mirroring – no access to mirrored volumes
RAC Extended Cluster

**High Availability**

- Limited protection from site failures
  - Zero data loss on site failures
  - Users at one site may continue despite failure of other site
  - With RAC Fast Application Notification (FAN), users of failed site may be directed to the other site within a few seconds and rebalanced after a node and instance and reinstated
  - Follow MAA best practices to minimize failover times
    - Tune `FAST_START_INSTANCE_RECOVERY_TARGET`
    - Set `FAST_START_PARALLEL_ROLLBACK=HIGH`
    - Optimize I/O
  - Protection for metro-distance only (no protection from regional disasters, database-wide or cluster-wide problems)
- Limited support for data corruption protection
  - ASM allows reading from secondary extents if primary extent corrupted, and also replacing corrupted extent with a valid mirror copy
  - Corruptions may be propagated to mirror site
- Limited support for planned maintenance
  - Rolling application of one-off database software patches, CPUs, CRS and ASM
  - Rolling hardware upgrades, but requires identical platform architecture
  - No support for rolling database upgrades
RAC Extended Cluster

Manageability

• Managed as a single unified RAC configuration through Oracle Enterprise Manager
  • Leverages RAC administration / monitoring capabilities of EM
  • Additional work required for network setup and monitoring
  • Performance and outage testing is a required
  • Additional setup and administration of third site (voting disk)
• No downtime to add nodes / instances / disks at either cluster sites
  • Leverages RAC scalability capabilities
  • Scales reads and writes with correct design and tuning
• Supports only two sites for the cluster
RAC Extended Cluster

*Enhancements*

- **ASM Fast Mirror Resync**
  - ASM keeps track of changes directed to a failed disk for a time duration configured through the `DISK_REPAIR_TIME` parameter
  - When failed disks replaced, they are quickly synchronized
  - No need to rebuild an ASM failure group after transient storage errors

- **ASM Preferred Read Failure Groups**
  - ASM may be configured to read from a secondary extent if that extent is local to the node, instead of reading from the primary extent which may be farther from the node
  - Uses `ASM_PREFERRED_READ_FAILURE_GROUPS` parameter to specify a list of failure group names as the preferred read disk
RAC Extended Cluster for Active-Active

**Bottom Line**

- Ideally suited for prospective / existing RAC users who want to build a single clustered database spanning data centers located within metro distance

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Both sites are fully active</td>
<td>Does NOT provide full HA / DR / Data Protection (Data Guard needed)</td>
</tr>
<tr>
<td>Additional HA compared to traditional RAC</td>
<td>Customers need to be aware of the design limitations</td>
</tr>
</tbody>
</table>
Oracle Data Guard
Oracle Data Guard

What Is It?

• Data Availability & Data Protection solution for Oracle
• Automates the creation and maintenance of one or more synchronized copies (standby) of the production (or primary) database
• If the primary database becomes unavailable, a standby database can easily assume the primary role
• Feature of Oracle Database Enterprise Edition (EE)
  • Basic feature available at no extra cost
  • Active Data Guard (Oracle Database 11g) is extra license option
  • Primary and standby databases need to be licensed EE
Data Guard Architecture

*With Oracle Active Data Guard in Oracle Database 11g*
• Physical Standby Database is a block-for-block copy of the primary database
• Uses the database recovery functionality to apply changes
• While apply active, can be opened in read-only mode for reporting/queries*
• Can also be used for fast* backups, further offloading the production database

* Requires additional license for Active Data Guard
Data Guard SQL Apply

- Logical Standby Database is an open, independent, active database
  - Contains the same logical information (rows) as the production database
  - Physical organization and structure can be very different
  - Can host multiple schemas
- Can be queried for reports while redo data is being applied via SQL
- Can create additional indexes and materialized views for better query performance
### Active-Active Databases with Data Guard

**Redo Apply or SQL Apply?**

<table>
<thead>
<tr>
<th>Redo Apply</th>
<th>SQL Apply</th>
</tr>
</thead>
<tbody>
<tr>
<td>Active-Active requires Active Data Guard (Oracle Database 11g)</td>
<td>Active-Active supported with SQL Apply starting with Oracle9i Release 2</td>
</tr>
<tr>
<td>Physical standby database can only be opened for reads</td>
<td>Local writes allowed for unprotected / skipped tables on logical standby database</td>
</tr>
<tr>
<td>No local writes, hence no data-conflicts</td>
<td>No data-conflict handling for local writes</td>
</tr>
<tr>
<td>Higher performance</td>
<td>Involves extra transformation to SQL</td>
</tr>
<tr>
<td>Supports all datatypes</td>
<td>Doesn’t support certain datatypes</td>
</tr>
</tbody>
</table>
Reader Farm with Active Data Guard

*Scale-out query performance to web-scale*

**Single Node**

- updates

**Production Database**

**Active Data Guard Reader Farm**

- queries
- Standby Databases
Data Guard

Distance & Data Synchronization

- No distance limitation
  - Leverages Oracle Net Services & TCP/IP for redo block transport
  - Asynchronous redo transport – minimal impact for 1000’s of miles
  - Smart synchronous redo transport – transmits only redo blocks, may span hundreds of miles with minimal impact on application throughput

- Standby sites could at best be open read-only
  - Standby databases kept in sync through redo block transport
  - Redo Apply can support high throughput (e.g. 50 MB/sec redo rate)
  - May configure SYNC or ASYNC for redo transport
  - Updates occur only on the primary => no data conflicts
  - Synchronous redo transport + real-time apply => minimal read latency (few seconds)
Data Guard

High Availability

• Protection from site & network failures
  • With Fast-Start Failover users of failed site are automatically directed to the standby site within a few seconds
  • Old primary database is automatically reinstated as new standby
  • Zero data loss on site failures with synchronous redo transport
  • Effective protection from regional disasters
  • Standby automatically synchronized with primary after fixing temporary network failures

• Protection from data corruptions
  • Corruptions not propagated to standby site: benefits of fault isolation from Data Guard’s loosely coupled architecture
  • Upon data corruptions at primary, best to failover to valid standby and continue
  • Oracle Database 11g enhancement: detection of lost writes with Data Guard

• Extensive support for planned maintenance
  • Rolling application of one-off database software patches
  • Rolling database upgrades
  • Rolling hardware upgrades, data center migration
  • Some heterogeneous platforms* (e.g. Windows -> Linux, PA-RISC -> Itanium)

* Ref. MetaLink Note 413484.1
Data Guard

Manageability

• Managed as a unified configuration through Oracle Enterprise Manager, or Data Guard Broker CLI (DGMGRL)
  • Simple interface for several complex operations (e.g. switchover)

• Fine-grained monitoring
  • E.g. track standby data latency with respect to the primary - transport lag, apply lag from `V$DATAGUARD_STATS`

• No downtime during creation / addition of standby databases
  • Standby databases created with online RMAN backups of the primary
  • Easy way to scale read-access for web-facing applications
  • Up to nine standby databases may be directly linked with the primary (ref. MetaLink Note 409013.1)
Data Guard for Active-Active

**Bottom Line**

- Ideally suited for customers primarily interested in HA + DR, but who also want to maximize their DR resource utilization

<table>
<thead>
<tr>
<th>Pros</th>
<th>Cons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Best HA + DR + data protection solution</td>
<td>Standby databases may be effectively utilized only for reads</td>
</tr>
<tr>
<td>Simple</td>
<td>Limited support for heterogeneous platforms</td>
</tr>
</tbody>
</table>
Oracle Streams
Oracle Streams

What Is It?

- Simple solution for information sharing
- Provides
  - Uniquely flexible information sharing
  - Active/Active replication
  - Real-time ETL for data warehouses
  - Availability during database migration
  - Availability during application upgrade
  - Message queuing
  - Event management and notification
Streams Architecture

**Powerful Solution for Information Sharing**

- All sites active and updateable
- Automatic conflict detection & optional resolution
- Supports data transformations
- Database platform / release / schema structure can differ
- Some datatypes are not supported
Streams – Ideal for Active-Active Deployment

• Asynchronous message-driven architecture
  • Loosely coupled, fault isolated
  • All sites updateable, data conflict detection / resolution
• Numerous ways to extend based on business rules
  • Interface through PL/SQL APIs
  • Ability to deploy custom code at various interfaces
• High performance log-based capture of changes
  • No need to define custom triggers
  • No need to create additional files outside the database
• Supports a wide variety of active-active configurations
  • N-way multi-master, bi-directional, hub & spoke, etc.
  • Logical change capture allows significant heterogeneity
Streams

Distance & Data Synchronization

- No distance limitation
  - Leverages Oracle Net Services & TCP/IP for propagating changes
  - Asynchronous propagation allows deployment across 1000’s of miles
  - Synchronous redo transport also possible through downstream capture

- All Streams sites can be fully active (read/write)
  - Databases kept in synch through capture & apply of logical changes
  - Automatically detects various data conflicts during apply – update, uniqueness, delete, foreign key
  - Provides pre-built conflict handlers to resolve update conflicts – **OVERWRITE**, **DISCARD**, **MAXIMUM**, **MINIMUM**
  - Also allows creation of custom conflict handlers to resolve data conflicts

- **DBMS_COMPARISON**
  - New package in Oracle Database 11g to compare tables, views, materialized views across replicated databases, and converge them so they are consistent
Streams

Data Synchronization – Best Practices

• If replicating DDL, perform DDL from single database
  • Consider impact of specific DDL across multiple databases
    • Example: Compiling procedures, functions

• For key columns generated from sequences:
  • Manage separate sequence ranges across databases
    • Change start and increment by settings
      • Odd/even
      • Last digit indicates database (modulo)
    • Use unique string in combination with sequence as key

• Avoid replication cycles by setting Streams Tag
  • Tag is null by default
  • Changes made by Streams Apply process have non-NULL tags
  • Rules indicate if tagged LCRs are replicated
  • Tag can be set in local user session to avoid replication of specific session changes
Streams

*High Availability*

- Protection from site & network failures
  - Users at other sites may continue despite failure of one or more sites
  - Users of failed sites could be directed to the valid sites within a few seconds
  - Real-time asynchronous change propagation ensures minimal data loss
  - Automatic re-synchronization after restoring failed systems or fixing temporary network failures

- Protection from data corruptions
  - Corruptions not propagated to replicated site: benefits of fault isolation from Stream’s loosely coupled architecture
  - Upon data corruptions at source, best to redirect to a valid target and continue

- Best support for planned maintenance
  - Rolling application of all database software and CPU patches
  - Rolling database upgrades
  - Rolling hardware upgrades, data center migration
  - Heterogeneous OS platforms, database releases and character sets
  - Rolling application upgrades in some cases
Streams

Manageability

• Managed as a unified configuration through Oracle Enterprise Manager, or through extensive PL/SQL APIs
  • `DBMS_STREAMS_ADM` package provides various `MAINTAIN_*` procedures that significantly simplify setting up a Streams configuration
  • Operational investment to handle conflicts and for advanced tuning

• Fine-grained monitoring
  • Streams Performance Advisor (new in Oracle Database 11g) allows monitoring of various Streams components (`DBMS_STREAMS_ADVISOR_ADM` and `UTL_SPADV` packages)

• No downtime during creation / addition of Streams targets
  • Replicated databases may be created using RMAN (including from a physical standby), Data Pump, Transportable Tablespace
  • No theoretical limit on the number of destinations supported by a source, but need to monitor performance for complex configurations
Streams for Active-Active

*Bottom Line*

- Ideally suited for customers who want a flexible way to distribute data across geographical boundaries, with maximum utilization of all databases

<table>
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<th>Cons</th>
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<tbody>
<tr>
<td>Best support for active-active databases</td>
<td>Not application transparent – doesn’t support certain datatypes</td>
</tr>
<tr>
<td>Flexible</td>
<td>Some performance dependency on transaction profiles</td>
</tr>
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Implementing Active-Active Databases with Oracle Solutions

• Deploying active-active sites?
  • Oracle’s recommended solution: Oracle Streams
    • Best support for global, update-everywhere topologies
    • May be complemented with Data Guard for best disaster protection
  • Data Guard is the best choice for reader farms
  • RAC Extended Clusters is applicable in selected configurations

• Recommended strategy
  ✓ Understand current and future requirements
  ✓ Understand active-active design issues
  ✓ Understand relative capabilities of each solution
  ✓ Choose the one that is the best fit
  ✓ Test, test, test!
Global Automotive Manufacturer

Using Streams + Data Guard for Global Active-Active Deployment

- 1 TB central engineering repository (hub) maintained at HQ
- Replicas (spokes) at factories worldwide for fast, reliable, local access
- Replicas synchronized with Streams
- Physical standby for protecting central repository

- $100,000 - $200,000/hr per site savings in downtime costs
- Fully bi-directional, automatic conflict detection and resolution
- Minimum subset of data replicated across WAN (about 1/3 out of 200 tables)
HA Sessions, Labs, Demos From Oracle Development

Mon, Sep 22
• 2:30 pm - Database 11g: Next-Gen HA, Moscone South 103

Tue, Sep 23
• 9:00 am - Active-Active Data Centers, Moscone South 103
• 11:30 am - Sharding with Oracle, Moscone South 302
• 11:30 am - HA with Oracle VM, Moscone West 3024
• 1:00 pm - Active Data Guard, Moscone South 104

Wed, Sep 24
• 9:00 am - Fusion Middleware Grid HA, Marriott Nob Hill AB
• 11:30 am - RMAN Best Practices, Moscone South 103
• 1:00 pm - Database in the Cloud, Moscone South 305
• 5:00 pm - Data Guard & Real Application Testing, Moscone 102

Wed, Sep 24 (contd.)
• 5:00 pm - EM in Secure MAA, Moscone West 2001
• 5:00 pm - E-Business Suite HA, Moscone West 2002/04

Thu, Sep 25
• 9:00 am - Oracle Secure Backup, Moscone South 102
• 10:30 am - Streams Replication, Moscone South 102
• 12:00 pm - Rolling Database Upgrades, Moscone South 103
• 1:30 pm - Streams Performance, Moscone South 102
• 3:00 pm - Oracle Grid Computing, Moscone South 303
• 3:00 pm - E-Business Suite R12 MAA, Moscone West 2007
• 3:00 pm - Siebel MAA, Moscone South 308
• 3:00 pm - Fusion SOA HA & Scalability, Marriott Salon 14/15

Hands On Labs - Thu, Sep 25
• 10:30 - 11:30 am, 12:00 - 1:00 pm - Active Data Guard, Marriott Golden Gate A3

DEMOgrounds, Mon-Thu
• Active Data Guard, Streams, Oracle Secure Backup, RMAN/Flashback, MAA
For More Information

search.oracle.com

or

oracle.com