Oracle Global Data Services (GDS)
Automated Workload Management for Replicated Databases

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March 15, 2017
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Program Agenda

1. Workload management challenges of replicas
2. Introduction to Global Data Services (GDS)
3. GDS concepts and architecture
4. GDS use cases
5. Summary
Challenges of Replicas – Workload Balance

- No automated load balancing
- Sub-optimal resource utilization

Unbalanced

Data Center 1
Primary

Data Center 2
Active Standby
Challenges of Replicas – Service Failover

No Global Service Failover

- App outages when replicas fail
- No Service HA
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Oracle Global Data Services (GDS)

- Automatic and transparent client workload management across replicas
- Extends the concept of services to replicas
- Capabilities
  - Workload routing based on load, locality or lag
  - Service failover across replicas
- Benefits
  - Maximize application performance
  - Mitigate downtime during planned and unplanned outages
  - Manage resources of replicas with one interface
Oracle Global Data Services (GDS)

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Global Service Failover with GDS

Data Center 1
Primary

GDS

Data Center 2
Active Standby

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Workload Management for Database Replicas with GDS

- Centralized service management
- Workload routing (region-based & lag-based)
- Inter-database service failover
- Role based global services
- Load balancing (connect-time & run-time)
Workload Balance – Maximize Application Performance

Unbalanced without GDS

Data Center 1
Primary

Data Center 2
Active Standby

Balanced with GDS

GDS

Data Center 1
Primary

Data Center 2
Active Standby
Global Service Failover – Maximize Application Availability

No Global Service Failover without GDS

Global Service Failover with GDS

Data Center 1
Primary

Data Center 2
Active Standby

GDS

Data Center 1
Primary

Data Center 2
Active Standby
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GDS Architecture

Data Center 1

Data Center 2

App/Mid-Tier

Global Data Services

Global Service Managers ➔ GDS Catalog ➔ GDS Catalog Standby

DB-Tier

Sales GDS Pool (order_entry_service) ➔ Active DataGuard or Oracle GoldenGate
One GDS Infrastructure For Many Replicated Configurations

Global Data Services

Global Service Managers | GDS Catalog | GDS Catalog Standby

App/Mid-Tier

Data Center 1

Data Center 2

Global Data Services

DB-Tier

Sales GDS Pool (order_entry_service)

Active DataGuard or Oracle GoldenGate

Oracle GoldenGate

HR GDS Pool (payroll_service)

...
GDS Components

- **Global Service Manager (GSM):**
  - Regional listener to the incoming database connections
  - Performs Connect-time load balancing
  - Publishes FAN events (via ONS) for service failovers and run-time load balancing advisory
  - Inter-database Service failover & management

- **GDS Catalog:** stores GDS configuration metadata

- **GDS Region:** Group of databases and clients in close network proximity, e.g., East, West

- **GDS Pool:** Databases that offer a common set of global services, e.g., HR, Sales

- **Global Service:** Database Service provided by multiple databases with replicated data
  - Local service + {Locality, replication lag, role, database cardinality, load balancing goals}
  - Establish workload management policies via Service attributes
# GDS – A shared infrastructure

**A Single GDS manages**

- 20 GDS Pools
- 10 GDS Regions
- 5 GSMs per Region
- 300 Database instances
- 1000 Global Services
- 1000 Mid-tier connection pools

**GDS Databases**

- Must be Oracle Database EE 12.1+
- Can be Single Instance or RAC
- Can be CDB or Non-CDB
- Can run on commodity or Engineered systems (Oracle Exadata, ODA)
- Managed with GDSCTL CLI or Enterprise Manager DB Plug-in
- Must be licensed for Active Data Guard or Oracle GoldenGate
GDS Deployment

High Level Steps

• Install GSM software on GSM servers
  – Min of 1 GSM per region
  – Recommended 3 GSMs/region

• Pre-create GDS catalog database

• Setup GDS Administrator accounts & privileges

• Configure GDS
  – Create GDS Catalog
  – Add GSMs, Regions, Pools, Databases, Global Services

• Setup client connectivity
GDS Deployment

Setup GDS Accounts & Privileges

• On the GDS Catalog database:
  SQL> create user mygdsadmin identified by passwd_mygdsadmin;
  SQL> grant gsmadmin_role to mygdsadmin;

  SQL> alter user gsmcatuser account unlock;
  SQL> alter user gsmcatuser identified by passwd_gsmcatuser;

• On each of the GDS Pool databases:
  SQL> alter user gsmuser account unlock;
  SQL> alter user gsmuser identified by passwd_gsmuser;
GDS Deployment

Configure GDS

• From a GSM node, use GDSCTL to configure GDS

  - `create catalog -database <host_name>:1521:catdb.acme.com -user mygdsadmin/ passwd_mygdsadmin -region siteA, siteB`
  - `add gsm -gsm gsml -listener 1571 -catalog <host_name>:1521:catdb -region siteA`
  - `start gsm -gsm gsml`

  ...
  - `add gdspool -gdspool sales`
  - `add database -connect <host_name>:1521:db01 -gdspool sales -region SiteA`
  - `add database -connect <host_name>:1521:db02 -gdspool sales -region SiteB`
  - `add service -service sales_qry_srvc -gdspool sales -preferred db01 -available db02`
  - `start service -service sales_qry_srvc -gdspool sales`
  - For Data Guard, use "add brokerconfig" instead of "add database"
Client Connectivity in GDS – TNS Entry

```
sales_reporting_srvc =
  (DESCRIPTION = (CONNECT_TIMEOUT=90) (RETRY_COUNT=30) (RETRY_DELAY=3) (TRANSPORT_CONNECT_TIMEOUT=3))
  (FAILOVER=ON)
  (ADDRESS_LIST =
    (LOAD_BALANCE=ON)
    (ADDRESS = (PROTOCOL = TCP) (HOST = gsm-host1a) (PORT = 1571))
    (ADDRESS = (PROTOCOL = TCP) (HOST = gsm-host2a) (PORT = 1571))
    (ADDRESS = (PROTOCOL = TCP) (HOST = gms-host3a) (PORT = 1571))
  )
  (ADDRESS_LIST =
    (LOAD_BALANCE=ON)
    (ADDRESS = (PROTOCOL = TCP) (HOST = gsm-host1b) (PORT = 1572))
    (ADDRESS = (PROTOCOL = TCP) (HOST = gsm-host2b) (PORT = 1572))
    (ADDRESS = (PROTOCOL = TCP) (HOST = gsm-host3b) (PORT = 1572))
  )
  (CONNECT_DATA =
    (SERVICE_NAME = sales_reporting_srvc.sales.oradbcloud) (REGION=WEST)
  )
```

← DatacenterA’s GSMs

← DatacenterB’s GSMs
GDS-Ready Application - Requirements

• Define the Global Services as per the application requirements

• Use Oracle Integrated Connection Pools/Drivers (OCI, JDBC, ODP.NET, WebLogic)
  – IBM WebSphere, Apache Tomcat, Red Hat JBoss are supported when using Oracle UCP
  – For UCP, include the ojdbc8.jar, ucp.jar and ons.jar in the CLASSPATH

• Connection URL (or TNS entry) must include:
  – GSM Listener end points
  – CONNECT_TIMEOUT, RETRY_COUNT, RETRY_DELAY, TRANSPORT_CONNECT_TIMEOUT parameters
  – SERVICE_NAME
  – For locality based routing, specify client’s REGION

• Use 12.2 clients (after GA) - Fast Connection Failover (FCF) is auto-enabled
  – For pre 12.2 clients, enable (FCF) via setFastConnectionFailoverEnabled = true

• Set planned draining period system property for graceful draining
  – For UCP –Doracle.ucp.PlannedDrainingPeriod=30
Supported GDS Clients for Load Balancing & Failover

• All clients
  – Connect-time Load Balancing (CLB) across databases
    • Choose the best DB instance to connect

• Oracle integrated connection pool based clients
  – Run-time load balancing (RLB)
    • Selecting a cached connection (belonging to least loaded database instance) for a work request
  – Gravitation
    • Redistribution of connections between instances
      – Instances that are able to process more database requests have more connections established to them
  – Proactive handling of instance UP and DOWN events
    • Remove dead connections from pool preventing application from using them
    • Proactively establish connections to a instance which was restarted

• Oracle clients use GDS's ONS to receive FAN events (CLB, RLB & Fast Connection Failover (FCF))
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Service Failover for Oracle GoldenGate Master-Replica

- Inter-database Service failover within and across regions
- Higher availability and improved manageability

```
GDSCTL>add service -service order_entry_service -gdspool sales
        -preferred DB01 -available DB02
```
Load Balancing for Reader Farms

- With GDS, route Read Write workload to primary/master
- Balance Read Only workload on the reader farm
- Improved resource utilization and higher scalability for Read workloads

GDS

Data Center 1
- Master (DB01)
  - Order Entry Service
- Replica (DB02)
  - Reporting Service

Data Center 2
- Replica (DB03)
  - Reporting Service
- Replica (DB04)
  - Reporting Service

Oracle GoldenGate or Active Data Guard Reading Farm

GDSCTL>add service -service reporting_srvc -gdspool sales
  -preferred_all -role PHYSICAL_STANDBY -clbgoal LONG -rlbgoal SERVICE_TIME
Load Balancing for Active/Active Oracle GoldenGate

- Application handles multi-master conflict resolution
- GDS provides connect-time and run-time load balancing (within and across data centers) for all work requests

```
GDSCTL>add service -service order_entry_srvc -gdspool sales -preferred_all -clbgoal LONG
```
Region Affinity in Active/Active Oracle GoldenGate

- Application handles multi-master conflict resolution
- GDS can route all workloads to nearest and best database in the client’s region

GDSCTL>add service -service order_entry_service -gdspool sales -preferred_all -locality LOCAL_ONLY -region_failover
Service Failover for Active Data Guard

- Inter-database Service failover within and across regions
- Higher availability and improved manageability

GDSCTL>add service -service reporting_service -gdspool sales -preferred_all -role PHYSICAL_STANDBY -failover_primary
Role based Global Services

For Active Data Guard

- Order Entry Service runs on Primary
- Reporting Service runs on Standby
Role based Global Services

For Active Data Guard

- Order Entry Service runs on Primary
- Reporting Service runs on Standby
- Upon Data Guard role change, GDS fails over services based on Role

GDSCTL>add service -service order_entry_service -gdspool sales -preferred_all -role PRIMARY
GDSCTL>add service -service reporting_service -gdspool sales -preferred_all -role PHYSICAL_STANDBY
Routing based on Replication Lag Tolerance

For Active Data Guard

- Specify replication lag limit for a service.
- GDS ensures that service runs on Active Data Guard standby(s) with lag less than this limit
- Improved data quality
Routing based on Replication Lag Tolerance

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Routing based on Replication Lag Tolerance
For Active Data Guard

- Specify replication lag limit for a service.
- GDS ensures that service runs on Active Data Guard standby(s) with lag less than this limit
- Improved data quality

GDS

Data Center 1

- Standby (DB02) Reporting Service
- Primary (DB01) Order Entry Service

GDSCTL>add service -service reporting_srvc -gdspool sales
-preferrred_all -role PHYSICAL_STANDBY -lag 180

Data Center 2

- Standby (DB03) Reporting Service

Active Data Guard

Lag > Threshold
# Mitigate Unplanned Outage with Oracle GDS

## Automatic Failover of Client Workload to another Datacenter

### Applications using...

<table>
<thead>
<tr>
<th>Oracle pools or drivers</th>
<th>UCP, ODP.NET, OCI, WebLogic Active GridLink</th>
</tr>
</thead>
<tbody>
<tr>
<td>3rd party App Servers using UCP</td>
<td>IBM WebSphere, Apache Tomcat</td>
</tr>
</tbody>
</table>

### Application config

- Subscribe to FAN events (published by GDS via ONS) by enabling Fast Connection Failover (FCF)
- TNS entry to include RETRY_COUNT, CONNECT_TIMEOUT and TRANSPORT_CONNECT_TIMEOUT

### Unplanned events

- For Oracle GoldenGate and Active Data Guard: Global Service failovers
- For Active Data Guard: Data Guard role change

### Sessions Drain

- FAN posts unplanned downtime event and FCF ensues.
- New work is redirected by GSM listeners immediately
- Idle sessions are released immediately
- Checked out connections receive invalid connection; Application closes the connection and gets new one from another database in the pool
# Zero-downtime Planned Maintenance with Oracle GDS

## Transparently move Client Workload to another Datacenter

<table>
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| Application config     | • Subscribe to FAN events (published by GDS via ONS) by enabling Fast Connection Failover (FCF) |
|                       | • TNS entry to include RETRY_COUNT, CONNECT_TIMEOUT and TRANSPORT_CONNECT_TIMEOUT |

| DBA Step during planned event | GDSCTL> relocate service -gdspool sales -service sales_global_srvc -old_db ogg1 -new_db ogg2 |

| Sessions Drain           | FAN posts planned downtime event (REASON: USER) and FCF drains sessions as work completes |
|                         | • New work is redirected by GSM listeners immediately |
|                         | • Idle sessions are released immediately |
|                         | • Active sessions are released when returned to pools |
Customer’s Perspective
“Global Data Services will help MorphoTrak improve systems utilization by dynamically load balancing application queries between replicated databases across distributed data centers. We had already eliminated the cost of idle capacity by deploying Oracle RAC and Active Data Guard, and Oracle Database 12c takes us to another level. It replaces static load balancing between data centers with intelligent, real-time automation that efficiently utilizes all available capacity yielding greater ROI.”

– Aris Prassinos, Chief Engineer, MorphoTrak, SAFRAN Group
Global Database Services

Oracle Global Data Services

Al Fischer
Manager IT – Database Services
GDS advantages

Leverage existing infrastructure resource utilization

- Primary database
- DR database
- Data Guard Broker
- Existing services
  - No application change except for TNS connectivity
  - Already separated for read-only and OLTP operations

Minimal set-up (DBA time)

- Quick deployment
- Adaptable for maintenance
- 2-3 hours after delivery of servers

UpTime

- Read only transactions can get another ‘9’ without major infrastructure changes
Oracle 12c Maximum Availability Architecture (MAA) at PayPal

Saibabu Devabhaktuni, Director of Data Platform
12c Availability – Global Data Services

- PayPal has 200+ of Active Data Guard instances, across multiple data centers, for fault tolerance and servicing our read-only workload
  - Over 50% of our workload can potentially be handled by Active Data Guard

- Today, we load balance the workload across our databases using locality, ad-hoc rules and custom application logic. Redirecting requests in response to failures is also done by custom application logic and TAF

- We plan to use Global Data Services to improve overall response time, provide greater resiliency, and improve manageability for our replicated databases
  - We were a Beta customer for Global Data Services and tested it within PayPal

- Global Data Services will allow us to achieve better service levels and greater efficiencies from our infrastructure
Oracle Database 12c MAA at PayPal

Oracle Database 12c Global Data Services
- Global service management and High Availability
- Global load balancing and routing

Primary Data Center
- Data Guard 12c FAST SYNC
- Mission-Critical Payment Processing Databases
- Active Data Guard Standby
  - Offload queries and reads
  - Automatic corruption repair
  - Offload read-mostly
- Offload read-mostly
- Offload real-time data mining

DR Data Center
- Active Data Guard 12c Real Time Cascade
- WAN, 650+ miles
- Active Data Guard Standby
  - Offload queries and reads
  - Automatic corruption repair
  - Offload read-mostly
  - Offload real-time data mining
- Data Guard Physical Standby
  - Supports DR
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# Database Workload Management for Oracle Replicas

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<th>Feature</th>
<th>Network Load Balancers</th>
<th>Oracle GDS</th>
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</thead>
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<tr>
<td>Locality based routing</td>
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<td>✅</td>
</tr>
<tr>
<td>Connect-time database load balancing</td>
<td>✅</td>
<td>✅</td>
</tr>
<tr>
<td>Publish routing and failover intelligence to clients</td>
<td></td>
<td>✅</td>
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<tr>
<td>Replication lag based database workload routing</td>
<td></td>
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<tr>
<td>Inter-database global Service failover</td>
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<td>✅</td>
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<tr>
<td>Automatic role based global Services</td>
<td></td>
<td>✅</td>
</tr>
<tr>
<td>Centralized management of database Services across replicas</td>
<td></td>
<td>✅</td>
</tr>
<tr>
<td>Native integration for Active Data Guard</td>
<td></td>
<td>Included with Active Data Guard or Oracle GoldenGate</td>
</tr>
<tr>
<td>Cost Effectiveness</td>
<td>Additional $$$</td>
<td></td>
</tr>
</tbody>
</table>
Oracle Maximum Availability Architecture (MAA)

**Production Site**

- RAC
  - Scalability
  - Server HA
- ASM
  - Local storage protection
- Flashback
  - Human error correction

**Global Data Services**
- Service Failover / Load Balancing
- Application Continuity
  - Application HA
- Enterprise Manager Cloud Control
  - Site Guard, Coordinated Site Failover

**Active Replica**

- Active Data Guard
  - Data Protection, DR
  - Query Offload
- GoldenGate
  - Active-active replication
  - Heterogeneous

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

**Recovery Appliance,**
**RMAN,**
**Oracle Secure Backup,**
- Backup to disk, tape or cloud
Summary

• GDS provides workload routing, load balancing, service failover & management for replicated databases

• Key benefits
  – Applications use GDS to maximize performance and availability
  – Mitigate downtime during planned and unplanned outages
  – Better resource utilization of replicas
Additional Resources

**Oracle** Maximum Availability Architecture

[www.oracle.com/goto/maa](http://www.oracle.com/goto/maa)

Social Media Links:

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[www.oracle.com/goto/gds](http://www.oracle.com/goto/gds)
Backup Slides
Global Service Attributes – Service Placement

• Preferred
  – Databases designated to provide the Global Service

• Available
  – Databases that provide Global Service if not enough Preferred databases are running
  – If one of the preferred databases fails, then GSM maintains the cardinality of the Global service by starting the service on an Available database

• Preferred_All
  – All databases in a GDS Pool are preferred for the Global Service

• Options for Add Service:
  • \{-preferred_all | -preferred dbname_list [-available dbname_list] \}
  – GDSCTL>add service -service sales_qry_srvc -gdspool sales -preferred sfo -available bos
  – GDSCTL>add service -service sales_reporting_srvc -gdspool sales -preferred_all
Global Service Attributes – Service Placement (cont’d)

• **Role** based Global Service
  – Service should be active only when the database is either a primary or standby
  – Can be started on a database if its role matches global service’s role attribute
  – Options for **Add Service**:
    • `[-role {PRIMARY | PHYSICAL_STANDBY [-failover_primary] | LOGICAL_STANDBY | SNAPSHOT_STANDBY}]`
    
    GDSCTL>add service -gdspool sales -service sales_reporting_srvc -preferred_all -role physical_standby

• **Lag** Tolerance
  – Establish application’s tolerance for non-current data
  – Specify the lag limit for the Global Service in seconds
  – Options for **Add or Modify Service**:
    • `-lag {lag_value | ANY}`
    
    GDSCTL>add service -service sales_reader_lag180_srvc -gdspool sales -preferred_all -role physical_standby -lag 180
Global Service Attributes - Locality Based Routing

• Achieve geographical affinity between clients and databases

• Options for Add or Modify Service
  – [-locality {ANYWHERE | LOCAL_ONLY [-region_failover]}]

• Locality ANYWHERE
  – Client connections and work requests are routed to any region for load balancing or failover
  – GDSCTL>add service -service sales_reader_srvc -gdspool sales -preferred_all -locality ANYWHERE

• Locality LOCAL_ONLY
  – Regardless of load, GDS will not route to databases in other regions
  – GDSCTL>add service -service sales_reader_srvc -gdspool sales -preferred_all -locality LOCAL_ONLY

• Locality LOCAL_ONLY –region_failover
  – Client connections and work requests are routed to another region when all databases in a region have failed
  – GDSCTL>add service -service sales_reader_srvc -gdspool sales -preferred_all -locality LOCAL_ONLY -region_failover
Global Service Attributes – Load Balancing

Connect-time Load Balancing (CLB)

• GDS support CLB for all clients
  – Directs connection requests to the best database instance in GDS pool
  – Takes into account
    • Load statistics from all GDS pool databases
    • Inter-region network latency, locality and CLB goal
  – Options for Add Service :
    • [-clbgoal {SHORT | LONG}]
    • GDSCTL>add service -service sales_clb_srvc -gdspool sales – preferred_all -clbgoal LONG

Run-time Load Balancing (RLB)

• GDS supports RLB feature of connection pools for OCI, JDBC/UCP, ODP.NET, WLS
  – Publishes RLB Advisory to clients
  – Based on advisory, clients distribute workload requests across persistent connections spanning GDS Pool database instances
  – Takes into account
    • Per-service performance data from pool databases
    • Inter-region network latency, locality and RLB goal
  – Options for Add Service :
    • [-rlbgoal {SERVICE_TIME | THROUGHPUT}]
    • GDSCTL>add service -service sales_rlb_srvc -gdspool sales – preferred_all -rlbgoal SERVICE_TIME
Run-time Load Balancing with GDS
Standalone Identical Database Servers with External Load

Routing responds gracefully to changing system conditions
Run-time Load Balancing with GDS

Standalone Asymmetrical Database Servers

DB b: 4 CPUs

DB c: 3 CPUs

DB d: 2 CPUs

GDS does intelligent load balancing even across asymmetrical database servers
Integrated Cloud
Applications & Platform Services