Distributed System

Oracle GoldenGate

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- http://www.ildba.co.il/author/cimid/
- http://www.sqlserver.co.il/?cat=940
- 3rd Israeli Conference on Software Architecture
- Global Hebrew Virtual PASS Chapter:
  - https://www.youtube.com/watch?v=x4hGj
  - https://www.youtube.com/watch?v=eJO8G
- Sqlsaturday Israel 2016:
- Sqlsaturday Israel 2017:
- Sqlsaturday Israel 2018
- Course 236510: Technion - Israel Institute of Technology
Reference

Oracle GoldenGate 12c Implementer's Guide

Leverage the power of real-time data access for designing, building, and tuning your GoldenGate Enterprise

Best Site: http://gavinsoorma.com

Oracle GoldenGate Documentation
Introduction to OGG 12C

- What is OGG.
- Competitor to OGG
- Oracle GG solutions
- Use cases
- OGG Overview
- How Oracle GoldenGate Works
- OGG Solutions (Logical)
- DG or Replication?
- OGG Process Flow
- OGG architecture
- Design Issues
- OGG Prerequisites: Primary Key
- Table Mapping, Data selection & filtering
- Initial data synchronization
- OGG CSN (Commit Sequence Number).
What is OGG?

- Fast, robust, real-time based replication & data integration solution between operational and analytical systems.
- Implements a uniform format to perform data replication
- OGG captures, filters, routes, verifies, transforms, and delivers transactional data across Oracle & heterogeneous environments
- Transaction integrity between source and target systems (read consistency, referential integrity)
- Oracle no longer supports Streams but several key features immigrated to GG 12C.
- Oracle no longer supports Advanced Replication.
OGG and Data Integration: Over 10K Customers Worldwide.

Competitors: Mainly storage replication solutions with point-in-time data restoration. Examples:

- Attunity
- NetApp Snapmirror
- Dell SharePlex
- Microsoft Sync Framework
- EMC SRDF & EMC RecoverPoint
- IBM InfoSphere data replication
- Hitachi TrueCopy
- Symantec Volume Replicator & File Replicator
# Competitor to OGG

<table>
<thead>
<tr>
<th>Replication Feature</th>
<th>Oracle GoldenGate</th>
<th>MySQL Native</th>
<th>Dell Shareplex</th>
</tr>
</thead>
<tbody>
<tr>
<td>Master to Master</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
<tr>
<td>Multi-source Master</td>
<td>✓</td>
<td>MySQL 5.7</td>
<td>✓</td>
</tr>
<tr>
<td>Confliction Resolution</td>
<td>Custom SQL code or parameter</td>
<td>No</td>
<td>Custom SQL code</td>
</tr>
<tr>
<td>Heterogeneous</td>
<td>Many DB platforms</td>
<td>No</td>
<td>Oracle or SQL Server</td>
</tr>
<tr>
<td>Point of Replication</td>
<td>After commit</td>
<td>After commit</td>
<td>Before commit</td>
</tr>
<tr>
<td>Data Synchronization</td>
<td>Veridata</td>
<td>3rd party or custom solution</td>
<td>Built-in</td>
</tr>
<tr>
<td>Backward Compatibility</td>
<td>✓</td>
<td>Limited</td>
<td>✓</td>
</tr>
<tr>
<td>Oracle Integration</td>
<td>✓</td>
<td>✓</td>
<td>✓</td>
</tr>
</tbody>
</table>
OGG Solutions

1. Business Continuity
   • Active-Active for Maximum Availability and transactional load distribution between two or more active systems
   • Hot-standby database for failover purposes.
   • Zero downtime upgrades & migrations.

2. Operational BI:
   • Real-time data integration to operational data stores or data warehouses directly or via Extract, Load, and Transform (E-LT) tools
   • Integration support with Oracle Data Integrator that leverages E-LT processes for OLAP and Data Warehouse implementations
   • Replication to data warehouses that eliminates batch or Extract, Load, and Transform processes

3. Reporting or query-offloading purposes BI users or tools (One-Way Replication).
OGG Solutions

4. Transactional Data Integration:
   • Real-time data feeds to messaging systems for business activity & process monitoring and complex event processing
   • OGG can integrate with JMS-based messaging systems to enable Event-Driven Architecture (EDA) and to support Service Oriented Architecture (SOA).

5. Big Data
   • Real-time data consolidation into Big Data targets.
   • Interfaces with standard software components to access to semi-structured data

6. Cloud and On-Premises:
   • Real-time bidirectional data feeds between On-Premises and public Clouds that are both secure and reliable.
Oracle GoldenGate Modular Architecture

High Performance
Low Impact and Non-Intrusive
Flexible and Heterogeneous
Resilient and FIPS Secure
Big Data and Cloud Ready
Use cases

GoldenGate

- Public Cloud
- On Premise
- Legacy

Data Availability
- High Availability
- Zero Downtime, Upgrades and Migrations

Live Reporting
- New DB/OS/HW
- Reporting DB

Business Intelligence
- ODI
- EDW

Service Oriented Architecture
- Message Bus
- SOA

Big Data Targets

Oracle

- Fully Active Distributed DB
- New DB/HW/OS/APP
- Global Data Centers
- Big Data, DW & Marts
- Application Offloading
- Message Bus & Data Grid
- Data Streaming

MySQL

- Real-time BI, Hadoop Data Staging, Data Ingestion
- Query & Report Offloading
- Event Driven Architecture, SOA/JMS, Coherence
- Real-time Analytics & Massive Parallelization

IBM

- OGG for Big Data (v12.2.x)

OGG Replicat for Java

OGG-AA Module

Java Big Data module

Trail Files

kafka

Jini

Targets
OGG Flexible Deployment Model

- Operational Reporting
- Migrations, Continuous Availability
- Load Balancing
- Information Hubs
- Real-time Data Warehousing
- Streaming Analytics
- Event Processing
OGG Flexible Cloud Deployment Model

- Operational Reporting
- Test/Dev
- Real-time Data Warehousing

- Disaster Recovery
- Zero Downtime Migration*
- Information Hubs

- Zero Downtime Migration*
- Load Balancing
- Geo Distribution
- Database Consolidation
- High Availability

- On-Premises to Cloud
- Cloud to On-Premises
- Cloud to Cloud
OGG Overview

• Building blocks: capture process, trail files, data pump, server collector, and apply processes
• Manager process runs on both source and target systems.
• All individual processes are modular: can be easily decoupled or combined for best solution.
• We can configure multiple captures and apply processes to balance the load and enhance the performance.
• Filtering and transformation of data at source by capture process or target by the apply process with parameter files.

GGSCI - GG Software Command Interpreter

• OGG 12c is command-line-driven.
• Provides admins with rich set of commands to create, configure, and monitor all OGG processes
Extract - capture process

- The Extract, also know as Capture, is the Change Data Capture component for GoldenGate
- Extract is DBMS/OS specific: i.e.-an Oracle Extract will not Capture from DB2
- From GG 11gR2, can be configured in three different modes:
  1. **Classic capture**: Get committed transactions from the DB transaction logs
  2. **Integrated capture**
  3. **Downstream integrated capture**
- Extract for other non-Oracle databases is Classic Extract
- Non-Oracle Extracts read from logs or VAM depending on the Source
- Regularly checkpoint it's read and write position to the trail file to ensure GG can recover its processes without data loss in the case of failure.
- statuses:
  1. **STOPPED**
  2. **STARTING**
  3. **RUNNING**
Trail File

- GG converts the captured data into a canonical format written to trail files both on source and target.
- Canonical record of captured GoldenGate DML and DDL (for Oracle DB).
- Extracts and Pumps produce Trail Files.
- 2 alphanumeric character prefix and 9 sequence numbers –GG123456789
- No single point of failure.
- Can be encrypted and compressed.
- Checkpoint process keeps track of the data being written to the trails on both, the source and target for fault tolerance.
- Extract process can send data across a TCP/IP directly from DB redo logs to target server data collector.
  - Not recommended because of possible data loss in case of system failure or network problems.
Data pump

- Additional Extract process that sends data in large blocks across a TCP/IP network to the target system.
- Configured with target host TCP/IP connection and target trail file path/prefix

Server Collector

- Runs on the target system and accepts data from the source (Extract/data pump).
- Reassemble the data and write it to a OGG trail file (remote trail)
- Decryption of received data when configured.
Replicat - the apply process

- Final step in the data delivery: Reads trail file and applies it to the target DBMS/Big Data systems as DML and/or DDL.

- Can be parallel or performed later.

- Regularly checkpoint its read and write position (usually DB table) to ensure OGG recovers its processes without data loss in case of failure.

- Statuses:
  1. STOPPED
  2. STARTING
  3. RUNNING
  4. ABENDED

- DDL is only supported in unidirectional replication and non-heterogeneous (Oracle to Oracle) environments.

- 3 Modes of Replicat: Integrated, Coordinate, Classic
Manager Process

- Always exist in any OGG Instance. Runs on both source and target systems.
- Manager (and all OGG processes) are configured from a Parameter file.
- Minimum parameter for Manager:
  - PORT 7809<<TCP/IP port
- Can have multiple installations of OGG on a system.
- Control activities like starting, stopping, monitoring, and restarting processes; allocating data storage; and reporting errors and events.
- Statuses:
  1. STOPPED
  2. RUNNING
- Runs on the target system and accepts data from the source (Extract/data pump).
- Reassemble the data and write it to a OGG trail file, (remote trail).
- Decryption of received data when configured.
OGG Process Flow

1. Rule: Related Objects (Like FK relationships) and related DDL and DDL should be together in the same process group to ensure data integrity
OGG Process flow: Data delivery with a data pump

<table>
<thead>
<tr>
<th>Start component</th>
<th>End component</th>
</tr>
</thead>
<tbody>
<tr>
<td>Extract process</td>
<td>Local trail file</td>
</tr>
<tr>
<td>Local trail file</td>
<td>Data pump</td>
</tr>
<tr>
<td>Data pump</td>
<td>Server collector</td>
</tr>
<tr>
<td>Server collector</td>
<td>Remote trail file</td>
</tr>
<tr>
<td>Remote trail file</td>
<td>Replicat process</td>
</tr>
</tbody>
</table>

Source Database

Source Server

Manager

Extract

Data Pump

Remote Trail

Server Collector

Target Database

Target Server

Manager

Replicat

Remote Trail

CKPT

Local Trail

CKPT
OGG Process flow: Data delivery without data pump

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<tr>
<td>Server collector</td>
<td>Remote trail file</td>
</tr>
<tr>
<td>Remote trail file</td>
<td>Replicat process</td>
</tr>
</tbody>
</table>
Real Time Data movement with OGG
**How Oracle GoldenGate Works**

- **Capture**: Committed transactions are captured (and can be filtered) by reading the transaction logs.
- **Trail**: Stages and queues data for routing.
- **Pump**: Distributes data for routing to target(s).
- **Route**: Data is compressed, encrypted for routing to target(s).
- **Delivery**: Applies data with transaction integrity, transforming the data as required.

The process involves a source Oracle & Non-Oracle Database(s) that captures transactions, which then go through the Trail, Pump, Route, and Delivery stages. The data is transmitted over LAN/WAN/Internet over TCP/IP to the target Oracle & Non-Oracle Database(s).
How Oracle GoldenGate Works

Capture: committed transactions are captured (and can be filtered) by reading the transaction logs.

Trail: stages and queues data for routing.

Pump: distributes data for routing to target(s).

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

Delivery: applies data with transaction integrity, transforming the data as required.

Source Oracle & Non-Oracle Database(s)

Capture ➔ Trail Files ➔ Pump ➔ Trail Files ➔ Delivery ➔ Target Oracle & Non-Oracle Database(s)

Bi-directional
How Oracle GoldenGate Works: Checkpoint

Checkpointing
Capture, Pump, and Delivery save positions to a checkpoint file so they can recover in case of failure.

1. Begin, TX 1
2. Insert, TX 1
3. Begin, TX 2
4. Update, TX 1
5. Insert, TX 2
6. Commit, TX 2
7. Begin, TX 3
8. Insert, TX 3
9. Commit, TX 3
10. Begin, TX 4
11. Commit, TX 4
12. Delete, TX 4

Start of Oldest Open (Uncommitted) Transaction

Capture Checkpoint

Current Read Position
Current Write Position

Pump Checkpoint
Pump

Commit Ordered Source Trail
Commit Ordered Target Trail

Delivery Checkpoint
Delivery

Source Database
Target Database
OGG Solutions (Logical)

Unidirectional
Zero downtime migrations
Query Off-loading/Reporting
Application integration

Active-Active (Bidirectional)
High Availability
Active Meshes with CDR

Hub & Spoke
Centralized sharing
Data distribution

Consolidation
Data Warehouse
Single Source of Truth
Mergers & Acquisitions

Distribution
Data dissemination
Cascade replication
1. One-to-one (source to target)
2. One-to-many (one source to many targets)
3. Many-to-one
4. Cascading
5. Bidirectional (active active)
6. Bidirectional (active passive)
7. Reporting Configuration with a Data Pump on an Intermediary System
8. peer-to-peer Configurations
9. Hub & Spoke Configurations
OGG Solutions (Logical)

**Unidirectional**
Zero downtime migrations
Query Offloading/Reporting
Application integration

**Active-Active (Bidirectional)**
High Availability
Active Meshes with CDR

**Hub & Spoke**
Centralized sharing
Data distribution

**Consolidation**
Data Warehouse
Single Source of Truth
Mergers & Acquisitions

**Distribution**
Data dissemination
Cascade replication
One-to-one architecture

• key benefits:
  ✓ Live reporting
  ✓ Fastest possible recovery and switchover (when the target is synchronized with the source)
  ✓ Backup site that can be used for reporting
  ✓ Supports DDL replication
One-to-Many architecture

Data Distribution Configuration

- key benefits:
  - Dedicated site for live reporting.
  - Dedicated site to backup data from the source database.
  - Offers the fastest possible recovery and switchover when using a dedicated backup site. It minimizes logical data corruption, as the backup database is separate from the read-write OLAP database.
Many-to-One architecture

Data Warehousing Configuration

- key benefits:
  ✓ Consolidation-scenario is common in all industries

Important Points:
Conflict Handling
Data needs to be available on the central database and cannot become lost or corrupted.
Cascading Reporting Configuration

- data replication at \( n \) sites originating from a single source
- Loop detection
Active-Active Configuration

- key benefits:
  - ✓ High availability
  - ✓ Transaction load distribution
  - ✓ Performance and scalability
Reporting Configuration with a Data Pump on an Intermediary System

- key point:
  - ✓ source and target systems are in different networks and there is no direct connection between them (Cloud and on premise).
  - ✓ Form of cascaded replication.
  - ✓ Performing data filtering and conversion if the character sets on all systems are identical. If character sets differ configure Replicat to perform the conversion and transformation on the target.
peer-to-peer Configurations

- One extract capture process at each DB site.
- \(<n-1>\) extract pump processes that points to the other DB.
- \(<n-1>\) Replicat processes at each DB site that applies the DML-changes from each of the other \(<n-1>\) sites
Hub & Spoke Configurations

- DML changes from the hub itself will be routed to all spokes.

- DML changes from a spoke will be routed and applied at the hub and forwarded to all other spokes except of the spoke, where the DML change was originally initiated using (tag functionality).

- DML changes are bi-directionally replicated.

- It works with the classic integrated Extract and not with integrated Extract (tag functionality)- In our labs
**peer-to-peer Configurations**

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- \(<n-1>\) extract pump processes that points to the other DB.
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It works with the classic integrated Extract and not with integrated Extract.
## Configuration Comparison

<table>
<thead>
<tr>
<th></th>
<th>Peer-to-Peer</th>
<th>Hub &amp; Spoke</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Creating Environment</strong></td>
<td>$O(n^2)$</td>
<td>$O(2n)$</td>
</tr>
<tr>
<td><strong>Adding Node</strong></td>
<td>$O(2*n)$</td>
<td>$O(2)$</td>
</tr>
<tr>
<td><strong>Point of failure</strong></td>
<td>No single point</td>
<td>Hub must be highly available. This is a single point of failure. Combination of RAC &amp; Data Guard or a &quot;Double Hub &amp; Spoke&quot;</td>
</tr>
<tr>
<td><strong>No. of Processes</strong></td>
<td>Every sides has many processes</td>
<td>At spokes : 3 processes At Hub : 1 Extract, n Pumps, n Replicate Processes $O(2n+1)$</td>
</tr>
</tbody>
</table>
Hub & Spoke
Chained Hub & Spoke
Double Hub & Spoke
Design Issues

• Configuration Comparison

• Good schema design.
  • Example: complex cascading referential constraints -> impossible to divide tables for extract, OGG to spent more CPU time on processing.

• What to replicate? If you need to replicate everything, ADG may be a better solution.

• Network: Maximum accepted latency
OGG Prerequisites: Primary Key

• Ensure each source and target table has a primary key
  ✓ If PK does not exist on source table, OGG will unique
    identifier by concatenating all the table columns together ->
    not efficient
  ✓ If the primary key does not exist on the target table, you may
    receive in OGG error log:

    WARNING OGG-00869 No unique key is defined for table
    'TARGET_TABLE_NAME'. All viable columns will be used to
    represent the key, but may not guarantee uniqueness. KEYCOLS
    may be used to define the key.

• Recommended to put PK on target tables - very important to
  UPDATE and DELETE operations.
Table Mapping, Data selection & filtering

- **TABLE/MAP**
  - Specifies source and target objects to replicate. Used in Extract and MAP in Replicat parameter files.

- **WHERE**
  - Enables basic data filtering in TABLE or MAP parameter (like in SQL)

- **FILTER**
  - Complex data filtering. Used a TABLE or MAP parameter.

- **COLS/COLSEXCEPT**
  - Allows columns to be mapped or excluded with a TABLE or MAP parameter.
Initial data synchronization

• **Data synchronization between source and target - the load is being applied users can update the source**: 
  1. A database load utility such as import/export or Oracle data pump.
  2. An Extract process to write data to files in ASCII format. Replicat then applies the files to the target tables.
  3. An Extract process to write data to files in ASCII format. SQL*Loader (direct load) can be used to load the data into the target tables.
  4. An Extract process that communicates directly with the Replicat process across a TCP/IP network without using a collector process or files.

• **If data synchronization is not required then best practice are**: 
  ✓ Data: Target table should be empty to avoid errors (Empty schema).
  ✓ Constraints: Disable foreign key constraints and check constraints which sloa loading process. Enable them after load completes.
  ✓ Indexes: Remove indexes from the target tables (apart from primary keys). Recreate indexes after the load completes.
OGG CSN (Commit Sequence Number).

- Oracle DB uses **System Change Number (SCN)** to keep track of transactions.
  - Every commit, a new SCN is generated. The data changes, including primary key and SCN, are written to DB online redo logs for crash recovery (committed transactions are committed, uncommitted transactions are rolled back).

- OGG read extract data and SCN as a series of bytes.

- Replicat process replays data in SCN order while applying data changes to the target database.

- In OGG docs SCN is called **CSN**.
Conflict Detection and Resolution (CDR)

- In earlier versions CDR was not readily available out of the box—we have to programmatically resolve any data conflict in the replication process.

- In OGG 12c version, the feature has emerged from Oracle streams as an easily configurable option through Extract and Replicat parameters.
OGG Capture Configuration Option

Capture = Extract
Integrated Capture
Integrated Extract

- Classic Capture
  - Redo Logs + Archive Logs
  - Archive Logs Only

- Integrated Capture
  - Upstream Capture
  - Downstream Capture
Downstream capture

- Integrated Extract runs on different database – typically on different machines.

- A **real-time downstream capture** process Uses Oracle Data Guard's log transportation mechanism, which writes changed data to standby redo logs.

- Real-time mine configuration that falls back to archive log mining when the apply process cannot keep up.

- Real-time mine process is re-enabled automatically when the data throughput decreases.
Downstream capture

- Real Time Downstream Mode
**Downstream capture**

- Downstream Archive log Mode

![Diagram of downstream capture process]

- Primary Database (Source Server) sends Online Redo Logs to Standby Database (Downstream Server).
- The Standby Database processes the Archive Redo Logs and Logical Change Records to create Integrated Extract.
- The Integrated Extract is further processed to create the Trail File.
Parameter Files:

- In Spoke you have 4 parameter files: mgr, extract, data-pump, replicate. In hub (2n+1).
- Basic parameters used to configure setups.
MACRO FILES

- Reusable files that can be used within parameter files.
- Designed to reduce errors and simplify manageability of environment.
- Macro for exception table for each schema to record replication conflicts.
OBELY FILES

- Minimizes typing and increases the successful run of commonly used commands for anything in Oracle GoldenGate.
- Are used to build replication, add node, delete node and delete replication by developers.

---

--- Adds Extract process
ADD EXTRACT ESRC1, TRANLOG, BEGIN NOW

--- Adds local trail file
ADD EXTRAIL ./dirdat/lt, EXTRACT ESRC1, megabytes 50

--- Adds Data Pump Process
ADD EXTRACT PSRC1, EXTRAILSOURCE ./dirdat/lt

--- Adds remote trail file
ADD RMTRAIL ./dirdat/rt, EXTRACT PSRC1, megabytes 50

| dblogin userid ggate password ggate |
| delete extract esrc1                |
| dblogin userid ggate password ggate |
| delete extract ext_hb               |
| dblogin userid c##ggate password ggate |
| delete extract pmp                   |
| dblogin userid c##ggate password ggate |
| delete extract pmp_hb                |

---

Quick connect...

/u01/app/oracle/product/golden_gate/dobby/

<table>
<thead>
<tr>
<th>Name</th>
<th>Size (KB)</th>
<th>Last modified</th>
<th>Owner</th>
</tr>
</thead>
<tbody>
<tr>
<td>__setup_spoke2_25_5_15.oby</td>
<td>3</td>
<td>2014-09-18 09:37:02</td>
<td>oracle</td>
</tr>
<tr>
<td>clean_hub_spoke.oby</td>
<td>1</td>
<td>2014-09-18 09:32:30</td>
<td>oracle</td>
</tr>
<tr>
<td>setup_spoke2.oby</td>
<td>4</td>
<td>2015-11-11 14:24:34</td>
<td>oracle</td>
</tr>
<tr>
<td>setup_spoke2_11_11_15.oby</td>
<td>3</td>
<td>2015-11-11 12:51:03</td>
<td>oracle</td>
</tr>
</tbody>
</table>
SECURITY

- Security is important at every level of Oracle GoldenGate.
- Options:
  - Password Security: Credential Store
  - Command Security
  - Trail File Encryption
PASSWORD SECURITY

GGSCI > ALTER CREDENTIALSTORE ADD USER OGG_ADMIN
ALIAS OGG_ADMIN

Password:

Credential store in ./dircrd/ altered.

GGSCI > DBLOGIN USERID ALIAS OGG_ADMIN

Successfully logged into database.
COMMAND SECURITY

- CMDSEC - File used to control access to GoldenGate functions

- command_name  command_object  OS_group  OS_user  { YES | NO }

```
STATUS REPLICAT * Curtis NO
START REPLICAT root * YES
* * * * * NO
```
**TRAIL FILE ENCRYPTION**

- ENCRYPTTRAIL - controls whether GoldenGate encrypts data written to the trail file.

ENCRYPTTRAIL {AES128 | AES192 | AES256}

- Example Extract process:
  - Master key and wallet method is used.
  - 2 trails encrypted with AES-192 and the other is not encrypted

ENCRYPTTRAIL AES192
RMTTRAIL /home/ggsora/dirdat/em
TABLE hr.emp;
NOENCRYPTTRAIL
RMTTRAIL /home/ggsora/dirdat/st
TABLE ops.stores;
OGG MONITORING

OEM 12c Plugin
- Fits into Enterprise monitoring policies
- Issues with installation and Jagent

GoldenGate Monitor
- Great user interface
- Displays historical data

GoldenGate Studio
- Design and deploy

Crontab Scripts
- Highly customizable
- Decentralized
• Each requires additional license:
  - Oracle Enterprise Manager 12c Plug-In
  - OGG Monitor

Oracle Enterprise Manager 12c Plug-In
• The OGG Plug for OEM 12c Cloud Control: allowing starting, stopping, monitoring, and alerting of GoldenGate processes.
• Create user defined metric in OEM 12c Cloud Control that provides the necessary monitoring and alerting without the additional license cost.
OGG MONITOR

- Standalone product dedicated to managing, monitoring, and alerting on OOG components
- Should replace the aging OGG Director product
- Graphically provides a real-time view of your OGG Enterprise, allowing control over Extract and Replicat processes as well as the ability to edit parameter files.