Oracle GoldenGate: Architecture for Real-Time Replication

Fred Louis
Oracle Enterprise Architect
Ohio Valley Region
Agenda

- Introduction to Oracle GoldenGate
- Technology Overview
- Architecture Deep Dive: Differentiators
  - Component Architecture
  - Performance & Scalability
  - Transaction Integrity & Reliability
  - Heterogeneity
- Other Key Features
  - Instantiation
  - SQL Interface
  - Event Marker Infrastructure
  - ETL Integration
GoldenGate: A Strategic Acquisition

Best-in-class leader in real-time data movement

- Complements existing Oracle products
  - Data replication for heterogeneous databases
  - Real-time information feeds to Oracle BI/EPM
  - Zero-downtime migrations and upgrades to Oracle Database and Applications

- Over 400 customers with 4,000+ implementations across Fortune 500 companies:
  - Top 3 of 5 largest commercial banks
  - Top 7 of 10 financial data services companies
  - Top 4 of 5 telecommunications providers
  - Top 3 of 5 largest food & drug stores
Oracle GoldenGate Technology Differentiators

**Oracle GoldenGate provides low-impact capture, routing, transformation, and delivery of transactional data across heterogeneous environments in real time**

Key Differentiators:

- **Performance**
  - Non-intrusive, low-impact, sub-second latency

- **Extensible & Flexible**
  - Open, modular architecture - Supports heterogeneous sources and targets

- **Reliable**
  - Maintains transactional integrity - Resilient against interruptions and failures
Oracle GoldenGate Solutions
Enterprise-wide Solution for Real Time Data Needs

- Standardize on Single Technology for Multiple Requirements
- Deploy for Continuous Availability and Real-time Data Access for Reporting / BI
- Highly Flexible
- Fast Deployments
- Lower TCO & Improved ROI
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Oracle GoldenGate
Simple, Flexible Instantiation

1. Start CDC
2. Initial Snapshot
3. Synchronization
**Capture:** Committed changes are captured (and can be filtered) as they occur by reading the transaction logs.

**Trail files:** Universal data format enables heterogeneity.
How GoldenGate Works: Modular “Building Blocks”

**Capture:** Committed changes are captured (and can be filtered) as they occur by reading the transaction logs.

**Trail files:** Universal data format enables heterogeneity.

**Route:** No distance constraints via TCP/IP. Compression & encryption.

**Delivery:** Applies transactional data with guaranteed integrity.

Source Database

Source Trail

LAN / WAN / Internet

Target Trail

Deliver

Target Database
**How GoldenGate Works: Modular “Building Blocks”**

**Capture:** Committed changes are captured (and can be filtered) as they occur by reading the transaction logs.

**Trail files:** Universal data format enables heterogeneity.

**Route:** No distance constraints via TCP/IP. Compression & encryption.

**Delivery:** Applies transactional data with guaranteed integrity.

**Bi-directional**
Oracle GoldenGate Heterogeneity supports applications running on...

<table>
<thead>
<tr>
<th>Databases</th>
<th>O/S and Platforms</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Capture:</strong></td>
<td>Windows 2000, 2003, XP</td>
</tr>
<tr>
<td>- Oracle</td>
<td>Linux</td>
</tr>
<tr>
<td>- DB2</td>
<td>Sun Solaris</td>
</tr>
<tr>
<td>- Microsoft SQL Server</td>
<td>HP NonStop</td>
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<tr>
<td>- Sybase ASE</td>
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<td>- Teradata</td>
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<td>- Enscribe</td>
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<tr>
<td>- SQL/MP</td>
<td>IBM AIX</td>
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<tr>
<td>- SQL/MX</td>
<td>IBM z/OS</td>
</tr>
<tr>
<td><strong>Delivery:</strong></td>
<td></td>
</tr>
<tr>
<td>- All listed above, plus:</td>
<td></td>
</tr>
<tr>
<td>- MySQL, TimesTen, Netezza, Greenplum, HP Neoview and any ODBC compatible databases</td>
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<td></td>
<td>ETL products</td>
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<td></td>
<td>JMS message queues</td>
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</tbody>
</table>
Oracle GoldenGate Topologies

Unidirectional
Query Offloading

Bi-Directional
Live Standby or
Active-Active for HA

Peer-to-Peer
Load Balancing,
Multi-Master

Broadcast
Data Distribution

Integration/Consolidation
Data Warehouse

Cascading
Data Marts
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  - ETL Integration
Architecture Components (Processes)

**CAPTURE**
- Log-based
- VAM-based
- Local/Remote Queuing
- Filtering
- Parallel Coordination
- Local/Remote*

**DELIVERY**
- Native database API
- ODBC
- Batched Operations
- Filtering
- Transaction/Operations Grouping
- Parallel Coordination
- Local/Remote*

**PUMP**
- Filtering
- Local/Remote
- TCP/IP
- Compression
- Encryption

**MANAGER**
- Queue (Trail) Management
- Process Management (Dynamic)
- Monitoring and Administration (Lag reports)
- Reporting (Events, Errors, Thresholds)
- Receive/Route requests from UI

**On-disk Components**
- Trail Files
- Checkpoint Files (Capture, Pump, Delivery)
- Data Definition Files (SOURCEDEFS/TARGETDEFS)
- Configuration Files
- Discard Files
- Report/Log Files
- Binaries
Oracle GoldenGate Components

Communications and Startup

**Source**
- Source Database
- Capture
- Source Trail
- Pump

**Target**
- Collector
- Target Trail
- Delivery
- Target Database

**Network**
- TCP/IP
- Process Start
- Shared Memory (for Monitoring)
Oracle GoldenGate Components

Communications and Startup

Source

- Source Database
- Capture
- Source Trail
- Pump

Target

- Target Database
- Collector
- Target Trail
- Delivery

Network

TCP/IP

Process Start

Shared Memory (for Monitoring)
Oracle GoldenGate Components

Communications and Startup

Source

Target

GGSCI Interactive Interface
Manager
Source Trail
GGSCI Interactive Interface
Manager
Collector
Target Trail
Delivery
Target Database

Source Database
Capture
Source Trail
Pump

TCP/IP
Process Start
Shared Memory (for Monitoring)
Oracle GoldenGate Components

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Oracle GoldenGate Components

Communications and Startup

Source

GGSCI Interactive Interface
Capture
Source Trail
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Target

Manager
GGSCI Interactive Interface
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Target Database

TCP/IP
Process Start
Shared Memory (for Monitoring)
Oracle GoldenGate Capture

Capture

Source Database

GoldenGate Parameter File

Transaction Logs

Source Database

GoldenGate Trail Files

GoldenGate Event Log

GoldenGate Checkpoint File

GoldenGate Command Interpreter

Command and Control

Serialization and Routing

Transformation Engine

SQL Interface

Message Subsystem

Checkpoint Manager

Memory Manager

Transaction Log Reader

VAM API/Redo API (log reader interface)

Formatting

Filtering

Transformation and Mapping

Parser

Metadata Manager

Metadata Manager

Database Access

File Parser

GoldenGate Parameter File

GoldenGate Trail Files

GoldenGate Event Log

GoldenGate Checkpoint File

GoldenGate Command Interpreter

Command and Control

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Differentiator: Performance and Scalability

GoldenGate Capture

- Log-based change data capture
  - High volume
  - Low overhead

- Decoupled architecture
  - Multiple capture processes may be used to scale, but generally not required
  - Possible to split “hot” tables into a separate capture process

- Filtering and compression
  - Unnecessary change data is discarded immediately
  - Updates and deletes are “compressed” by default
  - Before images are discarded by default
Differentiator: Performance and Scalability
GoldenGate Delivery

• Decoupled architecture
  – Multiple delivery processes may be used to scale
  – Possible to split “hot” tables into a separate delivery process
  – Possible for multiple delivery processes to split the work for a single table

• Transaction grouping
  – Small transactions are grouped by default to reduce commit overhead

• Record batching
  – Records are batched by table and operation within a single SQL execution
  – Automatic reordering of batches
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Differentiator: Transaction Integrity

- **Transaction boundaries**
  - Recorded in GoldenGate trail file
  - Transactions ordered in commit sequence
  - Boundaries adjusted automatically due to record filtering or trail splits

- **Transaction integrity**
  - Checkpointing and recovery are based on transaction boundaries
  - Original commit sequence is maintained by the delivery process
Differentiator: Reliability

- **Decoupled architecture**
  - Individual processes can be restarted automatically
  - Tolerance to network outages (configurable)

- **Recovery**
  - Recovery ensures that no operations are skipped or duplicated after failure of any kind
  - Recovery of the Capture process is more involved than recovery the Delivery process
  - Although GoldenGate processes are completely decoupled, the Delivery process must be aware of a recovery performed by the Capture process or pump
GoldenGate Checkpointing

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

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Differentiator: Heterogeneity

- **Core Infrastructure**
  - Core product components are utilized for all databases
  - Canonical trail file format
  - Canonical metadata definitions
  - Automatic mapping of common datatypes

- **Capture Methods**
  - Log scraping (direct file access)
  - Database built-in log interface (transaction log API)
  - Intercepts/exits
  - Vendor-provided access modules

- **Delivery utilizes native database interfaces**
**Differentiator: Heterogeneity**

**Oracle Capture**

- Support for Oracle RAC
- Support for ASM
- Support for index-organized tables (IOTs) with overflow
- Support for clustered tables
- Support for object tables
- Support for object types (UDTs)
- Support for DDL operations
- Archived log only (ALO) mode
- Off-platform capture (LOGSOURCE)
- Multi-threaded capture
Differentiator: Heterogeneity
Microsoft SQL Server Capture

- Ability to capture from native backups
- Coexistence with SQL Server Replication
- SQL Server Replication components are not required
- Support tables with no unique key (not supported by SQL Server Replication)
- Support for computed columns
- Support for identity columns
Differentiator: Heterogeneity

DB2 LUW Capture

- Support for Multi Dimensional Clustered Tables (MDC)
- Support for Materialized Query Tables (MQT)
- Support for data compression (tablespace)
Differentiator: Heterogeneity

DB2 z/OS Capture

- Runs under Unix System Services (USS)
- Support for data sharing environments
- Automatic EBCDIC/ASCII translation
- Support for EBCDIC, ASCII, and Unicode encoded tables
- Support for data compression (tablespace)
Differentiator: Heterogeneity

HP NonStop Capture (Enscribe and SQL/MP)

- Logger used for non-TMF (non-audited) enabled applications
- ARLIB2 interface utilized by AUDSERV process
- HP Blades Support
- Support for TCP/IP and EXPAND networks
- Fast block-based unload
- Support for network distributed transactions
- Support primary key updates from open systems
Differentiator: Heterogeneity
HP NonStop Capture (SQL/MX)

- Runs under Open Systems Services (OSS)
- ARLIB2 interface utilized by VAMSERV process
- Based on open systems core infrastructure
Differentiator: Heterogeneity

Teradata Capture

- Teradata-provided access module (TAM)
- TAM is a shared library dynamically linked at runtime
- CDC runs on Relay Services Gateway (RSG) vprocs
- Max protection mode and max performance mode
- Full Unicode support for Windows and Linux
- Support for DDL operations
- Support for LOB and UDT datatypes
- Support for identity datatypes
Differentiator: Heterogeneity

Delivery

- Native APIs
- Transaction grouping
- Transaction splitting (if necessary)
- Array operations
- Integration with load utilities
- Flat file integration for data warehousing appliances (Netezza and Greenplum)
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GoldenGate Instantiation

- Start change data capture on Source Database
  - Current source Commit Sequence Number (CSN) is 222

Current CSN is 222

Source Database → Capture → Commit Ordered Source Trail → Pump → Commit Ordered Target Trail

CSNs 222 through ...

Target Database
GoldenGate Instantiation

- Wait for any open transactions to close
- Use a backup (or export/import) to copy source to target as of a consistency point
  - Current source Commit Sequence Number (CSN) is 245

Current CSN is 245

Source Database

Capture

Commit Ordered Source Trail

Pump

Commit Ordered Target Trail

CSNs 222 through …

Consistent as of CSN 245

Target Database

Take Backup as of CSN 245

Apply Backup as of CSN 245
GoldenGate Instantiation

- Start delivery at or after given backup CSN (245 in this case)
  - Current source Commit Sequence Number (CSN) is 356
- Once Delivery is current the source and target are in sync

Current CSN is 356

Source Database

Capture

Commit Ordered Source Trail

Pump

Commit Ordered Target Trail

Deliver transactions after CSN 245

Target Database

CSNs 222 through 356

In Sync!

Take Backup as of CSN 245

Apply Backup as of CSN 245

Consistent as of CSN 356
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Other Key Features

SQL Interface

- **Standalone execution**
  - Add parameter to the root level of a parameter file
  - Executes independently of a table or map statement
  - Execution order is based on the order it appears in the parameter file

- **Execute once**
  - SQLEXEC "call prc_job_count ()"
  - SQLEXEC "truncate table scott.target_table"
  - SQLEXEC "SET TRIGGERS OFF"

- **Execute at user-defined interval**
  - SQLEXEC "call prc_job_count ()" EVERY 30 SECONDS

- **Execute on application exit**
  - SQLEXEC "call prc_job_count ()" ONEXIT
  - SQLEXEC "SET TRIGGERS ON"
Other Key Features

SQL Interface

• **Inline execution**
  - Add a clause to the table/map statement in the parameter file
  - Executes for records that meet the map condition
  - The procedure or query can accept input parameters and return output parameters
  - Executed within the target database transaction context

• **Execute once (always execute by default)**
  
  ```sql
  MAP sales.cust, TARGET sales.cust_extended, &
  S Q L E X E C ( SP N A M E lookup, P A R A M S &
  (long_name = birth_state), EXEC ONCE), &
  COLMAP (custid = custid, birth_state_long = lookup.long_name);
  ```

• **Execute once per transaction**
  
  ```sql
  MAP sales.cust, TARGET sales.cust_extended, &
  S Q L E X E C ( SP N A M E lookup, P A R A M S &
  (long_name = birth_state), EXEC TRANSACTION), &
  COLMAP (custid = custid, birth_state_long = lookup.long_name);
  ```
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Other Key Features
Event Marker Infrastructure

- INSERT/UPDATE/DELETE Values(...) in “EVENT TABLE”
- INSERT/UPDATE/DELETE Values(...) in “DATA TABLE”

Source Database
  - Capture
  - Source Trail
  - Pump
  - Target Trail
  - Delivery

Target Database
  - Event Log
  - Discard File
  - Checkpoint

EVENT PROCESSING
Reports
Event Log
Discard File
Checkpoint
Other Key Features
Event Marker Infrastructure

• Currently supported events…
  – STOP – Graceful stop.
  – ABORT – Immediate exit.
  – FORCESTOP – Graceful stop or abort.
  – IGNORE – Ignore record or transaction.
  – DISCARD – Write record to discard file.
  – LOG – Log a message to the report, error and systems event files.
  – ROLLOVER – Roll the capture trail file.
  – SHELL - Execute a shell command.
  – TRACE – Send trace info to file.
  – CHECKPOINT – Cause a checkpoint operation
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Other Key Features
ETL Integration

• Integration via:
  – Staging tables
  – Flat files
  – Messaging
Other Key Features
Delivery to JMS (Java Message System)

- GoldenGate captures new transactions from source systems and publishes to:
  - JMS Queue – point-to-point
  - JMS Topic – publish/subscribe

- Writes as:
  - Transactions (with guaranteed integrity)
  - Individual DB Operations (insert, delete…)

[Diagram showing the process of data capture, transformation, and delivery to JMS Queue or Topic, including interactions with XML and Third Party Systems, Partners, Customers, and Applications.]
Other Key Features
Delivery to Flat File

- Delimited/fixed format data file and control file

- Time/size-based rollover
- One file, or one table per file
Sun/Oracle Information

http://tinyurl.com/sunorcl

or

oracle.com
High Availability

Oracle GoldenGate
- GoldenGate is Oracle’s strategic replication solution

Oracle Streams
- Streams continues to be a supported Oracle Database feature

Active Data Guard
- Combine both technologies for total data protection and information distribution
Real-Time Data Integration

Oracle GoldenGate

Other Oracle Products...

Bulk Data Movement and Transformation
- Fastest E-LT Solution
- Optimized SET-based transformation for high volume transformations
- Data lineage for improved manageability
- Integrates to Data Quality

Real-Time Data Integration and Replication
- Fastest real-time solution
- Sub-second latency for real-time feeds
- Guaranteed delivery eliminates data loss
- Eliminates down-time for migration and upgrades
- Least intrusive to source systems
- Requires ELT/ETL for complex transformation

Combine both technologies for comprehensive data integration
GoldenGate Information

http://oracle.com/goldengate
COMPANY OVERVIEW
DIRECTV is a $17 billion provider of satellite-based television services. DIRECTV’s 7,500 employees operate the company’s broadcast centers, monitor satellites, and deliver service to about 17 million U.S. and over 5 million Latin American customers.

CHALLENGES / OPPORTUNITIES
• Maintain high quality customer service in competitive market – reduce churn!
• Centralize customer information for a single view to support sales, marketing, support & field service
• Significantly reduce data latency in central data warehouse for all queries & reports – edict for < 15 minutes!

Oracle GoldenGate PROVIDES
• Real-time data integration from Siebel CRM on Oracle to central Teradata Warehouse
• 1,500 service agents log 600,000 customer calls p/day
• GoldenGate moves 150-200 million records per day with 1.5 second latency.

RESULTS
• Significantly reduced churn by 25%
• All business units have access to real-time business data.

Customer Case Study
Real-time Data for Better BI and Reduce Customer Churn
**COMPANY OVERVIEW**
Overstock.com is an online “closeout” retailer offering high-quality, brand-name merchandise, including bed-and-bath goods, home décor, kitchenware, watches, jewelry, electronics and computers, sporting goods, apparel and designer accessories among other products at discount prices.

**CHALLENGES / OPPORTUNITIES**
- Better understand customer purchasing behavior
- Provide timely information to support marketing, merchandising and operational decisions
- Improve shopping database reliability and uptime

**Oracle GoldenGate PROVIDES**
- Support for high availability & disaster tolerance across Oracle production sites
- Zero-downtime system migration and upgrade
- Enable active data warehouse roll-out in 90 days with real-time data feeds
- Complements Oracle Data Integrator for data transforms on target

**RESULTS**
- Customer analysis now done in minutes, rather than days
- Dashboard reports using real-time data for P&L & customer profitability
- Google Adwords adjusted based on real-time data reports
- Ranked #4 in customer service by National Retail Federation
Customer Case Study
Query Offloading Provides Continuous Availability and Saves Millions $

COMPANY OVERVIEW
A world leader in the travel marketplace, Sabre Holdings merchandises and retails travel products and provides distribution and technology solutions for the travel industry.

CHALLENGES / OPPORTUNITIES
• Optimize OLTP system performance – offload all query activity
• Reduce TCO via platform changes and segment “lookers” from “bookers”
• Handle growing data volumes and support heterogeneous systems over life-cycle of Air Travel Shopping Engine (ATSE)
• Maintain data integrity across all systems

Oracle GoldenGate PROVIDES
• Supports 1.6TB of data movement per day to read-only servers
• Source – Oracle 10g | Target – MySQL
• Current plans to migrate to Oracle 11g on both source and target.

RESULTS
• 80% TCO Reduction – Millions $$ saved

“Bookers vs Lookers”
Customer Case Study
High Availability of Manufacturing Application Meets SLAs

COMPANY OVERVIEW
Research In Motion (RIM) is a leading designer, manufacturer and marketer of innovative wireless solutions for the worldwide mobile communications market.

CHALLENGES / OPPORTUNITIES
• Experiencing exponential growth and stringent carrier SLA’s to meet growing demand for Blackberry devices
• Maintain continuous availability of critical data across all global data centers (4) for manufacturing plants
• All plants see same data and can move devices based on regional demand

Oracle GoldenGate PROVIDES
• 5 way Active-Active configuration provides same data across worldwide plants
• Improved system performance & response times
• Zero downtime DB migration to new version using phased approach
• Real-time data integration for new Exadata data warehouse for up-to-minute reports

RESULTS
• All of manufacturing from VP to engineer on plant floor can access most up to date info.
COMPANY OVERVIEW
Retail Decisions (ReD) is a payment card issuer and a world leader in card fraud prevention and payment processing. A specialist supplier to the payments industry worldwide. Its blue-chip international clients come from the global telecommunications, retail, travel, petroleum, banking and the broader e-commerce sectors.

CHALLENGES / OPPORTUNITIES
- Typical Service Level Agreements dictate 99.95% availability & aggressive sub-second average response times
- Must ensure quick, massive scalability
- High cost of downtime -- ReD’s clients lose millions of dollars per hour
- Global clients; data centers on 4 continents

Oracle PROVIDES:
- Fraud Detection (ReDShield) using Oracle 9i and 10g databases
- U.S. Payment Processing system, using SQL Server databases – also supports data access for Web apps and Reporting

RESULTS
- “Lightning Fast” implementation
- Time to recover: ZERO minutes
- Reduced database license & infrastructure costs

"We needed a mega-scalable architecture capable of handling increasing e-commerce traffic, while meeting our customers’ stringent SLAs.” - Chris Uriarte, CTO
Continuous Availability Use Case
Siebel Application Upgrade & Database Migration

COMPANY OVERVIEW
HSN is an interactive lifestyle network and retail destination, offering a curated assortment of exclusive products combined with top brand names. HSN incorporates experts, entertainment, inspiration, solutions, tips and ideas to provide an entirely unique shopping experience for its customers.

CHALLENGES / OPPORTUNITIES
- Eliminate downtime during major Siebel upgrade from version 6.2 to 8.0
- Additionally, upgrade Oracle database 8i to 10g with no downtime
- Conduct a phased migration approach to allow time for training & testing
- Minimal business disruption

Oracle PROVIDES:
- Continuous availability during major migration project.
- Active-Active configuration provided data synchronized across old & new systems
- Provided upgrade & downgrade logic between old and new Siebel versions

RESULTS
- Enabled migration of 1500+ users to new system
- Reduced risk with live parallel running of both old and new
- Zero downtime
- No disruption to the business & continuous order processing on mission critical system
ORACLE IS THE INFORMATION COMPANY