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ORACLE GOLDENGATE 12C:
REAL-TIME ACCESS TO
REAL-TIME INFORMATION

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Oracle GoldenGate 12*c*:
Real-Time Access to Real-Time Information

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Executive Overview

Today businesses are faced with an ever increasing volume and detail of data. As online transactions happen anywhere, anytime, and we have increased the number of devices and connectivity between these devices, turning this data deluge into an asset has become a key priority for IT executives. The outcome of our fast-paced business environment is that much of the data now diminishes in value if it is not used soon after it is generated. That's why, to extract maximum value out of dynamically changing data, organizations need to capture, analyze and act upon them with a near real-time speed. At the same time, organizations need to ensure high availability and performance to support 24/7 operations. This desire to turn big data into actionable insights and real value for the organization, and compete in a 24/7 world creates a need for real-time data integration and replication solutions that are easy to implement and have little to no impact on business-critical applications.

Oracle GoldenGate is used by major Fortune 500 companies and other industry leaders worldwide to support mission-critical systems for data availability and integration. Written for business project owners, key stakeholders, and the entire IT organization, this white paper provides a detailed look at Oracle GoldenGate 12*c*, its underlying technology architecture, and the typical solution use cases.

Oracle GoldenGate 12*c* is now available for all major databases and operating systems. If you would like to learn about the latest release in detail, please read "Oracle GoldenGate 12*c* New Features White Paper" in the Oracle GoldenGate resource kit

Introduction

As data volumes grow at an exponential rate, many organizations are looking at ways to leverage big data as an advantage to their business. However research indicates that most organizations do not think they are prepared to leverage the enterprise data that they have. Data velocity in particular, seems to be a key challenge in handling big data. In a recent study by Aberdeen Group that surveyed 247 executives 53% of respondents said that too much crucial information is delivered too late[1].

Today data is generated at a much faster rate due to online transactions taking place anywhere and anytime, as well as due to the increased number of devices, along with the increased connectivity and communication between these devices, also called "the Internet of Things". Most of this data, though, loses its inherent value very fast by becoming less relevant and less effective in influencing operational decisions— unless it is integrated, analyzed and consumed almost immediately.

To extract value from such perishable data in a dynamically changing environment that includes a diversity of sources, both on cloud and on premises, organizations need to capture, analyze and act upon them in near real-time. In addition they need to ensure that their systems can run uninterrupted to support customers 24/7 with reliable data meaning without experiencing interruptions in data availability, sluggish application performance, or stale data. There are four aspects to this challenge.

- » **Availability.** Business-critical applications and underlying data must be accessible at or near 24/7/365 without service interruption or performance degradation
- » **Reduced latency.** Data must remain fresh. As it ages, data becomes less relevant and less valuable—day-old data is often insufficient in today's competitive landscape.
- » **Heterogeneity and IT flexibility.** Integration and replication solutions must have the flexibility to be easily modified and distributed across diverse IT systems including on premises and cloud environments.
- » **Transaction integrity.** Data completeness and accuracy must be ensured as it is moved between systems.

In short, companies need a platform that allows business applications to benefit from continuous access to real-time information in diverse IT environments, without compromising performance and data integrity or demanding significant resources to deploy and manage.

Oracle GoldenGate 12*c* empowers organizations to capture, route, transform, and deliver transactional data between heterogeneous databases and applications in real time with minimal overhead. Using unique real-time, log-based replication technology, Oracle provides high availability and real-time data integration solutions that enable the management and movement of transactional data across the enterprise. Oracle GoldenGate is designed for low-impact and easy implementation, operation, modification, and extension to support the evolving needs of enterprise information management.

Oracle GoldenGate 12*c*

Oracle GoldenGate 12*c* offers a real-time, log-based change data capture (CDC) and replication software platform to meet the needs of today's transaction-driven applications. The software provides capture, routing, transformation, and delivery of transactional data across heterogeneous environments in real time. Oracle GoldenGate only captures and moves committed database transactions to insure that transactional integrity is

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1 Aberdeen Group – January 2012, survey of 247 executives - Data Management for BI – Big Data, Bigger Insight, Superior Performance

maintained at all times. The application carefully ensures the integrity of data as it is moved from the source database or messaging system, and is applied to any number of target databases or messaging systems.

The latest release sets GoldenGate further apart from competition by bringing extreme performance and advanced capabilities such as intelligent and integrated data delivery and cloud-based real-time replication, while simplifying product deployment significantly.

Table 1. Oracle GoldenGate Key Features and Differentiators

Feature	Detail
Real-time data feeds	Provides continuous capture and delivery of data from sources to targets with end-to-end low latency. Operates at high performance with low overhead even at high volumes.
Heterogeneity	Captures and delivers data between a variety of relational, open systems/open source, and legacy databases on all major platforms. Captures from, and delivers to, Java Messaging Service (JMS) based messaging systems.
Transactional integrity	Maintains the reliability and accuracy of transactional data as it is moved between systems by enforcing ACID properties and referential integrity.

For more than two decades, industry leaders worldwide have put their trust in Oracle to enable the movement and management of their critical, rapidly changing transactional data.

Figure 1. Oracle GoldenGate provides real-time access to real-time information through a comprehensive view of operational systems

Designed for Real Time

Oracle GoldenGate 12c enables the continuous, real-time capture, routing, transformation, and delivery of transactional data across heterogeneous environments. As new or updated data is committed at the source system, it is continuously captured and applied to one or more target systems with low latency. Only changed data is moved, so a lower burden is placed on the infrastructure.

Oracle GoldenGate 12c offers several key advantages:

» Continuous, real-time data movement with low latency
» Negligible impact and overhead on source and target systems
» No requirement for a middle-tier server
» Tight integration with Oracle Data Integrator Enterprise Edition for complex transformations
» No downtime for batch processing

» Complete data recoverability in case of outages or failures

» Read-consistent data movement while maintaining referential integrity

» Ability to apply transformations and mappings within the target database

» Ability to use the same product in different topologies for different solutions such as continuous availability and zero-downtime upgrades and migrations

Modular Decoupled Architecture

The Oracle GoldenGate 12*c* architecture consists of decoupled modules that can be combined across the enterprise to provide maximum flexibility, availability, and performance. This architecture facilitates the movement of transactional data in four simple, yet powerful steps.

» **Capture.** Oracle GoldenGate captures changed data operations committed in the database transaction logs in a nonintrusive, high-performance, low-overhead implementation. Via the Oracle GoldenGate Application Adapter, it can also capture messages from JMS message queues.

» **Route.** Oracle GoldenGate can use a variety of means to route this changed data to one or more locations, and can compress and encrypt changed data prior to routing.

» **Transform.** At any point prior to applying the data to the target system, Oracle GoldenGate can be used to execute a number of built-in functions, such as filtering and transformations.

» **Delivery.** While preserving transactional integrity, Oracle GoldenGate applies the changed data to one or more targets with minimal latency. Transactional data can be delivered via selected Open Database Connectivity−compliant databases or through a specialized adapter to a JMS message queue or topic.

Flexible Topology Support and Bidirectional Configurations

As a result of its decoupled modular design, Oracle GoldenGate easily supports a wide variety of topologies. These include one-to-one, one-to-many, many-to-one, and many-to-many—for both unidirectional and bidirectional configurations.

For unlimited scalability, cascading topologies can be created to eliminate any potential bottlenecks. By staging specific sets of database changes on the source or target system, different requirements can be met through a single pass on the data source. Each set of staged data can contain unique or overlapping sets of data.
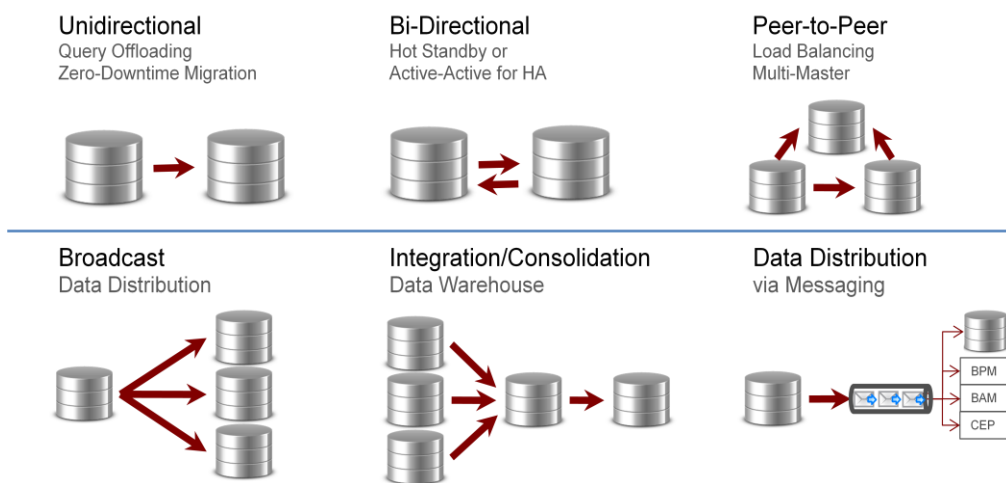
Figure 2. Oracle GoldenGate supports numerous data propagation solutions to support real-time visibility across the enterprise.

Oracle GoldenGate Application Adapters allows Oracle GoldenGate to integrate with JMS messaging systems for increased flexibility in distributing real-time data. This capability, along with the flat file delivery feature, allows Oracle GoldenGate to provide different integration architectures to augment existing investments.

Architecture Overview

A decoupled architecture addresses numerous problems inherent in tightly coupled alternatives. Process-to-process coupling creates a dependency between data capture and delivery. For example, if delivery is slower than capture, capture activities must be held up. In the event of an unplanned outage, decoupling ensures that the non-impacted systems continue to operate.

Tightly coupled or process-to-process implementations can impose scalability challenges. A great deal of interprocess checkpointing needs to occur to ensure no data is lost, thereby creating many more messages and still more overhead. Network outages lasting more than a few minutes can also cause excessive resource consumption, because outstanding transactions need to be queued in memory and eventually swapped to disk. Neither the physical nor the virtual memory activities are persistent; therefore if the process fails, data inconsistencies—or even loss—ensues.

By staging data in Trail Files, Oracle GoldenGate's unique queuing mechanism, GoldenGate decouples the data source and target for heterogeneous support. Unlike architectures that implement a tight process-to-process coupling, this decoupled architecture allows each module to perform its tasks independently.

Oracle GoldenGate also provides flexibility in the choice of hardware, operating system, and databases for sources and targets. For maximum flexibility and ease of use, customers can use different versions of Capture, Delivery, and Trail Files in the same implementation.

Architectural Components

The Oracle GoldenGate architecture consists of four distinct modules and components:

- » Oracle GoldenGate Capture
- » Oracle GoldenGate Trail Files
- » Oracle GoldenGate Delivery
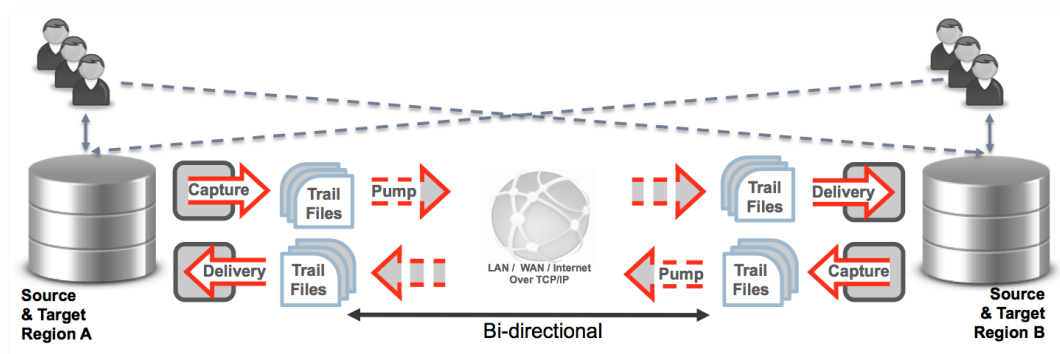- » Oracle GoldenGate Manager

Figure 3. Oracle GoldenGate's modular architecture for database to database replication enables high speed, reliability and flexibility
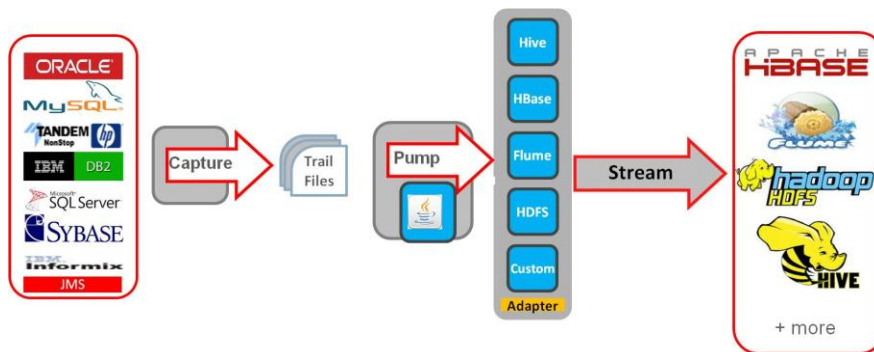
Figure 4. Oracle GoldenGate for Big Data enables real-time transactional data streaming to big data system
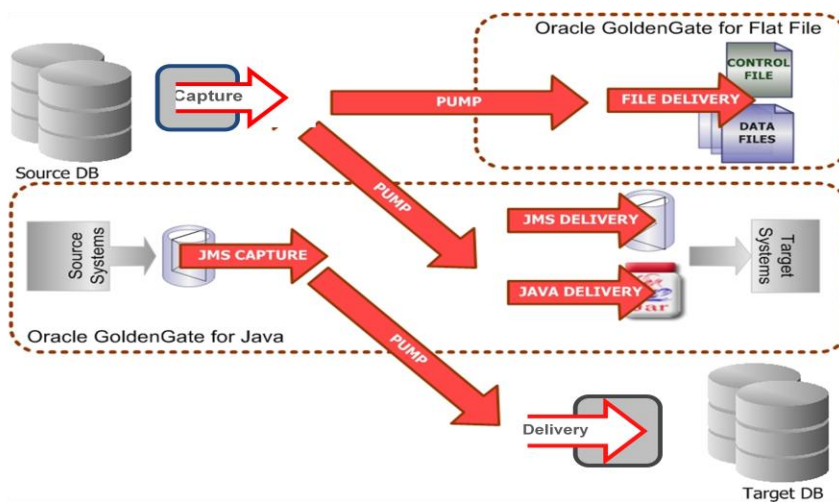

Figure 5. Oracle GoldenGate Application Adapters supports capture and delivery of transactional changes from/to targets other than relational databases.

Oracle GoldenGate Capture

The Capture module grabs committed transactions resulting from insert, update, and delete operations executed against a database, and routes them for distribution. When used with the Oracle GoldenGate Application Adapters for Java, transactions can also be captured from JMS messages.

High-Speed, Low-Impact Data Capture

The Capture module does not require any changes to be made to the source database or the application it supports. To maintain optimal performance, the Capture module employs a range of change data capture techniques against the source database. For instance, in most databases, changes are captured through direct file access to transaction logs (redo logs in Oracle and MySQL). For Teradata at the source, custom APIs have been developed to allow Oracle GoldenGate to capture committed transactions with the same efficiencies. The Oracle Certification Matrix contains the complete list of platforms supported by Oracle GoldenGate.

Transaction logs contain all changes made to the database and are automatically maintained by the database application independently of Oracle GoldenGate. Consequently, no additional tables are required to run the Capture module, and overhead is greatly reduced as compared with trigger-based capture techniques. Many customers report only single-digit percentage overhead when running the Capture module on the source database. The Capture module can automatically adjust its transaction memory based on the size and number of the transactions it is capturing, which optimizes memory usage, allowing even lower overhead on the source systems. When used with Oracle GoldenGate Application Adapters, the product also offers capabilities to capture from JMS.

Table, Row, and Column Selectivity

When not all changed data from the source needs to be replicated to the target system—such as for real-time reporting purposes—the Capture module allows users to filter tables and rows based on user-defined criteria and ignores the entries in the transaction log that don't meet the end-user's needs. Users can optionally select and apply transformation rules to specific columns via built-in Oracle GoldenGate functions, user-supplied code, stored procedures, or through Oracle Data Integrator Enterprise Edition.

Efficient Network Use and Large Data Volumes

The Capture module can route transactions over WANs and LANs as well as the internet, and it can reduce network bandwidth requirements in a number of ways. Typically, the amount of data transmitted is only a fraction of the data that is generated by the database and stored in transaction logs. Because only committed transactions are propagated, intermediate activities and rolled-back operations are not transferred. Traffic is optimized by bundling individual records into larger, more-efficient packets and avoiding record-at-a-time bottlenecks. Several levels of data compression are available to further reduce the amount of network bandwidth required for transmission. Depending on data types, data compression can reduce byte transfer by 75 percent or more.

For scenarios requiring very large changed data volumes, users can deploy multiple Capture modules to minimize the lag between source and target systems. Additionally, customers running Capture on an Oracle Database can take advantage of Integrated Capture, a multi-threaded capture mechanism that improves performance by interacting directly with a database log mining server to receive data changes. Integrated Capture also provides users with the ability to reduce overhead on the source system by offloading the Capture process to an alternate location, such as the target. For more information on this feature please review in our resource kit the white paper: Using Oracle GoldenGate 12*c* for Oracle Database.

Checkpoints for Reliable Data Delivery

Oracle GoldenGate creates a checkpoint at the last changed transaction whenever a commit boundary is encountered. This enables the delivery of all committed records to the target, even in the event of a restart or cluster failover. Checkpoints store the current position as processed by both the Capture and Delivery modules. Following a network or system outage, Oracle GoldenGate restarts from the last good checkpoint. Oracle GoldenGate also persists uncommitted operations to disk to enable fast and simple data recovery for long running transactions in the event that the replication process is paused or interrupted.

Oracle GoldenGate Trail Files

Trail Files contain the most recent changed data in a transportable, platform-independent format called the Oracle GoldenGate Universal Data Format, and can be converted to XML and other popular formats for

consumption by different applications. Based on the requirements of the implementation, users can store Trail Files on the target system, the source system, or both. Trail Files can be delivered to alternative queue types and application interfaces.

Routing (Data Pumps)

A separate Capture process continually scans the staging Trail File, awaiting new data. When new data is detected in the staging Trail File, it is packaged for routing via TCP/IP to specific target locations. The target location can be a single server disk location, multiple disk locations, or multiple servers and disk locations. This configuration enhances the fault tolerance and reliability of the overall Oracle GoldenGate environment. In the event of a network failure (between the source and the target systems), Oracle GoldenGate can continue to capture transactions because the data can be queued up locally in the Trail Files on the source, enhancing the recoverability in case of network failures.

Fault tolerance is also greatly increased in such a configuration because any failure associated with one target has no impact on the source capture or delivery to other targets—transactions will continue to be captured, routed, and delivered to the other targets even when one of them is down. Data can also be routed through an intermediate system, even if that system doesn't have a database installed.

Oracle GoldenGate uses TCP/IP, including IPV6, for sending data, so no geographical distance constraints are imposed between the source and target systems. Advanced options provide for encryption (using FIPS or Blowfish) and compression of the data within the TCP/IP packet. At the target locations, a communications process receives the incoming transmission from TCP/IP, decrypts and decompresses the data packet, and writes the transaction information to a local trail file. Archival and Audit Capabilities

Delivery processes can create an archive of purged information from the source database by transforming delete and update records in Trail Files into inserts in a different location. For auditing and compliance purposes, Oracle GoldenGate can also maintain a separate history table to track each update to individual records as they change.

Oracle GoldenGate Delivery

The Delivery module takes any changed transactional data that has been placed in a Trail File and immediately applies it to the target database. In addition to supporting Oracle Database (including Oracle Exadata), Microsoft SQL Server, IBM DB2, and most other popular databases. Through the use of Oracle GoldenGate Application Adapters, Oracle GoldenGate also has the capability to publish changed data to a messaging system in XML or other formats, as well as provide data in flat files for third-party products, such as an ETL system. The Oracle Certification Matrix contains the complete list of platforms supported by Oracle GoldenGate. Oracle GoldenGate for Big Data enables streaming transactional data into big data systems, including Apache HDFS, Apache Hive, Apache Hbase, Apache Flume and more.

Data Integrity and Transaction Consistency

The Delivery module applies captured database changes in the same order as they were committed in the source database to provide data and referential integrity. In addition, it applies changes within the same transaction context as they were on the source system for consistency on the target.

Column Mapping and Transformation

As with Capture, users can configure the Delivery module via user-defined criteria to not only specify target tables but also individual rows and columns. By default, the Delivery module populates any target table column

with data from a source table column if the two columns share the same name, and this is also true of like-named tables. However, you can easily configure Oracle GoldenGate to move data from a single table into multiple target tables or vice versa. This can be used to normalize or denormalize data in a data warehouse or OLTP environment.

Users can also define explicit mapping and transformation rules, ranging from simple column assignments to more-complex transformations for which Oracle GoldenGate provides a suite of date, math, string, and utility functions. The module also supports the use of stored database procedures and functions and enables implicit mapping and explicit rules to be combined. If additional transformations, data quality, aggregation, and other functionality are required, Oracle GoldenGate 12c integrates with Oracle Data Integrator Enterprise Edition 12c to support end-to-end data integration.

Optimized High-Speed, High-Volume Data Delivery

The Delivery module provides a variety of techniques to optimize the posting of changed transactions to the target database. Oracle GoldenGate's posting processes, where possible, run local to the target database, maximizing throughput by avoiding network limitations.. In addition, where possible, updates are executed via native database interfaces rather than through middleware, and internal caches are used to ensure fast execution of repetitive statements.

Multiple Delivery modules can be deployed to minimize lag time in the event of high data volumes during peak processing times or seasonality. This capture-route-transform-apply process runs continuously, so that the most recent transactions committed at the source are immediately moved and delivered to the target.

Deferred Delivery

For maximum flexibility, the Delivery module can apply data immediately or at a deferred time interval chosen by the user, without losing transactional integrity. This allows an additional layer of data protection when needed and keeps the secondary system at a consistent state behind the primary system. In this configuration, Oracle GoldenGate routes the changed data to the Trail File on the target server but does not deliver it to the target database until a pre-determined time interval has elapsed.

Integrated Delivery

Customers delivering data to an Oracle Database 11*g* Release 11.2.0.4 or Oracle Database 12*c* Release 12.1.0.1 and higher database, can improve performance and provide better scalability and load balancing by using Integrated Delivery. Minimal changes are required to implement this change, which leverages the database parallel apply servers for automatic dependency aware parallel apply. With Integrated Delivery, there is no need for users to manually split the delivery process into multiple threads and manage multiple parameter files. For more information on using Integrated Delivery please see Using Oracle GoldenGate 12*c* for Oracle Database.

Coordinated Delivery

Customers delivering data to heterogeneous data stores (and Oracle Database versions before 11.2.0.4) who find it necessary to split their delivery process into multiple threads can use the Coordinated Delivery feature available with Oracle GoldenGate 12*c* to eliminate the need to manage multiple parameter files. In addition to requiring a single parameter file for multiple Delivery processes, Coordinated Delivery also automatically provides coordination across selected events that require ordering, including DDL, Primary Key updates, EMI and SQLEXEC.

Delivery using Oracle GoldenGate Application Adapters

Customers who need to apply transactional changes to targets other than a relational database can take advantage of the Oracle GoldenGate Adapters for Java and Flat File. These adapters provide a variety of options for integration with Oracle GoldenGate including delivery to JMS, flat files, and Java APIs.

Oracle GoldenGate can publish changed data to JMS queues and topics by using Oracle GoldenGate Application Adapters for Java. After capturing from source database transaction logs, Oracle GoldenGate converts captured records into JMS text and map messages (name-value pairs), and it formats text in any way, including XML. Changed data can be published as transactions with preserved integrity or as individual database operations such as inserts or deletes. This allows Oracle GoldenGate to provide improved support for SOA and enable event-driven architectures.

Using Oracle GoldenGate Application Adapters for Flat File, Oracle GoldenGate can publish changed data in the form of flat files to integrate with third-party data management products such as ETL. For those ETL systems that perform faster reading files than scanning staging tables, this method minimizes storage resources and system maintenance. It also enables the user to decrease the data latency by configuring the frequency of micro batches. Oracle GoldenGate has the ability to provide the data in a variety of formats, including delimited text files and binary files, to create the optimal feeding mechanism. Note that an out-of-the-box solution for delivery to Oracle Coherence is included with Oracle TopLink Grid, although it is also possible to create a custom solution using the GoldenGate adapters.

To learn more about these adapters, please consult *Oracle GoldenGate Adapters for Java and Flat File*.

Streaming Transactional Data to Big Data Systems with Oracle GoldenGate for Big Data

Oracle GoldenGate for Big Data provides optimized and high performance delivery to Flume, HDFS, Hive and Hbase to support customers with their real-time big data analytics initiatives. Oracle GoldenGate for Big Data includes Oracle GoldenGate for Java, which enables customers to easily integrate to additional big data systems, such as Oracle NoSQL, Apache Kafka, Apache Storm, Apache Spark, and others.

The below diagram illustrates a general high level architecture for integrating with Hadoop.
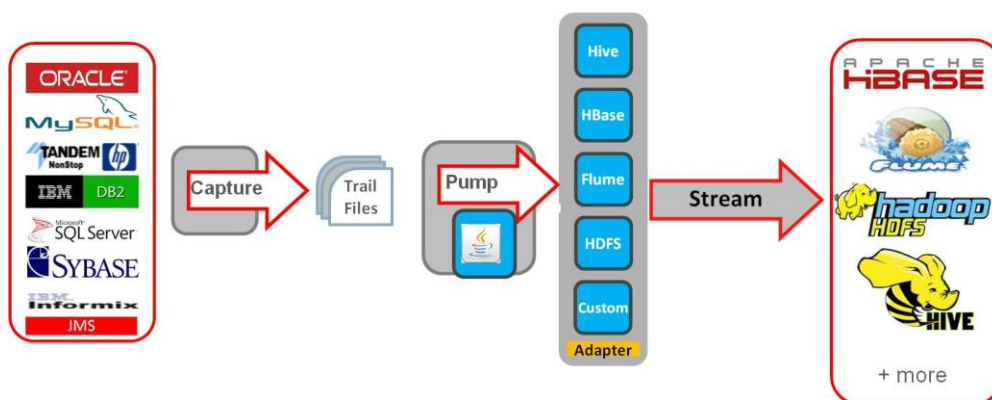

Figure 6. High-level architecture for feeding transactional data into Hadoop using Oracle GoldenGate and Oracle GoldenGate for Big Data

Oracle GoldenGate Manager

The Oracle GoldenGate Manager module is the controlling process that performs a variety of administrative, housekeeping, and reporting activities, including

» Starting the Capture and Delivery modules
» Critical, informational event, and threshold reporting
» Resource management
» Trail File management

The Manager module executes requests on demand as well as unattended. For example, it can be used to restart Oracle GoldenGate components as well as send latency information. The module can be configured to recycle Trail File data when no longer needed, providing insurance against inadvertent disk-full conditions and offering an alternative to error-prone manual housekeeping procedures. Oracle GoldenGate 12c offers increased transaction tracing flexibility to easily identify bottlenecks and tune the Oracle GoldenGate implementation for optimum performance.

For enhanced management of Oracle GoldenGate 12c processes and solutions, customers should consider adding the Management Pack for Oracle GoldenGate described later is this paper.

Associated Products

There are two primary products that augment Oracle GoldenGate to enhance a customer's real-time information platform:

» **Management Pack for Oracle GoldenGate.** A tool for visually deploying and managing Oracle GoldenGate processes across the enterprise.
» **Oracle GoldenGate Veridata.** A data comparison utility that quickly compares data between two online databases and reports any discrepancies (can run as a standalone product).

Management Pack for Oracle GoldenGate

Management Pack for Oracle GoldenGate is a centralized, server-based graphical enterprise application that offers an intuitive way to define, configure, manage, monitor and report Oracle GoldenGate processes. It leverages the management services of the core Oracle GoldenGate platform to help users reduce the deployment time for their continuous availability and real-time data integration configurations.

Management Pack for Oracle GoldenGate includes a license for the plug-in for Oracle Enterprise Manager as well as for both of the monitoring and configuration products, Oracle GoldenGate Monitor and Oracle GoldenGate Director, respectively. Both are server-based products that feature an intuitive graphical interface, each with a specific focus. As shown in the figure below, the plug-in for Oracle Enterprise Manager provides customers with a single interface that allows them to easily monitor key metrics and trends, such as status, lag and number of operations performed, for their entire replication environment. From here, administrators can easily troubleshoot their environment by drilling down for greater detail.
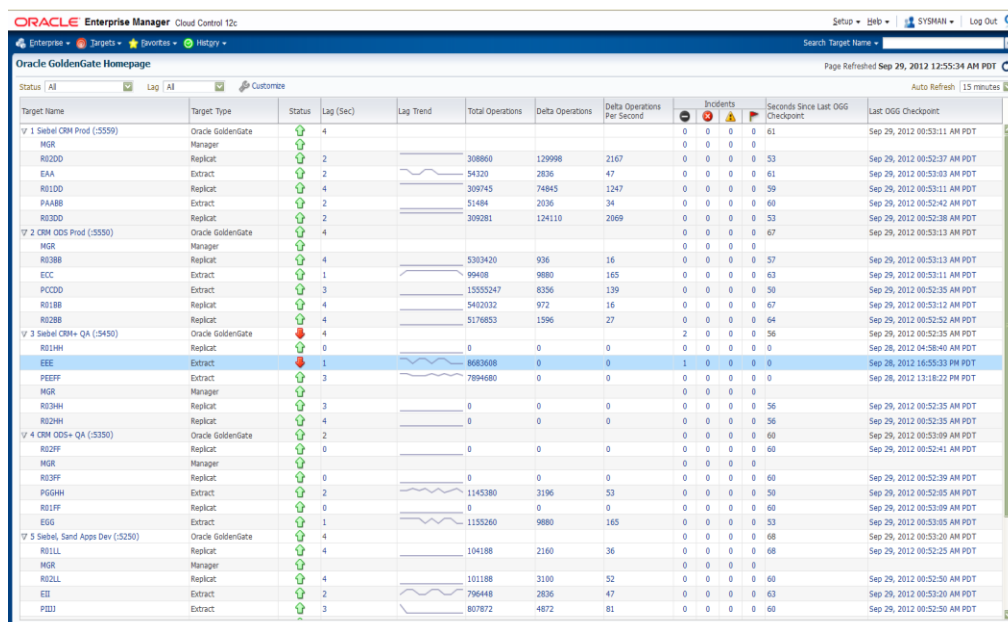
Figure 7. Using Oracle Enterprise Manager plug-in for Oracle GoldenGate to monitor key metrics and trends

To learn more about how these applications help companies improve the productivity of their IT staff, leverage existing infrastructure to maximize return on investment, and reduce the time to production for continuous availability, disaster tolerance, and real-time data integration solutions, refer to *Oracle Management Pack for Oracle GoldenGate*.

Oracle GoldenGate Veridata

Oracle GoldenGate Veridata is a high-speed, low-impact data comparison and repair solution that identifies, reports and fixes data discrepancies between two databases, without interrupting those systems or the business processes they support. A standalone product, Oracle GoldenGate Veridata does not depend on the presence of Oracle GoldenGate's core components.

Data discrepancies result from a wide variety of causes. Applications that input out of bounds data and bad dates, improper instantiation of replication, user errors, application errors, and infrastructure problems can all lead to out-of-sync conditions.

Oracle GoldenGate Veridata offers an intuitive, Web-based graphical user interface as well as command-line capabilities to allow for scheduled comparisons.
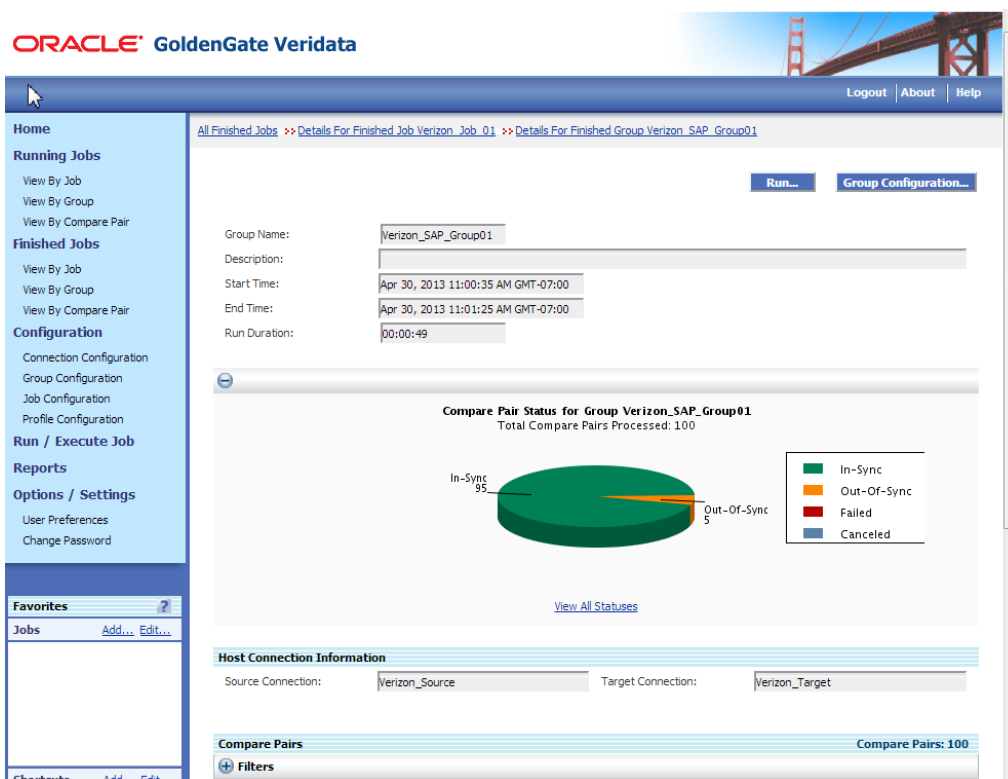
Figure 8. Identifying out-of-sync data using Oracle GoldenGate Veridata's intuitive graphical user interface.

To learn more about Oracle GoldenGate Veridata please refer *to Oracle GoldenGate Veridata* and *Ensuring Consistency with Oracle GoldenGate Veridata.*

One Platform, Many Solutions

Oracle GoldenGate, together with its associated management and monitoring tools, enables companies to easily and successfully implement a variety of solutions for improving the availability, accessibility, performance, and integration of critical data across the enterprise. With its robust technology Oracle GoldenGate addresses two primary business needs that we mentioned earlier in the paper:

» Continuous availability : Supporting 24/7 business operations
» Real-time data integration: Enabling low-latency data for operational decision making

Continuous Availability

Businesses are facing increased pressure to meet end-users' expectations for 24/7 system availability and to surpass competitors' service levels. This means the IT organization must implement solutions that keep key business applications operating with an acceptable level of continuity, even under a range of potentially damaging or interrupting conditions.

Typically, companies might first consider traditional disaster recovery products and practices. But for databases that support applications requiring high-availability targets, such as fast recovery time objectives and strict recovery point objectives, traditional disaster recovery technologies alone are not likely to be sufficient, because with these solutions database recovery is typically required, which extends the failover time.

Continuous availability and disaster tolerance of critical data systems is more than "after-the-fact" data recovery. Oracle GoldenGate allows customers to avoid experiencing downtime or the data loss effects of a disaster. In addition, it improves system availability when faced with not only unplanned outages but also planned outages and performance-related issues that impact the end-users' perception of availability—regardless of whether the system is down or available. Oracle GoldenGate can be implemented to support each of these states of availability. See Figure 7.
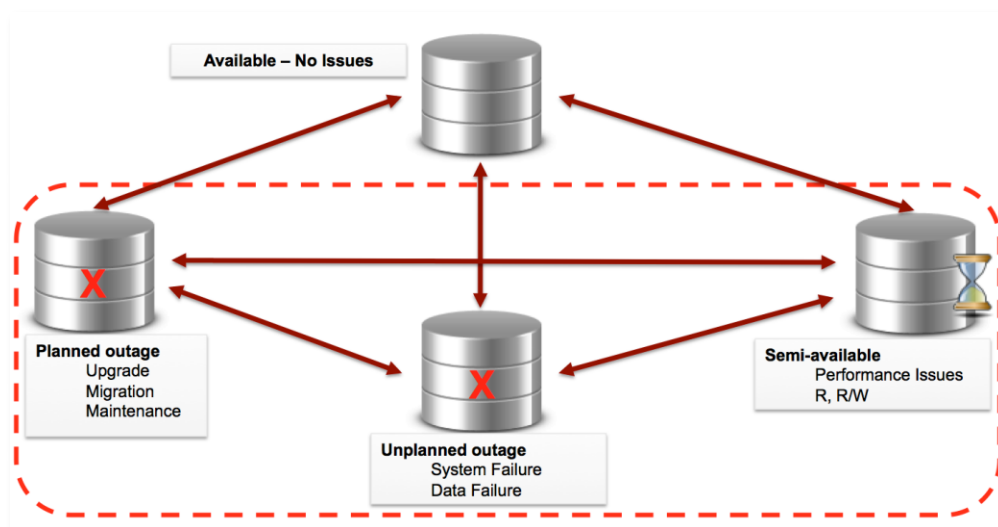

Figure 9. Continuous availability solutions must address planned and unplanned outages and support access for critical applications.

State #1: Active but with Performance Challenges

If the application or database is up but experiencing performance degradation that affecting throughput and response times, one of the most effective approaches is to offload or distribute the processing activity.

Deploying Oracle GoldenGate 12*c* for Active-Active Database Replication

Deploying Oracle GoldenGate 12c for active-active database replication allows for the highest availability and performance on critical systems, because it enables load balancing by continuously and multi-directionally moving data between two or more active and heterogeneous databases, as shown in Figure 8. Oracle GoldenGate 12c offers advanced capabilities for conflict detection and resolution that can be required in multi-master configurations.
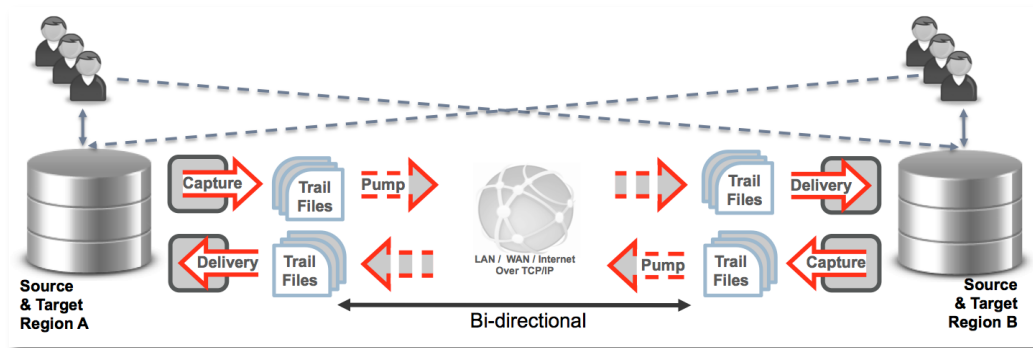
Figure 10. Oracle GoldenGate enables multidirectional data replication to support a multi-master application configuration.

Deploying Oracle GoldenGate 12*c* for Query Offloading

High volume, read-only queries that run on online transaction processing (OLTP) systems—such as product searches by customers—can cause significant overhead on the production environment, leading to high CPU utilization and performance degradation. In many cases, to address the issue, organizations upgrade their existing expensive legacy systems with additional investments to be able to provide acceptable performance. To improve transaction processing performance and reduce costs, Oracle GoldenGate creates a real-time replica of the production environment on lower-cost platforms and allows read-only queries to be pointed to this environment. With this architecture, the production environment is freed up from supporting expensive read-only activity and can support transaction processing activity with better performance and a longer lifetime.
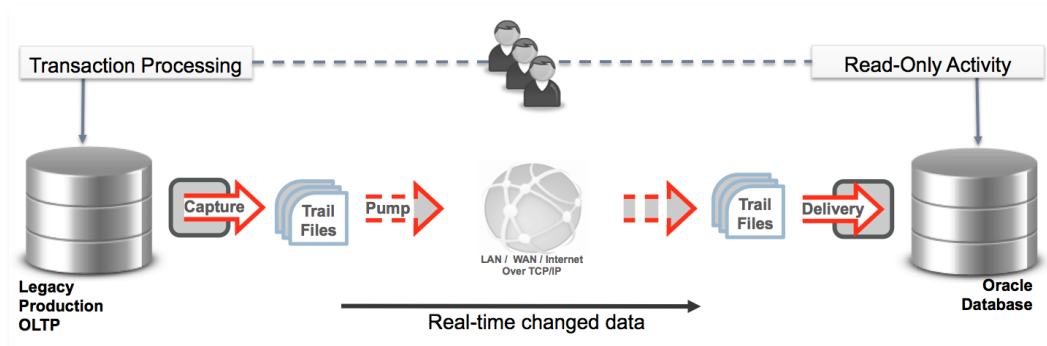

Figure 11. Oracle GoldenGate, enables to offload queries from production systems to reduce overhead & optimize reporting

State #2: Planned Outages

IT groups occasionally need to schedule planned outages to modify hardware or database software, upgrade applications or databases, apply software patches, or migrate to a different computing architecture. Oracle GoldenGate eliminates the downtime traditionally associated with these planned outages.

Deploying Oracle GoldenGate 12*c* for Zero-Downtime Migration, Upgrade, and Consolidation into Cloud

Through real-time, bidirectional data movement and synchronization between old and new systems, Oracle GoldenGate enables automated switchover from the existing system to the new system, when the new system is ready—without ever denying access to the application. The solution can support heterogeneous environments for cross-platform upgrades and database migrations from non-Oracle databases to Oracle databases including

Oracle Exadata. In addition, the solution provides robust failback contingencies by keeping the old and new environments in sync in real time. By simultaneously using Oracle GoldenGate Veridata, users can identify and report data discrepancies across systems before switchover, without impacting the production environment.

Oracle GoldenGate offers a unique solution for upgrades from Oracle 8*i*, Oracle 9*i*, Oracle 10*g*, and Oracle 11*g* to Oracle Database 12*c*, where the database downtime is reduced to mere seconds or minutes during the upgrade. For customers who want to consolidate to a private cloud or hybrid model Oracle GoldenGate offers a strong solution to move to a cloud environment without interrupting business operations and with minimized risk. The new Oracle Database 12*c* release introduced new multitenant architecture, which simplifies the process of consolidating databases onto the cloud, enabling customers to manage many databases as one - without changing their applications. Oracle GoldenGate 12*c* is optimized for Oracle Database 12*c* and supports its new multitenant architecture, making it a perfect solution for consolidation without impacting business operations. A failback option allows the IT team to test the target environment as long as necessary, minimizing risk.

In addition, the same Oracle GoldenGate product can be used for application upgrades for Oracle JD Edwards, Oracle Communications Billing and Revenue Management (BRM), and Oracle's Siebel Customer Relationship Management (CRM) without any downtime and with options to perform phased user migrations. Oracle GoldenGate provides prebuilt upgrade and downgrade transformation logic for Oracle's Siebel CRM, Communications BRM, and JD Edwards applications.
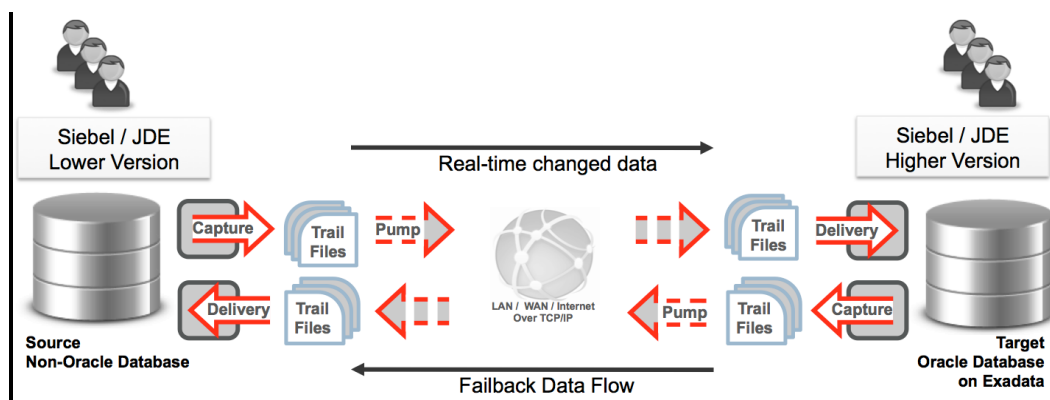

Figure 12. Oracle GoldenGate enables organizations to upgrade and migrate mission-critical applications with no downtime.

State #3: Unplanned Outages

Unplanned outages may be caused by system or data failures at the site or system level. For mission-critical systems, businesses must confidently fail over to a backup as quickly as possible, and easily revert back to normal operating conditions once the primary system is back online.

Deploying Oracle GoldenGate 12*c* for Disaster Recovery and Data Protection

When configured for disaster recovery and data protection, Oracle GoldenGate provides a continuous availability solution that significantly improves recovery time for mission-critical systems. Oracle GoldenGate's disaster recovery and data protection configuration complements Oracle Active Data Guard, by offering continuous availability via active-active bidirectional database synchronization, for non-Oracle databases, and for environments that require replication between different operating systems and Oracle Database versions. Oracle GoldenGate delivers up-to-the-second data to the backup system and enables immediate switchover to the new

system if an outage occurs. It also immediately initiates real-time data capture from the standby database to update the primary system, once it is online, with any new data processed by the standby system.
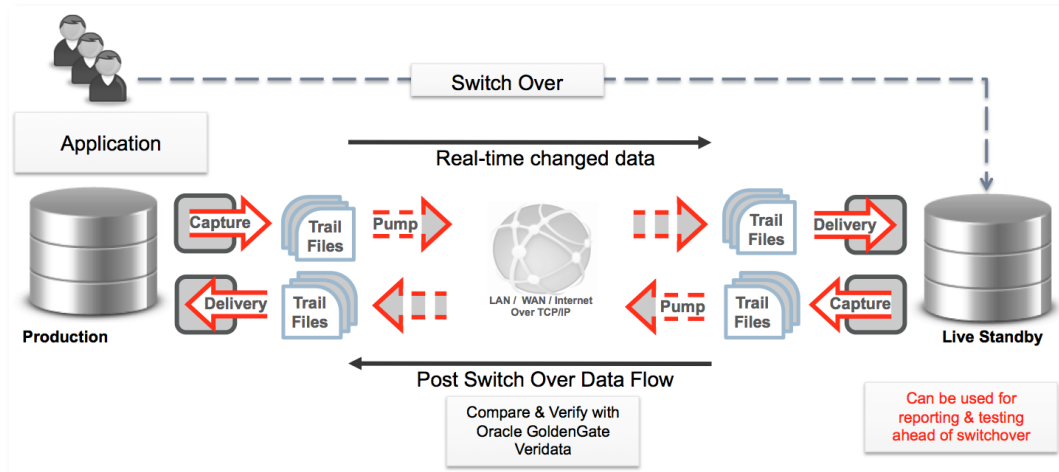

Figure 13. Oracle GoldenGate provides a robust solution for failover in the event of an unplanned outage.

Integration with Data Guard Fast-Start Failover (FSFO) provides automated and transparent failover of Oracle GoldenGate components with the failover/switchover of the primary database so your replication can continue without any manual intervention. In the instance of a failover/switchover, Oracle GoldenGate processes are started on the standby system during the role transition and insure that no data is lost during the switchover.

Real-Time Data Integration

As businesses work on turning big data into a competitive advantage for their organization they focus on integrating a wide variety of data to gain insight that can improve business operations. Some of the key customer -facing business operations require business insights that use the most current data to enable employees to take action with completely reliable and accurate information. When we consider that our fast-paced, highly-connected world now delivers large volumes of dynamically changing data from transaction systems as well as devices, immediate data capture, analysis and action becomes critical to retain the inherent economic value of this perishable data. To improve operational efficiency and effectiveness using big data, companies must now rely on business intelligence (BI) that uses timely operational information as well as historical context.

For data integration needs, companies have generally relied upon moving bulk data periodically to their analytical systems. The overhead of running bulk data extract processes impacts OLTP systems' performance significantly and typically requires downtime; therefore, this batch data extract is processed typically in the night when lower transaction volumes are expected. For many mission-critical systems that need to support users at or near 24/7 uptime, these batch windows can be a major issue, because they have to limit the time the systems are unavailable. As we face massive data volumes with the big data trend, IT teams might not be able to complete the extraction of data they need to move within the allotted time window. The same problem occurs if they need to restart the batch process for any reason; the allotted time window might not be adequate.

To overcome this dilemma, companies should avoid focusing on custom scripts or piecemeal bulk data handling solutions. Instead, they should adopt more-comprehensive approaches that combine both bulk data movement and transformation with real-time data integration to enable highly available systems and real-time BI.
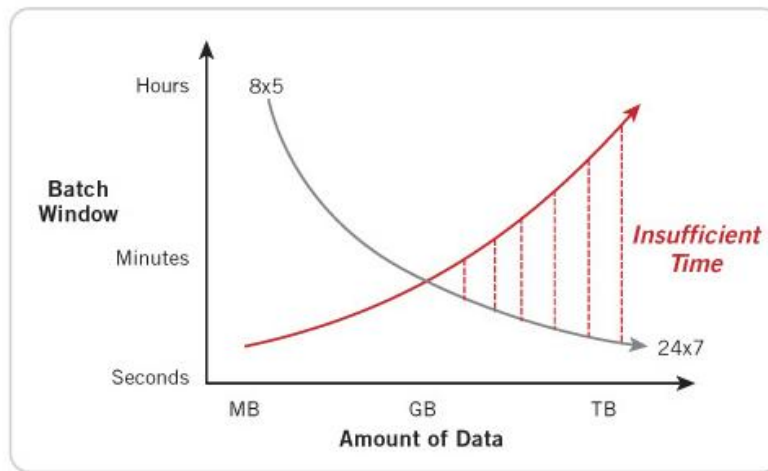

Figure 14. Transactional data volume has exceeded the point in which batch processing of data can be completed within the desired time window. Real-time changed data movement eliminates these risks and operates without business interruption.

Augmenting extract, transform, and load (ETL) systems with a real-time, log-based change data capture (CDC) solution enables IT teams to meet the requirements of mission-critical systems and better manage large data volumes. Through a log-based CDC approach, organizations can source data from OLTP systems without impacting performance and feed the ETL system with a continuous stream of real-time data. This method not only decreases data latency for BI systems, but it also eliminates the constraints of batch-processing windows, while allowing continuous operations for business-critical systems.

Customers worldwide are increasingly implementing Oracle GoldenGate for real-time data integration. Among the popular solutions from Oracle in this area are:

» Real-time analytics
» Operational reporting
» OLTP data integration
» Integrating with a public or private cloud

Deploying Oracle GoldenGate 12c for Real-Time Analytics

With its real-time, log-based CDC and delivery capabilities, Oracle GoldenGate complements Oracle Data Integrator Enterprise Edition. For real-time BI and data warehousing use cases, Oracle Data Integrator Enterprise Edition and Oracle GoldenGate offer together an end-to-end integrated solution that includes data quality and data profiling, and delivers low-impact real-time change data capture and high-speed optimized transformation and loading within the data warehouse. Oracle GoldenGate 12c and Oracle Data Integrator EE 12c are certified to support Oracle Exadata to enable real-time data warehousing solutions.

Oracle GoldenGate allows companies to implement real-time BI solutions, empowering a much larger number of front-line users across the enterprise to make better-informed operational decisions and create a sustainable competitive advantage.
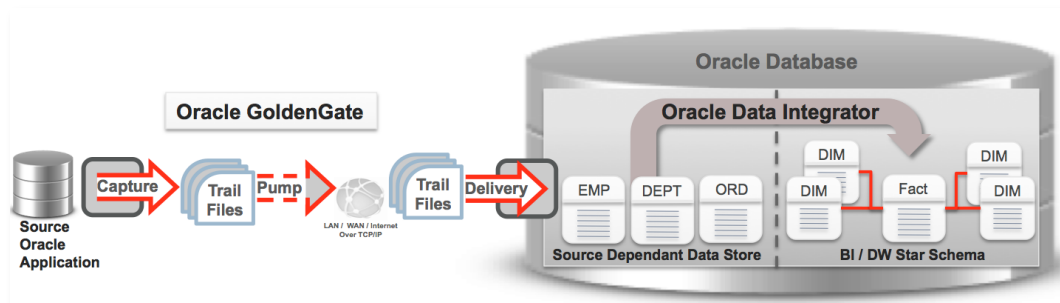

Figure 15. Oracle GoldenGate can rapidly populate data warehouses with real-time data without impacting system performance.

Oracle GoldenGate for Big Data Solutions

While gaining business intelligence from transactional data continues to be a dominant factor in the decision making process, businesses have realized that gaining intelligence from other forms of data, unstructured or semi-structured, enables them achieve a more complete view, address additional business objectives, and lead to better decision making.

When using other forms of data for analytics, better contextual intelligence is obtained when the analysis is combined with transactional data. Especially low-latency transactional data brings additional value to dynamically changing operations that day-old data, structured or unstructured, cannot deliver. In order to ensure an efficient supply of transactional data for big data analytics, there are several requirements that the data integration solution should address:

» Reliable change data capture and streaming mechanism
» Minimal resource consumption when extracting data from the relational data source
» Secured data delivery
» Ability to customize data delivery
» Support heterogeneous database sources
» Easy to install, configure and maintain

A solution which can reliably stream database transactions to a desired target enables that the effort is spent on data analysis rather than data acquisition. Also, when the solution is non-intrusive and minimally impacts the source database, it minimizes the need for additional resources and changes on the source database.

Oracle GoldenGate is a time tested and proven product for real-time, heterogeneous relational database replication and provides a variety of integration options to facilitate delivering transactions on relational databases into non-relational targets. As mentioned earlier in the "Delivery" section, Oracle GoldenGate for Big Data streams transactional data into big data systems in real time, without impacting the performance of source systems. It streamlines real-time data delivery into most popular big data solutions, including Apache Hadoop, Apache HBase, Apache Hive, and Apache Flume, and facilitates improved insight and timely action.

Oracle GoldenGate for Big Data Reservoir

Hadoop has become a popular environment for exploratory analytics without time-consuming modeling. It also offers end users with lower cost data staging and data preparation environment as well *as* for storing questionable business data.

Oracle's data integration products, particularly Oracle Data Integrator and Oracle GoldenGate for Big Data, provide the integration capabilities to enable staging in a Hadoop-based "Big Data Reservoir" to help customers make the most of their relational database systems. In the diagram below, you can see how Oracle GoldenGate for Big Data can enable Big Data Reservoir to stage and prepare data on less expensive Hadoop environments.
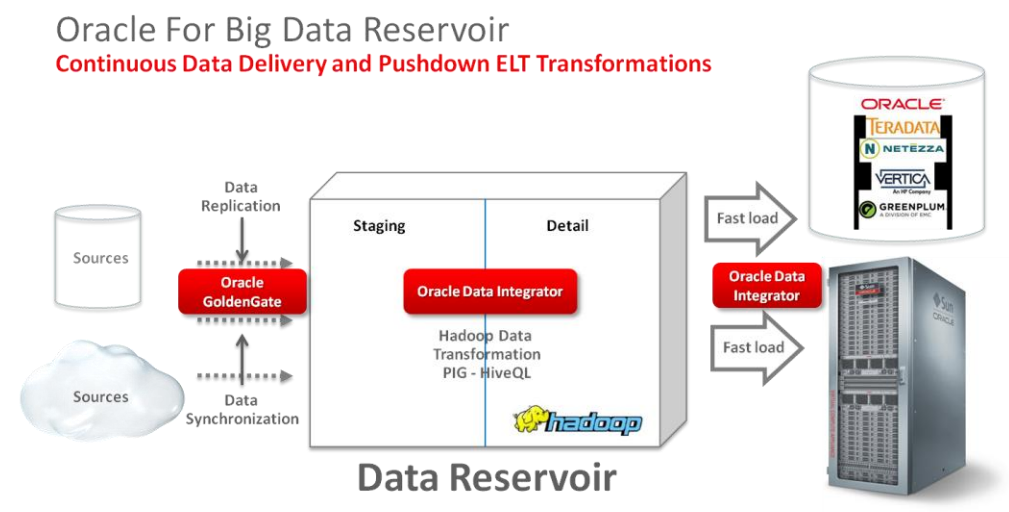
Figure 16. Oracle GoldenGate for Big Data delivers real-time transactional data to Hadoop environments to enable lower cost data staging and exploratory analytics

Deploying Oracle GoldenGate 12c for Operational Reporting

Many operational reporting activities ideally seek to use the latest data available, and that often means running reports against production databases, which degrades performance. With Oracle GoldenGate, a secondary, cost-effective system can be deployed to serve the purposes of real-time, operational reporting, freeing up the resources of the critical source systems.
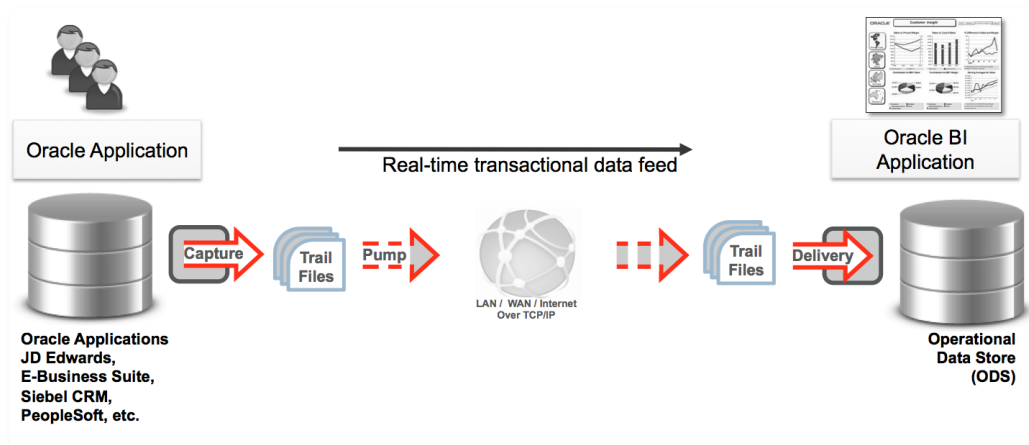
Figure 17. By continuously moving source data to a reporting database, users can access real-time information with no production impact.

Oracle GoldenGate 12c is certified to support operational reporting solutions for major Oracle applications including Oracle E-Business Suite, JD Edwards, PeopleSoft and Siebel CRM.

Oracle GoldenGate can complement other ETL products with real-time CDC capabilities to help customers realize better value from their existing investments. The solution reads changed data from database transaction logs, eliminates batch windows, and causes negligible impact on source systems while maintaining transaction integrity. Oracle GoldenGate persists changed data outside of the databases, which means the solution enables complete recoverability from failures in the case of an outage.

Oracle GoldenGate offers three different methods to augment ETL solutions:

» **Staging tables.** Oracle GoldenGate moves real-time transactional data from multiple production databases into staging tables within the data warehouse, at which point the ETL system pulls the data from the staging tables and loads the user tables after making any required transformations. This method is the recommended method for integration with Oracle Data Integrator Enterprise Edition. With Oracle Data Integrator's ELT architecture, there is no need for a middle-tier transformation server. This method optimizes performance and scalability and lowers overall solution costs. Oracle Data Integrator Enterprise Edition 12c offers an integrated design environment with Oracle GoldenGate 12c's log-based real-time change data capture and delivery capabilities.

» **Flat files.** Oracle GoldenGate writes the changed data into a flat file that is stored on a server of the customer's choosing. The ETL system reads from the flat file, performs the necessary transformations, and loads the data warehouse. Oracle GoldenGate can provide the data in a variety of formats to create the optimal feeding mechanism for existing ETL technology.

» **Messaging systems.** Oracle GoldenGate can publish changed data in real time from source OLTP systems to messaging systems. From there, ETL systems can receive the changed data in XML format, or any other customizable/user-defined format, in real time.

Deploying Oracle GoldenGate 12c for OLTP Data Integration

Oracle GoldenGate offers a solution for distributing and sharing timely data between transaction processing systems across the globe. Oracle GoldenGate distributes data in real time across Oracle and non-Oracle environments and enables access to consistent data across geographically dispersed data centers. In addition to

handling large and growing data volumes, this configuration allows continuous availability for business operations if one data center is not available.

This configuration is used heavily in global companies that have distributed systems and need to keep local databases synchronized in real time. For this purpose, Oracle GoldenGate provides a nonintrusive, fast-to-deploy method for moving data in real time, with minimal impact, using an architecture that is substantially easier to customize and maintain as application requirements change.

By deploying Oracle GoldenGate Application Adapters for Java Message Service (JMS), in conjunction with Oracle GoldenGate, organizations can publish changed data to JMS systems from heterogeneous transaction processing or analytical systems to support service-oriented architecture (SOA) and enable event-driven architectures (EDAs) and enterprise service bus (ESBs) architectures. This enhanced version of the product can integrate with Oracle SOA Suite with its ability to publish data to Oracle WebLogic Server, IBM WebSphere MQ JMS, TIBCO Enterprise Message Service, Red Hat JBoss, Apache ActiveMQ, and others.

Oracle GoldenGate Application Adapters also offers capabilities to capture from JMS messaging systems to deliver real-time data to heterogeneous databases. With this capability, Oracle GoldenGate can deliver real-time data integration solutions for legacy systems for which it does not offer log-based change data capture. Companies can publish transactional data from their legacy systems to an existing messaging infrastructure, from which Oracle GoldenGate can capture changed data in real time non-intrusively, and distribute across the enterprise with reliability and complete recoverability.

Integrating Public & Private Cloud Environments with On Premises Systems

Oracle GoldenGate offers real-time data replication between on premises databases and databases hosted on public cloud environments to enable reliable, secure and timely data integration.

Security is a key concern when replicating between cloud-based and on-premises instances. Oracle GoldenGate 12*c* is SOCKS5 compliant and can replicate to premise and cloud without a need to have an extra private VPN connection open. It leverages customers' SOCKS compliance setting and uses it for data transfer. This capability strengthens Oracle GoldenGate's support for today's hybrid IT environments.

There are three options to consider, which are outlined below. Depending on the options selected, the configuration of Oracle GoldenGate 12*c* may vary.

Option 1 – Secured network established between the cloud and on-premises

A secured network is established between the cloud and on-premises, which enables the database instances hosted in the cloud and on-premises to have seamless connectivity between each other irrespective of where they are physically located.
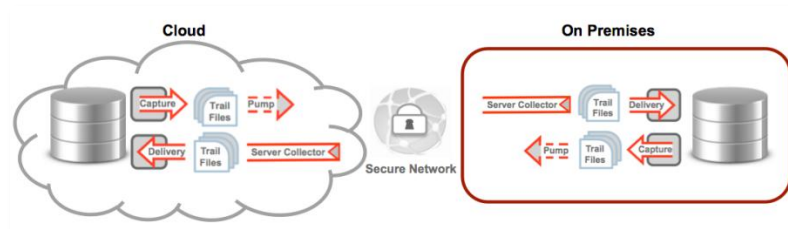
Figure 17.0. Secure Networks

Option 2 – Restricted network established between the cloud and on-premises

A restricted network is established between the cloud and on-premises instances which enables certain ports (required by replication) to be opened on both the cloud and on the on-premises instances and white lists the IP addresses of the cloud and on-premises instances.
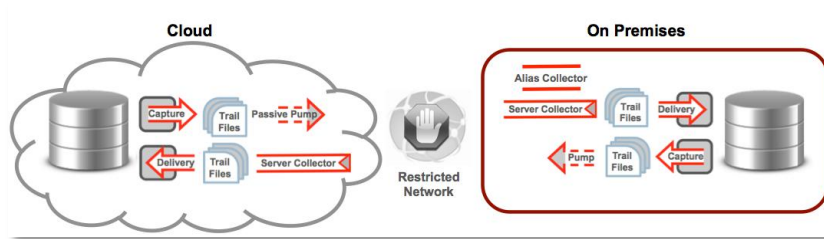

Figure 17.1. Restricted Networks

Option 3 – Restricted network access from on-premises and cloud through HTTP proxy

This option can be considered when the ports required by the applications (including replication software) are not open and the cloud instance is not white listed on the on-premises instance. This option of tunneling through the HTTP proxy may only be considered when proper security exceptions are obtained.
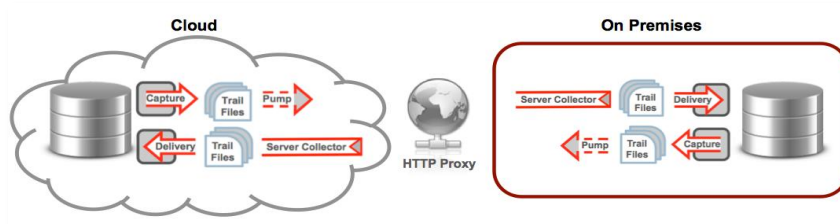

Figure 17.2. Restricted networks using HTTP proxy

For more information please review the knowledge article (ID - 1588484.1) titled ' Replicating between Cloud and On-Premises using Oracle GoldenGate'**.**

Implement and Expand

Fortune 1000 companies and other large business entities leverage the Oracle GoldenGate product and configuration solutions to manage critical initiatives in a range of business areas including real-time analytics, continuous availability, disaster tolerance, operational reporting for applications, cloud migration and integration, modernization and more. Oracle's technology is extremely versatile in its ability to meet a wide variety of today's and future business requirements. Leveraging the application's modular architecture and design, these organizations quickly scale their investment in Oracle GoldenGate across the enterprise as return on investment is achieved.

Table 2 highlights how Oracle GoldenGate deployments have progressed for three such customers in their pursuit of a robust, real-time data infrastructure.

TABLE 2. CUSTOMER SUCCESS: EXPANDING THE ORACLE GOLDENGATE FOOTPRINT ACROSS THE ENTERPRISE

Phase	SABRE HOLDINGS	BANK OF AMERICA	THOMSON REUTERS
1	**Query Offloading.** Created replica databases for its reservation system to offload travel search related queries to a lower-cost Oracle databases	**Continuous availability** Data generated by its 18,000+ ATM network is backed up in real time to multiple data centers for immediate failover.	**Active-active database replication across data centers.** Uses Oracle GoldenGate's conflict management capabilities in achieving continuous availability
2	**Zero downtime migration.** Moved different versions of Oracle Database, MySQL, and HP NonStop Kernel (NSK) systems—to Oracle Database 11*g* with Real Application Clusters. With zero downtime	**Zero-downtime upgrades** ATM business processes are kept online during large upgrade of production servers.	**Database comparison** uses GoldenGate Veridata for database comparison to ensure data integrity for its leading legal research solutions
3	**Real-time data warehousing.** Uses Oracle GoldenGate with Oracle Data Integrator to feed its Enterprise Travel Data Warehouse near real-time data to provide right-time market insights and drive new business opportunities		

Additional Oracle GoldenGate Features

In addition to its core modules and functionality, Oracle GoldenGate provides the following features and benefits to support a comprehensive real-time information environment.

Event-Based Processing

Using an event marker infrastructure (EMI), Oracle GoldenGate processes can act upon a specific database operation captured and stored in the Trail Files. For example, when a transaction that meets user-defined criteria is captured, Oracle GoldenGate can automatically start or stop Capture or Delivery processes, perform certain transformations, or provide statistics.

Beginning with Oracle GoldenGate 12c, event markers can now be triggered by DDL operations, and variables can now be passed into system shell scripts. Supported event actions include: TRACE, LOG, CHECKPOINT BEFORE, IGNORE, DISCARD, SHELL, ROLLOVER, REPORT ABORT, CHECKPOINT AFTER, FORCESTOP, SUSPEND, ABORT, and STOP.

This capability significantly improves Oracle GoldenGate's flexibility and manageability in a variety of use cases including:

» Automatic switchover to the secondary system during planned outages

» Better monitoring over source systems' performance and automated switchover to the standby system in case of an outage with the primary system

» Automatic switchover from initial load to changed data movement

- » Automatic synchronization of any type of batch processing taking place on both the source and target databases for database consistency
- » Automatic stoppage of the Delivery module to allow end-of-day reporting
- » Finding, tracking, and reporting on transactions that are of interest including the ones that do not have primary keys or transaction record numbers

Robust Data Security

Oracle GoldenGate 12c now supports Federal Information Protection Standard (FIPS) in addition to the default BLOWFISH encryption algorithms to provide secure data movement across systems and regions. FIPS compliant encryption can now be used for passwords, Trail File data, and across the wire communications and includes using crypto algorithms and key management/storage.

Conflict Detection and Resolution

Conflict detection and resolution are key prerequisites of active-active or multi-master database configurations. When both systems are processing transactions and the activity is shared across multiple systems, detecting and addressing data conflicts becomes an essential requirement.

Oracle GoldenGate provides a wide variety of options for avoiding, detecting, and resolving conflicts. These options can be implemented globally, on an object-by-object basis, based on data values and filters, or through event-driven criteria including database error messages.

Oracle GoldenGate offers conflict detection and resolution with a more complete framework that is more automated, and easier to implement than ever before. This is key when setting up conflict detection and resolution in complex environments using active-active and multi-master configurations.

Conflict detection and resolution takes less time to implement as there are now pre-built functions to identify the conditions under which an error occurs and how to handle the record when the condition occurs. Conflict detection and resolution is used the same way in all supported environments, which includes the following database platforms: Oracle, DB2 for z/OS, i Series, & LUW (Linux, Unix, Windows), SQL Server, MySQL, Sybase, SQL/MX, and Teradata.

For more information on this feature please consult Best Practices for Conflict Detection and Resolution in Active-Active Replication Environments using Oracle GoldenGate.

Dynamic Rollback

Oracle GoldenGate provides a Dynamic Rollback feature that eliminates the need for full restore; helps maintain large test databases, and enables point-in-time and selective data recovery.

Eliminate the Need for Full Restore

Oracle GoldenGate can perform selective back-out (reverse) processing on enterprise databases, eliminating the need for full restore operations that, for large databases, usually require several hours or more to complete. The Dynamic Rollback feature captures and uses "before" and "after" images to undo database changes for user-defined tables, records, and time periods. This makes it ideal when data becomes corrupted or erroneously deleted.

Maintain Large Test Databases

Dynamic Rollback is also very effective for maintaining large test databases. Administrators can restore a test database to its original state before a test run, enabling test cycles to occur more quickly against a predictable baseline of data. Since Dynamic Rollback can undo all changes, reverting the database takes a fraction of the time compared to a full restore.

Point-in-Time and Selective Data Recovery

Using the Capture module to retrieve the database changes that have been committed, Dynamic Rollback can be applied to reverse operations to a specific point in time. The data is then analyzed and prepared for rollback by inverting the order of the database operations retrieved. This guarantees that records with the same key will be properly applied when done so in reverse order. The before and after image indicator in each record is modified, delete operations are changed to inserts, and inserts are changed to deletes. Then, the begin and end transaction indicators are reversed to delimit each transaction. The Delivery module is invoked to apply the before images back to the database. Before executing, users can review the changes to be applied.

Customized Oracle GoldenGate Processing

Oracle GoldenGate 12c functionality can be customized to meet specific needs.

User Exits

User exits are custom routines that can be called at different points during processing. With user exits, customers can respond to database events when they occur without altering production programs. For example, users can perform arithmetic operations, implement archival functions, gather statistics, or use custom functions as an alternative to native data transformation functions.

Stored Procedures and Queries

Stored procedures and queries can be called from Oracle GoldenGate to perform custom operations in the database's native procedural language. They can execute a query and they can retrieve output parameters for input into Oracle GoldenGate's filtering and mapping functions.

Macros

Macros offer a way to easily reuse parameters, commands, and conversion functions. They enhance productivity by enabling users to implement multiple uses of a statement, consolidate multiple commands, and invoke other macros.

Initial Data Loads

Oracle GoldenGate can be used for real-time CDC as well as for the initial loading to instantiate a database. Oracle GoldenGate's initial load capabilities provide continuous uptime and allow the application to be introduced into the data environment quickly and effectively.

Oracle GoldenGate allows you to carry out an initial load across multiple systems non-intrusively and without downtime, in three steps.

» **Start Capture.** Places any changed data after its start in a Trail File. The Capture module acquires source data in arrays instead of rows for improved performance.

» **Snapshot Load.** Takes a snapshot from the source and loads it directly into the target.

» **Start Delivery.** Applies the data previously placed in the Trail File to the target to "catch up" the database until both are fully synchronized. Oracle GoldenGate can be configured to automatically switch to CDC after the initial load is completed.

Globalization

With the commitment for enhancing support for international implementations, Oracle GoldenGate 12c can now map and transform the data from databases using multi-byte/Unicode character sets. Oracle GoldenGate 12c is enhanced to support deployments in non-ASCII environments. This includes support for character set conversions between Oracle and non-Oracle databases of different character sets, database object names with any characters such as European accent, multi-byte, white space, and symbols as long as the database supports them. Database-like object-level case sensitivity support has also been added, which includes Oracle, DB2 for z/OS & LUW (Linux, Unix, Windows), and SQL/MX case sensitive object names as well as mapping case sensitive from/to case insensitive data stores.

Conclusion

To remain competitive, businesses need to be able to access transactional data across disparate systems without interruption, and then rapidly and accurately convert it into information that is readily available across the enterprise. This enables them to streamline their business processes, which helps to optimize customer service and capture market opportunities.

However, managing transactional data and ensuring its availability, accessibility, and accuracy is not a trivial task. Oracle is committed to providing the highest-quality real-time change data capture and replication software solutions that fully address the ever-evolving needs of mission-critical transactional systems. Oracle GoldenGate and supporting products are used to enable a range of IT solutions for thousands of companies today, spanning business needs for continuous availability and real-time data integration. The architecture of Oracle GoldenGate 12*c* allows for rapid deployment and enables Oracle to deliver real-time access to real-time information.

ÜBER HUNKLER

Das Karlsruher Systemhaus HUNKLER wurde 1988 erster offizieller Partner von Oracle in Deutschland. Ein Team von rund 20 Mitarbeitern unterstützt Kunden aus Industrie, öffentlicher Verwaltung, Gesundheits- und Finanzwesen mit Beratung, Lösungsentwicklung und Managed Services.

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