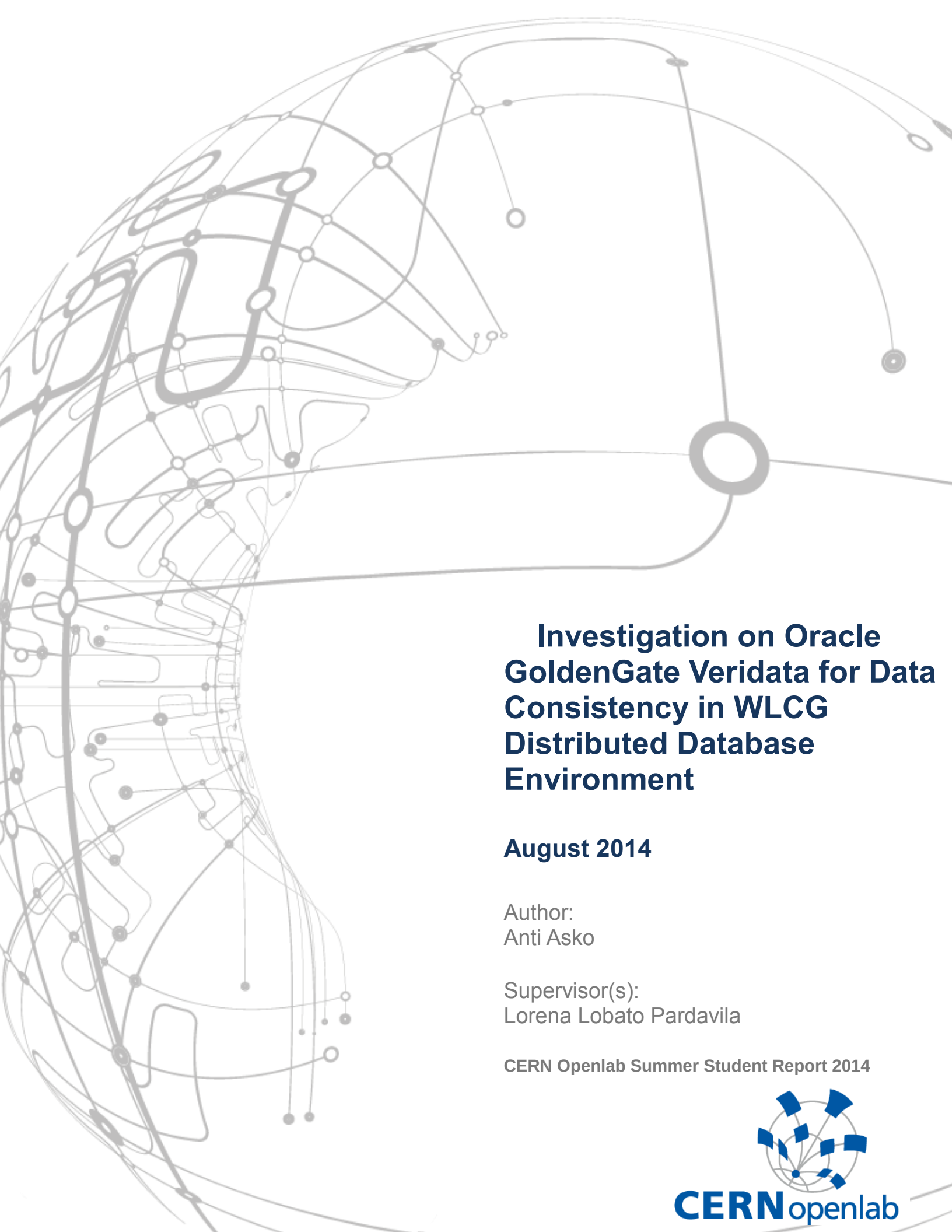

Investigation on Oracle GoldenGate Veridata for Data Consistency in WLCG Distributed Database Environment

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Abstract

In the distributed database environment, the data divergence can be an important problem: if it is not discovered and correctly identified, incorrect data can lead to poor decision making, errors in the service and in the operative errors. Oracle GoldenGate Veridata is a product to compare two sets of data and identify and report on data that is out of synchronization.

IT DB is providing a replication service between databases at CERN and other computer centers worldwide as a part of the WLCG project. One of the important and difficult tasks in provisioning of a reliable replication service is to measure and ensure consistency of data between databases. Oracle Veridata appears to be a promising solution for this challenge. The aim of the project is to evaluate the Oracle Veridata framework in the context of the WLCG database replication environment, to provide a study and feedback regarding functionality, usability and performance of the software for data consistency measuring between remote databases.

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1 Introduction

1.1. Worldwide LHC Computing Grid

The Worldwide LHC Computing Grid (WLCG) is a global collaboration of computer centres, which provides resources to store, distribute and analyse the generated data from Large Hadron Collider (LHC). WLCG is arranged in four layers, called Tier-0, Tier-1, Tier-2 and Tier-3. Tier-0 is CERN's datacentre, which is able to provide space for less than 20% of the grid's capacity. Tier-1 consists of 13 computer centers distributed worldwide. Tier-2 is formed by universities and scientific institutes, while Tier-3 includes individual scientists that have access to WLCG. With around 15 petabytes of data generated annually from the collider Tier-0 and Tier-1 can provide enough space for storing.

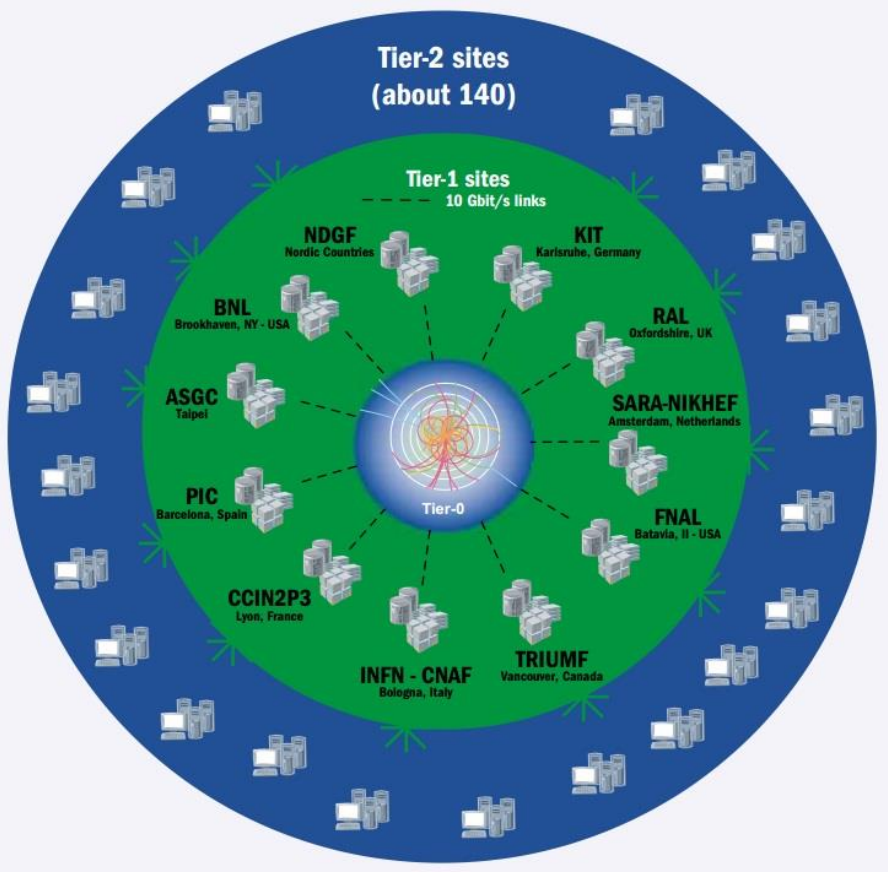


Figure 1. Worldwide LHC Computing Grid

1.2 Replication Process through WLCG

Data that is generated from the LHC is first stored in Tier-0 and then is being distributed to Tier-1s through replication processes. Until now, data replication was achieved with Oracle Streams. However, since 2012, Oracle Streams is phased out and no new enhancements will be developed. Oracle GoldenGate is the new replication tool proposed by Oracle and it functions in some of the Tier-1 datacentres. One of the most challenging parts on WLCG environment is data consistency from CERN to Tier-1s.

1.3 GoldenGate Veridata

As mentioned before, bad data among Tier-0 and Tier-1 may lead to wrong decisions and conclusions. Bad data may appear because of hardware malfunctions, connection problems etc. The requirement for data consistency between these two Tiers it is not a request but a necessity. Therefore, Oracle GoldenGate Veridata seems to be a promising solution for investigating data consistency and repairing discrepancies. GoldenGate Veridata is an easy-to-use tool that manages to identify out-of-sync data and in the new version optionally to repair it. It is cross-platform and is efficient of comparing data between divergent databases without affecting other ongoing operations.

1.4 GoldenGate Veridata Architecture

Before we go any further on how GoldenGate Veridata functions, its architecture should be inspected. The below diagram illustrates a detailed assemble of the GoldenGate Veridata's components. The two-way arrows indicate that all communications are duplex. It must be pointed out that GoldenGate Veridata repository, source and target databases can coincide on the same machine where GoldenGate Veridata components are deployed or on separate.

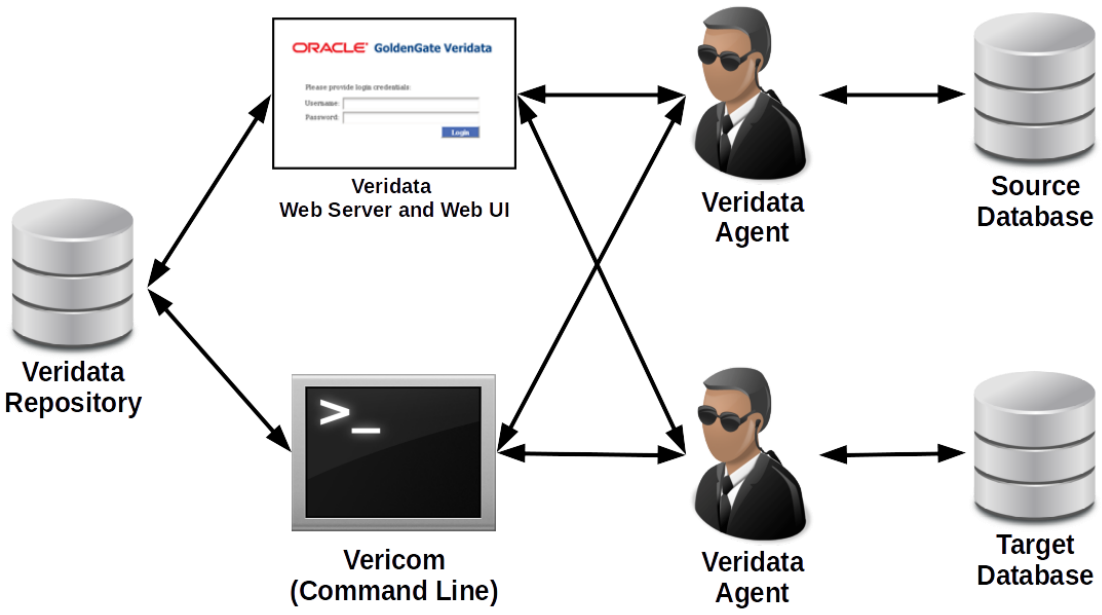


Figure 2. Oracle GoldenGate Veridata architecture

GoldenGate Veridata architecture consists of:

- GoldenGate Veridata server

The GoldenGate Veridata server coordinates all the tasks, sorts rows, compares the data between source and target database, confirms out-of-sync data and produces a report for review.

- GoldenGate Veridata web User Interface (UI)

GoldenGate Veridata web UI is a graphical user interface that is used for configuring comparison objects and rules, initiating comparisons, reviewing the status and output of comparisons, reviewing out-of-sync data and repairing them.

- GoldenGate Veridata repository

GoldenGate Veridata repository is a collection of database objects that persists configuration information, saving it permanently as a user environment.

- GoldenGate Veridata agent

GoldenGate Veridata agent is responsible for fetching and returning blocks of rows to compare, as well as returning column-level detail for out-of-sync rows on behalf of the GoldenGate Veridata Server. Also the agent hashes the row and then sends the row hash plus PK values to the Veridata Server for sorting and comparison.

- GoldenGate Veridata manager

The manager is part of the C-code based agent that is required for the Nonstop platforms. It controls the agents' process.

- GoldenGate Veridata Command Line Interface (CLI)

GoldenGate Veridata CLI or else called vericom is an interface that enables you to run comparisons, specify overrides and stop.

1.5 GoldenGate Veridata Compare/Repair Jobs

The most essential components of GoldenGate Veridata are comparing and repairing data. Therefore, we will go into details about these two components. GoldenGate Veridata classifies the compare and repair jobs in some categories. Compare and repair jobs are two separate entities of GoldenGate Veridata, but the categories are the same for both sets of jobs except the warning status, which is used only for repair jobs. The compare/repair jobs are categorized in real time through their execution and the categories are:

Icon	Status	Description
	Out-Of-Sync	It indicates that data in source and target are not synchronized. Furthermore, no repair procedures have been attempted yet.
	Pending	In this situation, the compare/repair job is waiting to be executed.
	Running	Indicates that the compare/repair job is being executed at this point.
	Warning	The question mark is used to warn the user that one or more rows could not be repaired during a repair job.
	Cancelling	The user has the option to cancel the compare/repair procedure, so this sign is shown while GoldenGate Veridata attempts to cancel a job.
	Cancelled	When the compare/repair job has finally stopped, GoldenGate Veridata displays the cancelled icon.
	Errors	If the compare/repair job was not possible to be executed, GoldenGate Veridata indicates that there have been errors during the procedure. *
	Successful	Finally, if no issues have indicated, GoldenGate Veridata informs the user that the data is in-sync or the repair job was successful.

*The most common reasons why errors can be initialized are:

- No privileges have been granted to the GoldenGate Veridata user for altering the target database when attempting to repair out of sync data.
- The proper agent could not connect to source or target database. In this situation, the most common problem is inaccurate connection essentials (username, password etc.), so the connection configuration should be checked.
- Issues may exist in the database of the source or the target and as a result, the connection establishment is denied (e.g. database query failure).

1.6 Release 12c (12.1.3)

In addition to the previous information about GoldenGate Veridata, the new features should be mentioned. GoldenGate Veridata 12c was released on June 2014 with some additional features from the previous release (11.2.0). Some of the most important new features are:

- Repairing out-of-sync data

As mentioned before, one of the most important new features is the ability to repair out-of-sync data between heterogeneous databases. Previous releases of GoldenGate Veridata have been only able to demonstrate the out-of-sync data. Release 12c gives the possibility to repair them.

- Scripting tool

With the scripting tool you can create XML files that can be used to configure GoldenGate Veridata. Scripting can create reusable configurations and can reduce the time required to define repetitive tasks.

- IPv6 support for java agents

Previous releases of GoldenGate Veridata supported only IPv4 for the java agents. The new release now provides IPv6 support too.

- Purging old reports

This new feature helps you with deleting unwanted reports from previous jobs to keep the report volume and disk space in control.

- Single sign-on support

Single sign-on provides the user with logging in once and gaining access to all GoldenGate Veridata tools without being prompted to log in again.

- Security enhancements

New security roles were added for the users in order to control their access in GoldenGate Veridata. Moreover, support for Secure Sockets Layer (SSL) communication between Veridata Server and Veridata Agents was added.

- Report encryption

GoldenGate Veridata now provides the option to encrypt the report files of the comparisons between the source and the replicated databases.

- Installation using Oracle universal installer

From this release, GoldenGate Veridata is a part of Oracle Fusion Middleware. Oracle Fusion Middleware is a platform for the enterprise and it consists of certain Oracle products. For this reason, GoldenGate Veridata 12c uses Oracle Universal Installer for the installation and configuration process.

- Installation process

GoldenGate Veridata 11 was operating through TomCat server. On the contrary, GoldenGate Veridata 12c, as part of Oracle Fusion Middleware is using Oracle WebLogic server. WebLogic is an application server developed by Oracle.

2 Configuration Steps

As a result of the architecture which GoldenGate Veridata adopts, there are some configuration steps the user must follow before comparing process is accessible. Below you can observe the steps in detail.

2.1 Deployment and configuration of Agents

First of all, Java agents or C-agents (C-agents are only supported for NonStop SQL/MP and Enscribe databases running on NonStop platforms) are used for the connection between databases and GoldenGate Veridata server. Agents must be deployed and configured with the **server port** from where the agent will communicate with GoldenGate Veridata server, **database url string** and the proper **jdbc driver version** for the database connection. The number of the source or target databases must be equal to the number of the deployed agents. The agents can coexist in the same machine with the database they serve or in separate.

```
# Copyright (c) 2011, 2014, Oracle and/or its affiliates. All rights reserved.
# The server.port property is the port where the Veridata agent listens
# for connection requests.
server.port=<server.port>

# The database.url specifies the JDBC connection URL for the database.
# Samples for all supported databases are shown below.
database.url=<database.url>

# drivers can be specified.
server.driversLocation = drivers

# The database.additional.repair.warnings is a list of DBMS specific error
# numbers/codes that should be considered as a warning if it is raised when
# For Oracle uncomment the following line:
server.jdbcDriver=ojdbc7.jar oracle.xdb_12.1.0.jar
```

Figure 3. Connection details to the corresponding database

2.2 Connection Configuration

In order to achieve comparisons between databases, GoldenGate Veridata needs to establish connections for both source and target databases. Following the GoldenGate Veridata's menu through:

Configuration ➡ Connection Configuration ➡ New…

While the agents for each database are deployed and functioning, the user can establish new connections filling in the proper information, in separate forms, for the source and target databases.

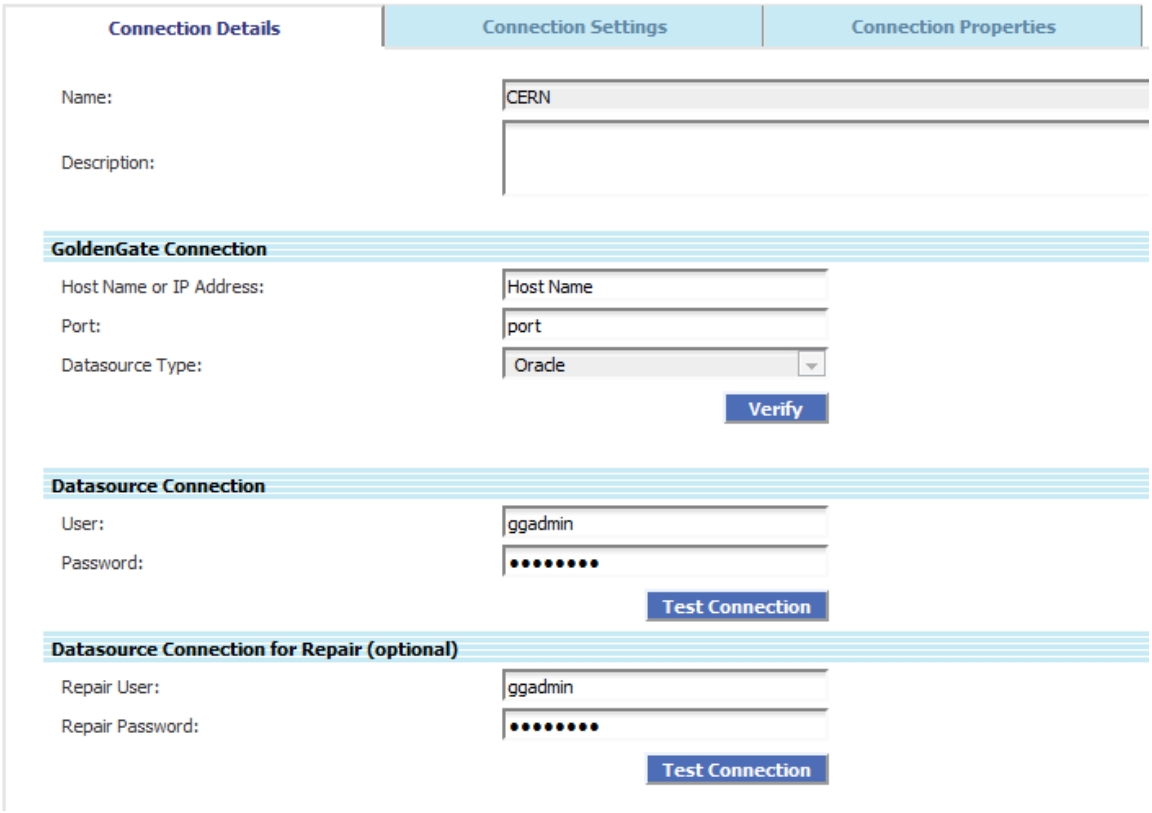


Figure 4. Connection details to the corresponding database

2.3 Group Configuration

After connections are established, compare groups must be formed. Group configuration is the establishment of compare groups that are linked to source and target databases. A compare group is a logical container for organizing the objects to be compared. A new group can be configured through the menu following:

Configuration ➡ Group Configuration ➡ New…

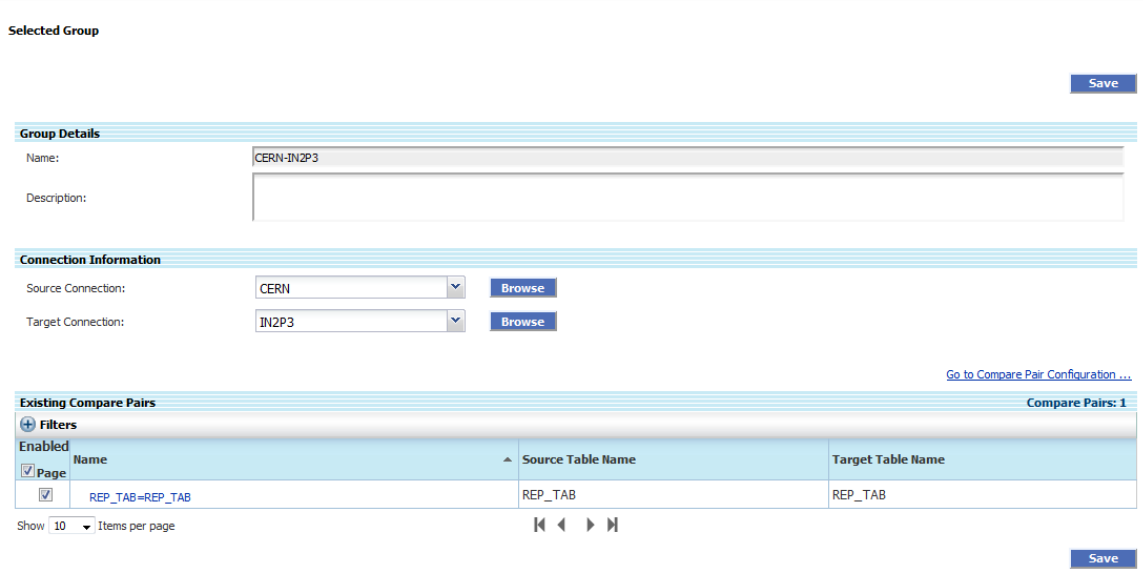


Figure 5. Group creation between CERN (source) and IN2P3 (target)

2.4 Compare Pair Configuration

After a compare group is created, compare pairs must be formed. A compare pair is a set of data tables or files between the source and the target databases. The user can create or manage compare pairs through:

Configuration ➡ Group Configuration ➡ Go to Compare Pair Configuration

As part of configuring a compare pair, source and target tables are mapped in order to establish a structural relationship between the objects. Compare pairs can be generated automatically through pattern mapping or can be manually deployed by the user choosing one by one the tables from the source and the target.

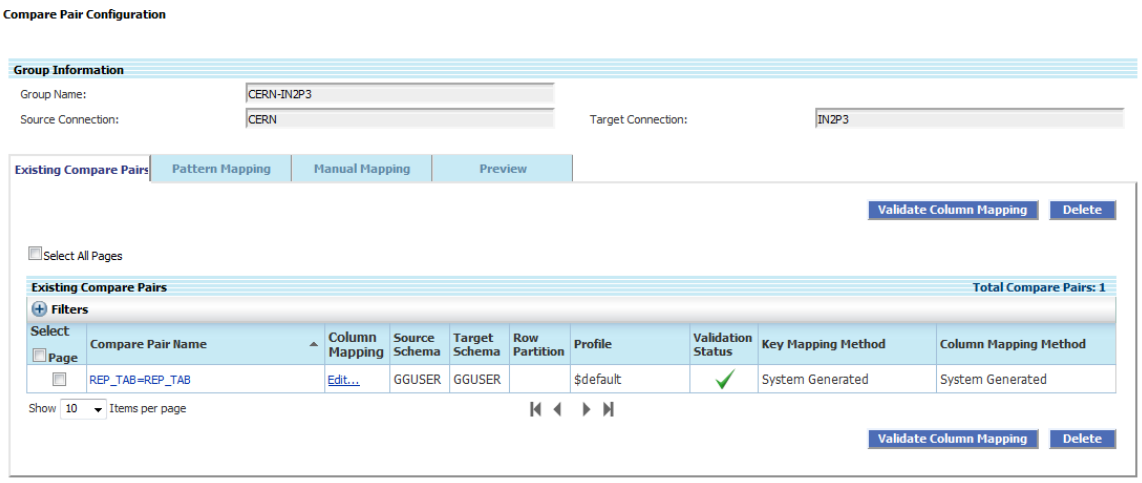


Figure 6. Established compare pairs between CERN (source) and IN2P3 (target)

2.5 Job configuration

Finally, the user has to produce the comparison job. A job is a logical container for one or even more compare groups and is the unit by which comparison processing is executed. The user can define a new job following the menu through:

Configuration ➡ Job Configuration ➡ New…

Jobs give the potential to manage and run large volumes of compare groups across numerous databases and systems, while the user can control the timing of the comparisons.

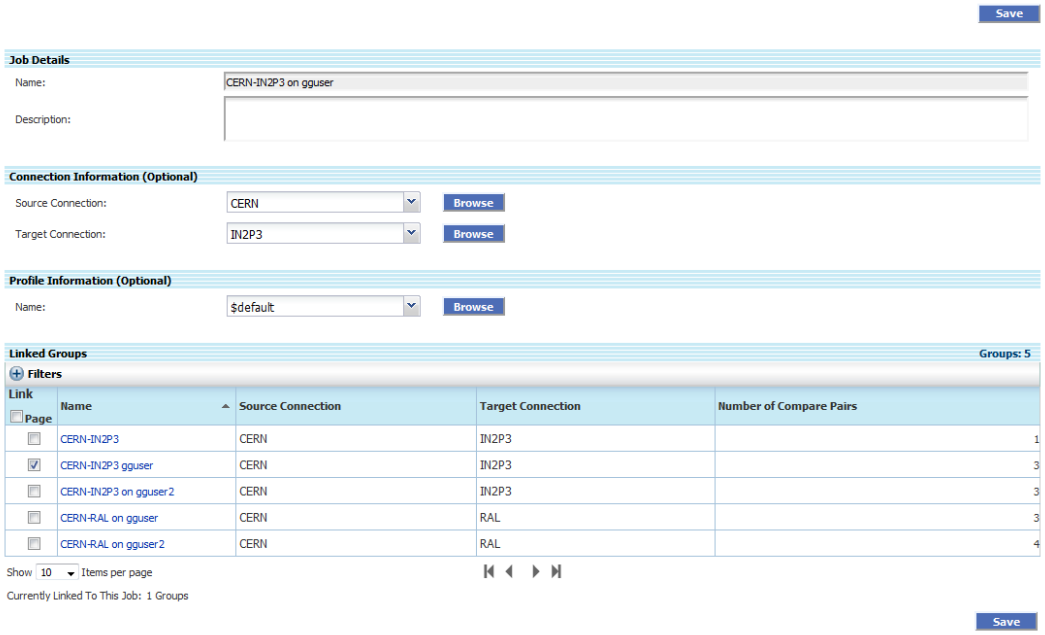


Figure 7. Job configuration and linked groups

2.6 Run/Execute a job

Through run configuration, a job that was previously created is selected and the compare pairs are displayed. The user has also the ability to choose which compare pairs will be examined. A job can be described as:

- Failed: In this condition the comparing could not be executed at all. This could be because:
    - The proper agent could not connect to source or target database. In this situation the most common problem is inaccurate connection essentials (username, password etc.), so the connection configuration must be checked.
    - Issues may exist in the database of the source or the target and as a result the connection establishment is denied (e.g. database query failure).
    - There were no mappable columns. In this situation some of the compare pairs were not mapped due to lack of primary key, unique key or a user defined unique key. In this case the user has to define a unique key column or the comparing will not be possible.
- In-sync: The data of the target database is synchronized to the data of the source database.
- Out-of-sync: There are discrepancies between the source and the target.
- Cancelled: The job was running but it was ceased by the user.
- Running: The job is being executed at the moment.
- Waiting: The job is in queue and soon will be executed.

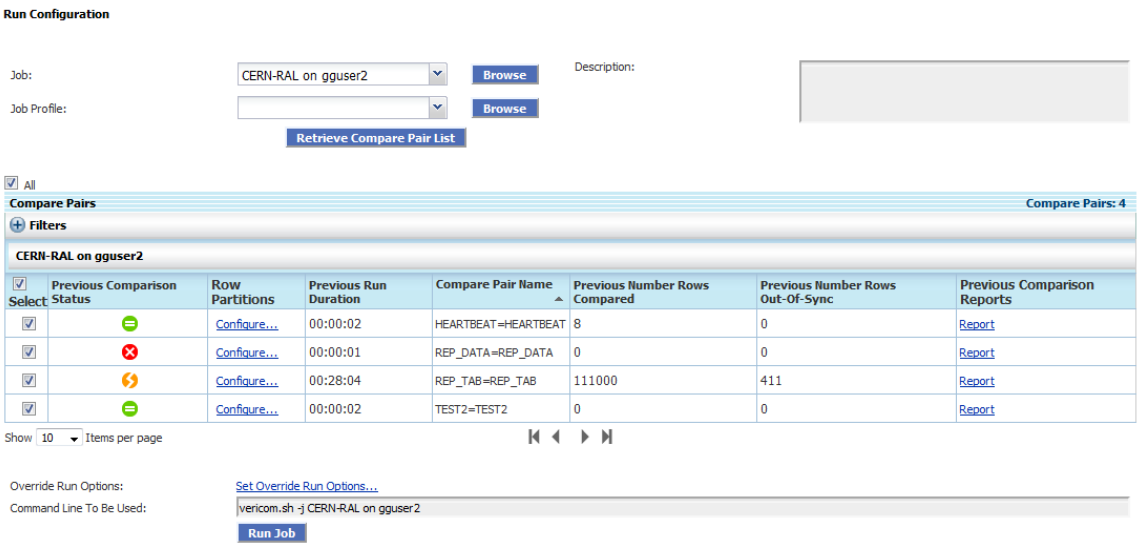


Figure 8. Run configuration and compare pair selection

While jobs are being executed, the user can observe the compare pair status in real time. The status is being refreshed occasionally without the user's interference.

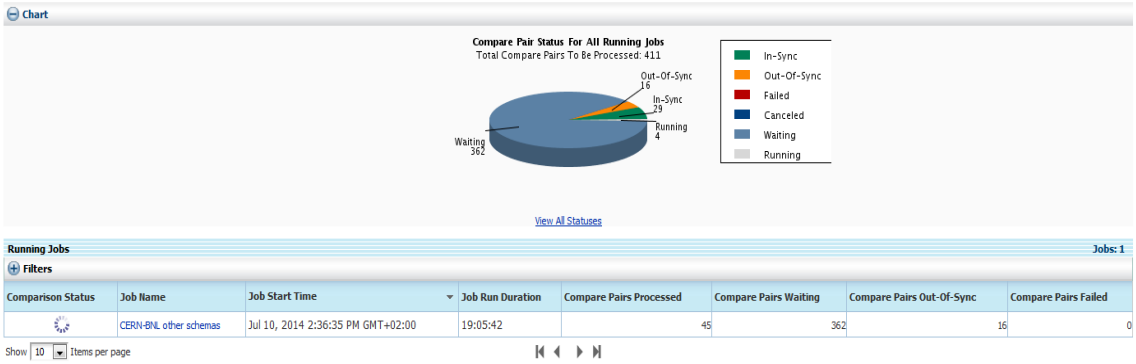


Figure 9. Compare pair status for all running jobs

2.6.1 Compare Process of a Running Job

The compare process is divided in steps. The first step is the initial compare. During the initial compare, the agents retrieve table rows from the source and the target, hash the row and send the key columns plus this unique digital signature for the entire row to the Veridata server for sorting and comparison. The outcome of the initial compare is a Maybe Out-Of-Sync (MOOS) queue and the rows' status is yet to be confirmed.

In the Confirm Out-Of-Sync (COOS) step, accurate results are ensured by confirming row status in a changing environment. The status is evaluated as one of the following:

- In-flight: due to latency, the row was out-of-sync in the initial comparison step, but has been updated. In this case, it is assumed the replication or another mechanism applied the change, but GoldenGate Veridata was unable to confirm if the rows are in-sync.
- In-sync: the source row values were applied to the target's row. Even a status of in-sync does not guarantee that the rows are synchronized at any particular moment if the tables are continuously changing, but it indicates that replication process is working.
- Persistently out-of-sync: the row has not been updated since the initial comparison and therefore can be assumed to be out-of-sync.

Confirm Out-Of-Sync (COOS) step occurs parallel to the initial comparison step, but the confirmation waits for specified replication latency (e.g. 60 seconds). After replication latency expires, rows are confirmed as persistently out-of-sync.

3 Finished Jobs and Results Reports

After the execution of a job, GoldenGate Veridata displays the results through reports and charts. GoldenGate Veridata has the ability to represent general charts for all finished jobs but it can also represent detailed reports for every job separately.

3.1 General Results

Some of the information that is represented in the general results is the total compare pairs that were processed and the amount of the failed, in-sync, out-of-sync and cancelled compare pairs.

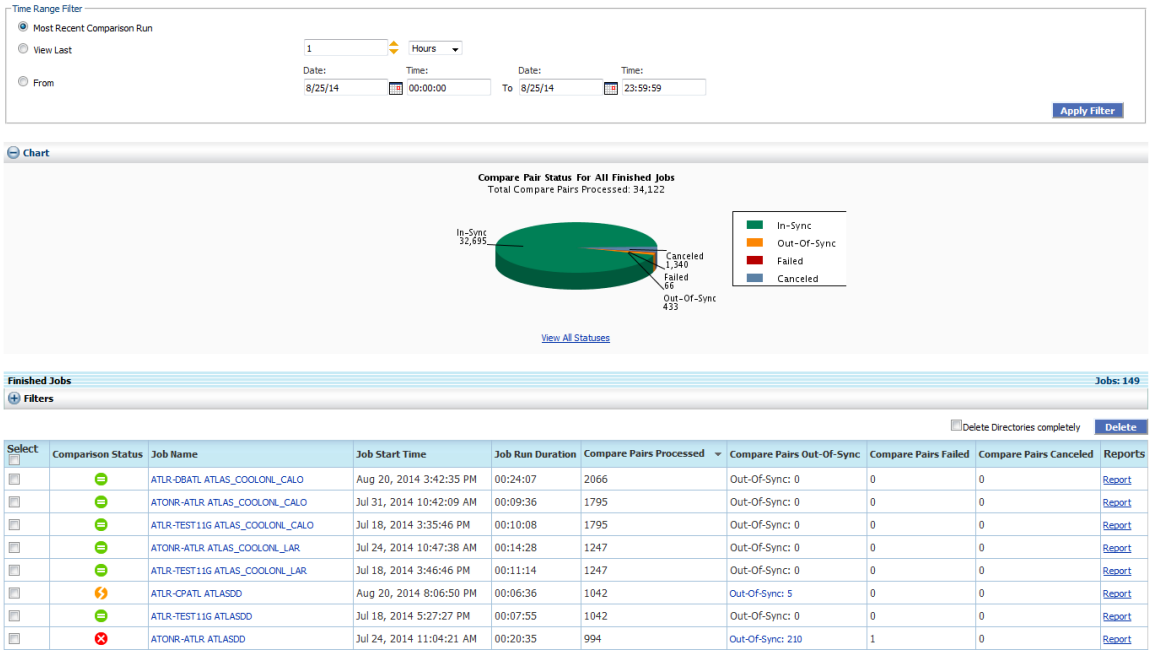


Figure 10. General results and chart from previous jobs

Moreover, below the chart, the user can observe a detailed list of all completed jobs. The user is able to filter the list with some advanced criteria such as the comparison status of the jobs, the name of the jobs etc. Furthermore, he can drill in and display specific columns of concern.

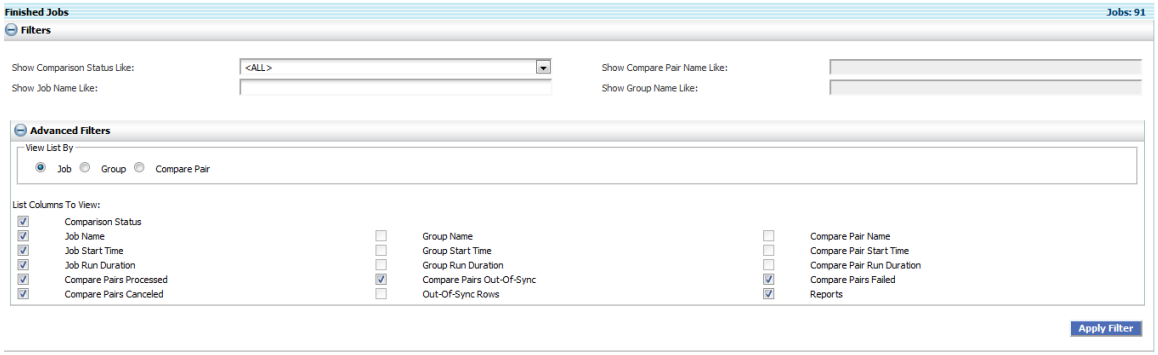


Figure 11. Advanced filtering of finished jobs

3.2 Compare Pair Status

GoldenGate Veridata is also capable of displaying further details for every compare pair that has been executed before. In more detail, the run duration and the amount of comparisons performed between the two tables are displayed. In addition, the out-of-sync column represents the exact number of rows that are not synchronized and the reports column redirects to a detailed report the further breaks down the timing, bytes, throughput, and other low level details. Lastly, if you mouse over the red failed icons a tool tip will display the exact error of failure.

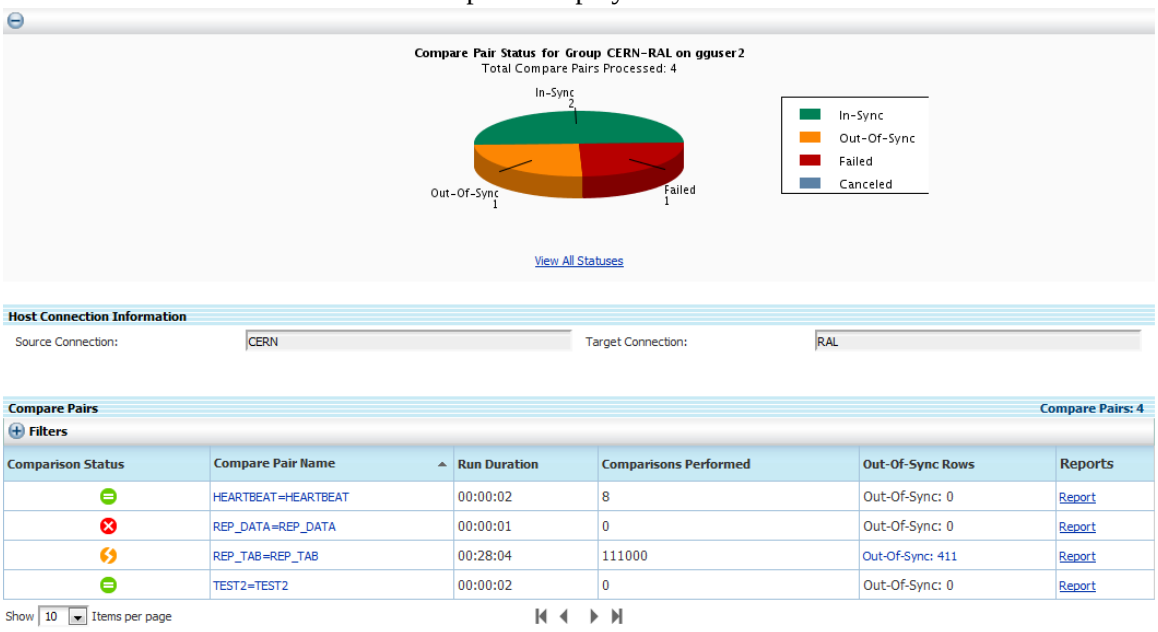


Figure 12. Specific results and chart for an executed job

3.3 Performance History

GoldenGate Veridata also represents the performance history of a specified compare pair. The user can view the performance history by the sorting step, the initial compare step or the confirm out-of-sync step. Furthermore, performance history can be viewed by the amount of rows or bytes that were processed during the comparing process and by the average number the rows or bytes that were processed per second. Finally, the user can review a graph with the run duration of every previous execution.

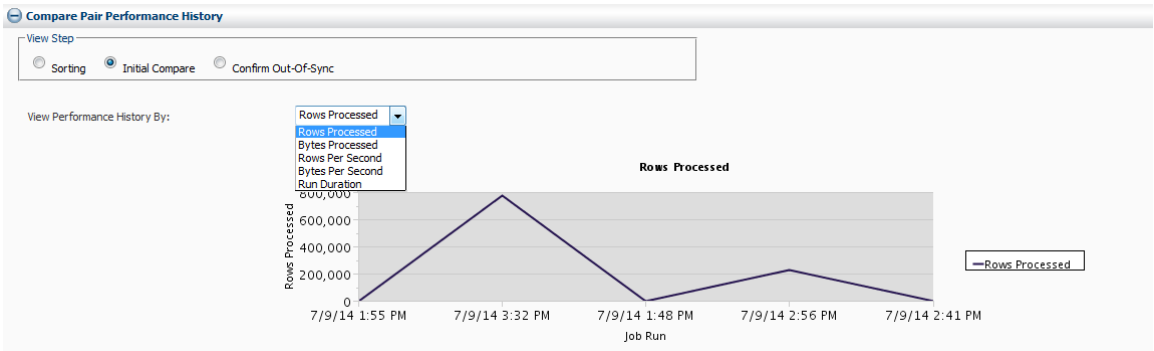


Figure 13. Compare pair performance history

3.4 Detailed Reports

GoldenGate Veridata stores detailed reports for every job that has been executed. A report displays the status of the compare pairs (in-sync, out-of-sync, failed, and cancelled), details about GoldenGate Veridata (version etc.), details about the server (operating system, architecture etc.) and useful information for the process. Detailed reports are stored in .rpt file extension and the user is able to download them for general use.

```
********************************************************************
                    Oracle GoldenGate Veridata
          12.1.3.0.0  OGGVDT_12.1.3.0.0_PLATFORMS_140616.1904

Copyright (C) 2004, 2014, Oracle and/or its affiliates. All rights reserved

           Starting Comaparison Group at 2014-07-15 15:06:19

********************************************************************

OS          : Linux
Version     : 2.6.18-371.el5
Node        : ----------------
Machine     : amd64
Process id  : 21914, Thread id : 425
Java version: 1.7.0_60
Java vendor : Oracle Corporation


Group: cern-in2p3 (1) Compare Pairs


Performing 1 comparisons ...
    Compare pair: HEARTBEAT=HEARTBEAT

2014-07-15 15:06:19. Submitted (1 of 1) Compare Pair (HEARTBEAT=HEARTBEAT) RunId (1199,1,1).

2014-07-15 15:09:35 Completed with 6,930 out-of-sync. Compare Pair (HEARTBEAT=HEARTBEAT). (0) Remaining

Compare Pairs with Errors: 1
Compare Pairs with Out-Of-Sync: 48
Compare Pairs without Out-Of-Sync: 81
Compare Pairs Cancelled: 281

Group terminated normally.
```

Figure 14. Detailed report for an executed compare pair

Last but not least, GoldenGate Veridata displays the out-of-sync rows with the differences in content between source and target.

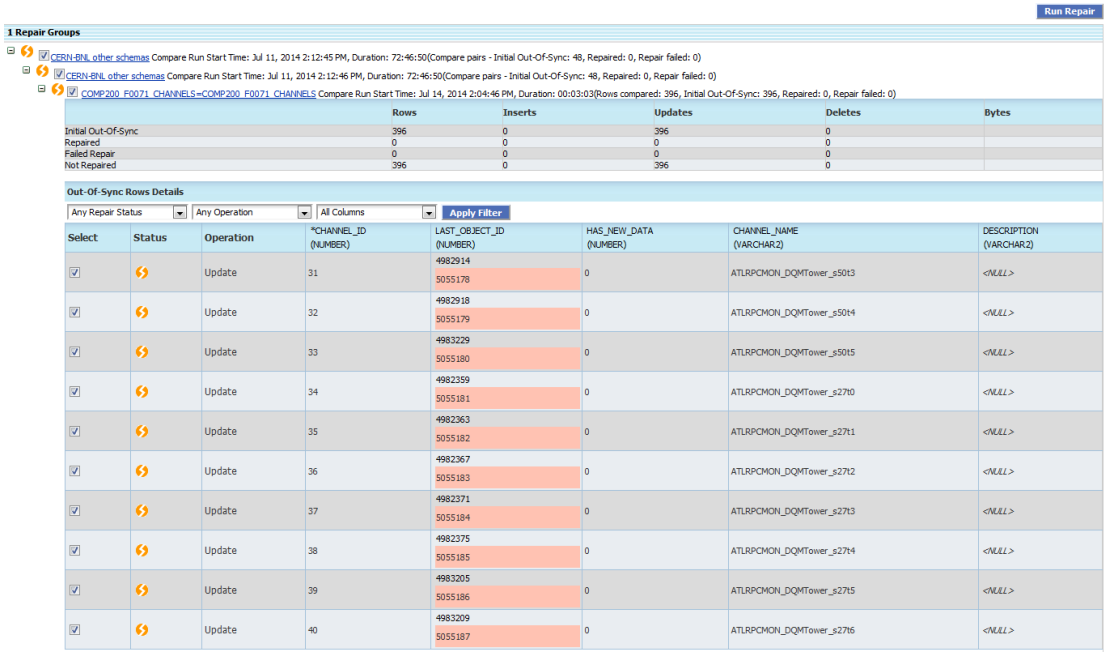


Figure 15. Out-of-sync rows details

4 Repair Job

In the previous releases, GoldenGate Veridata was able only to represent the results of a comparison. GoldenGate Veridata 12c grants the option of repairing the unsynchronized rows.

4.1 Repair Process

After a job is completed and discrepancies exist, GoldenGate Veridata is adequate of repairing out-of-sync data. The repair job finds the differences between the source and the target, recognizes the operation that is needed and it executes it. Once the repair process is successful, the selection checkbox is replaced with the repair timestamp, which links to a detailed repair job.

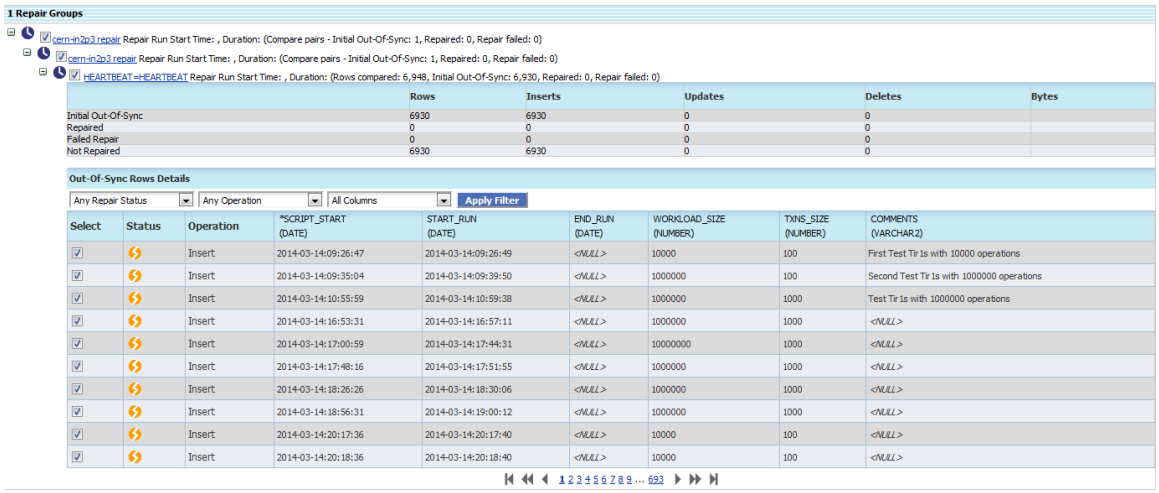


Figure 16. Repair job in progress

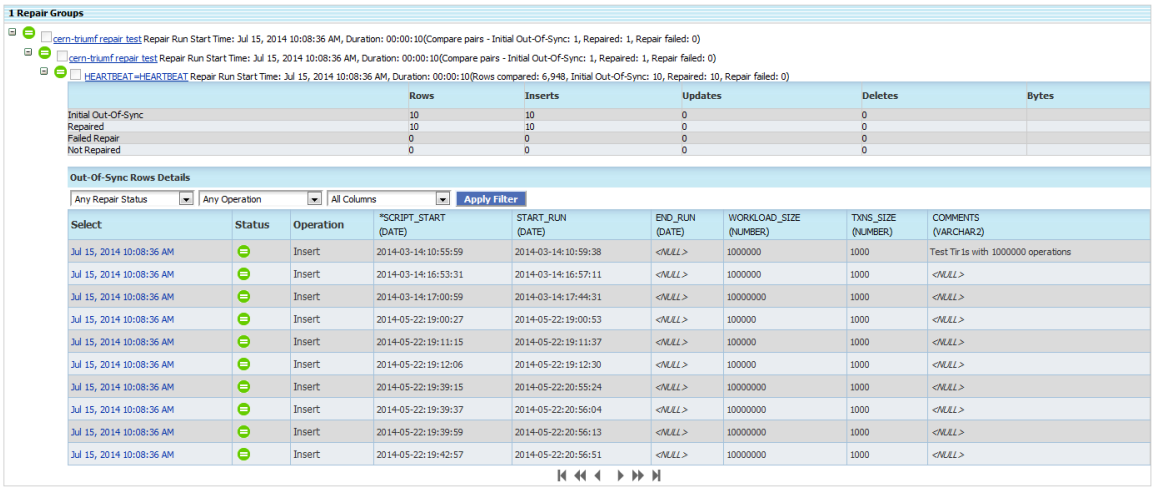


Figure 17. Successful repair job

5 Evaluation in Real Results.

In order to properly evaluate GoldenGate Veridata, we tested it through different WLCG conditions. In the first use case, CERN and 4 Tier-1 datacentres were used for the test evaluation process. Afterwards when the test process was successful, GoldenGate Veridata was used in real production data of ATLAS experiment.

5.1 Evaluation Process

In relation to what was mentioned before, Oracle GoldenGate is being used for replication between CERN and the 4 Tier-1s datacentres while GoldenGate Veridata confirms the consistency of the data. For this reason, in our use cases the connections we established were:

TIER-0 (CERN):

- NODE
    - Is a node on CERN's datacentre, which we used for the deployment of GoldenGate Veridata and the agents, which were responsible for the databases connections.

- ATONR
    - Is the online database of ATLAS experiment and the first storing place of ATLAS' data.

- ATLR
    - Is the offline database of ATLAS experiment where the data from the online database (ATONR) is replicated for general use and distribution to the Tier-1s.

TIER-1s:

- IN2P3
    - Founded in 1971, IN2P3 is a research institute of the National Centre of Scientific Research. Deployed in Lyon, France, IN2P3 provides storing and computing power for the LHC's experiments.
- BNL
    - Brookhaven National Laboratory is a national laboratory established in 1947. BNL is deployed in New York, U.S.A.
- RAL
    - Operated by Science and Technology Facilities Council in Oxfordshire, U.K., Rutherford Appleton Laboratory provides storing space and computational energy to LHC experiments.
- TRIUMF
    - Is the national laboratory for particle and nuclear physics of Canada. TRIUMF is located in Vancouver, Canada.

5.2 Case 1: Testing Process

During the testing process two schemas, GGUSER and GGUSER2 were produced in the NODE and the Tier-1s. Through scripts, we injected data in the two schemas and we replicated to the specified Tier-1s with Oracle GoldenGate. Simultaneously, GoldenGate Veridata was checking the data from source (NODE) and the targets (RAL, IN2P3, BNL, TRIUMF). These two schemas are consisted of three tables:

- HEARTBEAT: contains the precise information of the scripts running and it contains the bellow columns:

Column	Description
SCRIPT_START	It is a date type variable that stores the exact date of the script initialization. Furthermore, SCRIPT_START column is the unique key of the table.
START_RUN	It is a date type variable which indicates the moment the script starts the execution.
END_RUN	It is a date type variable which stores the time the script was completed.
WORKLOAD_SIZE	Contains the number of operations were introduced to the script.
TXNS_SIZE	Contains the size of the TXNS.

- REP_DATA: contains the fake data which was used on the script workloads:

Column	Description
VCOL	It is a Varchar2 data type and it is used as fake data in the script workloads.
RCOL	It is a RAW data type and it is used as fake data in the script workloads.

- REP_TAB: is the main testing table. The data of the workloads is stored in this table in the source database and at the same time was being replicated to the target data centers:

Column	Description
COL1	It is a number type column and it is the primary key of the table.
COL2	It is a number type
COL3	It is a timestamp data type in which the time of the executed operation is stored.
COL4	It is a varchar2 data type and is the fake data which is used from the script.
COL5	It is a RAW type and is the fake data which is used from the script.

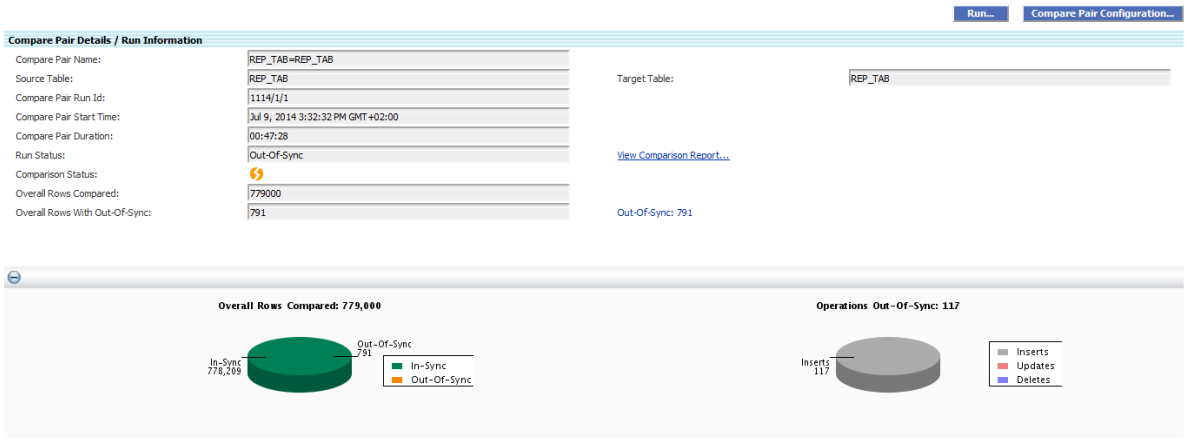
Various compare and repair jobs were created for a detailed evaluation of GoldenGate Veridata and its possibilities. A compare job was chosen to be demonstrated in order to represent a more realistic situation of how GoldenGate Veridata operates. A workload was used for the testing procedures:

The workload executes Data Manipulation Language (DML) operations on REP_TAB table. The tester submits an integer (e.g. 1000) and the script executes 1000 operations per command (1000 inserts, 1000 updated, 1000 deletes). Moreover a loop is used to remove a row every 1000 operations.

Concurrently, GoldenGate Veridata checks the consistency of the data which is being replicated. This means we are capable at the same time to validate the potentials of GoldenGate in replication and the precision of GoldenGate Veridata in data status.

While a workload of 1.000.000 was implied the results were:

- The compare procedure lasted 00:47:28 (hh:mm:ss).
- Number of overall rows compared was 779.000.
- Number of overall rows out-of-sync was 791.
- Number of overall rows in-sync was 778.209.
- Out-of-sync operations were 117 inserts.



	Sorting (Source)	Sorting (Target)	Initial Compare	Confirm Out-Of-Sync
Start Time:			7/9/14 3:32:46 PM	7/9/14 3:32:59 PM
Run Duration:			00:00:13	00:47:02
Rows Processed:	0	0	779000	81000
Rows Per Second:	0	0	59720	28
Bytes Processed:	0	0	18584895	3888000
Bytes Per Second:	0	0	1424784	1377

Figure 18. Compare pair details and run information

As it can be observed from figure 18 the duration difference between the initial compare and the confirmation process is notable. The duration of initial compares lasted only 13 second with a rate of 59.720 rows per second, while the confirmation process lasted for 47 minutes with a rate of 28 rows per second. This occurs because the rows during the initial compare are not compared value for value, while in the confirmation process are.

After a month of several test workloads the results were positive. GoldenGate Veridata was able to check the consistency thoroughly without any difficulties. There were no complications or failures. Essentially, the testing process of GoldenGate Veridata was considered successful and the migration in real production was decided.

5.3 Case 2: Real Production Data

The migration from Oracle Streams to Oracle GoldenGate in real production was first established to ATLAS offline and online databases. After intervention was successfully completed and replication was initialized with Oracle GoldenGate, the consistency of production data was investigated with GoldenGate Veridata. Connections, groups, compare pairs and jobs were configured for the source (ATONR) and the target (ATLR). The compare process was achieved through 25 different jobs as it is shown below.

Comparison Status	Job Name	Job Start Time	Job Run Duration	Compare Pairs Processed	Compare Pairs Out-Of-Sync	Compare Pairs Failed	Compare Pairs Canceled	Reports
	ATONR-ATLR ATLAS_COOLONL_TDAQ	Jul 31, 2014 11:13:47 AM	04:14:41	371	Out-Of-Sync: 2	0	0	Report
	ATONR-ATLR ATLAS_COOLONL_TRT	Jul 31, 2014 2:20:11 PM	00:05:10	423	Out-Of-Sync: 0	0	0	Report
	ATONR-ATLR ATLAS_COOLONL_TILE	Jul 31, 2014 10:59:47 AM	00:03:20	537	Out-Of-Sync: 0	0	0	Report
	ATONR-ATLR ATLAS_COOLONL_GLOBAL	Jul 31, 2014 10:56:44 AM	00:01:26	253	Out-Of-Sync: 0	0	0	Report
	ATONR-ATLR ATLAS_COOLONL_CALO	Jul 31, 2014 10:42:09 AM	00:09:36	1795	Out-Of-Sync: 0	0	0	Report
	ATONR-ATLR ATLAS_COOLONL_TRIGGER	Jul 28, 2014 9:49:37 AM	52:58:17	587	Out-Of-Sync: 0	0	0	Report
	ATONR-ATLR ATLAS_COOLONL_TGC	Jul 24, 2014 11:40:36 AM	00:42:39	149	Out-Of-Sync: 0	0	0	Report
	ATONR-ATLR ATLAS_COOLONL_SCT	Jul 24, 2014 11:25:13 AM	00:11:40	347	Out-Of-Sync: 0	0	0	Report
	ATONR-ATLR ATLAS_COOLONL_RPC	Jul 24, 2014 11:08:17 AM	00:02:42	36	Out-Of-Sync: 0	0	0	Report
	ATONR-ATLR ATLAS_RUN_NUMBER	Jul 24, 2014 11:02:14 AM	00:00:03	1	Out-Of-Sync: 0	0	0	Report
	ATONR-ATLR ATLAS_MDT_STATUS	Jul 24, 2014 11:01:27 AM	00:00:03	11	Out-Of-Sync: 0	0	0	Report
	ATONR-ATLR ATLAS_COOLONL_MUONALIGN	Jul 24, 2014 10:55:09 AM	00:04:49	148	Out-Of-Sync: 0	0	0	Report
	ATONR-ATLR ATLAS_COOLONL_MDT	Jul 24, 2014 10:54:29 AM	00:14:17	171	Out-Of-Sync: 0	0	0	Report
	ATONR-ATLR ATLAS_COOLONL_LAR	Jul 24, 2014 10:47:38 AM	00:14:28	1247	Out-Of-Sync: 0	0	0	Report
	ATONR-ATLR ATLAS_COOLONL_INDET	Jul 24, 2014 10:46:27 AM	00:13:46	215	Out-Of-Sync: 0	0	0	Report
	ATONR-ATLR ATLAS_COOLONL_FWD	Jul 24, 2014 10:42:16 AM	00:00:38	121	Out-Of-Sync: 0	0	0	Report
	ATONR-ATLR ATLAS_COOLONL_CSC	Jul 24, 2014 10:41:43 AM	00:04:47	367	Out-Of-Sync: 0	0	0	Report
	ATONR-ATLR ATLAS_CONF_TRIGGER_V2	Jul 24, 2014 10:37:13 AM	00:02:51	75	Out-Of-Sync: 0	0	0	Report
	ATONR-ATLR ATLAS_CONF_TRIGGER	Jul 24, 2014 10:36:51 AM	00:00:28	58	Out-Of-Sync: 0	0	0	Report
	ATONR-ATLR ATLAS_CONF_MDT	Jul 24, 2014 10:35:58 AM	00:00:13	24	Out-Of-Sync: 0	0	0	Report
	ATONR-ATLR ATLAS_ATLOG	Jul 24, 2014 10:35:00 AM	00:17:12	10	Out-Of-Sync: 0	0	0	Report
	ATONR-ATLR ATLAS_CONF_TGC	Jul 30, 2014 3:41:51 PM	00:13:12	17	Out-Of-Sync: 1	1	0	Report
	ATONR-ATLR ATLAS_COOLONL_PIXEL	Jul 24, 2014 11:27:02 AM	00:49:36	242	Out-Of-Sync: 0	2	0	Report
	ATONR-ATLR ATLAS_OKS_ARCHIVE	Jul 24, 2014 11:26:10 AM	00:13:19	13	Out-Of-Sync: 0	2	0	Report
	ATONR-ATLR ATLAS_SFO_T0	Jul 24, 2014 11:25:37 AM	00:11:51	5	Out-Of-Sync: 0	1	0	Report

Figure 19. ATONR-ATLR configured and completed jobs

It can be indicated that the efficiency of GoldenGate Veridata in huge amounts of data is notable. The results are remarkable:

- 25 schemas were inspected.
- More than 7220 compare pairs were processed.
- 6 compare pairs failed due to misconfiguration of the tables.
- Only 1 compare pair was out-of-sync. It must be pointed out that this alert is considered as false due to high transaction rate and the replication latency on the table.
- Overall jobs run duration was 61:11:04 (hh:mm:ss).
- More than 1.1 TB of data were checked during the procedure.

Afterwards, GoldenGate Veridata was examined further in WLCG conditions. ATLR, the offline database of ATLAS experiment and IN2P3 were inspected. Although, this time the replication was initialized from IN2P3 to ATLR. The compare process was achieved through 24 different jobs, as it can be observed in figure 20.

Comparison Status	Job Name	Job Start Time	Job Run Duration	Compare Pairs Processed	Compare Pairs Out-Of-Sync	Compare Pairs Failed	Compare Pairs Canceled	Reports
⊗	DBAMI-ATLR ATLAS_AMI_STREAMTEST07	Aug 11, 2014 1:39:33 PM	00:00:07	19	Out-Of-Sync: 0	1	0	Report
⊗	DBAMI-ATLR ATLAS_AMI_MC12_01	Aug 11, 2014 1:15:06 PM	04:54:17	18	Out-Of-Sync: 0	1	0	Report
⊗	DBAMI-ATLR ATLAS_AMI_MC11_01	Aug 11, 2014 1:10:56 PM	00:02:23	18	Out-Of-Sync: 0	1	0	Report
⊗	DBAMI-ATLR ATLAS_AMI_MC10_01	Aug 11, 2014 1:10:27 PM	00:01:49	18	Out-Of-Sync: 0	1	0	Report
⊗	DBAMI-ATLR ATLAS_AMI_MC08_01	Aug 11, 2014 11:50:19 AM	00:11:14	22	Out-Of-Sync: 0	1	0	Report
⊜	DBAMI-ATLR ATLAS_AMI_VALID_01	Aug 11, 2014 1:46:22 PM	00:25:48	17	Out-Of-Sync: 0	0	0	Report
⊜	DBAMI-ATLR ATLAS_AMI_SQ_02	Aug 11, 2014 1:38:59 PM	00:00:06	15	Out-Of-Sync: 0	0	0	Report
⊜	DBAMI-ATLR ATLAS_AMI_PRODUCTION_01	Aug 11, 2014 1:35:31 PM	00:02:22	98	Out-Of-Sync: 0	0	0	Report
⊜	DBAMI-ATLR ATLAS_AMI_PERFMUONS_01	Aug 11, 2014 1:33:29 PM	00:00:05	14	Out-Of-Sync: 0	0	0	Report
⊜	DBAMI-ATLR ATLAS_AMI_METADATADICT_01	Aug 11, 2014 1:32:20 PM	00:00:05	11	Out-Of-Sync: 0	0	0	Report
⊜	DBAMI-ATLR ATLAS_AMI_MC09_01	Aug 11, 2014 1:10:00 PM	01:17:17	19	Out-Of-Sync: 0	0	0	Report
⊜	DBAMI-ATLR ATLAS_AMI_LARG_01	Aug 11, 2014 11:49:49 AM	00:00:09	21	Out-Of-Sync: 0	0	0	Report
⊜	DBAMI-ATLR ATLAS_AMI_GENERATOR_01	Aug 11, 2014 11:46:39 AM	00:00:06	17	Out-Of-Sync: 0	0	0	Report
⊜	DBAMI-ATLR ATLAS_AMI_FDR08	Aug 11, 2014 11:46:13 AM	00:00:09	19	Out-Of-Sync: 0	0	0	Report
⊜	DBAMI-ATLR ATLAS_AMI_DATASUPER_01	Aug 11, 2014 11:45:52 AM	00:00:07	13	Out-Of-Sync: 0	0	0	Report
⊜	DBAMI-ATLR ATLAS_AMI_DATA13_01	Aug 11, 2014 11:39:17 AM	00:03:27	21	Out-Of-Sync: 0	0	0	Report
⊜	DBAMI-ATLR ATLAS_AMI_DATA12_01	Aug 11, 2014 11:38:39 AM	02:54:18	20	Out-Of-Sync: 0	0	0	Report
⊜	DBAMI-ATLR ATLAS_AMI_DATA11_01	Aug 11, 2014 11:32:43 AM	00:58:29	21	Out-Of-Sync: 0	0	0	Report
⊜	DBAMI-ATLR ATLAS_AMI_DATA10_01	Aug 11, 2014 11:32:06 AM	00:54:00	21	Out-Of-Sync: 0	0	0	Report
⊜	DBAMI-ATLR ATLAS_AMI_DATA09_01	Aug 11, 2014 11:31:41 AM	00:11:56	18	Out-Of-Sync: 0	0	0	Report
⊜	DBAMI-ATLR ATLAS_AMI_DATA08_01	Aug 11, 2014 11:31:03 AM	00:03:02	19	Out-Of-Sync: 0	0	0	Report
⊜	DBAMI-ATLR ATLAS_AMI_DATA07_COSM5	Aug 11, 2014 11:30:36 AM	00:00:08	17	Out-Of-Sync: 0	0	0	Report
⊜	DBAMI-ATLR ATLAS_AMI_DATA07_COSM4	Aug 11, 2014 11:30:09 AM	00:00:07	16	Out-Of-Sync: 0	0	0	Report
⊜	DBAMI-ATLR ATLAS_AMI_BKK_RO_03	Aug 11, 2014 11:29:42 AM	00:00:39	106	Out-Of-Sync: 0	0	0	Report

Figure 20. IN2P3-ATLR configured and completed jobs

The results are:

- 24 schemas were inspected.
- Around 600 compare pairs were processed.
- No compare pairs were out-of-sync.
- 13 compare pairs failed due to misconfiguration of the tables.
- Overall jobs run duration was 12:02:10 (hh:mm:ss).
- Around 70 GB of data were checked during the procedure.

Finally, GoldenGate Veridata was examined between a duplicate of ATLR to IN2P3 in which the replication process wasn't operating. We were expecting a lot of discrepancies between the two databases. The compare process was achieved through 24 different jobs.

Select	Comparison Status	Job Name	Job Start Time	Job Run Duration	Compare Pairs Processed	Compare Pairs Out-Of-Sync	Compare Pairs Failed	Compare Pairs Canceled	Reports
		ATLR-CPATL ATLAS_COOLOFL_DCS	Aug 25, 2014 3:37:04 PM	15:54:39	529	Out-Of-Sync: 24	1	0	Report
		ATLR-CPATL ATLAS_COOLONL_TRIGGER	Aug 20, 2014 11:27:54 PM	11:13:08	672	Out-Of-Sync: 44	9	0	Report
		ATLR-CPATL ATLAS_CONF_TRIGGER_MC	Aug 20, 2014 7:31:12 PM	00:06:40	75	Out-Of-Sync: 33	1	0	Report
		ATLR-CPATL ATLAS_COOLONL_TDAQ	Aug 20, 2014 7:02:20 PM	00:39:39	492	Out-Of-Sync: 17	5	0	Report
		ATLR-CPATL ATLAS_CONF_TRIGGER_REPR	Aug 20, 2014 4:16:12 PM	00:01:26	74	Out-Of-Sync: 0	5	0	Report
		ATLR-CPATL ATLAS_COOLONL_PIXEL	Aug 20, 2014 8:14:12 PM	00:02:10	304	Out-Of-Sync: 0	0	0	Report
		ATLR-CPATL ATLAS_COOLONL_MDT	Aug 20, 2014 7:59:01 PM	00:35:24	215	Out-Of-Sync: 0	0	0	Report
		ATLR-CPATL ATLAS_COOLONL_TRT	Aug 20, 2014 7:55:01 PM	00:03:13	529	Out-Of-Sync: 0	0	0	Report
		ATLR-CPATL ATLAS_COOLONL_TILE	Aug 20, 2014 7:44:48 PM	00:09:08	673	Out-Of-Sync: 0	0	0	Report
		ATLR-CPATL ATLAS_COOLONL_SCT	Aug 20, 2014 7:44:14 PM	00:21:36	410	Out-Of-Sync: 0	0	0	Report
		ATLR-CPATL STREVA	Aug 20, 2014 7:30:39 PM	00:00:02	3	Out-Of-Sync: 0	0	0	Report
		ATLR-CPATL ATLAS_COOLONL_GLOBAL	Aug 20, 2014 7:11:23 PM	00:02:19	279	Out-Of-Sync: 0	0	0	Report
		ATLR-CPATL ATLAS_COOLONL_TGC	Aug 20, 2014 6:27:13 PM	01:02:16	94	Out-Of-Sync: 0	0	0	Report
		ATLR-CPATL ATLAS_COOLONL_MUONALIGN	Aug 20, 2014 6:10:56 PM	00:08:00	184	Out-Of-Sync: 0	0	0	Report
		ATLR-CPATL ATLAS_COOLONL_CSC	Aug 20, 2014 6:01:49 PM	00:07:44	426	Out-Of-Sync: 0	0	0	Report
		ATLR-CPATL ATLAS_COOLONL_FWD	Aug 20, 2014 4:30:21 PM	00:02:15	122	Out-Of-Sync: 0	0	0	Report
		ATLR-CPATL ATLAS_COOLONL_RPC	Aug 20, 2014 4:28:55 PM	00:11:11	80	Out-Of-Sync: 0	0	0	Report
		ATLR-CPATL ATLAS_COOLONL_INDET	Aug 20, 2014 3:17:19 PM	00:10:29	256	Out-Of-Sync: 0	0	0	Report
		ATLR-CPATL ATLAS_COOLOFL_MUONALIGN	Aug 26, 2014 10:53:32 AM	02:13:59	175	Out-Of-Sync: 4	0	0	Report
		ATLR-CPATL ATLAS_COOLONL_LAR	Aug 26, 2014 10:37:46 AM	00:11:58	1568	Out-Of-Sync: 2	0	0	Report
		ATLR-CPATL ATLAS_COOLOFL_CALO	Aug 20, 2014 11:26:50 PM	06:37:53	558	Out-Of-Sync: 4	0	0	Report
		ATLR-CPATL ATLASDD	Aug 20, 2014 8:06:50 PM	00:06:36	1042	Out-Of-Sync: 5	0	0	Report
		ATLR-CPATL ATLAS_COOLOFL_CSC	Aug 20, 2014 6:27:44 PM	00:42:09	322	Out-Of-Sync: 4	0	0	Report
		ATLR-CPATL ATLAS_COOLOFL_PIXEL	Aug 20, 2014 6:01:21 PM	00:20:04	278	Out-Of-Sync: 4	0	0	Report
		ATLR-CPATL ATLAS_COOLOFL_LAR	Aug 20, 2014 5:58:41 PM	03:32:46	785	Out-Of-Sync: 4	0	0	Report
		ATLR-CPATL ATLAS_COOLOFL_TRIGGER	Aug 20, 2014 5:58:07 PM	00:48:20	162	Out-Of-Sync: 4	0	0	Report
		ATLR-CPATL ATLAS_COOLOFL_TRT	Aug 20, 2014 5:57:35 PM	00:02:23	348	Out-Of-Sync: 11	0	0	Report
		ATLR-CPATL ATLAS_COOLOFL_FWD	Aug 20, 2014 5:55:58 PM	00:00:13	34	Out-Of-Sync: 4	0	0	Report
		ATLR-CPATL ATLAS_COOLOFL_TGC	Aug 20, 2014 4:17:36 PM	00:00:07	18	Out-Of-Sync: 4	0	0	Report
		ATLR-CPATL ATLAS_CONF_TRIGGER_V2	Aug 20, 2014 4:12:55 PM	00:03:02	75	Out-Of-Sync: 1	0	0	Report
		ATLR-CPATL ATLAS_COOLOFL_INDET	Aug 20, 2014 3:55:57 PM	00:00:44	117	Out-Of-Sync: 4	0	0	Report
		ATLR-CPATL ATLAS_COOLOFL_RPC	Aug 20, 2014 3:14:39 PM	00:09:22	79	Out-Of-Sync: 4	0	0	Report
		ATLR-CPATL ATLAS_COOLOFL_TILE	Aug 20, 2014 3:11:57 PM	00:07:07	681	Out-Of-Sync: 4	0	0	Report

Figure 20. ATLR-IN2P3 configured and completed jobs

The results were as expected; there was a huge amount of discrepancies between the two databases. The size of the source was 1460 GB while the size of the target was only 660 GB.

The results are:

- 33 schemas were inspected.
- 11659 compare pairs were processed.
- 181 compare pairs were out-of-sync.
- 21 compare pairs failed due to misconfiguration of the tables.
- Overall jobs run duration was 31:48:02 (hh:mm:ss).
- Approximately 660 GB of data were checked during the procedure.

6 Conclusions

Overall, with more than 120 schemas inspected through 140 jobs during the evaluation, Oracle GoldenGate Veridata has proven its accuracy, as it was able to recognize the data discrepancies rapidly. With more than 1.87 TB of data checked, the prolonged duration of the tests was expected. In detail more than 34.888 of tables were processed with 96.2% being synchronized, 2.4% being cancelled, 1.3% being out-of-sync and only 0.2% failing.

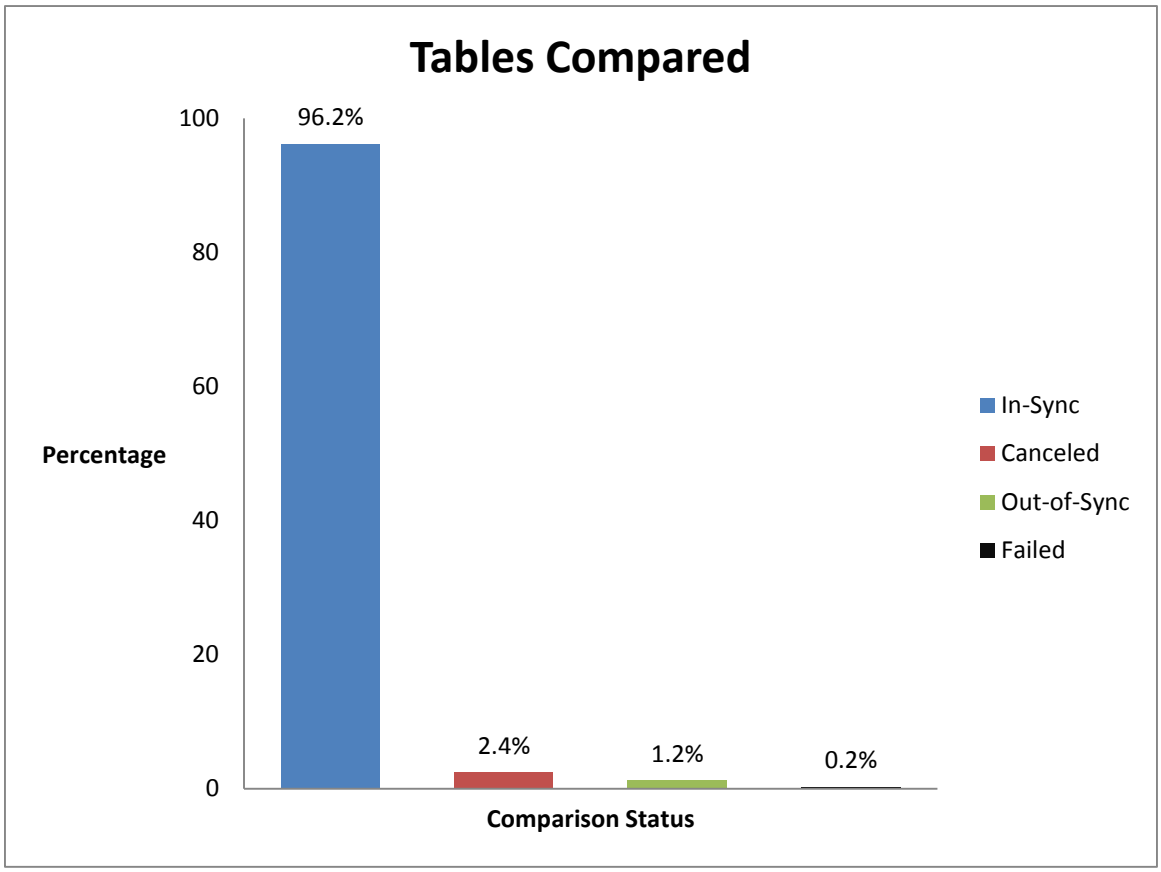


Figure 21. Table processed and status

From a user's point of view, GoldenGate Veridata provides a user-friendly environment through its web UI, so the user can find no difficulties in using or configuring GoldenGate Veridata's components. Therefore, it can be considered as a solid solution for data consistency between CERN and the WLCG environment.

7 Future Work

As mentioned, before GoldenGate Veridata was used in test and real production data cases. There is still room for further evaluation. GoldenGate Veridata should be evaluated in even higher transaction rates between the Tiers. Furthermore, due to our environment, GoldenGate Veridata was only tested with Oracle databases, thus, in the future it could be evaluated in different databases such as MySQL, SQL Server etc. Moreover, GoldenGate Veridata should be observed in trying to repair large amounts of data, as it was not possible during this evaluation. Finally, GoldenGate Veridata could be tested in different operating systems and servers with different amounts of cpus and memory for a deeper evaluation of its performance.

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8 References

1. GoldenGate Veridata Official website: http://www.oracle.com/us/products/middleware/data-integration/goldengate/veridata/overview/index.html

2. GoldenGate Veridata Data Sheet: http://www.oracle.com/us/products/middleware/059493.pdf

3. GoldenGate Veridata White Paper: http://www.oracle.com/us/products/middleware/data-integration/data-consistency-with-gg-veridata-1975236.pdf

4. Oracle GoldenGate Veridata Documentation:
    a. Get Started: http://docs.oracle.com/goldengate/1213/gg-veridata/index.html

    b. Install and Configure: http://docs.oracle.com/goldengate/1213/gg-veridata/gg-veridata-install-configure.htm

    c. Administer: http://docs.oracle.com/goldengate/1213/gg-veridata/gg-veridata-administer.htm

    d. Use: http://docs.oracle.com/goldengate/1213/gg-veridata/gg-veridata-use.htm

5. WLCG official website: http://wlcg.web.cern.ch/