

# OTN Case Study: Amadeus

## Using Oracle Transportable Tablespace in Oracle9i Database Migration with Minimal Downtime

*"Michael Amamoo, (DBA, Amadeus), proposed and executed a procedure using Data Guard together with Oracle Transportable Tablespace which resulted in the successful and timely migration of the Electronic Ticketing System from Oracle 9.2.0.3 on HP N-Class to Oracle 9.2.0.5 on HP-Superdome in just 8 minutes. This same procedure also gives us a fast, reliable way to upgrade from Oracle9i to Oracle Database10g with minimal downtime. And future database upgrades get even easier using Data Guard 10g Rolling Upgrades.*

*Vitor Pacheco  
Database Manager, Amadeus*

### OVERVIEW

#### Corporate Profile

- Global Ecommerce service and solutions provider to the travel industry
- \$1.9 Billion Annual Revenue (EUR)
- Central Reservation System - serves 64,000 Travel Agency locations & 16,000 Airline sales offices
- 5,000 employees
- [www.amadeus.com](http://www.amadeus.com)

#### Oracle High Availability Features Utilized

- Oracle Transportable Tablespace
- Oracle Real Application Cluster (RAC)
- Oracle Data Guard Redo Apply – (physical standby) for Disaster Recovery
- Oracle Data Guard SQL Apply –(logical standby) for reporting

Amadeus is the leading Global Distribution System (GDS) and technology provider serving the marketing, sales and distribution needs of travel and tourism industries in over 210 markets around the world. Through the Amadeus GDS, travel agencies and airline offices can make bookings on 95 per cent of the world's scheduled airline seats.

Amadeus has deployed [Oracle Data Guard](#) [1] for disaster recovery (DR) protection for numerous Oracle9i databases. Data Guard, a built-in feature of Oracle Database Enterprise Edition, guarantees a disaster recovery solution that is database aware and fully integrated with other Oracle High Availability (HA) features.

Amadeus also has a number of new projects in development on Oracle Database 10g. Amadeus plans to use Data Guard10g Rolling Upgrades, a new feature that dramatically reduces the downtime required to upgrade from one database release to the next (Oracle 10.1.0.3 is the minimum database release required for rolling upgrades).

Like many Oracle users, Amadeus will soon upgrade existing production systems from Oracle9i to Oracle Database 10g. Amadeus's testing showed that in their environment, the upgrade from Oracle9i to Oracle 10g requires a minimum of 25 minutes to complete. This would break the Amadeus IT service level agreement that stipulates planned database downtime cannot exceed 15 minutes per quarter. A solution needed to be found.

Demonstrating the ingenuity that Amadeus IT has become known for, they developed a procedure using the combination of Oracle9i Data Guard and [Oracle Transportable Tablespace](#) [2] to cut the downtime required for an Oracle Database 10g upgrade in half, to just 8 minutes.

# AMADEUS HIGH AVAILABILITY & DISASTER RECOVERY STRATEGY

## System Configuration

- HP Superdomes at primary and DR sites
- HP-UX 11.11
- EMC Symetrix and HP XP's at both sites
- Multiple databases, scaling from 50GB to 500GB
- OLTP systems with high transactions rates
- Oracle 9.2.0.5
- Oracle 10g
- 30km between primary and standby sites

Amadeus protects against CPU failures by using Oracle Real Application Clusters (RAC) for all database services, and implementing full application service redundancy in multiple nodes for the application tier.

In addition, the Amadeus Data Center is compartmented into 6 fully independent cells, each completely autonomous from the other with regards to power and cabling. All hardware components are distributed across these cells in a fully redundant mode: two fully independent networks, at least two production machines, redundant disk enclosures, etc. The application components are also distributed in a redundant mode over this same infrastructure. For example, each of the two RAC instances is implemented in different LPARS residing in different cells. This design addresses all the possible single failures that could impact availability.

Data Guard Redo Apply is used to maintain a transactionally consistent, physical copy of each Oracle database at a remote DR site located 30km from the primary data center. Data Guard SQL Apply is also used to maintain copies of production databases for reporting purposes. The reporting databases take advantage of SQL Apply's ability to provide read access at the same time as it is applying updates received from the production database. Traditional disk replication is used for application and other components, and for any data that resides outside of the Oracle Database.

Against this backdrop, Amadeus is preparing to upgrade from Oracle9i to Oracle Database 10g. The upgrade procedure must address the following requirements:

## AMADEUS UPGRADE REQUIREMENTS:

- Total database downtime for planned maintenance must be less than 15 minutes/quarter. Upgrading from Oracle9i to Oracle Database 10g can not exceed this 15 minute window
- One of the first databases to be upgraded supports the Amadeus Electronic Ticketing Server. It has 42 table spaces and is approximately 174 GB in size.
- In the event that anything goes wrong with a database upgrade, Amadeus must be able to fall back to their previous environment without exceeding the maximum allowed 15 minutes of downtime.

## AMADEUS UPGRADE PROCEDURE

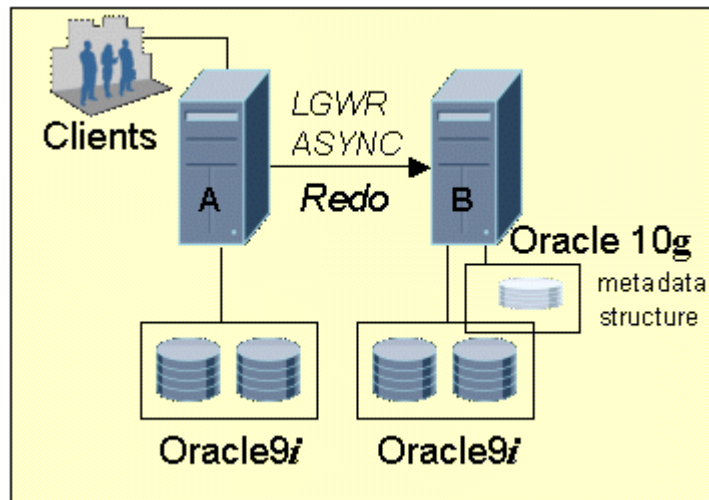
Amadeus utilizes the following steps to upgrade to Oracle Database 10g:

**Step 1:** A Redo Apply standby database (physical standby) is created on a separate system running Oracle9i. Standard procedures are used to instantiate the standby database from a hot backup taken of the primary production database.

The primary database is configured to ship redo data to the standby using Data Guard LGWR ASYNC transport services. LGWR ASYNC ships redo data to the standby server as it is committed using an asynchronous process. The standby database receives the redo data and writes it to standby redo logs (SRLs). Then following a log switch on the primary, Data Guard archives the SRL and completes the process of applying the redo data to the standby database.

Note that the process used by Data Guard to maintain the standby copy of the production database is significantly different from that used by remote mirroring solutions such as SRDF. SRDF must replicate every I/O to all database files, online logs, archive logs and the control file. This means that remote mirroring sends each database change at least three times to the remote site (compared to once for Data Guard), increasing network I/O significantly.

**Step 2:** The “shell” of an Oracle 10g database is created on the standby system using the same metadata structure as the primary database but with no data. (Figure 1).



*Figure 1 – Instantiation of the standby database and metadata structure*

**Step 3:** When ready to upgrade, a logs switch is done on the primary insuring that all redo in Data Guard’s asynchronous buffer has been shipped to the standby database. The application is then shutdown and the primary database is closed. A standard Data Guard failover operation is performed. This completes the process of applying all of the redo received by the standby server to the standby database. The standby database is then brought up in the primary role and opened for read/write access. This enables Transportable Tablespace to write to the database. Simple commands are used to execute the failover process:

```
SQL> alter database recover managed standby database  
finish;  
SQL> alter database commit to switchover to primary;  
SQL> shutdown immediate;  
SQL> startup;
```

In parallel with the above steps, the application is restarted on the “empty” Oracle 10g database.

**Step 4:** Export and Transportable Tablespace are used to move the tablespaces from the Oracle9i standby database to the new Oracle Database 10g shell. This is a two-step process. First set the tablespaces that are involved to be read only. Confirm that the tablespaces involved are self-contained as follows:

```
SQL> EXECUTE SYS.DBMS_TTS.TRANSPORT_SET_CHECK
('users,tools',TRUE,TRUE);
SQL> SELECT * FROM SYS.TRANSPORT_SET_VIOLATIONS;
```

This query should return no rows, identifying that there are no dependencies beyond these tablespaces. Secondly, create the transportable table set using export. Note this doesn't export the data itself just the metadata. Also do a full export of the database but specify ROWS=n so that only the metadata is exported. This will ensure that all the objects such as packages, procedures etc that will exist in the new Oracle 10g Database.

```
% exp SYS/oracle TRANSPORT_TABLESPACE=y
TABLESPACES=(users,tools) \
TTS_FULL_CHECK=y
% exp SYSTEM/oracle FULL=y FILE=full.dmp ROWS=n
```

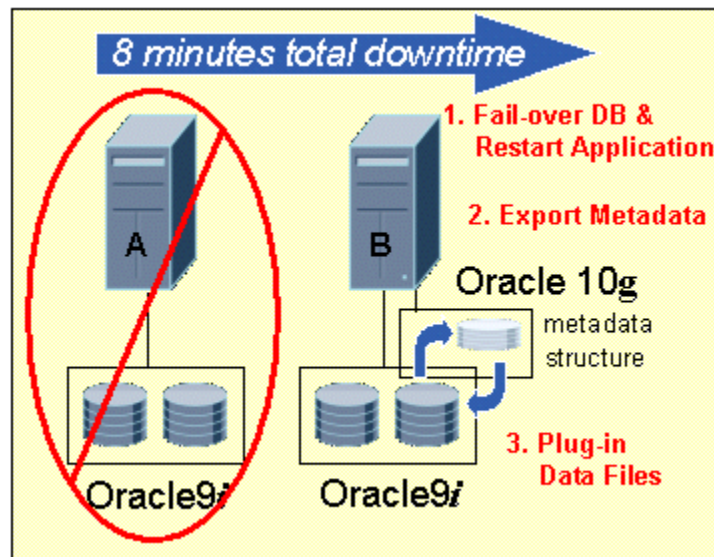


Figure 2 – Export metadata to Oracle 10g plug in data files

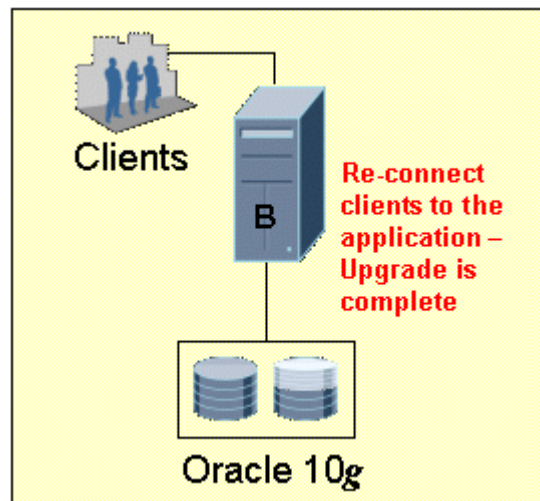
**Step 5:** Import the tablespaces into the new Oracle 10g database. Since the tablespaces are on the same system no data needs to be copied from one location to another.

The tablespaces are “plugged” into the new Oracle 10g database. Import the full import that you took earlier.

```
% imp SYS/oracle TRANSPORT_TABLESPACE=y FILE=expat.dmp
DATAFILES=('/oracle/oradata/users01.dbf','/oracle/oradata/tools01.dbf')
% imp SYS/oracle FILE=full.dmp ignore=y
```

Figure 2 illustrates steps 3-5, requiring total downtime of 8 minutes.

**Step 6:** The upgrade is complete. All that remains is to point users at application that is already running with the new Oracle 10g database.



*Figure 3: Upgrade Complete – Production running on Oracle 10g*

**Step 7:** The final step in the process is to take a hot backup of the new Oracle 10g version of the production database, and instantiate a physical standby at the remote DR site.

## FALLBACK SCENARIO

Should any problems occur while the upgrade is being done which would result in a more downtime than allowed, the original Oracle9i database is started, the application is pointed at it and restarted – and the upgrade is deferred to a later time.

## TRANSPORTABLE TABLESPACE

The Oracle [Transportable Tablespace](#) [2] feature allows users to move a user tablespace quickly across Oracle databases. It is the most efficient way to move bulk data between databases. In the Amadeus example above, the data does not move, it is simply “un-plugged” from the Oracle9i database, and “plugged” into Oracle Database 10g.

Moving data using Transportable Tablespace is much faster than performing either an export/import or unload/load of the same data. This is because transporting a tablespace only requires the copying of datafiles and integrating the tablespace structural information. Transportable Tablespace can also be used to move both table and index data, thereby avoiding the index rebuilds required when importing or loading table data.

Amadeus has used Transportable Tablespace in the example above to assist in database migration. Additional uses include:

- Exporting and importing partitions in data warehousing tables
- Publishing structured data on CDs
- Copying multiple read-only versions of a tablespace on multiple databases
- Archiving historical data
- Performing tablespace point-in-time-recovery (TSPITR)

Oracle9i Transportable Tablespace also provided Amadeus with a significant degree of flexibility. In one example, Amadeus was able to transport tablespaces from Oracle single instance (non-RAC) running on HP N-Class with HP Logical Volume Manager, to Oracle RAC running in HP Superdome with Veritas Cluster Volume Manager. However, Oracle9i still required both source and target databases to be on the same OS platform. Oracle Database 10g adds cross platform support to Transportable Tablespace, enabling users to transport tablespaces across OS platforms. This functionality can be used to:

- Provide an easier and more efficient means for content providers to publish structured data and distribute it to customers running Oracle on a different platform
- Simplify the distribution of data from a data warehouse environment to data marts which are often running on smaller systems on different platforms
- Enable the sharing of read only tablespaces across a heterogeneous cluster (the nodes must have same endianness)
- Allow a database to be migrated from one platform to another (use with Data Pump or Import/Export)

If the source platform and the target platform are of different endianness, then an additional conversion step can be automated using RMAN on either the source or target platform to convert the tablespace being transported to the target format. If they are of the same endianness, then no conversion is necessary and tablespaces can be transported as if they were on the same platform.

## **DATA GUARD 10G & ROLLING UPGRADES**

[Data Guard10g](#) [3], (from release 10.1.0.3 and forward), is an out-of-the-box solution for rolling database upgrades that greatly simplifies the above process and dramatically reduce total database downtime.

The Data Guard 10g Rolling Upgrade process begins in a similar fashion using standard Data Guard procedures to instantiate a standby database, but then differs by using Data Guard SQL Apply to create a logical copy of the primary database. Once the standby has been created and Data Guard is shipping redo data from primary to the standby database, the rolling upgrade process is executed as follows:

1. Stop SQL Apply on the standby database and upgrade the Oracle database software on the standby to version “n+1”. The primary database continues to process transactions. Redo accumulates on the primary server while the upgrade process proceeds to the next step.
2. SQL Apply is restarted on the standby database, and the Data Guard configuration operates in mixed mode (Oracle version “n” on the primary, and “n+1” on the standby). Data Guard automatically resynchronizes the two databases, making the standby database current with the latest transactions from the primary database. Production then continues for a period of time in this mixed mode until the DBA staff is confident that the new Oracle release is operating as expected. Through this phase of the upgrade, there has been zero application downtime. The upgrade process then proceeds to the next step.
3. Perform a standard Data Guard switchover, reversing the role of the standby server to that of the “new” primary. This is the first and only time during the upgrade process where downtime is required. Total database downtime is no greater than the time it takes to complete the switchover process, a task that is completed in seconds when following Oracle best practices. Activate user applications and services on the new primary database. If everything behaves as expected – complete the upgrade process by proceeding to step 4. If there are problems that cannot be quickly resolved, simply open the previous primary database, switch users back and start over.
4. Everything has checked out, the new primary is running production as expected. Now it is time to complete the process and upgrade the original primary (now the new standby database). Halt SQL Apply on the new standby. Upgrade the Oracle database software to version n+1. Restart SQL Apply and allow Data Guard to automatically bring the new standby completely up to date with the new primary. As with steps 1 and 2, step 4 requires zero downtime for the production application.

## CONCLUSION

Amadeus has expanded on its success with Data Guard as a DR solution, and is using it together with Transportable Tablespace to reduce database downtime and achieve service level agreements as they upgrade Oracle9i databases to Oracle Database 10g.

Data Guard 10g utilizes similar principles to implement rolling database upgrades that simplifies the previous, “hand crafted” process with a standard, out-of-the-box solution. Most importantly, Data Guard 10g Rolling Upgrades reduce database downtime to near zero.

## REFERENCES

1. Oracle Data Guard Overview -  
<http://otn.oracle.com/deploy/availability/htdocs/DataGuardOverview.html>
2. Oracle Transportable Tablespace  
<http://www.oracle.com/technology/deploy/availability/htdocs/xtts.htm>
3. Oracle Data Guard – Technical Overview for Oracle 10g  
[http://www.oracle.com/technology/deploy/availability/pdf/DataGuardTechOverview\\_10gR1.pdf](http://www.oracle.com/technology/deploy/availability/pdf/DataGuardTechOverview_10gR1.pdf)



Amadeus - DATA GUARD OTN PROFILE

December 2004

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