Backing up a Large Oracle Database with EMC NetWorker®
and EMC Business Continuity Solutions

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Introduction

As an EMC® Regional Software Specialist in Poland, I have been involved with many projects using the EMC NetWorker and EMC Business Continuity family of products to build advanced disaster recovery (DR) solutions.

Customers frequently ask how they can use EMC products to build backup solutions for their large, complex IT environments. This article will concentrate on the Oracle database to answer those questions. I’ve chosen the Oracle database based on its popularity in the market, but you can apply the concepts to other databases as well.

Many IT systems process and store terabytes of data that require backup. There are few articles that describe best practices in backup solutions using large databases to store data. These databases are called Very Large Database (VLDB). There is no official definition of this term, therefore we will assume the following for this article:

“VLDB is a database that occupies more than 1 terabyte or contains several billion rows. Typically, these are decision support systems or data warehouses and recently also transaction processing applications serving large numbers of users”.

VLDBs can occupy several or even tens of terabytes of data. Customers require increasingly fast backup and restore solutions as databases can expand very quickly. Backup architects are finding it more and more difficult to meet this challenge. There is a significant need to manage larger and more complex environments in today’s economic environment.

Every system should have a well designed backup subsystem. Scalability, performance, and manageability are the key features of a well designed backup solution. There are a number of critical questions we need to ask before proposing a solution.

What conditions must be satisfied in an effective backup solution?

- The solution should not have a negative, appreciable impact on production processing.
- It should be scalable and resistant on the fast growing database.
- Backup and restore operations should end in the fixed timeframe.
- The solution should be resilient to every kind of production system failure, including whole system breakdown.
- It should support all incomplete recovery scenarios supported by the system provider including the database vendor.
- Backup should be stored in a few copies over the specified time, necessarily on the removable storage (tape). In most cases, it should also be stored in physically separated locations.
- Most of the backup/restore operations should be automated and provide simple graphical user interfaces as well as command lines for creating scripts.
- It should provide a reporting and analyzing engine.
- The designed solution should be fully supported by the providers of the system components, including EMC and the database vendor.
As we’ve defined the requirements for a backup system, we are ready to begin designing the solution. Let’s start building the backup solution from the first condition – “Designed solution should not have a negative, appreciable impact on production processing”.

Compliance with this condition appears simple. The backup system should be designed to offload all components used by the production system from the backup process, including the server components, SAN and LAN network, and the storage subsystem.

This can be accomplished as follows:

- Separate the storage subsystem. To do this, allocate additional storage space and use array-base fast replication technology. This technology should have minimal impact on production processing.
- A dedicated host, not the production host, will read and write data to the secondary storage (e.g. tape) from the previously replicated, dedicated drives. It will act as a NetWorker Storage Node. Later, we will call it the Data Mover.
- Create dedicated backup LAN and SAN.

Which EMC technologies exploit array-based replication?

EMC has many Business Continuity Solutions that can be used for this purpose. In this article, we will choose some of them and describe their applications for building backup solutions.

What is Business Continuity?

Business Continuity is a process that prepares for, responds to, and recovers from an application outage that adversely affects business operations. It addresses systems unavailability, degraded application performance, or unacceptable recovery strategies.

To select one of the Business Continuity technologies that exploit the array-base replication, we must concentrate on a storage platform. Let’s choose the EMC Symmetrix DMX™ for this purpose; however EMC CLARiiON® has a similar mechanism.

The Symmetrix DMX offers local and remote replication services. EMC TimeFinder® is the family of products for local replication. TimeFinder allows dynamic full image copies of data with Business Continuance Volumes (BCV), point-in-time copies through Clones, and logical point-in-time views of production information through Snapshots. Solutions for remote replication include EMC SRDF® and OpenReplicator. Local and remote solutions can be integrated with each other.

These technologies work on the storage array level in the SAN network, relieving the servers’ processes and guaranteeing fast data transfer. They enable incremental synchronization; copying only the last changes to data.

Details about these technologies will not be discussed in this article except for their role in building backup solutions. There is a comprehensive list of resources at the end of this article to increase your understanding of these technologies.
Let’s focus on TimeFinder/BCV as a local replication solution.

BCV devices are standard Symmetrix DMX devices that are configured as dynamic mirrors. Each BCV device has its own host address and is configured as a stand-alone device. They can be dynamically and non-disruptively established and synchronized as well as instantly split to create a “point-in-time” copy.

After completing business continuity processes on a BCV device (e.g. backup to tape), the user can re-establish a BCV pair. Typical BCV operations include establish, split, re-establish, restore, incrementally restore, and verify.

**If data is read from production storage, why is there minimal impact on production processing?**

TimeFinder/BCV’s incremental synchronization copies only a small portion of data, reducing synchronization time.

Second, there are advanced algorithms on the array such as “Dual Mirror Policy” that allow both production mirrors to remain evenly balanced during read operations. Another algorithm, “Quality of Service,” controls the impact of synchronization on production storage. It provides flexibility in managing Symmetrix DMX performance. By increasing response time for specific copy operations, e.g. TimeFinder/BCV on selected devices, we can increase the overall performance of other devices.

Front-end, Back-end, and disks used by the production host and the Data Mover can be separated. In this way, backup operations from the BCV to tape will have almost no impact on storage components used by the production host.

To minimize the impact of synchronization on the production host, BCV synchronization can be started on the production system during the least load (e.g. off hours). We can safely assume that the number of changes in the database during the day is no greater than 1 terabyte. The production data is primarily distributed across many fast disks in order to serve many transactions (I/O operations) in the shortest possible time. In such a configuration, it can take less than one hour to synchronize 1 terabyte of data.

**What about the database during the BCV volume operations?**

The answer depends on the role of the BCV volumes as well as the tool that is used to perform a backup from the BCV to the secondary storage (e.g. tape). Should the BCVs be treated as a backup copy, from which the data will be restored in case of any failure, or only the storage space from which the data is copied to the other place (e.g. tape)?

First, we have to specify ways to backup the Oracle database. Oracle Corporation distinguishes two primary ways. The first method uses the built-in Oracle tool RMAN; the second is described as “User-managed backup.”

“**User-managed backup and recovery is any strategy in which Recovery Manager (RMAN) is not used as the principal backup and recovery tool. The basic user-managed backup strategy is to make periodic backups of data files and archived logs with operating system commands.**"
For our discussion, instead of using the operation system commands we will use the TimeFinder/BCV mechanisms to perform the Oracle database copy.

RMAN is the primary Oracle utility for backing up, restoring, and recovering Oracle data files, control files, and archived redo log files. It stores information about its operations in the control file of the backed-up database (the target database) and, optionally, in the Recovery Catalog. RMAN can do off-line and on-line database backups. It cannot, however, write directly to tape, but various 3rd-party tools (like EMC NetWorker Module for Oracle) can integrate with RMAN to handle tape library management.

TimeFinder can be integrated with RMAN in two ways:

- RMAN Proxy Copy
- RMAN backup from BCV

A Proxy Copy is a special type of backup, in which RMAN turns over control of the data transfer to a media manager that supports this feature. The proxy functionality was first introduced in Oracle8i Release 1 (8.1.5). EMC offers the special module “NetWorker Module for Oracle” which works as a media manager and the additional “EMC NetWorker PowerSnap™ Module” that allows integration with the TimeFinder mechanisms. Both modules, in conjunction with the RMAN mechanism, allow performing the proxy backup.

The second method “RMAN backup from BCV” is the regular RMAN backup that uses BCV volumes instead of production volumes to read from during a backup process.

Coming back to the previously asked question, “what about the database during the operations on the BCV volumes”?

We must put all of the tablespaces in a hot backup mode after the BCV volumes are synchronized (where Oracle data files are located) and before a split. Exceptions include Read-only and temporary tablespaces. After the split, the tablespaces can be taken out of hot backup mode.

EMC provides the `symioct1` tool included in the Solution Enabler package that performs control operations on a specified database application. This utility is intended for use in conjunction with a TimeFinder or SRDF split operation. It has an option for the Oracle database to place (or take out) the specified or all tablespaces at once into hot backup mode without using SQL commands.

**What happens with the database during a hot backup, and why is it necessary to put tablespaces in this mode?**

Data files are written in almost the same way as in the normal mode. Three actions occur when a tablespace is put in a hot backup mode:

- The tablespace is checkpointed
- The checkpoint SCN marker in the data file headers cease to increment with checkpoints
- Full images of changed DB blocks are written to the redo logs
By freezing the checkpoint SCN in the file headers, any subsequent recovery on that backup copy of the file will know that it must commence at that SCN. Having an old SCN in the file header tells recovery that the file is an old one, and that it should look for the redo log file containing that SCN, and begin recovery there. By logging full images of changed DB blocks to the redo logs during backup mode, Oracle eliminates the possibility of the backup containing irresolvable “split blocks”.

A more detailed explanation of this process, including examples, can be found in the article “Common Oracle Database Misconception” referenced at the end of the article.

**Can the hot backup mode be replaced by something else (e.g. Consistent Split)?**

The backup solution should support all incomplete recovery scenarios supported by the system provider including the database vendor.

EMC storage provides a Consistent Split mechanism. It allows the creation of an image of one or more databases that are DBMS-restartable copies. It does this by momentarily holding all write IOs to the specified volumes while performing a split.

In an Oracle context, it looks as if all database instances were aborted simultaneously. Aborting an instance can be considered a normal operational procedure, so thinking of it like this makes it easier to understand the validity of the solution. Also, since restarting an aborted instance does not require the database to be in Oracle hot backup mode, we are able to create restartable database clones without stipulating that the user place the database tablespaces in hot backup mode.

Oracle will allow roll forward of redo logs from this point, however we must roll forward to the next crash recovery marker in the log, or to the end of all redo as specified by a current control file (that is, a complete recovery).

**What about the incomplete recovery in this case?**

There are some situations when the backup mode cannot be replaced by consistent technology if the RMAN utility is not used. In this case, database recovery to any earlier point in time requires tablespaces in hot backup mode before a split. This means that incomplete recovery is not possible.

If we attempt to open the database with the RESETLOG option, we receive a message stating that the files require additional recovery. It will not be possible to open the database. This backup will not be able to satisfy ALL incomplete recovery scenarios normally supported by Oracle.

**Why isn’t it possible?**

Since hot backup mode was used, Oracle has end hot backup markers in the log that are used to determine whether the fuzziness has been removed from data files. Roll forward may be terminated as long as, minimally, we have rolled forward past the end hot backup markers for the data files that will be brought online when the database is opened. This is the only
restriction on incomplete recoveries. This type of backup can satisfy all incomplete recovery scenarios supported by Oracle.

We can set the undocumented parameter _allow_resetlogs_corruption =  but remember what Oracle says about it:

“This is an internal Oracle parameter. Do NOT use it unless instructed to do so by Oracle Support. Playing with this parameter may be harmful”.

So we cannot use it if we would like to comply with our previously defined condition “The backup solution should support all incomplete recovery scenarios supported by the system provider including the database vendor”.

What about when we use the RMAN utility for recovery?

Backup should be prepared with RMAN in order to recover data files with this tool. BCV as backup copies are not created with RMAN, but rather with TimeFinder. However, we can imagine a situation when the BCV copy is used only as a source from which data is copied to another place (e.g. to tape) with the RMAN utility. Then, the BCV is removed. Recovery is always performed from tape in this case. It is the only case when we can replace the hot backup option with the Consistent Split.

How is it possible?

When RMAN made this backup, every data file block was read from a consistently split BCV. RMAN is able to inspect the SCN of each block during this process. In the RMAN Catalog metadata that describes the backup of each data file, RMAN records the highest SCN encountered for any block of data file during backup. When this file is later restored, RMAN places this information in the file header. The Oracle recovery algorithm now knows that in order to remove the fuzziness from the file, it must be rolled forward minimally to this SCN value.

I should mention here that hot backup mode and consistent technology can be used simultaneously.

More detailed information about the consistent technology with application to the Oracle database can be found in the document “Understanding EMC Consistent Split with Oracle Database”.

We already know how the database mechanisms recognize the consistency of Oracle data from the Oracle point of view. But the Oracle data files are, in most cases, placed on the filesystem and managed by the Logical Volume Manager (LVM).

What mechanisms guarantee the consistency of the filesystem and LVM group?

Remember to place all volumes with Oracle data files in the LVM group and split them simultaneously.
We can place Oracle data files on the filesystem. In this case, we recommend unbuffered filesystems. The database provides the mechanisms to buffer the data in memory; therefore double buffering is not needed and can sometimes cause performance problems. When the buffered filesystem is used to store the data files, we must synchronize the filesystem buffers by flashing the memory before the split occurs. This can be done with operation system commands or additional tools.

In a UNIX system we can use `sync` command to flush the filesystem cache. Remember that this command should be used a few times. Sometimes, primarily when large filesystems are used, one execution of `sync` flashes only a portion of the memory buffers.

**What about the Windows host?**

There is no tool in the Windows operating system to flush cache buffers. But, there are two options. The first is to remove the drive letter from the disk, which causes the memory buffers to flash. The second and more appropriate option is to use the special tool `symntctl` provided by EMC. This utility is included in the Symmetrix Integration Utilities (SIU), which provides the disk management functions missing from the Windows operating system when working with TimeFinder and SRDF.

**What about others database objects such as redo logs, archive logs and control files?**

We need the copy of the archive logs and control files to guarantee that the database is recoverable. Redo logs do not need to be backed up because we can switch them to the archive logs. Redo logs are automatically recreated when the database is opened with the `RESETLOG` option.

We can also use BCV volumes to create archive log backups. In this case, remember to place archive logs on the separate volumes, LVM group and filesystem, then data files. This is required because the split operation for archive logs should take place after data files has been split.

This is based on the fact that Oracle uses the end backup markers in the logs to determine whether fuzziness has been removed from data files. This marker is written in redo logs after taking the tablespaces out of backup mode, which is done after the split operation for Oracle data files. Copy the redo log to archive, and then split the archive logs. Control files backup can be sent to the same volumes as archive logs before splitting them.

Using the BCV copy only for Oracle data files is another popular solution. We should not forget about backing up the Oracle configuration files such as init.ora, password files, listener configuration, etc.

More information about using the BCV technology with Oracle databases can be found in the whitepaper “Oracle and EMC TimeFinder”.

Now we have to concentrate on the mechanisms used to perform a backup from BCV to another place (e.g. to tape).
How can we back up Oracle data from a BCV to secondary storage (e.g. to tape)?

EMC offers the central backup system NetWorker to protect critical business data by centralizing, automating and accelerating backup and recovery operations across an enterprise. NetWorker provides support for database backup including Oracle databases and the mechanisms for integrating with TimeFinder technology.

There are three primary types of NetWorker hosts. They are NetWorker Server, NetWorker Storage Node and NetWorker Client.

The NetWorker Client is the largest NetWorker software component and the fundamental host. The client’s most important functions are to generate backups called save sets, push them to a NetWorker storage node and retrieve them during a recovery. NetWorker clients are usually the data servers in an IT environment. The types of data that are typically backed up as save sets include file system data and applications (e.g. Oracle database data). While performing a backup, the client also generates tracking information, including file and directory names in the backup and the time of the backup, and sends the information to the server to facilitate point in time recoveries.

NetWorker Storage Nodes are hosts with directly-attached or SAN-accessible devices that provide the NetWorker interface for backup devices and volumes. During a backup, a NetWorker client sends backup data to a particular storage node based on that client’s configuration. The storage node organizes the client’s data and writes the client’s data to one of its devices. Storage nodes also send tracking information about the save sets written to the volume during the backup to the NetWorker server. This information is used for future backups as well as for recoveries.

The NetWorker Server is the host that stores configuration information such as supported clients, devices and when to run backups. The NetWorker server also stores online NetWorker databases that track backups and volumes.

**How can we perform the Oracle database backup from the BCV volumes?**

There are three ways to perform an Oracle database backup from the BCV:

- Filesystem backup
- RMAN backup
- PowerSnap™ backup

The first method uses the traditional filesystem backup, where the Oracle data files are copied to another location (e.g. to tape) in the same way as other files located on the filesystem. So the specific operations to the Oracle database (e.g. putting the database in the hot backup mode) should be performed separately.

The second method uses the RMAN tool to backup from the BCV, which integrates with NetWorker using the special NetWorker module NMO (NetWorker Module for Oracle). It works as an Oracle media manager; picks up the RMAN backup objects called backup set, and sends them to the NetWorker subsystem. This subsystem writes the data to the secondary storage (e.g. tape) and stores the metadata about the backup in its repository.
Metadata is also stored in the control file and Oracle RMAN catalog, if it is in use. Both repositories synchronize one another to guarantee the consistency of backup metadata.

Both the first and second methods work on prepared BCV volumes. So all of the BCV operations, as well as the system specific operations (e.g. importing the LVM group, mounting the filesystem) have to be performed separately. Usually, special scripts are created to control them.

The last method, PowerSnap, uses the special module for NetWorker PowerSnap that implements a snapshot solution for applications that is seamlessly integrated with traditional backups. It provides scheduling, browse, retention policies, etc. of snapshots and enables instant backups and rapid recovery. Backup is virtually instantaneous, despite the size of the volume.

PowerSnap enables frequent backups with little impact to the network or application server to provide non-disruptive backups of large databases or data stored in file systems. The PowerSnap solution provides high-performance block level (image) as well as traditional file/OS-based backup technology. Block level (image) backups are similar to traditional NetWorker backups, but when the file data is saved, the file system and volume manager are circumvented, and the data is read directly from the disk. Snapshot technology integrated with PowerSnap can be of two sorts, array based snapshot technology (e.g. TimeFinder) and software based (e.g. EMC RecoverPoint).

PowerSnap in conjunction with NMO allows building the complete backup solution for an Oracle database. Oracle RMAN starts the backup using the Proxy Copy feature. It turns over control of the data transfer to a media manager that supports this feature (NMO in this case). NMO communicates with the PowerSnap module, which calls the storage platform-specific application programming interface (API), which takes a snapshot of the Oracle data on the primary storage (creates the BCV copy in our case). Instant backups can be scheduled to occur many times in a single day, with little impact to the Oracle server or network. A separate host from the Oracle server can be used to move the point-in-time copy to the traditional storage medium, such as tape.

Note: Certain RMAN features, such as checking for corrupt blocks, are not applicable to proxy backups since the NMO controls that process. Specific types of Oracle files, such as control files, cannot be backed up through a Proxy Copy. This is an Oracle constraint.

When we already to perform the Oracle database backup from the BCV volumes, it is time to compare our options.

See the following pages for advantages and disadvantages of each option.
<table>
<thead>
<tr>
<th>Backup method</th>
<th>Advantages</th>
<th>Disadvantages/Limitations</th>
</tr>
</thead>
</table>
| Filesystem backup | - Simple backup operations  
- High rate of backup  
- RMAN catalog does not have to be maintained  
- NMO module does not have to be maintained  
- Oracle database does not have to be installed on the host with the BCV mounted | - Manual management of the operations on the BCV volumes  
- Scripts have to be created and maintained  
- RMAN is not used, therefore certain features, such as checking for corrupt blocks, are not applicable  
- RMAN catalog is not used; therefore the recovery of database has to be performed with the manual control  
- Database has to be put in hot backup mode before a BCV split |
| RMAN backup    | - Simple backup operations  
- Checking for corrupt blocks during backup and recovery  
- RMAN automatically manages the recovery of the database  
- Detailed information about the performed backup is maintained in the RMAN catalog, influencing the simplicity of database recovery in case of any failure  
- Incomplete recoveries are more optimistic when RMAN has processed all of the database blocks  
- Consistent BCV copy without hot backup mode can be backed up further with RMAN. The resultant RMAN backup can then be used for restore and recovery without restriction on recoveries. | - Manual management of the operations on the BCV volumes  
- Scripts have to be created and maintained  
- NMO module and Oracle binaries on the backup host with BCV mounted have to be present  
- RMAN catalog has to be maintained |
<table>
<thead>
<tr>
<th>Backup method</th>
<th>Advantages</th>
<th>Disadvantages/Limitations</th>
</tr>
</thead>
</table>
| PowerSnap backup | • High rate of backup  
• Automated backup, restore and recovery processes  
• Full integration with NetWorker environment and RMAN  
• RMAN automatically manages the backup and recovery of the database  
• Detailed information about the performed backup is maintained in the RMAN catalog, influencing the simplicity of database recovery in case of any failure.  
• BCV copy is treated as a backup copy by NetWorker and Oracle RMAN, so the same procedure can be used to restore and recover the database regardless of whether the backup is located on the BCV or on tape.  
• Possibility of implementation of the very fast block level backup to tape from BCV | • Some limitations as far as the supportability of certain IT environments  
• Certain RMAN features, such as checking for corrupt blocks, are not applicable to proxy backups  
• RMAN catalog has to be maintained |

We have already collected the essential information needed to design the backup subsystem for an Oracle database using the NetWorker and TimeFinder solutions. Let’s build one.

First, we have to define some the production system architecture. Then, we need to build the backup subsystem fulfilling the previously assumed conditions.

**An example of the backup solution**

**Configuration of the production system:**

- Production system works in a distributed cluster environment. Cluster nodes are located in two locations.
- Production system consists of a few Oracle databases, evenly distributed across two cluster nodes with failover capability.
- Oracle data are located on two EMC DMX-3 arrays (one in each location).
- Database volumes are under control of SRDF/S (bi-directional).
**Configuration of the backup subsystem:**

- Each Oracle database will have two BCV copies (one on each site).
- BCV volumes will be located on separate disks than those with production data.
- EMC NetWorker with PowerSnap module and NMO will be used to build the backup solution.
- Two dedicated servers Data Movers will perform backup to tape from BCV volumes; one server in each location.
- Separated LAN network for backup purpose will be created.
- BCV copies will be established every 4 hours, alternating in both locations and will be the primary restore copy in case of any database failure.
- Backup of Oracle data files will be performed once per day (full backup) from the BCV volumes mounted on the Data Mover through the SAN network.
- Archive logs backup and control files will go through the dedicated backup LAN every few hours directly from the production server.
- NetWorker server will work in a cluster as well as the RMAN catalog.
- BCV copy will be used to verify against the corrupt blocks using the Oracle tool dbverify.

The diagrams on the following page illustrate the synchronization of BCV volumes in a 24h period and the backup environment:
Diagram of synchronizing the BCV volumes in 24h period - example
Summary

Offloading production systems from backup operations, and reducing the backup, restore and recovery times are key elements. In most cases, customers already have storage systems that support Business Continuity technology; they only need to adapt them to build an efficient backup subsystem.

In this article, we described a solution for the Oracle database. However, it can be adapted for other databases.
References

The documents below are divided into three sections based on their application, and cover the following areas:

- Oracle backup and recovery
- EMC Business Continuity integration with an Oracle database
- EMC NetWorker integration with an Oracle database

Some of the documents listed below cannot be easily found; for your convenience I have compiled them in one location: ftp://ftp.emc.com/outgoing/ArticleMM/

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- Best Practices for Oracle Database 10g Backup and Recovery, Oracle White Paper, 2005
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