Backup Strategies for Always-Online Business

A Case Study Comparing Split-Mirror Backups with Database-aware Backups Using VERITAS NetBackup™ for Oracle

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Introduction

This paper presents the results of a backup and recovery architectural review which Convergent Data Services prepared for a Web conferencing company.

Convergent Data Services is a business consulting company that specializes in information storage and access. As part of a business continuance review, the company analyzes system architecture and the backup and recovery systems protecting critical data, matching technical capacity with business requirements.

Convergent Data Services used VERITAS NetBackup™ for Oracle to create a database-aware backup and recovery solution. VERITAS NetBackup™ is an enterprise-wide backup and recovery solution. VERITAS Software has worked closely with Oracle Corporation to develop a highly scalable and reliable online backup and recovery solution for Oracle databases. NetBackup for Oracle protects data and the availability of Oracle applications.

This particular case study is of interest because it concerns a business with stringent data reliability and availability needs. The e-business in question already had implemented a backup approach that included hardware mirroring using EMC Symmetrix devices and EMC TimeFinder software. Using this configuration, the company created a point-in-time copy of the database data, accessed the copy from a different host, then performed backups from that copy. Performing backups from a mirrored copy of data theoretically minimizes the impact of the backup on the production system, as the backup uses a copy of the production data and a different host system.

Many companies assume that performing backups from split mirrors offers the best solution for large database backups. This paper demonstrates that is not always the case. Convergent contrasted this hardware-intensive method with an alternative method using VERITAS NetBackup for Oracle. It created a hot backup solution leveraging Oracle-aware backup and recovery capabilities to SAN-attached tape devices.

The conclusions illustrate that more hardware resources do not always deliver better backup and recovery capabilities. Convergent concluded that the simpler approach was to use VERITAS NetBackup for Oracle to implement a database-aware backup and recovery solution that is tightly integrated with the Oracle database. The result was a better approach for the company, with better and faster recoverability of data.

This paper describes the two approaches in some detail, then discusses Convergent's conclusions for the company.
Background

The company, which will be unnamed in this case study, is a leading Internet communication service provider offering a comprehensive suite of Web-based voice, video and visual collaboration services. Large Oracle databases maintain customer connectivity and information about Web conferences and Webcasts.

The nature of the business, as an online service provider, dictates a number of database backup and recovery requirements:

- The company must secure systems from loss of data; data is critical to billing as well as customer relationship management.
- The company must minimize any service disruption in case of a failure. If the company needs to recover all or part of an Oracle database, it must do so quickly and accurately, as downtime is costly.
- Production system performance is critical, so the company must minimize the performance impact of backups.
- The databases, already large, will continue to grow as the company adds more customers and services. The backup and recovery solution must be able to handle large volumes of data.

The company already had a legacy backup solution leveraging split-mirror capabilities of the EMC Symmetrix storage arrays and EMC TimeFinder software. But the staff had serious reservations about the system in place:

- They were concerned about the recoverability of their data—not only how quickly they could recover, but if they could recover completely and accurately in case of failure.
- The process of splitting and then resynching the mirror had a significant performance impact on the production database.
- The solution itself was complex, requiring expertise to maintain and recover appropriately.

The company engaged Convergent Data Services, which provides business consulting services focused on information storage and access. Convergent Data Services performed an architectural review with a specific focus on the backup and recovery of the company’s critical Oracle data.
Existing Split-Mirror Backup Solution

As mentioned above, the company already had in place a legacy backup solution that used a split-mirror approach to performing backups. The company used an EMC Symmetrix storage device attached to the production and backup servers, and the following software components to manage backups:

- **EMC TimeFinder** – This software, available from EMC, supports a feature called a Business Continuance Volume (BCV), essentially a mirror of a production volume. If the Symmetrix device is shared with another host, users can create a BCV of a production database, then perform backups from the secondary host using the BCV. The EMC TimeFinder software manages the processes of splitting and resynching the mirrored volumes, although further coordination with the Oracle database is necessary.

- **VERITAS NetBackup™** – The company used VERITAS NetBackup to back up the file system on the EMC TimeFinder split mirror. Note that this is not the Oracle-specific backup support enabled with VERITAS NetBackup for Oracle. The company simply used NetBackup to back up the file system containing the mirrored copy of the Oracle database.

- **VERITAS Volume Manager™** – VERITAS’ logical volume management software offers flexible, high performance and highly reliable storage configurations. It also simplifies the process of mirroring data. You can use VERITAS Volume Manager™ to define the disk groups serving the Oracle database, and use these to facilitate splitting the BCVs.

- **Proprietary scripts** – The company had developed a number of scripts to run backup processes, which required understanding the Oracle database structure, the logical volume structure and the EMC TimeFinder software.

Architecture

The company’s backup architecture used two Sun 450 servers—the production server running Oracle 8.1.6 and a backup server.

The database was stored on a direct-attached SCSI-based EMC disk. The EMC TimeFinder product created local mirror images of production volumes (the SCSI connection introduces some limitations, including a restricted stripe depth and limited use of Dynamic Multi-Pathing). VERITAS NetBackup backed up file system data to a Spectra Logic Gator 64000 with AIT drives, connected to the NetBackup server using Brocade Silkworm 2800 (see Figure 1 below).
Although the company had implemented a Fibre Channel-based tape library, this design limited the availability of that resource to the NetBackup server, failing to take advantage of the any-to-any capabilities of fibre channel networks.

**Backup Procedures**

The existing backup procedure involved several steps, managed primarily with custom scripts.

In short, the process for off-host, file system-based backups is to put the database into backup mode and create the BCV split for the database files. The split mirror then is mounted from the backup server and NetBackup makes the backup to tape. At this point, the BCV disk groups are re-mirrored.

A custom script performs the following tasks, executed with a scheduled NetBackup class:

1. An Oracle script on the Oracle server puts the database into backup mode.
2. The script checks the BCV pairs to be sure they are synchronized (they cannot be split if they are not synchronized).
3. The script executes the `vxsysmsplit` command to split the datafile disk groups.
4. The script executes the BCV splits and checks that they completed successfully.
5. The script returns the database to normal operation mode.
6. The script then splits the control file, redo and archive log disk groups with the database in normal mode.
7. VERITAS Volume Manager "deports" the BCV disk groups.
8. A script on the backup server imports the disk groups and mounts them to the appropriate mount point. Supporting files contain the disk groups to import and associated mount points. Structural changes to the database require modifications to these files.
9. NetBackup performs the backup.
10. A local script unmounts the file systems and "deports" the disk groups from the backup server.
11. A script on the Oracle production server re-mirrors the BCV disk groups; once for data disk groups and once for archive data groups.

Samples of some of these scripts are included in the Appendix on page 10.

There are several points worth noting about this backup process:

- These scripts are not trivial to create or maintain. As noted above, structural changes to the database can require manual changes to the scripts or to configuration files the scripts access.
- The database must be put into backup mode to perform the BCV split, impacting the production database during the backup (backup mode puts additional strains on redo logs and rollback segments).
- The backup itself always is a full, cold backup of the database. This approach cannot leverage the value of incremental backups.
- The EMC Symmetrix only has one or two channels connected to the backup server. This means the BCV split disk groups are backed up across either a 40 MB/second I/O channel, or two channels with a combined bandwidth of 80 MB/second. In practice, the transfer rate per channel is about 1.5 MB/second, due to SCSI overhead. This becomes a bottleneck to the backup processes, as the tape drives have a capacity of 8-9 MB/second, and there are 16 drives available with this solution.
- This backup process requires expensive disk resources—the EMC Symmetrix must have enough space to completely mirror the production database for the BCV split, in addition to any mirroring the company may be doing already for availability purposes.
Recovery Procedures

The recovery process for this method involves restoring the file system files from NetBackup and then resynching the BCV split. But before this can happen, the BCV split has to occur—in other words, the initial steps of the backup must take place. The database administrator must, either manually or through scripts, put the database into backup mode and then manage the BCV split.

In its backup and recovery analysis, Convergent identified the following limitations of the recovery scenario:

- The original steps to the backup process must be run, which introduces a fairly tedious process at the beginning of the recovery process.
- This approach requires a full database restore at all times because it uses a full, cold backup. The DBA cannot restore individual tablespaces or data files, or perform a point-in-time recovery.
- Keeping any changes since the last backup requires additional manual processes for the DBA. The DBA has to save archived redo logs and redo logs to an alternate location before the restore, to be reapplied after the database is restored. This introduces the possibility for data loss for any changes made to the database since the last backup. It also lengthens recovery processes and database downtime.
- There is no mechanism to check or track the database state information for restores. For example, the restore would wipe out structural changes made to the database since the last full backup.

Using this backup method prevented the company from taking advantage of several of Oracle’s more powerful and flexible recovery options, such as online restore of non-system tablespaces or point-in-time recovery. It also required the database administrators to track and maintain database system information so an accurate recovery would be possible.

The result is a significant risk that data could be lost during a recovery and/or that the recovery process itself could be prolonged. That would increase the outage and the impact on the company’s customers.

These reasons were sufficient for Convergent to strongly encourage the adoption of another backup and recovery approach for its Oracle database.
A Database-Aware Backup and Recovery Solution with NetBackup for Oracle

Rather than splitting off an image of the production database, Convergent proposed a solution that uses hot database backups from the production database and leverages SAN-based storage for optimal throughput. This solution uses VERITAS NetBackup in combination with Fibre Channel fabric technologies for performance enhancements. It leverages Oracle backup and recovery capabilities available from the database vendor through the Oracle Recovery Manager (RMAN) and its integration with NetBackup for Oracle.

This approach introduces the following software components:

- **VERITAS NetBackup for Oracle and Oracle 8 Recovery Manager (RMAN)** – The VERITAS NetBackup for Oracle agent integrates with Oracle Recovery Manager (RMAN) with NetBackup's scalable, enterprise-level backup and recovery. RMAN is Oracle Corp.'s interface to database-specific backup and recovery capabilities such as incremental backups, partial recoveries, and point-in-time recoveries.

- **VERITAS NetBackup™ Shared Storage Option** – a heterogeneous, SAN-ready storage solution for UNIX and Windows NT and Windows 2000 that enables dynamic sharing of individual tape drives. “Virtualizing” tape resources in this way reduces overall costs while offering better hardware utilization and resource optimization during backup and recovery.

**Architecture**

The company’s backup architecture used two Sun 450 servers—the production server was running Oracle 8.1.6.

Using this approach, the Oracle server is connected into a Fibre Channel fabric using an Emulex LP8000 Host Bus Adapter with version 4.0 driver, a Brocade Silkworm 2800 fibre channel switch and a fibre-attached Spectra Logic Gator 64000 tape library for tape storage.

VERITAS NetBackup for Oracle and the NetBackup Media Server software run on the Oracle server. Another system hosts the NetBackup master server, which controls access to the tape drives and maintains robotic control (see Figure 2).
One key point to note in this architecture is that many hosts potentially can access the tape resources. The fibre channel solution offers many-to-many connectivity, with much better performance than standard Ethernet.

**Backup Procedures**

The backup process using this alternative approach is much simpler than the previous solution, using simple scripts that invoke RMAN, a published and supported interface for Oracle backup and recovery.

The overall backup process is as follows:

1. The NetBackup scheduler starts a NetBackup job at a predefined start period. The start job may be for a full, partial, or incremental database backup.
2. NetBackup on the Oracle server requests any tape drives not being used from the NetBackup™ Shared Storage Option Device Allocator (the NetBackup Master server). Any free drives are allocated for the Oracle server at this point.
3. NetBackup calls RMAN on the Oracle server to start the backup of the defined database in the RMAN .rcv script. This requires a simple script:

   The .rcv file creates channels to back up to four tapes simultaneously. The following script implements a full backup for the entire database:

   ```
   connect catalog 'rman/rman@oracat';
   connect target 'rman/rman@oraprod';
   run {
   # Hot database level 0 whole backup
   allocate channel t1 type 'SBT_TAPE';
   allocate channel t2 type 'SBT_TAPE';
   allocate channel t3 type 'SBT_TAPE';
   allocate channel t4 type 'SBT_TAPE';
   backup
   incremental level 0
   tag hot_db_bk_level0
   filesperset 5
   (database)
   (current controlfile);
   }
   ```

4. NetBackup backs up the data to tape.

Note the script connected to the RMAN catalog (rman/rman@oracat in this example). RMAN maintains a recovery catalog containing database metadata. This information is used for backup, recovery and maintenance.
This solution offers several significant benefits over the company’s original, EMC TimeFinder-based backup and recovery methodology:

- The NetBackup for Oracle solution manages the backup and recovery of all parts of the Oracle database, including archive redo logs and control files. The integration with RMAN automatically sets the database state appropriately for the backup type, managing the backup mode, or for bringing the database up and down for cold backups.
- The backup scripts are simple to create and maintain. For example, the RCV script does not list the complete set of datafiles or tablespaces. This information is stored in the RMAN catalog. If a DBA changes the database structure, a simple RMAN command refreshes the database catalog with the new structure. This is much simpler than maintaining scripts pointing to specific data files.
- The company can use incremental backups to reduce backup times by writing only changed data.
- A checksum validation ensures that the backups are reliable.

Recovery Procedures

Recovery using the Oracle Recovery Manager interface is simple and much more flexible than the split-mirror approach. The RMAN interface offers a wide variety of recovery alternatives and reduces the possibility of operator error on recovery.

The advantages of using NetBackup for Oracle to recover the Oracle database are as follows:

- The company can restore specific data files or tablespaces rather than the entire database.
- The NetBackup and RMAN catalogs track all necessary information for data restoration and database recovery, reducing the possibility of error and ensuring a fast recovery.
- The interface offers a simplified point-in-time recovery, restoring files and replaying archived redo logs until the specified point-in-time.
- The NetBackup for Oracle solution lets administrators simulate recoveries to practice processes and ensure recoverability of data.
- In contrast to the mirroring solution, the NetBackup for Oracle approach only requires enough additional disk space to maintain the RMAN recovery catalog.
Summary

Convergent concluded that the proposed VERITAS NetBackup for Oracle backup and recovery solution was better suited to meet the company’s business needs than its existing split-mirror backup solution. The NetBackup for Oracle database-aware solution provides scalability for ongoing growth, offers easier manageability, minimizes production database impact and, most importantly, ensures the recoverability of critical data in case of failure or data corruption.

The following table illustrates some of the key differences between the EMC TimeFinder mirrored, off-host backup approach and the NetBackup for Oracle solution using the Shared Storage Option.

<table>
<thead>
<tr>
<th>Old Approach</th>
<th>New Approach</th>
</tr>
</thead>
<tbody>
<tr>
<td>TimeFinder and NetBackup and Oracle</td>
<td>NetBackup for Oracle, Oracle RMAN and NetBackup Shared Storage Option</td>
</tr>
<tr>
<td>Only can perform full backups</td>
<td>Can perform full and incremental backups</td>
</tr>
<tr>
<td>Only performs full restores, which may cause a</td>
<td>RMAN allows for incremental recovery that restores older data and applies</td>
</tr>
<tr>
<td>loss in newer data</td>
<td>only some of the redo data</td>
</tr>
<tr>
<td>Lengthy process to execute backups and restores</td>
<td>One call to RMAN from NetBackup to perform backups and restores</td>
</tr>
<tr>
<td>Does not check or track database information for</td>
<td>Maintains a recovery catalog that contains database metadata to check</td>
</tr>
<tr>
<td>restores</td>
<td>validity of the backups and restores</td>
</tr>
<tr>
<td>Requires costly additional disk resources</td>
<td>Only requires disk space for recovery catalog</td>
</tr>
<tr>
<td>EMC TimeFinder initial and management costs could</td>
<td>The initial investments are considerably smaller and the management of these</td>
</tr>
<tr>
<td>be prohibitive</td>
<td>products is minimal</td>
</tr>
<tr>
<td>NetBackup server is the only host with access to</td>
<td>NetBackup Shared Storage Option allows the Oracle server to share tape</td>
</tr>
<tr>
<td>tape resources via fibre channel</td>
<td>resources on the fibre channel network</td>
</tr>
</tbody>
</table>

In summary, VERITAS NetBackup for Oracle offers better protection for critical data than the split-mirror backup strategy, reducing the chance of errors and shortening potential downtime in case a recovery is necessary.
Appendix: Scripts

These scripts were used in the company’s legacy backup routine to put the Oracle database into backup mode (RMAN handles this process automatically).

```bash
SQLPLUS_UID_PW=rman/oracle
SQLPLUS="$\{ORACLE_HOME\}/bin/sqlplus -s $\{SQLPLUS_UID_PW\}\"
BACKUPBCV='/export/home/oracle/bcv_begin'$fildate'.log'
$SQLPLUS > $(BACKUPBCV) <<EOF
alter system switch logfile;
select sequence# from v\$log where status = 'CURRENT';
alter tablespace SYSTEM begin backup;
alter tablespace TOOLS begin backup;
alter tablespace RBS begin backup;
alter tablespace TEMP begin backup;
alter tablespace USERS begin backup;
alter tablespace INDX begin backup;
alter tablespace RPTDAT begin backup;
alter tablespace RPTIDX begin backup;
quit
EOF
```

These scripts were used in the company’s legacy backup routine to put the Oracle database out of backup mode (RMAN handles this process automatically).

```bash
SQLPLUS_UID_PW=rman/oracle
SQLPLUS="$\{ORACLE_HOME\}/bin/sqlplus -s $\{SQLPLUS_UID_PW\}\"
BACKUPBCV='/export/home/oracle/bcv_begin'$fildate'.log'
$SQLPLUS > $(BACKUPBCV) <<EOF
$SQLPLUS
alter tablespace SYSTEM end backup;
alter tablespace TOOLS end backup;
alter tablespace RBS end backup;
alter tablespace TEMP end backup;
alter tablespace USERS end backup;
alter tablespace INDX end backup;
alter tablespace RPTDAT end backup;
alter tablespace RPTIDX end backup;
quit
EOF
```

Note that each tablespace is listed explicitly. If the structure of the database changes, this script must be updated. Sometimes, a company forgets to update its backup scripts, resulting in the loss of data.