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DATABASE APPLIANCE

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Backup and Recovery Best Practices for the Oracle Database Appliance

Introduction

The Oracle Database Appliance (ODA) is an engineered systems offering that saves time and money by simplifying the deployment, maintenance, and support of a high availability database solution - all supported by a single vendor – Oracle. It is a fully integrated system with software, servers, storage and networking in a single box capable of supporting a wide range of home grown, packaged OLTP and Data Warehousing applications.

The Oracle Database Appliance offers customers a unique pay-as-you-grow software licensing capability allowing seamless scalability from 4 to 24 processor cores without any hardware upgrades. It comes as a rack unit (RU) server appliance that consists of two server nodes and 12 TB raw storage capacity running Oracle Database 11*g* Release 2 (11.2) on Oracle Linux 5. It offers an ideal solution for customers who value simplicity and who seek to reduce the required skills, complexity, costs and risks in deploying a highly available database solution.

A key operational aspect of deploying Oracle's Database Appliance is to ensure that database backups are performed so that Oracle databases that reside on the Database Appliance can be restored if disaster strikes. This white paper is based on Oracle Database 11*g* Release 2 and describes the best practices for setting up optimal backup and recovery strategies to protect mission-critical data. The Oracle Database includes sophisticated and scalable backup technologies. These technologies work well on the Oracle Database Appliance with its high bandwidth bonded 1 GbE (bond0, bond1, bond2) and 10 GbE (xbond0) interfaces.

The following technologies make it possible to achieve simple and reliable backup/restore procedures on the Oracle Database Appliance:

- Oracle Recovery Manager (RMAN) provides the native backup and recovery infrastructure within Oracle Database, enabling optimized data protection in the Oracle Database Appliance environments:
    - Backup, restore, and recovery operations are performed using standard RMAN commands.
    - RMAN can parallelize backup operations across both Real Application Cluster (RAC) nodes. This allows all disks, all network connections, and all CPUs in the system to contribute towards performing backup operations.

    - RMAN block change tracking allows incremental backups to run very quickly and efficiently. With block change tracking, only the areas of the database that have been modified since the last incremental backup, or full backup, are read from disk.

- Oracle Secure Backup (OSB) is a centralized tape backup management solution for the entire IT environment including file systems and Oracle Databases. With built-in RMAN integration, Oracle Secure Backup delivers the fastest Oracle Database backups to tape. Some important backup optimizations that provide substantial savings in backup time and tape costs are available only with Oracle Secure Backup and RMAN:

    - Unused block compression eliminates the time and space needed to backup blocks that are allocated to tablespaces that are not currently used by tables.

    - Undo optimization eliminates the time and space usage needed to back up undo data that is not required to recover the current backup.

- It's highly recommended that users store all scripts and configuration files in the shared ACFS filesystem (i.e identified as /cloudfs mount point) and take backups on a regular basis to external storage.

This paper discusses backup strategies to tape and local Fast Recovery Area (FRA) together with best practices.

Test Environment

This paper describes the backup and recovery testing of the Oracle Database Appliance with various CPU core count configurations:

- Tape backup and restore testing was performed using Oracle Secure Backup Release 10.4.0.1, with a single Master/Media server attached to an Oracle StorageTek SL24 tape autoloader and 2 LTO-5 tape drives.
- Disk backup and restore testing was performed with image copy formats and backup sets using the Fast Recovery Area (FRA) located on the Oracle Database Appliance using varying degrees of RMAN parallelism.

General Decisions

Customers need to look at their backup window, RTO (Recovery Time Objective), and RPO (Recovery Point Objective) requirements before they implement a backup strategy. Based on these needs a single backup strategy or a mixture of the proposed backup options can be established.

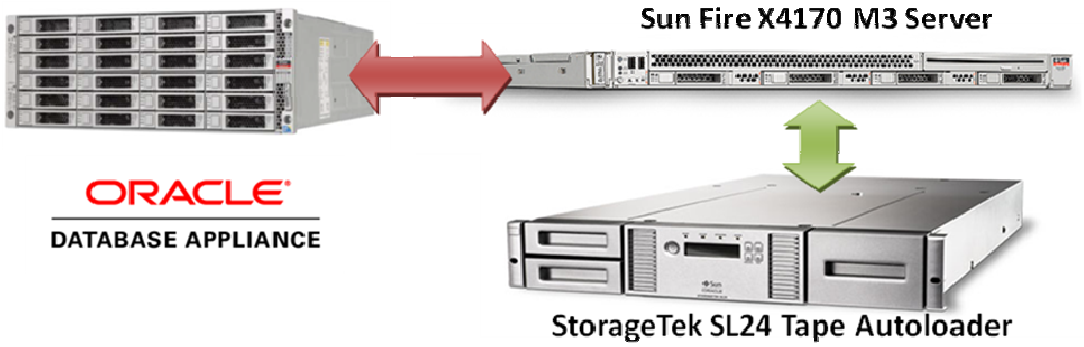
Tape-Based Backup Strategy

Some of the key benefits of a tape-based backup strategy include:

- The Oracle Database Appliance and tape-based backups provide fast backup and restore rates.
- Tape-only solutions isolate faults from the Oracle Database Appliance.
- Oracle Database Appliance capacity and bandwidth are maximized.
- Tape media is easily transportable and satisfies off-site disaster recovery requirements.
- Tape offers the lowest cost and most energy efficient backup storage.

For a tape-based backup solution, the recommended strategy is to perform the following backups:

- Weekly RMAN level 0 (full) backups of the database
- Daily cumulative RMAN incremental level 1 backups of the database
- Daily backups of the Oracle Secure Backup catalog



Example Tape Based Backup Configuration

Media Management Software for Tape Backups

RMAN is integrated with media management software to facilitate RMAN backups to tape. Oracle Secure Backup (OSB) is the media management software used for the testing described in this white paper. It is a highly scalable backup solution with a client/server architecture in which all hosts in the backup domain have one or more Oracle Secure Backup roles. For more information about OSB reference the Oracle Secure Backup Documentation.

Performance Numbers for Tape-Based Backup Configurations

The performance numbers below were achieved using a single Oracle Secure Backup Master/Media server with a dedicated 1Gb active-passive bonded network and a 10Gb active-passive bonded network with an Oracle StorageTek SL24 containing two LTO-5 tape drives attached via a 6 Gb/sec SAS connection to the OSB Media Server.

- The target database contained 1TB of data with an approximate data compression of 1.4 to 1. Depending on the composition of the data, compression ratios will vary as well as transfer rates to tape.
- There were minimal archive logs to backup and the database was idle during online backup. If a significant number of archive logs are present this will impact backup times as backing up a large number of small files slows performance.
- The performance of the 1Gb backup was limited by the single active-passive bonded network on the OSB Media Server. Each node on the ODA has a 1Gb bonded interface that can send 120MB/sec for an aggregate transfer rate of 240 MB/sec, but since there is only 1 bonded NIC on the Media Server, it can consume a maximum of 120MB/sec limiting the transfer rate to 120MB/sec.

- The performance of the 10Gb backup was limited by the two LTO-5 tape drives. Data rates averaged 175MB/sec per tape drive. Additional tape drives could have been added up to 1 GB/sec assuming the Database Appliance or OSB Media Server I/O bandwidth was not first consumed.
- Restore tests consisted of restoring the controlfile and data files from tape, archive logs were recovered from the Fast Recovery Area (FRA).
- Backup rates do not include tape mount and dismount times and are calculated on data transfer time utilizing OSB recorded start/stop times.

	BACKUP RATE (TB/HR)	RESTORE RATE (TB/HR)	HOST CPU USAGE
1Gb Load Balanced Across Both Nodes, 2 Cores	.43TB	.43TB	2 – 6%
1Gb Load Balanced Across Both Nodes, 24 Cores	.43TB	.43TB	.5 – 3%
1Gb Single Node, 2 Cores	.43TB	.43TB	2 – 6%
10Gb Load Balanced Across Both Nodes, 2 Cores	1.2TB	1.6TB	2 – 6%
10Gb Load Balanced Across Both Nodes, 24 Cores	1.2TB	1.6TB	.5 – 3%
10Gb Single Node, 2 Cores	1.2TB	1.6TB	2 – 6%

Disk-based backups

Depending on backup/restore requirements and available resources, disk-based backup may be required. You may also want to use a disk-based backup solution if you require Tablespace Point in Time Recovery (TSPITR), switching to a copy, or incremental merges as these options are not available with tape. This section discusses the backup to the Fast Recovery Area located in the RECO disk group.

Some of the benefits to a disk-based backup strategy include:

- Better recovery times for data and logical corruptions, and capability for Tablespace Point in Time (TSPITR) scenarios.
- Ability to use backups directly with no restore by switching to a copy of the database, tablespace or data file
- Fastest database backup and recovery performance

For disk-based backup solutions, Oracle recommends the following:

- Use a Fast Recovery Area (FRA)
- Perform an initial RMAN level 0 (full) backup
- Perform daily RMAN incremental level 1 backups
- Roll incremental backups into full backup and delay by 24 hours (see the Backup and Recovery User's Guide)

RMAN backups to Fast Recovery Area (FRA)

To help manage disk backups, you can define a special disk area that serves as the location for database backup and recovery files. This location is the Fast Recovery Area (FRA). Oracle Database manages the space inside this area; keeps track of backups that are needed; and if necessary, deletes old ones to make room for new backups. By default, Oracle RMAN backs up both backup set and image copies, online redo logs, archived logs, control files, and flashback logs in the FRA. When new backups or files demand more room, Oracle Database automatically removes the nonessential backups, freeing the DBA from this chore. The files in the FRA are considered nonessential when they become obsolete according to RMAN retention policies, or when they have already been backed up to tape with Oracle RMAN.

ODA Local and External Backup Implications

The layout of the Oracle Database Appliance disk groups depends on the selection of the Backup Type option in the Oracle Database Appliance Manager Configurator (custom installation option) utility during deployment. The Local Backup Type selection assigns 40% of the disk to the DATA disk group, and 60% of the disk is assigned to the Fast Recovery Area - RECO disk group. On the other hand the External Backup Type option, assigns 80% of the disk to the DATA disk group, and 20% of the disk is assigned to the Fast Recovery Area +RECO disk group.

In order to reserve more space for the DATA disk group, Oracle recommends selecting the External Backup Type and using an external storage-based backup and recovery solution leveraging Oracle's StorageTek Tape and/or Sun ZFS Storage Appliance (ZFSSA) disk-based solution. Additionally, a hybrid approach can be used where full database backups go to tape or the ZFSSA and incremental disk backups are directed to the Fast Recovery Area.

To summarize, choosing external versus local backup in the Oracle Database Appliance Manager during deployment will affect the size of the disk groups, +DATA and +RECO, which will determine the FRA size as follows:

	LOCAL BACKUP	EXTERNAL BACKUP
ASM Disk group +DATA	1.6 TB	3.2 TB
ASM Disk group +RECO	2.4 TB	0.8 TB

If further space is needed, the FRA can also be created on a ZFS Storage Appliance via NFS mounts.

Backup Format

RMAN stores data in one of two formats – Image Copy or Backup Set.

- An Image Copy is an exact copy of a single data file, archived redo log file, or control file. Image copies are not stored in an RMAN-specific format. They are identical to the results of copying a file with operating system commands.
- A Backup Set is a complete set of backup pieces that make up a full or incremental backup of the objects specified in the RMAN `BACKUP` command. A **Backup Set**, which is a logical object, contains one or more physical **backup pieces**. Backup Sets are in an RMAN-specific format.

Refer to Oracle Database High Availability Best Practices 11g Release 2 document for more information about the FRA.

Performance Numbers for local FRA-Based Backup Configurations

To scale backup rates for disk on ODA using a RAC configuration:

- Use both instances and start with one RMAN channel per instance
- Continue to add additional RMAN channels for performance per instance.

To scale backup rates for disk on ODA using a Single Instance and RAC One Node configuration:

- Start with one RMAN channel
- Continue to add RMAN channels to the single database instance to increase performance.

On the Oracle Database Appliance, optimal backup rates were achieved with all RAC instances and one to four RMAN channels per instance. For a single instance configuration, optimal rates were observed with two to four RMAN channels.

RAC	BACKUP RATE (TB/HR)	RESTORE RATE (TB/HR)	HOST CPU USAGE
Image copy, 4 Cores, 4 channels	2.3TB	2.4TB	35-50%
Image Copy, 24 Cores, 8 channels	2.5TB	2.6TB	7-12%

SINGLE INSTANCE	BACKUP RATE (TB/HR)	RESTORE RATE (TB/HR)	HOST CPU USAGE
Image copy, 2 Cores, 2 channels	2.0TB	2.1TB	30-38%
Image Copy, 12 Cores, 4 channels	2.3TB	2.4TB	10-12%

RMAN Backup sets were created and restored with similar CPU usage. Compression required more CPU depending on the compression algorithm chosen.

Best Practices

Use Oracle Secure Backup for low-cost, fast, and validated tape backups. [Tape]

Oracle Secure Backup provides the fastest database backup to tape due to its tight integration with RMAN. If you are backing up to tape using Oracle Secure Backup, then the unused-block optimization capability is enabled. This functionality is not available with 3rd party media management software.

Configure Network Time Protocol (NTP) daemon on the Oracle Secure Backup Server. [Tape]

Ensure that the NTP daemon service on the Oracle Secure Backup Admin/Media Server is running and configured to use the same time source as the Oracle Database Appliance. Oracle Secure Backup schedules jobs based on the time of the database node, but the scheduler executes the job based on the time of the Oracle Secure Backup Admin server. If the time on the two systems is different, job start can be delayed.

Configure Dedicated Gigabit Ethernet or 10 Gigabit Ethernet. [Tape]

Using a dedicated interface for the transport eliminates the impact to the client access network. See the Appendix for details on available interfaces on the ODA.

Configure the Preferred Network Interface (PNI) to direct Oracle Secure Backup traffic over the 1 Gb and 10 Gb network interface. [Tape]

The Preferred Network Interface setting in OSB is the configuration parameter that OSB uses to route backup traffic across a specific interface. If you are using a dedicated network for backup, as is recommended, this must be setup. When configuring the PNI you must also disable the Reliable Datagram Socket (RDS) protocol and load balancing, as these two settings are enabled by default in OSB 10.4.0.1 and will cause problems with the PNI setup. To transfer data using RDS, both the client and media server must use Infiniband which is not available with the Oracle Database Appliance.

To disable RDS and load balancing, execute the following commands from the OSB Administrative Server:

```
# obtool setp operations/disablerds yes
# obtool setp testing/supressrdma yes
```

Set RMAN configuration setting `FILESPERSET=1` when performing incremental backups

Specify `BACKUP ... FILESPERSET` to specify the maximum number of files in each backup set. A setting of 1 will allow for faster single file database restore operation.

Configure one RMAN channel per tape drive and add tape drives to scale backup rates. [Tape]

Tape drive performance rates vary by model and vendor. Depending on the drive type, compression options and data, various transfer rates will occur. Note that tape drive compression becomes less effective when backing up tables that are compressed at the database level. Backup performance scales when you add more tape drives and RMAN channels, assuming there is available throughput on the Administrative/Media Server.

Configure Oracle RAC Service for load balanced backups running on all database instances. [Tape] [FRA]

In order to efficiently allocate resources across the database nodes during backups, the backup load should be spread evenly between the RAC nodes. See the Appendix for details on creating RAC services.

Use RMAN incremental backups and block change tracking. [Tape] [FRA]

If your backup strategy involves incremental backups, enable block change tracking to achieve fast incremental backups. Block change tracking allows RMAN to avoid scanning blocks that have not changed when creating incremental backups. Block change tracking is disabled by default. The benefits of avoiding full data file scans during backup are considerable, especially if only a small percentage of data blocks are changed between backups. Block change tracking in no way changes the commands used to perform incremental backups. The change tracking files themselves generally require little maintenance after initial configuration. Testing is recommended to ensure that backup times are reduced.

For Example:

```
SQL> ALTER DATABASE ENABLE BLOCK CHANGE TRACKING USING FILE '+RECO';
```

Use an external RMAN recovery catalog. [Tape] [FRA]

See the *Oracle Database Backup and Recovery User's Guide* for more information about the RMAN repository.

Tune the network communication if you are using a third-party media management vendor. [Tape]

If you are using a non-Oracle Media Management Vendor (MMV), contact the vendor for their configuration best practices. Most vendors test and validate their own products with the Oracle Database Appliance and can recommend how to exploit the full potential of the 1 Gb or 10 Gb networks. Note that there is no special certification required for RMAN and the Media Management Vendor (MMV) to work with Oracle Database Appliance. The MMV is required to certify with Oracle Database 11*g* release 2 (11.2) and Oracle Linux.

Set DB_RECOVERY_FILE_DEST_SIZE to bound space in the fast recovery area. [FRA]

The database writes archived redo log files and any additional recovery files to the Fast Recovery Area. These include any disk backup files such as level 0 image copies and level 1 backup sets as well as Flashback log files (if Flashback Database is enabled). It is important that you set the value of this parameter to less than the total free space in the disk group. Additionally, if multiple databases are sharing the Fast Recovery Area, ensure that the sum of the space allocated to the different databases is less than the total free space in the disk group. Note that the ODA specific Oracle Database Machine templates set the DB_RECOVERY_FILE_DEST to +RECO.

For example:

```
SQL> ALTER DATABSE SET DB_RECOVERY_FILE_DEST_SIZE=30G;
```

Use one to four RMAN channels per instance. [FRA]

In most cases, two RMAN channels per database server are sufficient to maximize backup performance. During backup operations, sufficient CPU resources are available for production usage because less than 10% CPU utilization is required for backups. Listener load balancing distributes the connections between the two instances. For backing up a single instance database 4 or fewer channels are recommended.

Enable RMAN Compression [FRA]

Oracle 11g Release 2 introduced compression algorithm levels which can be used for compressing table data in RMAN backups. The compression levels are BASIC, LOW, MEDIUM and HIGH, and each affords a tradeoff related to backup throughput and the degree of compression achieved. However, it should be noted that use of LOW, MEDIUM and HIGH requires the Advanced Compression license. Oracle users are encouraged to test the compression algorithms and decide which one best fits their requirements.

Tests carried out on an 865 GB database returned backup compression ratios of approximately 4:1 in the best case scenario.

Conclusion

The Oracle Database Appliance when employed with the best practices described in this white paper allow you to backup, restore, and recover the Oracle Database, using either disk-based or tape-based solutions. Customers will need to identify backup and recovery requirements – RPO, RTO, backup window - as well as Database Appliance capacity requirements -+DATA and +RECO sizing - and then select the disk and/or tape backup solution that fits best. Customers may chose one or a combination of the solutions or even integrate into existing backup environments.

Appendix

Configure Oracle RAC Service for load-balanced backups running on all database instances.

In order to efficiently allocate resources across the database nodes during backups, the backup load should be spread evenly between the RAC nodes.

Create a service that runs on the selected nodes in the cluster

```
$ srvctl add service –d <dbname> -s <service name> -r
<instance1>,<instance2>

$ srvctl add service –d isr –s isrsvc –r isr1,isr2
```

Start the service

```
$ srvctl start service –d <db_unique_name> -s <service_name>

$ srvctl start service –d isr –s isrsvc
```

Add a net service name to `$ORACLE_HOME/network/admin/tnsnames.ora` which is used for automatic load balancing the connection:

```
ISR =
(DESCRIPTION =
      (ADDRESS = (PROTOCOL = TCP)(HOST = hamms-scan)(PORT = 1521))
      (CONNECT_DATA =
      (SERVER = DEDICATED)
      (SERVICE_NAME = isr)
      )
)
```

A restore script can allocate channels to specific instances using these instance-specific net names as shown below.

```
ISR1 =
(DESCRIPTION =
          (ADDRESS = (PROTOCOL = TCP)(HOST = hamms1)(PORT = 1521))
          (CONNECT_DATA =
            (SERVER = DEDICATED)
            (SERVICE_NAME = isr)
            (SID = isr1)
```

```
          )
  )

ISR2 =
(DESCRIPTION =
          (ADDRESS = (PROTOCOL = TCP)(HOST = hamms2)(PORT = 1521))
          (CONNECT_DATA =
            (SERVER = DEDICATED)
            (SERVICE_NAME = isr)
            (SID = isr2)
          )
  )
```

Sample Scripts

For all scripts in this section archive logs needed for recovery are available on disk. The scripts do not cover special considerations that may arise when restoring a production database. Customers may use these examples, adjust them to their needs and embed them in shell scripts.

Sample Script for Tape Backup in RAC

The script allocates two channels for two tape drives and creates a full backup including the archivelogs.

```
RUN {
ALLOCATE CHANNEL ch00 TYPE 'SBT_TAPE' CONNECT='@isr';
ALLOCATE CHANNEL ch01 TYPE 'SBT_TAPE' CONNECT='@isr';
BACKUP INCREMENTAL LEVEL 0 DATABASE PLUS ARCHIVELOG;
}
```

Note: Channels are load balanced in RAC

Sample Script for Tape Restore for Single Instance and RAC One Node

For the restore operation, two channels are allocated and the database is recovered automatically from the available archive logs. Sometimes even the old redo logs were available so that the database could be recovered without open resetlogs.

```
ALTER DATABASE MOUNT
RUN
{
ALLOCATE CHANNEL ch00 TYPE 'SBT_TAPE';
ALLOCATE CHANNEL ch01 TYPE 'SBT_TAPE';
RESTORE DATABASE;
RECOVER DATABASE;
{
ALTER DATABASE OPEN RESETLOGS;
```

Note: To run parallel restores you must mount the database on the second node and allocate channels using connect strings.

Sample script for image copy backup (RAC, RAC One Node and Single Instance)

Before executing the backup as copy operation the configuration details like backup type and parallelism are set.

```
CONFIGURE DEFAULT DEVICE TYPE TO DISK;
CONFIGURE SNAPSHOT CONTROLFILE NAME TO '+RECO';
CONFIGURE DEVICE TYPE DISK BACKUP TYPE TO COPY;
CONFIGURE DEVICE TYPE disk PARALLELISM 2;
CONFIGURE CONTROLFILE AUTOBACKUP ON;
RUN
{
backup as copy database;
}
```

Sample script for image copy restore for RAC

The channel allocations use the credentials of the user connected to the instance.

```
run
{
ALLOCATE CHANNEL ch1 DEVICE TYPE DISK CONNECT '@isr1';
ALLOCATE CHANNEL ch2 DEVICE TYPE DISK CONNECT '@isr2';
restore database;
recover database;
}
startup;
```

Note: To run parallel restores you must mount the database on the second node and allocate channels using connect strings.

Sample script for image restore RAC One Node and Single Instance

Restore can also be parallelized and speed up performance.

```
CONFIGURE DEVICE TYPE disk PARALLELISM 2;
run
{
restore database;
recover database;
}
startup;
```

Sample backup script for backup set:

The configure command sets the backup type for the backup operation.

```
CONFIGURE DEFAULT DEVICE TYPE DISK;
CONFIGURE DEVICE TYPE DISK BACKUP TYPE TO BACKUPSET;
CONFIGURE SNAPSHOT CONTROLFILE NAME TO '+RECO';
CONFIGURE DEVICE TYPE disk PARALLELISM 2;
CONFIGURE CONTROLFILE AUTOBACKUP ON;
Run
{
Backup database;
}
```

Monitoring disk based backups

When an RMAN job is executed the job transcript is written to stdout by default, but the output can be redirected to a log file that can be analyzed for errors and warnings, as well as to review backup piece names that are written. Additionally, RMAN uses the NLS_DATE_FORMAT environment variable to report times in hours / minutes and seconds, that can be useful to monitor run times.

```
SELECT sid, serial#, context, sofar, totalwork,
           round(sofar/totalwork*100,2) "% Complete"
         FROM v$session_longops
         WHERE opname LIKE 'RMAN%'
           AND opname NOT LIKE '%aggregate%'
           AND totalwork != 0
           AND sofar <> totalwork
       /
```

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