An Oracle White Paper
April 2014

Backup and Recovery Best Practices for the Oracle Database Appliance

Introduction

Backup and recovery of databases and systems are important to customers. Oracle offers proven solutions for backing up databases to local storage, NFS or tape. While this has been working for most customers who use the Oracle Database Appliance as database server, support of Oracle VM in ODA 2.5 has opened the requirement to back up virtual machines. This whitepaper will discuss the different options and considerations for backing up databases and virtual environments.

The Oracle Database Appliance is an Oracle Engineered System consisting of hardware and software that saves customers time and money by simplifying deployment, maintenance, and support of high availability database solutions. Built using the world's most popular database - Oracle Database. Along with Oracle Real Applications Clusters (Oracle RAC), the Database Appliance offers customers a fully integrated system of software, servers, storage and networking that delivers high availability database services for a wide range of custom and packaged OLTP and Data Warehousing workloads.

The Oracle Database Appliance offers customers capacity-on-demand database software licensing, allowing seamless scalability from 2 to 48 processor cores without any hardware upgrades. The appliance also offers the option of deploying a virtualized platform based on Oracle VM. Support for virtualization allows customers and ISVs to build a solution-in-a-box that efficiently utilizes resources and extends capacity-on-demand licensing to both database and application workloads by leveraging Oracle VM hard partitioning.

Backing up and Restoring Virtual Machines

Oracle Database Appliance can be set up with Oracle VM which enables you to run virtual machines from local repositories or shared repositories. Shared repositories are highly available by use of Oracle CloudFS and were introduced in Oracle Appliance Manager version 2.8. The advantage of shared repositories is that in case of maintenance or a node failure the VM can be started on the other node or fail over automatically. Although you have high availability with shared repositories virtual machines need to be protected against risk of logical and physical destruction.

Backup of Virtual Machines

All VMs stored on local or shared repositories including ODA_BASE, which is the virtual machine that runs the databases, can be backed up using a backup client or Linux tools to save files on an NFS mount point or tape.
VMs can also be saved by backing up their config file and virtual disks from dom0 using

normal Linux tools, like tar, cpio, rsync, scp or sftp. Complete repositories can be saved using the same Linux tools.

Shared repositories are based on Oracle Cloud File System, which offers the creation of snapshots. Oracle recommends storing VMs in a shared repository, because of the switchover and automatic failover capability of VMs. While not yet supported within Oracle Appliance Manager with oakcli commands, customers can create read only snapshots themselves if the snapshot capability was licensed. It takes only a few minutes to stop the VM, create a read only snapshot and then start the VM. The snapshot can be destroyed after backing up the VM files or repositories from the snapshots. Read-write snapshots are not supported on ODA.

In all cases Oracle recommends to take offline backups of virtual machines. Snapshots reduce downtime of VMs dramatically. Virtual machines that do not store data on their local file systems may be backed up less often. VMs which hold data locally may need regular backups or back up their data by backup clients. MOS note 1633166.1 shows the various options to backing up VMs.

Restore of Virtual Machines

When a VM has been damaged and needs to be restored, only the files belonging to the VM need to be copied back to its original location.
For a completely damaged repository an import and clone of the VMs is recommended. See MOS note 1633166.1 for details about restoring VMs.

Database Backup

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. Changing the storage configuration of the Oracle Database Appliance from triple mirroring to double mirroring or vice versa is best secured by backing up and restoring the database. 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 and environments. 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 and 10 GbE 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:

    o Backup, restore, and recovery operations are performed using standard RMAN commands.

    o 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.

    o 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:

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

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

- Oracle ZFS Storage Appliance can be used as a backup storage location for databases. The high speed networks support good performance. With the ZFS HA solutions, customers do not have to worry about single point of network failures.

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

This paper discusses database backup strategies as well as virtual backup techniques and best practices.

Test Environment

The backup and recovery testing of the Oracle Database Appliance was conducted with various CPU core count configurations on both virtual as well as bare metal deployments on an Oracle Database Appliance X3-2 with triple mirroring (high redundancy):

• Tape backup and restore testing was performed using Oracle Secure Backup Release 10.4.0.3, with a single Administrative/Media server attached to an Oracle StorageTek SL150 tape library and 2 half height LTO-6 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.

• Network-attached storage testing was performed with RMAN backup sets being sent to an Oracle ZFS Storage Appliance 7120 over 1 Gb and 10 Gb network interfaces.

General Decisions

You should review your RTO (Recovery Time Objective) and RPO (Recovery Point Objective) requirements before implementing a backup strategy. Based on your recovery 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.

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
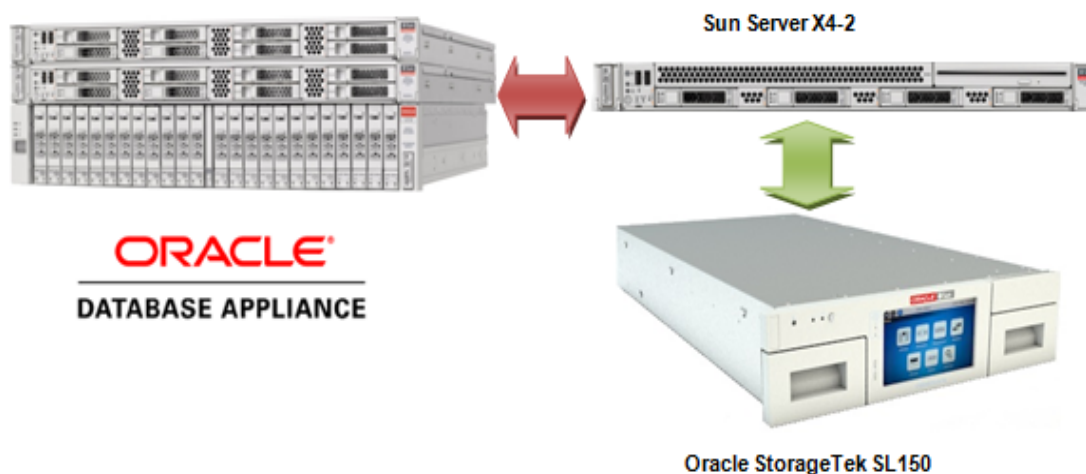
Example Tape Based Backup Configuration

Media Management Software for Tape Backups

RMAN is integrated with media management software for backups to tape. Media management software is the software layer that facilitates RMAN backups to tape. Oracle Secure Backup is used as the media management software 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 see the Oracle Secure Backup Documentation.

Tape Based Backups

The performance numbers reported in this white paper were achieved using a single OSB Administrative/Media server with a dedicated 1 Gb active-passive bonded network and a 10 Gb active-passive bonded network with an Oracle StorageTek SL150 containing two LTO-6 tape drives attached via a 6 Gb/sec SAS connection to the OSB Media Server.

- Target database has 1 TB of data with a data compression of approximately 1.4 to 1. Depending on the composition of the data, compression will vary and so will transfer rates to the tape drive.

- There were minimal archive logs to backup and the database was idle during 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. Additionally, if there is a heavy load on the database and CPU is fully consumed, backup rates could be affected.

- The performance of the 1 Gb backup was limited by the single active-passive bond on the OSB Media Server. Each node on the Oracle Database Appliance has multiple 1 Gb bonded interfaces. Through any configured interface it can send 120 MB/sec for an aggregate transfer rate of 240 MB/sec, but since there is only one bonded NIC on the

Media Server, it can consume a maximum of 120 MB/sec which limits the transfer to 120 MB/sec.

• The performance of the 10 Gb backup was limited by the two LTO-6 tape drives. Average rates were 373 MB/sec per tape drive and additional tape drives could be added up to 1 GB/sec assuming the Database Appliance I/O bandwidth is not exhausted first (single active-passive bond on OSB Media Server).

• Restore tests consisted of restoring the controlfile and data files from tape, but the recovery operation retrieved archive logs from the local Fast Recovery Area (FRA).

• Backup rates assume tape drives are mounted before the job starts and rates are calculated on data transfer time utilizing OSB recorded start/stop times.

	BACKUP RATE (TB/HR)	HOST CPU USAGE
1 Gb Load Balanced Across Both Nodes 2 Cores	.43 TB	2 – 6%
1 Gb Load Balanced Across Both Nodes 24 Cores	.43 TB	.5 – 3%
1 Gb Single Node 2 Cores	.43 TB	2 – 6%
10 Gb Load Balanced Across Both Nodes 2 Cores	2.7 TB	2 – 6%
10 Gb Load Balanced Across Both Nodes 24 Cores	2.7 TB	.5 – 3%
10 GB Single Node 2 Cores	2.7 TB	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 FRA located in the RECO disk group.

Some of the key 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.

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 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 backups. This location is the Fast Recovery Area (FRA). Together the Oracle Database and RMAN manages the space inside this area; keeps track of backups that are needed; and if necessary, deletes old ones to make room for new ones. Oracle RMAN backs up image copies, online redo logs, archived logs, control files, and flashback logs into 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 the retention policy, or when they have already been backed up to tape with Oracle RMAN.

Oracle Database Appliance 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 utility. The configurator also allows you to select between triple mirroring (high redundancy) and double mirroring (normal redundancy). For the Local Backup Type option, 40% of the disk is assigned to the DATA area, and 60% of the disk is assigned to the Fast Recovery Area (RECO) area. For the External Backup Type option, 80% of the disk is assigned to the DATA area, and 20% of the disk is assigned to the Fast Recovery Area (RECO) area. This can be configured during deployment.

To summarize, choosing external versus local backup in the Oracle Database Appliance Manager during deployment on an X3-2 or X4-2 will affect the size of the diskgroups, +DATA and +RECO, which will determine the FRA size as follows:

WITHOUT EXPANSION BOX	LOCAL BACKUP	EXTERNAL BACKUP
ASM Diskgroup +DATA	2.4 TB	4.8 TB
ASM Diskgroup +RECO	3.056 TB	0.657 TB
WITH EXPANSION BOX	LOCAL BACKUP	EXTERNAL BACKUP
ASM Diskgroup +DATA	4.8 TB	9.6 TB
ASM Diskgroup +RECO	6.114 TB	1.314 TB

FRA can also be created on a NAS storage appliance via NFS mounts.

To reserve more space for the DATA disk group, Oracle recommends using a tape-based backup solution with the External Backup Type specified as the Backup Type during deployment, or at the very least, a hybrid approach where full database backups go to tape or a ZFS Storage Appliance (ZFSSA) and incremental disk backups go to the Fast Recovery Area.

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. RMAN can use Image Copies during RMAN restore and recovery operations, and it can also use Image Copies with non-RMAN restore and recovery techniques.

• A backup set contains the data from one or more data files, archived redo log files, control files or server parameter file. The smallest unit of a backup set is a binary file called a backup piece. Backup sets are the only form in which RMAN can write backups to sequential devices such as tape drives. Refer to Oracle Database High Availability Best Practices 11g Release 2 document for more information about the FRA.

Performance Numbers for Local Disk Based Backup Configurations

To scale backup rates written to local disk in the Fast Recovery Area on Oracle Database Appliance 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.

• Optimal backup rates were observed with all RAC instances and one to four RMAN channels per instance.

RAC	BACKUP RATE (TB/HR)	RESTORE RATE (TB/HR)	HOST BUSY
Image copy 8 Cores 4 channels	2.22 TB	2.35 TB	28-38%
Image Copy 32 Cores 8 channels	2.25 TB	2.40 TB	10-20%

To scale backup rates written to local disk in the Fast Recovery Area on Oracle Database Appliance 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.

• Optimal backup rates were observed with two to four RMAN channels.

SINGLE INSTANCE	BACKUP RATE (TB/HR)	RESTORE RATE (TB/HR)	HOST BUSY
Image copy 2 Cores 2 channels	1.92 TB	2.05 TB	50-80%
Image copy 4 Cores 2 channels	1.99 TB	2.10 TB	25-38%
Image Copy 16 Cores 4 channels	2.16 TB	2.24 TB	15-20%

The performance numbers shown in these tables are for Bare Metal installations, except for single instance with 2 cores. The same tests performed in a virtualized environment showed backup rates which were 2-5% lower and the hosts more busy.

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

Network-Attached Storage Backups

The Oracle ZFS Appliance 7000 is a unified storage system that provides flexible configuration and attachment options for a wide range of storage demands. The Oracle ZFS 7120 was selected to demonstrate the ability to send RMAN backups over the 10 Gb interfaces on the Oracle Database Appliance to network storage using the Oracle-exclusive dNFS high performance NFS client.

Using network-attached storage for database backups allows isolation of backups from the internal storage, and opens a range of possibilities for management of the backups including replication to a remote site, snapshots for additional copies of backups, compression of backups by the ZFS Appliance, and sharing of the backups with another database server.

The methodology for network-attached storage is similar to FRA-based backups:

- Use NFS shares and define the NFS Appliance shares to dNFS so that the dNFS client is used

- 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 [Backup and Recovery User's Guide](#))

RMAN Backups to the Oracle ZFS Storage Appliance 7120

The ZFSSA 7120 is a single-head storage controller with capacity and performance that matches well with the Database Appliance. It can be configured from 3.3 TB to 177 TB of raw capacity and 73 GB of write-optimized flash storage that can be accessed using 1 Gb, 10 Gb, or fiber channel interfaces, using a wide variety of protocols. For use as a Database Appliance backup target, NFS shares accessed over 10 Gb interfaces are recommended. The 7120 comes standard with 4 x 1 Gb network interfaces. For optimal backup performance, the optional 10 Gb interfaces are recommended for the 7120.

The ZFSSA architecture provides flexible configuration options. For this white paper, we chose a configuration that optimizes the RMAN large block, streaming write and read performance over Ethernet interfaces, while maintaining fault-tolerance. Defining NFS shares in a single double parity (RAID-Z2) storage pool provides the necessary performance and availability. We will assume the ZFSSA 7120 has an optional dual 10 Gb network interface card, two dedicated boot drives, and twelve 2 TB or 3 TB HDD for data storage.

The ZFS Storage Appliance 7120 can be configured using the web-based Browser User Interface (BUI) or via CLI commands executed directly on the ZFS Appliance. In all examples below it is assumed the user has logged into the BUI using the root user and password. The usual form of the BUI URL is:

https://<ZFSSA Name or IP Address>:215

The complete documentation for the configuration of all aspects of the Storage Appliance is available in the BUI help screens.

- **Pools** - The ZFS Storage Appliance 7120 stores data in groups of hard disks aggregated into pools. There are several possible pool configurations: Single, double or triple parity and mirrored or striped. Given the emphasis with Oracle Database Appliance on maximum data availability and good performance, choosing double parity (RAID-Z2) is the best balance between performance and availability. While multiple pools can be configured on a dedicated 7120 the best choice is to define a single storage pool.

    - Click Configuration->Storage

    - Click the plus sign (+) next to Available Pools

    - Give the pool a name (Pool-0 for example) and click Apply

    - At the "Verify and add devices" screen select all HDDs but do not select the Boot drives

    - Click "Commit"

    - On the next screen choose the Double parity storage profile

    - Click "Commit"

- **Shares** - The ZFS Storage Appliance 7120 supports NFS, CIFS/SMB and iSCSI network storage protocols, as well as Fiber Channel with an optional interface card. The Oracle Database Appliance has the ability to run a highly-optimized version of the NFS file system client called dNFS, so defining and using NFS shares as targets for Oracle Database Appliance backup is a natural choice. NFS shares can be defined with several options, and for targets for Oracle Database Appliance backup, these are recommended:

    - Database record size: **128 KB**

    - Synchronous write bias: **Throughput**

    - Data Compression: **Off** for best performance, **LZJB** for good inflight compression

    The number of NFS shares to define for Oracle Database Appliance backup depends on the number of services and RMAN channels defined to execute the RMAN backups. Generally, one NFS share per RMAN channel provides optimum throughput. As with the FRA based backup configurations, two RMAN channels per server are a good

starting point. For a RAC configuration, a total of four RMAN channels and four shares work well.   NFS shares belong to a Project on the appliance, so first we define a Project, then the shares owned by the Project.

- In the BUI:

    - Click Shares->Projects

    - In the Projects pane on the left side, click the plus sign (+) next to the word "All"

    - Enter a name for the project and click Apply

    - Click on the new Project name in the Projects pane, then click General

    - Change Synchronous Write Bias to Throughput, Database record size to 128K, and set Data compression to Off or LZJB as desired.

    - Adjust the default permissions for the shares in the project

    - Click Apply – You now have a Project for your ODA backup shares

    - The Filesystems pane will appear, click the plus sign (+) next to the word "Filesystems"

    - Provide a share name

    - Adjust the default permissions given to the share if necessary

    - Click Apply

    - Create three more shares

    - Note the export mount point name shown in the Properties page of each share

- **Network Configuration –** We will assume a 7120 configuration with the optional 2 x 10 Gb interface card.   The ports can be used independently or can be bound together using the Link Aggregation Protocol (LACP) or IP MultiPathing (IPMP). In general, LACP is used for improved performance, while IPMP is used for availability. LACP requires a switch that can use the LACP techniques to load balance between physical ports, while IPMP does not require special switch configuration. Alternatively, the 10 Gb ports on the ZFSSA 7120 can be directly connected, one port to each server on the Oracle Database Appliance, without a switch, using a 192.168.* private non-routable network domain between the Oracle Database Appliance and the 7120. Jumbo frames should be specified.

Mounting the Shares on the ODA and Configuring dNFS

The /etc/fstab file on each server should be modified on each ODA server to mount each share created on the ZFSSA 7120 on mount points created on each server.

1. mkdir /mnt/backup1 /mnt/backup2 /mnt/backup3 /mnt/backup4

2. Edit /etc/fstab to include an entry for each mount. Example:
   192.168.2.1:/export/ODA/backup1 on /mnt/backup1 type nfs
   (rw,bg,hard,nointr,rsize=1048576,wsize=1048576,tcp,nfsver=3,timeo=600)

3. Issue the command 'mount –a' to read fstab

4. Adjust ownership/permissions if desired (chown/chmod)

The Oracle database has a special NFS client called Direct NFS or dNFS. The I/O
throughput from an Oracle database to an NFS share is greatly increased if dNFS is used.

A summary of how to configure dNFS follows:

1. Shut down the Oracle database instance(s) on each server

2. Issue this command from the oracle user on each server:

```
$  make –f  $ORACLE_HOME/rdbms/lib/ins_rdbms.mk dnfs_on
```

3. Create a file called $ORACLE_HOME/dbs/oranfstab on each server with entries
   showing the shares defined on the 7120 Appliance

   server: zfs-server
   path: 192.168.2.1
   export /export/ODA/backup1 mount: /mnt/backup1
   export /export/ODA/backup2 mount: /mnt/backup2
   export /export/ODA/backup3 mount: /mnt/backup3
   export /export/ODA/backup4 mount: /mnt/backup4

4. Restart the Oracle database instance(s) on each server

When executing RMAN, the following SQL queries can verify the use of dNFS:

```
select * from v$dnfs_servers;

select * from v$dnfs_files;
```

You may also want to review the database alert log and check database startup messages.

Configuring RMAN to Use the ZFSSA 7120

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

1. Create one service for each RMAN Channel/NFS mount point to run on selected nodes in the cluster:

   $ srvctl add service –d <dbname> -s <service name1> -r <instance1> -a<instance2>
   $ srvctl add service –d <dbname> -s <service name2> -r <instance2> -a <instance1>

   Example:
   ```
   srvctl add service -d isr -s isrsvc1 -r isr1 -a isr2
   srvctl add service -d isr -s isrsvc2 -r isr2 -a isr1
   ```

2. Start the services:

   $ srvctl start service –d <db_unique_name> -s <service_name1>
   $ srvctl start service –d <db_unique_name> -s <service_name2>

   Example:
   ```
   srvctl start service -d isr -s isrsvc1
   srvctl start service -d isr -s isrsvc2
   ```

The database backup and recovery strategies when using the ZFSSA 7120 as the target are similar to RMAN commands backing up to the local FRA . The ALLOCATE CHANNEL commands in the RMAN run block need to target the NFS mountpoints created on the 7120, and they need to connect to the services created to write to each mount. In the example, service isrsvc1 will write to /mnt/backup1 and service isrsvc2 will write to /mnt/backup2. If each service is running on a different server, the resources of both servers will be used to create the RMAN backup set.

Example:
```
run {
allocate channel oem_backup_disk1 type disk format '/mnt/backup1/%U'
connect '@isrsvc1';
allocate channel oem_backup_disk2 type disk format '/mnt/backup2/%U'
connect '@isrsvc2';
allocate channel oem_backup_disk3 type disk format '/mnt/backup3/%U'
connect '@isrsvc3';
allocate channel oem_backup_disk4 type disk format '/mnt/backup4/%U'
connect '@isrsvc4';


backup as BACKUPSET tag '%TAG' database;
backup as BACKUPSET tag '%TAG' archivelog all not backed up;
```

```
release channel oem_backup_disk1;
release channel oem_backup_disk2;
release channel oem_backup_disk3;
release channel oem_backup_disk4;
}
```

Performance Numbers for ZFSSA-Based Backup Configurations

To scale backup rates for disk on Oracle Database Appliance using a RAC configuration:

• Use both instances and start with two RMAN channels per instance

• Dedicate an NFS mount point to each channel

• Continue to add additional RMAN channels for performance per instance.

On the Oracle Database Appliance with a 12 TB 7120 configuration, optimal backup rates were achieved with both RAC instances and two RMAN channels per instance.

	BACKUP RATE (TB/HR)	RESTORE RATE (TB/HR)
10 Gb Load Balanced Across Both Nodes	1.2 TB	0.6 TB

Engineered Systems Backup Utility

RMAN backups of the ODA to an Oracle ZFS Storage Appliance can be configured automatically using the Engineered Systems Backup Utility 2.0 (ESBU), a free utility available on OTN. The ESBU 2.0 User's Guide can guide the user through the setup of the utility.   This document illustrates an alternative method of configuring backups to the ZFS Appliance using manual interfaces.

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 executes jobs based on the time of the database node, but the scheduler executes the job based on the time on 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] [ZFSSA]

Using a dedicated interface for the transport or ZFSSA eliminates the impact to the client access network. See 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 RDS balancing, as this setting is enabled by default in OSB 10.4.0.3 and will cause problems with the PNI setup. 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 Admin/Media Server.

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

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.

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 for each database to a reasonable size after the deployment.
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 Oracle Database Appliance templates set the DB_RECOVERY_FILE_DEST to +RECO.

For example:
```
SQL> ALTER DATABASE SET DB_RECOVERY_FILE_DEST_SIZE=30G;
```

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

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. If your backup strategy involves incremental backups, then block change tracking is recommended. 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][ZFSSA]

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.

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

In most cases, two RMAN channels per database server are sufficient. During backup operations, usually 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 less than 4 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 algorithm options 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 and resulted in storage space savings at the cost of additional CPU consumption.

Conclusion

The Oracle Database Appliance running Oracle VM is best suited as solution in a box running both the application and database. Customers have the choice to run their VMs from local or shared repositories. Shared repositories offer high availability which can be crucial for a solution in a box. All VMs can be backed up with standard tools while virtual machines are offline. Advanced technologies like snapshots will require a license but allow very short downtimes.

The Oracle Database Appliance benefits from native backup integration with Oracle Database (RMAN) and the variety of backup destinations. When deployed with the best practices described in this white paper backup, restore, and recover operations for your Oracle Database can be optimized. The backup configurations range from local disk backups to external backups. Local backups are written to the FRA whereas external backups can either be stored on NAS (disk) or tape. The peak backup performance ranges from 1.2 TB/hr to ZFS Storage Appliance over 2.7 TB/hr to Oracle StorageTek SL150 to 2.5 TB/hr to local FRA backups.

Oracle ZFS Storage Appliance provides a unique value proposition for hosting external database backups for databases running on Oracle Database Appliance. Oracle StorageTek SL150 offers excellent performance with additional growth flexibility.

Appendix: Configure Load Balanced Backups

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)
      )
)
```

For specific node connectivity use net names as shown here

```
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)
      )
  )
```

Appendix: 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.

Tape Backup in RAC

The script allocates two channels because we have tested with 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

Tape Restore for Single Instance and RAC One Node

For the restore two channels are allocated well and the database is recovered automatically with 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.

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/ISR/snap.cf';
CONFIGURE DEVICE TYPE DISK BACKUP TYPE TO COPY;
CONFIGURE DEVICE TYPE disk PARALLELISM 2;
CONFIGURE CONTROLFILE AUTOBACKUP ON;
RUN
{
backup as copy database;
}
```

Image copy restores on 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.

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;
```

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/ISR/snap.cf';
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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Oracle Database Appliance
April 2014

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