Hewlett Packard Enterprise

Reference Architecture

HPE REFERENCE CONFIGURATION FOR COPY DATA MANAGEMENT AND DATA PROTECTION OF ORACLE ENVIRONMENTS WITH HPE STOREONCE CATALYST AND RMAN

Oracle database backup and CDM using HPE StoreOnce Catalyst Plug-in for Oracle RMAN

CONTENTS

EXECUTIVE SUMMARY

The HPE StoreOnce Catalyst Plug-in for Oracle RMAN (RMAN Plug-in) integrates with the HPE StoreOnce backup appliance to deliver a unique combination of features providing high-performing, efficient, long-term data storage through HPE StoreOnce Catalyst and deduplication software, high availability through HPE StoreOnce Catalyst Copy, and integration to the cloud through HPE StoreOnce Cloud Bank stores. Many Oracle databases today are protected by backing up to HPE StoreOnce appliances through the use of a variety of supported data protection applications.

This Reference Configuration, addressed to Oracle DBAs, describes how Hewlett Packard Enterprise integrates the familiar Oracle Recovery Manager (RMAN) utility with HPE StoreOnce systems through the RMAN Plug-in. DBAs can utilize the highly efficient HPE StoreOnce Catalyst stores for data protection and copy data management (CDM) tasks without using a data protection application.

The following are key benefits when using the RMAN Plug-in:

- **Optimized deduplication:** Intelligent RMAN data stream analysis produces reduced network bandwidth and data storage requirements.
- **Increase backup performance:** Use multiple RMAN backup channels to improve throughput performance with little or no impact on deduplication ratios.
- **DBA controlled backups:** Database backups are controlled by the DBA. No independent data protection software is required. Existing RMAN scripts can be utilized with minimum modifications. Oracle DBAs can recover databases from any of the backup copies without involving the backup administrator or the backup application.
- **Improved scalability:** HPE StoreOnce Catalyst stores support millions of backup objects, providing better scalability than NFS targets. The RMAN Plug-in can be used to store database backups on local and DR site HPE StoreOnce appliances.
- **RMAN duplexed backup sets:** Create up to four copies of the backup sets (initial backup plus three copies) for redundancy and off-site disaster recovery (DR) protection.
- **HPE StoreOnce Catalyst Managed Copy:** The RMAN Plug-in supports HPE StoreOnce Catalyst Managed Copy. Additional copies of the backup are performed by the HPE StoreOnce appliances (appliance-to-appliance copy). RMAN remains fully aware of these copies, but having the HPE StoreOnce appliances manage them frees CPU cycles on the Oracle production server.
- **Faster Backup with offline DR copies:** The RMAN-Plug-in includes the HPE StoreOnce Catalyst Copy Utility. The utility allows DR copies of the primary RMAN backups to be made at a later time. RMAN backups to the primary HPE StoreOnce appliance complete without needing to wait for DR copies to finish. Decoupling the primary backup from creating DR copies allows the primary backups to complete more quickly.
- **Seamless restores from offline DR copies:** The RMAN Plug-in HPE StoreOnce Catalyst Copy Utility enables *Restore Redirect*—a feature that allows the RMAN Plug-in to search and restore from DR sites in the event of a primary backup becoming unavailable. RMAN is not aware of the redirection because the offline DR backup copies retain the same name as what was written to the RMAN catalog during the primary backup.
- **Enhanced security through encryption and Secure Erase:** HPE StoreOnce provides Industry-standard AES-256 bit encryption and FIPS 140-2 Level 1 encryption for the backup data at rest as well as Secure Erase functionality for protection against the recovery or reconstruction of deleted information. This secure data shredding meets the stringent NIST SP 880-88 standard.

Target audience: This document is intended for presales consultants, solution architects, DBAs, and backup, system, or storage administrators who are designing, implementing, and maintaining Oracle database backup and CDM tasks. It provides setup and configuration recommendations and best practices on how to incorporate RMAN Plug-in into an effective and efficient backup and CDM environment. Readers of this Reference Configuration should have a functional understanding of Oracle databases, RMAN, and data protection, backup concepts, and technologies for HPE StoreOnce backup appliances.

SOLUTION OVERVIEW

An important part of Oracle database administration is maintaining a consistent set of backup data. Whether data is lost due to user error, system failure, or site catastrophe, there is a need for data recovery. An HPE StoreOnce appliance, integrated with the RMAN Plug-in is part of a well-planned data protection strategy that includes regular Oracle database backups to maintain a consistent set of data for recovery purposes. The RMAN Plug-in allows DBAs to back up their Oracle databases directly to HPE StoreOnce Catalyst backup targets on HPE StoreOnce appliances. HPE StoreOnce Catalyst is a Hewlett Packard Enterprise-developed protocol that is optimized for backup and restore operations.[1] The HPE StoreOnce Catalyst server runs on the HPE StoreOnce data protection system. The RMAN Plug-in provides RMAN access to the HPE StoreOnce Catalyst client without requiring any changes to RMAN itself. Through the plug-in, RMAN intelligently processes the backup data stream, then uses HPE StoreOnce Catalyst to transmit the backup to the HPE StoreOnce appliance. HPE StoreOnce Catalyst protocol reduces backup times, and combined with deduplication, consumes less network bandwidth. Deduplicated data also consumes less storage space on the HPE StoreOnce backup appliance.

The RMAN Plug-in supports the HPE StoreOnce Catalyst Copy feature, allowing HPE StoreOnce Catalyst stores to be copied to a secondary HPE StoreOnce appliance or an HPE Cloud Bank Store for disaster recovery purposes. These HPE StoreOnce backups are self-contained volumes that can be restored back to the original database server or a different server in the event of a disaster or for CDM purposes.

The RMAN Plug-in and the RMAN utility effectively mitigate the threat of data loss by supporting the 3-2-1 rule for best practice Hybrid IT data protection, which states:

- Maintain three copies of the data: a primary copy and at least two additional copies.
- Store the copies on two different types of media.
- Keep one copy off site in the event of local hazards or infections within the network.

Production database volumes are hosted by storage arrays internal or external to the production server. Using the plug-in, RMAN interfaces primary storage with HPE StoreOnce appliances, creating a second copy of the data on the HPE StoreOnce backup appliance. Through the plug-in, RMAN also interfaces to the HPE StoreOnce Catalyst Copy feature to support creating a third copy. This third copy can be placed off site, either on a secondary HPE StoreOnce appliance or written to an HPE Cloud Bank Storage store.

The RMAN Plug-in is supported on Microsoft Windows® and a variety of UNIX® operating systems. It is supported across the entire range of HPE StoreOnce appliances, including the HPE StoreOnce VSA. The RMAN Plug-in supports Oracle 11gR2, 12cR1 and 12cR2 running in Oracle Stand Alone or Oracle RAC configurations. The RMAN Plug-in also supports Oracle Exadata appliances.[2]

[1] See the "HPE StoreOnce Catalyst" technical white paper for a detailed description of HPE StoreOnce Catalyst.
[2] See the current StoreOnce G4 Support Matrix – StoreOnce G4 Catalyst Application Support – Oracle RMAN in SPOCK for the latest Oracle platform and host operating systems that support the RMAN Plug-in.

Figure 1 shows a high-level block diagram of one possible RMAN Plug-in solution. The configuration shows an Oracle production server with the RMAN Plug-in installed. The RMAN backup is directed to a primary HPE StoreOnce appliance. The RMAN Plug-in is configured to use HPE StoreOnce Catalyst Managed Copy to send copies of the backup data to two other HPE StoreOnce appliances (see RMAN duplexed backup sets). The RMAN backup session is complete when all copies have been made. RMAN communicates with all the HPE StoreOnce appliances through a management network. RMAN only needs a high-bandwidth connection (10GbE or higher recommended) to the primary HPE StoreOnce appliance. The primary HPE StoreOnce appliance then uses a high-bandwidth connection to the other HPE StoreOnce appliances to complete the Catalyst Copy operations.

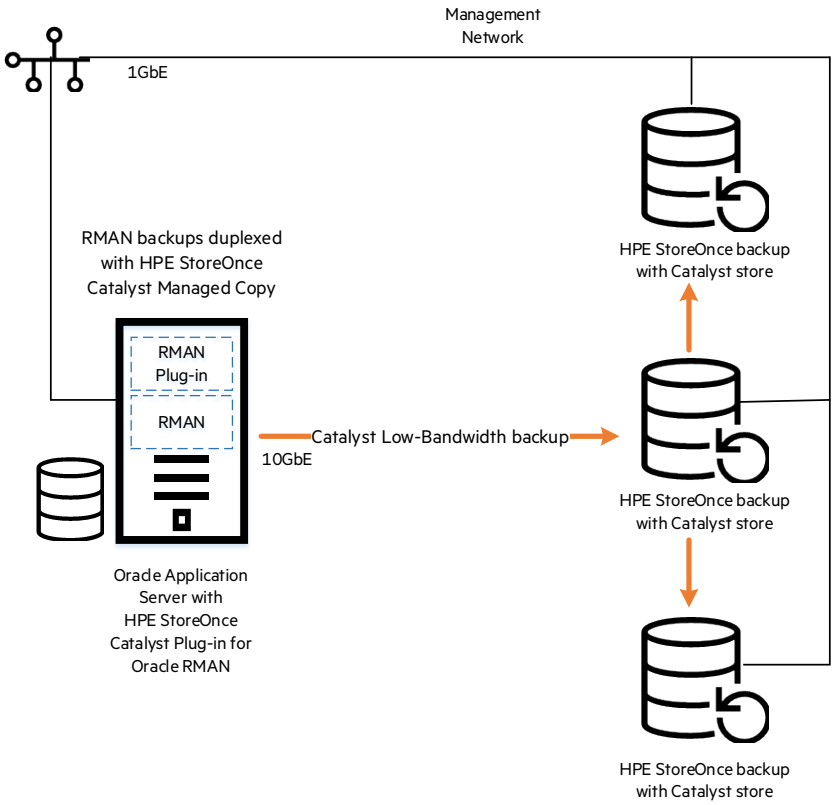


FIGURE 1. High-level RMAN Plug-in solution overview—writing backups to HPE StoreOnce and utilizing HPE StoreOnce Catalyst Copy to make two copies

SOLUTION COMPONENTS

Hewlett Packard Enterprise validated the RMAN Plug-in solution in a lab environment. This section provides details on each major component incorporated into the solution and concludes with a diagram of the lab setup (see Figure 2).

Primary Storage

The RMAN Plug-in is not dependent on a specific type of storage. This Reference Configuration uses an HPE 3PAR StoreServ 8400 storage array, using 24 x 1.2 TB hard disk drives and OS version 3.3.1460, and was connected to a 16 Gb Fibre Channel (FC) back-end fabric. Thin-provisioned virtual volumes were presented to the Oracle Real Application Cluster (Oracle RAC) for the Oracle Automatic Storage Management (Oracle ASM) disk groups and to the Oracle standby server for the Oracle file system disks.

HPE StoreOnce backup appliance

An HPE StoreOnce 5650 appliance acted as the primary backup device for all RMAN Plug-in operations that utilized the appliance's HPE StoreOnce Catalyst and HPE StoreOnce Catalyst Copy features. The system also supported the HPE Cloud Bank Storage extension to HPE StoreOnce Catalyst to permit creating HPE Catalyst Cloud Bank stores using either on-premises or cloud object storage. HPE Cloud Bank storage is a licensed feature of HPE StoreOnce.

Oracle RAC application servers

Two servers hosted the Oracle RAC production database. Red Hat® Enterprise Linux® (RHEL) release 7.4 was installed on each HPE ProLiant DL380 Gen9 32-core (2 x Intel® Xeon® CPU E5-2698 v3 @ 2.30 GHz) server. Each server was configured with 512 GB of physical memory. Both servers supported a 1GbE network connection for local management, a 10GbE connection to the data network, and a 16 Gb FC SAN connection for HPE 3PAR array storage. Each RAC node hosted an instance of a server-class, Oracle Enterprise Edition 12c (12.1.0.2.0) database installation.

Oracle standby server

An HPE ProLiant DL380 server hosted a single-node clone of the RAC database. Potential CDM uses of a production database clone include providing: a test and development environment, a platform for ISV-supported backups, a database reporting system, and a disaster recovery host. RHEL release 7.2 was installed on this server. The server was a 12-core system with 32 GB of physical memory. The server supported a 1GbE network connection for local management, a 10GbE connection to the data network, and a 16 Gb FC SAN connection for HPE 3PAR array storage. Oracle 12c Enterprise Edition 12c (12.1.0.2.0) was installed on this server. The server used a file system setup for storage.

HPE StoreOnce Catalyst Plug-in for Oracle RMAN

The RMAN Plug-in version 3.3.0 was installed on both nodes in the RAC cluster. It is not required to be installed on all nodes in the RAC cluster, in fact, RMAN backups can only be run from one server. However, if the RMAN Plug-in is installed on each node in the cluster, each node can provide backup streams for a backup operation, thereby distributing the workload across multiple servers.

The RMAN Plug-in was installed on the standby server to support the RMAN `DUPLICATE` command that is used to clone the database.

The RMAN Plug-in has a zero-cost license to use, but an HPE StoreOnce Catalyst license must be purchased and installed on the HPE StoreOnce appliances that host target Catalyst stores.

The RMAN Plug-in is supported on Microsoft Windows and a variety of Linux/Unix platforms. For full details about version and environmental compatibility, see the HPE StoreOnce Support Matrix.

To obtain the RMAN Plug-in host OS installation kits and the *HPE StoreOnce Catalyst Plug-in 3.3.0 for Oracle RMAN User Guide* see HPE StoreOnce Catalyst Plug-in for Oracle RMAN.

Database generation tools

The solution environment included the following tools used to populate and modify the production database installed on the Oracle application server in the solution lab.

Swingbench

Swingbench is a free load-generator and benchmark tool designed to stress test an Oracle database. The tool can be obtained from http://dominicgiles.com/swingbench.html. The software enables generating a workload and charting, and then recording the transactions and response times during execution. For this solution environment the Swingbench Simple Order Entry (SOE) benchmark was used. The Order Entry Wizard creates the required schema (tablespace, users, and tables). Provided command line tools permit modifying the size of the initial database, running transactions against the database, and monitoring database performance metrics. Swingbench was used in the solution lab to populate the table spaces and to change the database content between RMAN Plug-in incremental backups.

RealDB

RealDB is an internal Hewlett Packard Enterprise tool that was used in the solution lab to load and modify the Oracle database. The data comes from webpages downloaded from the internet or imported from previously downloaded data files. To increase the tablespace volume, data is stored under different encodings. Webpage headers and select statistics are also included to provide a mix of data types. A command line interface is used to add, update, or delete data.

Solution database details

Table 1 describes the layout of the ASM disk groups used in the solution lab RAC environment. Each disk group was configured for normal redundancy. The total capacity for the +DATA disk group was 16 TB, which was populated to approximately 80% full.

TABLE 1 Solution lab Oracle RAC ASM disk group layout

ASM Disk Group	Number of HPE 3PAR virtual volumes	Content
+DATA	4	Datafiles for tablespaces, undo tablespace, temp tablespace, controlfile, SPFILE, password file
+MGMT	2	Grid Infrastructure Management Repository (GIMR)
+REDO	2	Online redo logs; redundant copy of controlfile
+ARCHIVE	2	Archive redo logs

Figure 2 illustrates the components and interconnects used in the Hewlett Packard Enterprise solution lab to validate the RMAN Plug-solution.

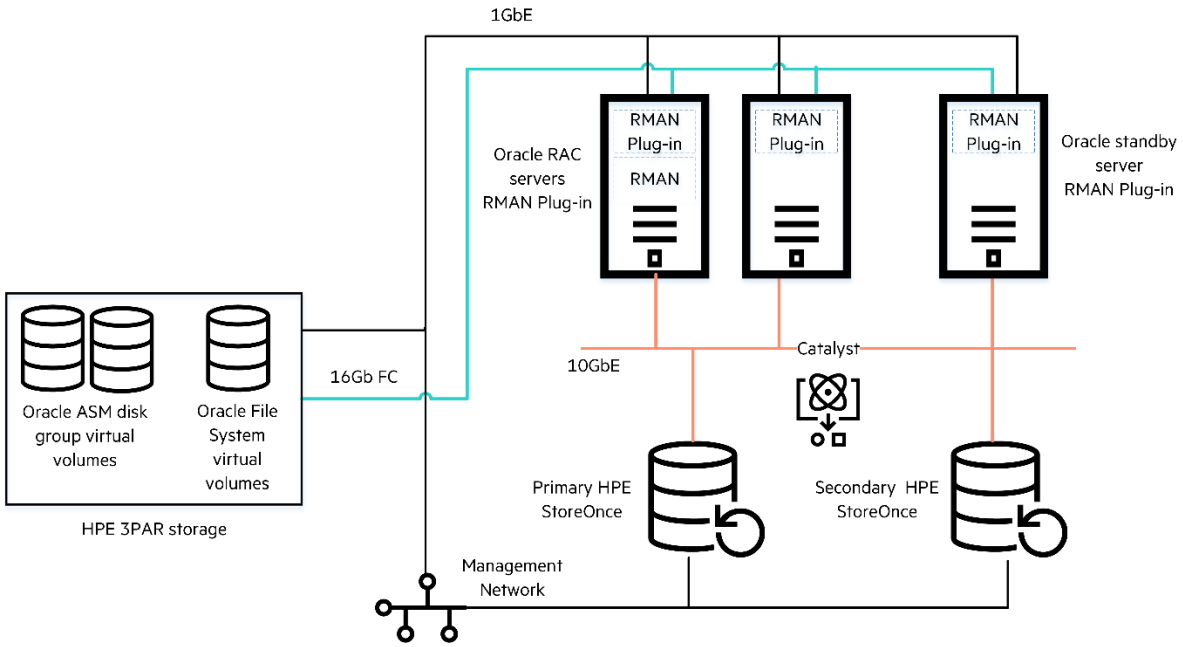


FIGURE 2. Solution lab environment

IMPLEMENTING THE HPE STOREONCE CATALYST PLUG-IN FOR ORACLE RMAN

The RMAN Plug-in is installed on the Oracle database servers using the plug-in installation tool (GUI, command line, and silent install options are available). The plug-in installation directory may be user specified, but the default install path is based on the definition of the ORACLE_HOME environment variable.

NOTE

Running the installer as user root is not allowed. The installer must be run as the database administrator user, typically user oracle.

RECOMMENDATION

If the HPE Catalyst backup will be performed over a WAN, Hewlett Packard Enterprise recommends that the **Enable network compression and network checksums** checkbox is selected during installation. Selecting this option will ensure reliable and safe transport of backup data.

Standard RMAN backup commands are used to back up the Oracle database to the HPE StoreOnce Catalyst stores. The Catalyst stores that are the target of the RMAN backup must be preconfigured separately; the RMAN Plug-in does not create the stores. For details on how to create and configure HPE StoreOnce Catalyst stores see the HPE StoreOnce User Guide.

Configuration of the RMAN Plug-in is accomplished through simple modifications to a plug-in configuration file. The installation places the, `plugin_template.conf` template file in the `<installdir>/config` directory. Plug-in configuration file names are user defined. Multiple plug-in configuration files can exist—each specifying different HPE StoreOnce Catalyst backup targets and backup methods.

RMAN Plug-in backups use the RMAN `ALLOCATE CHANNEL TYPE SBT_TAPE` command with the `PARMS` qualifier to reference the path to the RMAN Plug-in SBT library and the path to the plug-in configuration file (see Figure 4).

Getting started – backup to single HPE StoreOnce Catalyst store

The following steps provide a simple example of getting started using the RMAN Plug-in in an Oracle RAC environment. This example performs a full database backup to an HPE StoreOnce Catalyst store. One RMAN channel will be allocated from each RAC node.

1. Assume the plug-in installation directory is `/u01/app/hpe/HPE-Catalyst-RMAN-Plugin`.
2. Assume the IP address of the HPE StoreOnce appliance is `10.1.2.10` and the Catalyst store name is `rman-store1`.
3. Assume the RAC server hostnames are `sedb01` and `sedb02`.
4. RMAN will run on node `sedb01`, however, RMAN will allocate and use channels on both RAC nodes for the backup.
5. Log in to host `sedb01` as user `oracle`. Edit the `/u01/app/hpe/HPE-Catalyst-RMAN-Plugin/config/plugin.conf` file, modifying the `CATALYST_STORE_ADDRESS` and `CATALYST_STORE_NAME` entries as shown in Figure 3.

```
# (C) Copyright 2015-2016 Hewlett Packard Enterprise Development LP

##########################################################################
# BASIC CATALYST SETTINGS
##########################################################################

# StoreOnce node address used for backup. Supply the address of the StoreOnce service set
# Required
# Accepts: IPv4, FQDN, COFC- & IPv6. IPv6 addresses should be quoted; e.g.
"fdca:cd45:5ab0:995::7"
# CATALYST_STORE_ADDRESS:<StoreOnce Backup Node Address>
CATALYST_STORE_ADDRESS:10.1.2.10

# Catalyst store name used for backup.
# Required
# CATALYST_STORE_NAME:<Catalyst Store Name>
CATALYST_STORE_NAME:rman_store1
```

FIGURE 3. Modifying Catalyst store address and name in `plugin.conf` file

6. Use the Linux `scp` command to copy the `plugin.conf` file from host `sedb01` to `sedb02`. This example uses `SBT_TAPE` channels from both cluster members to perform the backup. The `plugin.conf file` on both nodes must specify the same `CATALYST_STORE_ADDRESS` and `CATALYST_STORE_NAME`.

RECOMMENDATION

When installing the RMAN Plug-in on multiple nodes in a RAC environment, use the same installation path on each server for consistency and ease of use. An alternative is to place the plug-in configuration files in a shared location accessible by all nodes in the RAC environment. This is beneficial when there are more than two nodes in the RAC.

7. Create an RMAN script that defines a `run` block allocating two `SBT_TAPE` channels for backup: one channel executed from host `sedb01` and one channel executed from host `sedb02` (Figure 4). In an Oracle RAC environment, the RMAN `ALLOCATE CHANNEL` statement must contain a `CONNECT` string specifying the RAC scan name and the instance name.

```
run
{
ALLOCATE CHANNEL T1 TYPE 'SBT_TAPE' PARMS
'SBT_LIBRARY=/u01/app/hpe/HPE-Catalyst-RMAN-Plugin/bin/libisvsupport_rman.so
ENV=(CONFIG_FILE=/u01/app/hpe/HPE-Catalyst-RMAN-Plugin/config/plugin.conf)'
FORMAT 'Channel1_%U'
CONNECT'sys/password@sedb01.localdomain/orcl.localdomain';

ALLOCATE CHANNEL T2 TYPE 'SBT_TAPE' PARMS
'SBT_LIBRARY=/u01/app/hpe/HPE-Catalyst-RMAN-Plugin/bin/libisvsupport_rman.so
ENV=(CONFIG_FILE=/u01/app/hpe/HPE-Catalyst-RMAN-Plugin/config/plugin.conf)'
FORMAT 'Channel2_%U'
CONNECT'sys/password@sedb02.localdomain/orcl.localdomain';

backup filesperset 2 database tag 'plugin-full';

release channel T1;
release channel T2;
}
```

FIGURE 4. RMAN script allocating one channel on each RAC node for RMAN Plug-in backup

Some comments on the script in Figure 4:

- The `SBT_LIBRARY` parameter specifies the location of the RMAN Plug-in library file, `libisvsupport_rman.so`.
- The `ENV` parameter specifies the location and name of the RMAN Plug-in configuration file, `plugin.conf`.
- The `SBT_LIBRARY` and `ENV` parameter settings on both `ALLOCATE CHANNEL` statements are identical because the RMAN Plug-in installation directory was the same on both cluster nodes.
- The `FORMAT` string must include the `%u` and `%c` syntax elements to guarantee a unique name for the backup piece that includes the copy number for duplexed backup pieces. The `%U` syntax element when used with backup pieces is equivalent to specifying `%u_%p_%c`.
- The `CONNECT` string is required on each `ALLOCATE CHANNEL` entry to specify the RAC node that will run an RMAN process for the assigned channel.
- `FILESPERSET 2` was chosen in this example to limit each Catalyst backup stream on each channel to two Oracle database files at a time.

8. Log in to node `sedb01` as user `oracle` and start the RMAN backup using the following command:

```
[oracle@sedb01 ~]$ rman target / cmdfile=<script_filename> log=<log_filename>
```

9. Log in to the HPE StoreOnce Management Console and select **Data Services→Catalyst Stores** to navigate to the Catalyst stores. Click the store named `rman_store1` and then select the **Backup/Restore** heading. Figure 5 shows a partial listing of the Catalyst jobs running for this backup. Note that there are two jobs per channel, one for data and one for metadata. At this point in the backup, four jobs have completed and four jobs are running.

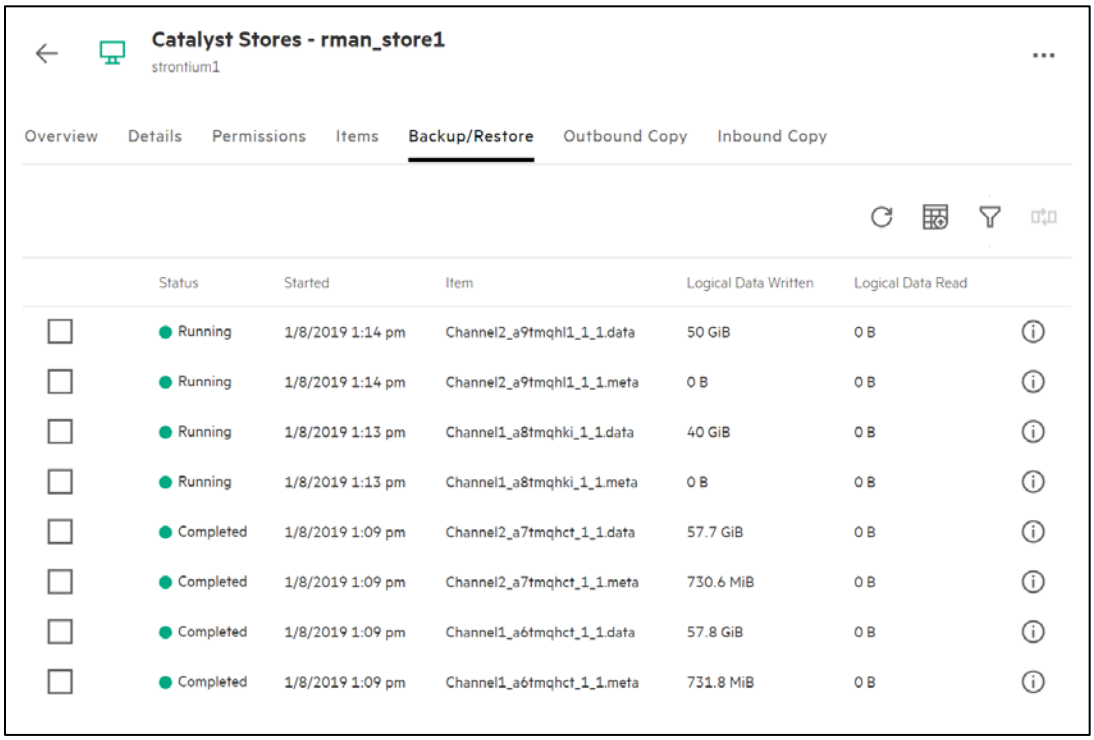


FIGURE 5. Partial list of the Catalyst jobs for two-channel full database backup in progress

10. Because the `FILESPERSET` parameter was set to two (2) for this backup, each backup job represents the backup of two database data files.

When the RMAN backup completes, log in to the HPE StoreOnce Management Console, select **Data Services→Catalyst Stores,** and then click the store name `rman_store1`. Figure 6 shows the **Overview** panel providing the results of the backup, including the **User Data Stored** (total data written by the backup application before the data was deduplicated), the **Size on Disk** (the amount of disk space used to store all of the deduplicated data), and the corresponding **Store Dedupe Ratio** (the total amount of data written by the backup application before deduplication divided by the actual capacity used after deduplication).

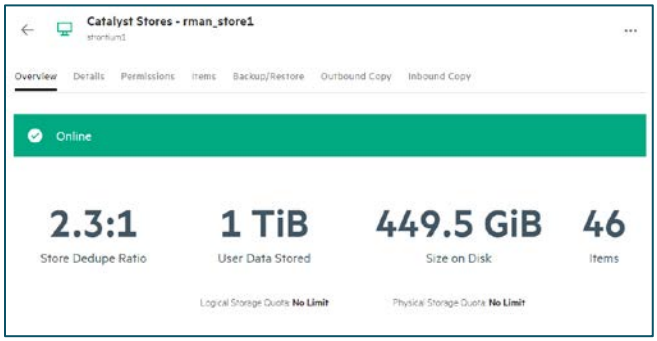


FIGURE 6. Overview of Catalyst store "rman_store1" after backup completes

11. From the **Overview** panel select the **Items menu entry.** Figure 7 shows a partial listing of the items in the "rman"store1" Catalyst store after the backup has completed. The `CONTROLFILE` and `SPFILE` backup items are highlighted. The item list also reflects how both allocated channels, Channel 1 and Channel 2, were utilized.

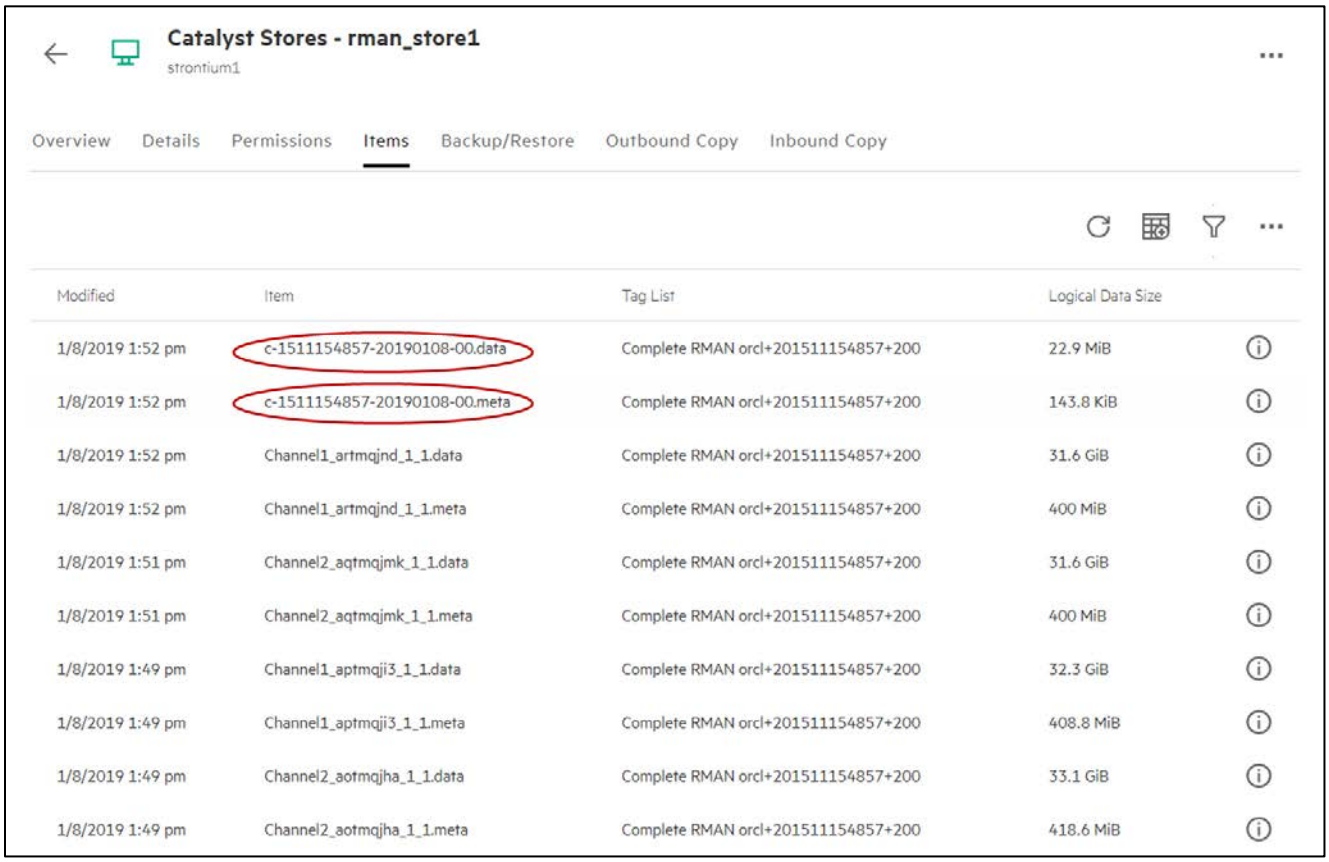


FIGURE 7. Partial listing of the "**Items"** in the "rman_store1" Catalyst store

NOTE
The Catalyst store item names correspond to the `Handle` name displayed for each backup set listed as part of an RMAN `List Backupset` command.

RMAN duplexed backup sets

The RMAN Plug-in is easily configured to support RMAN duplexed backup sets. The RMAN Plug-in can send up to four identical copies (initial backup plus three backup copies) of each database backup piece to different Catalyst stores. In support of the 3-2-1 best practices rule for data protection, the backup copies can be sent to different HPE StoreOnce appliances, located either locally or at a remote site for disaster recovery.

There are two methods to create copies of database backups to provide recovery from database failures. In both methods, the RMAN Plug-in configuration file provides the HPE StoreOnce system IP addresses and Catalyst store names of the copy targets. The methods differ as to which system manages creating the copies:

- **Catalyst Managed Copy**— (see Figure 1) The RMAN Plug-in sends a backup stream to the primary HPE StoreOnce appliance. The primary HPE StoreOnce appliance then handles the physical duplication of copies to the targets. The copies are done on a per-backup-file basis; as a backup file is written to the primary store, it is replicated to the secondary stores in parallel streams. This method frees up resources on the Oracle RMAN host.

- **Host-managed (application-managed) copy**— (see Figure 8) Backup copies are triggered and run from the Oracle RMAN host. In this method the RMAN server and the RMAN Plug-in stream backups to multiple HPE StoreOnce appliances in parallel. The HPE StoreOnce appliance does not participate in the copy operations. This creates a heavier resource load on the RMAN host server as the RMAN Plug-in has to perform multiple writes for every read operation.

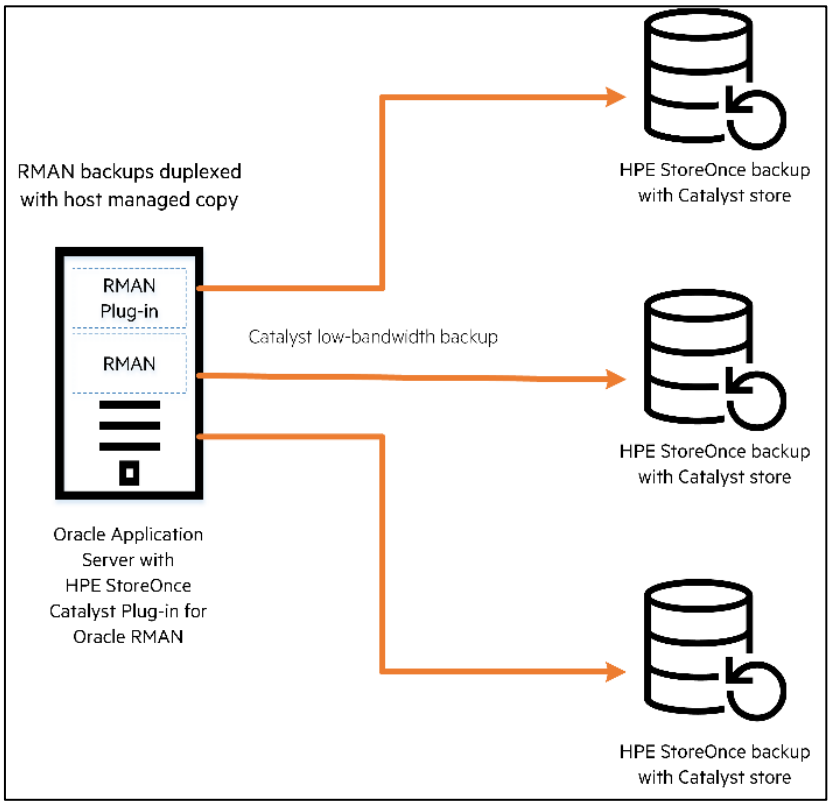


FIGURE 8. Host-managed duplexed backups

IMPORTANT
When an RMAN backup with additional copies is requested, the backup is marked as complete and cataloged only when the primary backup and all additional copies have successfully completed. Even if the primary backup is successful, if one of the copies fails, RMAN considers the entire backups job as failed.

Restoring from duplexed backups

During a restore operation, RMAN will first try to connect to the primary Catalyst store to retrieve the requested data. If the primary backup Catalyst store is not available, RMAN, having knowledge of the duplexed copies that have been made, will then use the RMAN Plug-in to access the appropriate HPE StoreOnce appliance containing the DR copy,

Modifying the RMAN Plug-in configuration file for duplexed backups

The following parameters in the RMAN Plug-in configuration file control managed copies:

- `APPLICATION_MANAGED_COPIES:`
- The pair `CATALYST_COPY1_STORE_ADDRESS:` and `CATALYST_COPY1_STORE_NAME:`
- The pair `CATALYST_COPY2_STORE_ADDRESS:` and `CATALYST_COPY2_STORE_NAME:`
- The pair `CATALYST_COPY3_STORE_ADDRESS:` and `CATALYST_COPY3_STORE_NAME:`

Commenting out the parameter `APPLICATION_MANAGED_COPIES` triggers duplexed backups. At a minimum, the `CATALYST_COPY1_STORE_ADDREESS` and `CATALYST_COPY1_STORE_NAME`: parameters must also be set.

Host-managed copy, which is the default setting, is triggered by setting `APPLICATION_MANAGED_COPIES:ENABLE.`

Catalyst Managed Copy is triggered by setting `APPLICATION_MANAGED_COPIES:DISABLE`.

IMPORTANT

To initiate duplexed copies within RMAN, the `COPIES N` parameter (where `N` is the number of copies to be created) must be part of the `BACKUP` command.

Because the RMAN Plug-in appears to RMAN as an `SBT_TAPE` device, the database parameter `BACKUP_TAPE_IO_SLAVES` must be set to `TRUE` to support the `COPIES` command.

Use case – using HPE Cloud Bank Stores for Catalyst Managed Copy duplexed backups

RMAN cannot write a backup directly to an HPE Cloud Bank store. Therefore, the RMAN Plug-in configuration file parameters `CATALYST_STORE_ADDRESS` and `CATALYST_STORE_NAME` cannot specify the location and name of an HPE Cloud Bank store. However, an HPE Cloud Bank store can be selected as the Catalyst Copy target when configuring duplexed backups, providing an additional option when planning an off-site backup strategy. [3]

[3] For more information about HPE Cloud Bank Storage, refer to HPE Reference Configuration for HPE Cloud Bank Storage with Microsoft Azure and HPE Reference Configuration for HPE Cloud Bank Storage with S3 Connector and Scality (see Resources and additional links).

The following steps outline setting up and executing an RMAN Plug-in backup that will use Catalyst Managed Copy to make a copy of the backup to a secondary HPE StoreOnce appliance.

1. Assume the RAC server hostnames are `sedb01` and `sedb02`.
2. Figure 9 shows a partial listing of an RMAN Plug-in configuration file supporting Catalyst Managed Copy. (Some intervening lines are omitted for brevity). The file was created in the RMAN Plug-in `<installdir>/config` directory on node `sedb01` and for this example, was given the name `plugin-copy.conf`. The configuration file sets up the following environment:
   a. The primary HPE StoreOnce appliance IP is 10.1.2.10; and the store name is "`rman_store2`".
   b. `APPLICATION_MANAGED_COPIES` is set to `DISABLE` to activate Catalyst Managed Copy.
   c. One copy will be made to the secondary HPE StoreOnce appliance whose IP address is 10.1.5.23; and the store name is "`rman_store2_copy`".

```
#############################################################################################
# BASIC CATALYST SETTINGS
#############################################################################################
#
# StoreOnce node address used for backup. Supply the address of the StoreOnce service set
# Required
# Accepts: IPv4, FQDN, COFC- & IPv6. IPv6 addresses should be quoted; e.g. "fdca:cd45:5ab0:995::7"
# CATALYST_STORE_ADDRESS:<StoreOnce Backup Node Address>
CATALYST_STORE_ADDRESS:10.1.2.10
# Catalyst store name used for backup.
# Required
# CATALYST_STORE_NAME:<Catalyst Store Name>
CATALYST_STORE_NAME:rman_store2
#############################################################################################
#
# CATALYST COPY TARGETS
#############################################################################################
#
# Set this to ENABLE, to let the ISV to manage the copies. Set this to DISABLE, to let the StoreOnce Catalyst Plug-in to manage
the copies. Enabled by default.
# Optional
# APPLICATION_MANAGED_COPIES:<ENABLE/DISABLE>
APPLICATION_MANAGED_COPIES:DISABLE
# StoreOnce node address of the 1st Catalyst copy target.
# Optional
# Accepts: IPv4, FQDN, IPv6, COFC. IPv6 addresses should be quoted; e.g. "fdca:cd45:5ab0:995::7".
# CATALYST_COPY1_STORE_ADDRESS:<StoreOnce Copy Node Address>
CATALYST_COPY1_STORE_ADDRESS:10.1.5.23
# Catalyst store name of the 1st copy target.
# Optional
# CATALYST_COPY1_STORE_NAME:<Catalyst Store Name>
CATALYST_COPY1_STORE_NAME:rman_store2_copy
```

FIGURE 9. RMAN Plug-in configuration file for Catalyst Managed Copy

3. RMAN will allocate multiple backup channels on both nodes for this backup. If a shared location for the RMAN Plug-in configuration files is not used, then the plug-in configuration files must identical on both nodes in the RAC. Use the Linux `scp` command to copy this configuration file to the RMAN Plug-in the `<installdir>/config` directory on node `sedb02`.

4. Figure 10 shows the RMAN script prepared for this backup. This script will be executed on host `sedb01`. A total of six channels will be allocated for this backup, thee running on each cluster node.[4] This will be a full database backup and each backup set will contain three files (`FILESPERSET 3`). Two copies of the backup will be created (`COPIES 2`).

```
run
{
ALLOCATE CHANNEL T1 TYPE 'SBT_TAPE' PARMS
'SBT_LIBRARY=/u01/app/hpe/HPE-Catalyst-RMAN-Plugin/bin/libisvsupport_rman.so
ENV=(CONFIG_FILE=/u01/app/hpe/HPE-Catalyst-RMAN-Plugin/config/plugin-copy.conf)'
FORMAT 'Channel1_%U' CONNECT'sys/password@sedb01.localdomain/orcl.localdomain';

ALLOCATE CHANNEL T2 TYPE 'SBT_TAPE' PARMS
'SBT_LIBRARY=/u01/app/hpe/HPE-Catalyst-RMAN-Plugin/bin/libisvsupport_rman.so
ENV=(CONFIG_FILE=/u01/app/hpe/HPE-Catalyst-RMAN-Plugin/config/plugin-copy.conf)'
FORMAT 'Channel2_%U' CONNECT'sys/password@sedb02.localdomain/orcl.localdomain';

ALLOCATE CHANNEL T3 TYPE 'SBT_TAPE' PARMS
'SBT_LIBRARY=/u01/app/hpe/HPE-Catalyst-RMAN-Plugin/bin/libisvsupport_rman.so
ENV=(CONFIG_FILE=/u01/app/hpe/HPE-Catalyst-RMAN-Plugin/config/plugin-copy.conf)'
FORMAT 'Channel3_%U' CONNECT'sys/password@sedb01.localdomain/orcl.localdomain';

ALLOCATE CHANNEL T4 TYPE 'SBT_TAPE' PARMS
'SBT_LIBRARY=/u01/app/hpe/HPE-Catalyst-RMAN-Plugin/bin/libisvsupport_rman.so
ENV=(CONFIG_FILE=/u01/app/hpe/HPE-Catalyst-RMAN-Plugin/config/plugin-copy.conf)'
FORMAT 'Channel4_%U' CONNECT'sys/password@sedb02.localdomain/orcl.localdomain';

ALLOCATE CHANNEL T5 TYPE 'SBT_TAPE' PARMS
'SBT_LIBRARY=/u01/app/hpe/HPE-Catalyst-RMAN-Plugin/bin/libisvsupport_rman.so
ENV=(CONFIG_FILE=/u01/app/hpe/HPE-Catalyst-RMAN-Plugin/config/plugin-copy.conf)'
FORMAT 'Channel5_%U' CONNECT'sys/password@sedb01.localdomain/orcl.localdomain';

ALLOCATE CHANNEL T6 TYPE 'SBT_TAPE' PARMS
'SBT_LIBRARY=/u01/app/hpe/HPE-Catalyst-RMAN-Plugin/bin/libisvsupport_rman.so
ENV=(CONFIG_FILE=/u01/app/hpe/HPE-Catalyst-RMAN-Plugin/config/plugin-copy.conf)'
FORMAT 'Channel6_%U' CONNECT'sys/password@sedb02.localdomain/orcl.localdomain';

backup copies 2 filesperset 3 database tag 'plugin copy';

release channel T1;
release channel T2;
release channel T3;
release channel T4;
release channel T5;
release channel T6;
}
```

FIGURE 10. RMAN script to allocate six channels and make two copies of the data

5. Log in to node `sedb01` as user `oracle` and start the RMAN backup using the command:

```
[oracle@sedb01 ~]$ rman target / cmdfile=<catalyst_copy_script_filename> log=<log_filename>
```

[4] The channels were allocated in round-robin fashion, odd channels to `sedb01` and even channels to `sedb02` to best distribute the channels across both nodes of the RAC cluster.

6. While the backup is running, run the following SQL statement to verify which RMAN channels are currently in use on each RAC node:

```
select b.sid, b.serial#, a.spid, b.client_info from v$process a, v$session b
where a.addr=b.paddr and client_info like 'rman%';
```

The output from the SQL command executed on host sedb01 confirms that channels T1, T3, and T5, as specified in the RMAN script, are in use on this server.

```
 SID    SERIAL# SPID     CLIENT_INFO
------- ------- -------- ------------------
 609    23141   1557     rman channel=T1
 2301   22033   1788     rman channel=T3
 248    17573   2008     rman channel=T5
```

Log in to host sedb02 as user oracle and execute the same SQL command. The output that follows confirms that channels T2, T4, and T6 are in use on this server.

```
 SID    SERIAL# SPID     CLIENT_INFO
------- ------- -------- ------------------
 2383   49257   60552    rman channel=T2
 2627   48291   60626    rman channel=T4
 2749   27852   61116    rman channel=T6
```

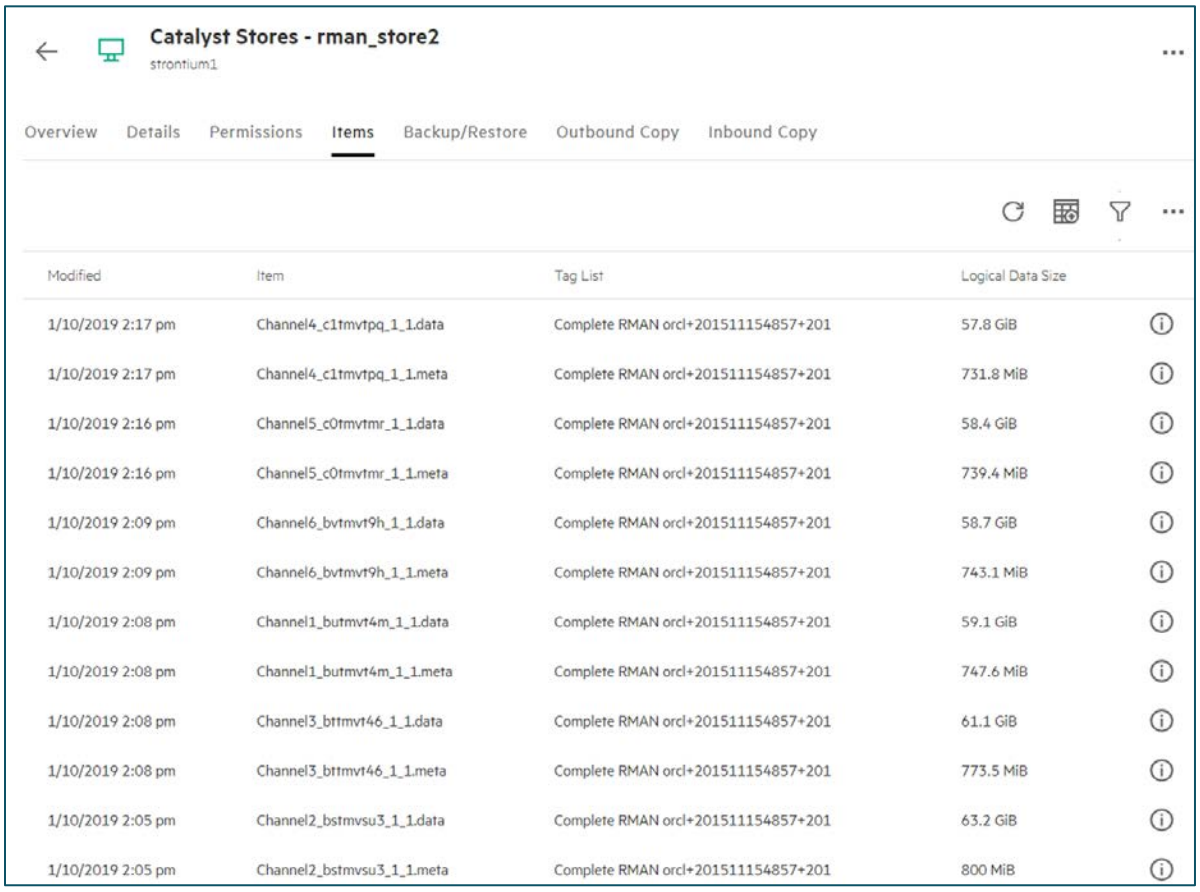
To view the actual system processes for each channel, use the Linux ps -ef | grep "LOCAL=NO" command. Execute this command on each RAC node. Note that the process IDs match those provided in the SPID output from the SQL statement.

```
[oracle@sedb01 ~]$ ps -ef |grep "LOCAL=NO"
oracle    1557     1  4 12:11 ?        00:00:17 oracleorcl1 (LOCAL=NO)
oracle    1788     1  4 12:11 ?        00:00:16 oracleorcl1 (LOCAL=NO)
oracle    2008     1  5 12:12 ?        00:00:17 oracleorcl1 (LOCAL=NO)

oracle@sedb02 ~]$ ps -ef |grep "LOCAL=NO"
oracle   60552     1  5 12:11 ?        00:00:20 oracleorcl2 (LOCAL=NO)
oracle   60626     1  5 12:12 ?        00:00:19 oracleorcl2 (LOCAL=NO)
oracle   61116     1  5 12:12 ?        00:00:19 oracleorcl2 (LOCAL=NO)
```

7. When the RMAN backup completes, click the store name "rman_store2" from the HPE StoreOnce Management Console **Data Services→Catalyst Stores listing** to display the **Overview** panel. This will look similar to Figure 6 with the exception of the **Items** count. Setting FILESPERSET 3 for this backup did not affect the deduplication ratio, but as expected, this did reduce the number of items in the store.

8. From the **Overview** panel select the **Items** menu entry. Figure 11 shows a partial listing of the Catalyst store items for this backup illustrating that all six channels contributed to the backup.



Modified	Item	Tag List	Logical Data Size
1/10/2019 2:17 pm	Channel4_c1tmvtpq_1_1.data	Complete RMAN orcl+201511154857+201	57.8 GiB
1/10/2019 2:17 pm	Channel4_c1tmvtpq_1_1.meta	Complete RMAN orcl+201511154857+201	731.8 MiB
1/10/2019 2:16 pm	Channel5_c0tmvtmr_1_1.data	Complete RMAN orcl+201511154857+201	58.4 GiB
1/10/2019 2:16 pm	Channel5_c0tmvtmr_1_1.meta	Complete RMAN orcl+201511154857+201	739.4 MiB
1/10/2019 2:09 pm	Channel6_bvtmvt9h_1_1.data	Complete RMAN orcl+201511154857+201	58.7 GiB
1/10/2019 2:09 pm	Channel6_bvtmvt9h_1_1.meta	Complete RMAN orcl+201511154857+201	743.1 MiB
1/10/2019 2:08 pm	Channel1_butmvt4m_1_1.data	Complete RMAN orcl+201511154857+201	59.1 GiB
1/10/2019 2:08 pm	Channel1_butmvt4m_1_1.meta	Complete RMAN orcl+201511154857+201	747.6 MiB
1/10/2019 2:08 pm	Channel3_bttmvt46_1_1.data	Complete RMAN orcl+201511154857+201	61.1 GiB
1/10/2019 2:08 pm	Channel3_bttmvt46_1_1.meta	Complete RMAN orcl+201511154857+201	773.5 MiB
1/10/2019 2:05 pm	Channel2_bstmvsu3_1_1.data	Complete RMAN orcl+201511154857+201	63.2 GiB
1/10/2019 2:05 pm	Channel2_bstmvsu3_1_1.meta	Complete RMAN orcl+201511154857+201	800 MiB

FIGURE 11. Catalyst items for "rman_store2" store showing all six channels were used during backup

9. Because this backup specified that a copy be made, select the **Outbound Copy** menu entry to view the source items that were sent to the secondary HPE StoreOnce appliance. Figure 12 shows a partial display of the outbound copy jobs from this backup.

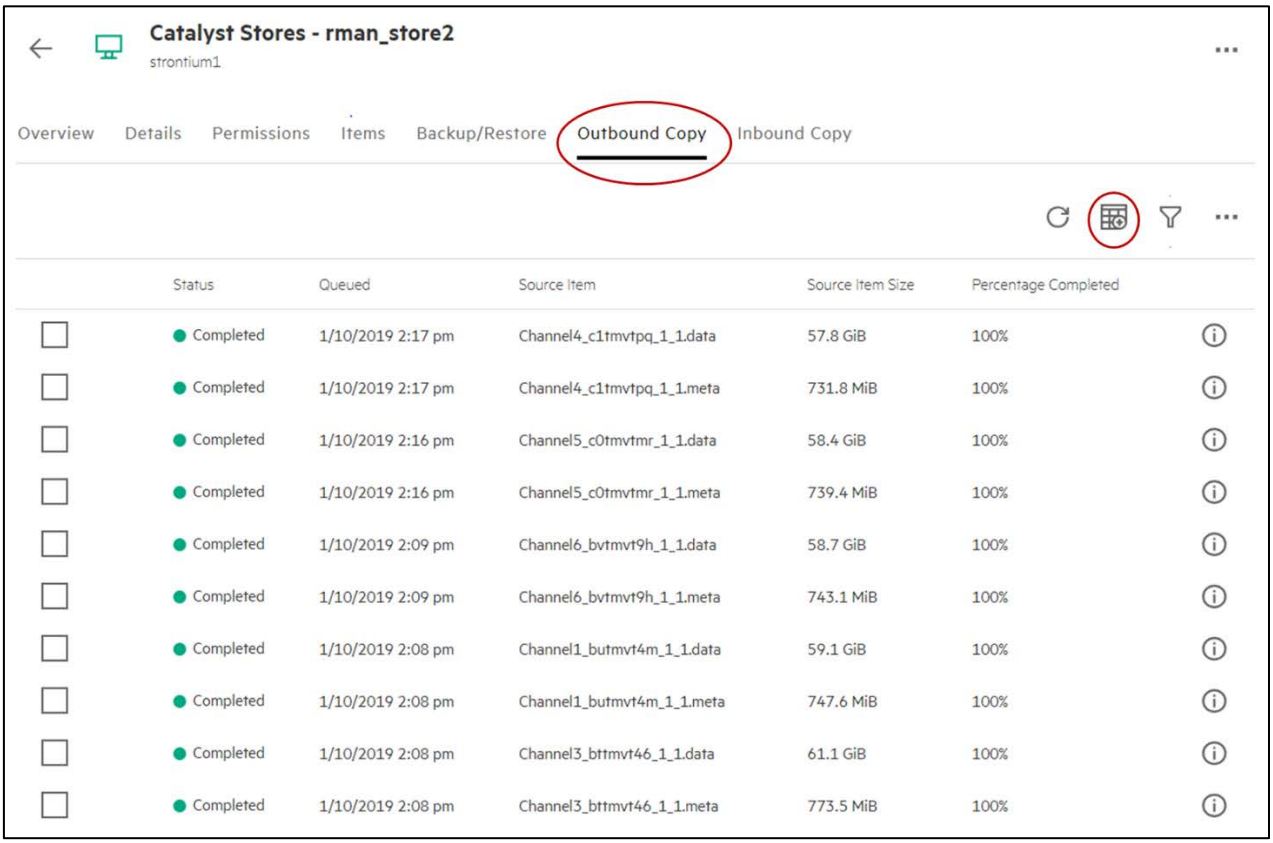


FIGURE 12. Outbound copy jobs from primary HPE StoreOnce appliance

NOTE
The **Select Columns** icon of the **Outbound Copy** display is highlighted in Figure 12. Click this icon to bring up a scroll-through menu of additional headings that can be included in the **Outbound Copy** display. Headings can be added or removed using a checkbox. Three headings of interest to add to the **Outbound Copy** display for a copy operation are **Target Address, Target Store Name**, and **Target Item**.

To complete the validation of the backup and the copies, log in to the HPE StoreOnce Management Console on the secondary HPE StoreOnce appliance. Navigate to **Data Services→Catalyst Stores** and select the "`rman_store2_copy`" store. Select the **Inbound Copy** menu item to verify and match up the incoming copy jobs.

NOTE
No changes are necessary to the above procedure to create a Catalyst Managed Copy to an HPE Cloud Bank store. It is only necessary to be sure that the `CATALYST_COPY1_STORE_ADDRESS:` and `CATALYST_COPY1_STORE_NAME:` parameters in the plug-in configuration file identify the proper HPE StoreOnce appliance and HPE Cloud Bank store.

IMPORTANT
The previous two examples used two different Catalyst stores. This was done to illustrate employing differing number of channels allocated and different `FILESPERSET` values. A best practice when backing up a database is to use the same store for each backup. This will maximize the deduplication ratio by maintaining a lower size-on-disk value (see Using separate Catalyst stores).

Decoupling HPE StoreOnce Catalyst Copy from the backup

The RMAN Plug-in supports an additional method for making disaster recovery (DR) copies of backups. This approach ensures that at least one successful backup has completed first. This method frees the primary backup from the duplex backup dependency that "all copies must succeed." With this decoupling method, DR copies are made offline any time after the primary backup—at a time more convenient determined by the DBA. Making these copies does not burden the database. Using this method, any number of DR copies may be made. Besides making DR copies, additional copies may be made for CDM use cases.

These offline copies are created using the HPE StoreOnce Catalyst Copy Utility, which is installed as part of the RMAN Plug-in installation. The path to the executable is `<installdir>/bin/StoreOnceCatalystCopy`.

There are five main operations to the `StoreOnceCatalystCopy` utility:

- `--copy` - copy the items from the specified origin Catalyst store to the specified destination Catalyst store
- `--list` - lists the status of a running copy job and provides job metrics
- `--cancel` - cancel any jobs that have been queued
- `--expire-items` - delete Catalyst items on the destination Catalyst store that were created by the `StoreOnceCatalystCopy` utility and that do not exist on the origin Catalyst store
- `--delete-items` - delete Catalyst items on the origin Catalyst store

IMPORTANT
RMAN has no knowledge about copies make with the `StoreOnceCatalystCopy` utility. `RMAN does, however, have knowledge of the items in the origin Catalyst store, so observe caution when using the --delete-items option.`

Figure 13 shows a first step in preparing to create a copy using the `StoreOnceCatalystCopy` utility. The example uses the `--preview` option on the `--copy` operation to list the items available in the specific Catalyst store (`--origin-store` option) on the primary HPE StoreOnce appliance—items that were created on a specific date (`--filtercreateddaterange` option). By default, the command reads the `<installdir>/config/plugin.conf` file to determine the IP address of the origin Catalyst store (as well as the store name if `--origin-store` had not been specified).

The command requires that the `--destination` and `--destination-store` options must be present. These options specify the IP address and Catalyst store name where the copy will be written. In Figure 13 the destination IP is 10.1.5.99 and the destination Catalyst store is "`rman_store2_DR_Copy`". Note, the destination store must exist on the target HPE StoreOnce appliance or the command will fail.

```
root@sedb01 bin]# cd /u01/app/hpe/HPE-Catalyst-RMAN-Plugin/bin
[root@sedb01 bin]# ./StoreOnceCatalystCopy --copy --origin-store rman_store2
--filtercreateddaterange [11/01/2019-00:00:00]:[12/01/2019-00:00:00] --preview
--destination 10.1.5.99 --destination-store rman_store2_DR_copy
Objects that can be copied:
Channel2_cgtn2b58_1_1.meta
Channel2_cgtn2b58_1_1.data
Channel1_cftn2b58_1_1.meta
Channel1_cftn2b58_1_1.data
Channel4_citn2b59_1_1.meta
Channel4_citn2b59_1_1.data
Channel3_chtn2b59_1_1.meta
Channel6_cktn2b5a_1_1.meta
Channel3_chtn2b59_1_1.data
Channel6_cktn2b5a_1_1.data
Channel5_cjtn2b5a_1_1.meta
Channel5_cjtn2b5a_1_1.data
Channel6_cltn2c6l_1_1.meta
Channel6_cltn2c6l_1_1.data
Channel4_cmtn2cdd_1_1.meta
Channel4_cmtn2cdd_1_1.data
Channel2_cntn2cf4_1_1.meta
Channel2_cntn2cf4_1_1.data
Channel5_cotn2cfb_1_1.meta
Channel5_cotn2cfb_1_1.data
Channel3_cqtn2ch3_1_1.meta
Channel1_cptn2ch3_1_1.meta
Channel3_cqtn2ch3_1_1.data
Channel1_cptn2ch3_1_1.data
Channel6_crtn2ctf_1_1.meta
Channel6_crtn2ctf_1_1.data
Channel4_cstn2daf_1_1.meta
Channel4_cstn2daf_1_1.data
Channel2_cttn2dau_1_1.meta
Channel2_cttn2dau_1_1.data
```

FIGURE 13. Using the `--preview` option with the `--copy` operation to review the available Catalyst items in the origin store

If the items returned by the `--preview` option are correct, all that is required to initiate the copy is to repeat the command omitting the `--preview` option. Use the `--list` operation to view the progress of the queued copy jobs.

Restore Redirect

If the primary backup image is not available when RMAN initiates a restore operation, any offline DR copies of the primary backup made with the HPE StoreOnce Catalyst Copy Utility are automatically searched by the RMAN Plug-in according to the copy targets specified in the appropriate `plugin.conf` file. The RMAN Plug-in seamlessly connects to the alternate (DR) site and the restore proceeds. RMAN is unaware of this redirection as the offline copies have the same name as the original backup. To enable this feature the `CATALYST_RESTORE_AUTOREDIRECT:ENABLE` option must be set in the plug-in configuration file.

For more information on Restore Redirect, including restoring from HPE Cloud Bank Storage, see the section *Performing a Restore* in the HPE StoreOnce Catalyst Plug-in 3.3.0 for Oracle RMAN User Guide.

Use case – creating a single-node standby database from the RAC database

This section describes how RMAN Plug-in backups to Catalyst stores can be used to create a clone of the RAC database on a single-node standby database. The clone can serve as a DR solution for the RAC database or can be used for CDM purposes.

There are many options when setting up the structure of the standby server. The following steps should be considered as general guidelines.

IMPORTANT

Critical to the cloning process are the changes required to the RMAN settings to properly configure the SBT_TAPE channels. The RMAN Plug-in uses these settings to retrieve the backup data from the HPE StoreOnce appliance (see Figure 14).

The following steps assume the RAC server hosts are sedb01 and sedb02 running instances orcl1 and orcl2, respectively. It is also assumed that the RMAN Plug-in has been used to create a full backup of the Oracle RAC database to a Catalyst store.

The RMAN DUPLICATE command is the key to creating the clone of the RAC database. The DUPLCATE command references a target server and an auxiliary (or standby) server. In the procedure, RAC node sedb01 is the target server.

1. Log in to the standby server as user root. Create the oinstall user group and oracle user. Create the /u01 mount path. Use the following commands to create the Oracle installation directory structure:

```
mkdir -p /u01/app/oracle/12.2.0.dbhome
chown -R oracle:oinstall /u01
chmod -R 775 /u01
```

2. This example uses a standard Oracle File System setup for the standby database and follows the disk volumes used in the solutions lab (see Table 1). Create two virtual volumes on the HPE 3PAR array, each of equal or larger capacity than the non-redundant capacity of the +DATA and +ARCHIVE disk groups. Present these volumes to the standby server. Log in to the standby server as user root and set the device mount paths as /u02 and /u04, respectively. Use the following sequence of commands to prepare the directory structure for the datafiles and archive logs:

```
mkdir -p /u02/oradata/datafiles
chown -R oracle:oinstall /u02
chmod -R 775 /u02
mkdir -p /u04/archive
chown -R oracle:oinstall /u04
chmod -R 775 /u04
```

3. Log in to the standby server as user oracle. Set the ORACLE_HOME environment variable to /u01/app/oracle/12.2.0/dbhome. Install the Oracle 12.2.0 binaries.
4. Log in to the RAC node sedb01 as user oracle. Create the /home/oracle/scratchpad directory. If the orcl1 instance uses a PFILE, copy the PFILE to this location. If the orcl1 instance uses an SPFILE then execute the following SQL command to create the init.ora file:

```
SQL> create pfile='/home/oracle/scratchpad/init.ora' from spfile;
```

5. Set the working directory as /home/oracle/scratchpad and issue the >cp init.ora initorcl_standby.ora command. This will create a working copy of the RAC node's init.ora file, which will be edited to create the PFILE for the standby server.

NOTE

The choice of the location and name of the /home/oracle/scratchpad directory is arbitrary. The important point is that the PFILE that will be referenced when starting the database on the standby server must be located in a directory on the target server.

6. Edit the initorcl_standby.ora file to prepare it for use on the standby server. This involves removing some RAC-specific parameters and modifying others to reflect the Oracle directory structure on the standby server. Some of the changes will be:
   a. Remove all lines beginning with orcl1._ or orcl2._.
   b. Remove the following parameters entirely:

```
cluster_database=true
orcl1.instance_number=1
orcl2.instance_number=2
orcl2.thread=2
orcl1.thread=1
orcl1.undo_tablespace='UNDOTBS1'
orcl2.undo_tablespace='UNDOTBS2'
```

   Replace the above parameters with the following:

```
instance_name='orcl'
undo_tablespace='UNDOTBS2'
```

   c. Change the locations and filename for the following parameters:

```
control_files='/u01/app/oracle/12.2.0/control01.ctl'
core_dump_dest='/u01/app/oracle/admin/orcl/cdump'
db_create_file_dest='u02/oradata'
log_archive_dest_1='location=/u04/archive'
```

   d. Use the DB_FILE_NAME_CONVERT parameter to switch files from ASM disk groups to normal noncluster file systems:

```
db_file_name_convert=('+DATA' , '/u02')
```

IMPORTANT
The DB_FILE_NAME_CONVERT parameter is key to the process of using the RMAN duplication process.

7. Log in to the standby server as user oracle and create an Oracle password file. The passwords must match on both the target and standby servers.

```
>cd $ORACLE_HOME/dbs
>orapwd file=orapworcl password=<password> format=12
```

8. Configure the network files for proper connection between the target server and the standby server. Remember to restart the Oracle listener after making changes to the Oracle Net files.
   a. The tnsnames.ora file on the target server should have an entry such as:

```
AUX =
 (DESCRIPTION =
   (ADDRESS = (PROTOCOL = TCP)(HOST = <standby_server>)(PORT = 1521))
   (CONNECT_DATA =
     (SERVER = DEDICATED)
     (SERVICE_NAME = orcl)
   )
 )
```

b. The `listener.ora` file on the standby server should have an entry such as:

```
 LISTENER=
    (description_list =
      (description =
        (address=(protocol=tcp)(host=<standby_server>)(port=1521))
        (address=(protocol=ipc)(key=extproc1521))
      )
    )
SID_LIST_LISTENER=
   (SID_LIST=
       (SID_DESC=
          (GLOBAL_DBNAME=orcl)
          (ORACLE_HOME=/u01/app/oracle/12.2.0/dbhome)
          (SID_NAME=orcl)
       )
   )
```

c. Use the `tnsping` command to verify that the network files are properly set up:

```
[oracle@sedb01 dbhome]$ tnsping aux 5
TNS Ping Utility for Linux: Version 12.2.0.1.0 - Production on 29-JAN-2019 10:07:58
Copyright (c) 1997, 2016, Oracle.  All rights reserved.
Used parameter files:
Used TNSNAMES adapter to resolve the alias
Attempting to contact (DESCRIPTION = (ADDRESS = (PROTOCOL = TCP)(HOST =
<standby_server>)(PORT = 1521)) (CONNECT_DATA = (SERVER = DEDICATED)
(SERVICE_NAME = orcl)))
OK (40 msec)
OK (50 msec)
OK (50 msec)
OK (50 msec)
OK (40 msec)
```

9. Log in to the standby server as user `oracle` and start the standby database in `NOMOUNT` mode.

```
> export ORACLE_SID=orcl
> SQLPlus / as sysdba
  SQL> startup nomount
```

10. The RMAN Plug-in uses `SBT_TAPE` channels to communicate with the HPE StoreOnce appliance. When using the RMAN `DUPLICATE` command there must be both a primary `CHANNEL` and an `AUXILIARY CHANNEL` configured. The primary channel connects to the target host database instance. The auxiliary channel must connect to the database instance on the standby server. Log in to the target server (`sedb01`) as user `oracle` and start RMAN.

11. Figure 14 shows the RMAN commands needed to configure these two channels for use with the RMAN Plug-in.

```
[oracle@sedb01 ~]$ rman target /
Recovery Manager: Release 12.2.0.1.0 - Production on Tue Jan 29 11:12:17 2019
Copyright (c) 1982, 2017, Oracle and/or its affiliates.  All rights reserved.
connected to target database: ORCL (DBID=1511154857)

RMAN>CONFIGURE CHANNEL 1 DEVICE TYPE 'SBT_TAPE' PARMS
'SBT_LIBRARY=/u01/app/hpe/HPE-Catalyst-RMAN-Plugin/bin/libisvsupport_rman.so
ENV=(CONFIG_FILE=/u01/app/hpe/HPE-Catalyst-RMAN-Plugin/config/plugin.conf)' FORMAT
'Channel1_%U'
CONNECT'sys/<password>@sedb01.localdomain/orcl.localdomain';

RMAN>CONFIGURE AUXILIARY CHANNEL 1 DEVICE TYPE 'SBT_TAPE' PARMS
'SBT_LIBRARY=/u01/app/hpe/HPE-Catalyst-RMAN-Plugin/bin/libisvsupport_rman.so
ENV=(CONFIG_FILE=/u01/app/hpe/HPE-Catalyst-RMAN-Plugin/config/plugin.conf)' FORMAT
'Channel1_%U'
CONNECT'sys/<password>@<standby_server>/orcl';

RMAN>show all;
```

FIGURE 14. Configuring RMAN channels for RMAN-Plug-in

12. As user `oracle` on the target server (`sedb01`), start RMAN, connecting to the target database. Use the RMAN `CONNECT AUXILIARY` command to connect to the instance on the standby server. Create an RMAN run block that sets a recovery point (this is optional) and then issues the `DUPLICATE` command with the appropriate qualifiers. These steps are shown in Figure 15.

```
[oracle@sedb01 ~]$ rman target /
Recovery Manager: Release 12.2.0.1.0 - Production on Tue Jan 29 11:12:17 2019
Copyright (c) 1982, 2017, Oracle and/or its affiliates.  All rights reserved.
connected to target database: ORCL (DBID=1511154857)

RMAN>connect auxiliary sys/password@orcl

RMAN>run {
2>set until time “sysdate - 2”;
3>duplicate target database to orcl pfile=/home/oracle/scratchpad/initorcl_standby.ora device
type sbt;
4>}
```

FIGURE 15. RMAN `DUPLICATE` command in run block

13. When the `DUPLICATE` process completes, log in to the standby server as user `oracle` and complete any steps necessary to start up the standby database instance.

NOTE
The same Catalyst store can be used again to create multiple single-node standby servers.

BEST PRACTICES AND CONFIGURATION GUIDANCE FOR RMAN PLUG-IN

Deduplication considerations

Full database datafile backups deduplicate at a higher ratio when compared to archive log backups, because archived redo logs tend to contain more unique data. For this reason, Hewlett Packard Enterprise recommends that separate Catalyst stores be used for database backups and archive log backups. This means configuring separate backup channels, each referencing separate plug-in configuration files.

HPE Catalyst does not deduplicate RMAN backup data when RMAN-encrypted or compressed backups are enabled, because these options will always generate unique backup data for every backup. Therefore, Hewlett Packard Enterprise recommends disabling RMAN encryption and compression. If data encryption is required, Catalyst stores can be created with encryption enabled to encrypt the backup data on the HPE StoreOnce appliance. A license is required to enable the encryption capabilities for each HPE StoreOnce appliance.

Typically, deduplication ratios are a factor of the data type, daily rate of change, backup schedule type, and backup retention period. Deduplication ratios will vary according to these environmental factors.

Using separate Catalyst stores

A plug-in configuration file references only a single Catalyst store for backup, recovery, and RMAN catalog maintenance. Using separate Catalyst stores for datafile backups and archive log backups requires separate plug-in configuration files. This also means allocating separate RMAN channels for datafile backups and archive log backups—each referencing the applicable plug-in configuration file in the `ENV` variable of the `ALLOCATE CHANNEL` statement.

Listing the backups in the RMAN catalog will show different media for the archive log backups than it shows for the datafile backups when different Catalyst stores are used.

The scenario where multiple Catalyst stores are used for backup and recovery presents RMAN catalog maintenance challenges. Specifically, when maintaining the RMAN catalog to delete backups, the user allocates a channel for maintenance to communicate with the HPE StoreOnce appliance, but that channel can only reference a single Catalyst store. When a cross-check is run to synchronize the RMAN catalog with the backup files on the HPE StoreOnce appliance, only backups on the Catalyst store that is referenced by the allocated channel will be found. This can cause all other backups to be marked as expired when in fact they might still exist on a different Catalyst store.

To ensure that maintenance operations are performed on the correct backup sets, Hewlett Packard Enterprise recommends including the `TAG` parameter with the RMAN `BACKUP` command. Consider including the Catalyst store name as part of the `TAG` string, such as:

```
RMAN> BACKUP DATABASE INCLUDE CURRENT CONTROLFILE TAG 'oradb_catalyst_store';
```

The tag can be used to take action only in the RMAN catalog for backups that match the tag. For example, if an RMAN maintenance channel is opened to the Catalyst store named "`oradb_catalyst_store`,", then the tag could be used by the following RMAN commands:

```
RMAN> LIST BACKUP TAG 'oradb_catalyst_store';
RMAN> CROSSCHECK BACKUP TAG 'oradb_catalyst_store';
RMAN> DELETE BACKUP TAG 'oradb_catalyst_store';
```

Backup schedules

Many backup environments use a weekly full and daily incremental backup schedule. Some characteristics of full and incremental backups are:

- Full backups include both the changed and unchanged data in a data set.
- Incremental backups include only changed data in a data set.
- Changed data does not deduplicate as well as unchanged data, therefore, incremental backups might not deduplicate as well as full backups.
- Incremental backups are usually much quicker than full backups and use fewer resources, which results in less impact to the backup server, disk storage device, and HPE StoreOnce appliance.
- Use Block Change Tracking (BCT) to improve performance of Level 1 (incremental) backups. Using BCT does not affect HPE StoreOnce deduplication ratios.

- End-to-end data compaction is greater for schedules that include incremental backups when compared with daily full backup schedules; the result is less storage space usage on the HPE StoreOnce appliance even though deduplication ratios are lower for incremental backups.

Full backups enable faster and simpler recovery than incremental backups or a mix of full and incremental backups. Other considerations are:

- Daily Oracle full backups deduplicate at a much higher rate than weekly full with daily incremental backups, but require more server and HPE StoreOnce system storage resources.
- Full backups are easier and faster for most restore operations.
- Weekly full with daily incremental backups send much less data to the HPE StoreOnce appliance for deduplication processing.
- If daily full backups and faster restore operations are not required, Hewlett Packard Enterprise recommends a backup schedule that includes incremental backups to reduce the resource load required for Oracle database backup.

Backup retention periods that include regular backup expiration affect deduplication ratios:

- HPE StoreOnce deduplication ratios and size on disk for a backup target will continue to increase until backups to the target exceed their retention period and are expired. At this point, deduplication ratios and size on disk will likely level off.
- For capacity planning, consider that size on disk will likely level off when backups begin to expire, as long as the size of the database remains constant.

Backup throughput

The RMAN Plug-in supports opening multiple RMAN channels simultaneously to the same Catalyst store. This is called media manager multiplexing, in which the RMAN Plug-in interleaves data from multiple RMAN channels, writing the data to the same store.

Allocating additional RMAN channels for backup results in increased Oracle database backup throughput. Note that allocating more channels also leads to increased host CPU resource load. In an RAC environment, the RMAN Plug-in can utilize multiple channels running across multiple nodes, thus distributing the increased CPU resource load across multiple servers. This can be fine-tuned further by only allocating channels on just the RAC nodes that have extra CPU resources available at the time the backup is executed.

However, allocating more and more RMAN channels and opening more and more datafiles simultaneously could eventually exhaust Oracle server and HPE StoreOnce resources. The optimal number of allocated channels and open datafiles is dependent upon the environment.

Hewlett Packard Enterprise recommends allocating multiple channels for backups when using the RMAN Plug-in.

The RMAN parameters `MAXOPENFILES` and `FILESPERSET` also affect data interleaving in terms of the number of backup sets created and utilization of the allocated channels.

`The MAXOPENFILES` parameter specifies the maximum number of datafiles that can be open at a given time for a single allocated channel. RMAN will read multiple datafiles simultaneously and combine the blocks into a single backup piece. This is called a *multiplexed backup set*. The default value is `MAXOPENFILES 8` unless otherwise specified in the `ALLOCATE CHANNEL` statement.

Hewlett Packard Enterprise recommends setting `MAXOPENFILES 1` as there was no observed performance benefit with the RMAN Plug-in having RMAN read multiple files from disk simultaneously. Oracle also recommends this setting when the database files are striped across a large number of disks.

`The FILESPERSET` parameter specifies the number of datafiles to be written into a backup set. The default value is the total number of datafiles to be backed up divided by the number of allocated channels. For example, if there are 24 datafiles in the database and six channels have been allocated, then `FILESPERSET` will default to four datafiles per backup set. Each channel will be used once to perform the backup and the resulting backup will consist of six backup sets. Alternatively, if there are 24 datafiles in the database and six channels are allocated for the backup, but `FILESPERSET 2` is specified on the `BACKUP` command, then the backup will consist of 12 backup sets, with each set containing two datafiles. Each channel will be used twice to write the backup to the Catalyst store.

NOTE

The resulting number of backup sets in a backup influences the number of Catalyst items in the Catalyst store. The total number of Catalyst **Items** will be twice the number of backup sets as there is a Catalyst data item and a Catalyst metadata item created for each backup set.

Figure 16 illustrates a series of full backups run against the solutions lab database, varying the number of allocated channels and the FILESPERSET setting. Better performance was observed for full backups with FILESPERSET set to 2 against an allocated channel count of eight or higher. (The channels were allocated evenly across both nodes in the RAC.) The solutions lab database consisted of 43 datafiles, so in all cases except one, the FILESPERSET value specified with the RMAN BACKUP command ensured that each channel was utilized at least once.

The exception was the case of 16 allocated channels and FILESPERSET 4. In this case RMAN automatically changed the default FILESPERSET to 3 to maximize the number of channels used. (Three files per set on 13 channels, two files per set on two channels, for a total of 15 out of 16 channels used.)

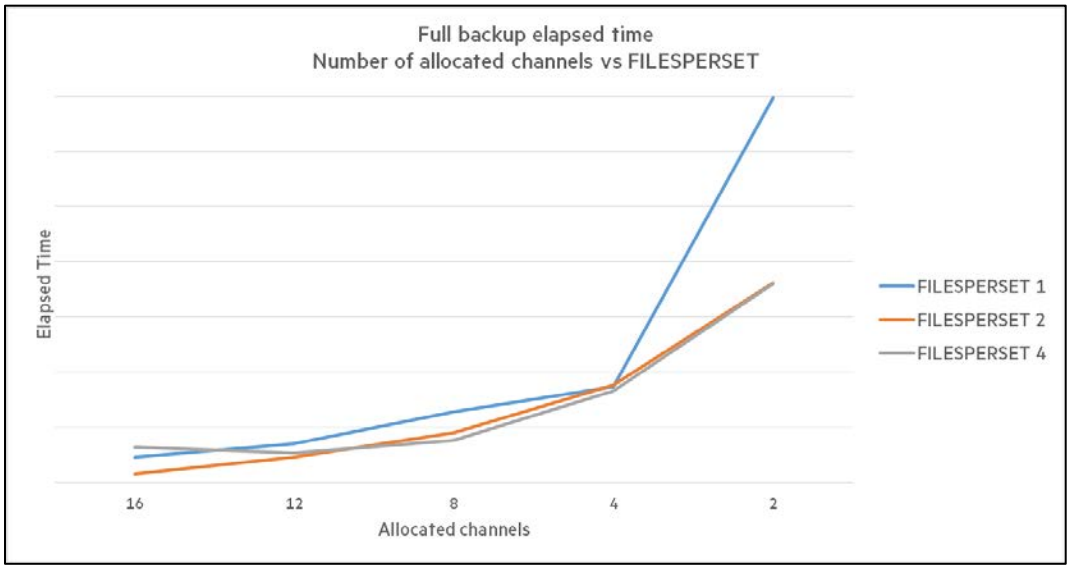


FIGURE 16. Comparing performance of allocated channels vs. FILESPERSET

Careful tuning of the number of channels allocated and the FILESPERSET value in relationship to the number of datafiles to be backed up must be balanced against host server and HPE StoreOnce resource utilization.

In terms of Catalyst store deduplication, MAXOPENFILES, FILESPERSET, and ALLOCATE CHANNEL have minimal effect on deduplication ratios when using the RMAN Plug-in.

Comparing RMAN Plug-in backups with backups to an NFS share

Figure 17 compares the elapsed times for three sets of full backups of the solutions lab database. The elapsed times for RMAN backups written to a Catalyst store via the RMAN Plug-in are compared against RMAN backups written to an NFS share. Only the number of allocated channels changed for each backup set. The allocated channels were evenly distributed across both Oracle RAC nodes. The RMAN parameters `FILESPERSET` and `MAXOPENFILES` remained identical for each backup: `FILESPERSET 4` and `MAXOPENFILES 1`. The figure shows that the RMAN backups to NFS on average took three times longer to complete than the RMAN Plug-in backups.

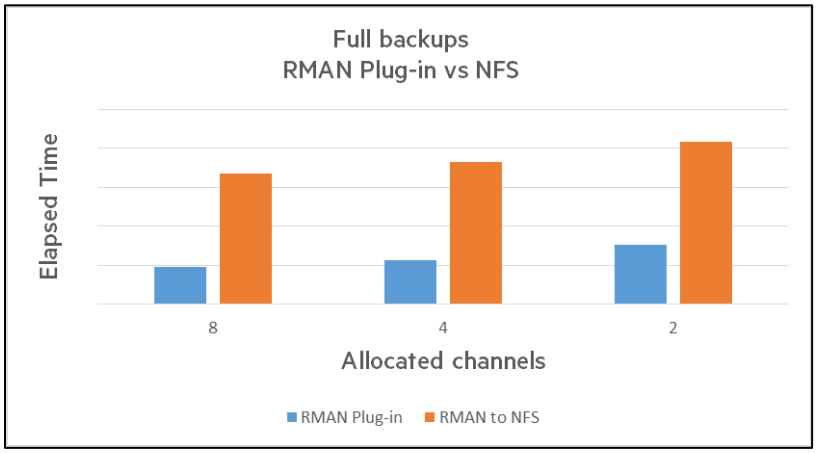


FIGURE 17. RMAN Plug-in backup to HPE StoreOnce vs RMAN backups to NFS

Required disk space is another factor to consider when comparing RMAN Plug-in backups against RMAN backups to NFS. Figure 6 shows the Catalyst deduplication ratio and size-on-disk values for an initial full backup of the database to a Catalyst store. The solutions lab database is 1 TiB in size, but due to advantage of Catalyst deduplication, only 450 GiB of disk space is used on the HPE StoreOnce appliance. For subsequent RMAN Plug-in full backups, the size on disk will grow based only on the incremental changes made to the database and how well any new data deduplicates. Figure 18 represents the disk space required for the initial full backup of the solutions lab database on the NFS share. Because there is no deduplication writing to the NFS share, the total size on disk is 1 TB (1022 GB).

```
[root@sedb02]# ls -lah /nfsshare/8channel
total 1022G
drwxr-xr-x 2 oracle oinstall 4.0K Mar  8 12:33 .
drwxrwxr-x 9 oracle oinstall 4.0K Mar  8 11:52 ..
-rw-r----- 1 oracle asmadmin 113G Mar  8 12:40 sedb_u3trtscn_1_1
-rw-r----- 1 oracle asmadmin 112G Mar  8 12:40 sedb_u4trtscn_1_1
-rw-r----- 1 oracle asmadmin  96G Mar  8 12:36 sedb_u5trtsco_1_1
-rw-r----- 1 oracle asmadmin  93G Mar  8 12:36 sedb_u6trtsco_1_1
-rw-r----- 1 oracle asmadmin  92G Mar  8 12:36 sedb_u7trtsco_1_1
-rw-r----- 1 oracle asmadmin  89G Mar  8 12:33 sedb_u8trtsco_1_1
-rw-r----- 1 oracle asmadmin  87G Mar  8 12:33 sedb_u9trtsco_1_1
-rw-r----- 1 oracle asmadmin  87G Mar  8 12:33 sedb_uatrtsco_1_1
-rw-r----- 1 oracle asmadmin  87G Mar  8 12:52 sedb_ubtrtugh_1_1
-rw-r----- 1 oracle asmadmin  87G Mar  8 12:52 sedb_uctrtuh0_1_1
-rw-r----- 1 oracle asmadmin  86G Mar  8 12:47 sedb_udtrtuh1_1_1
```

FIGURE 18. Listing of RMAN backup to NFS share

Each subsequent full backup to the NFS share will require another 1 TB (1022 GB) of disk space.

SUMMARY

Oracle customers demand an efficient, reliable data growth management backup system environment while keeping costs under control, and some Oracle DBAs need full control of database backup and recovery. Hewlett Packard Enterprise provides a variety of reliable data protection storage solutions that address such requirements, such as HPE StoreOnce systems and the HPE StoreOnce Catalyst Plug-in for Oracle RMAN.

HPE StoreOnce systems offer high performance and reliability while addressing data growth through HPE StoreOnce data deduplication technology. The RMAN Plug-in gives DBAs full control of database backup and recovery using HPE StoreOnce backup appliances With the RMAN Plug-in, HPE StoreOnce appliances integrate easily with Oracle RMAN to protect important mission-critical databases. The RMAN Plug-in supports duplexed backups to accomplish disaster recovery and CDM use cases. Combining Oracle RMAN and HPE StoreOnce with the HPE StoreOnce Catalyst Plug-in for Oracle RMAN provides a comprehensive data protection solution for Oracle application data.

IMPLEMENTING A PROOF-OF-CONCEPT WITH HPE STOREONCE VSA

As a matter of best practice for all deployments, Hewlett Packard Enterprise recommends implementing a proof-of-concept using a test environment that matches as closely as possible the planned production environment. In this way, appropriate performance and scalability characterizations can be obtained.

Implementing a proof-of-concept for the RMAN Plug-in can easily be done using the HPE StoreOnce VSA trialware. The HPE StoreOnce VSA trialware enables a 90-day evaluation demo of all HPE StoreOnce VSA features (including HPE Cloud Bank Storage) and up to 500 TB capacity. See HPE StoreOnce VSA Gen 4 90-Day Evaluation for product details and downloads.

After the HPE StoreOnce VSA is installed and a Catalyst store has been created, download the RMAN Plug-in software (see HPE StoreOnce Catalyst Plug-in for Oracle RMAN). Install the RMAN Plug-in on a nonproduction Oracle server for this trial.

Copy the RMAN Plug-in `plugin_template.conf` file to `plugin.conf`. Edit the `plugin.conf` file for the correct `CATALYST_STORE_ADDRESS` and `CATALYST_STORE_NAME` of the Catalyst store created on the HPE StoreOnce VSA.

Create a simple RMAN backup script allocating a single `SBT_TAPE` channel for the RMAN Plug-in (see Figure 4 for an example). Execute the RMAN script and when it completes, log in to the HPE StoreOnce VSA and review the activity to the Catalyst store.

Additional testing would include modifying the `ALLOCATE CHANNEL` statements in an existing RMAN backup script to have the script write to a Catalyst store using the RMAN Plug-in.

RESOURCES AND ADDITIONAL LINKS

HPE StoreOnce Catalyst Plug-in for Oracle RMAN, https://h20392.www2.hpe.com/portal/swdepot/displayProductInfo.do?productNumber=StoreOnceForRMAN

HPE StoreOnce Catalyst, http://h20195.www2.hpe.com/V2/GetDocument.aspx?docname=a00045521enw

HPE Reference Configuration for HPE Cloud Bank Storage with Microsoft Azure, http://h20195.www2.hpe.com/V2/GetDocument.aspx?docname=a00043317enw

HPE Reference Configuration for HPE Cloud Bank Storage with S3 Connector and Scality, https://h20195.www2.hpe.com/v2/Getdocument.aspx?docname=a00047299enw

HPE Reference Configuration for HPE Recovery Manager Central, http://h20195.www2.hpe.com/V2/GetDocument.aspx?docname=a00046137enw

HPE Recovery Manager Central 5.0 User Guide, https://support.hpe.com/hpesc/public/home/documentHome?docId=emr_na-a00042435en_us&sp4ts.oid=1008734156

HPE Recovery Manager Central 5.0 for Oracle User Guide, https://support.hpe.com/hpesc/public/home/documentHome?docId=emr_na-a00042430en_us&sp4ts.oid=1008734156

HPE Recovery Manager Central, hpe.com/us/en/storage/rmc-backup.html

HPE StoreOnce Data Protection Backup Appliances, hpe.com/us/en/storage/storeonce.html

HPE 3PAR StoreServ Storage, hpe.com/storage/3par

HPE Storage for Oracle Databases, hpe.com/us/en/storage/oracle

HPE StoreOnce Support Matrix (requires an HPE Passport account), https://h20272.www2.hpe.com/spock/utility/document.aspx?docurl=Shared%20Documents/hw/nearline/storeonce_compatibility_g4_matrix.pdf

HPE Recovery Manager Central Software (requires an HPE Passport account), https://h20272.www2.hpe.com/spock/Pages/spock2Html.aspx?htmlFile=dp_recovery_manager.html

HPE Recovery Manager Central (RMC) Software Development Kit (SDK), https://h20392.www2.hpe.com/portal/swdepot/displayProductInfo.do?productNumber=HPSTOREONCERMCSDK

To identify storage system configuration specifications and compatibility information, go to Single Point of Connectivity Knowledge (SPOCK), https://h20272.www2.hpe.com/spock

To help us improve our documents, please provide feedback at hpe.com/contact/feedback.

LEARN MORE AT

hpe.com/us/en/storage/storeonce.html

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