Hewlett Packard Enterprise

HPE Reference Configuration for Copy Data Management and Data Protection of Oracle environments with HPE Recovery Manager Central for Oracle

Contents

Executive summary

Protecting database environments is proving ever more challenging in the face of larger and increasing numbers of data volumes, rising business demands, and the pressures of cost efficiency and sustainable growth. Many organizations now measure downtime tolerance in minutes. Traditional Oracle backup and recovery management methods can visibly affect service levels, incur escalating IT costs, and introduce increased complexity. In addition to data protection, DBAs also have a need to quickly and efficiently make copies of the production database—whether it be for database cloning or database migration. This Reference Configuration describes how Hewlett Packard Enterprise provides a direct data protection solution for Oracle environments that improves on traditional backup approaches, as well as satisfying the copy data management (CDM) needs of the DBA.

HPE Recovery Manager Central for Oracle (RMC-O) is an application plug-in to HPE Recovery Manager Central (RMC) that offers a practical, efficient approach to Oracle CDM and database protection. RMC-O interfaces directly to HPE 3PAR storage to provide snapshot management services—fast, nondisruptive point-in-time copies of the HPE 3PAR virtual volumes—the foundation for RMC-O operations.

To meet CDM needs, RMC-O provides easy-to-use, one-click operations that automatically create snapshots of the Oracle datafile and archive log volumes. The DBA can either mount the snapshots on a designated backup server for further operations or use the snapshots to bring up a clone of the databases on a backup server.

Snapshots alone cannot deliver a comprehensive backup. Snapshots have retention limitations, corruption vulnerabilities, and dependence on the underlying storage system. Snapshots are at risk if the storage system fails. To meet data protection needs, RMC-O combines the benefits of both snapshots and backups in a simple-to-use, application-managed, storage-integrated, and cost-effective data protection solution. RMC-O eliminates the impact on Oracle application resources and users that happens with traditional backup solutions. RMC-O provides one-click Express Protect operations that integrates HPE 3PAR storage snapshots directly to the HPE StoreOnce backup appliance.

Yet, Oracle customers who are running an unsupported operating system for RMC-O can use RMC to snap an Oracle database without having to put the database in Hot Backup mode.

RMC and RMC-O 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.

RMC-O interfaces HPE 3PAR primary storage with HPE StoreOnce systems to provide a converged availability and direct backup service for Oracle environments. The RMC-O Express Protect feature creates a second copy of the data on the HPE StoreOnce backup appliance and 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 an HPE Cloud Bank Storage store.

Combining the performance of local and remote array-based snapshots with the protection of backups and satisfying CDM needs, RMC-O enables fast, effective, reliable, and simple protection of Oracle databases and instances.

Target audience: This document is intended for presales consultants, solution architects, database backup, system, or storage operators, and administrators who are designing, implementing, and maintaining common Oracle database backup and CDM tasks. Readers of this Reference Configuration should have a functional understanding of Oracle databases, HPE Recovery Manager Central, HPE 3PAR storage systems, and data protection, backup concepts, and technologies for HPE StoreOnce backup appliances.

Document purpose: This document describes HPE RMC-O components and functionality, provides setup and configuration recommendations, and best practices on how to run an effective and efficient backup environment. In addition, this document provides guidance on how to use RMC to take snapshots of an Oracle database without putting the database in Hot Backup mode.

This document supplements existing documentation for the following HPE products that are part of this solution:

- HPE Recovery Manager Central
- HPE StoreOnce Systems
- HPE 3PAR StoreServ Storage

Solution overview

With HPE Recovery Manager Central for Oracle, Oracle database administrators create, schedule, and manage Oracle application-consistent snapshots of Oracle datafile and archived redo log volumes being served from an HPE 3PAR storage array. These snapshots can then be used for CDM use cases, such as database cloning for test-development, QA, reporting, analytics, or migration purposes. The RMC-O Express Protect feature enables automatic backup of those snapshots directly from HPE 3PAR storage to HPE StoreOnce appliances using HPE StoreOnce Catalyst—independent of any backup server software.

HPE StoreOnce Catalyst is an HPE-developed protocol that is optimized for backup and restore operations. The HPE StoreOnce Catalyst server runs on the HPE StoreOnce data protection system. The HPE StoreOnce Catalyst client is built into RMC-O. RMC-O intelligently processes the backup data stream, then uses HPE StoreOnce Catalyst to transmit the backup to the HPE StoreOnce system. HPE StoreOnce Catalyst reduces backup times, while consuming less network bandwidth. Data is deduplicated so it consumes less storage space on the HPE StoreOnce backup appliance. RMC-O 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 HPE 3PAR array or to a different HPE 3PAR array in the event of a disaster.

Figure 1 shows the basic elements of a complete RMC-O solution, incorporating levels of data protection, including copy data management.
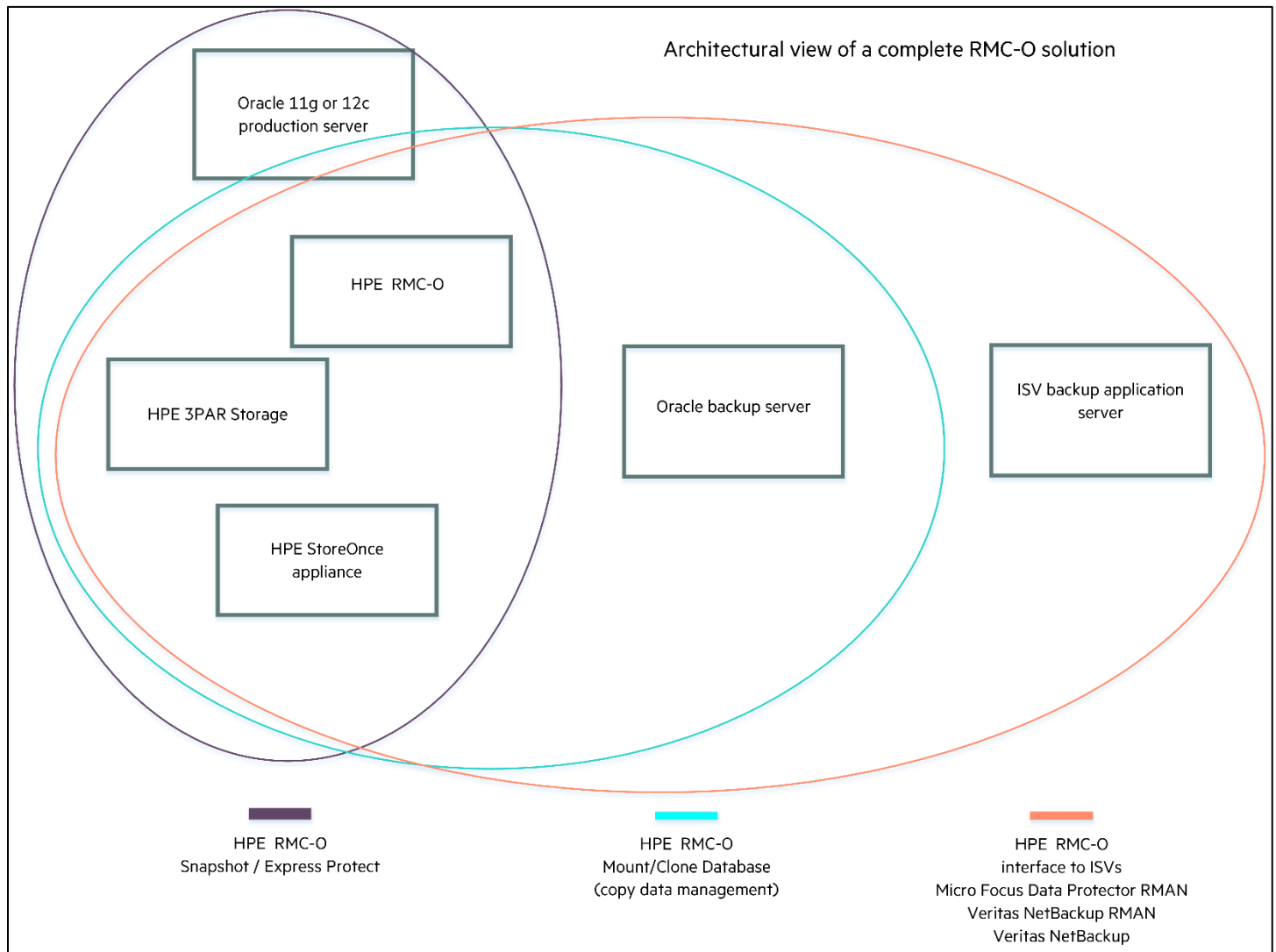

Figure 1. Conceptual view of a comprehensive RMC-O solution

Solution components

HPE validated the RMC-O solution in a lab environment. This section provides details on each major component incorporated into the solution and concludes with a diagram (Figure 2) of the lab setup.

HPE Recovery Manager Central and RMC-O plug-in

An HPE ProLiant DL380 Generation 9 (Gen9) 12-core server (2 x Intel® Xeon® CPU E5-2603 v3 @ 1.60GHz) with 96 GB of physical memory was used to install HPE RMC V5.0 as a virtual machine on a VMware® ESXi™ 6.5.0 host[1]. RMC-O is a plug-in to RMC and is automatically installed as part of the RMC installation. A separate installation of the RMC-O plug-in is not required.

RMC-O client

RMC-O gathers specific Oracle database and instance information through an RMC-O client running on the Oracle server. The RMC-O client is installed on all Oracle application and backup servers. The RMC-O client also provides the RMC-O command line interface (CLI) to manage RMC-O features and operations using CLI commands.

HPE StoreOnce 6600 backup appliance

The HPE StoreOnce 6600 backup appliance used firmware version 3.18.2. The backup appliance contained one couplet with two drive enclosures containing 36 x 4 TB drives per shelf. The HPE StoreOnce 6600 backup appliance acted as the primary backup device for all RMC-O Express Protect (backup) operations. Replication, HPE StoreOnce Catalyst, and HPE Cloud Bank Detach were licensed and enabled.

For Express Backups of the singe Oracle application server used in the lab setup, only one Catalyst store needed to be configured in the HPE StoreOnce appliance. The Oracle datafiles and archive redo logs were backed up together as the catalyst items included in a single catalyst job. HPE recommends dedicating a Catalyst store for each database being protected.

HPE 3PAR StoreServ 8400 Storage

The HPE 3PAR 8400 StoreServ Storage array, using 24 x 1.2 TB hard disk drives and OS version 3.2.2.612, was connected to a 16 Gb Fibre Channel (FC) back-end fabric. Two thin-provisioned virtual volumes on this array, presented to the Oracle application server, housed the datafiles and archive log files for the database.

Oracle application server

This server hosts the production database. Red Hat® Enterprise Linux® (RHEL) release 7.4 was installed on an HPE ProLiant DL380 Gen9 32-core (2 x Intel Xeon CPU E5-2698 v3 @ 2.30 GHz) server with 512 GB of physical memory. The server supported a 1 GbE network connection for local management, a 10 GbE connection to the data network, and a 16 Gb FC SAN connection. This server hosted a server-class, single-instance Oracle Enterprise Edition 12c (12.1.0.2.0) database installation.[2] The Oracle software was installed under the `root` ("/") file system in the path `/u01/app/oracle/software`. This server acted as the Oracle production server for all RMC-O protection operations.

Oracle backup server

This server is where the mounting or cloning of a snapshot takes place. It permits CDM activities, such as RMAN or ISV supported backups, or making a copy of the production database for test and development. A second HPE ProLiant DL380 Gen9 server, having the same hardware and OS configuration as the application server, was added to the lab setup as the backup server.[3] The Oracle 12c software binaries were installed on this server in the same manner as the application server.

Note

The backup server must use the same operating system as the database application server and must be at the same major version number.

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[1] RMC can also be installed on Microsoft® Hyper-V hypervisor hosts.
[2] RMC-O also supports Oracle Standard Edition.
[3] RMC-O does not require that the backup server be the same exact hardware configuration as the application server. However, Oracle does require that the backup server have at a minimum, the same amount of memory as the production server.

Database generation tools

The solution environment included the following tools that were 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.

RealDB

RealDB is an internal HPE tool that was used in the solution lab to load and then modify data in a relational database. The data loaded into the DB comes from webpages downloaded from the internet or imported from previously downloaded datafiles. 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

RMC-O requires that the Oracle datafiles and archived redo logs must reside on the same HPE 3PAR array. RMC-O supports Oracle Automatic Storage Management (ASM) disk groups, Logical Volume Manager (LVM) volume groups, or standard file system volumes for storing datafiles and archive redo logs. However, the datafiles and archive logs cannot coexist on the same volumes or reside in the same ASM or LVM group. The Oracle online redo logs and control files cannot be present on the volumes used by the datafiles or archive logs.

The Oracle application server deployed in the lab setup supported a server-class, single-instance Oracle Enterprise Edition 12c database using standard file system volumes. The Oracle binaries were installed under the `root` ("/") directory and the `ORACLE_HOME` environment variable was set to the path `/u01/app/oracle/software`.

The Oracle online redo logs were also installed under the `root` ("/") filesystem at `/u03/redo`.

The lab configuration employed the RHEL standard file system for the Oracle datafiles and archive logs. RMC-O requires that the datafiles and archive redo logs reside on separate volumes, so two HPE 3PAR thin-provisioned virtual volumes were presented from the same HPE 3PAR array to the application server. The RHEL device mapper multipath driver mapped these two volumes to two single devices on the host that were mounted at `/u02 and /u04`. A 1 TB volume held the Oracle datafiles installed under the path `/u02/oradata/orcl`. A 250 GB volume held the Oracle archive logs installed under the path `/u04/archive.`

The RealDB and Swingbench tools populated the REALDBDATA and SOE tablespaces respectively. The REALDBDATA schema used four datafiles: two files 30 GB in size and two files 22 GB in size. The REALDBDATA tablespace was 98% used. Two SOE benchmark schemas, SOE1 and SOE2, were created, each employing a single, bigfile tablespace. The SOE1 tablespace consisted of one 449 GB datafile; and this tablespace was 95% used. The SOE2 tablespace consisted of one 401 GB datafile; and this tablespace was 99% used. Together the datafiles for the REALDBDATA and SOE tablespaces accounted for 950 GB of the 957 GB used space in the `/u02/oradata/orcl` directory.[4]

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[4] The high-use percentage for the tablespaces was deliberate. With RMC-O Express Protect the magnitude of the deduplication ratio is affected by the size of the HPE 3PAR storage Virtual Volumes compared to the actual size of the datafiles and archive logs. The unused capacity of the volumes will skew the reported dedupe ratio.

Table 1 summarizes the layout of the solution lab Oracle database.

Table 1. Solution lab Oracle database layout

File Type	Filesystem	Mounted on	Directory
Oracle binaries	`/dev/mapper/rhel-root`	`/`	`/u01/app/oracle/software` `(ORACLE_HOME)`
Oracle online redo logs	`/dev/mapper/rhel-root`	`/`	`/u03/redo`
Oracle control files	`/dev/mapper/rhel-root`	`/`	`/u01/app/oracle/control01.ctl` `/u03/control02.ctl`
Oracle datafiles	`/dev/mapper/mpathe` HPE 3PAR 1 TB LUN	`/u02`	`/u02/oradata/orcl`
Oracle archived redo logs (archive logs)	`/dev/mapper/mpathg` HPE 3PAR 250 GB LUN	`/u04`	`/u04/archive`

Figure 2 shows the components in the lab setup that were used to verify this solution.
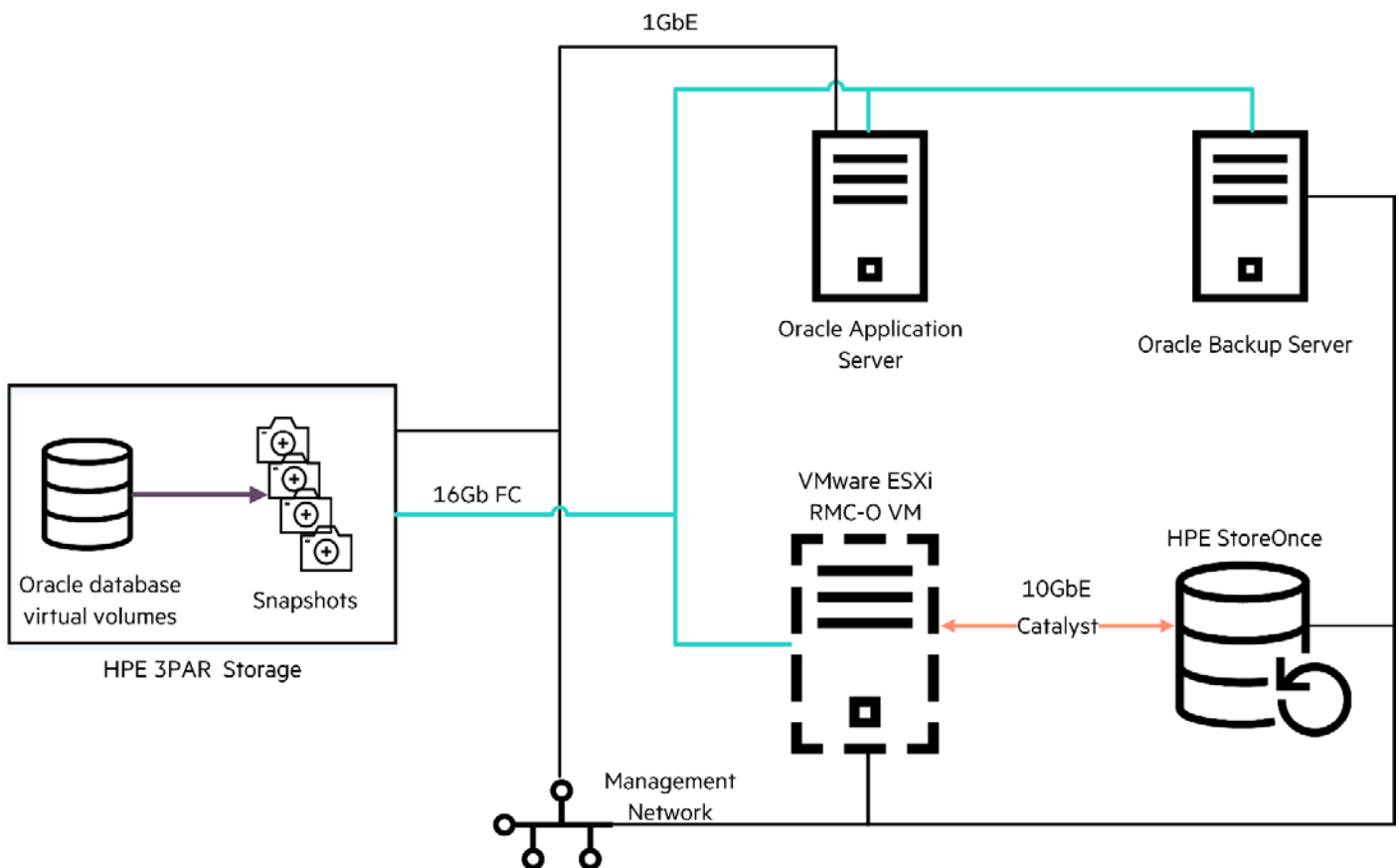

Figure 2. Solution environment setup

Figure 2 highlights the communication paths between solution components. The 16 Gb FC SAN connects together the HPE 3PAR storage array, the Oracle application and backup servers, and the RMC VM running RMC-O. Virtual volumes configured on the HPE 3PAR storage are

presented to the Oracle application server over the FC SAN. During the installation of the Oracle production database on the application server, separate virtual volumes are configured to hold the Oracle datafiles and the archive redo logs.

During RMC-O CDM operations, RMC-O communicates with HPE 3PAR storage through the management network to direct the creation of the snapshot sets of the production volumes. RMC-O then requests that HPE 3PAR storage mounts these snapshots on the designated backup server, which occurs over the FC SAN. For example, when RMC-O clones the production database to the backup server, the management interface on the HPE 3PAR storage shows the parent virtual volumes presented to the Oracle application server host and the read-write snapshots of those parent volumes presented to the Oracle backup server host. Only an IP interface between the RMC-O VM and the HPE 3PAR array is needed for CDM.

For backup and restore operations, RMC-O needs to communicate to HPE 3PAR storage through the FC SAN. RMC-O communicates to the HPE StoreOnce appliance either through FC or Ethernet. In the lab setup, a 10 GbE network supports the HPE Catalyst communications between the RMC-O VM and the HPE StoreOnce appliance. For RMC-O Express Protect backup operations, RMC-O directs the HPE 3PAR array, via the management network, to create the necessary snapshots of the production volumes. RMC-O retrieves the data from the HPE 3PAR array via the FC SAN. RMC-O then sends the appropriate data to the HPE StoreOnce appliance via the HPE Catalyst protocol over the 10 GbE connection. For RMC-O Express Restore operations this process is reversed. RMC-O communicates with HPE StoreOnce to retrieve the data from the HPE StoreOnce Catalyst store, using the HPE Catalyst protocol over the 10 GbE interface, and then writes the data to the appropriate target on the HPE 3PAR storage using the FC SAN.

Best practices and configuration guidance for HPE RMC-O

RMC-O is an application plug-in that is configured as part of an RMC installation to specifically handle operations to protect Oracle databases.[5] Installation of RMC is performed using the HPE RMC Installation Wizard. No separate installation is required for any of the RMC plug-ins, including RMC-O. All of the plug-ins are installed with RMC.

Note

The HPE RMC Installation Wizard includes a copy of the HPE StoreOnce Virtual Storage Appliance (VSA) to give users who have not yet integrated a hardware-based HPE StoreOnce appliance the opportunity to experience first-hand the RMC-O Express Protect feature. Express Protect provides the added protection of backing up HPE 3PAR snapshots created through RMC-O.

For more information about using the HPE RMC Installation Wizard, see HPE Reference Configuration for HPE Recovery Manager Central.

RMC-O client installation
RMC-O gathers specific Oracle database and instance information through an RMC-O client running on the Oracle server. The client responds to requests from RMC-O only on demand. Unlike an agent or a daemon, it only consumes resources while servicing a request. The RMC-O client must be installed on all Oracle application and backup servers.[6] The RMC-O client installation file is pulled from the RMC appliance. The installation script installs the client and CLI binaries in the `/opt/hpe/rmc/oracle` directory. See the HPE Recovery Manager Central 5.0 for Oracle User Guide for detailed information regarding the prerequisites for the RMC-O client installation and for information on how to use the RMC-O command line utilities.

Note

The database must be running in `ARCHIVELOG` mode and the parameter `LOG_ARCHIVE_DEST_1` must be set before RMC-O can create online, datafile, or archive log snapshots.

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[5] Other HPE RMC plug-ins include: RMC for Microsoft SQL Server (RMC-S), RMC for SAP HANA® (RMC-SH) and RMC for Microsoft Exchange (RMC-E).

[6] Refer to the current *HPE Data Availability, Protection and Retention Compatibility Matrix – Recovery Manager Central* in SPOCK for a list of operating systems that support the RMC-O client.

Logging in to RMC-O for the first time

RMC-O automates several post-installation setup processes upon logging in for the first time. Actions include:

- Setting the application persona for the RMC VM

- Setting Oracle as the application to configure for data protection

- Launching the Protection Wizard to automatically create the first snapshot or Express Protect backup job

This section provides details on each of these steps.

RMC login

To access RMC, open a web browser and enter the URL `https://<IP address of RMC VM>`. Enter the user name and password credentials that were set for the appliance during installation.

Appliance persona

When logging in to RMC for the first time, the appliance persona must be set. Backup is the default persona. The Backup persona includes HPE StoreOnce Express Protect and HPE StoreOnce Catalyst Copy operations. This is the persona to choose for all RMC-O operations.

Data protection configuration

Next, RMC-O prompts to select the application to which data protection operations will apply. Select Oracle on the **Data Protection** Basic Configuration screen as the application to configure. This ensures that menus and action dialogs will include options specific to Oracle operations.

Clicking **Yes, Proceed** launches the Protection Wizard.

RMC-O Protection Wizard – first time login

RMC-O uses protection policies and protection jobs to define and manage database protection schemes. Policies support creating snapshots for CDM operations or creating an Express Protect operation for backup to HPE StoreOnce. Snapshots can be local or replicated to a remote HPE 3PAR array using the HPE 3PAR Remote Copy feature.[7] Protection jobs are either ad hoc (one-off) or scheduled.

The parameters of a protection job are described in a protection policy that is associated with the given protection job. When logging in to RMC-O for the first time, RMC-O launches the Protection Wizard to quickly walk through all the necessary steps to automatically create the first snapshot or Express Protect backup of a selected Oracle database. See the HPE Recovery Manager Central 5.0 User Guide for more information on working with the Protection Wizard.

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[7] RMC-O does not support the RMC Peer Copy feature.

When the Protection Wizard completes, RMC-O opens the **ORACLE→Databases→Overview** screen as shown in Figure 3. Figure 3 also illustrates how clicking **Overview** expands the **View** menu, showing access to the **Protection View** and **Protection Job View** screens.
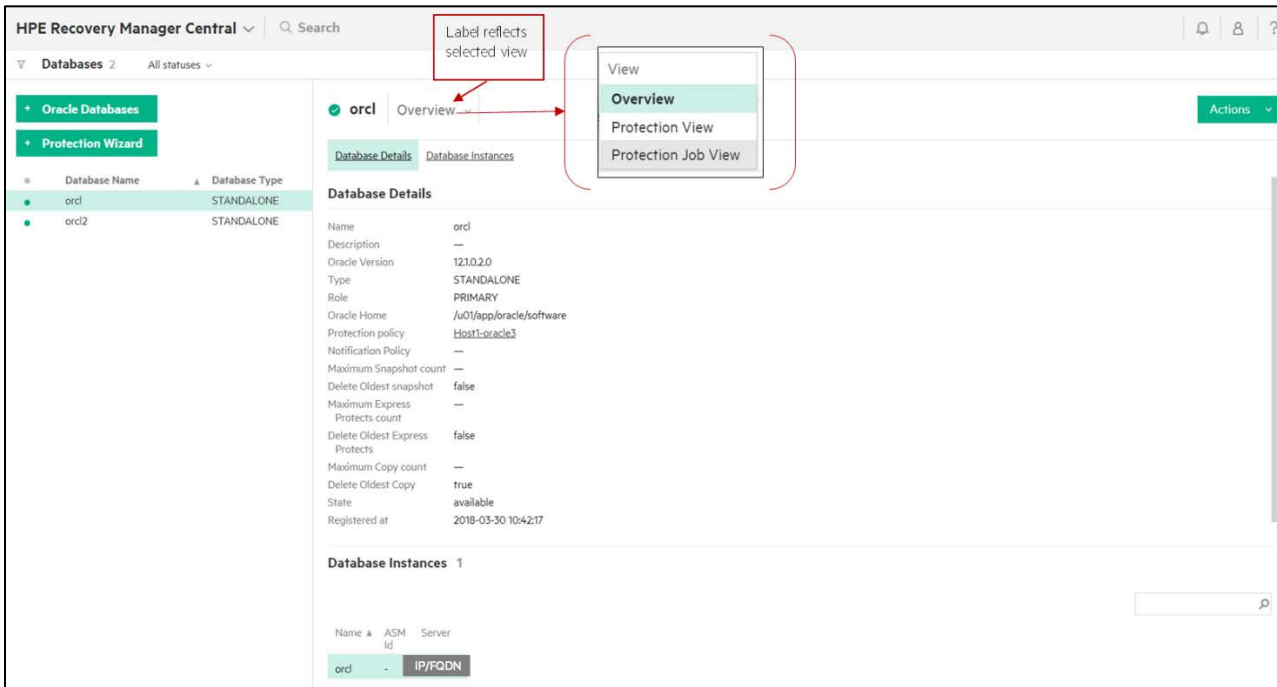

Figure 3. The expanded "View" menu

If the protection job was a scheduled job, click **Protection Job View** from the **View** drop-down menu to see the job information. Click the expansion arrow (►) next to the job entry to see additional details about the job.

From the **View** drop-down menu, click **Protection View**. The **Snapshots** and **Protects** panels of the **Protection View** screen display the objects created by the Protection Wizard.

Figure 4 shows a **Protection View** screen listing the **Snapshots** and **Protects** that have been created for the "orcl" database. Highlighted in this view are a snapshot and corresponding Express Protect that were created by a single, combined snapshot-then-protect operation.
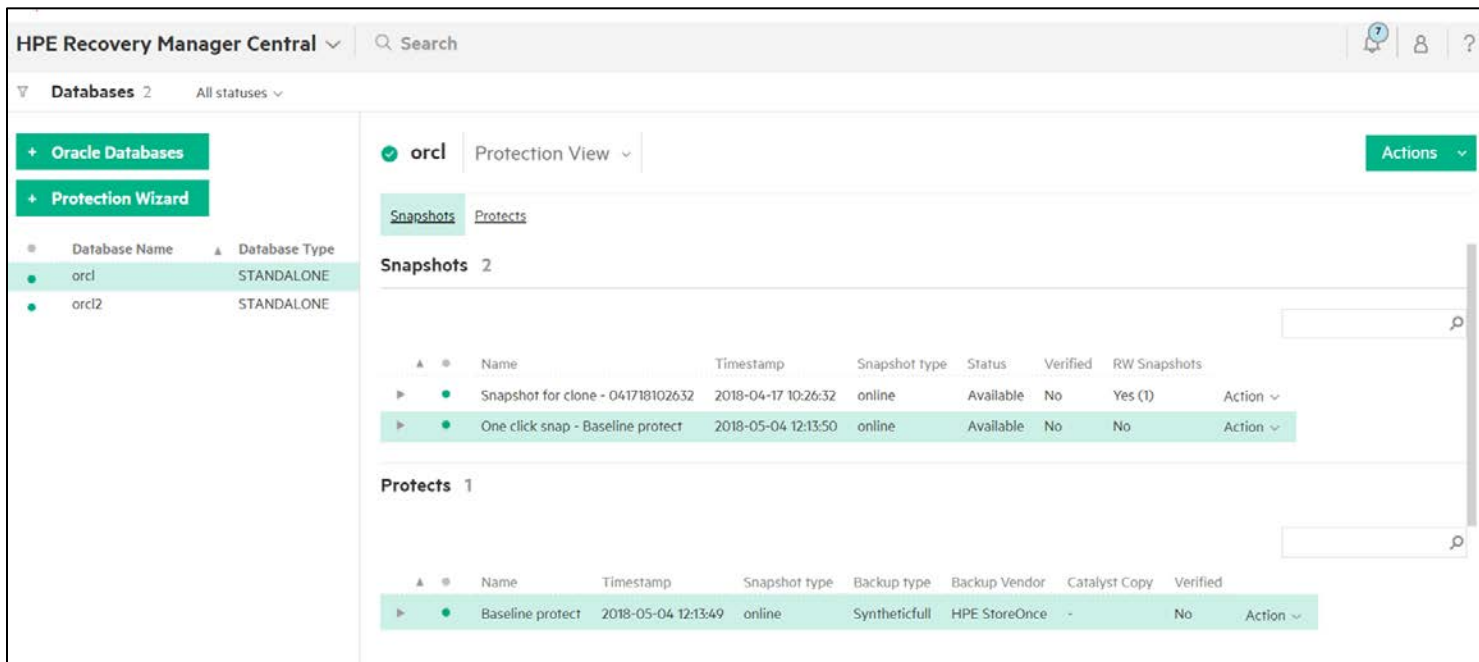

Figure 4. Listing the Snapshots and Protects from the "Databases→Protection View" screen

This section has described the RMC-O Protection Wizard and how RMC-O automatically launches this wizard when logging in for the first time. Figures 3 and 4 show screens accessed from the **View** drop-down menu of the **ORACLE→Databases** screen. Note that in the upper-left corner of each screen is a menu item labeled **+ Protection Wizard**. Click **+ Protection Wizard** in any of these screens to launch Protection Wizard at any time.

Subsequent RMC-O logins

The previous section described how the initial RMC-O login automatically sets the appliance persona, sets the Data Protection application, and launches the Protection Wizard to create a protect job and associated protection policy.

Subsequent logins to the RMC appliance will automatically open the HPE RMC Dashboard, which displays a dynamic visual summary of the current RMC environment. See the HPE Recovery Manager Central 5.0 User Guide for more information on monitoring the RMC appliance via the dashboard.

RMC main menu

The uppermost menu bar visible from any RMC or RMC-O screen displays the **HPE Recovery Manager Central** drop-down menu. Click **HPE Recovery Manager Central** to display the RMC main menu. The main menu is divided into several submenu options. Figure 5 shows the main menu with the **ORACLE** submenu circled in red.
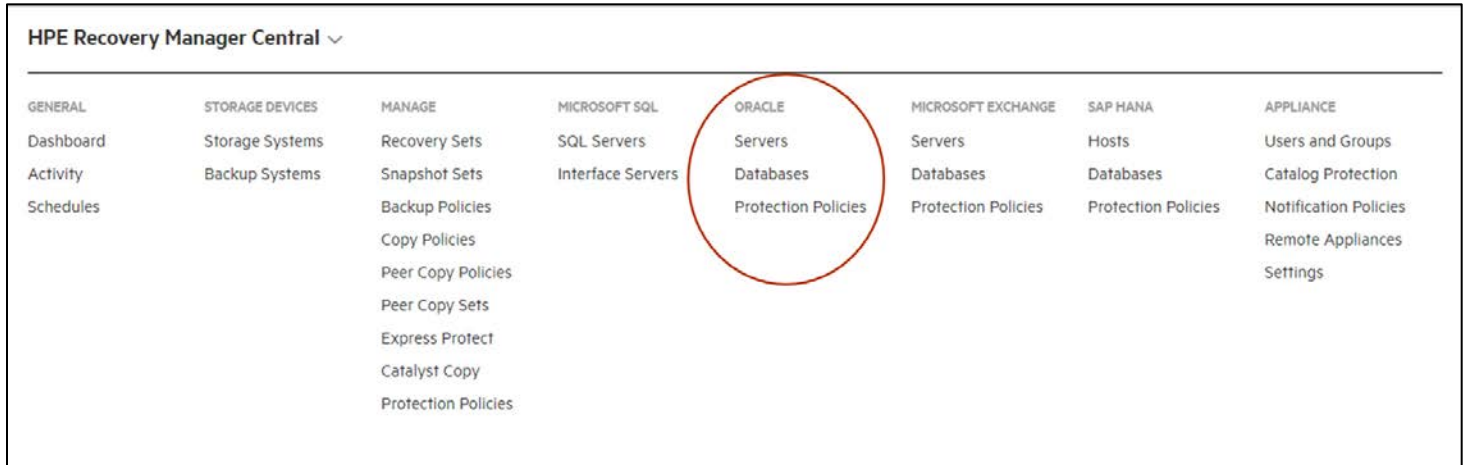

HPE Recovery Manager Central ˅						
GENERAL	STORAGE DEVICES	MANAGE	MICROSOFT SQL	ORACLE	MICROSOFT EXCHANGE	SAP HANA	APPLIANCE
Dashboard	Storage Systems	Recovery Sets	SQL Servers	Servers	Servers	Hosts	Users and Groups
Activity	Backup Systems	Snapshot Sets	Interface Servers	Databases	Databases	Databases	Catalog Protection
Schedules		Backup Policies		Protection Policies	Protection Policies	Protection Policies	Notification Policies
		Copy Policies					Remote Appliances
		Peer Copy Policies					Settings
		Peer Copy Sets					
		Express Protect					
		Catalyst Copy					
		Protection Policies					

Figure 5. RMC main menu with the "ORACLE" submenu highlighted

Notice

Perform all RMC-O operations from the **ORACLE** submenu. Attempting to use **MANAGE→Recovery Sets** or **MANAGE→Snapshot Sets** to modify or delete RMC-O entities can lead to snapshots or protects that are unusable for restoring the Oracle database. These options in the **MANAGE** submenu will not take application-consistent snapshots of Oracle datafiles and archive redo logs.

Email notification

First-time users of RMC and RMC-O can find it very helpful to create an email notification policy. A notification policy identifies who receives email notifications—either information, error messages, or both—for specific RMC-O operations. To access notification policies, select **APPLIANCE→Notification Policies** from the RMC main menu. This displays the **Notification Policies** screen listing any existing notification policies and permits editing them (if necessary). To create a new policy, click **+ Notification Policies** (in the upper-left corner). This displays the **Add Notification Policy** dialog. The upper panel of this screen is the **Configuration** panel.

It is very important to change the setting in the **Application Type** field. The default application type is **RMC**, but this must be changed to **RMC-O.** Click the **Application Type** field entry and select **RMC-O** as the application type for this email notification policy. Figure 6 shows the **Application Type** field options with **RMC-O** being highlighted as the new selection.

Figure 6. Setting the Notification Policy application type to RMC-O

Complete the other fields in the **Configuration** panel as appropriate for the environment. Typically, the designated receiver is the DBA responsible for managing the database. The **Operations** panel follows the **Configuration** panel. Use this panel to select which of the six operations listed will send email and whether a notification will be sent for informational messages, error messages, or both. The default action is to send an email notification to the designated receiver whenever there is an error during a **Create Snapshot** operation.

Tip

Users can initially elect to check **Select All** to receive informational and error messages for all six categories of RMC-O operations. As DBAs gain experience with RMC-O, the notification policy can be edited to narrow the focus of the email notifications.

After the notification policy has been defined, the policy is associated with a specific database. The same policy can be associated with multiple databases (for example, in the case of the designated receiver being a DBA managing multiple databases). To associate a notification policy with a given database, navigate to the **ORACLE→Databases→Overview** screen, select the appropriate database name, and select **Edit** from the **Actions** drop-down menu. From the **Database Properties** panel of the **Edit** dialog, click the **Select** button next to the **Notification Policy** field. Select the name of the Notification Policy to apply it to the selected database.

Monitoring RMC-O operations

To monitor active or completed RMC-O operations, select **GENERAL→Activity** from the RMC main menu to display a list of **Actions**. Each item includes a descriptive name of the action, the resources involved, the state and execution duration, and a time stamp. Click the expansion arrow (▶) next to a specific action name to display the tasks and subtasks executed as part of the action. Click the expansion arrows next to each of the activities listed to get additional detailed information on individual items. For further information on the **Activity** screen, see the HPE Reference Configuration for HPE Recovery Manager Central.

RMC-O one-click actions

RMC-O provides one-click **Actions** to allow DBAs to conveniently and quickly initiate CDM and database protection operations. Each action automatically creates any dependent entities required to complete that action. These actions are available from any of the **ORACLE→Databases→View** menu items (see Figure 3). There are four one-click actions:

- **Actions→Create Snapshot:** Creates a read-only (RO) snapshot of the Oracle datafile and archive redo log volumes. The snapshot is created locally or remote (replicated to a remote HPE 3PAR array using the RMC Peer Copy feature).

- **Actions→Protect**: Creates a local RO snapshot, and then initiates an Express Protect backup.

- **Actions→Catalyst Copy**: Creates an RO snapshot, initiates an Express Protect backup, and then initiates a Catalyst Copy from the primary HPE StoreOnce appliance to the secondary HPE StoreOnce appliance.

- **Actions→Clone Database**: Creates an RO parent snapshot, creates a read-write (RW) child snapshot, mounts the RW snapshot on the designated Oracle backup server, recovers the database, and places the cloned database in an OPEN/ACTIVE state.

Each of these one-click actions is addressed in a later section of this paper: **Create Snapshot** is discussed in Creating HPE 3PAR Oracle-consistent storage snapshots, **Protect** and **Catalyst Copy** are discussed in Protecting the production database – backups**,** and **Clone Database** is discussed in Copy Data Management.

Creating HPE 3PAR Oracle-consistent storage snapshots

All RMC-O operations revolve around creating and managing snapshots of the HPE 3PAR Oracle datafile and archive redo log volumes. Snapshots can be created via protection jobs or through the one-click operation **Actions→Create Snapshot**. Snapshot policies can include a schedule definition to automatically create recurring snapshots. The policy can also specify snapshot expiration and retention times.

Important

HPE recommends maintaining separate schedules and retention policies for snapshot-only and Express Protect backup operations. Snapshot-only operations are scheduled more frequently, but these snapshots have a shorter retention time. Express Protect operations are scheduled less frequently, but the Protects have a longer retention time. Snapshots that are associated with an Express Protect must have a retention policy separate from general snapshot retention. Care must be taken so as to not delete all the snapshots associated with valid Express Protect backups (see Scheduling Express Protects).

Note

When creating and managing snapshots, RMC-O communicates with the HPE 3PAR array via an Ethernet connection. An FC SAN connection between RMC-O and the HPE 3PAR array is not needed for snapshot management.

When creating a snapshot through either a protection job or a one-click operation, a **Backup Method** must be selected. The options include:

- Online (Hot) Backup

- Archive logs only

- Offline (Cold) Backup

- Datafile only

The **Snapshot type** column as seen in the **Snapshots** panel from **ORACLE→Databases→Protection View** displays the **Backup Method** chosen when the snapshot was created. Figure 7 shows four snapshots, one of each type, associated with the "orcl2" database.

Figure 7. Confirming Backup Method used when each snapshot was created

If the backup method specified is **Offline (Cold) Backup** the Oracle database or Real Application Clusters (RAC) instances must be shut down. There is no need to dismount ASM disk groups or export LVM volume groups; however, file systems must be unmounted. Figure 8 shows the error message that is displayed in the **Task Errors** details under the **General→Activity** screen for the failed **Create Snapshot** action.

Figure 8. Snapshot creation error when selected backup method was "Offline (Cold) Backup," but the database was not shut down first

If **Archive logs only** is the specified backup method, the database must be in the MOUNTED/OPEN state.

Key point

In order to provide complete protection and recoverability for Oracle databases, RMC-O automatically retains the Oracle metadata files with the key information about the database structure and security. The control file, PFILE, password file, and other critical structure files are protected in a secure area on the RMC VM during each online or offline snapshot[8].

Snapshot actions

This section focuses on the **Snapshots** panel of the **ORACLE→Databases→Protection View** screen and the action items available for parent and child snapshots. All completed snapshot operations, whether one-off or scheduled, are listed in the **Snapshots** panel. For convenience there is a total count provided next to the **Snapshots** panel title. Click any one of the heading entries at the top of the display to change the order of presentation based on that heading. The default presentation is by ascending time stamp.

Click the expansion arrow (▶) to the left of any snapshot entry to view additional details of the parent snapshot. The information in the expanded display includes:

- List of any child (RW) snapshots associated with this parent

- Hostname/IP and Oracle SID

- Operating system information

- Archive log destination

- Oracle information such as database type, role, and version

- Path and filename for all datafiles

- Status, name, and size of the tablespaces

---

[8] The metadata is not retained during archive log only snapshot or backup jobs.

Figure 9 shows an expanded view of a parent snapshot (RO) that has one (RW) child snapshot. (The other details of the expanded view have been removed for brevity.) Several important items are highlighted and numbered in red.

Figure 9. Expanded view of a snapshot entry

Key takeaways from the numbered entries in Figure 9 are:

1. The name of the parent, RO snapshot.

2. This RO snapshot has one RW child snapshot.

3. The name of the child snapshot (parent snapshot name with –*RW Snapshot* appended).

4. This RW child snapshot is the result of an **Actions→Clone Database** operation.

5. The RW snapshot has been mounted on the backup server with the given IP address/fully qualified domain name.

6. RMC-O supports additional actions that can be taken on the parent snapshot and the child snapshot. Each snapshot has its own **Action** drop-down menu.

Each snapshot entry in the **Snapshots** panel of the **Database→Protection View** supports an **Action** drop-down menu. Table 2 describes the parent, RO snapshot **Action** items.

Table 2. RO (parent) snapshot **Action** drop-down menu items

Parent snapshot Action drop-down menu	Description of action	Used for	Key benefit
Edit	Change the snapshot name, description, snapshot expiration, and retention time.	Modifying snapshot	Retention time cannot be removed or reduced once set. The volume cannot be removed until the retention time expires.
Verify	Creates a cloned database and automatically recovers the same, checking each datafile for corrupted blocks. Reports back through task details in Activity log. RMC-O unwinds clone and mount.	Copy data management	Validates that the snapshot can create a recoverable database. Retains RO snapshot with status **Available**.
Mount	A subset of Verify, only mounting the snapshots on the backup server. Provides flexibility as to mount points and controlfile options.	Copy data management	Creates an RW snapshot. Provides for manually creating and recovering a cloned database.
Remove	Removes a snapshot from the HPE 3PAR virtual volumes.	Snap shot maintenance	The recovery point provided by this snapshot is no longer needed.
Protect	Immediately launch an Express Protect operation using a specified Protection Policy	Backup	Backup this snapshot to an HPE StoreOnce Catalyst store.
Catalyst Copy	Immediately launch an Express Protect – Catalyst Copy operation using a specified protection policy	Backup	Creates an Express Protect and then a Catalyst Copy for additional protection.
Restore	Database will be rolled back using the selected snapshot. RMC-O specifies the /tmp file path where the metadata will be placed.	Restore	Rollback the datafiles, archive logs, or both.

Snapshots – behind the scenes

One of the key features of RMC-O is the ability to create snapshots of the production database while it is online. If the **Online (Hot) Backup** method is selected for an RMC-O snapshot protection job, RMC-O prompts the Oracle production server (via the RMC-O client) to put the tablespaces in backup mode. When the database is ready, the RMC VM then communicates with the HPE 3PAR array to create the HPE 3PAR Virtual Copy snapshots of the appropriate HPE 3PAR virtual volumes. When the snapshots are complete, RMC-O then prompts Oracle to take the tablespaces out of backup mode and the protection job is complete. Snapshot creation is a very quick process. Figure 10 shows a graph of the Swingbench Stress Test executed against the SOE1 schema of the lab database (see Table 1). The graph shows the transactions-per-second workload generated by 150 users. The gap in the graph illustrates the minimal impact to users while the database was placed in backup mode to allow for the creation of the snapshot. The **Create Snapshot Sets** details reported under the **General→Activity** screen reported that the total time to create the snapshot of the datafile volume and the archive redo log volumes was four seconds.
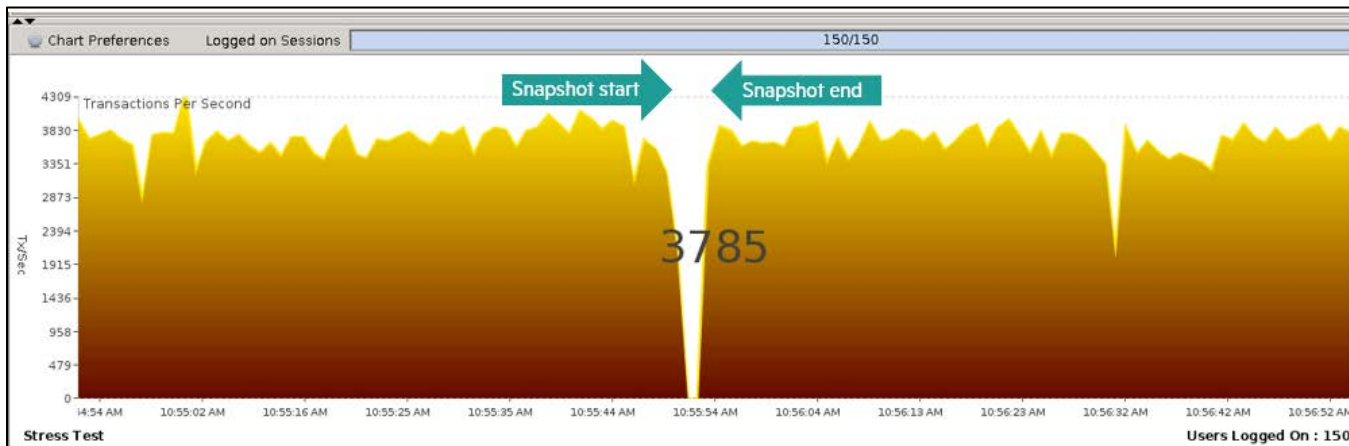

Figure 10. Minimal impact to user transactions with RMC-O online backup snapshot method

Copy Data Management

A range of IT functions depend on copies of data beyond data protection. Copy data management refers to the simple and efficient creation and management of these copies, and doing something useful with them.

This section discusses the features of RMC-O that enable DBAs to make copies of the production database quickly and efficiently. Through the one-click **Clone Database** action, RMC-O automatically brings up a fully functional single-instance database clone. This provides a copy of the production database to be used for: development and testing of code, report generation, database migration, or preparing standby servers for disaster recovery. RMC-O also provides for starting the database clone in **MOUNTED** mode for backup and restore operations using Oracle's RMAN utility or for support of media backups with RMAN and ISVs, such as Micro Focus Data Protector™ and Veritas NetBackup. Moving these operations off of the production server reduces risk and improves performance of the production environment.

RMC-O CDM operations are directed from the **ORACLE→Databases→Protection View** screen, specifically from the **Snapshots** panel and specifically from an RW snapshot. There are three conditions in which RMC-O creates an RW child of a parent snapshot.

1. Restoring from an Express Protect (Express Restore) by selecting the **Restore Express Protect to another Snapshot** option from **Protects→Action→Restore** (see Restore from a Protect)

2. Mounting an RO snapshot onto a backup server using **Snapshots→Action→Mount**

3. Using the one-click action **Actions→Clone Database** from the **ORACLE→Databases→Protection View** screen (see RMC-O one-click actions)

The detailed display for each RW snapshot lists a **Status** column and an **Action** drop-down menu. The **Status** entry for a given RW snapshot varies, depending upon how the RW snapshot was created, and this in turn affects the options available from the **Action** drop-down menu. Table 3 summarizes these differences.

Table 3. RW (child) snapshot **Action** drop-down menus

RW snapshot Status	How generated	Options from associated Action drop-down menu
Available	Result of Express Restore	Mount, Remove, Restore
Mounted	Result of **Action→Mount** on an RW snapshot in **Available** status	Mount, Unmount, Remount, Remove, Remove Cloned Database, Restore, Clone
Cloned	Result of one-click **Actions→Clone Database** or the result of **Action→Cone** on an RW snapshot in **Mounted** status.	Remount, Restore, Remove Cloned Database

Note

When creating and managing snapshots, RMC-O communicates with the HPE 3PAR array via an Ethernet connection. An FC SAN connection between RMC-O and the HPE 3PAR array is not needed for snapshot management.

Mounting an RW snapshot

Mounting an RW snapshot on a backup server allows the DBA to have access to a copy of the production database datafiles, archive logs, and metadata files such as the control file and `PFILE`. Using the RMAN utility, the DBA manually completes the desired restore and recover operations; for example, changing database parameters or specifying new locations for the Oracle datafiles, redo logs, or archived redo logs.

The RW snapshot must be in the **Available** status to be mounted (**Action→Mount**). After it is mounted, the entry under the **Server** heading identifies the name of the backup server where this RW snapshot is mounted. Selecting **Action→Unmount** for an RW snapshot with **Mount** status provides an option to retain the RW snapshot.

Figure 11 shows the **Mount Snapshot** dialog displayed when **Action**→**Mount** is selected for an RW snapshot in **Available** status. Click **Select** to choose the desired **Backup Server**.

Figure 11. Mounting an RW snapshot on a backup server

Tip
The same parent RO snapshot can be mounted on multiple backup servers, creating multiple RW snapshots.

RMC-O places the metadata files needed for recovering the database in the following path on the backup server: `/opt/hpe/rmc/oracle/data/<hostname>.ora.<sid>/<snapshot_id>`.[9]

The **Mount Point** selection specifies the file system mount point for mounting the datafile and archive log volumes on the backup server. If the mount point is specified as "`/`" (without the quotes), the mount point matches that of the production server. For example, in the case of the solution lab database, the mount points for the RW snapshot are `/u02` and `/u04` for the datafiles and archived redo logs, respectively (see Table 1). In this case, the binary controlfile can be used for recovery because the structure of the database has not changed. And because the snapshot does not copy the controlfile and redo logs, the directory structure for these files must be previously created on the backup server. In the solutions lab database where file systems were used for storage, if the **Mount Point** is left blank (the default), RMC-O makes the following paths available:

- `/opt/hpe/rmc/oracle/data/<hostname>.ora.<sid>/<snapshot_id>/u02`
- `/opt/hpe/rmc/oracle/data/<hostname>.ora.<sid>/<snapshot_id>/u04`

In this case, using the ASCII control file provides the flexibility to change the locations of the datafiles and archive logs, and optionally, the database instance name.

---

[9] `/opt/hpe/rmc/oracle` is the RMC-O client installation path (see RMC-O client installation)

See the HPE Recovery Manager Central 5.0 for Oracle User Guide for details on the RMAN and SQL*PLUS commands to complete the recovery process.

Cloning the database

With one-click, a DBA can have RMC-O automatically create a snapshot of the database, mount the snapshot on a designated secondary server, and automatically recover the clone database. The clone database can now be used for test and development, database upgrades, report generation, or RMAN or ISV media backups. To create a clone instance that can be recovered, the snapshot **Backup Type** used for cloning must be either an online or offline snapshot (see Creating HPE 3PAR Oracle-consistent storage snapshots).

Figure 12 shows the **Clone Database** dialog screen. The **General** panel is used to select one of the backup servers that has been registered with RMC-O. In Figure 12, the **Customize** box is checked, which expands the options available for creating the clone.

Figure 12. One-click "Clone Database" dialog

Figure 13 shows a display of the DBID from the production server (using SQL*Plus command) and from the clone of the database on the secondary server (using RMAN command), confirming that the clone is a valid copy of the production database.

```
[oracle@production ~]sqlplus / as sysdba
SQL*Plus: Release 12.1.0.2.0 Production on Tue Jun 12 12:01:45 2018
Copyright (c) 1982, 2014, Oracle.  All rights reserved.
Connected to:
Oracle Database 12c Enterprise Edition Release 12.1.0.2.0 - 64bit Production
With the Partitioning, OLAP, Advanced Analytics and Real Application Testing options

SQL> select DBID from v$database;
     DBID
----------
1500077495
SQL>
```

```
[oracle@backup ~]rman target /
Recovery Manager: Release 12.1.0.2.0 - Production on Tue Jun 12
11:02:22 2018
Copyright (c) 1982, 2014, Oracle and/or its affiliates.  All rights
reserved.

connected to target database: ORCL (DBID=1500077495)

RMAN>
```

Figure 13. Comparing DBID on the production and clone databases

Protecting the production database—backups

RMC-O operations are directed from the **ORACLE→Databases→Protection View** screen. The **Protection View** screen displays a **Snapshots** panel and a **Protects** panel. The **Actions** button in the upper right of the **Protection View** screen launches any of the RMC-O one-click operations.

Express Protects – behind the scenes

When configuring an Express Protect job (such as the one-click **Actions→Protect**) the options for **Backup Type** are **Full Backup** or **Auto**. For full backups, RMC-O writes each block from the HPE 3PAR snapshot to the HPE StoreOnce appliance. An **Auto** backup performs a full backup if no **Protect** exists, but otherwise performs a synthetic full backup. A key feature of RMC-O is the integration with HPE 3PAR SnapDiff changed-block detection functionality. This allows RMC-O to send only unique blocks to the HPE StoreOnce Catalyst store, where RMC-O creates a synthetic full backup. This provides the benefits of a full backup with the network bandwidth use of an incremental backup.

Tip

As a best practice, always select **Backup Type Auto** when configuring Express Protect jobs with RMC-O.

Scheduling Express Protects

An Express Protect operation first creates an RO snapshot before initiating the backup to HPE StoreOnce. When creating an Express Protect protection policy, both a backup lifecycle retention policy and a snapshot retention policy can be specified. Keep in mind that to restore a backup using Express Restore (**Restore Express Protect to another Snapshot**) there must be at least one snapshot associated with a valid Express Protect (see Restore from a Protect). HPE recommends maintaining a separate retention schedule for Express Protect-associated snapshots so they are not deleted as part of a general snapshot-only retention schedule (see Creating HPE 3PAR Oracle-consistent storage snapshots).

Important

When creating an Express Protect, HPE recommends that you leave the **Retain Snapshot after Protect** box checked (this is the default). This helps ensure that a snapshot will be available for Express Restore operations.

Backup from an RO snapshot

There are four ways to create an Express Protect backup of an Oracle database. Two of those four methods creates a Catalyst Copy, but as this automatically creates an Express Protect backup as part of the complete operation, they have been included in the list.

All four methods begin with an RO snapshot. Two methods use one-click actions, which first creates an RO snapshot before proceeding with the selected action. Two methods use an existing RO snapshot (which might be the result of a one-click **Actions→Create Snapshot**).

All four methods are initiated from the **ORACLE→Databases→Protection View** screen.

1. One-click **Actions**

    a. Click **Actions→Protect**

    b. Click **Actions→Catalyst Copy**

2. From the **Snapshots** panel, select an existing RO snapshot, and then:

    a. Click **Action→Protect**

    b. Click **Action→Catalyst Copy**

Figure 14 shows the **Create Protect** dialog resulting when **Action→Protect** has been selected from the **Action** drop-down menu associated with an existing RO snapshot.
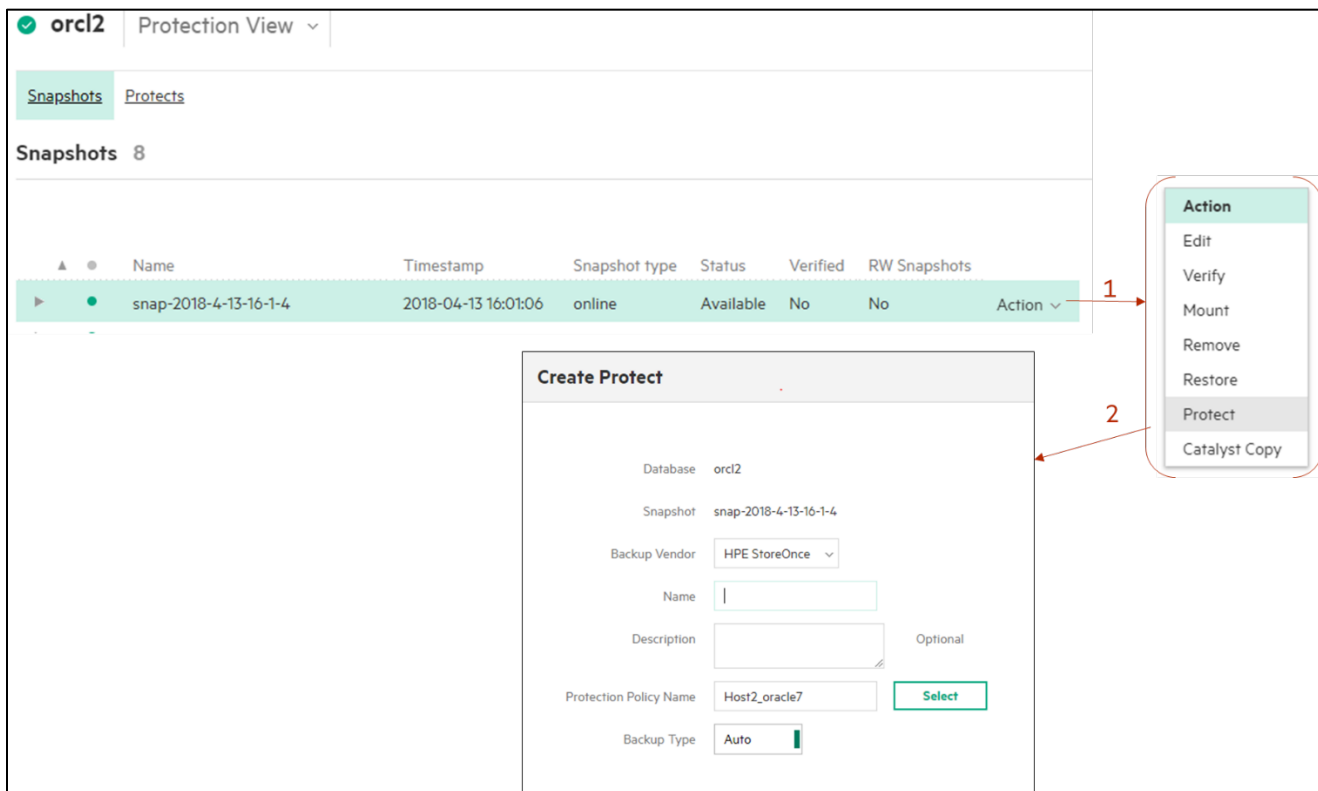

Figure 14. Initiating an Express Protect backup from an RO snapshot

Note

For an Express Protect backup, the **Backup Vendor** must be specified as **HPE StoreOnce**. Also, an Express Protect backup requires a Protection Policy Name. Click **Select** by the **Protection Policy Name** field to view all existing protection policies.

Note

A Protection Policy that includes both Express Protect and Catalyst Copy can be used for **Actions→Protect** as well as **Actions→Catalyst Copy**. If used with **Actions→Protect**, the job completes when the Express Protect backup has finished, and does not start a Catalyst Copy job.

Important

RMC-O supports HPE Cloud Bank Storage, a feature of HPE StoreOnce systems. When creating a protection policy, an existing Cloud Bank store may be selected as the **Catalyst Copy Target**. The **Add Store** operation of the **Create Protection Policy** dialog does not support adding a Cloud Bank store; this must be done prior through the HPE StoreOnce management console.[10]

Protecting the production database—restore

As with backup operations, RMC-O restore and recovery operations are directed from the **ORACLE→Databases→Protection View** screen. Restore operations are available from the **Action** drop-down menu present on RO parent snapshots, RW child snapshots (both listed in the **Snapshots** panel), and Express Protects (listed in the **Protects** panel).

---

[10] For more information about HPE Cloud Bank Storage, see Resources and additional links

Restore from an RO or RW snapshot

Restoring from an RMC-O RO or RW snapshot is a rollback of the HPE 3PAR virtual volumes to the selected point in time. For a file system database, to prepare for the rollback restore, the Oracle database must be shut down and the mounted file systems that house the database and archive redo logs must be unmounted. For ASM-managed storage, RMC-O automates the pre- and post-steps of the restore/rollback operations. Figure 15 shows the **Restore Snapshot** dialog that appears when **Action→Restore** is selected for the RO snapshot named *"One click snap - Baseline protect."*

Restore Snapshot One click snap - Baseline protect   ?

The database 'orcl' would be rollbacked with snapshot 'One click snap - Baseline protect' which was created at '2018-05-04 12:13:50'

General

Snapshot Name   One click snap - Baseline protect

Creation Time   2018-05-04 12:13:50

Meta Data File Path   /tmp/e49891df-8fe6-4a8c-8a20-83ef486541ad

Restore Type   ○ Data   ○ Archive Logs   ● Both

Yes, Restore   **Cancel**

Figure 15. Initiating a restore or rollback of an RO snapshot

The **Restore Snapshot** dialog provides the date and time of the snapshot so DBAs can confirm the point in time that applies to the rollback. The dialog also specifies the file path to the metadata, which will be needed to complete the Oracle database recovery. This path can be changed if desired. See the HPE Recovery Manager Central 5.0 for Oracle User Guide for details on performing a post-restore operation, including the commands needed to recover the database.

Tip

As a best practice, always make a note of the **Meta Data File Path** specification.

A rollback from an RW snapshot is an identical process. First, select the expansion arrow (▶) next to an RO snapshot to list any RW child snapshots whose timestamp represents the desired restore point in time. Restoring from an RW snapshot is most valuable if the RW snapshot has **Cloned** status. Rolling back from an RW snapshot whose status is **Available** is the same as restoring from an RO snapshot. Click **Action→Restore** to open the same **Restore Snapshot** dialog, as seen in Figure 15.

Restore from a Protect

Restoring from an Express Protect job is very similar to a restore from a snapshot, but provides important, additional options. Restore from an Express Protect allows data to be restored either to the parent volumes or to alternate volumes. In addition, the data can be restored to a different Oracle application server, meaning that Express Protect can be used to migrate a database to a new server or HPE 3PAR array.

Restoring from an Express Protect begins with reviewing the list of backups in the **Protects** panel of the **ORACLE→Databases→Protection View** screen. Choose a Protect whose timestamp represents the desired restore point in time. Click **Action→Restore** to open the **Restore** dialog, as shown in Figure 16.
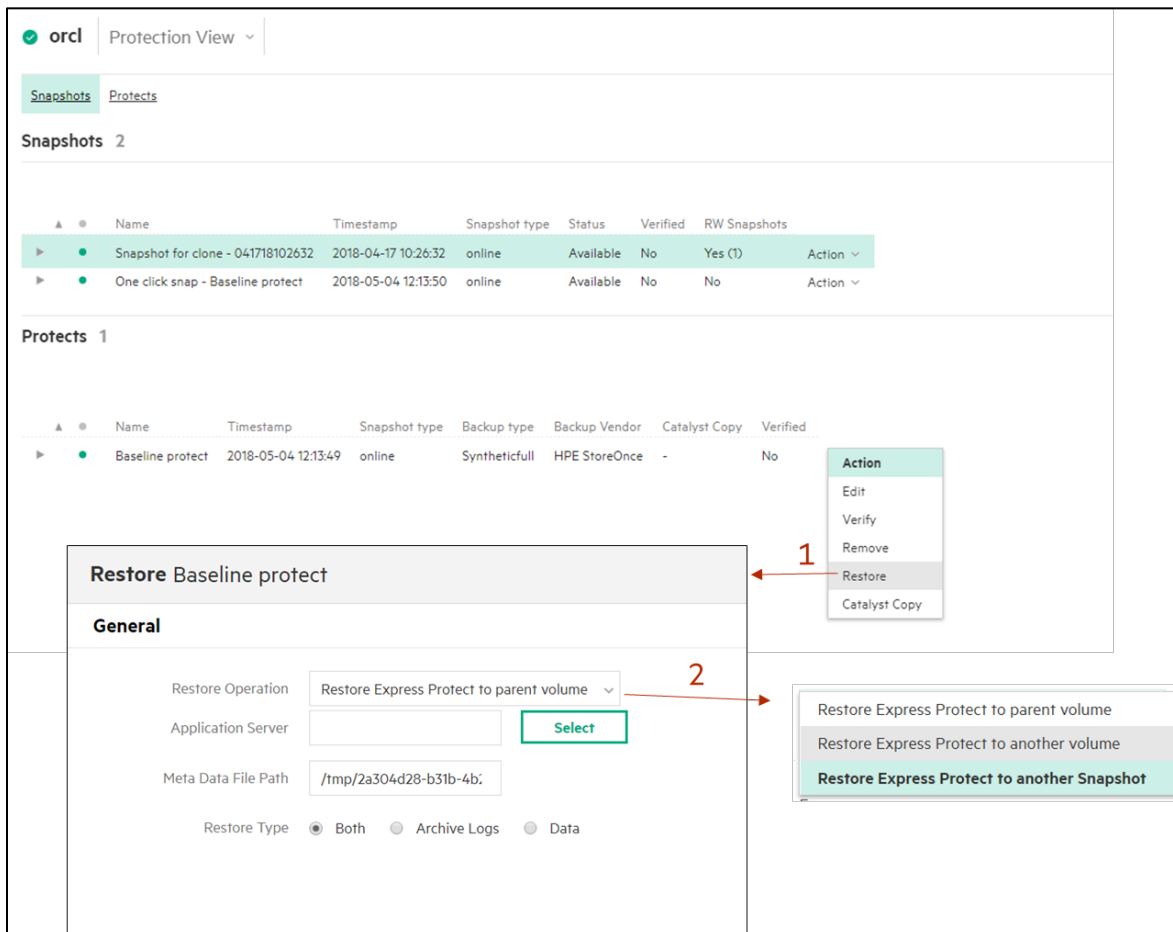

Figure 16. Initiating a restore from an Express Protect

The first field in the dialog is labeled **Restore Operation**. The following three options are available in this drop-down menu:

- **Restore Express Protect to parent volume** – This action reads each block from the Catalyst store and writes every block back to the original volumes on the source HPE 3PAR array.

- **Restore Express Protect to another volume** – This action is similar to the above, but with the option to choose either the primary HPE 3PAR array or an alternate storage system. This requires selecting a new virtual volume as a resource for the datafiles and a new virtual volume as a resource for the archive redo logs. The number of target volumes must match the number of source volumes. The size of the target volumes must be equal to or greater than the size of the source volumes.

- **Restore Express Protect to another Snapshot** – This action, known as an *Express Restore*, uses a selected Protect representing the desired recovery point along with a reference snapshot to create an RW snapshot. The snapshot can then be used to restore the parent volume or as part of a CDM operation. Unlike restoring to a volume, **Express Restore** compares the contents of the Catalyst store (the selected backup) with the reference snapshot and copies only the changed blocks to the new RW snapshot. This action creates an RW child snapshot whose status is **Available**.

With the **Restore Express Protect to another Snapshot** option, a **Reference Snapshot Set** must be chosen. A reference snapshot is a snapshot that is associated with a valid Express Protect. There must be at least one snapshot associated with a Protect in order to use Express Restore.

The default selection setting is **Auto**, allowing RMC-O to choose the most recent snapshot set. Click **Auto** to change the selection to **Manual**. If **Manual** is chosen, click **Select** to open the **Select Reference Snapshot Set** dialog. This lists the available snapshot sets and provides the following information to aid in selecting the appropriate snapshot set:

- Name and Description

- Create At time

- Archive log Restore Delta

- Datafile Restore Delta

Note

The reference snapshot must be associated with an Express Protect that is different from the Protect chosen as the recovery point. If none is available, then Express Protect cannot be used for restore and another restore method will need to be specified.[11]

When choosing a reference snapshot, the reported restore delta indicates the time difference between the create time for the selected Protect and the reference snapshot. The time delta can either be ahead or behind. The time delta does not necessarily indicate the amount of changed blocks to be processed; however, small deltas will generally involve fewer changed blocks.

Consider the following example. Suppose three Express Protects were executed at the following times: 09:45, 13:45 and 17:45. In all three cases, the associated snapshots were retained. Further assume that these are the only Protects associated with the given database. The following are some possible Express Restore scenarios:

- An Express Restore request initiated at 11:00, choosing the 09:45 Protect restore point, will fail because no valid reference snapshot exists.

- An Express Restore request initiated at 15:00, choosing the 09:45 Protect restore point, will have the snapshot created at 13:45 available to use as the reference set. The restore delta will be +4 hours.

- An Express Protect initiated at 19:00, choosing the 13:45 Protect restore point, will have the following reference snapshots to choose from:

  - Snapshot created at 09:45; restore delta −4 hours

  - Snapshot created at 17:45; restore delta +4 hours

---

[11] Separate retention schedules must be kept to avoid snapshots associated with a Protect from being removed as part of a general snapshot retention policy (see Creating HPE 3PAR Oracle-consistent storage snapshots).

A **Restore Express Protect to another Snapshot** operation creates an RW child snapshot under the reference snapshot selected for the **Express Restore.** Figure 17 shows a parent snapshot whose **RW Snapshots** heading is marked **Yes**.

Figure 17. An RW snapshot created from an Express Restore operation

To complete the recovery process, select an RW child snapshot whose **Restored from Protect** heading is marked **Yes** and whose **Status** is **Available**, as shown in Figure 17. Click the **Action** drop-down menu on the RW snapshot and select **Restore**. This displays the **Restore Snapshot** dialog, as shown in Figure 15, to initiate the rollback of the database to the specified point in time.

To view the progress of the **Express Restore**, select **GENERAL→Activity** and review the status of the Restore RW Snapshot **Action**. When all tasks have successfully completed, log in to the Oracle application server as user `Oracle.` Follow these post-restore tasks:

1. Check to confirm that the Oracle datafile and archived redo log volumes have been mounted on the server.

2. Because the form of the database has not changed, there is no need to restore the `CONTROLFILE` from the metadata file path, which was specified in the RMC-O **Restore Snapshot** dialog (see Figure 15).

3. Connect to SQL*Plus and run the following commands:

```
SQL> startup mount
SQL> recover database using backup controlfile until cancel;
SQL> alter database open resetlogs;
```

Figure 18 shows the recovery of the solution lab database following an **Express Restore**.

```
[oracle@production ~]sqlplus / as sysdba
SQL*Plus: Release 12.1.0.2.0 Production on Thu Jun 14 06:42:27 2018
Copyright (c) 1982, 2014, Oracle.  All rights reserved.

Connected to an idle instance.

SQL> startup mount
ORACLE instance started.

Total System Global Area 3741319168 bytes
Fixed Size                   2931040 bytes
Variable Size              855639712 bytes
Database Buffers          2868903936 bytes
Redo Buffers                13844480 bytes
Database mounted.
SQL> recover database using backup controlfile until cancel;
ORA-00279: change 7686207 generated at 06/13/2018 17:36:48 needed for thread 1
ORA-00289: suggestion : /u04/archive/1_167_972464461.dbf
ORA-00280: change 7686207 for thread 1 is in sequence #167

Specify log: {<RET>=suggested | filename | AUTO | CANCEL}

ORA-00279: change 7686223 generated at 06/13/2018 17:36:57 needed for thread 1
ORA-00289: suggestion : /u04/archive/1_168_972464461.dbf
ORA-00280: change 7686223 for thread 1 is in sequence #168
ORA-00278: log file '/u04/archive/1_167_972464461.dbf' no longer needed for this recovery

Specify log: {<RET>=suggested | filename | AUTO | CANCEL}
cancel
Media recovery cancelled.
SQL> alter database open resetlogs;
Database altered.

SQL> select instance_name, status, database_status, active_state, instance_role, instance_mode from v$instance;

INSTANCE_NAME    STATUS        DATABASE_STATUS   ACTIVE_ST INSTANCE_ROLE       INS
---------------- ------------- ----------------- --------- ------------------- ---
orcl             OPEN          ACTIVE            NORMAL    PRIMARY_INSTANCE    REG
```

Figure 18. Completed database recovery from Express Restore

Recommendation

HPE recommends **Restore Express protect to another Snapshot** as the preferred method to restore from Express Protect. The **Express Restore** option is faster and more flexible. The RW child snapshot created by this operation cannot only be used for rolling back the production database, but can also be used for CDM operations (see Copy Data Management).

Comparing RMC-O Express Protect backup and restore with RMAN utility

To highlight the speed and efficiency of RMC-O, a comparison was made between backup and restore operations using RMC-O versus the traditional approach of using Oracle's RMAN utility.

Backup

RMC-O Express Protect backups were directed to a Catalyst store on the HPE StoreOnce appliance in the solution lab. RMAN backups were directed to an NFS share, which was hosted from a RAID 0 set using internal drives on the solution lab's Oracle backup server. The NFS share was presented on the 10 Gb network. Table 4 shows the results of performing an online backup of the solution lab's Oracle database (see Solution database details) using these two methods.

Table 4. Solution lab database backup – RMC-O vs. RMAN

Backup method	Description of action	Number of streams / channels	Elapsed time	Resulting size on disk	Notes on follow-on incremental backups
RMC-O	One-click **Actions→Protect**	8	1h 44m	431 GB	1. Automatic scheduling (set with Protection Policy) 2. Policy **Backup Type Auto** chooses incremental 3. Synthetic full created at HPE StoreOnce
RMAN	1. Issued RMAN command to set compression algorithm to High 2. Created RMAN script to allocate channels and issue the backup commands (multisection tablespaces, database and control file)	8	2h 31m	187 GB	1. Requires new scripts 2. Set up and maintain schedule 3. Several backup sets needed to restore

The backups presented in Table 4 are the initial (or seed) backups. RMC-O and RMAN dedupe/compress differently, so, in this case, they produce different results for the backup size on disk. As discussed in the Considerations for subsequent backups section, RMC-O quickly shows improvement in size on disk over RMAN for further backups, because RMAN does not deduplicate against existing data on the backup target.

Launching the RMC-O Express Protect is a one-click operation. The parameters of the Protect were set in the Protection Policy associated with the database—a one-time definition. Figure 19 highlights the details of the RMC Express Protect operation directed to the HPE StoreOnce Catalyst store *jh_oracle7*. The **Stores** section shows 1.4 TB of user data was processed, resulting in 430.7 GB actually stored on disk. The **Data Jobs** section shows eight streams (Catalyst items) for processing the datafiles (1 TB) and eight streams for processing the archived redo logs (250 GB). In addition, there are three Catalyst items related to this Express Protect: two items hold HPE 3PAR array and volume metadata for each snapshot-set (datafile and archive logs), and the third contains the Oracle `SPFILE`, `CONTROLFILE`, and `ORAPWD` files along with additional database configuration information.

Stores
Name ▲	Version	Status	Created	Number of Catalyst I...	User Data Stored	Size On Disk	Size In Cloud	Dedupe Ratio	Service Set	Cloud Bank Storage
jh_oracle7	2	✅ Online	15:55 2018/04/13	21	1.4 TB	430.7 GB	0 B	3.1	2	☐

jh_oracle7

Catalyst Store Details | Permissions | Catalyst Item Summary | Data Jobs | Outbound Copy Jobs | Inbound Copy Jobs

Data Jobs

+ Click to show/hide filter options
Current Filter : [Sort : Descending]
ℹ Please click on an Catalyst Item in the table below to display additional details

<< Prev   Next >>   Items Per Page: 50 ▼

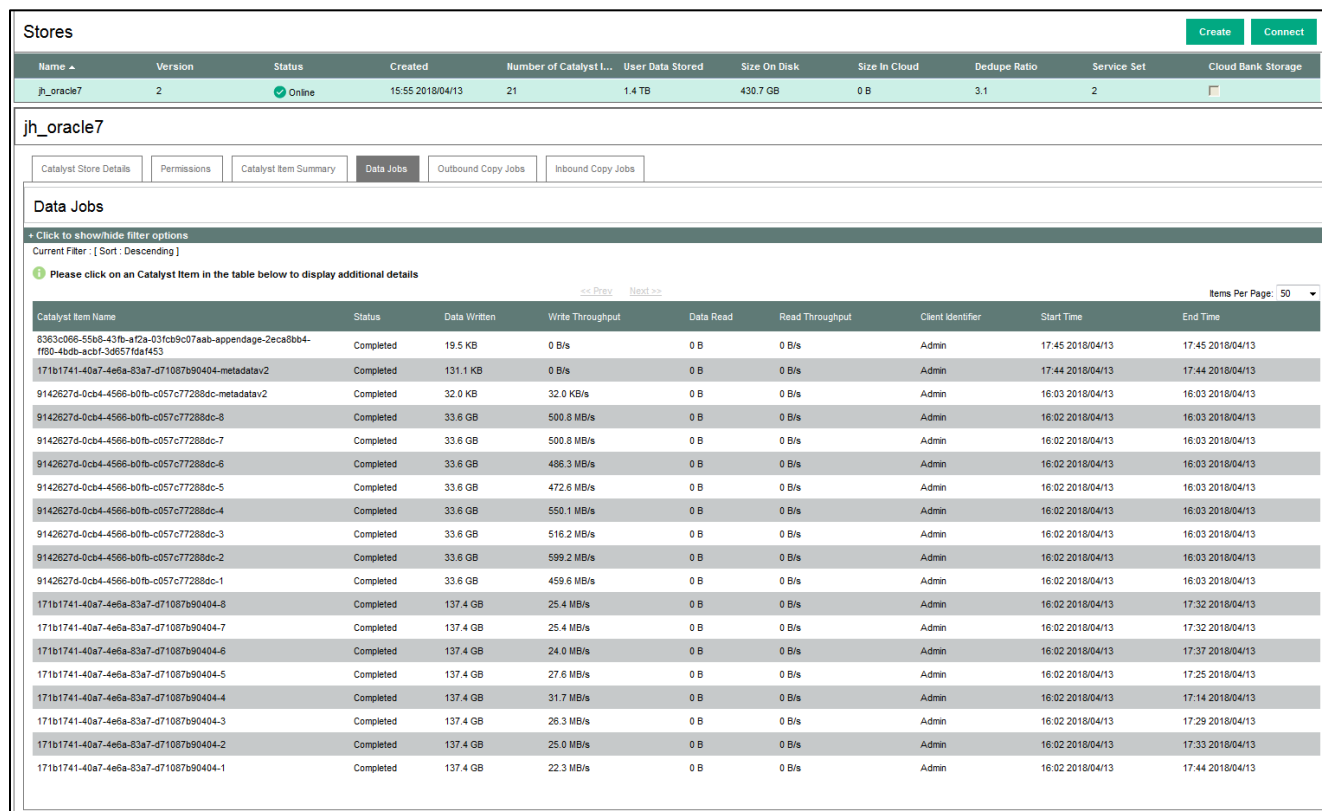| Catalyst Item Name	Status	Data Written	Write Throughput	Data Read	Read Throughput	Client Identifier	Start Time	End Time
8363c066-55b8-43fb-af2a-03fcb9c07aab-appendage-2eca8bb4-ff80-4bdb-acbf-3d657fdaf453	Completed	19.5 KB	0 B/s	0 B	0 B/s	Admin	17:45 2018/04/13	17:45 2018/04/13
171b1741-40a7-4e6a-83a7-d71087b90404-metadatav2	Completed	131.1 KB	0 B/s	0 B	0 B/s	Admin	17:44 2018/04/13	17:44 2018/04/13
9142627d-0cb4-4566-b0fb-c057c77288dc-metadatav2	Completed	32.0 KB	32.0 KB/s	0 B	0 B/s	Admin	16:03 2018/04/13	16:03 2018/04/13
9142627d-0cb4-4566-b0fb-c057c77288dc-8	Completed	33.6 GB	500.8 MB/s	0 B	0 B/s	Admin	16:02 2018/04/13	16:03 2018/04/13
9142627d-0cb4-4566-b0fb-c057c77288dc-7	Completed	33.6 GB	500.8 MB/s	0 B	0 B/s	Admin	16:02 2018/04/13	16:03 2018/04/13
9142627d-0cb4-4566-b0fb-c057c77288dc-6	Completed	33.6 GB	486.3 MB/s	0 B	0 B/s	Admin	16:02 2018/04/13	16:03 2018/04/13
9142627d-0cb4-4566-b0fb-c057c77288dc-5	Completed	33.6 GB	472.6 MB/s	0 B	0 B/s	Admin	16:02 2018/04/13	16:03 2018/04/13
9142627d-0cb4-4566-b0fb-c057c77288dc-4	Completed	33.6 GB	550.1 MB/s	0 B	0 B/s	Admin	16:02 2018/04/13	16:03 2018/04/13
9142627d-0cb4-4566-b0fb-c057c77288dc-3	Completed	33.6 GB	516.2 MB/s	0 B	0 B/s	Admin	16:02 2018/04/13	16:03 2018/04/13
9142627d-0cb4-4566-b0fb-c057c77288dc-2	Completed	33.6 GB	599.2 MB/s	0 B	0 B/s	Admin	16:02 2018/04/13	16:03 2018/04/13
9142627d-0cb4-4566-b0fb-c057c77288dc-1	Completed	33.6 GB	459.6 MB/s	0 B	0 B/s	Admin	16:02 2018/04/13	16:03 2018/04/13
171b1741-40a7-4e6a-83a7-d71087b90404-8	Completed	137.4 GB	25.4 MB/s	0 B	0 B/s	Admin	16:02 2018/04/13	17:32 2018/04/13
171b1741-40a7-4e6a-83a7-d71087b90404-7	Completed	137.4 GB	25.4 MB/s	0 B	0 B/s	Admin	16:02 2018/04/13	17:32 2018/04/13
171b1741-40a7-4e6a-83a7-d71087b90404-6	Completed	137.4 GB	24.0 MB/s	0 B	0 B/s	Admin	16:02 2018/04/13	17:37 2018/04/13
171b1741-40a7-4e6a-83a7-d71087b90404-5	Completed	137.4 GB	27.6 MB/s	0 B	0 B/s	Admin	16:02 2018/04/13	17:25 2018/04/13
171b1741-40a7-4e6a-83a7-d71087b90404-4	Completed	137.4 GB	31.7 MB/s	0 B	0 B/s	Admin	16:02 2018/04/13	17:14 2018/04/13
171b1741-40a7-4e6a-83a7-d71087b90404-3	Completed	137.4 GB	26.3 MB/s	0 B	0 B/s	Admin	16:02 2018/04/13	17:29 2018/04/13
171b1741-40a7-4e6a-83a7-d71087b90404-2	Completed	137.4 GB	25.0 MB/s	0 B	0 B/s	Admin	16:02 2018/04/13	17:33 2018/04/13
171b1741-40a7-4e6a-83a7-d71087b90404-1	Completed	137.4 GB	22.3 MB/s	0 B	0 B/s	Admin	16:02 2018/04/13	17:44 2018/04/13

Figure 19. HPE StoreOnce Catalyst items supporting RMC-O Express Protect

The RMAN online backup required writing a SQL script to allocate the channels, perform the backup of the database and archive logs, and perform the backup of the current control file. Special consideration was given to backing up the two bigfile tablespaces in the solution lab database. In order to spread the load of backing up the SOE and SOE2 tablespaces across different channels, a multisection backup was used. Without doing this, two channels would have been entirely consumed—one for each tablespace—just to back up the `soe.dbf` and `soe2.dbf` datafiles. Therefore, the total time to back up the database would have been paced solely by the performance of these two channels.

Using a multisection backup means that these two tablespaces must be backed up independently from the database backup, which also means that they must be excluded from the database backup. Sixteen channels were allocated for the backup. Specifying both tablespaces in a single multisection RMAN backup command (`backup as compressed backupset section size 60g tablespace SOE, SOE2;`) resulted in fifteen channels being used to backup these two tablespaces. Figure 20 shows the portion of the output from the RMAN `list backup` executed after the complete database backup finished.

```
BS Key   Type LV Size        Device Type Elapsed Time Completion Time
-------  ---- -- ----------  ----------- ------------ ---------------
266      Full    91.11G      DISK        01:31:26     16-MAY-18
  List of Datafiles in backup set 266
  File LV Type Ckp SCN    Ckp Time   Name
  ---- -- ---- ---------- ---------- ----
  10      Full 10535091   16-MAY-18 /u02/oradata/orcl2/soe.dbf

  Backup Set Copy #1 of backup set 266
  Device Type Elapsed Time Completion Time Compressed Tag
  ----------- ------------ --------------- ---------- ---
  DISK        01:31:26     16-MAY-18       YES        TAG20180516T132210

    List of Backup Pieces for backup set 266 Copy #1
    BP Key  Pc# Status      Piece Name
    ------- --- ----------- ----------
    336     1   AVAILABLE   /mnt/rman/host2/high/orcl2_c1_bft31o42_1_1
    344     2   AVAILABLE   /mnt/rman/host2/high/orcl2_c3_bft31o42_2_1
    340     3   AVAILABLE   /mnt/rman/host2/high/orcl2_c4_bft31o42_3_1
    346     4   AVAILABLE   /mnt/rman/host2/high/orcl2_c5_bft31o42_4_1
    345     5   AVAILABLE   /mnt/rman/host2/high/orcl2_c6_bft31o42_5_1
    343     6   AVAILABLE   /mnt/rman/host2/high/orcl2_c7_bft31o42_6_1
    339     7   AVAILABLE   /mnt/rman/host2/high/orcl2_c8_bft31o42_7_1
    333     8   AVAILABLE   /mnt/rman/host2/high/orcl2_c9_bft31o42_8_1

BS Key   Type LV Size        Device Type Elapsed Time Completion Time
-------  ---- -- ----------  ----------- ------------ ---------------
267      Full    84.27G      DISK        01:31:59     16-MAY-18
  List of Datafiles in backup set 267
  File LV Type Ckp SCN    Ckp Time   Name
  ---- -- ---- ---------- ---------- ----
  11      Full 10535092   16-MAY-18 /u02/oradata/orcl2/soe2.dbf

  Backup Set Copy #1 of backup set 267
  Device Type Elapsed Time Completion Time Compressed Tag
  ----------- ------------ --------------- ---------- ---
  DISK        01:31:59     16-MAY-18       YES        TAG20180516T132210

    List of Backup Pieces for backup set 267 Copy #1
    BP Key  Pc# Status      Piece Name
    ------- --- ----------- ----------
    335     1   AVAILABLE   /mnt/rman/host2/high/orcl2_c2_bgt31o42_1_1
    347     2   AVAILABLE   /mnt/rman/host2/high/orcl2_c10_bgt31o42_2_1
    342     3   AVAILABLE   /mnt/rman/host2/high/orcl2_c11_bgt31o42_3_1
    341     4   AVAILABLE   /mnt/rman/host2/high/orcl2_c12_bgt31o42_4_1
    337     5   AVAILABLE   /mnt/rman/host2/high/orcl2_c13_bgt31o42_5_1
    338     6   AVAILABLE   /mnt/rman/host2/high/orcl2_c14_bgt31o42_6_1
    334     7   AVAILABLE   /mnt/rman/host2/high/orcl2_c15_bgt31o42_7_1
```

Figure 20. RMAN elapsed time to backup SOE1 and SOE2 tablespaces

Each backup set (listed by BS Key in Figure 20) finished in approximately 1 hour and 32 minutes. Each backup set contains multiple backup pieces (BP Key). The number of backup pieces in the backup set corresponds to the number of channels used to back up that given datafile.

The remaining 59 minutes of the total elapsed time of 2 hours and 31 minutes was needed to back up the remaining nine datafiles, the archive redo logs, and the control file.

RMC-O has an advantage when monitoring the backup operations. RMC-O will alert the DBA via email notification should something go wrong during the backup; this is set in the E-Mail Notification Policy (see Email notification). In contrast, analyzing RMAN errors and providing alerts to the DBA requires custom scripting based on reviewing the data provided with the `V$RMAN_BACKUP_JOB_DETAILS` database view.

Considerations for subsequent backups

RMC-O has additional advantages when performing subsequent backups to the same HPE StoreOnce Catalyst store. First, RMC-O automatically executes future backups based on the schedule specified when the Protection Policy was created. Second, with the Protection Policy **Backup Type** set to **Auto**, RMC-O automatically determines the type of backup required. RMC-O Express Protect copies only the changed data to the HPE StoreOnce appliance after the first backup; however, RMC-O interacts with the HPE StoreOnce appliance to create and maintain a synthetic full backup. The user data stored on the HPE StoreOnce appliance reflects the increasing capacity of the synthetic full backups; however, the size on disk only reflects the deduplicated data. Contrast this with RMAN where each subsequent full backup increases the amount of data needed to be stored on disk.[12]

Figure 21 shows the effective deduplication ratio of RMC-O backups increasing with each subsequent backup, while the size on disk remains relatively the same—reflecting only the deduplicated changed data. In comparison, Figure 21 shows that the RMAN compression remains constant for each backup while the size on disk grows linearly.
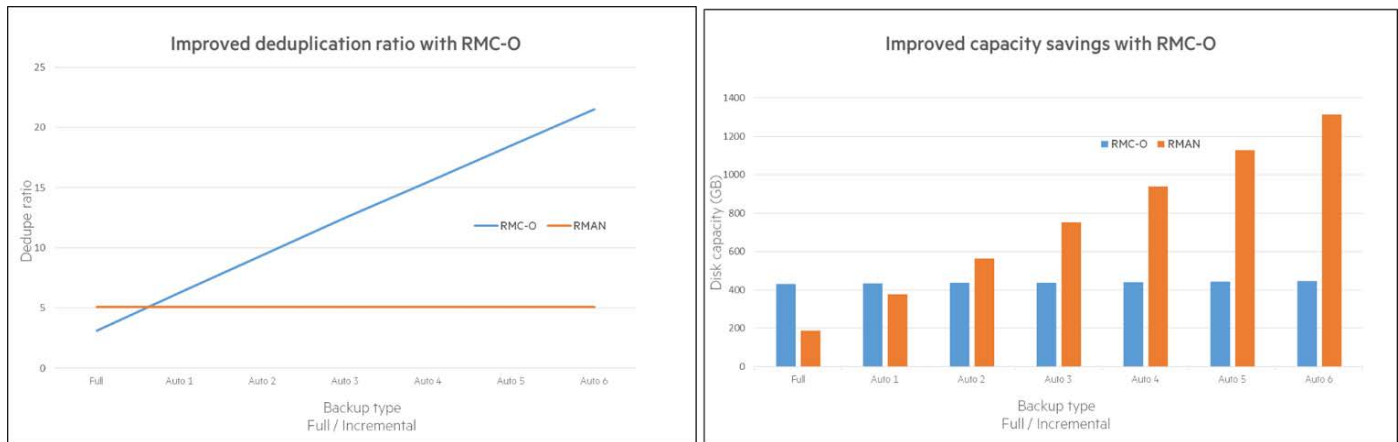
Figure 21. Comparing RMC-O and RMAN deduplication and size on disk for full and six incremental backups

---

[12] This is true for the solution lab database. Actual results will vary with each database and type of data stored.

RMC-O also has an advantage of being able to complete subsequent backups in a shorter period of time, because only the changed blocks are being sent to the HPE StoreOnce appliance. Figure 22 compares the elapsed times for the RMC-O backups versus RMAN backups.
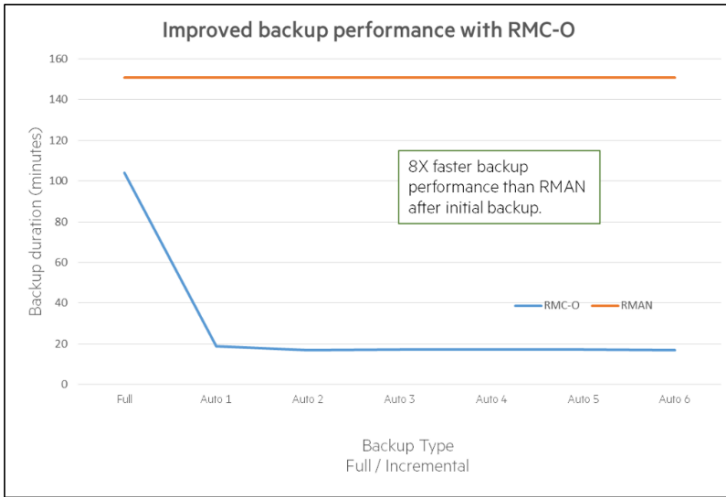

Figure 22. Comparing elapsed time for RMC-O Express Protect backups versus RMAN

Restore

The next task was to compare restore operations. Table 5 compares performing a restore of the recently completed full backups using RMC-O **Express Restore** versus using the RMAN utility.

Table 5. Solution lab database restore – RMC-O vs. RMAN

Restore method	Description of action	Elapsed time	Result	Steps to complete
RMC-O	1. Select the appropriate Express Protect, choose **Action→Restore** 2. Choose **Restore Express protect to another Snapshot** (Express Restore)	22m 17s	Only the unique blocks are read from HPE StoreOnce as RMC-O creates an RW child snapshot from the reference snapshot (see Figure 17).	1. Select the RW child snapshot and click **Action→Restore** (see Figure 15). This includes restoring the metadata. 2. Issue appropriate RMAN and SQL commands to recover database.
RMAN	1. Use RMAN commands to select the appropriate backup sets; confirm availability using RMAN command `restore database preview` 2. Create RMAN script with `set until SCN` or `set until time` to choose the correct backup sets, allocate channels, issue `restore database`	2h 51m	1. Reads backup sets from NFS share restoring datafiles and archived redo logs to their original location (/u02, /u04) 2. Must recover SPFILEs and control files.	Issue appropriate RMAN and SQL commands to recover database.

RMC-O Express Restore is extremely efficient—restoring only the blocks that have changed since the parent snapshot was created. Alternatively, RMAN must process each backup set and completely restore each file to its original location.

The RMC-O GUI makes it very easy for a DBA to select the appropriate backup required to recover to a specific point in time. The **Protects** panel of the **ORACLE→Databases→Protection View** screen lists all of the Express Protect backups along with a timestamp of when they were created. Simply clicking **Action→Restore** starts the process of restoring the selected Protect. Alternatively, with RMAN, choosing the recovery point target requires using the RMAN `set until` command to recover to a specific System Change Number (SCN) or a specific date and time. The RMAN `restore database preview` command lets the DBA know if the needed backup sets are available, and if so, the DBA then issues the RMAN `restore database` command to have RMAN automatically restore the datafiles and archived redo logs as required.

Although there is an extra step with RMC-O to select the RW child snapshot and clicking **Action→Restore** to initiate the rollback, the benefit of having this RW snapshot available for CDM (see Copy Data Management) outweighs the small amount of time this step requires.

Considerations for restoring from incremental backups

With RMC-O, Express Restores are always done from a synthetic full backup. Express Protect automatically rolls each backup iteration into a full backup maintained on the HPE StoreOnce appliance. When a Protect is chosen as the recovery point, RMC-O Express Restore selects an appropriate reference snapshot to use as the basis for the restore (see Restore from a Protect). As noted in Table 5, RMC-O compares the content of the backup at that point in time with the blocks in the reference snapshot, and then resolves the differences, restoring only the unique blocks to create the new RW snapshot. This procedure is more efficient than the traditional method of restoring a full backup first and then restoring any incremental backups required to achieve the desired recovery point.

With RMAN, when an incremental backup strategy is used, Oracle might need several backup sets to recover the database. Generally, the last full backup must be restored, followed by the incrementals up to the point in time of recovery.[13] The RMAN `restore database` command only restores the base backup. During the follow-on RMAN `recover database` command, Oracle applies the incremental backups to the database, followed by the application of the archived redo logs. Applying multiple backup sets during the `recover` operation might take a bit longer, but this could be faster than having to apply a large amount of redo.

Creating application-consistent Oracle backups with RMC Core

For environments where Oracle databases cannot be put into backup mode, it is possible to create application-consistent backups of an Oracle database via RMC managed snapshots. This section presents uses cases for CDM and data protection of an Oracle database using RMC without using the Oracle plug-in (RMC Core)[14]

Oracle supports the use of snapshot copy for creating application-consistent backups without requiring that the database be placed in backup mode. The vendor's snapshot technology must conform to the following requirements:[15]

- The database is crash consistent during the snapshot.

- The snapshot preserves write order for each file.

- The snapshot technology stores the time at which the snapshot is completed.

HPE 3PAR Virtual Copy meets these requirements.[16]

The key to creating application-consistent backups with RMC Core is to place all the HPE 3PAR volumes for a given database into an RMC Recovery Set. Placing the database volumes into a recovery set guarantees that all snapshot operations against the volumes in a recovery set are group-consistent (occur simultaneously).[17] RMC Snapshot Sets created from the recovery set provide a point-in-time copy of the database control files, datafiles, redo logs, and archived redo log files. Databases recovered from a point-in-time copy can be opened immediately—no recovery is required.

To validate using RMC Core to create application-consistent backups of an Oracle database, a two-node RAC cluster was set up in the HPE solution lab. Table 6 shows the composition of the ASM disk groups associated with this RAC cluster.

Table 6. Solution lab Oracle RAC ASM disk 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

---

[13] Oracle incremental backups include backing up any datafile that is changed in any way. To make incremental backups smaller and take less time, RMAN supports using a block-change tracking file, so that just the changed blocks are backed up.
[14] The term "RMC Core" is used to refer to the RMC product without the RMC Oracle application plug-in.
[15] See *Making Backups with Third-Party Snapshot Technologies* in the Oracle Database Backup and Recovery User's Guide. Also see My Oracle Support (MOS) note 604683.1.
[16] See HPE 3PAR Virtual Copy for a detailed description of the HPE 3PAR Virtual Copy software.
[17] For more information about using creating recovery sets, see HPE Reference Configuration for HPE Recovery Manager Central.

Using the RMC Recovery Set wizard (**Manage→Recovery Sets→+Recovery Set**), a recovery set named "Oracle_RAC" is created that includes each of the HPE 3PAR virtual volumes associated with ASM disk groups supporting the RAC installation.

Figure 23 shows the RMC **Manage→Recovery Sets→Overview** panel displaying the ten HPE 3PAR virtual volumes added to the recovery set "Oracle_RAC." The **Volumes** panel displays the name of the volume, the volume's Fibre Channel world-wide ID, and the names of the two hosts to which the volumes are attached. All names in the **Volumes** panel match the names of the respective objects on the HPE 3PAR array.

Name	Size (MiB)	WWN	Attached To
asm1_1	819200	60002AC0000000000000007981000188F4	jh_fire-g9r1, jh_fire-g9r2
asm1_10	25600	60002AC00000000000000007DFD000188F4	jh_fire-g9r1, jh_fire-g9r2
asm1_13	10240	60002AC00000000000000007DFE000188F4	jh_fire-g9r1, jh_fire-g9r2
asm1_14	10240	60002AC00000000000000007DFF000188F4	jh_fire-g9r1, jh_fire-g9r2
asm1_2	819200	60002AC0000000000000007982000188F4	jh_fire-g9r1, jh_fire-g9r2
asm1_3	819200	60002AC0000000000000007983000188F4	jh_fire-g9r1, jh_fire-g9r2
asm1_4	819200	60002AC0000000000000007984000188F4	jh_fire-g9r1, jh_fire-g9r2
asm1_5	102400	60002AC0000000000000007985000188F4	jh_fire-g9r1, jh_fire-g9r2
asm1_6	102400	60002AC0000000000000007986000188F4	jh_fire-g9r1, jh_fire-g9r2
asm1_9	25600	60002AC00000000000000007DFC000188F4	jh_fire-g9r1, jh_fire-g9r2

Figure 23. HPE 3PAR virtual volumes assigned to solution lab "Oracle_RAC" recovery set

With a recovery set defined for the RAC ASM disks, Table 7 highlights the possible RMC operations. Use cases include creating snapshot sets, point-in-time recovery of the database by promoting snapshots back to the parent volume, backing up the snapshot sets to an HPE StoreOnce Catalyst store, and restoring those backups for recovery or CDM purposes

Table 7. RMC Core operations with HPE 3PAR virtual volumes in a Recovery Set

RMC object	RMC Action	Use case
Recovery Sets	Create snapshot set (**+Protection** wizard)	Create a one-off (ad hoc) snapshot before making major changes to production database.
		Create a snapshot schedule in order to meet RPOs.
		Create a backup policy to backup snapshot sets to HPE StoreOnce Catalyst store (Express Protect).
Snapshot Sets	Restore snapshot	Promotes snapshot set to parent volume to create a point-in-time restore.
	Attach snapshot	Present RW snapshot set to another host for CDM operations. (RW snapshot created from Express Restore)
Express Protect	Restore	Restore backup from HPE StoreOnce Catalyst store. There are three options for specifying the target destination: • Parent volume • Other recovery set • New Snapshot Set (known as Express Restore)

The remainder of this section will focus on the following two RMC Core use cases:

• Recovering the database from a point-in-time-copy

• Cloning the database for CDM purposes

These use cases do not involve the HPE StoreOnce appliance. See HPE Reference Configuration for HPE Recovery Manager Central for RMC and HPE StoreOnce Express Protect and Express Restore operations.

Creating a snapshot set—a point-in-time-copy of the database

A snapshot set is an RMC object that consists of snapshots taken in a group-consistent manner of each of the HPE 3PAR virtual volumes that comprise a given recovery set. Snapshot sets can be created using either the **+Protection Wizard** available from the **Manage→Recovery Sets** panel or via the **+Snapshot Sets** wizard available from the **Manage→Snapshot Sets** panel. Snapshot sets can be created as one-off or can be scheduled on a regular basis to meet required RPOs.

Figure 24 shows the **Add Protection Jobs** screen displayed when a **SnapProtect** policy is chosen using the **Manage→Recovery Sets→ +Protection Wizard**. The figure shows that a one-off snapshot set **(Level -> Now)** is to be created. (For more information on creating snapshot sets, including how to establish a snapshot schedule, see the HPE Reference Configuration for HPE Recovery Manager Central.)

Figure 24. Creating a one-time snapshot set

When the **+Protection Wizard** is complete, select **General**→**Activity** to verify the details of the **Create Snapshots Sets** action. The **Resource** column shows the name of the snapshot set created and the **Parent Resource** column shows the name of the recovery set associated with the snapshot set.

Select **Manage**→**Recovery Sets** →**Restore Points** to list all the available snapshot sets associated with the selected recovery set. Figure 25 shows two snapshot sets have been created for the recovery set "Oracle_RAC."

Figure 25. Viewing the restore points (snapshot sets) for the "Oracle_RAC" recovery set

To obtain more details on any snapshot set listed in the **Restore Points** panel, click the snapshot set **Name**. This will bring up the **Snapshot Set** overview screen shown in figure 26. The figure shows the **Associated Snapshots** panel for snapshot set "snap-2019-1-2-13-13-4."

Figure 26. Viewing the snapshots associated with the snapshot set "snap-2019-1-2-13-13-4"

Note that the snapshot set consists of ten snapshots, one for each of the HPE 3PAR virtual volumes in the recovery set. Each snapshot name includes the snapshot type—in this case "ro" indicating these are read-only snapshots.

Restoring a snapshot set—recovering the database to a point in time

With RMC Core it is possible to restore the Oracle database back to the point in time when the snapshot set was created. The primary use case for restoring a snapshot set to the parent volumes is when the database has suffered a catastrophic software failure.

Before initiating a snapshot set restore, the following tasks must be completed:

- The database must be shut down and any other workloads on the volumes must be stopped.

- The volumes must be detached from the host servers.

To detach the recovery set volumes, select the **Actions→Detach** operation from the **Manage→Recovery Sets** panel. Figure 27 shows the resulting **Host Detach** screen for the recovery set "Oracle_RAC."
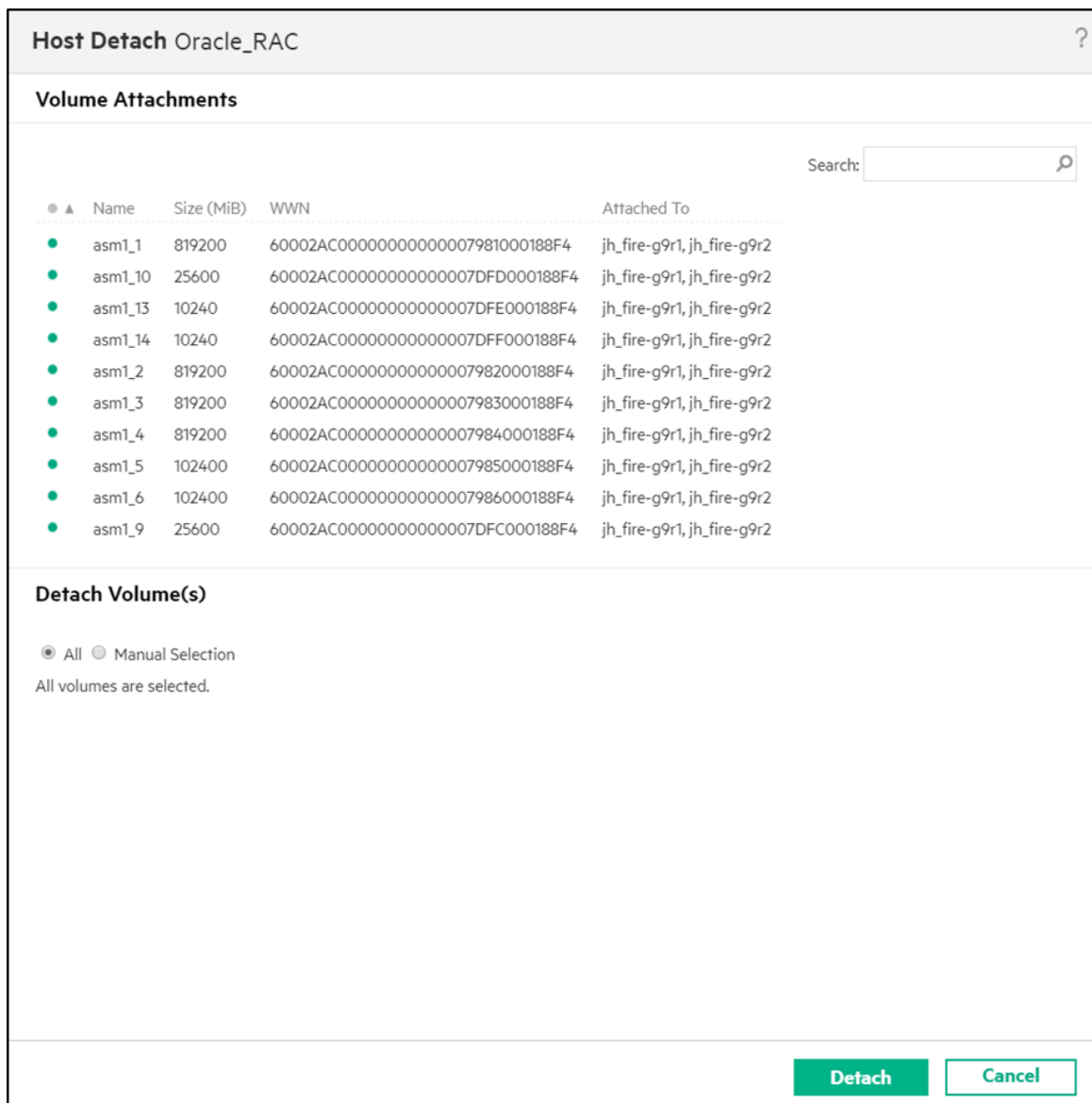

Figure 27. Detaching all volumes of the recovery set "Oracle_RAC" from the two RAC host servers

Notice in the **Detach Volume(s)** panel, the choice to detach **All** volumes is the default selection, which is the desired action for preparing to perform a snapshot set restore. Click **Detach** to initiate the operation.

Initiating a snapshot set restore

There are two ways to initiate the restore of a snapshot set. The first method is initiated from the **Manage→Recovery Sets→Restore Points** panel as seen in Figure 25. Notice in Figure 25 that each snapshot set entry includes a **Restore** field that is underlined. This is an active link and clicking this link brings up the **Restore** panel shown in Figure 28. Note that all the volumes in the recovery set are automatically selected for restoring.
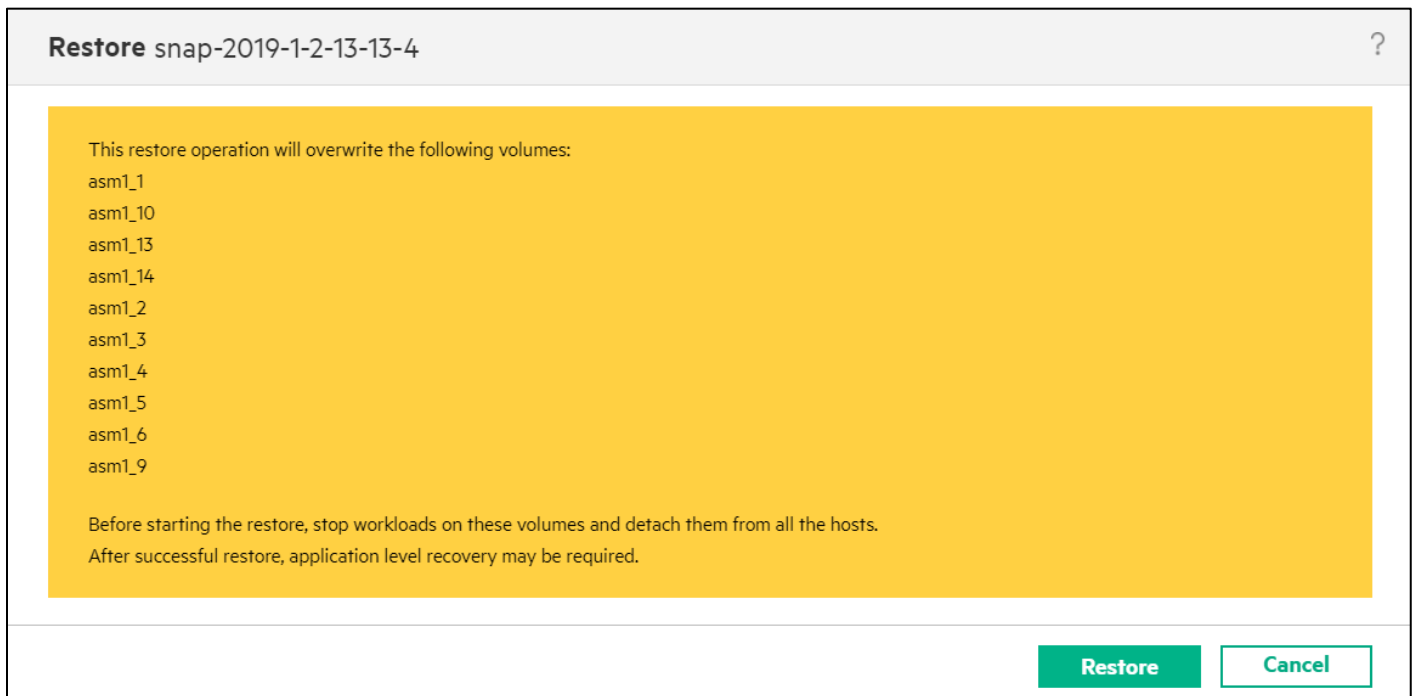

Figure 28. Restoring snapshot set "snap-2019-1-2-13-13-4" back to the parent volumes

If the stated prerequisites have been completed, click **Restore** to initiate the snapshot set restore process.

The second way to initiate a snapshot set restore is to select the **Actions→Restore** operation from the **Manage→Snapshot Sets** panel. This brings up the **Snapshot Restore** panel as shown in Figure 29.

Figure 29. Restoring snapshot set "snap-2019-1-2-13-13-4" via **Manage→Snapshot Sets→Actions→Restore**

In contrast to the **Restore** panel in Figure 28, the **Snapshot Restore** panel in Figure 29 provides the option to select which volumes are to be restored. However, the default is to **Restore All Volumes**—the desired action for a complete database restore.

Click **Restore** to initiate the snapshot set restore operation.

View the **General→Activity** panel to check the progress of the **Restore Snapshot Sets** operation.

Completing the database point-in-time recovery

After the **Restore Snapshot Sets** operation is complete, the volumes must be reattached to the hosts. Use the **Actions→ Attach** operation from the **Manage →Recovery Sets** panel to attach the volumes to the desired hosts.

Log in to the RAC environment to verify the volumes have been recognized by the RAC hosts and the +ASM instance is up.

Because the snapshot set provides a point-in-time copy of the database control files, datafiles, and redo logs, Oracle will initiate a recovery when the `SQL>STARTUP` command is issued. The database will be consistent to the last redo commit of the snapshot set copy.

Cloning the database from a snapshot set

In order to clone an Oracle database using snapshot technology, an RW snapshot set must be presented to the standby server. Creating a snapshot set of a snapshot set automatically creates an RW snapshot set; this is a feature of the HPE 3PAR Virtual Copy software The first snapshot set of a recovery set is called the parent snapshot set and is an RO snapshot set (see Figure 26). A snapshot set created from this parent snapshot set is called the child snapshot set. The child snapshot set is an RW snapshot set.

RMC Core v5.0 does not support creating a snapshot set of a snapshot set from within the RMC GUI. Instead, this operation must be done using the RMC REST API. The RMC REST API is provided via a software development kit (SDK).[18] The HPE RMC REST SDK includes sample scripts that can be used to perform RMC operations. The scripts folder includes Linux bash shell scripts, Perl scripts, and Windows PowerShell scripts. For complete documentation on using the RMC REST API, see the *Recovery Manager Central REST API Implementation Guide* included in the SDK.

This section describes using the RMC REST API to:

- Create an RW child snapshot set of a parent snapshot
- Attach the RW snapshot set to the Oracle standby server

The following steps describe how to use the RMC REST SDK PowerShell scripts to clone the Oracle RAC database to a standby server. This procedure assumes the proper version of the operating system is installed on the standby server and that the Grid Infrastructure and Oracle installations are complete.

The procedure assumes that a recovery set has been defined and that one or more snapshot sets are associated with the recovery set. The following elements in the solutions lab environment are referenced in the PowerShell scripts:

- The recovery set name is "Oracle_RAC" (see Figure 23).
- Two parent snapshot sets have been created for this recovery set: "snap-2019-1-2-13-13-4" and "snap-2019-1-3-9-30-21" (see Figure 25).
- A child snapshot set of the parent snapshot set "snap-2019-1-2-13-13-4" will be created. This will be an RW snapshot set and will be given the name "RW-Snap-For-Clone."
- The RW snapshot set will be attached to the standby Oracle host server named `jh_ses-host11` [19]

For this procedure, a `C:\Users\RESTPS` directory was created on a Windows® server in the solution lab. The contents of the RMC REST API SDK `powershell` folder were copied to this location.

1. Open Windows PowerShell and set the working directory to `C:\Users\RESTPS`.

2. Edit the `C:\Users\RESTPS\credentials.txt` file providing the IP address and logon credentials for the RMC appliance.

Tip
If there is more than one RMC appliance in the environment, create multiple entries in the `credentials.txt` file following the syntax shown in the `credentials_2.txt` file included in the SDK PowerShell scripts folder. Use the `$rmc_instance` variable to specify which appliance is to be used for the upcoming session. For example, if the `credentials.txt` file includes two appliances, `rmc_north` and `rmc_south`, issue the command `PS C:\Users\RestPS> $rmc_instance='rmc-north'` at the start of the session to have all RMC REST API commands issued to this appliance.

---

3. To add the REST API modules to this PowerShell session issue the command

```
PS C:\Users\RestPS> Import-Module .\RMC-Core.psm1
```

---

[18] HPE Recovery Manager Central Software Development Kit (SDK)
[19] The host must be already defined on the HPE 3PAR array.

Tip

To see a list of all the functions provided by the RMC REST API, edit/view the `C:\Users\RestPS \RMC-Core.psm1` file and scroll to the end of the file.

To learn what parameters are required when using a specific PowerShell RMC REST API function, issue the command `PS C:\Users\RestPS> ${function:function_name}`. The `Param` section of the display indicates the parameters accepted by the function and whether or not they are mandatory.

---

4. Use the `GET-RecoverySets` command to list all the recovery sets defined on the appliance (see Figure 30). The output from this command gives the name and id of each recovery set. This command is useful when multiple recovery sets are defined on the RMC appliance. Snapshot sets are associated with a specific recovery set, so if the environment includes multiple recovery and snapshot sets, the recovery set id is useful to verify the REST API operations are applied to the right snapshot set.

```
PS C:\Users\RestPS> Get-RecoverySets

domain                :
appType               : RMC
snapCount             : 0
removeOldestSnap      : False
notificationPolicyId  :
id                    : 18f5581e-e3aa-4110-8fe3-1362bdf7e526
createdAt             : 2018-11-26T18:10:05.535281Z
resourceUri           : /rest/rm-central/v1/recovery-sets/18f5581e-e3aa-4110-8fe3-1362bdf7e526
snapOnly              : False
backupCount           : 0
storageSystemName     : skyrim_3PAR_8400
deviceType            : STORESERV
removeOldestBackup    : False
status                : available
description           : 2 node RAC
wwnlist               : {60002AC0000000000007981000188F4, 60002AC00000000000007DFD000188F4, 60002AC00000000000007DFE000188F4,
associatedResourceUri : /rest/rm-central/v1/storage-pools/77c1ab14-49bc-4d3c-9cc9-3ab33a01ab23
storageSystemId       : b7953816-ca6d-4327-9d42-f9ccafddadda
remoteEnabled         : False
name                  : Oracle_RAC
volumelist            : {asm1_1, asm1_10, asm1_13, asm1_14...}
backupPolicyId        :
appResourceContent    :
poolId                : 77c1ab14-49bc-4d3c-9cc9-3ab33a01ab23
parentSnapshotsetId   :
```

Figure 30. `GET-RecoverySets` function returns the recovery set id and name

5. Use the `Get-SnapshotSets` function to list all of the snapshot sets defined on the appliance. The output from this command provides the id of each snapshot set and the id of its associated recovery set (see Figure 31). The snapshot set id will be needed as input to subsequent commands.

```
PS C:\Users\RestPS> Get-SnapshotSets

Key                     Value
---                     -----
status                  available
resourceUri             /rest/rm-central/v1/snapshot-sets/d259b475-52f4-40e9-a825-af7872e5f63f
description
appType                 RMC
associatedResourceUri   /rest/rm-central/v1/recovery-sets/18f5581e-e3aa-4110-8fe3-1362bdf7e526
protectionPolicyId      23948a42-aade-4b84-abaa-401a7358ee92
recoverySetId           18f5581e-e3aa-4110-8fe3-1362bdf7e526
appResourceContent
snapCreationTime        2019-01-03T09:37:11.000000
protectionPolicyName
attachStatus
id                      d259b475-52f4-40e9-a825-af7872e5f63f
createdAt               2019-01-03T16:30:23.065643Z
name                    snap-2019-1-3-9-30-21
status                  available
resourceUri             /rest/rm-central/v1/snapshot-sets/a6d607b4-a7a9-4b8b-bc73-7abaef99b977
description
appType                 RMC
associatedResourceUri   /rest/rm-central/v1/recovery-sets/18f5581e-e3aa-4110-8fe3-1362bdf7e526
protectionPolicyId      23948a42-aade-4b84-abaa-401a7358ee92
recoverySetId           18f5581e-e3aa-4110-8fe3-1362bdf7e526
appResourceContent
snapCreationTime        2019-01-02T13:19:51.000000
protectionPolicyName
attachStatus
id                      a6d607b4-a7a9-4b8b-bc73-7abaef99b977
createdAt               2019-01-02T20:13:05.8441462Z
name                    snap-2019-1-2-13-13-4
```

Figure 31. `Get-SnapshotSets` function returns the name and id of each snapshot set defined

6. Use the `New-RWSnapshot` function to create an RW child of the parent snapshot set. There are two inputs to this command: the name of the new snapshot set and the id of the parent snapshot. Figure 32 shows creating an RW child snapshot, named "RW-Snap-For-Clone" from the snapshot set "snap-2019-1-2-13-13-4," whose identifier was copied from the output of the `Get_SnapshotSets` command (see Figure 31).

```
PS C:\Users\RestPS> New-RWSnapshot "RW-Snap-For-Clone" a6d607b4-a7a9-4b8b-bc73-7abaef99b977

taskUri
-------
/rest/rm-central/v2/tasks/9cd57f0a-127f-4082-b03f-84d508bb5ace
```

Figure 32. Creating an RW snapshot set

The `New_RWSnapshot` function returns a task id. To view the progress of the task, use the `Get-Task` function, providing the task id as input. This is shown in Figure 33.

```
PS C:\Users\RestPS> Get-Tasks "9cd57f0a-127f-4082-b03f-84d508bb5ace"

Key                   Value
---                   -----
taskOutput
owner                 fe5852deb29848c3b58103a076684533
updatedAt             2019-01-03T21:29:49.742837Z
duration              2000
nativeJob             False
id                    9cd57f0a-127f-4082-b03f-84d508bb5ace
createdAt             2019-01-03T21:29:47.102327Z
associatedData        {System.Collections.Generic.Dictionary`2[System.String,System.Object], System.Collections.Generic.Dictio...
taskProgress          {System.Collections.Generic.Dictionary`2[System.String,System.Object], System.Collections.Generic.Dictio...
taskStatus            Ok
priority
parentTaskId
taskErrors
completedPercentage   100
associatedResource    {[resourceName, RW-Snap-For-Clone], [resourceUri, /rest/rm-central/v1/snapshot-sets/a6d607b4-a7a9-4b8b-b...
taskUri               /rest/rm-central/v2/tasks/9cd57f0a-127f-4082-b03f-84d508bb5ace
initiator             RMC
name                  Create_RW_Snapshot_Set
parentResourceName    snap-2019-1-2-13-13-4
resourceType          RW Snapshot Sets
taskState             Completed
action                Create RW Snapshot Sets
```

Figure 33. Using the `Get-Tasks` function to review the progress of the `Create_RW_Snapshot_Set` operation

Note that the progress of the `Create_RW_Snapshot_Set` task can also be viewed in the RMC GUI **General→Activity** panel, as shown in Figure 34.
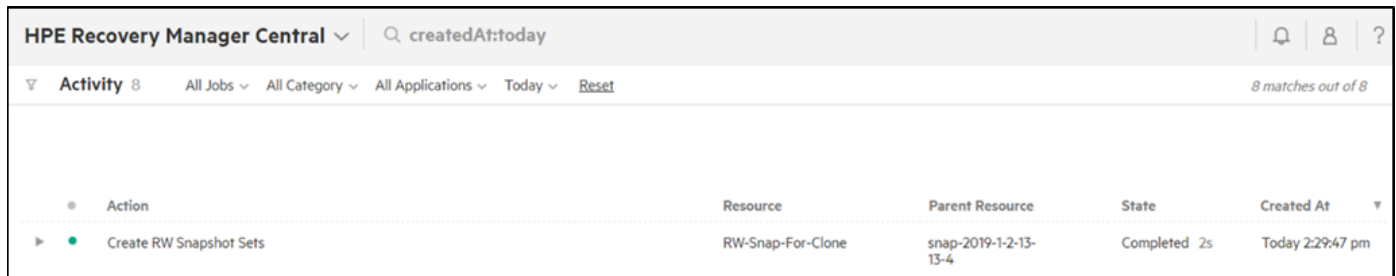

Figure 34. Using the RMC GUI activity monitor to review the progress of the `Create RW Snapshot Sets` action

7. In order to attach the RW snapshot set to a host, the id of the RW snapshot set is needed. Use a variation of the `Get_SnapshotSets`
    command to get the id of the RW snapshot set. Figure 35 shows the two required parameters for this function: the id of the parent snapshot
    set and the request to view any child RW snapshot sets associated with the parent.

```
PS C:\Users\RestPS> Get-SnapshotSets "a6d607b4-a7a9-4b8b-bc73-7abaef99b977"
 -rw_set $true

Key                  Value
---                  -----
status               available
resourceUri          /rest/rm-central/v1/snapshot-sets/a6d607b4-a7a9...
description
appType
associatedResourceUri /rest/rm-central/v1/snapshot-sets/a6d607b4-a7a9...
protectionPolicyId
snapshotSetId        a6d607b4-a7a9-4b8b-bc73-7abaef99b977
appResourceContent
snapCreationTime     2019-01-03T14:36:35.000000
attachStatus         attached
id                   c012833a-4da2-4574-b18f-457730e0b3bb
createdAt            2019-01-03T21:29:46.871755Z
name                 RW-Snap-For-Clone
```

Figure 35. Obtaining the id of any child RW snapshot sets associated with the given parent snapshot set

By supplying the id of a specific snapshot set, in this case the id of the parent snapshot "snap-2019-1-2-13-13-4" (see Figure 31), the
`Get_SnapshotSets` command will provide details of this snapshot set only. The additional qualifier `-rw_set $true` requests that only
information about RW snapshots associated with this parent snapshot is to be returned. From this output the id of the RW snapshot is obtained.

8. Use the `Request-AttachDetachSnapshot` command to attach the RW snapshot set to the standby server (see Figure 36). This
    command requires four parameters:

    a. The parent snapshot set id (see Figure 31)

    b. The host name of the standby server (`jh_ses-host11`)

    c. The `-attach` qualifier set to `$true` to specify attach operation

    d. The `-rw_set_id` qualifier set to the id of the RW snapshot (see Figure 35)

```
PS C:\Users\RestPS> Request-AttachDetachSnapshot "a6d607b4-a7a9-4b8b-bc73-7abaef99b977" "jh_ses-host11"
 -attach $true -rw_set_id "c012833a-4da2-4574-b18f-457730e0b3bb"

taskUri
-------
/rest/rm-central/v2/tasks/6307e1b5-a2c2-454d-8764-3489cc773a61
```

Figure 36. Attaching the RW snapshot set to the Oracle standby server

Tip
To detach a RW snapshot set from a host, use the `Request-AttachDetachSnapshot` function, but change the `-attach $true`
parameter to `-attach $false`.

The `Request-AttachDetachSnapshot` function returns a task id. Use the `Get-Tasks` function with the task id as the input parameter to monitor the progress of the attach task, as shown in Figure 37.

```
PS C:\Users\RestPS> Get-Tasks "6307e1b5-a2c2-454d-8764-3489cc773a61"

Key                   Value
---                   -----
taskOutput
owner                 fe5852deb29848c3b58103a076684533
updatedAt             2019-01-03T22:01:58.289637Z
duration              1000
nativeJob             False
id                    6307e1b5-a2c2-454d-8764-3489cc773a61
createdAt             2019-01-03T22:01:56.929079Z
associatedData        {System.Collections.Generic.Dictionary`2[System.String,System.Object], System.Collections.Generic.Diction...
taskProgress          {System.Collections.Generic.Dictionary`2[System.String,System.Object], System.Collections.Generic.Diction...
taskStatus            Ok
priority
parentTaskId
taskErrors
completedPercentage   100
associatedResource    {[resourceName, RW-Snap-For-Clone], [resourceUri, /rest/rm-central/v1/snapshot-sets/a6d607b4-a7a9-4b8b-bc...
taskUri               /rest/rm-central/v2/tasks/6307e1b5-a2c2-454d-8764-3489cc773a61
initiator             RMC
name                  Attach_RW_Snapshot_Set
parentResourceName    snap-2019-1-2-13-13-4
resourceType          RW Snapshot Sets
taskState             Completed
action                Attach RW Snapshot Sets
```

Figure 37. Monitoring the progress of the `Attach_RW_Snapshot_Set` task

The progress of the `Attach RW Snapshot Sets` action can also be viewed from the RMC GUI **General→Activity** panel, as shown in Figure 38.
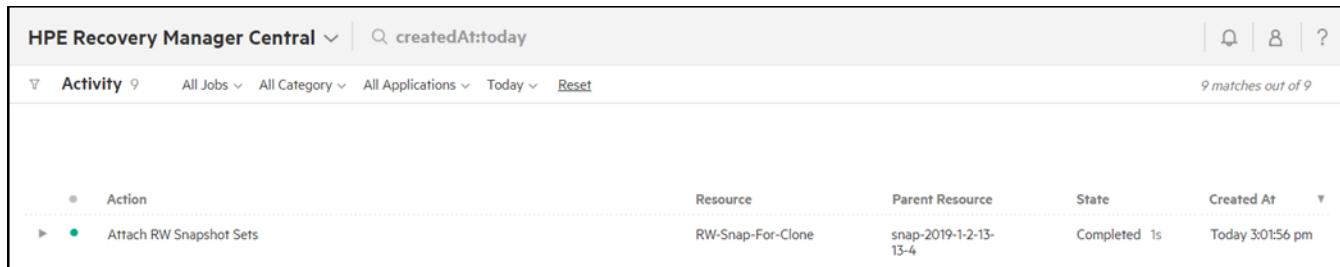

Figure 38. Using the RMC activity monitor to review the progress of the `Attach RW Snapshot Sets` action

9. When the `Attach RW Snapshot Sets` action completes, verify that the RW snapshots have been presented to the standby server. Use the HPE 3PAR StoreServ Management Console or the HPE 3PAR CLI to verify the RW snapshots are attached to the `jh_ses-host11` host.

Figure 39 shows the output from the HPE 3PAR CLI `showvlun` command.

```
3PAR_8400 cli% showvlun -host jh_ses-host11
Active VLUNs
no vluns listed

VLUN Templates
Lun VVName                HostName     -Host_WWN/iSCSI_Name- Port Type
 0 rmc-0032545-rw-190103142947693 jh_ses-host11 ---------------    --- host
 1 rmc-0032546-rw-190103142947693 jh_ses-host11 ---------------    --- host
 2 rmc-0032547-rw-190103142947693 jh_ses-host11 ---------------    --- host
 3 rmc-0032548-rw-190103142947693 jh_ses-host11 ---------------    --- host
 4 rmc-0032549-rw-190103142947693 jh_ses-host11 ---------------    --- host
 5 rmc-0032550-rw-190103142947693 jh_ses-host11 ---------------    --- host
 6 rmc-0032551-rw-190103142947693 jh_ses-host11 ---------------    --- host
 7 rmc-0032552-rw-190103142947693 jh_ses-host11 ---------------    --- host
 8 rmc-0032553-rw-190103142947693 jh_ses-host11 ---------------    --- host
 9 rmc-0032554-rw-190103142947693 jh_ses-host11 ---------------    --- host
---------------------------------------------------------------------
10 total
```

Figure 39. Verifying that the RW snapshots are presented to the standby server

Use the HPE 3PAR StoreServ Management Console or the HPE 3PAR CLI to determine the Fibre Channel WWIDs for the RW snapshots. Figure 40 shows the output from the HPE 3PAR CLI `showvv` command listing the WWIDs for each of the RW snapshots.

```
3PAR_8400 cli% showvv -d rmc*-rw-190103142947693
 Id Name              Rd Mstr  Prnt Roch Rwch PPrnt SPrnt PBlkRemain ------------VV_WWN------------- -------------------------CreationTime---------------- Udid
32585 rmc-0032545-rw-190103142947693 RW 0/1/- 32545 --- --- --- -- -- 60002AC00000000000007F49000188F4 2019-01-03 14:36:35 MST 32585
32586 rmc-0032546-rw-190103142947693 RW 0/1/- 32546 --- --- --- -- -- 60002AC00000000000007F4A000188F4 2019-01-03 14:36:35 MST 32586
32587 rmc-0032547-rw-190103142947693 RW 1/0/- 32547 --- --- --- -- -- 60002AC00000000000007F4B000188F4 2019-01-03 14:36:35 MST 32587
32588 rmc-0032548-rw-190103142947693 RW 0/1/- 32548 --- --- --- -- -- 60002AC00000000000007F4C000188F4 2019-01-03 14:36:35 MST 32588
32589 rmc-0032549-rw-190103142947693 RW 1/0/- 32549 --- --- --- -- -- 60002AC00000000000007F4D000188F4 2019-01-03 14:36:35 MST 32589
32590 rmc-0032550-rw-190103142947693 RW 0/1/- 32550 --- --- --- -- -- 60002AC00000000000007F4E000188F4 2019-01-03 14:36:35 MST 32590
32591 rmc-0032551-rw-190103142947693 RW 1/0/- 32551 --- --- --- -- -- 60002AC00000000000007F4F000188F4 2019-01-03 14:36:35 MST 32591
32592 rmc-0032552-rw-190103142947693 RW 0/1/- 32552 --- --- --- -- -- 60002AC00000000000007F50000188F4 2019-01-03 14:36:35 MST 32592
32593 rmc-0032553-rw-190103142947693 RW 1/0/- 32553 --- --- --- -- -- 60002AC00000000000007F51000188F4 2019-01-03 14:36:35 MST 32593
32594 rmc-0032554-rw-190103142947693 RW 1/0/- 32554 --- --- --- -- -- 60002AC00000000000007F52000188F4 2019-01-03 14:36:35 MST 32594
----------------------------------------------------------------------------------------------------------------------------------------------
10 total
```

Figure 40. Listing the Fibre Channel WWIDs for the RW snapshots

10. Log in to the standby server as user `root`. Issue the `multipath -ll` command to verify that the newly presented volumes have been discovered (see Figure 41). Compare the Fibre Channel WWIDs of the `mpath` devices present at the standby server with those of the RW snapshots presented to the host.

```
[root@ses-host11 ~]# multipath -ll |grep mpath*
mpathe (360002ac00000000000007f49000188f4) dm-6 3PARdata,VV
mpathd (360002ac00000000000007f4e000188f4) dm-5 3PARdata,VV
mpathc (360002ac00000000000007f4b000188f4) dm-4 3PARdata,VV
mpathb (360002ac00000000000007f4c000188f4) dm-3 3PARdata,VV
mpatha (360002ac00000000000007f4a000188f4) dm-2 3PARdata,VV
mpathj (360002ac00000000000007f4f000188f4) dm-11 3PARdata,VV
mpathi (360002ac00000000000007f51000188f4) dm-10 3PARdata,VV
mpathh (360002ac00000000000007f4d000188f4) dm-9 3PARdata,VV
mpathg (360002ac00000000000007f52000188f4) dm-8 3PARdata,VV
mpathf (360002ac00000000000007f50000188f4) dm-7 3PARdata,VV
```

Figure 41. Using `multipath -ll` command to view the Fibre Channel WWIDS for the newly discovered volumes

11. Log in to the standby server as user `grid`. Set the `ORACLE_SID` environment variable to "+ASM" and connect to the running ASM instance (`sqlplus / as sysasm`).

    To mount the ASM disk groups, issue this command: `SQL>alter system set asm_diskstring='dev/mapper/mpath*';`.

    Confirm the discovery was successful by issuing this command: `SQL> select name,state from v$asm_diskgroup;`. Figure 42 shows the output of these commands.

```
Connected to:
Oracle Database 12c Enterprise Edition Release 12.2.0.1.0 - 64bit Production

SQL> show parameter instance_name
NAME                    TYPE        VALUE
----------------------------------  ----------  -------------------------------
instance_name           string      +ASM
SQL>

SQL> alter system set asm_diskstring='/dev/mapper/mpath*';
System altered.

SQL> show parameter asm_diskstring
NAME                    TYPE        VALUE
----------------------------------  ----------  -------------------------------
asm_diskstring          string      /dev/mapper/mpath*

SQL> select name,state from v$asm_diskgroup;

NAME                    STATE
----------------------------  ----------
ARCHIVE1            MOUNTED
DATA               MOUNTED
MGMT               MOUNTED
REDO1              MOUNTED
```

Figure 42. As user `grid`, confirm that the ASM disk groups are mounted to the +ASM instance

12. Log in to the node in the RAC cluster running Oracle instance `orcl1`. Log in as user `oracle`. Connect to the instance (`sqlplus / as sysdba`) and issue this command: `SQL> create pfile = '/home/oracle/rac_pfile.ora' from spfile;`.

13. Use the command `scp /home/oracle/rac_pfile.ora ses-host11:/home/oracle/standby.ora` to copy the RAC `pfile` to the standby server.

14. Log in to the standby server as user `oracle`. Edit the `/home/oracle/standby.ora` file, removing the following entries:

    a. All lines beginning with `orcl2._`

    b. `*.cluster_database=true`

    c. `orcl1.instance_number=1`

    d. `orcl2.instance_number=2`

    e. `oracl1.thread=1`

    f. `oracl2.thread=2`

    g. `oracl2.undo+_tablespace='UNDOTBS2'`

    h. Replace `oracl1.undo_tablespace='UNDOTBS1'` with `*.undo_tablespace='UNDOTBS1'`

15. As user `oracle`, set the `ORACLE_SID` environment variable to `orcl` and connect to the idle instance (`>sqlplus / as sysdba`). Issue the command `SQL>startup pfile='/home/oracle/standby.ora';` to start the database. Figure 43 shows the successful startup of the database on the standby server.

```
[oracle@ses-host11 ~]$ sqlplus / as sysdba

SQL*Plus: Release 12.2.0.1.0 Production on Thu Jan 3 17:17:28 2019

Copyright (c) 1982, 2016, Oracle.  All rights reserved.

Connected to an idle instance.

SQL> startup pfile='/home/oracle/standby.ora';
ORACLE instance started.

Total System Global Area 3791650816 bytes
Fixed Size                  8627488 bytes
Variable Size             872418016 bytes
Database Buffers         2902458368 bytes
Redo Buffers                8146944 bytes
Database mounted.
Database opened.

SQL> select DBID from v$database;
    DBID
----------
1511154857

SQL> select instance_name, status, database_status, active_state from v$instance;

INSTANCE_NAME   STATUS     DATABASE_STATUS  ACTIVE_ST
--------------- ---------- ---------------- ---------
orcl       OPEN      ACTIVE         NORMAL
```

Figure 43. Successful startup of the cloned database on the standby server

Changing the `PFILE` to remove references to the RAC environment was the only change necessary to recover the database to the standby server. The snapshot set contained all the files necessary for the recovery, and because the snapshots are group-consistent, the control file was current with all the necessary information about the archived redo logs.

Summary

Customers who run critical production applications on Oracle databases cannot afford to have any performance impact with their applications while running backups. Be it for copy data management or data protection, the operations need to be carried out without any impact to the business-critical implementations that can span petabytes of storage. HPE has an integrated end-to-end solution for such demanding workloads and makes sure that customer data is protected and replicated for addressing critical backup recovery and disaster recovery scenarios.

RMC-O leverages HPE 3PAR storage snapshots, providing point-in-time backups that are truly integrated with Oracle databases. RMC-O integration with HPE 3PAR smart snapshot technology and HPE StoreOnce Catalyst results in much less disk use for backups when compared to RMAN backups to an NFS share.

The copy data management features of RMC-O provide DBAs with quick and efficient operations for creating clones and copies of production databases.

RMC-O integrates with HPE StoreOnce, bringing together the advantages of both backups and snapshots in an application-managed, storage-integrated data protection solution—eliminating the server-centric traditional backup methods. RMC-O interfaces with both HPE StoreOnce Catalyst Copy and HPE 3PAR Remote Copy to provide data replication across sites and integration with disaster recovery scenarios. RMC-O combines a rich feature set with ease of operations, ensuring DBAs can meet their RPO and RTO objectives on a day-to-day basis. In summary, RMC-O provides simple, fast, and space-economical protection and cloning of Oracle databases.

By combining this portfolio of products, HPE truly demonstrates the power of converged infrastructure with the right integration for protecting customer data, and hence, their critical business.

Resources and additional links

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

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

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 StoreOnce Support Matrix
https://h20272.www2.hpe.com/SPOCK/Pages/spock2Html.aspx?htmlFile=hw_storeonce.html&lang=en&cc=us&hpappid=117135_SPOCK_PRO_HPE

HPE Recovery Manager Central (RMC) Software
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

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

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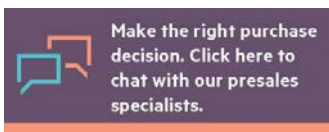https://h20272.www2.hpe.com/spock

Additional references

HPE Reference Architectures
hpe.com/info/ra

HPE Advisory and Transformation Services
hpe.com/us/en/services/consulting.html

HPE Pointnext
hpe.com/us/en/services.html

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