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Hitachi Universal Storage Platform V
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Hitachi Copy-on-Write Snapshot User's Guide

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MK-96RD607-15

Contents

Preface

This document describes and provides instructions for performing Hitachi Copy-on-Write Snapshot operations on the Hitachi Universal Storage Platform V and Hitachi Universal Storage Platform VM (USP V/VM) storage systems.

Please read this document carefully to understand how to use this product, and maintain a copy for reference purposes.

This preface includes the following information:

Intended Audience

This document is intended for system administrators, Hitachi Data Systems representatives, and Authorized Service Providers who are involved in installing, configuring, and operating the Hitachi Universal Storage Platform V and VM storage systems.

This document assumes the following:

- The user has a background in data processing and understands RAID storage systems and their basic functions.
- The user is familiar with the Universal Storage Platform V and/or VM storage system and has read the *Universal Storage Platform V/VM User and Reference Guide*.
- The user is familiar with the Storage Navigator software for the Universal Storage Platform V/VM and has read the *Storage Navigator User's Guide*.

Product Version

This document revision applies to USP V/VM microcode 60-08-0*x* and higher.

Document Revision Level

Revision	Date	Description
MK-96RD607-P	February 2007	Preliminary Release
MK-96RD607-00	April 2007	Initial Release, supersedes and replaces MK-96RD607-P
MK-96RD607-01	May 2007	Revision 1, supersedes and replaces MK-96RD607-00
MK-96RD607-02	July 15 2007	Revision 2, supersedes and replaces MK-96RD607-01
MP-96RD607-03	September 2007	Revision 3, supersedes and replaces MK-96RD607-02
MK-96RD607-04	November 2007	Revision 4, supersedes and replaces MK-96RD607-03
MK-96RD607-05	January 2008	Revision 5, supersedes and replaces MK-96RD607-04
MK-96RD607-06	March 2008	Revision 6, supersedes and replaces MK-96RD607-05
MK-96RD607-07	May 2008	Revision 7, supersedes and replaces MK-96RD607-06
MK-96RD607-08	August 2008	Revision 8, supersedes and replaces MK-96RD607-07
MK-96RD607-09	November 2008	Revision 9, supersedes and replaces MK-96RD607-08
MK-96RD607-10	January 2009	Revision 10, supersedes and replaces MK-96RD607-09
MK-96RD607-11	March 2009	Revision 11, supersedes and replaces MK-96RD607-10
MK-96RD607-12	June 2009	Revision 12, supersedes and replaces MK-96RD607-11
MK-96RD607-13	February 2010	Revision 13, supersedes and replaces MK-96RD607-12
MK-96RD607-14	December 2010	Revision 14, supersedes and replaces MK-96RD607-13
MK-96RD607-15	April 2011	Revision 15, supersedes and replaces MK-96RD607-14

Source Documents for this Revision

- MK-96RD607-15b-RSD-V08

Changes in this Revision

- Added information about the system option modes (SOMs) that apply to Copy-on-Write Snapshot operations (new section System Option Modes).
- Updated information about TrueCopy and Universal Replicator (TrueCopy or Universal Replicator).
- Updated the description of error codes 97a2 and 97a3 (SSB2) (Table 6-2).

Document Organization

The following table provides an overview of the contents and organization of this document. Click the chapter title in the left column to go to that chapter. The first page of each chapter provides links to the sections in that chapter.

Chapter	Description
Overview of Copy-on-Write Snapshot	Provides an overview of the Hitachi Copy-on-Write Snapshot software and describes the features and benefits of Hitachi Copy-on-Write Snapshot.
About Copy-on-Write Snapshot Operations	Describes the volumes used by Copy-on-Write Snapshot and the functions of Copy-on-Write Snapshot.
Preparing for Copy-on-Write Snapshot Operations	Describes requirements for using Copy-on-Write Snapshot, installation procedure of Copy-on-Write Snapshot, and calculation of the number of pairs that Copy-on-Write Snapshot can create.
Using the Copy-on-Write Snapshot GUI	Describes the Storage Navigator windows that present the Copy-on-Write Snapshot information and allow you to perform Copy-on-Write Snapshot operations.
Performing Copy-on-Write Snapshot Operations	Provides instructions for performing Copy-on-Write Snapshot operations.
Troubleshooting	Provides troubleshooting information for Copy-on-Write Snapshot and instructions for calling technical support.

Referenced Documents

Hitachi Universal Storage Platform V/VM:

- *User and Reference Guide*, MK-96RD635
- *Storage Navigator User's Guide*, MK-96RD621
- *Dynamic Provisioning User's Guide*, MK-96RD641
- *ShadowImage User's Guide*, MK-96RD618
- *TrueCopy User's Guide*, MK-96RD622
- *Universal Replicator User's Guide*, MK-96RD624
- *Virtual LVI/LUN and Volume Shredder User's Guide*, MK-96RD630
- *Data Retention Utility User's Guide*, MK-96RD612
- *Performance Manager User's Guide*, MK-96RD617
- *Command Control Interface User and Reference Guide*, MK-90RD011
- *Compatible Mirroring for IBM FlashCopy User's Guide,* MK-96RD614
- Universal *Volume Manager User's Guide,* MK-96RD626
- *Storage Navigator Messages,* MK-96RD613

Document Conventions

The terms “Universal Storage Platform V” and “Universal Storage Platform VM” refer to all models of the Hitachi Universal Storage Platform V and VM storage systems, unless otherwise noted.

This document uses the following typographic conventions:

Convention	Description
Bold	Indicates text on a window, other than the window title, including menus, menu options, buttons, fields, and labels. Example: Click **OK**.
Italic	Indicates a variable, which is a placeholder for actual text provided by the user or system. Example: copy *source-file target-file* ***Note:*** Angled brackets (< >) are also used to indicate variables.
screen/code	Indicates text that is displayed on screen or entered by the user. Example: `# pairdisplay -g oradb`
< > angled brackets	Indicates a variable, which is a placeholder for actual text provided by the user or system. Example: `# pairdisplay -g <group>` ***Note:*** Italic font is also used to indicate variables.
[ ] square brackets	Indicates optional values. Example: [a | b] indicates that you can choose a, b, or nothing.
{ } braces	Indicates required or expected values. Example: { a | b } indicates that you must choose either a or b.
| vertical bar	Indicates that you have a choice between two or more options or arguments. Examples: [a | b] indicates that you can choose a, b, or nothing. { a | b } indicates that you must choose either a or b.
underline	Indicates the default value. Example: [a | b]

This document uses the following icons to draw attention to information:

Icon	Meaning	Description
	Note	Calls attention to important and/or additional information.
	Tip	Provides helpful information, guidelines, or suggestions for performing tasks more effectively.
	Caution	Warns the user of adverse conditions and/or consequences (e.g., disruptive operations).
	WARNING	Warns the user of severe conditions and/or consequences (e.g., destructive operations).

Convention for Storage Capacity Values

Physical storage capacity values (e.g., disk drive capacity) are calculated based on the following values:

Physical capacity unit	Value
1 KB	1,000 (10^3) bytes
1 MB	1,000 KB or $1,000^2$ bytes
1 GB	1,000 MB or $1,000^3$ bytes
1 TB	1,000 GB or $1,000^4$ bytes
1 PB	1,000 TB or $1,000^5$ bytes
1 EB	1,000 PB or $1,000^6$ bytes

Logical storage capacity values (e.g., logical device capacity) are calculated based on the following values:

Logical capacity unit	Value
1 block	512 bytes
1 KB	1,024 (2^{10}) bytes
1 MB	1,024 KB or $1,024^2$ bytes
1 GB	1,024 MB or $1,024^3$ bytes
1 TB	1,024 GB or $1,024^4$ bytes
1 PB	1,024 TB or $1,024^5$ bytes
1 EB	1,024 PB or $1,024^6$ bytes

Getting Help

The Hitachi Data Systems customer support staff is available 24 hours a day, seven days a week. If you need technical support, log on to the Hitachi Data Systems Portal for contact information: https://hdssupport.hds.com

Comments

Please send us your comments on this document: doc.comments@hds.com. Include the document title, number, and revision, and refer to specific section(s) and paragraph(s) whenever possible.

Thank you! (All comments become the property of Hitachi Data Systems.)

1

Overview of Copy-on-Write Snapshot

This chapter provides an overview of the Hitachi Copy-on-Write Snapshot software and describes the features and benefits of the Hitachi Copy-on-Write Snapshot feature.

- ☐ Hitachi Copy-on-Write Snapshot
- ☐ FeaturesBenefits
- ☐ Differentiation from Hitachi ShadowImage

Hitachi Copy-on-Write Snapshot

The Hitachi Copy-on-Write Snapshot feature of the Hitachi Universal Storage Platform V and the Hitachi Universal Storage Platform VM (herein after referred to as USP V/VM) storage system rapidly creates logical point-in-time snapshot copies of data volumes within the Hitachi storage system, or behind the storage system as external storage, without impacting host service or performance levels. Copy-on-Write Snapshot accelerates backup and recovery processes by reducing the amount of disk storage required for the snapshot copies. Since only the changed data blocks are stored in the Copy-on-Write Snapshot storage pool, the storage capacity required for each snapshot copy is substantially less than the source volume, which results in a significant savings compared with full cloning methods. Copy-on-Write Snapshot's capability for quick restoration of data reduces traditional, tape-based application restore time from hours to seconds.

Features

The key features of Hitachi Copy-on-Write Snapshot are:

- Point-in-time copies of only changed blocks in a data pool, not full volume.
- Instantaneous restore of just the data you need.
- Versioning of backups for easy restore.
- RAID protection of all Copy-on-Write Snapshot copies.
- Near-instant copy creation and deletion.
- Can be integrated with industry-leading backup software applications.

Benefits

Hitachi Copy-on-Write Snapshot provides the following business benefits:

- Greatly reduces recovery time from data corruption or human error via an immediate restore from a disk-resident, point-in-time data snapshot copy.
- Allows frequent data backup operations to be performed nondisruptively, while critical applications run unaffected.
- Accelerates application testing and deployment by always providing available copies of current production information.
- Enables immediate access to time-critical information.
- Eliminates the backup window.
- Improves operational efficiency by allowing multiple processes to run in parallel with access to the same information.
- Allows disk space to be used efficiently through volume snapshots rather than full-copy clones, which helps maximize disk.

Differentiation from Hitachi ShadowImage

Hitachi ShadowImage copies differ from Copy-on-Write snapshots in that they are physically separate copies of the data and no portion is shared between primary and secondary volumes. Table 1-1 and Figure 1-1 highlights the key differences between the Copy-on-Write Snapshot and ShadowImage products.

Table 1-1 COW Snapshot-ShadowImage Differentiators

Item	Copy-on-Write Virtual Volume	ShadowImage Clone
Features	Provides a very quick copy because it is a virtual volume	Superior protection because it is a complete copy Immediate restore if P-VOL becomes corrupted
Time to Create	Instantaneous	From minutes to hours, depending on the size of the P-VOL
Disk Space Used	Size will vary depending upon rate of data change but will be far less than the P-VOL	Same amount as P-VOL
Data Recovery Time After P-VOL is corrupted	Two stage restore: 1. V-VOL verify, data not available to host 2. Copy back from a tape storage or else, data available	Instantaneous
Size of Physical Volume	P-VOL ≥ Pool for one V-VOL	P-VOL = S-VOL
Pair Configuration	P-VOL : V-VOL = 1 : 64	P-VOL : S-VOL = 1 : 3
Restore	P-VOL can be restored from any V-VOL	P-VOL can be restored from S-VOL

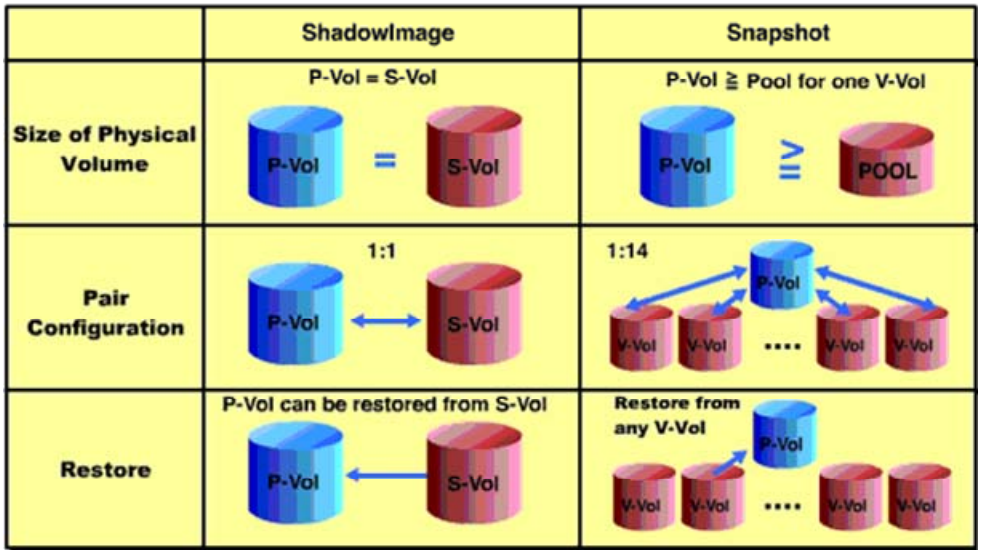

Figure 1-1 Product Differentiators for Copy-on-Write Snapshot and ShadowImage

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About Copy-on-Write Snapshot Operations

This chapter describes the volumes used by Copy-on-Write Snapshot and the functions of Copy-on-Write Snapshot.

Copy-on-Write Snapshot Components

A storage system using Copy-on-Write Snapshot usually contains the following components.

- Pair of volumes (P-VOL and S-VOL)
- Consistency group
- Copy-on-Write Snapshot program product
- Licensed ShadowImage program product
- Command Control Interface

Volumes and Volume Pairs

Copy-on-Write Snapshot copies the original data in a P-VOL to a V-VOL, which is specified as an S-VOL. It also manages a P-VOL, which is the logical volume and an S-VOL, which is the V-VOL as the volume for a Copy-on-Write Snapshot pair.

- A virtual volume of Dynamic Provisioning (DP-VOL) can be specified as a logical volume, but a virtual volume of Copy-on-Write Snapshot should not be specified.
- The differential data between the P-VOL and the S-VOL will be stored in a pool-VOL as snapshot data. Therefore, you need at least one logical volume as a copy source (P-VOL), one V-VOL as a copy target (S-VOL), and one pool-VOL where you can store snapshot data.

Volume Pairs and Consistency Group

You can define plural Copy-on-Write Snapshot pairs as one consistency group by using Command Control Interface. If you define consistency group to pairs, you can store snapshot data by a consistency group, and the data at the time when USP V/VM accepts the request to store the snapshot data is ensured for all P-VOLs in the consistency group.

Copy-on-Write Snapshot Software

Hitachi Data-at-Rest Encryption operations are performed using the Hitachi Storage Navigator software for the Universal Storage Platform V/VM storage system. Access to Storage Navigator is required for Copy-on-right operations. For information about Storage Navigator, see the *Storage Navigator User's Guide*.

License

You need to install the ShadowImage program product in the Storage Navigator computer before you operate Copy-on-Write Snapshot. In addition, to create Copy-on-Write Snapshot pairs, you must purchase the ShadowImage license and ensure that there is enough licensed capacity according to the capacity of pairs you are going to create.

Copy-on-Write Snapshot P-VOL, P-VOLs, S-VOLs, and the reserved volumes of ShadowImage are the volumes that require the license capacity of ShadowImage. These volumes are called used volumes. When determining how much license capacity to purchase, ensure that there will be enough licensed capacity for these used volumes. You must hold down the total capacity of the used volumes, so that it will be equal to or less than the licensed capacity.

Command Control Interface

Some Copy-on-Write Snapshot operations require Command Control Interface (CCI). When you use CCI, you do not need to use the Storage Navigator computer because you operate Copy-on-Write Snapshot directly from the host by executing the commands.

Copy-on-Write Snapshot Operations

Figure 2-1 illustrates how data is copied in the USP V/VM storage system using Copy-on-Write Snapshot. Copy-on-Write Snapshot enables you to maintain and copy data on the USP V/VM storage system. Copy-on-Write Snapshot is used for data for open systems such as UNIX® and PC servers.

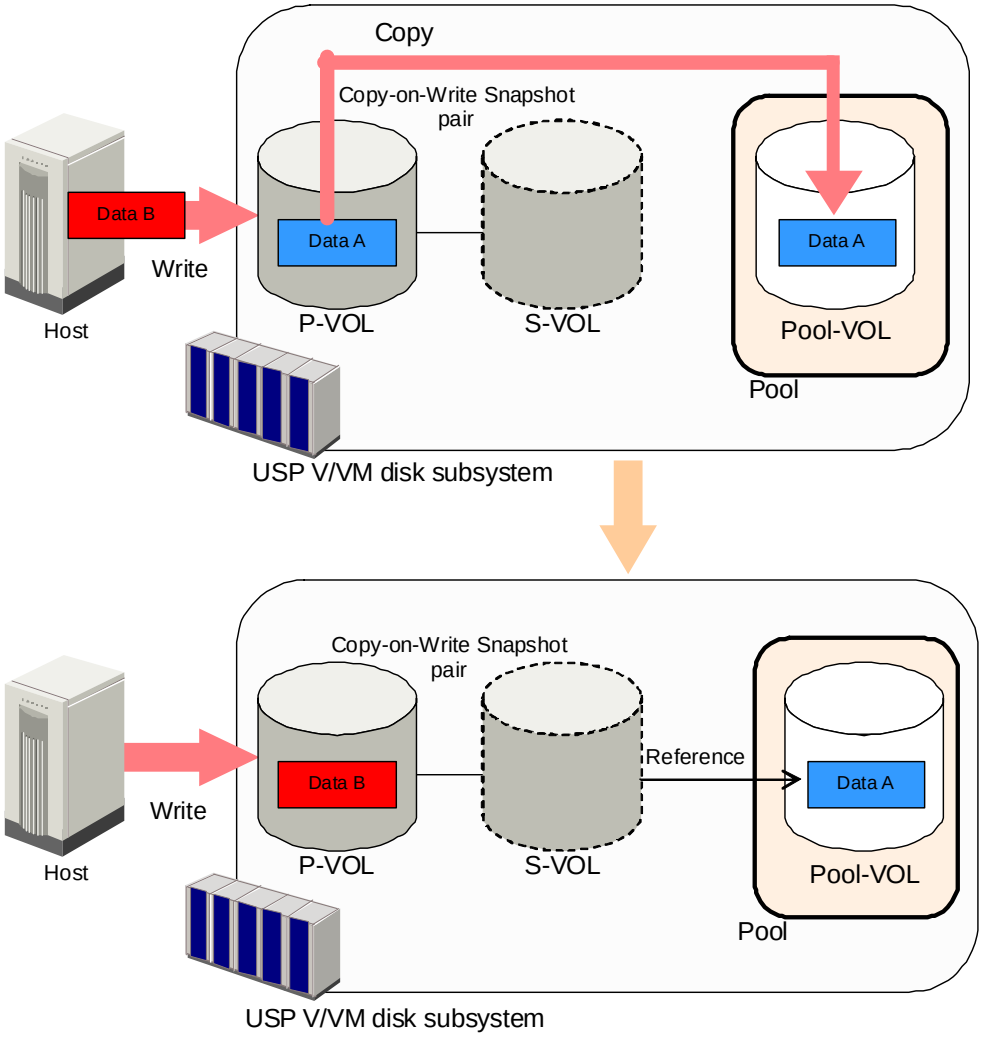

Figure 2-1 How Data is Copied in the USP V/VM Storage System Using Copy-on-Write Snapshot

In Figure 2-1, "Data A" is stored in some part of the P-VOL of a Copy-on-Write Snapshot pair. When the host requests to update "Data A" to "Data B", Copy-on-Write Snapshot copies "Data A" to the pool-volume in the pool before the P-VOL is updated. After the copy operation of "Data A" is complete, “Data B" is written to the part where "Data A” was stored in P-VOL, and the P-VOL is updated. From the S-VOL, you can access "Data B" in the P-VOL and "Data A" in the pool-VOL.

Create V-VOL Management Area Operation

A V-VOL management area needs to be created in the shared memory before you use Copy-on-Write Snapshot. V-VOL management area is an important area for associating an S-VOL (a V-VOL) of Copy-on-Write Snapshot with a pool-VOL. The V-VOL management area is created automatically when the additional shared memory is installed. Please call the Support Center for the installation of additional shared memory.

There are two kinds of areas in the V-VOL management area: pool management block and pool association information. When you create pools or Copy-on-Write Snapshot pairs, pool management block or pool association information will be stored in the V-VOL management area, therefore the available capacity of the V-VOL management area decreases. When all capacity of the V-VOL management area is used, the capacity ratio of the pool management block and the pool association information in the V-VOL management area will be fixed. If the capacity of the pool management block is insufficient, problems may occur; for example, you cannot create new pools or you cannot create pools with large amount of capacity. To solve such problems, you need to optimize the V-VOL management area.

Creation of Pool

A Copy-on-Write Snapshot pool is an area to store snapshot data. A pool consists of multiple pool-VOLs and actually, snapshot data is stored in a pool-VOL. 1,024 pool-VOLs can be registered in a pool, and 128 pools can be created in a storage system. Figure 2-2 illustrates the relationship between Copy-on-Write Snapshot pair and pool.

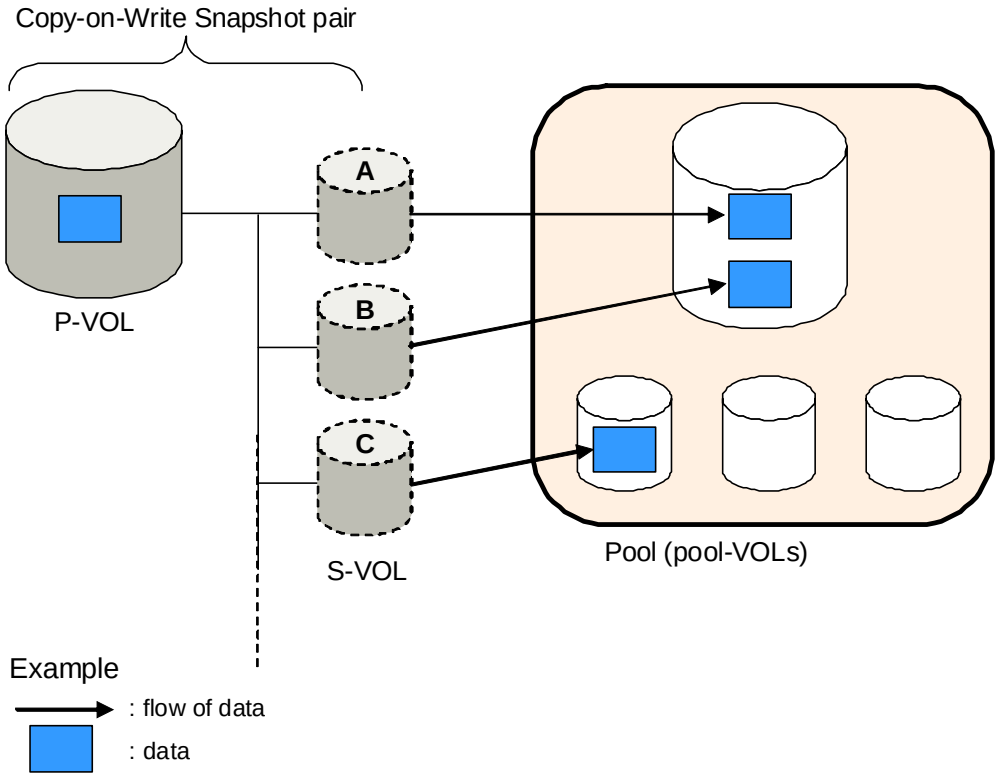

Figure 2-2 Relationship between Copy-on-Write Snapshot Pair and Pool

You need to create a pool when you use Copy-on-Write Snapshot. Pool-VOLs registered in a pool can be added but cannot be deleted during the operation. In addition, the entire snapshot data in the pool must be deleted if you want to delete the pool itself. To create a pool, use the Pool window of the Storage Navigator.

WARNING: The capacity of a pool is equal to the total of the capacity of pool-VOLs registered in the pool. The status of the Copy-on-Write Snapshot pair will be PSUE (status when failure occurred) when the usage rate of the pool exceeds the capacity of the pool as a result of writing data in the volume of that pair. Snapshot data cannot be stored in the pool, and no new Copy-on-Write Snapshot pair can be created. Please read Notes on Defining Pool Capacity and ensure that there is sufficient pool capacity.

Creation of Virtual Volume

V-VOL is a virtual volume that does not have physical memory space. V-VOL needs to be created before you create a Copy-on-Write Snapshot pair because you must use a V-VOL as the S-VOL of a Copy-on-Write Snapshot pair.

The definition of a V-VOL cannot be released if the V-VOL is being used as the S-VOL of a Copy-on-Write Snapshot pair. To release the definition, you must delete the Copy-on-Write Snapshot pair that uses the V-VOL.

Caution: If you are using HP-UX as a host server, keep the following in mind when you execute the command on V-VOLs in order to recognize the device from the host server.

- If the device is already recognized by the host server, do not change its volumes to V-VOLs.
- Before executing the command to recognize the device, create Copy-on-Write Snapshot pairs and store snapshot data.

If you do not follow the cautions above, an error may occur and the host server may be terminated. When the host server is terminated because of the command to recognize the device, retry the command by performing the following steps:

1. Force the command process and its parent process to terminate.
2. Create a Copy-on-Write Snapshot pair.
3. Store the snapshot data in the pool.
4. Execute the command again to recognize the device.

- Servers (including Command Control Interface) will show you the emulation type of the V-VOLs with “0” (e.g., OPEN-0V). When you create a Copy-on-Write Snapshot pair, specify the volume whose emulation type displays with “0” like OPEN-0V as the S-VOL.
- Before creating a V-VOL, you need to define a V-VOL group. As well as the emulation type of V-VOLs, the emulation type of VDEV for a V-VOL group is OPEN-V. In addition, the capacity of the VDEV is always 4 TB. Therefore, the maximum capacity of a V-VOL is also 4 TB.

Creation of Copy-on-Write Snapshot Pair

A Copy-on-Write Snapshot pair uses a V-VOL as its S-VOL. Therefore, you need to create a V-VOL before creating a Copy-on-Write Snapshot pair. In a Copy-on-Write Snapshot pair, up to 64 S-VOLs can be specified for a P-VOL.

Caution: When you create a Copy-on-Write Snapshot pair, you decide which pool to use by the pair. If you create two or more Copy-on-Write Snapshot pairs that share the same P-VOL, you need to specify the same pool for these pairs. For example, if you specify three S-VOLs for one P-VOL, you need to specify the same pool for these three pairs.

When you delete a Copy-on-Write Snapshot pair, the status of the volumes becomes SMPL (PD). You cannot create pairs by using SMPL (PD) volumes. If the volumes are in SMPL (PD) status, wait for a while and issue the command to create pairs after the volume status changes to SMPL.

Use the ShadowImage Pair Operation window to see the status of the volume.

Using Command Control Interface (CCI), you can distinguish between SMPL volumes and SMPL (PD) volumes by the pairdisplay command and the Inqraid command.

- If the result of the pairdisplay command is SMPL and the result of the Inqraid command is PVOL or SVOL, the Snapshot pair status is SMPL (PD).
- If the result of the pairdisplay command is SMPL and the result of the Inqraid command is SMPL, the Snapshot pair status is SMPL.

Specify -fw option when using the Inqraid command. The result of the Inqraid command is displayed not only for the pair whose Snapshot ID is 0 to 2, but also for the pair whose Snapshot ID is 3 to 63.

Storing of Snapshot Data

Snapshot data is a replica of a data in the P-VOL of a Copy-on-Write Snapshot pair and is stored in a pool. When the P-VOL is updated, the updated part of the data is copied to the pool as a snapshot data before the P-VOL is updated. This process is called the storing of snapshot data.

If you issue a command to a Copy-on-Write Snapshot pair to store snapshot data, the snapshot data will be stored in the pool when a host makes a write request to the P-VOL of a Copy-on-Write Snapshot pair. Copy-on-Write Snapshot pair can store up to 64 snapshot data per a P-VOL.

To store snapshot data, you can use the Command Control Interface command.

You can also store snapshot data for each consistency group by using Command Control Interface. If you store snapshot data by a consistency group, the data at the time when USP V/VM accepts the request to store the snapshot data is ensured for all P-VOLs in the consistency group. Figure 2-3 shows an overview of storing snapshot data by a consistency group.

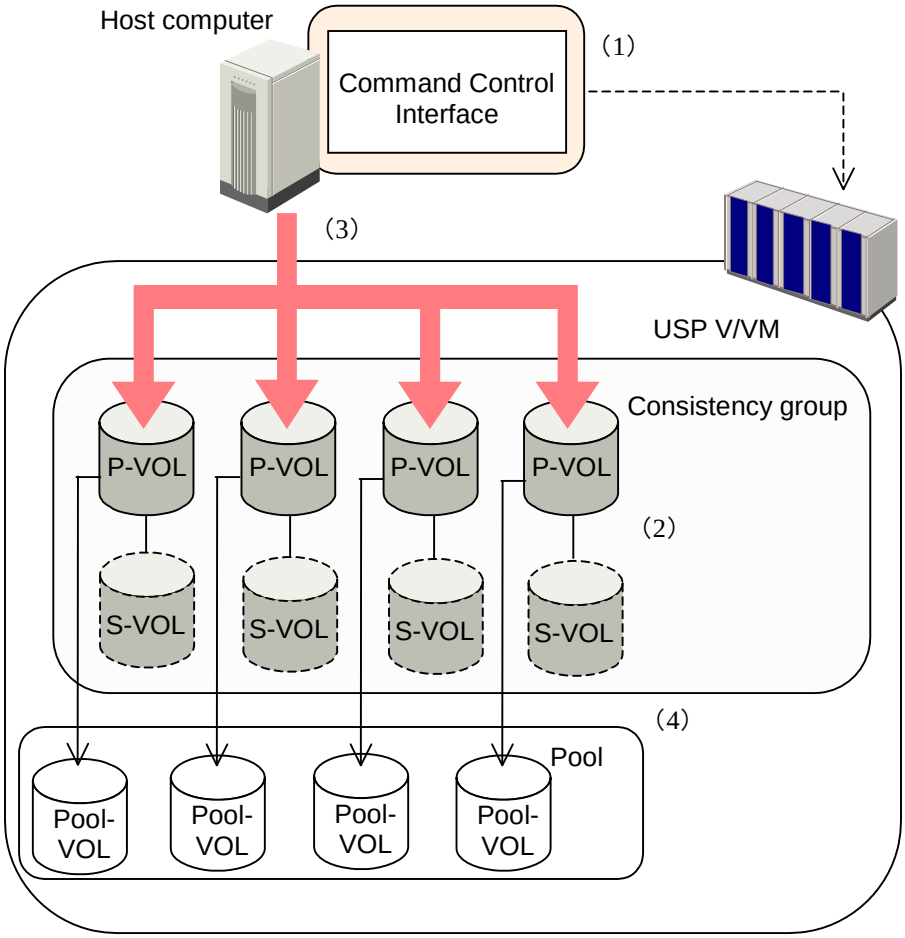

Figure 2-3 Overview of Storing Snapshot Data by a Consistency Group

When USP V/VM accepts the command from Command Control Interface, which requests storing the data by a consistency group (see (1) in Figure 2-3), the all status of the Copy-on-Write Snapshot pairs in the corresponding consistency group will change to PSUS ((2) in Figure 2-3). After that, when the host issues write I/O request to each P-VOL in the corresponding consistency group (see (3) in Figure 2-3), snapshot data of corresponding volume is stored (see (4) in Figure 2-3).

You can also use the Command Control Interface commands to store snapshot data by a consistency group. From Storage Navigator, you can only view the consistency groups.

Restoration of Copy-on-Write Snapshot Pair

Copy-on-Write Snapshot can restore the contents of the P-VOL to the state when the snapshot data was stored in the pool, by writing the snapshot data back to the P-VOL. Writing the snapshot data to the P-VOL is called restoration of Copy-on-Write Snapshot pair.

If you restore the pair when the data is written in the S-VOL, instead of the snapshot data, the data in the S-VOL will be written back to the P-VOL.

If there are problems with the data of P-VOL during a failure, you can restore the P-VOL to the normal state when the snapshot data was stored by executing restoration.

Deletion of Snapshot Data or Copy-on-Write Snapshot Pair

The status of the Copy-on-Write Snapshot pair will be PSUE (status when the failure occurred) when as a result of writing data in the volume of that pair, the capacity of snapshot data exceeds the capacity of the pool specified when the pool was defined. Copy-on-Write snapshot pair cannot be created newly and snapshot data cannot be stored in the pool. Therefore, unnecessary snapshot data needs to be deleted. There are two ways to delete snapshot data.

- Delete the Copy-on-Write Snapshot pair.
- Delete only the snapshot data.

When Copy-on-Write Snapshot pair itself is deleted, not only the snapshot data stored in the pool is deleted but also the relationship between P-VOL and S-VOL will be released. If only the snapshot data is deleted, the relationship between P-VOL and S-VOL is maintained. When only the snapshot data is deleted, the snapshot ID of the deleted snapshot data can be assigned to the newly stored snapshot data of the Copy-on-Write Snapshot pair.

- After the command is issued to delete snapshot data, no more snapshot data of that Copy-on-Write Snapshot pair will be stored in the pool even if the host tries to write data in the P-VOL. If you want to store snapshot data of that Copy-on-Write Snapshot pair again, you need to issue the command for storing snapshot data.
- The required time for deleting snapshot data or Copy-on-Write Snapshot pairs is several seconds and sometimes more than ten minutes. The time will increase if the deleted pair uses large amount of the pool, or if multiple pairs are deleted at one time. When you delete a Copy-on-Write Snapshot pair, the status of the volumes becomes SMPL (PD). Use the ShadowImage Pair Operation window to see the status of the volume.

Using Command Control Interface (CCI), you can distinguish between SMPL volumes and SMPL (PD) volumes by the pairdisplay command and the Inqraid command.

- If the result of the pairdisplay command is SMPL and the result of the Inqraid command for the P-VOL is PVOL, the Snapshot pair status is SMPL (PD).
- If the result of the pairdisplay command is SMPL and the result of the Inqraid command for the P-VOL is SMPL, the Snapshot pair status is SMPL.

Specify -fw option when using the Inqraid command. The result of the Inqraid command is displayed not only for the pair whose Snapshot ID is 0 to 2, but also for the pair whose Snapshot ID is 3 to 63.

Status of the Copy-on-Write Snapshot Pairs

When you create or split a Copy-on-Write Snapshot pair, the status of the pair changes. Figure 2-4 shows the transition of the status of a Copy-on-Write Snapshot pair.

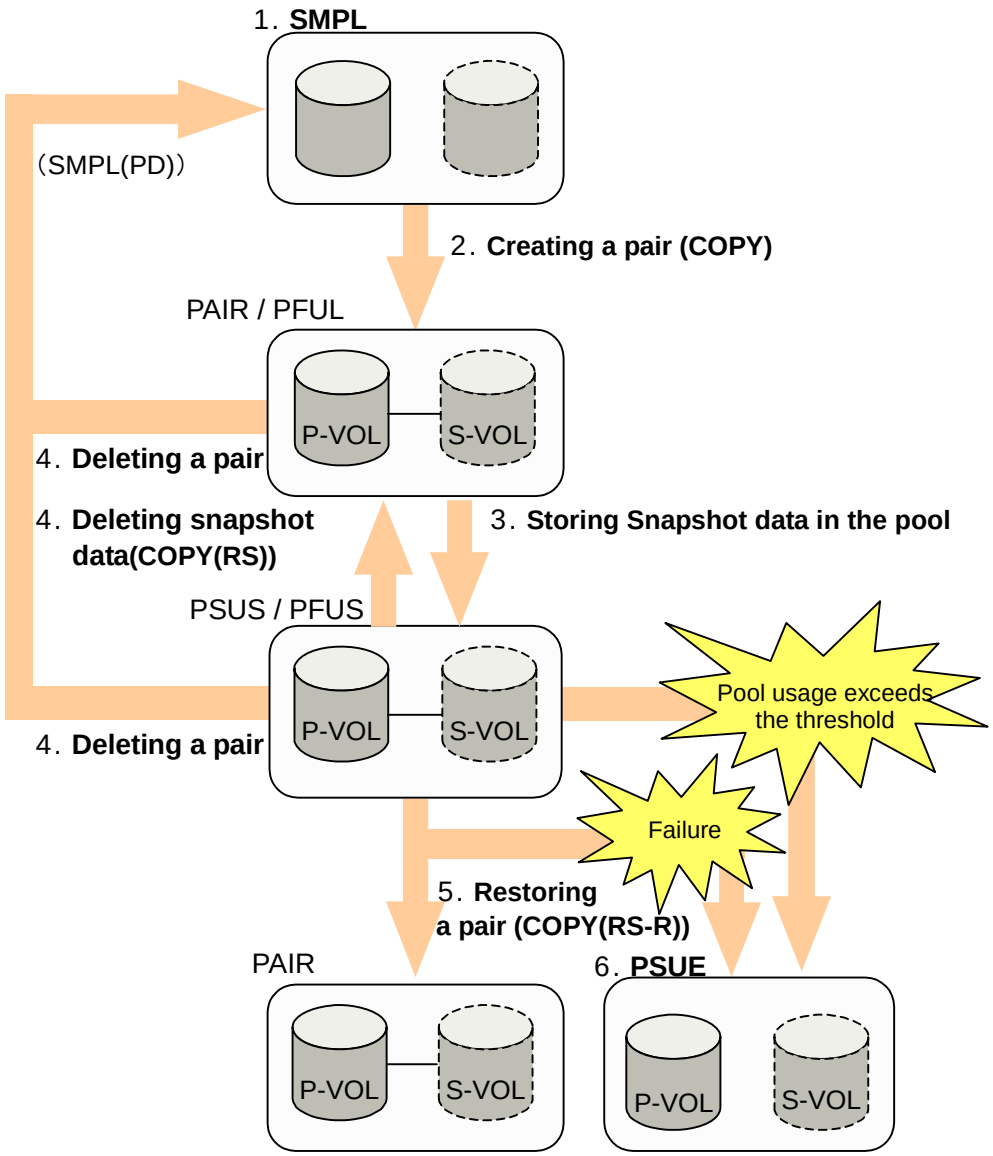

Figure 2-4 Copy-on-Write Snapshot Pair Status Transition

1. If a volume is not assigned to a Copy-on-Write Snapshot pair, its status is SMPL.
2. Issue the paircreate command on the SMPL volume to create a Copy-on-Write Snapshot pair. When you create the first pair for the P-VOL, the pair status changes to COPY, and then the pair status changes to PAIR when the operation completes. If you specify the volume that is already paired with one or more than one S-VOL as the P-VOL to create another pair, the pair status will not change to COPY. The pair status will change to PAIR when the operation completes.
3. Issue the pairsplit command on the Copy-on-Write Snapshot pair in PAIR status to store the snapshot data in the pool. When the operation completes, the pair status changes to PSUS.
   - If you execute the paircreate command immediately after deleting the last snapshot data of the P-VOL, it may take time to create a new pair.
   - If the pool capacity exceeds the threshold when a Copy-on-Write Snapshot pair is in PAIR status, the pair status changes to PFUL in Command Control Interface. For details, see the *Command Control Interface (CCI) User and Reference Guide*.
   - If you issue the paircreate command when the pool capacity exceeds the threshold, the command will be rejected and the pair cannot be created.
4. Issue the pairsplit command on the Copy-on-Write Snapshot pair in PAIR status to store the snapshot data in the pool. When the operation completes, the pair status changes to PSUS.
   - If the pool capacity exceeds the threshold when a Copy-on-Write Snapshot pair is in PSUS status, the pair status changes to PFUS in Command Control Interface. For details, see the *Command Control Interface (CCI) User and Reference Guide*.
5. If you want to delete only snapshot data and leave Copy-on-Write Snapshot pair, issue the pairresync command to the PSUS or PFUS pair. During the operation, the pair status changes to COPY(RS). If you want to delete the Copy-on-Write Snapshot pair, issue the pairsplit-S command or use Storage Navigator. During the operation, the pair status changes to SMPL(PD).
6. Issue the pairresync-restore command on the Copy-on-Write Snapshot pair in PSUS status to restore the pair. After that, the snapshot data will be written back to the P-VOL. During the operation, the pair status changes to COPY(RS-R). When the operation completes, the pair status change to PAIR.
7. A pool can contain only a predefined amount of data. If the total capacity of the snapshot data in the pool exceeds the pool capacity, the pair status changes to PSUE. The pair status changes to PSUE also when a failure occurs while restoring the pair or when the usage rate of the pool reaches to 100 percent. The pair status may changes to PSUE when the failure occurs during the process other than restoring.

Whether the host can read and write the P-VOL or S-VOL of a Copy-on-Write Snapshot pair depends on the status of the pair. Table 2-1 shows the relationship between the pair status and the availability of the host access.

Table 2-1 Whether Hosts can Access P-VOL and S-VOL

Pair Status	P-VOL		S-VOL	
	Read	Write	Read	Write
SMPL	OK	OK	-	-
COPY	OK	OK	No	No
PAIR/PFUL	OK	OK	No	No
PSUS/PFUS	OK	OK	OK	OK
SMPL(PD)	OK	OK	No	No
COPY(RS)	OK	OK	No	No
COPY(RS-R)	OK	OK	No	No
PSUE	OK*	OK*	No	No

OK: Host can access the volume.
No: Host cannot access the volume.

*: If the pair status changes to PSUE because of the failure during the restoration, the host cannot access that pair.

Caution: If the host computer uses application software to monitor the volumes of the Copy-on-Write Snapshot pairs, problems such as abnormal end may occur. For example, since the S-VOL whose status is not PSUS (or PFUS) rejects the access from the host, problems may occur on the monitoring application software whose access is rejected. In addition, if the host computer connects to more than one port, problems may also occur on the ports that are not connected to the S-VOL that rejected the host access. You need to terminate the application software that monitors the volumes to solve these problems.

Use CCI commands to operate Copy-on-Write Snapshot pairs. However, whether or not the operations complete normally depends on the status of the pairs. Table 2-2 shows the pair statuses and the results of the CCI commands.

Table 2-2 Pair Statuses and the Results of the CCI Commands

Pair Status	CCI Command						
	paircreate	paircreate –split	pairsplit	pairresync	pairresync -restore	pairsplit -S	pairsplit -E
SMPL	OK	No	No	No	No	NOP	No
COPY	NOP	No	No	NOP	NOP	No	No
PAIR / PFUL	NOP	OK	OK	NOP	NOP	OK	No
PSUS / PFUS	No	NOP	NOP	OK	OK	OK	No
SMPL(PD)	No	No	No	No	No	NOP	No
COPY(RS)	NOP	No	No	NOP	NOP	No	No
COPY(RS-R)	NOP	No	No	NOP	NOP	No	No
PSUE	No	No	No	OK*	No	OK	NOP

OK: The command executes the process and ends normally.
NOP: The command does not execute the process but ends normally.
No: The command ends abnormally (i.e., command rejected).

*: If you issue the pairresync command to the pair whose status has changed to PSUE because of the shortage of the shared memory for the V-VOL management area, the command will be rejected and end abnormally.

When the command executes the process and ends normally, the pair status changes according to the process. For information about how the pair status changes when the command ends normally, see Figure 2-4 and the paragraphs under the figure.

- The hide mode (-m noread) on the S-VOL is not supported. If you specify the hide mode on the S-VOL and create a pair, the command will end normally but the hide mode will be ignored.
- When the CCI command ends abnormally (for example, when the CCI command is rejected), and if the OS of the host computer is HP-UX, SSB (sense byte), which indicates the cause of the error, will be generated in the CCI's error log file. For more information about the SSBs and the cause of the errors, see Troubleshooting When Using Command Control Interface.

Copy Threshold Option

If the load of USP V/VM subsystem increases, host server I/O performance (response) may be degraded. If Copy-on-Write Snapshot performs restore operation when the load of the subsystem is heavy, it is more likely that host server I/O performance (response) may be degraded. The Copy Threshold option temporarily stops copy processing caused by restore operation when the load of the subsystem is heavy. If you set this option in effect, you can minimize the degradation of host I/O performance by temporarily stopping copy processing caused by restore operation when the load of the subsystem is heavy.

The Copy Threshold option is effective only when the load of the subsystem is heavy. When the Copy Threshold option is in effect, all the copy processing by restore operation stop. For information about the setting of the Copy Threshold option, please call the Support Center.

Copy operations that are stopped by the Copy Threshold option will resume when the load of the subsystem becomes light. If this option is in effect, not only Copy-on-Write Snapshot copy operation but also the copy operations of the following program products will stop when the load of the subsystem is heavy:

- ShadowImage
- ShadowImage for IBM® z/OS®
- Compatible Mirroring for IBM FlashCopy® (both Version 1 and Version 2)
- Volume Migration
  For information about using Volume Migration, contact the Hitachi Data Systems Support Center (see Calling the Hitachi Data Systems Support Center).

Interoperability with Other Products and Functions

Copy-on-Write Snapshot can create pairs by sharing volumes with other program products such as Hitachi TrueCopy® or ShadowImage. In addition, you can create Copy-on-Write Snapshot pairs by using volumes to which attributes are assigned by the Data Retention Utility or Command Control Interface. The following table shows whether or not Copy-on-Write Snapshot pairs can share volumes with other program products.

Table 2-3 Volume Sharing with Other Program Products

Volumes of Other Program Products	Copy-on-Write Snapshot P-VOL	Copy-on-Write Snapshot S-VOL
ShadowImage P-VOL	OK*1	No
ShadowImage S-VOL	OK*1	No
TrueCopy P-VOL	OK	No
TrueCopy S-VOL	OK	No
Universal Replicator P-VOL	OK	No
Universal Replicator S-VOL	OK	No
Volume Migration source volume*2	OK	No
Volume Migration target volume*2	No	No
Read Only volume	OK	OK
Protect volume	OK	OK
"S-VOL Disable" volume	OK	OK
Zero Read Capacity volume	OK	OK
Invisible volume	OK	OK

OK: The Copy-on-Write Snapshot volume can be shared.

No: The Copy-on-Write Snapshot volume cannot be shared.

*1: A ShadowImage pair and a Copy-on-Write Snapshot pair cannot have the same mirror unit (MU) number. For example, if the MU number of the ShadowImage pair is 0, you cannot create a Copy-on-Write Snapshot pair whose MU number is 0 and whose P-VOL is also used as a ShadowImage P-VOL. Also, if the MU number of the Copy-on-Write Snapshot pair is 1, you cannot create a ShadowImage pair whose MU number is 1 and whose P-VOL is also used as a Copy-on-Write Snapshot P-VOL.

*2: For information on using Volume Migration, contact the Hitachi Data Systems Support Center (see Calling the Hitachi Data Systems Support Center).

When Copy-on-Write Snapshot shares the volumes with the other program products, some operations are restricted according to the pair statuses. For detailed information, see the following sections.

- You need Data Retention Utility to set the Read Only attribute, Protect attribute, or “S-VOL Disable”. For details, see the *Data Retention Utility User’s Guide*.
- You need Command Control Interface to set Zero Read Capacity attribute, or Invisible attribute. For details, see the *Command Control Interface (CCI) User and Reference Guide*.
- You can check if the volume has *Read Only* attribute, *Protect* attribute, “S-VOL Disable”, *Zero Read Capacity* attribute, or *Invisible* attribute by looking at the Data Retention Utility window. For details, see the *Data Retention Utility User’s Guide*.

Data Retention Utility

Data Retention Utility can set four different kinds of access attributes on the volumes; Read/Write, Read Only, Protect, S-VOL Disable. Copy-on-Write Snapshot cannot create a pair by specifying the volume whose access attribute is S-VOL Disable as the S-VOL. In addition, if S-VOL Disable attribute is set on the P-VOL of the Copy-on-Write Snapshot pair, you cannot restore the pair.

By using Data Retention Utility, you may set Read/Write, Read Only, Protect, or S-VOL Disable attribute on the volumes that are already used by the Copy-on-Write Snapshot pairs. However, when the pair is in the following status, you cannot set S-VOL Disable attribute on the pair volumes.

- COPY*
- SMPL(PD)*
- COPY(RS)*
- COPY(RS-R)
- PSUE*

  *: You may set S-VOL Disable on the P-VOL even if the pair status is COPY, SMPL (PD), COPY(RS), or PSUE.

For detailed information about setting the access attribute, see the *Data Retention Utility User's Guide*.

Volume Migration

Regardless of the status of the migration plans of Volume Migration, you cannot perform any Copy-on-Write Snapshot operations on the volume that is used by the migration plan. To use a Copy-on-Write Snapshot P-VOL as the source volume of the migration plan, you need to create the Copy-on-Write Snapshot pair first, then create the migration plan.

When Copy-on-Write Snapshot P-VOL and the source volume of the migration plan are shared, you can execute the migration plan only when the Copy-on-Write Snapshot pair is in PAIR status. Deleting and canceling the migration plan are always allowed. These operations are not affected by the Copy-on-Write Snapshot pair status.

For information on using Volume Migration, contact the Hitachi Data Systems Support Center (see Calling the Hitachi Data Systems Support Center).

ShadowImage

Table 2-4 and Table 2-5 show the relationship between ShadowImage pair status and Copy-on-Write Snapshot operations when the Copy-on-Write Snapshot P-VOL is shared with a ShadowImage volume. The relationship between the Copy-on-Write Snapshot pair status and ShadowImage operations for shared volumes is shown in Table 2-6 and Table 2-7.

For detailed information on ShadowImage pair status and operations, see the *ShadowImage User's Guide*.

- Since a Copy-on-Write Snapshot S-VOL uses the data in the P-VOL, the ShadowImage Quick Restore operation is not allowed.
- If a volume of a ShadowImage pair has consistency group settings, you cannot use this volume to create a Copy-on-Write snapshot pair. Also, if you use a volume of a Copy-on-Write snapshot pair to create the ShadowImage pair, you cannot set consistency group to the ShadowImage pair.
- If a volume of a Copy-on-Write snapshot pair has consistency group settings, you cannot use this volume to create a ShadowImage pair. Also, if you use a volume of a ShadowImage pair to create the Copy-on-Write snapshot pair, you cannot set consistency group to the Copy-on-Write snapshot pair.

Table 2-4 COW Snapshot Operations for Shared COW Snapshot P-VOL/ShadowImage P-VOL

Copy-on-Write Snapshot Operations	ShadowImage Pair Status							
	COPY	PAIR	COPY (SP)	PSUS (SP)	PSUS	COPY (RS)	COPY (RS-R)	PSUE
Creating pairs (paircreate)	OK	OK	OK	OK	OK	OK	No	OK
Storing snapshot data (pairsplit)	OK	OK	OK	OK	OK	OK	No	OK
Restoring pairs (pairresync –restore)	No	No	No	No	OK	No	No	OK
Deleting snapshot data (pairresync)	OK	OK	OK	OK	OK	OK	OK	OK
Deleting pairs (pairsplit –S)	OK	OK	OK	OK	OK	OK	OK	OK

OK: Operation is allowed.
No: Operation is not allowed (command rejected).

Table 2-5 COW Snapshot Operations for Shared COW Snapshot P-VOL/ShadowImage S-VOL

Copy-on-Write Snapshot Operations	ShadowImage Pair Status							
	COPY	PAIR	COPY (SP)	PSUS (SP)	PSUS	COPY (RS)	COPY (RS-R)	PSUE
Creating pairs (paircreate)	No	No	No	No	OK	No	No	No
Storing snapshot data (pairsplit)	N/A	No	No	No	OK	No	No	No
Restoring pairs (pairresync –restore)	N/A	No	No	No	OK	No	No	No
Deleting snapshot data (pairresync)	N/A	OK	OK	OK	OK	OK	OK	OK
Deleting pairs (pairsplit –S)	N/A	OK	OK	OK	OK	OK	OK	OK

OK: Operation is allowed.
No: Operation is not allowed (command rejected).
N/A: Not applicable.

Table 2-6 ShadowImage Operations for Shared COW Snapshot P-VOL/ShadowImage P-VOL

ShadowImage Operations	Copy-on-Write Snapshot Pair Status						
	COPY	PAIR	PSUS	SMPL (PD)	COPY (RS)	COPY (RS-R)	PSUE
Creating pairs (paircreate)	OK	OK	OK	OK	OK	No	OK
Creating and splitting pairs (paircreate –split)	OK	OK	OK	OK	OK	No	OK
Splitting pairs (pairsplit)	OK	OK	OK	OK	OK	No	OK
Forward pair resynchronization (pairresync)	OK	OK	OK	OK	OK	No	OK
Normal backward pair resynchronization (pairresync –restore)	OK	OK	OK	OK	OK	No	OK
Quick backward pair resynchronization (pairresync –restore)	No	No	No	No	No	No	No
Suspending pairs (pairsplit –E)	OK	OK	OK	OK	OK	OK	OK
Deleting pairs (pairsplit –S)	OK	OK	OK	OK	OK	OK	OK

OK: Operation is allowed.
No: Operation is not allowed (command rejected).

Table 2-7 ShadowImage Operations for Shared COW Snapshot P-VOL/ShadowImage S-VOL

ShadowImage Operations	Copy-on-Write Snapshot Pair Status						
	COPY	PAIR	PSUS	SMPL (PD)	COPY (RS)	COPY (RS-R)	PSUE
Creating pairs (paircreate)	No	No	No	No	No	No	No
Creating and splitting pairs (paircreate –split)	No	No	No	No	No	No	No
Splitting pairs (pairsplit)	OK	OK	OK	OK	OK	No	OK
Forward pair resynchronization (pairresync)	OK	OK	OK	OK	OK	No	OK
Normal backward pair resynchronization (pairresync –restore)	OK	OK	OK	OK	OK	No	OK
Quick backward pair resynchronization (pairresync –restore)	No	No	No	No	No	No	No
Suspending pairs (pairsplit –E)	OK	OK	OK	OK	OK	No	OK
Deleting pairs (pairsplit –S)	OK	OK	OK	OK	OK	OK	OK

OK: Operation is allowed.
No: Operation is not allowed (command rejected).

TrueCopy or Universal Replicator

Table 2-8 and Table 2-9 show the relationship between the TrueCopy or Universal Replicator pair status and Copy-on-Write Snapshot operations when the Copy-on-Write Snapshot P-VOL is shared with a TrueCopy (TC) or Universal Replicator (UR) volume. Table 2-10 and Table 2-11 show the relationship between the Copy-on-Write Snapshot pair status and TrueCopy or Universal Replicator operations for shared volumes.

You cannot use a volume using two mirrors in a 3DC multi-target configuration, 3DC cascade configuration, or delta resync configuration in three Universal Replicator sites as a Snapshot pair volume.

If a volume uses two mirrors in the 3DC multi-target configuration, the 3DC cascade configuration, or the delta resync configuration consisting of three UR sites, the volume cannot be used as a Snapshot pair volume.

For detailed information on TrueCopy pair status and operations, see the *TrueCopy User's Guide*. For detailed information on Universal Replicator pair status and operations, see the *Universal Replicator User's Guide*.

Table 2-8 COW Snapshot Operations for Shared COW Snapshot P-VOL/TC or UR P-VOL

Copy-on-Write Snapshot Operations	TrueCopy / Universal Replicator Pair Status					
	COPY	PAIR	PSUS	PSUE	Suspending	Deleting
Creating pairs (paircreate)	OK*	OK*	OK*	OK*	OK*	OK*
Storing snapshot data (pairsplit)	OK	OK	OK	OK	OK	OK
Restoring pairs (pairresync –restore)	No	No	OK	OK	No	No
Deleting snapshot data (pairresync)	OK	OK	OK	OK	OK	OK
Deleting pairs (pairsplit –S)	OK	OK	OK	OK	OK	OK

OK: Operation is allowed.
No: Operation is not allowed (command rejected).
***:** These pairs cannot be used as Universal Replicator delta resync pair volumes.

Table 2-9 COW Snapshot Operations for Shared COW Snapshot P-VOL/TC or UR S-VOL

Copy-on-Write Snapshot Operations	TrueCopy / Universal Replicator Pair Status						
	COPY	PAIR	PSUS	PSUE	SSWS*1	Suspending	Deleting
Creating pairs (paircreate)	OK*3	OK*3	OK*3	OK*3	OK*3	OK*3	OK*3
Storing snapshot data (pairsplit)	No	OK	OK	OK	OK	OK	OK
Restoring pairs (pairresync –restore) *2	No	No	No	No	No	No	No
Deleting snapshot data (pairresync)	OK	OK	OK	OK	OK	OK	OK
Deleting pairs (pairsplit –S)	OK	OK	OK	OK	OK	OK	OK

OK: Operation is allowed.

No: Operation is not allowed (command rejected).

1: SSWS is a status of Universal Replicator pairs. TrueCopy pairs will not change to SSWS status.

2: When you restore the Copy-on-Write Snapshot pair whose P-VOL is used as a TrueCopy or Universal Replicator S-VOL, you need to switch operations from the local site to the remote site by executing the horctakeover command.

3: These pairs cannot be used as Universal Replicator delta resync pair volumes.

Table 2-10 TrueCopy / Universal Replicator Operations for Shared COW Snapshot P-VOL/TC or UR P-VOL

TrueCopy / Universal Replicator Operations	Copy-on-Write Snapshot Pair Status						
	COPY	PAIR	PSUS	SMPL (PD)	COPY (RS)	COPY (RS-R)	PSUE
Creating pairs (paircreate)	OK	OK	OK	OK	OK	No	OK
Splitting pairs (pairsplit)	OK	OK	OK	OK	OK	N/A	OK
Resynchronizing pairs (pairresync)	OK	OK	OK	OK	OK	No	OK
Deleting pairs (pairsplit –S)	OK	OK	OK	OK	OK	OK	OK
Switching to remote site (horctakeover)	OK	OK	OK	OK	OK	No	OK

OK: Operation is allowed.
No: Operation is not allowed (command rejected).
N/A: Not applicable.

Table 2-11 TrueCopy / Universal Replicator Operations for Shared COW Snapshot P-VOL/TC or UR S-VOL

TrueCopy / Universal Replicator Operations	Copy-on-Write Snapshot Pair Status						
	COPY	PAIR	PSUS	SMPL (PD)	COPY (RS)	COPY (RS-R)	PSUE
Creating pairs (paircreate)	No	No	No	OK	No	No	No
Splitting pairs (pairsplit)	OK	OK	OK	OK	OK	OK	OK
Resynchronizing pairs (pairresync)	OK	OK	OK	OK	OK	No	OK
Deleting pairs (pairsplit –S)	OK	OK	OK	OK	OK	OK	OK
Switching to remote site (horctakeover)	OK	OK	OK	OK	OK	No	OK
OK: Operation is allowed. **No**: Operation is not allowed (command rejected).							

Dynamic Provisioning

If you plan to use both Copy-on-Write Snapshot and Dynamic Provisioning in one storage system, please note the following:

- You cannot use pools for Dynamic Provisioning as pools for Copy-on-Write Snapshot, and vice versa.
- If you create pools for Dynamic Provisioning, the number of available pools for Copy-on-Write Snapshot decreases according to the number of Dynamic Provisioning pools.
- You cannot create a Copy-on-Write Snapshot pair with a Dynamic Provisioning virtual volume that is being expanded in capacity. You must wait until the expansion is complete and then create the pair.
- You cannot expand the capacity of a Dynamic Provisioning virtual volume that is in a Copy-on-Write Snapshot pair. You must split the pair to simplex (delete the pair), change the size of both volumes in the pair, and then recreate the pair.

System Option Modes

To provide greater flexibility, the USP V/VM storage system has additional operational parameters called *system option modes* (SOMs) that allow you to tailor the USP V/VM to your unique operating requirements. The SOMs are set on the service processor (SVP) by your Hitachi Data Systems representative.

To set and manage the SOMs

1. Review the SOMs for your operational environment. The SOMs are described in detail in the *User and Reference Guide*.
2. Work with your Hitachi Data Systems team to make sure the appropriate SOMs are set on your storage system.
3. Check each new revision of the *User and Reference Guide* to see if there are any SOM changes that may apply to your operational environment. If so, contact your Hitachi Data Systems team.

The following table lists and describes the SOMs applicable to Copy-on-Write Snapshot operations for USP V/VM microcode 60-07-58-00/00. For a complete list of all SOMs for the USP V/VM, see the *User and Reference Guide*. The SOM information may change in future microcode releases. Contact your Hitachi Data Systems team for the latest SOM information.

- **SOM:** SOM number
- **Category:** Functions to which the SOM applies
- **Description:**
  - Function that the SOM provides
  - Default setting (ON or OFF)
  - For remote copy functions, storage system on which the SOM should be set: main control unit (MCU) or remote control unit (RCU)

SOM	Category	Description
460	TrueCopy TrueCopy for z/OS ShadowImage ShadowImage for z/OS Universal Replicator Universal Replicator for z/OS Volume Migration FlashCopy V1, v2 Copy-on-Write Snapshot Dynamic Provisioning	Backup and recovery of control information of certain products from the SVP when the storage system is powered OFF for more than 72 hours. When power is turned off, the control information (in shared memory) of certain products is backed up on the SVP. After that, when volatile power ON is performed, the control information is restored into shared memory from the SVP. **MCU / RCU:** This SOM applies to both the MCU and the RCU. **ON:** Set this SOM to ON when using TC, TCz, SI, SIz, VM, FCv1, FCv2, UR, URz, COW Snapshot, or DP. **OFF (default):** Disabled ***Notes:*** 1. When this SOM is ON, the completion time of power OFF for shared memory backup, or the completion time of volatile power ON after shared memory recovery, is up to 30 minutes. 2. When using power monitoring devices (such as PCI), the monitoring time for power OFF/ON must be set to the maximum of 30 minutes. 3. When the storage system is powered off automatically in a power outage while destage mode is ON, shared memory is not backed up on the SVP even when this SOM is ON. 4. For Dynamic Provisioning: The DP management information is stored in a dedicated area in the pool in case data is lost from shared memory. However, restoring the data from the dedicated area in the pool may take more time than restoring the data from the SVP. Therefore, setting this SOM to ON is recommended to enable data backup and recovery functions from the SVP.
467	ShadowImage ShadowImage for z/OS FlashCopy Copy-on-Write Snapshot Volume Migration Universal Volume Manager	Controls the copy threshold to slow down copy processing to provide overload protection so that host I/O performance is not affected. Copy processing slows down when the percentage of “dirty” data is 60% or higher, and it stops when the percentage is 75% or higher. This happens when using these replication products: ShadowImage, ShadowImage for z/OS, FlashCopy, Copy-on-Write SnapShot, Volume Migration, Universal Volume Manager. This SOM is provided to prevent the percentage from exceeding 60% so that host performance is not affected. **ON (default):** Enables copy overload prevention. Copy processing stops when the percentage of “dirty” data reaches 60% or higher. When the percentage falls below 60%, copy processing restarts. **OFF:** Normal operation. Copy processing slows down if the dirty percentage is 60% or larger, and it stops if the dirty percentage is 75% or larger. ***Caution:*** This SOM must always be set to ON when using an external volume as the secondary volume of any of the above-mentioned replication products. ***Notes:*** ▪ It takes longer to finish the copy processing because it stops for prioritizing the host I/O performance. ▪ This SOM supports background copy only. This SOM does not support the processing to copy the pre-update data to the S-VOL, which occurs when overwriting data to un-copied slots of P-VOL in Split processing or reading or writing data to un-copied slots of S-VOL.

SOM	Category	Description
471	Copy-on-Write Snapshot	Controls whether certain SIMs are reported to maintenance personnel. SIMs with RC 601xxx (Snapshot pool usage rate exceeds the threshold) can be resolved by users, so you can choose whether to report these SIMs to maintenance personnel. **ON:** Report these SIMs to maintenance personnel. **OFF (default):** Do not report these SIMs to maintenance personnel.
585	Copy-on-Write Snapshot	Controls whether page allocation is performed in random or sequential order. At the time of page allocation during the host write operation of COW Snapshot, HDD blocks are sequentially allocated from the top to improve performance in destaging to the pool by achieving efficient HDD access. **ON:** Page allocation is performed in random order. **OFF (default):** Page allocation is performed in sequential order. ***Notes:*** 1. Set this SOM to ON when you want to deactivate the new HDD block allocation method. 2. The action of this SOM has been reversed in the USP V/VM, so that the desired functionality is achieved with the SOM set to OFF (default). For TagmaStore USP/NSC the desired functionality is achieved with the SOM set to ON. ***Caution:*** Setting this SOM to ON for USP V/VM deactivates this functionality. 3. As the HDD blocks are allocated in random order, a pool can become bottleneck, and performance may be affected. 4. Pools created when this SOM was OFF continue to operate on the new logic (function enabling HDD blocks to be allocated from the top), even when this SOM is ON. To change this, you need to delete all pools created while this SOM was OFF.
704	ShadowImage ShadowImage for z/OS Volume Migration Copy-on-Write Snapshot FlashCopy Resync copy	Controls whether copy processing is registered into a new queue or an existing queue. To reduce the chance of MIH, use this SOM to lower the priority of copy processing so that host I/O has a higher priority. This SOM creates new work queues where these jobs can be assigned with a lower priority. **ON:** Copy processing requested is registered into a new queue so that the processing is scheduled with a lower priority than host I/O. **OFF (default):** Copy processing requested is not registered into a new queue. The existing queue is used. ***Note:*** If the PDEV is highly loaded, the priority of read/write copy processing may become lower. As a consequence the copy speed may be slower.

SOM	Category	Description
727	ShadowImage ShadowImage for z/OS FlashCopy V1, V2 Volume Migration Copy-on-Write Snapshot Dynamic Provisioning	Controls whether control information for local copy products that resides in shared memory is saved and recovered to a system disk when power to the storage system is turned OFF. **ON:** The control information in shared memory is automatically saved to a system disk for use after power off. A system disk is required to use this setting. If shared memory is volatilized and recovery of the control information from the SVP fails when power is restored following power off, recovery of the control information from the system disk to shared memory is implemented. **OFF (default):** Automatic save and recovery of control information using a system disk is not available. ***Notes:*** 1. Set this SOM to ON when the following local copy products are used and you want to save and recover control information for these products: SI, SIz, FCv1, FCv2, Volume Migration, COW Snapshot, or Dynamic Provisioning. 2. Set this SOM to ON after preparing a normal system disk that has more than 7.744 MB available capacity (9,082 cylinders for 3390 format). If Define Configuration & Install is performed at the SVP, set this SOM to ON after formatting the system disk. 3. Review the timeout settings on connected systems when this SOM is ON, because power ON/OFF can take up to 15 minutes longer than when this SOM is OFF. 4. You can also set this SOM to ON or OFF using Virtual LVI/LUN (**Additional Configuration Back Up** setting on the **System Disk Options** dialog box).

3

Preparing for Copy-on-Write Snapshot Operations

This chapter describes requirements for using Copy-on-Write Snapshot, installation procedure of Copy-on-Write Snapshot, and calculation of the number of pairs that Copy-on-Write Snapshot can create. Please read this chapter before starting Copy-on-Write Snapshot.

System Requirements

Copy-on-Write Snapshot operations involve the USP V/VM subsystem containing the primary and secondary volumes and the licensed Copy-on-Write Snapshot and ShadowImage feature enabled on the Storage Navigator. The system requirements for Copy-on-Write Snapshot are as follows.

Volume Requirements

Copy-on-Write Snapshot uses P-VOL, S-VOL, and pool-VOL. The requirements (such as emulation type or path definition) of the volumes used for the Copy-on-Write Snapshot are described in this section.

Copy-on-Write Snapshot supports RAID1, RAID5, and RAID6.

Table 3-1 P-VOL Requirements

Item	Requirement
Volume type	Logical volume (LDEV) LUSE volume can be specified. ***Note:*** A LUSE P-VOL must be paired with an S-VOL of the same size and the same structure. For example, if a LUSE P-VOL is created by combining the volumes of 1 GB, 2 GB, and 3 GB in this order, you must specify the LUSE volume that has exactly the same size and the same combination order as the S-VOL. You cannot specify the following volumes as Copy-on-Write Snapshot P-VOLs. ▪ Volumes used as pool-VOLs ▪ Volumes used as S-VOLs of Copy-on-Write Snapshot pairs
Emulation type	OPEN-V
Maximum number	16,384
Path definition	Required
Maximum capacity	4 TB

Table 3-2 S-VOL Requirements

Item	Requirement
Volume type	V-VOL You cannot specify the following volumes as Copy-on-Write Snapshot S-VOLs. ▪ Volumes used as S-VOLs of Copy-on-Write Snapshot pairs ▪ Volumes used by a pair or migration plan of another program product ***Note:*** A LUSE S-VOL must be paired with a P-VOL of the same size and the same structure.
Emulation type	OPEN-V
Maximum number	16,384
Path definition	Required

Table 3-3 Pool-VOL Requirements

Item	Requirement
Volume type	Logical volume (LDEV) ***Note:*** Separating normal volumes and pool-VOLs into different parity groups is recommended for the best performance. You cannot specify the following volumes as Copy-on-Write Snapshot pool-VOLs. ▪ Volumes whose LDEV status is other than Normal or Normal (Quick Format). You cannot specify volumes in blocked status or volumes in copying process. ▪ LUSE volumes ▪ Volumes used as P-VOLs or S-VOLs of Copy-on-Write Snapshot pairs ▪ Volumes already registered in pools of Copy-on-Write Snapshot or Dynamic Provisioning ▪ Volumes used by a pair or migration plan of another program product ▪ Volumes that are set Protect or Read Only attribute, or "S-VOL Disable" setting by Data Retention Utility ▪ Volumes that have Cache Residency Manager settings ▪ System disks ▪ Command devices ▪ Quorum disks You cannot store the following Pool-VOLs in a pool: ▪ Internal volumes and external volumes ▪ In case of external volumes, pool-VOLs whose cache mode is enabled and pool-VOLs whose cache mode is disabled
Emulation type	OPEN-V
RAID level	All RAID levels are supported. You may register the pool-VOLs whose RAID levels are different in the same pool, however, in order to not lower the performance, it is recommended that you specify the same RAID level for pool-VOLs registered in the same pool.
Drive type	FC and SATA and flash drive can be used as drive type. When internal volumes are used, Pool-VOLs with different drive types cannot be intermixed in the same pool. When external volumes are used, Pool-VOLs with different drive types can be intermixed in the same pool. However, for best performance, volumes with different drive types in a pool are not recommended.
Maximum number	8,192 However, the maximum number of pool-VOLs that can be registered in each pool is 1,024. You can create up to 128 pools in one storage system. In addition, the volume already registered as a pool-VOL in a pool cannot be registered in another pool. Also note that if you create pools for Dynamic Provisioning, the number of available pools for Copy-on-Write Snapshot will decrease according to the number of Dynamic Provisioning pools.
Volume capacity	8 GB to 4 TB. ***Note:*** Dividing a parity group into 16 volumes is recommended for the best performance.
Path definition	Not required. The volumes with path definition cannot be specified as a pool-VOL

Copy-on-Write Snapshot Software Requirements

To use Copy-on-Write Snapshot, all USP V/VM hardware, microcode, and software required for ShadowImage operations must be installed and enabled. You also need to purchase a license key for ShadowImage, and install it in Storage Navigator. For detailed information about the license key and software installation, see the *Storage Navigator User's Guide*.

You must operate the Storage Navigator in **Modify** mode to perform Copy-on-Write Snapshot operations. Users in **View** mode can only view Copy-on-Write Snapshot information, but they cannot create new pairs or change the pair status. For information about how to set up and use the Storage Navigator computer, see the *Storage Navigator User's Guide*.

License Requirements

Capacity used by Copy-on-Write Snapshot will be subtracted from the licensed capacity for ShadowImage. Therefore, you need to ensure that the licensed capacity for ShadowImage is larger than the capacity to be used by both ShadowImage and Copy-on-Write Snapshot.

Even when a volume is used for multiple purposes, only the capacity of this volume itself is added to the total volume capacity, and there is no need to multiply the capacity of this volume by the number of purposes it is used for. For example, even if you share one volume as Copy-on-Write Snapshot P-VOL and ShadowImage P-VOL, only the capacity of the volume itself is added to the total volume capacity and there is no need for it to be doubled.

Shared Memory Requirements

The shared memory for the differential table and the V-VOL management area must be installed on the base board. Note that you cannot share the memory for the V-VOL management area with the memory of Dynamic Provisioning.

Requirements for Command Control Interface

To use CCI for Copy-on-Write Snapshot operations, you need to have one volume for CCI's command device. For details about how to set the command device, please refer to the *Command Control Interface (CCI) User and Reference Guide*.

Operational Requirements

This section shows the information you need to know when you perform Copy-on-Write Snapshot.

Calculating Maximum Number of Pairs

The number of Copy-on-Write Snapshot pairs that can be created for a subsystem depends on the number of differential tables, the capacity of shared memory for V-VOL management area, or the number of pair tables. Calculate the number of Copy-on-Write Snapshot pairs that can be created, first by using the number of differential tables, and then by using the capacity of shared memory for V-VOL management area, and finally by using the number of pair tables. Compare the three calculation results. The smallest value is the maximum number of Copy-on-Write Snapshot pairs that can be created for the subsystem. However, note that you may be able to create fewer number of Copy-on-Write Snapshot pairs than the calculation results when there are volumes for Dynamic Provisioning in the same subsystem.

The following are the descriptions of the calculation of the number of Copy-on-Write Snapshot pairs that can be created based on the number of differential tables, the capacity of shared memory for V-VOL management area, or the number of pair tables.

Calculating the Number of Copy-on-Write Snapshot Pairs by Using the Number of Differential Tables

If additional shared memory is installed, the maximum number of differential tables will be 26,176 or 57,600 or 104,768 or 146,688 or 209,600. To calculate the number of Copy-on-Write Snapshot pairs that can be created, calculate the number of differential tables required for the Copy-on-Write Snapshot pair, and compare it with the number of differential tables of the whole subsystem. Other than Copy-on-Write Snapshot, the following program products use differential tables in USP V/VM:

- ShadowImage
- ShadowImage for z/OS
- Compatible Mirroring for IBM FlashCopy Version 1
- Compatible Mirroring for IBM FlashCopy Version 2
- Volume Migration

If any of the program products listed above, other than Copy-on-Write Snapshot, are used in the same subsystem, the number of differential tables that can be used by Copy-on-Write Snapshot pairs is calculated by subtracting the number of differential tables used by the pairs (migration plan for Volume Migration) of the program products listed above from the number of differential tables of the whole subsystem.

Please refer to the manual of each program product for the calculation of the number of required differential tables for ShadowImage, ShadowImage for z/OS, Compatible Mirroring for IBM FlashCopy Version 1, Compatible Mirroring for IBM FlashCopy Version 2, and Volume Migration.

For information on using Volume Migration, contact the Hitachi Data Systems Support Center (see Calling the Hitachi Data Systems Support Center).

To calculate the number of differential tables for each Copy-on-Write Snapshot pair, use the formula below:

```
((X) ÷ 256) ÷ (Z)
```

(X): Capacity of the volume (in kilobytes)
(Z): The number of slots that a differential table can manage (639 × 32)
You must round up the result of the calculation to the nearest whole number.

When the capacity of the volume ((X) in the formula above) is 16 GB (16,777,216 kB), the number of differential tables for each Copy-on-Write Snapshot pair can be calculated as follows.

```
Example
(16,777,216 ÷ 256) ÷ (639 × 32) = 3.19523
```

3.19523 will be 4 when the value after the decimal point is rounded up. This indicates that 4 differential tables are required to create a Copy-on-Write Snapshot pair.

Assume that no other program products use differential tables in a subsystem where the number of differential table is 26,176. The number of differential tables that Copy-on-Write Snapshot can use is 26,176. To create Snapshot pairs that require 4 differential tables for each pair, the calculation will be as follows.

26,176 ÷ 4 = 6,544

Thus, the maximum number of Copy-on-Write Snapshot pairs that can be created is 6,544.

Calculating the Number of Copy-on-Write Snapshot Pairs by Using the Shared Memory Capacity for the Virtual Volume Management Area

The V-VOL management area consists of the following three elements:

- Pool association information
- Pool management block
- Management information other than these above (shared memory is fixed to 10 MB)

The shared memory of the V-VOL management area differs according to the additional shared memory. The following table shows the detailed information.

Table 3-4 Additional Shared Memory for the V-VOL Management Area

Shared Memory	Shared Memory Capacity
COW 1	751,619,276 bytes
COW 2	1,073,741,823 bytes
COW 3	2,147,483,647 bytes
COW 4	3,221,159,935 bytes
COW 5	4,294,901,759 bytes

To calculate the maximum number of Copy-on-Write Snapshot pairs that can be created for a subsystem, use the formula below:

```
Maximum number of Copy-on-Write Snapshot pairs = Total capacity of P-VOLs ÷ {↑(Capacity of one P-VOL ÷ 524,288)↑ × 524,288}
```

524,288: Unit by which pool association information manage the capacity of a P-VOL (in kilobytes)

You must round up the value enclosed by two upward arrows (↑) to the nearest whole number.

Note that pool association information manages the P-VOL capacity by 524,288 kB.

To calculate the total capacity of P-VOLs, use the formula below:

```
Total capacity of P-VOLs = ↑(S1 ÷ 8,736)↑ × 2,048 × 256
```

S1: Shared memory capacity for pool association information (in bytes)
8,736: Capacity of pool association information per one table (in bytes)
2,048: Number of slots of P-VOL that can be managed by the pool association information of one table
256: Capacity of one slot (in kilobytes)

You must round up the value enclosed by two upward arrows (↑) to the nearest whole number.

To calculate S1 (Shared memory capacity for pool association information), use the formula below:

```
S1 = S – S2 - 10,485,760
```

S: Shared memory capacity for the whole V-VOL management area (in bytes)
S2: Shared memory capacity for pool management block (in bytes)
10,485,760: Fixed management information (in bytes)

Note:

- You can check the capacity of the shared memory of pool association information and pool management block in the C.O.W. Snapshot window. See Figure 4-5.
- For the capacity of the shared memory of the whole V-VOL management area, see Table 3-4.

To calculate S2 (Shared memory capacity for pool management block), use the formula below:

```
S2 = ↑[{(P ÷ 256) × 32} ÷ 8,736]↑ × 8,736 + ↑[{(Y ÷ 256) ÷ 270} ÷ 2,048]↑ × 8,736
```

P: Total capacity of all pools (in kilobytes)
Y: Total capacity of the pool-VOLs (in kilobytes)
256: Capacity of one slot (in kilobytes)
32: Capacity of the table that you need to manage the pool of one slot
8,736: Minimum size of pool management block (in bytes)
270: Number of slots that can be managed by the slot management table
2,048: Number of slots that can be managed by the pool management block of the minimum size

You must round up the value enclosed by two upward arrows (↑) to the nearest whole number.

To calculate P (Total capacity of all pools), use the formula below:

```
P = Y – (4,116,000 + 84,000 × Number of pool-VOLs)
```

To calculate the usage of a pool:

- When copying snapshot data to the pool, Copy-on-Write Snapshot always consumes a multiple of 256 kB of the capacity of the pool. 256 kB will be consumed even the snapshot data is smaller than 256 kB.
- When snapshot data is stored consecutively, the capacity of the snapshot data and the usage of the pool will be almost the same. However, the usage of the pool will be larger than the capacity of the snapshot data in some cases, when snapshot data is stored in random.

When the shared memory capacity for the whole V-VOL management area (“S” in the formula above) is 1,024 MB, the capacity of the pool-VOL (“Y” in the formula above) is 4 TB (4,294,967,296 kB), the number of the pool-VOLs is 100, and the capacity of one P-VOL is 10 GB, the number of Copy-on-Write Snapshot pairs that can be created for a subsystem can be calculated as follows.

```
Example
P = 4,294,967,296 − (4,116,000 + 84,000 × 100)
  = 4,282,451,296

S2 = ↑[{( 4,282,451,296 ÷ 256) × 32} ÷ 8,736↑ × 8,736 +
     ↑[{( 4,282,451,296 ÷ 256) ÷ 270} ÷ 2,048 ]↑ × 8,736
  =↑61,275.917...↑ × 8,736 + ↑30.252...↑ × 8,736
  = 61,276 × 8,736 + 31 × 8,736
  = 535,577,952

S1 = 1,073,741,824 – 535,577,952 – 10,485,760
   = 527,678,112

Total capacity of P-VOLs (kB) = ↑( 527,678,112 ÷ 8,736)↑ × 2,048 × 256
                              = ↑60,402.714...↑ × 2,048 × 256
                              = 60,403 × 2,048 × 256
                              = 31,668,568,064

Maximum number of Copy-on-Write Snapshot pairs will be as follows:
Maximum number of Copy-on-Write Snapshot pairs
                              = 31,668,568,064 ÷
                                      [↑{ (10 × 1,024 × 1,024) ÷ 524,288}↑ × 524,288]
                              = 31,668,568,064 ÷ 10,485,760
                              = 3,020
```

According to the results above, the maximum number of Copy-on-Write Snapshot pairs that can be created is 3,020.

If a shared memory is added to your storage subsystem and you know the pool capacity, you can roughly estimate the capacity of a P-VOL that can be created, as explained in Table 3-5. To calculate the actual capacity of a P-VOL that can be created, use the above formulas.

Table 3-5 Rough Estimate of the Capacity of a P-VOL to be Created

If a Shared Memory is Added to		And If the Pool Capacity is								
		2,048 GB	4,096 GB	6,144 GB	8,192 GB	10,240 GB	12,288 GB	14,336 GB	20,480 GB	30,720 GB
USP V	COW 1	25.0 TB	10.5 TB	-	-	-	-	-	-	-
	COW 2	42.0 TB	28.0 TB	13.5 TB	-	-	-	-	-	-
	COW 3	100.0 TB	85.0 TB	71.0 TB	56.0 TB	42.0 TB	28.0 TB	13.5 TB	-	-
	COW 4	164.0 TB	149.0 TB	134.0 TB	120.0 TB	106.0 TB	92.0 TB	77.5 TB	29.0 TB	-
	COW 5	224.0 TB	209.0 TB	194.0 TB	184.0 TB	170.0 TB	156.0 TB	141.5 TB	89.0 TB	14.0 TB
USP VM		25.0 TB	10.5 TB	-	-	-	-	-	-	-
-: Not applicable										

Calculating the Number of COW Snapshot Pairs Using the Number of Pair Tables

Pair tables are used by Compatible FlashCopy Version 2 and Copy-on-Write Snapshot pairs to store control information that is needed to manage the pairs. To create a Compatible FlashCopy Version 2 pair or a Copy-on-Write Snapshot pair, you need one pair table for each pair.

Up to 1,048,575 pair tables are available in one subsystem.

Among USP V/VM program products, only Compatible FlashCopy Version 2 and Copy-on-Write Snapshot use pair tables. Therefore, if you use Compatible FlashCopy Version 2, the number of available pair tables for Copy-on-Write Snapshot pairs can be calculated by subtracting the number of differential tables used by the Compatible FlashCopy Version 2 pairs from the number of pair tables of the whole subsystem.

For information about how to check the number of pair tables used by Compatible FlashCopy Version 2 pairs (i.e., the number of already created Compatible FlashCopy Version 2 pairs), see the *Compatible Mirroring for IBM FlashCopy User's Guide*.

For example, when the number of pair tables used by Compatible FlashCopy Version 2 is 30,000, the number of Copy-on-Write Snapshot pairs that can be created for a subsystem can be calculated as follows.

```
Example
1,048,575 – 30,000 = 1,018,575
```

According to the result above, the maximum number of Copy-on-Write Snapshot pairs that can be created is 1,018,575.

Performance Considerations

If Copy-on-Write Snapshot performs restore operation when the load of the subsystem is heavy, it is more likely that host server I/O performance (response) may be degraded. The Copy Threshold option allows you to effectively decrease the load of the subsystem.

Notes on Defining Pool Capacity

The pool capacity is the total capacity of the pool volumes that are defined in the pool. If the pool capacity is not enough, the status of the Copy-on-Write Snapshot pairs could change to PSUE. When you create a pool, you must estimate the copy capacity (e.g., the capacity of the snapshot data to be copied to the pool) and set enough pool capacity for the estimated copy capacity. If the copy capacity would change according to the period of time, set enough pool capacity for the largest copy capacity.

- When snapshot data is copied to a pool, a multiple of 256 kB of the pool will be consumed. Even if the capacity of the snapshot data is less than 256 kB, you need 256 kB area in the pool for the data.
- If the same area in the P-VOL is updated more than one time, the snapshot data for the area is copied to the pool only when the first update was taken place. Therefore, when the same area in the P-VOL is updated only once, the written data capacity is equal to the copied data capacity. However, when the same area in the P-VOL is updated repeatedly, the copy capacity will be smaller than the written data capacity.
- It is recommended that you use a volume whose capacity is a multiple of 256 kB as a pool-VOL. If the capacity of the volume that is specified as a pool-VOL is not a multiple of 256 kB, the capacity that is less than 256 kB will be rounded off. For example, if you add a volume of 100.125 MB as a pool-VOL, 125 kB will be rounded off and the capacity of the pool will increase only by 100 MB.

When you estimate the copy capacity, you need to consider whether there is only one snapshot data or there are more than one snapshot data.

- In case of one snapshot data

  If the same area in the P-VOL is updated only once, the copy capacity is equal to the capacity of the data that is written between the storing and the deletion of the snapshot data.

  For example, if you want to make a backup by using Copy-on-Write Snapshot, you can backup the data from the S-VOL after storing the snapshot data, and then deleting the snapshot data. In this case, only the data that was written during the backup needs to be copied to the pool, and there is only one snapshot data. Therefore, you can make a backup with the pool of small capacity. However, since you need to read a large amount of data from the S-VOL during the backup, the access to the P-VOL increases and consequentially the host I/O performance may be lowered.

- In case of multiple snapshot data

  After the storing of each snapshot data, if the same area in the P-VOL is updated only once until the snapshot data is deleted, the copy capacity is equal to the capacity of the data that is written between the storing and the deletion of the snapshot data. If there is more than one P-VOL, the copy capacity is equal to the total capacity of the data written to each P-VOL.

When you store more than one snapshot data in the pool, some Copy-on-Write Snapshot pairs may share snapshot data in the pool. While the snapshot data are shared, you can delete the pairs but cannot delete the shared snapshot data from the pool. The shared snapshot data will not be deleted from the pool until all the Copy-on-Write Snapshot pairs that share the snapshot data are deleted.

Though you estimate the copied data capacity and set the pool capacity according to the notes in this section, if the pool capacity exceeds the threshold, see General Troubleshooting and implement measures.

Notes on Using External Volumes as Pool-VOLs

By using Universal Volume Manager, you may connect multiple storage systems to the USP V/VM storage system. In that case, the original USP V/VM storage system is called “local system”, and the connected storage subsystems are called “external systems”. A volume in an external system is called “external volume”. A volume in the local system is called “internal volume”.

If Universal Volume Manager is installed, as well as internal volumes, external volumes can be used as pool-VOLs. However, external volumes are more likely to fail than internal volumes. In addition, solutions for external volume failures are more complicated than those for internal volume failures. To minimize the effects of the failures, it is recommended that you use external volumes as follows:

- Specify the external volumes of only one external subsystem for one pool.
- Do not specify both internal and external volumes as pool-VOLs in one pool.

You may specify the external volumes of several external subsystems for one pool, or use both internal and external volumes as pool-VOLs in one pool, but in that case, mind that problems such as volume blockade might occur. For example, if a problem occurs and the external volume, which is being used as a pool-VOL is blocked, the pool becomes blocked as well. For information about how to recover the blocked pool, see Procedure to Recover a Blocked Pool.

For details about external subsystems and the solutions for the errors related to external volumes, see the *Universal Volume Manager User’s Guide*.

Requirements for Maintaining Copy-on-Write Snapshot

This section describes the notes on switching off the power supply or replacing microprogram offline while the Copy-on-Write Snapshot is in use.

Notes on Replacing the Microprogram Offline

Usually, replacement of the microprogram is performed online, but in some cases, such as when the configuration of the shared memory needs to be changed, replacement of microprogram will be performed offline. If the microprogram is replaced offline, pool information or Copy-on-Write Snapshot pair information in the shared memory will be lost. Therefore, you need to create the pools and the pairs again after the microprogram is replaced.

Notes on Switching Off the Power Supply

Before you switch off the power supply while Copy-on-Write Snapshot is running, stop the host I/O operations. When you switch on the power supply again, Copy-on-Write Snapshot behaves differently according to whether information in shared memory remains before and after switching off the power supply.

- If information in shared memory remains before and after switching off the power supply

  If information in shared memory remains before and after switching off the power supply, use the pools and Copy-on-Write Snapshot pairs that you were using before the switch-off. However, since the storage system checks the status of the pools and pool volumes, if the pool volumes are blocked at that moment, the pool is also blocked and the status of the Copy-on-Write Snapshot pairs changes to PSUE. When this occurs, you need to recover the pools after the switch-on. For details about recovering the pools, see Procedure to Recover a Blocked Pool.

  When you store snapshot data by a consistency group, if power is switched off before the status of all pairs in the same consistency group has changed completely, the storing of snapshot data is not resumed, and the status of some pairs may remain unchanged when power is switched on again.

- If information in shared memory is lost after switching off the power supply

  The USP V/VM has batteries to maintain the information in shared memory. However, if too much time elapses after the breaker is turned off, the battery fails and the information in shared memory is lost. If information in shared memory is lost after switching off the power supply, the information about the pools and Copy-on-Write Snapshot pairs is lost. Therefore, you need to create the pools and pairs again after power is switched on.

  For information about the amount of time before the information in shared memory is lost, when the breaker is turned off, ask the Support Center.

Installing and Uninstalling Copy-on-Write Snapshot

This section describes the procedure for installing and uninstalling Copy-on-Write Snapshot.

Installing Copy-on-Write Snapshot

The installation procedure of Copy-on-Write Snapshot is described below.

1. Install additional shared memory for differential tables.
2. Install additional shared memory for V-VOL management area.
3. Install ShadowImage, which is the prerequisite program product of Copy-on-Write Snapshot.
4. Install Copy-on-Write Snapshot.

- Please call the Support Center to install additional shared memory for V-VOL management area. The shared memory for Copy-on-Write Snapshot and the shared memory for Dynamic Provisioning must be installed separately.
- Once you installed additional shared memory for V-VOL management area, you cannot uninstall it partially. If you want to uninstall the additional shared memory for V-VOL management area, you need to uninstall the entire shared memory that was added for V-VOL management area.
- Skip step 1 if the shared memory for differential tables is already installed.
- Step 1 and 2 are interchangeable.
- Skip step 2 if ShadowImage is already installed to the storage system.
- Since the total capacity of Copy-on-Write Snapshot P-VOLs and pools will be considered as the capacity used by Copy-on-Write Snapshot, you need to purchase enough license for them.

Uninstalling Copy-on-Write Snapshot

The uninstallation procedure of Copy-on-Write Snapshot is described below.

1. Delete all Copy-on-Write Snapshot pairs.
2. Delete all pools.
3. Delete all V-VOLs.
4. Uninstall Copy-on-Write Snapshot.

For detailed information about the procedures for deleting the pairs, pools, and V-VOLs, see the next chapter.

Starting Copy-on-Write Snapshot

After you have enabled the feature for the Storage Navigator and prepared for Copy-on-Write Snapshot operations, you are ready to start up the Copy-on-Write Snapshot. However, since Copy-on-Write Snapshot does not have its own starting menu, you need to start up ShadowImage and LUN Expansion (LUSE) / Virtual LVI/LUN (VLL) in order to use Copy-on-Write Snapshot.

To start ShadowImage or LUN Expansion (LUSE) / Virtual LVI/LUN (VLL) and display the window:

1. Display the Storage Navigator main window.

   For information about how to display the Storage Navigator main window, see the *Storage Navigator User's Guide*.

2. Click **Go** and then **ShadowImage** or **LUN Expansion / VLL** on the menu bar of the Storage Navigator main window.

   The names of the windows that you need for Copy-on-Write Snapshot operations display in the submenu.

3. Click the name of the window you want to display.

   ShadowImage or LUN Expansion (LUSE) / Virtual LVI/LUN (VLL) starts, and the window whose name you clicked in the submenu displays.

   For details about the displayed windows, see the next chapter.

4

Using the Copy-on-Write Snapshot GUI

Copy-on-Write Snapshot information and operations are presented on Storage Navigator windows that are also used for ShadowImage and LUN Expansion/Virtual LVI/LUN (LUSE/VLL). Copy-on-Write Snapshot uses the ShadowImage Pair Operation window, ShadowImage History window, ShadowImage C.O.W. Snapshot window, LUSE/VLL Pool window, and LUSE/VLL V-VOL window.

This chapter describes the Storage Navigator windows that present the Copy-on-Write Snapshot information and allow you to perform Copy-on-Write Snapshot operations.

Pair Operation Window

The ShadowImage Pair Operation window displays information about both ShadowImage and Copy-on-Write Snapshot pairs. This section explains only the items related to the Copy-on-Write Snapshot pairs. For details about the items related to the ShadowImage pairs, see the *ShadowImage User's Guide*.

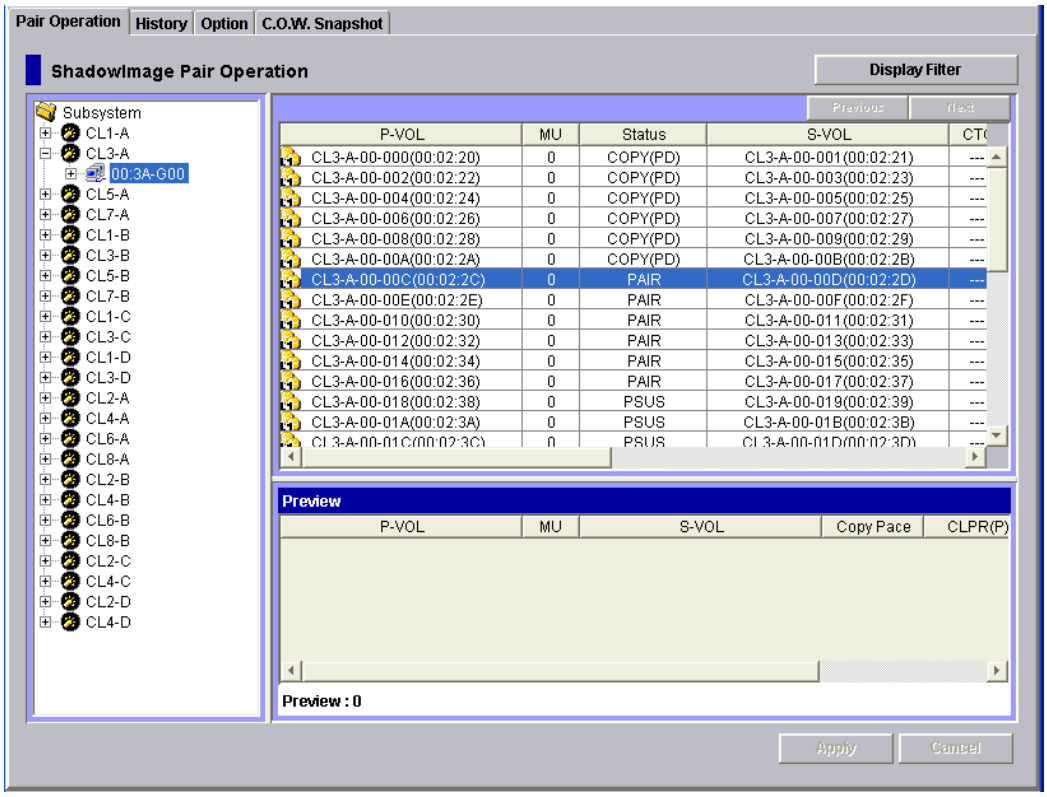

Figure 4-1 Pair Operation Window

Item	Description
Display Filter button	Displays the Display Filter dialog box (Figure 5-2) where you can filter the volumes displayed in the volume list.
Tree (i.e., the area in the left of the window)	Displays the ports that are defined paths or host groups, in Tree style. When you select the items in the tree, information about ShadowImage pairs or Copy-on-Write Snapshot pairs will be displayed in the volume list on the right of window. Note that no volume will be displayed when you select **Subsystem**, which is shown in the top of the tree.
Volume list (i.e., the area in the upper right of the window).	Displays all available volumes.

Item	Description
Icons	The following are the Copy-on-Write Snapshot icons and their meanings. For the icons related to ShadowImage, see the *ShadowImage User's Guide*.  : disk subsystem (storage system)  : port  : host group  : LUN or SMPL volume  : Copy-on-Write Snapshot pair
Preview (i.e., the area in the under the volume list)	Displays the operations that have been performed in the Pair Operation window, but are still not applied to the storage system.
Apply button	Applies the operations displayed in the **Preview** list to the storage system. If the specified operations are applied successfully, the **Preview** list will be cleared. If an error occurs during an operation, the failed operation will remain in the **Preview** list with an error icon () displayed in front. Details of the error (error code and message) are displayed on the error dialog box. For details about the list of the error code of Copy-on-Write Snapshot, see the *Storage Navigator Messages*.
Cancel button	Cancels all the operations set in the **Preview** list.

Volume List

The Volume List (see Figure 4-2) displays volume/pair information for Copy-on-Write Snapshot or ShadowImage, based on the filter options you select in the Tree (displayed on the left side of the window). When you select a port or host group in the tree on the left side of the Pair Operation window, information about the volumes that belong to what you selected in the tree will be displayed in the volume list. You can sort the volumes by any of the items displayed as the column header of the Volume List. You can also filter the volumes by reserve attribute, pair condition, and pair status using the Display Filter dialog box.

The number of volumes that can be displayed in the Volume List at the same time is limited to 1,024 volumes. In case the number of volumes defined in the subsystem exceeds this limit, use the **Previous** and **Next** buttons on the upper right of the Volume List to turn the pages of the Volume List and see the entire list.

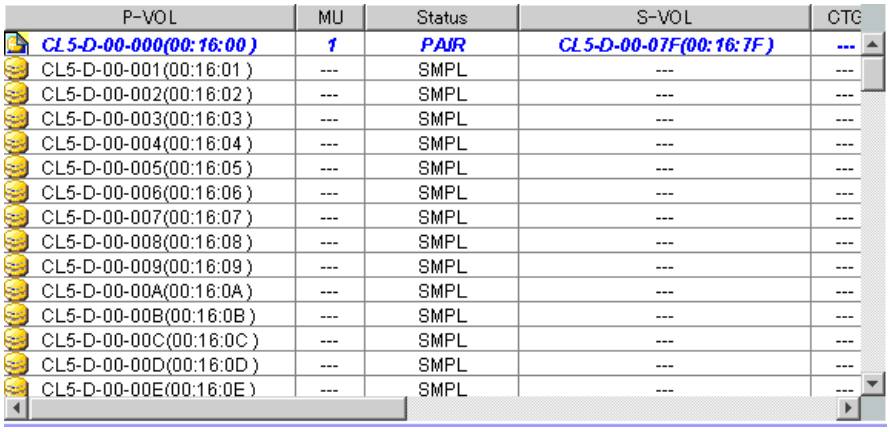

Figure 4-2 Volume List

Item	Description
Previous button	Displays the previous page of the volume list when the total number of the volumes in the storage system is more than 1,024. If the number of the items in the volume list is less than 1,024, this button is grayed out.
Next button	Displays the next page of the volume list when the total number of the volumes in the storage system is more than 1,024. If the number of the items in the volume list is less than 1,024, this button is grayed out.
Message	Displays when there is no volume or pair to be displayed. If you see the message in the Volume List, click a different icon in the Tree on the left area of the Pair Operation window.

Item	Description
P-VOL	Displays information about P-VOL in *AAA-BB-CCC(XX:YY:ZZ)* format. ▪ AAA: The port ID (cluster and channel number) ▪ BB: The group number of host group ▪ CCC: LU number ▪ XX:YY:ZZ: LDKC number:CU number:LDEV number An LDEV number that ends with a pound or gate (#) mark indicates that the LDEV is an external volume (e.g., 00:00:01#). An LDEV number that ends with a letter "X" indicates that the LDEV is a virtual volume used by Dynamic Provisioning (e.g., 00:00:00X). For details regarding the external volumes, see the *Universal Volume Manager User's Guide*. For information about Dynamic Provisioning, see the *Dynamic Provisioning User's Guide*.
MU	Displays the snapshot ID of a Copy-on-Write Snapshot pair. If the pair is in SMPL status, three hyphens (**---**) will display. For details about what displays in this item if you select ShadowImage pairs, see the *ShadowImage User's Guide.*
Status	Displays the status of a Copy-on-Write Snapshot pair or a ShadowImage pair. For details about the status of a Copy-on-Write Snapshot pair, see Status of the Copy-on-Write Snapshot Pairs. For details about the ShadowImage pair status, see the *ShadowImage User's Guide*.
S-VOL:	Displays information about S-VOL in *AAA-BB-CCC(XX:YY:ZZ)* format. AAA: The port ID (cluster and channel number) BB: The group number of host group CCC: LU number XX:YY:ZZ: LDKC number:CU number:LDEV number For LUs with more than one path, only one path is listed. The path is connected to the first port within the ports configured to a path that are shown in the tree view of the **Pair Operation** Window. An LDEV number that ends with a pound or gate (#) mark indicates that the LDEV is an external volume (e.g., 00:00:01#). An LDEV number that ends with a letter "X" indicates that the LDEV is a virtual volume used by Dynamic Provisioning (e.g., 00:00:00X). For details about external volumes, see the *Universal Volume Manager User's Guide*. For information about Dynamic Provisioning, see the *Dynamic Provisioning User's Guide*.
CTG	Displays the consistency group number of the Copy-on-Write Snapshot pair. When the consistency group is not specified, dotted lines (**---**) will display. For information about what displays if it is a ShadowImage pair, see the *ShadowImage User's Guide*.
SvolMode	Displays the status of the S-VOL. When the data is not written in the S-VOL, dotted lines (**---**) will display. When the data is written in the S-VOL, **W** displays. For information about what displays if it is a ShadowImage pair, see the *ShadowImage User's Guide*.
Copy Pace	Displays dotted lines (**---**). For information about what displays if it is a ShadowImage pair, see the *ShadowImage User's Guide*.
Sync.	Displays the consistency rate of the P-VOL and the S-VOL of the Copy-on-Write Snapshot pair. Displayed information changes according to the pair status. See Table 4-1.
Emulation	Displays the emulation type of the volume.
Capacity(MB)	Displays the storage capacity of the volume. The unit is megabyte (MB).
CLPR(P)	Displays the cache logical partition of the P-VOL.
CLPR(S)	Displays the cache logical partition of the S-VOL.

Item	Description
Menu	Displays the menus in Table 4-2 when you select and right-click the Copy-on-Write Snapshot pair volumes in the volume list.

Table 4-1 Information Displayed in Sync

Pair Status	Displayed Information
SMPL	**---** is displayed.
COPY	The consistency rate of the P-VOL and the S-VOL is displayed by percent (%).
PAIR	
COPY(RS)	
COPY(RS-R)	
PSUS	
PSUE	**---** is displayed.
SMPL(PD)	

Table 4-2 Menus of the Volume List of ShadowImage Pair Operation Window (In Case a Copy-on-Write Snapshot Pair is Selected)

Command	Function
Detail	Opens the Detail dialog box (Figure 5-12).
Pairsplit-S	Opens the Pairsplit-S dialog box (Figure 5-11).
S-VOL Path	Opens the S-VOL Path dialog box (Figure 5-13).
Information	Opens the Information dialog box (see Figure 5-14), which displays the number of pairs or reserved volumes.

- The grayed out commands are for ShadowImage pairs. For details about these commands, see the *ShadowImage User's Guide*.
- When you select the **Paircreate** or the **Pairsplit** command from the menu, the Paircreate dialog box or the Pairsplit dialog box will be displayed. However, you cannot create or split Copy-on-Write Snapshot pairs by using these dialog boxes.

Preview List

The **Preview** list is the lower right area in the ShadowImage Pair Operation window. The **Preview** list displays the content of ShadowImage or the Copy-on-Write Snapshot operations that are not applied to the storage system yet.

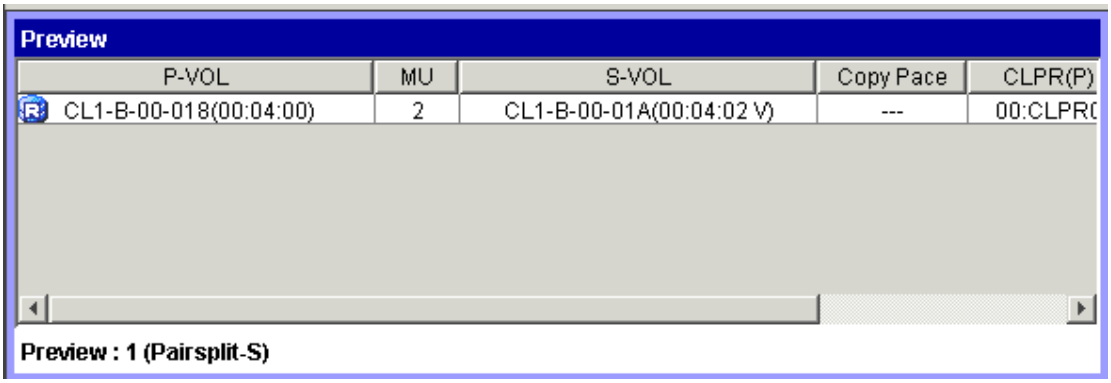

Figure 4-3 Preview List

Item	Description
P-VOL	Displays information about P-VOL in *AAA-BB-CCC(XX:YY:ZZ)* format. ▪ AAA: Port ID (cluster and channel number) ▪ BB: Group number of host group ▪ CCC: LU number ▪ XX:YY:ZZ: LDKC number:CU number:LDEV number An LDEV number that ends with a pound or gate (#) mark indicates that the LDEV is an external volume (e.g., 00:00:01#). An LDEV number that ends with a letter "X" indicates that the LDEV is a virtual volume used by Dynamic Provisioning (e.g., 00:00:00X). For details regarding the external volumes, see the *Universal Volume Manager User's Guide*. For information about Dynamic Provisioning, see the *Dynamic Provisioning User's Guide*.
MU	Displays the snapshot ID of the Copy-on-Write Snapshot pair. If the pair is in SMPL status, **---** will display. For details about what displays in this item if you select ShadowImage pairs, see the *ShadowImage User's Guide.*
S-VOL	Displays information about S-VOL in *AAA-BB-CCC(XX:YY:ZZ)* format. ▪ AAA: Port ID (cluster and channel number) ▪ BB: Group number of host group ▪ CCC: LU number ▪ XX:YY:ZZ: LDKC number:CU number:LDEV number An LDEV number that ends with a pound or gate (#) mark indicates that the LDEV is an external volume (e.g., 00:00:01#). An LDEV number that ends with a letter "X" indicates that the LDEV is a virtual volume used by Dynamic Provisioning (e.g., 00:00:00X). For details regarding the external volumes, see the *Universal Volume Manager User's Guide*. For information about Dynamic Provisioning, see the *Dynamic Provisioning User's Guide*.
Copy Pace	Displays dotted lines (---). For information about what displays if it is a ShadowImage pair, see the *ShadowImage User's Guide*.
CLPR(P)	Displays the cache logical partition of the P-VOL.
CLPR(S)	Displays the cache logical partition of the S-VOL.
Error Code	Displays the code that indicates the cause of the error. If there is no error, dotted lines (**---**) will display.
Menu	When you select and right-click items in the **Preview** list, the menu in displays the following commands: **Delete:** Cancels the selected operation(s) in the **Preview** list. **Error Detail:** Displays the error message dialog box, which displays the error code and message. For the Copy-on-Write Snapshot error codes, see the *Storage Navigator Messages*. **Note:** The grayed out commands are for ShadowImage pairs. For details about those commands, see the *ShadowImage User's Guide.*
Preview X(Y)	X indicates the total number of the operations displayed in the **Preview** list. Y indicates the type of operation.

History Window

The History window (see Figure 4-4) displays the past record of pair operations performed on the Copy-on-Write Snapshot pairs, such as creating or deleting pairs and storing snapshot data.

The upper area of the History window lists the operation history of ShadowImage pairs, and the lower area of the window lists the operation history of Copy-on-Write Snapshot pairs. For details about the operation history of ShadowImage pairs, see the *ShadowImage User's Guide*. The lower area of the History window displays the following items.

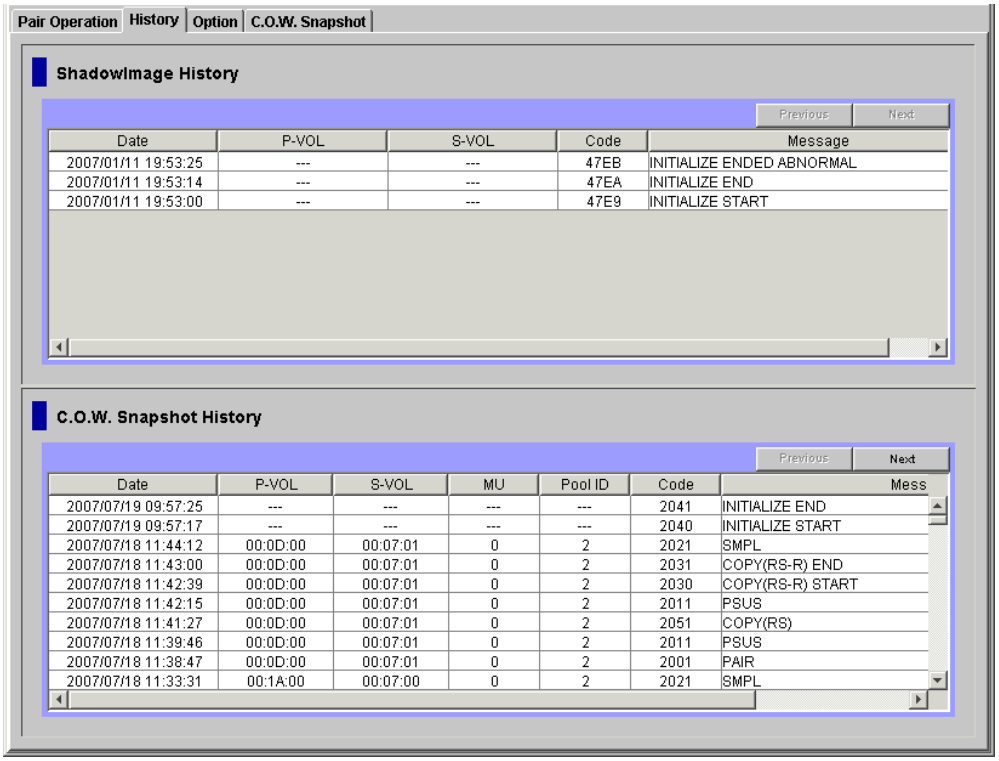

Figure 4-4 History Window

Item	Description
Previous button	Allows you to return to the previous page of the list**.** This button is selectable only when the number of operation histories in the subsystem exceeds 16,384, which is the maximum number of histories that can be displayed on one page. The button is grayed out if the total number of operation histories in the subsystem is less than 16,384.
Next button	Allows you to turn to the next page of the list. This button is selectable only when the number of operation histories in the subsystem exceeds 16,384 volumes, which is the maximum number of histories that can be displayed on one page. The button is grayed out if the total number of operation histories in the subsystem is less than 16,384.

Item	Description
Date	Displays the date and time (YYYY/MM/DD hour/min/sec) when a Copy-on-Write Snapshot pair or volume operation has been performed.
P-VOL	Displays the CU number and LDEV number of a P-VOL used for Copy-on-Write Snapshot operation. An LDEV number that ends with a pound or gate (#) mark indicates that the LDEV is an external volume (e.g., 00:00:01#). An LDEV number that ends with a letter "X" indicates that the LDEV is a virtual volume used by Dynamic Provisioning (e.g., 00:00:00X). For details regarding the external volumes, see the *Universal Volume Manager User's Guide*. For information about Dynamic Provisioning, see the *Dynamic Provisioning User's Guide*.
S-VOL	Displays the CU number and LDEV number of an S-VOL used for Copy-on-Write Snapshot operation. When there is no S-VOL, --- will display. An LDEV number that ends with a "V" indicates that the LDEV is a virtual volume (e.g., 00:00:01V).
MU	Displays the Snapshot data ID of snapshot data used for Copy-on-Write Snapshot operation.
Pool ID	Displays the Pool ID of the pool in which the Copy-on-Write Snapshot pair is registered.
Code	Displays the reference code for Copy-on-Write Snapshot is displayed. For details on reference code, see Table 4-3.
Message	Displays the message that indicates the operation or status of Copy-on-Write Snapshot pair. See Table 4-3.

Table 4-3 Copy-on-Write Snapshot History Reference Codes and Messages

Code	Message	Description
0x2001	PAIR	A COW Snapshot pair was created.
0x2011	PSUS	A COW Snapshot pair was split.
0x2021	SMPL	A COW Snapshot pair was deleted.
0x2030	COPY(RS-R) START	Restoration of a COW Snapshot pair started.
0x2031	COPY(RS-R) END	Restoration of a COW Snapshot pair ended normally.
0x2032	COPY(RS-R) ENDED ABNORMAL	Restoration of a COW Snapshot pair ended abnormally.
0x2051	COPY(RS)	Snapshot data was deleted.
0x2070	PSUE(ABNORMAL END)	A failure occurred and the status of the COW Snapshot pair changes to PSUE.
0x2040	INITIALIZE START	Initialization started.
0x2041	INITIALIZE END	Initialization ended normally.
0x2042	INITIALIZE ENDED ABNORMAL	Initialization ended abnormally.

C.O.W. Snapshot Window

The C.O.W. Snapshot window allows you to see the information of pools that are created for Copy-on-Write Snapshot.

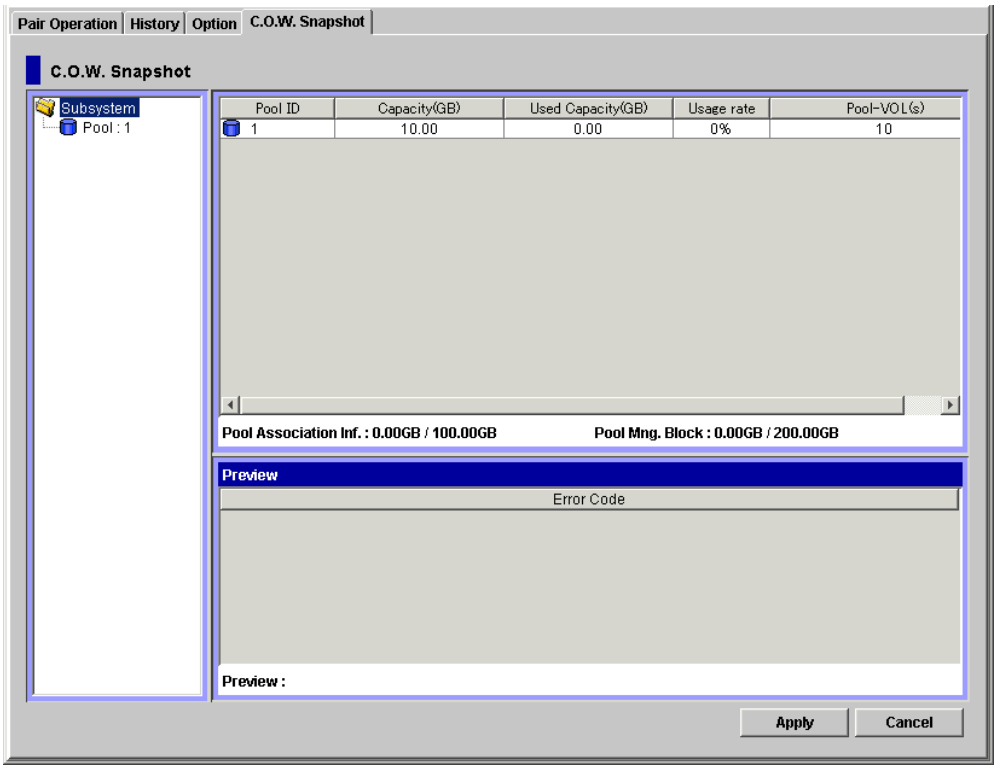

Figure 4-5 C.O.W. Snapshot Window

Item	Description
Tree (i.e., the area in the left of the window)	Pools in the storage system are displayed in the tree style. The following icons are displayed in the tree. : disk subsystem (storage system) Pool:X : pool in normal status (X indicates pool ID) Pool:X : pool whose usage rate exceeds the threshold (X indicates pool ID) Pool:X : blocked pool (X indicates pool ID)

Item	Description
Pool/volume list (i.e., the area in the upper right of the window)	If you select **Subsystem** in the tree, the pool/volume list displays the list of the pools in the storage system. When you selected **Subsystem** in the tree, the following items will be displayed in the pool/volume list. ▪ **Pool ID**: pool ID ▪ **Capacity(GB)**: storage capacity of the pool ▪ **Used Capacity(GB)**: capacity of the pool that is used by the Copy-on-Write Snapshot pairs ▪ **Usage rate**: usage rate of the pool ▪ **Pool-VOL(s)**: total number of the pool-VOLs in the pool ▪ **Snapshot pair(s)**: total number of snapshot data stored in the pool If you select a pool icon in the tree, the pool/volume list displays the list of the Copy-on-Write Snapshot pairs in the pool. When you selected a pool icon in the tree, the following items will be displayed in the pool/volume list. ▪ **P-VOL**: port ID, the group number of host group, and LUN (LDKC number, CU number, and LDEV number of the volume) of the P-VOL ▪ For P-VOL LUs with more than one path, only one path is listed. The path is connected to the first port within the ports configured to a path that are shown in the tree view of the **Pair Operation** Window. ▪ **MU**: snapshot ID ▪ **Status**: status of the Copy-on-Write Snapshot pair ▪ **S-VOL**: port ID, the group number of host group, and LUN (LDKC number, CU number, and LDEV number of the volume) of the S-VOL For S-VOL LUs with more than one path, only one path is listed. The path is connected to the first port within the ports configured to a path that are shown in the tree view of the **Pair Operation** Window. When the volume is unmounted, dotted lines (**---**) will display. ▪ **Pool used(GB)**: capacity of the pool that is used by the S-VOL ▪ **Sync.**: consistency rate of the data of the P-VOL and the S-VOL ▪ **CTG**: consistency group number of the Copy-on-Write Snapshot pair When the consistency group is not specified, dotted lines (**---**) will display.
Pool Association Inf.: X GB / Y GB	X indicates the capacity of the pool association information in use. Y indicates the maximum possible capacity of the pool association information, including the capacity of the pool association information in use. The maximum possible capacity of pool association information is calculated, based on the assumption that the remaining space of the V-VOL management area is used as pool association information. If the remaining space of the V-VOL management area is used for pool management blocks, the maximum possible capacity of pool association information is decreased due to decrease in the remaining space of the V-VOL management area.

Item	Description
Pool Mng. Block: X GB / Y GB	X indicates the capacity of the pool management blocks in use. Y indicates the maximum possible capacity of the pool management blocks, including the capacity of the pool management blocks in use. The maximum possible capacity of pool management blocks is calculated, based on the assumption that the remaining space of the V-VOL management area is used as pool management blocks. If the remaining space of the V-VOL management area is used for pool association information, the maximum possible capacity of pool management blocks is decreased due to decrease in the remaining space of the V-VOL management area. Pool association information and a pool management block are the elements of V-VOL management area. You need to know the capacity of these two elements to calculate the number of Copy-on-Write Snapshot pairs you can create. For information about how to calculate the number of Copy-on-Write Snapshot pairs you can create, see Calculating Maximum Number of Pairs.
Menu (pool/volume list)	When you select a pool icon in the Tree, and then select and right-click the Copy-on-Write Snapshot pairs in the pool/volume list, a menu **Pairsplit-S** will be displayed. If you select this menu, the Pairsplit-S dialog box (Figure 5-11) will be displayed.
Preview list	Displays the content of the operations that have been set or specified in the C.O.W. Snapshot window, but are still not applied to the storage system. To apply the operations displayed in the **Preview** list to the storage system, click **Apply**. **Preview** list displays the following items. ▪ **P-VOL**: port ID, the group number of host group, and LUN of the P-VOL ▪ MU: snapshot ID ▪ S-VOL: port ID, the group number of host group, and LUN of the S-VOL ▪ Error Code: code that indicates the cause of the error. If there is no error, **---** will display. ▪ **Preview X(Y)**: total number of the operations displayed in the **Preview** list(X) and the type of operation(Y)
Menu (**Preview** list in the C.O.W. Snapshot window)	If you select and right-click the operations in the **Preview** list, the menu displays. **Delete:** Cancels the selected operation and deletes the operation from the **Preview** list in the C.O.W. Snapshot window. **Error Detail:** Displays the error message dialog box, which displays the error code and message. For the Copy-on-Write Snapshot error codes, see the *Storage Navigator Messages*.
Apply button	Applies the operations displayed in the **Preview** list to the storage system. If the specified operations complete successfully, the **Preview** list will be cleared. If an error occurs during an operation, the failed operation will remain in the **Preview** list. Details of the error (error code and message) are displayed on the error dialog box. For details about the list of the error code of Copy-on-Write Snapshot, see the *Storage Navigator Messages*.
Cancel button	Cancels all the operations set in the **Preview** list.

Pool Window

The Pool window allows you to create or delete pools. You can also optimize the V-VOL management area or the pool management block by using the Pool window. For details, see the next chapter. (Chapter 5)

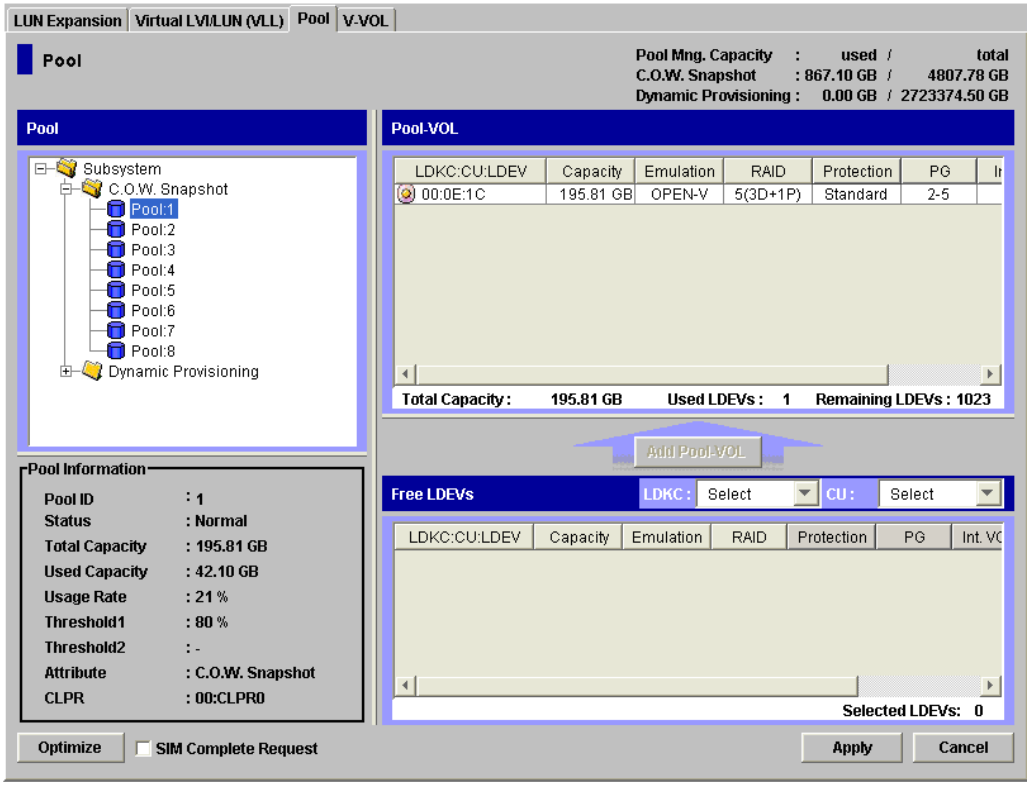

Figure 4-6 Pool Window

Item	Description
Pool **Mng.** Capacity	The names of the program product that uses pool management capacity are displayed. ▪ **used:** Indicates the capacity (GB) of the pool management blocks in use. ▪ **total:** Indicates the maximum possible capacity (GB) of the pool management blocks, including the capacity of the pool management blocks in use. The capacity of pool management blocks is calculated, based on the assumption that the remaining space of the V-VOL management area is used as pool management blocks. If the remaining space of the V-VOL management area is used for pool association information, the maximum possible capacity of pool management blocks is decreased due to decrease in the remaining space of the V-VOL management area. You need to keep the capacity of the pool management blocks in use less than its total cap  ***Caution:*** The value displayed at the **Total Capacity** of the **Pool Information** box and the value displayed at the **Pool Mng.** **Capacity : used** are approximately equal, but there may be some difference. Also note that even if the value displayed at the **Total Capacity** of the **Pool Information** box is updated when the pool-VOLs are added to or deleted from the pool, the value displayed at the **Pool Mng. Capacity : used** will not be updated until you click **Apply**.
Pool tree	Pools in the disk subsystem (storage system) are displayed in the tree style. The following icons are displayed in the tree. The disk subsystem (storage system) or Copy-on-Write Snapshot or Dynamic Provisioning  pool: X: A pool in normal status (X indicates the pool ID)  pool: X: A pool whose usage rate exceeds the threshold (X indicates the pool ID)  pool: X: A blocked pool (X indicates the pool ID)  : A normal pool (in the process of being deleted)  : A blocked pool (in the process of being deleted)
Menu	When you select an icon in the **Pool** tree and right-click the icon, one of the menus in Table 4-4 will be displayed.

Item	Description
Pool-VOL list	Information about the pool-VOLs that are registered in the pool selected in the **Pool** tree. The following items are displayed in the list. ▪ **LDKC:CU:LDEV**: LDKC number, CU number, and LDEV number of the pool-VOL. An LDEV number that ends with a "#" mark indicates that the LDEV is an external volume (e.g., 00:00:01#). An LDEV number that ends with a letter "X" indicates that the LDEV is a virtual volume used by Dynamic Provisioning (e.g., 00:00:00X). For details regarding the external volumes, see the *Universal Volume Manager User's Guide*. For information about Dynamic Provisioning, see the *Dynamic Provisioning User's Guide*. ▪ **Capacity**: capacity of the pool-VOL ▪ **Emulation**: emulation type of the pool-VOL ▪ **RAID**: RAID level (--- will display in case of an external volume) ▪ **Protection**: Data protection level **SATA-W/V**: Write & Verify method on SATA drives **SATA-E**: Enhancing method on SATA drives **Standard**: FC drives, flash drives, external volumes, or V-VOLs Hitachi Data Systems recommends that the data protection level of the pool-VOLs in the same pool be the same. ▪ **PG**: parity group to which the pool-VOL belongs ▪ **Int. VOL Info**: Drive type of internal volumes. Nothing will be displayed for FC drives. An asterisk (*) will be displayed for a SATA drive. A dollar sign ($) will be displayed for a flash drive. Three consecutive hyphens (---) will display for an external volume. Pool-VOLs with different drive types cannot be intermixed in the same pool. ▪ **Ext. VOL Info**: drive type of external volumes. Nothing will be displayed for FC drives. An asterisk (*) will be displayed for a SATA or BD drive. A dollar sign ($) will be displayed for a flash drive Three consecutive hyphens (---) will display for an internal volume. As a best practice, you should specify the same drive type for all Pool-VOLs registered in the same pool. ▪ **Cache Mode:** if the volume is an external volume, cache mode is displayed. This cache mode is specified when the external volume is mapped. Pool-VOLs with different cache modes cannot be intermixed in the same pool. ▪ **Total Capacity**: total capacity of the pool-VOLs in the pool ▪ **Used LDEVs**: total number of the pool-VOLs in the pool ▪ **Remaining LDEVs**: total number of the pool-VOLs that you can add to the pool
Add Pool-VOL button	Adds the selected volume(s) in the **Free LDEVs** list as pool-VOL(s) to the pool that you selected from the **Pool** tree.
LDKC dropdown list	If you select an LDKC from the dropdown list, only the CUs in the selected LDKC will be displayed in the **CU** dropdown list.
CU dropdown list	If you select a CU number from the dropdown list, the volumes in the CU will be displayed in the **Free LDEVs** list. Note that if you select an LDKC from the LDKC dropdown list, only the CUs in the selected LDKC are displayed.

Item	Description
Free LDEVs list	Among the volumes in the CU, which is selected from the **CU** dropdown list, the volumes that can be specified as pool-VOLs will be displayed. The following items are displayed in the list. ▪ **LDKC:CU:LDEV**: LDKC number, CU number, and LDEV number of the volume An LDEV number that ends with a pound or gate (#) mark indicates that the LDEV is an external volume (e.g., 00:00:01#). An LDEV number that ends with a letter "X" indicates that the LDEV is a virtual volume used by Dynamic Provisioning (e.g., 00:00:00X). For details regarding the external volumes, see the *Universal Volume Manager User's Guide*. For information about Dynamic Provisioning, see the *Dynamic Provisioning User's Guide.* ▪ **Capacity**: capacity of the volume ▪ **Emulation**: emulation type of the volume ▪ **RAID**: RAID level (--- will display in case of an external volume) ▪ **Protection**: Data protection level **SATA-W/V**: Write & Verify method on SATA drives **SATA-E**: Enhancing method on SATA drives **Standard**: FC drives, flash drives, external volumes, or V-VOLs Hitachi Data Systems recommends that the data protection level of the pool-VOLs in the same pool be the same. ▪ **PG**: parity group to which the volume belongs ▪ **Int. VOL Info**: drive type of internal volumes. Nothing will be displayed for FC drives. An asterisk (*) will be displayed for a SATA drive. A dollar sign ($) will be displayed for a flash drive. Three consecutive hyphens (---) will display for an external volume. Pool-VOLs with different drive types cannot be intermixed in the same pool. ▪ **Ext. VOL Info**: drive type of external volumes. Nothing will be displayed for FC drives. An asterisk (*) will be displayed for a SATA or BD drive. A dollar sign ($) will be displayed for a flash drive. Three consecutive hyphens (---) will display for an internal volume. As a best practice, you should specify the same drive type for all Pool-VOLs registered in the same pool. ▪ **Cache Mode:** if the volume is an external volume, cache mode is displayed. This cache mode is specified when the external volume is mapped. Pool-VOLs with different cache modes cannot be intermixed in the same pool. ▪ **CLPR**: CLPR number of the CLPR to which the volume belongs ▪ **Selected LDEVs**: total number of the volumes that are selected in the list

Item	Description
Pool Information box	Information about the pool that you selected in the **Pool** tree will be displayed. The following items are displayed in the box. ▪ **Pool ID**: number that identifies the pool ▪ **Status**: status of the pool **Normal**: pool is in the normal status **Blocked**: pool is blocked ▪ **Total Capacity**: total capacity of the pool ▪ **Used Capacity**: used capacity of the pool ▪ **Usage Rate**: proportion of the used pool capacity to the total pool capacity (%). If the usage rate exceeds the threshold, **Warning** will be displayed after the usage rate. If the usage rate reaches 100 %, **Error** will display after the usage rate. ▪ You can set two thresholds for a pool. However, only one threshold is available for a pool for Copy-on-Write Snapshot. **Threshold 1**: threshold for pool usage rate (%). Default setting is 80%. **Threshold 1** can be changed from 20% to 95% in every 5%. **Threshold 2**: Since Copy-on-Write Snapshot does not use **Threshold 2**, hyphen (-) will be displayed. ▪ **Attribute**: program product that uses the pool **C.O.W. Snapshot**: Copy-on-Write Snapshot **Dynamic Provisioning**: Dynamic Provisioning ▪ **CLPR**: CLPR number of the CLPR to which the pool belongs
Optimize button	If there is no pool in the storage system, this button optimizes the whole V-VOL management area. If pools exist in the storage system, this button optimizes the pool management block in the V-VOL management area. Optimization of the pool management block needs up to 20 minutes to complete. If you click this button, all the operations, which are performed in the Pool window before then but not yet applied to the storage system, will be canceled.
SIM Complete Request check box	Completes the SIMs related to pools. If you select the check box and click Apply, the SIMs that occurred when the usage rate of a pool exceeds the threshold, or when a pool becomes blocked will be completed.
Apply button	Applies the operations that have been performed in the Pool window to the storage system. If the specified operations complete successfully, the contents that have been displayed in the blue-italic fonts in the **Pool** tree or **Pool-VOL** list will be displayed in normal black fonts. If an error occurs during the operations, the error code and error message will be displayed in the error message dialog box. For a complete list Copy-on-Write Snapshot error codes, see the *Storage Navigator Messages*.
Cancel button	Cancels all the operations that are performed in the Pool window.

Table 4-4 Menus of the Pool Tree

Menu		Function
When you right-click the **C.O.W. Snapshot** icon:	New Pool	Opens the New Pool dialog box (Figure 5-3). You can select this menu command only when you right-click the **C.O.W. Snapshot** icon.
	Delete Pool(s)	Deletes multiple pools at the same time. You can select this menu command only when the pools that can be deleted exist.
	Restore Pool(s)	Recover multiple blocked pools to the normal status at the same time. You can select this menu command only when the blocked pools exist. However, note that you cannot select this command when the pool is blocked because its utilization ratio is 100% (i.e., POOL FULL).
When you right-click the pool icon:	Change Pool Information	Opens the Change Pool Information dialog box (Figure 5-4).
	Delete Pool	Deletes the pool.
	Restore Pool	Recover the blocked pool to the normal status. You can select this menu command only when you right-clicked the blocked pool icon. However, note that you cannot select this command when the pool is blocked because its utilization ratio is 100% (i.e., POOL FULL).

V-VOL Window

The V-VOL window allows you to create and delete V-VOLs.

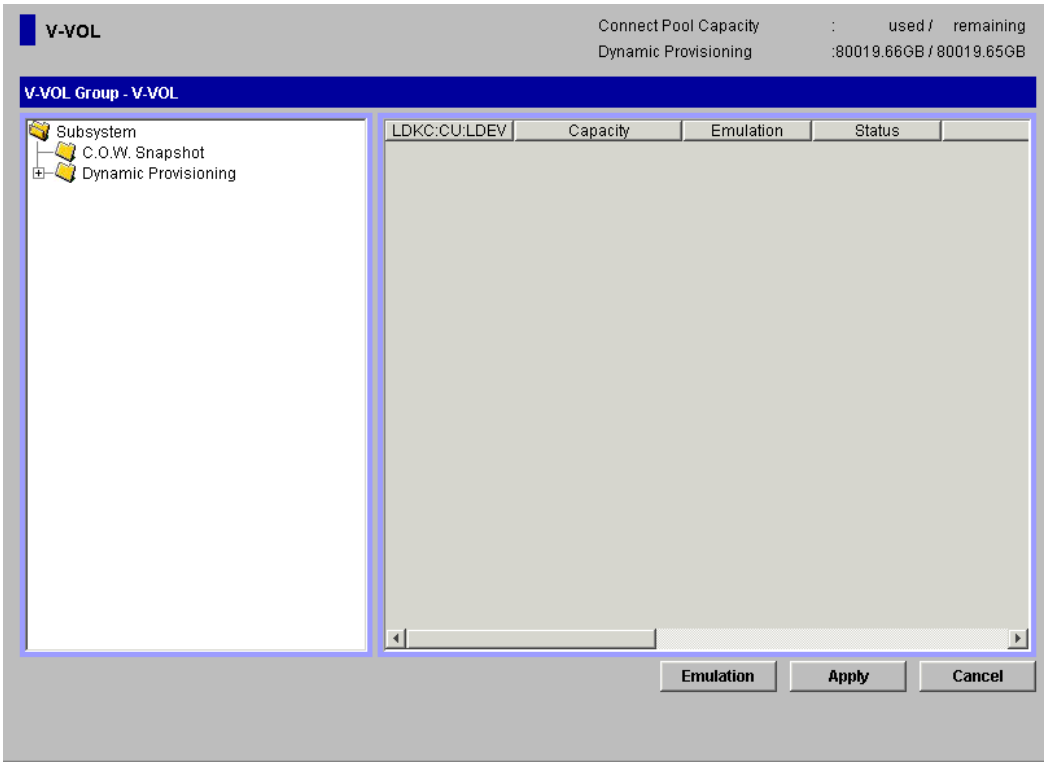

Figure 4-7 V-VOL Window

When you create V-VOLs in the V-VOL window, you create a V-VOL group and create the V-VOLs in the group. When you delete V-VOLs, you delete a V-VOL group including all the V-VOLs in the group. If you want to add V-VOLs to an existing V-VOL group, or if you want to delete only certain V-VOLs from an existing V-VOL group, use the Virtual LVI/LUN function. To use the Virtual LVI/LUN function, you need a license for this function. For details about the Virtual LVI/LUN function, see the *Virtual LVI/LUN and Volume Shredder User's Guide*.

Item	Description
V-VOL Group – V-VOL tree (i.e., the area in the left of the window)	The V-VOL groups in the disk subsystem (storage system) are displayed in the tree style. The following icons are displayed in the tree. : The disk subsystem (storage system) or a program product : V-VOL group : V-VOL group (in the process of being deleted) : VDEV

Item	Description
Menu	When you select the icons in the V-VOL group tree and right-click them, the menus in Table 4-5 will be displayed.
V-VOL list (i.e., the area in the right of the window)	Information about the V-VOLs that are registered in the VDEV selected in the V-VOL group tree. The following items are displayed in the list. ▪ **LDKC:CU:LDEV**: LDKC number, CU number, and LDEV number of the V-VOL V-VOLs available for Copy-on-Write Snapshot have the letter "V" after their LDEV numbers. V-VOLs that have the letter "X" after their LDEV numbers are to be used by Dynamic Provisioning, so you cannot use them for Copy-on-Write Snapshot S-VOLs. ▪ **Free** indicates free space. **Capacity**: capacity of the V-VOL **Emulation**: emulation type of the V-VOL If the emulation type is followed by the word "**CVS**", the volume is a CV (custom-sized volume). For details about CV, see the *Virtual LVI/LUN and Volume Shredder User's Guide*. ▪ **Status**: status of the V-VOL **Normal** **Blocked** ▪ **CLPR**: CLPR number of the CLPR to which the V-VOL belongs ▪ **Access Attribute**: access attribute of the V-VOL ▪ **Path**: LU path of the V-VOL
Emulation button	Changes the emulation type OPEN-0V of the virtual volume used by Dynamic Provisioning into OPEN-V. Also, the contents that have been displayed in blue-italic fonts in the V-VOL group tree or V-VOL list will be aborted.
Apply button	Applies the operations that have been performed in the V-VOL window to the storage system. If the specified operations are completed successfully, the contents that have been displayed in blue-italic fonts in the V-VOL group tree or V-VOL list will be displayed in normal black fonts. If an error occurs during the operations, the error code and error message will be displayed in the error message dialog box. For a complete list of Copy-on-Write Snapshot error codes, see the *Storage Navigator Messages*.
Cancel button	Cancels all the operations that are performed in the V-VOL window.

Table 4-5 Menus of the V-VOL Group Tree

Command	Function
New V-VOL Group	Opens the New V-VOL Group dialog box (Figure 5-5). You can select this command only when you right-click the icon of the program product. To create V-VOLs for Copy-on-Write Snapshot, right-click the **C.O.W. Snapshot** icon.
Delete V-VOL Group	Deletes the V-VOL group and the V-VOLs that are in that V-VOL group. You can select this command only when you right-click the V-VOL group icon.
Delete V-VOL Groups	Opens the Delete V-VOL Groups dialog box (Figure 5-10). Deletes multiple V-VOL groups and the V-VOLs that are in that V-VOL group at the same time. You can select this command when you right-click the **C.O.W. Snapshot** icon.

5

Performing Copy-on-Write Snapshot Operations

This chapter provides instructions for performing Copy-on-Write Snapshot operations.

When you want to check the result or progress of the operations, or when you want to display the latest information on the windows, click **File** and then **Refresh** on the menu bar of the Storage Navigator main window.

Copy-on-Write Snapshot Processes

Figure 5-1 shows the procedure for using Copy-on-Write Snapshot processes.

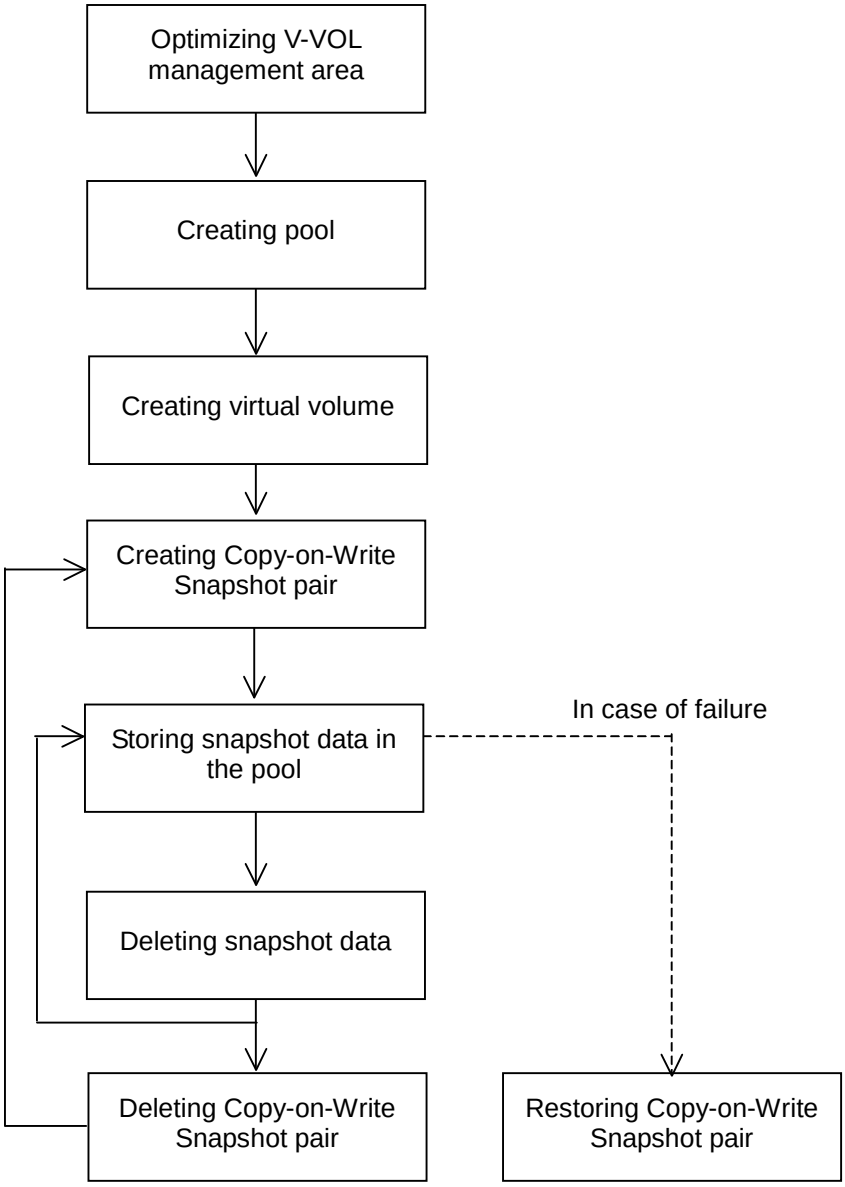

Figure 5-1 Using Copy-on-Write Snapshot

To create the pools and V-VOLs, you need to use Storage Navigator. To create Copy-on-Write Snapshot pairs and perform subsequent operations, you need to use the Command Control Interface. When deleting pairs, you can also use Storage Navigator.

- Before creating a pool, it is required that the virtual volume management area is created in the shared memory. The virtual volume management area is automatically created when the additional shared memory is installed. For details on installing additional shared memory, please call the Support Center.
- If any pools or Copy-on-Write Snapshot pairs are already created for testing purpose before you actually start using Copy-on-Write Snapshot for production purpose, Hitachi Data Systems recommends that you optimize the V-VOL management beforehand.

You do not always need to delete the Copy-on-Write Snapshot pairs after storing snapshot data in the pool. Since one P-VOL can be paired with up to 64 S-VOLs, you need to delete the snapshot data or the pairs that are not necessary. When you delete a Copy-on-Write Snapshot pair, the snapshot data of the pair will also be deleted from the pool.

If a failure occurs and when you restore a Copy-on-Write Snapshot pair, its snapshot data is written back to the P-VOL. You may not be able to restore the pair if another pair is being restored.

Configuring the Volume List

You can display only the specified volumes in the volume list if you specify the conditions in the Display Filter dialog box.

To display the Display Filter dialog box:

1. Display the **ShadowImage** Pair Operation window.
2. Click **Display Filter**. The Display Filter dialog box will be displayed.

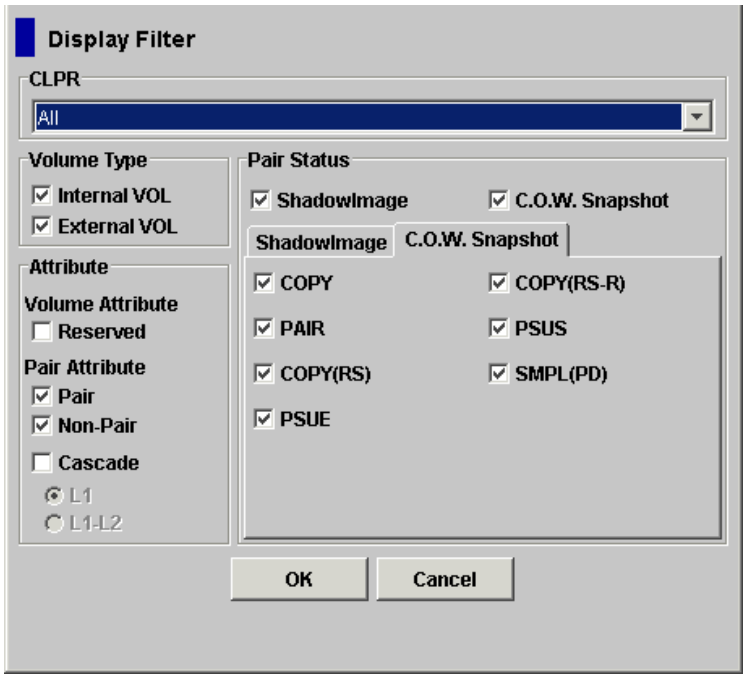

Figure 5-2 Display Filter Dialog Box (C.O.W. Snapshot Tab Selected)

- For details about the **ShadowImage** tab of the Display Filter dialog box, see the ShadowImage User's Guide.
- The filter settings are only effective within the current operations in the ShadowImage Pair Operation window. If you start another program product or click a button on the toolbar on the Storage Navigator main window, the settings will be reset.

If you select the check boxes in the Display Filter dialog box, only the volumes that meet the condition(s) are allowed to be displayed in the volume list. If you deselect the check boxes, the volumes that meet the condition(s) will not be displayed in the volume list.

The Display Filter dialog box displays the following items.

- **CLPR** dropdown list

  Allows you to display the volumes in the specified cache logical partition (CLPR). If you select **All** from the dropdown list, the volumes in all the CLPRs will be displayed in the volume list.

- **Volume Type** box

  The following check boxes are displayed. Both check boxes are selected by default.

  – **Internal VOL**: Displays or hides the internal volumes.

  – External VOL: Displays or hides the external volumes.

- **Attribute** box

  The following check boxes are displayed.

  – **Reserved**: This check box is for ShadowImage pairs. For details, see the *ShadowImage User's Guide*.

  – **Pair**: Displays or hide the volumes that form pair(s).

  – **Non-Pair**: Displays or hide the volumes in SMPL status.

  – **Cascade** (**L1** / **L2** radio buttons): This check box is for ShadowImage pairs. For details, see the *ShadowImage User's Guide*.

- **Pair Status** box

  The following check boxes are displayed.

  – **ShadowImage**: Displays or hides the ShadowImage pairs.

  – **C.O.W. Snapshot**: Displays or hides the Copy-on-Write Snapshot pairs.

  If the check box is not selected, all the check boxes in each tab will be grayed out.

- **ShadowImage tab**

  This tab is for ShadowImage pairs. For details, see the *ShadowImage User's Guide*.

- **C.O.W. Snapshot** tab

  The check boxes that indicate the status of Copy-on-Write Snapshot pairs are displayed. If you select or deselect the check boxes, the Copy-on-Write Snapshot pairs in those statuses will be displayed or hidden in the volume list. To use the check boxes in the **C.O.W. Snapshot** tab, you must select the **C.O.W. Snapshot** check box in the **Pair Status** box.

- **OK** button

  Applies the settings, and closes the Display Filter dialog box.

- **Cancel** button

  Resets the settings, and closes the Display Filter dialog box.

Deleting the Settings in Preview List

The **Preview** list temporarily retains multiple operations of the same type. The setting in the **Preview** list will be reflected in the storage system when you click **Apply**. If the specified operations complete successfully, the **Preview** list will be cleared. If an error occurs during an operation, the failed operation will remain in the **Preview** list with an error icon () displayed on the left of the operation name.

The Copy-on-Write Snapshot setting of the **Preview** list can be deleted only before clicking **Apply**. Procedures for deleting the setting of the **Preview** list are as below.

To delete all of the settings in the **Preview** list, click **Cancel**.

To delete only some of the settings in the **Preview** list:

3. Select and right-click the setting that you want to delete.

   A menu will be displayed.

4. Select the **Delete** command from the menu.

   Only the selected setting will be deleted from the **Preview** list.

Creating or Deleting Pools

This section describes how to create new pools. In addition, the procedures for changing the setting of pools or deleting pools are also described in this section.

Creating New Pools

Required time for creating pools depends on the number and the capacity of the pools and pool-VOLs that you add to the pool. If you create many pools, or if you add a pool-VOL of large capacity, it may take up to 20 minutes until the entire processing ends.

To create a new pool:

1. Change the mode of the Storage Navigator to **Modify**. If the mode is already changed to Modify, you can skip this step. For the information about how to change the mode, see the *Storage Navigator User's Guide*.
2. Right-click **C.O.W. Snapshot** in the Pool tree of the Pool window (Figure 4-6). A menu is displayed.
3. Select **New Pool** from the menu. The New Pool dialog box (Figure 5-3) is displayed.

   Enter the pool ID in the **Pool ID** text box.

   You can enter only a whole number from 0 to 127 in this text box. Do not enter any number that is already used for another pool.

   Select the threshold of the pool usage rate from the **Threshold** list.

Caution: If the usage rate of the pool exceeds the threshold, you cannot create new Copy-on-Write Snapshot pairs. Make sure that you do not set a value that is too small for the threshold.

4. Check the contents of the setting and if there is no problem, and click **Set**. The New Pool dialog box closes, and the new pool will be displayed in the **Pool** tree
5. Select the pool in the **Pool** tree.
6. Select the volumes that you want to register in the pool as the pool-VOLs from the **Free LDEVs** list.
   - If you select the CU number from the **CU** dropdown list, the volumes in the CU will be displayed in the list. Within the same CU, you can select the multiple volumes at the same time.
   - If you select an LDKC from the LDKC dropdown list, only the CUs in the selected LDKC are displayed in the CU dropdown list.
   - See the notes in Notes on Using External Volumes as Pool-VOLs when you select an external volume.

7. Click **Add Pool-VOL**. The dialog box that lists the volumes you selected in step 5 is displayed.

   If you select and right-click the volume in the **Free LDEVs** list, a menu will be displayed. If you select the **Add Pool-VOL** command from the menu, the result will be the same as when you click **Add Pool-VOL**.

8. Check the list of the volumes on the dialog box. If there is no problem, click **OK**. The dialog box closes, and the selected volumes will be displayed in the **Pool-VOL** list.
9. If you want to add more pool-VOLs, repeat step 5 and the subsequent steps.
   - The total capacity of the pool-VOLs in the pool is the storage capacity of the pool. See Notes on Defining Pool Capacity for notes on creating a pool.
   - The capacity of the pool management blocks in use will increase if you add the pool-VOLs. You need to be careful to keep the capacity of the pool management blocks in use less than its total capacity.
10. If you want to create another pool, repeat step 1 and the subsequent steps. Click **Apply**.

    The confirmation message indicating if it is OK to apply the setting to the storage system is displayed.

Caution: You cannot delete the pool-VOLs after you add them. Therefore, ensure that the settings of the pool-VOLs you are going to add are correct.

11. Click **OK**. The confirmation message closes, and the new pool information is applied to the subsystem.

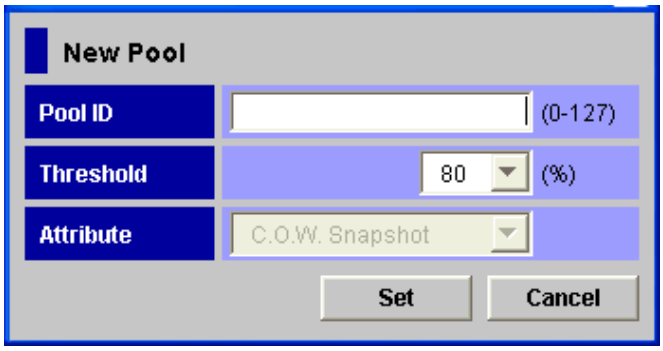

Figure 5-3 New Pool Dialog Box

The New Pool dialog box displays the following items.

- **Pool ID** text box

  You can enter the pool ID in the text box. A whole number from 0 to 127 can be entered in the text box.

  Do not enter the pool ID that is already used by another pool. If you enter the pool ID that is already used by another pool and click **Set**, an error message will be displayed. In that case, enter a different number for the new pool ID.

- **Threshold** dropdown list

  You can select the threshold of the pool usage rate between 20 and 95.

  Unit of the threshold is percent (%). If the pool usage rate exceeds the threshold, the pool status changes to Warning. You cannot create new Copy-on-Write Snapshot pairs to the pool in Warning status. Be careful not to set a very small value for the threshold.

- **Attribute** dropdown list

  The program product that uses the pool is displayed. You cannot select the items from this dropdown list.

- **Set** button

  Creates a new pool according to the settings in the New Pool dialog box and closes the dialog box.

- **Cancel** button

  Cancels the settings in the New Pool dialog box and closes the dialog box. No pool will be created.

Changing the Information of the Pools

After you created the pool, the only setting you can change is the threshold.

To change the threshold of the pool:

1. Change the mode of the Storage Navigator to **Modify**. If the mode is already changed to **Modify**, you can skip this step. For the information about how to change the mode, see the *Storage Navigator User's Guide*.
2. Select and right-click the pool whose setting you want to change in the **Pool** tree of the Pool window. A menu displays. If the pool usage rate is 95 % or higher, the menu will not be displayed.
3. Select the **Change Pool Information** command from the menu. The Change Pool Information dialog box (Figure 5-4) displays.
4. Select the value for the threshold from the **Threshold** dropdown list.

   In the dropdown list, only the values that are higher than the pool usage rate are displayed.
5. Click **OK**. The Change Pool Information dialog box closes.
6. Click **Apply**. The confirmation message indicating if it is OK to apply the setting to the storage system is displayed.
7. Click **OK**. The confirmation message closes, and the change of the setting is applied to the subsystem.

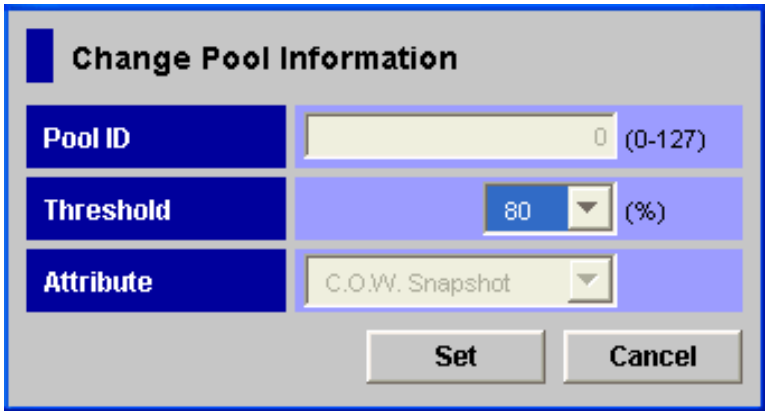

Figure 5-4 Change Pool Information Dialog Box

The items in the Change Pool Information dialog box are the same as those of the New Pool dialog box. However, in the Change Pool Information dialog box, you cannot enter or select the items other than the **Threshold** dropdown list.

Deleting Pools

Usually, you specify one pool and delete only the specified pool. However, you may delete multiple pools at the same time, if necessary. This section describes the procedures for deleting one specified pool and deleting multiple pools at the same time.

Deleting a Pool

To delete a pool:

1. Change the mode of the Storage Navigator to **Modify**. If the mode is already changed to **Modify**, you can skip this step. For information about how to change the mode, see the *Storage Navigator User's Guide*.
2. Select and right-click the pool you want to delete in the Pool tree of the Pool window. A menu displays. If the amount of the pool capacity that is used is other than zero (0) GB, the menu will not be displayed.
3. Select the **Delete Pool** command from the menu. The confirmation message indicating if it is OK to delete the selected pool is displayed.
4. Click **OK**. The icon of the selected pool changes to the icon that indicates the deleting process.
5. Click **Apply**. The confirmation message indicating if it is OK to apply the setting to the storage system is displayed.
6. Click **OK**. The confirmation message closes, and the deletion of the pool is applied to the subsystem.

Deleting Multiple Pools

Caution: If you execute the following operation, all the pools that can be deleted will be deleted. If there is any pool that you do not want to delete, you must delete one pool at a time by following the steps in Deleting a Pool.

To delete multiple pools:

1. Change the mode of the Storage Navigator to **Modify**. If the mode is already changed to **Modify**, you can skip this step. For information about how to change the mode, see the *Storage Navigator User's Guide*.
2. Select and right-click the **C.O.W. Snapshot** icon in the Pool tree of the Pool window. A menu is displayed.
3. Select the **Delete Pool(s)** command from the menu. The confirmation message indicating if it is OK to delete the pools is displayed.
4. Click **OK**. The icons of the pools change to indicate the pools that are being deleted.
5. Click **Apply**. The confirmation message indicating if it is OK to apply the setting to the storage system is displayed.
6. Click **OK**. The confirmation message closes, and the deletion of the pools is applied to the subsystem.

Optimizing V-VOL Management Area or Pool Management Block

This section describes how to optimize the whole V-VOL management area or the pool management block in the V-VOL management area.

Initializing V-VOL Management Area

By initializing the entire V-VOL management area, the V-VOL management area to be used is more efficient. Therefore, you will be able to create the pool whose capacity is larger than before initializing, or you will be able to create more pools compared to before the initialization.

You need to delete all pools in the storage system in order to initialize the V-VOL management area. If pools exist in the storage system, only the pool management block will be optimized instead of the entire V-VOL management area, which will not be initialized.

To initialize the V-VOL management area:

1. Change the mode of the Storage Navigator to **Modify**. If the mode is already changed to Modify, you can skip this step. For information about how to change the mode, see the *Storage Navigator User's Guide*.
2. Click **Optimize** in the Pool window. The confirmation message asking you if it is OK to initialize the V-VOL management area or the pool management block is displayed.
3. Click **OK**. The confirmation message indicating if it is OK to cancel all the operations performed in the Pool window is displayed.
4. Click **OK**. The confirmation message indicating if it is OK to apply the setting to the storage system and perform the initialization is displayed.
5. Click **OK**. The initialization of the V-VOL management area or the pool management block is performed.

Optimizing Pool Management Block

If you optimize the pool management block, I/O performance of the pool will improve compared to before initialization. You can optimize the pool management block without changing the pools already created in the storage system.

The procedure of optimizing the pool management block is same as the procedure of initializing the V-VOL management area. Therefore, follow the instructions in the previous section to optimize the pool management block. You may need up to 20 minutes to optimize the pool management block.

Creating or Deleting Virtual Volumes

This section describes how to create new V-VOLs. In addition, the procedures for deleting pools are also described in this section.

Creating New Virtual Volumes

To create new virtual volumes:

1. Change the mode of the Storage Navigator to **Modify**. If the mode is already changed to **Modify**, you can skip this step. For information about how to change the mode, see the *Storage Navigator User's Guide*.
2. Right-click **C.O.W. Snapshot** in the V-VOL group tree of the V-VOL dialog box. A menu is displayed.
3. Select the **New V-VOL Group** command from the menu. The New V-VOL Group dialog box (Figure 5-5) is displayed.
4. Select or enter the V-VOL group ID in the **V-VOL Group** dropdown list.

   You can enter only the whole number from 1 to 65536. Do not enter the number that is already used for another V-VOL group.
5. Select the emulation type of the V-VOL group from the **Emulation Type** dropdown list.
6. Select the CLPR number of the CLPR in which you want to register the V-VOL group from the **CLPR** dropdown list.
7. Enter the number of the V-VOL group to the **Copy of V-VOL Groups** text box.
   - You can enter only the whole number from 0 to 63231 to the **Copy of V-VOL Groups** text box. However, when the external volume groups of Universal Volume Manager or the V-VOL groups of Dynamic Provisioning are created, the available V-VOL groups for Copy-on-Write Snapshot will be fewer than the maximum number according to the number of the external volume groups and V-VOL groups of Dynamic Provisioning. For example, if 10 external volume groups are created for Universal Volume Manager, you can enter only the whole number under 63221.
   - If you create multiple V-VOL groups at the same time, all V-VOLs that are going to be registered in each V-VOL group will have the same emulation type and capacity.
8. Click **Next**. The Create V-VOL wizard dialog box (1) (Figure 5-6) is displayed.
9. Select the emulation type of the V-VOL from the **Emulation Type** dropdown list.
10. Select the unit of the capacity of the V-VOL from the **Capacity Unit** dropdown list. The selected unit is displayed after the **Capacity** text box.

11. Enter the capacity of the V-VOL in the **Capacity** text box.
    - If the unit is megabyte (MB), you can enter only the whole number from 46 to 4194303. If the unit is block, enter the whole number from 96000 to 8589934592. If the unit is cylinder, enter the whole number from 50 to 4473924.
    - The V-VOLs you are creating will be used when you specify the S-VOLs of the Copy-on-Write Snapshot pairs. Since the capacity of the P-VOL and the S-VOL of the Copy-on-Write Snapshot pair must be equal, consider the capacity of the P-VOLs when you decide the V-VOL capacity.
    - When you specify the **Capacity Unit** as MB or Cyl, the storage system adjusts the capacity to an optimal value. Therefore, when you want to set the capacity accurately to the largest possible V-VOL capacity, specify the **Capacity Unit** as block.
12. Enter the number of the V-VOLs you want to create in the **Number of V-VOL** text box.

    You can enter only the whole number from 1 to 1024 in this text box.
13. Click **Set**. The volumes are added to the V-VOL information setting list (i.e., middle of the dialog box). If you want to create more V-VOLs, repeat step 8 to step 13.

    By using Copy-on-Write Snapshot, you cannot add new V-VOLs to the V-VOL group when you complete the operations to create the V-VOLs. Make sure to add enough V-VOLs to create the Copy-on-Write Snapshot pairs at this point.
14. Click **Next**. The Create V-VOL wizard dialog box (2) (Figure 5-7) is displayed.
15. Select the volume in the V-VOL information setting list (i.e., upper right area of the dialog box).
16. Select the LDKC number from the **Select LDKC No.** dropdown list, and select the CU number from the **Select CU No.** dropdown list. Areas of the CU selected from the dropdown list are displayed in the **Select LDEV No.** area (i.e., middle of the dialog box).
    - Only the areas displayed by the white cells are available for the V-VOLs. You cannot use the areas displayed by the gray cells to create the V-VOLs.
    - If you want to select the CUs that belong to other SLPRs, select the **CU number of another SLPR is used.** check box.
17. Select the interval between the LDEV numbers from the **Interval** dropdown list.

    If you select **0**, the LDEV number will be sequential.

18. Select the area in the **Select LDEV No.** area. The color of the selected area changes to blue. CU number and LDEV number are added to the V-VOL information setting list, and the blue italic fonts change to the black normal fonts. If there are multiple V-VOLs to set, repeat the step 14 to step 18.
19. Click **Next**. The Create V-VOL wizard dialog box (3) (Figure 5-9) is displayed.
20. Check the settings. If there is no problem, click **OK**. The Create V-VOL wizard dialog box (3) (Figure 5-9) closes and the V-VOL window is displayed again. In the V-VOL window, the settings are displayed in the blue italic fonts.
21. Click **Apply**. The confirmation message indicating if it is OK to apply the setting to the storage system is displayed.
22. Click **OK**. The confirmation message closes and the new V-VOL information is applied to the subsystem.

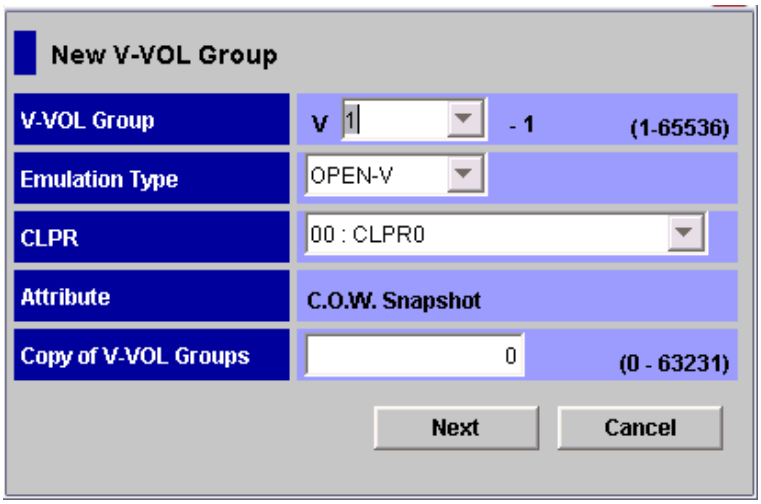

Figure 5-5 New V-VOL Group Dialog Box

The new V-VOL Group dialog box displays the following items.

- **V-VOL Group** dropdown list

  You can select or enter the V-VOL group ID in the dropdown list. The whole number from 1 to 65536 can be selected or entered in the dropdown list.

  Do not enter the V-VOL group ID that is already used by another V-VOL group. If you enter the V-VOL group ID that is already used by another V-VOL group and click **Next**, an error message will be displayed. In that case, please select or enter a different number for the new V-VOL group ID.

- **Emulation Type** dropdown list

  You can select the emulation type of the V-VOL group.

- **CLPR** dropdown list

You can select the CLPR of the V-VOL group.

- **Attribute**

  The name of the program product that is going to use the V-VOL group is displayed. This is the name of the program product whose icon you right-clicked to display the New V-VOL Group dialog box.

- **Copy of V-VOL Groups** text box

  The number of the V-VOL groups to be copied can be entered. You may enter the whole number from 0 to 63231. Note that no V-VOL group will be copied if you enter 0.

- **Next** button

  Fixes the settings in the New V-VOL Group dialog box and displays the Create V-VOL wizard dialog box (1).

- **Cancel** button

  Cancels the settings in the New V-VOL Group dialog box and closes the dialog box.

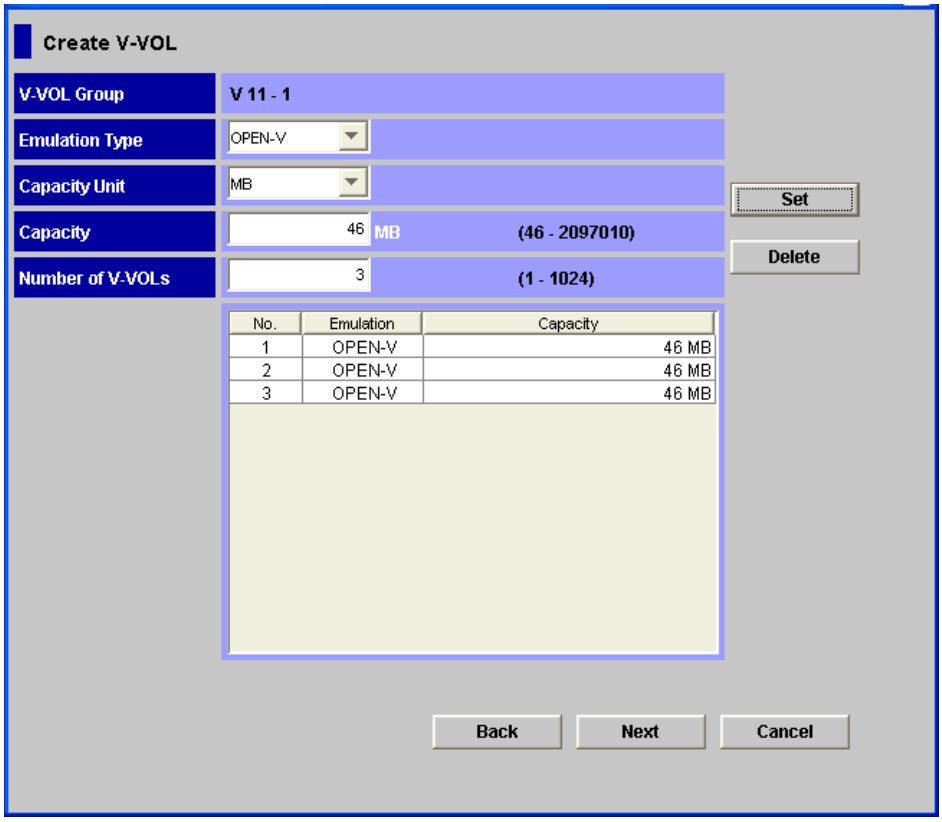

Figure 5-6 Create V-VOL Wizard Dialog Box (1)

The Create V-VOL wizard dialog box (1) displays the following items.

- **V-VOL Group**

  V-VOL group ID that you set in the New V-VOL Group dialog box is displayed.

- **Emulation Type dropdown** list

  You can select the emulation type of the V-VOL.

- **Capacity Unit dropdown** list

  You can select the unit of the capacity of the V-VOL. **MB** (megabyte), **block**, or **Cyl**.

- **Capacity** text box

  You can enter the capacity of the V-VOL in the text box. If you selected **MB** from the **Capacity Unit** dropdown list, you can enter the whole number from 46 to 4194303. If you selected **block** from the dropdown list, you can enter the whole number from 96000 to 8589934592. If you selected **Cyl** from the **Capacity Unit** dropdown list, you can enter the whole number from 50 to 4473924.

  When you specify the **Capacity Unit** as MB or Cyl, the storage system adjusts the capacity to an optimal value. Therefore, when you want to set the capacity accurately to the largest possible V-VOL capacity, specify the **Capacity Unit** as block

- **Number of V-VOL** text box

  You can enter the number of the V-VOLs that you want to add in the text box. Enter the whole number from 1 to 1024.

  The number of the V-VOLs that you can enter changes by the number of the V-VOL groups to be copied and set in the New V-VOL Group dialog box (Figure 5-5). For example, when the number of available V-VOLs is 1024, and if you enter 100 into the **Copy of V-VOL Groups** text box in the New V-VOL Group dialog box, you can specify up to 10 V-VOLs per one V-VOL group. In this case, (1 - 10) is displayed on the right of the **Number of V-VOL** text box.

- **Set** button

  Adds the V-VOL(s) to the V-VOL information setting list.

- **Delete** button

  Deletes the selected V-VOL(s) from the V-VOL information setting list.

- V-VOL information setting list (i.e., middle of the dialog box)

  Information about the V-VOL(s) that you are going to create is displayed.

  – **No.**: number
  – **Emulation**: emulation type of the V-VOL
  – **Capacity**: capacity of the V-VOL

- **Back** button

  Returns to the New V-VOL Group dialog box while maintaining the settings in this dialog box.

- **Next** button

  Confirms the setting in this dialog box and moves to the Create V-VOL wizard dialog box (2).

- **Cancel** button

  Cancels the setting in the Create V-VOL wizard dialog box (1) and closes the dialog box.

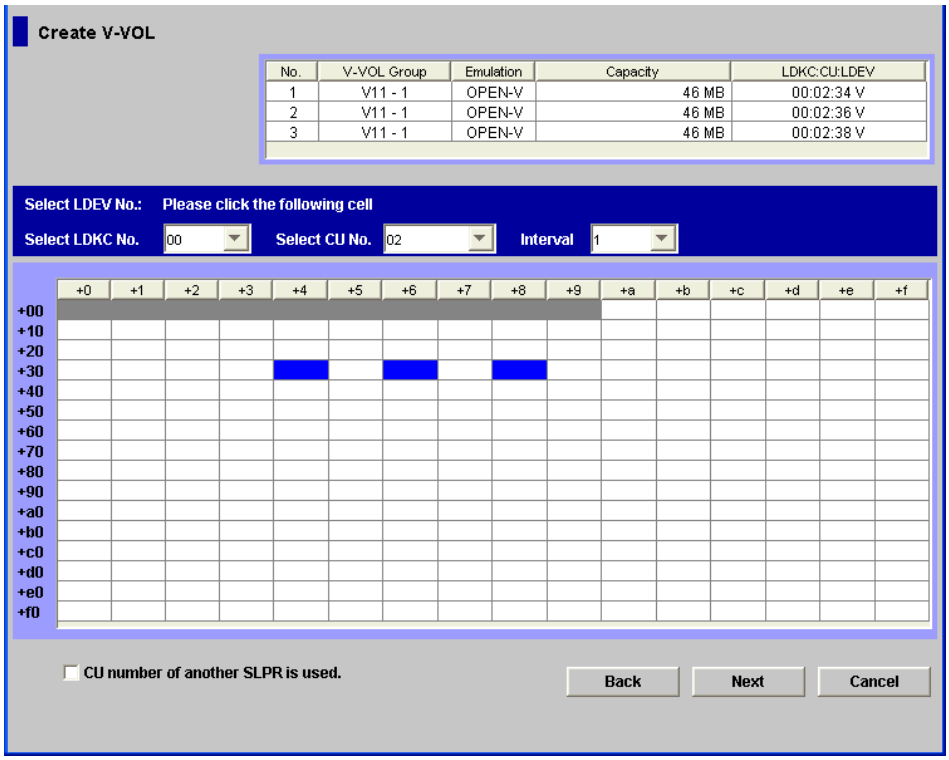

Figure 5-7 Create V-VOL Wizard Dialog Box (2)

The Create V-VOL wizard dialog box (2) displays the following items.

- V-VOL information setting list (i.e., upper right area of the dialog box)

  Information about the V-VOL(s) that you are going to create is displayed.

  - **No.**: number
  - **V-VOL Group.**: V-VOL group ID
  - **Emulation**: emulation type of the V-VOL
  - **Capacity**: capacity of the V-VOL
  - **LDKC:CU:LDEV**: LDKC number, CU number, and LDEV number of the V-VOL

- **Select LDKC** No**.** dropdown list

  You can select the LDKC number.

- **Select CU No.** dropdown list

  You can select the CU number.

- **Interval** dropdown list

  You can select the interval between the LDEV numbers that need to be assigned to the newly created V-VOLs. If you select **0**, the LDEV numbers will be sequential.

  – The value you specify as the interval between LDEV numbers counts only the available LDEV numbers and skips those that are not selectable.

  – Even when you use the multiple CUs, LDEV numbers will be assigned according to the setting in the **Interval** dropdown list.

- **Select LDEV No.** area

  Among the CUs that belong to the LDK you selected in the **Select LDKC No.** dropdown list, the settings of LDEV numbers for the CU number selected from the **Select CU No.** dropdown list are displayed. Numbers in the upper end and the left side indicate the LDEV number. For example, the LDEV number of the cell whose upper end is **+2** and the left side is **+10** is 12.

  Gray cells indicate the LDEV numbers that are already used for other volumes, white cells indicate the unused LDEV numbers, and blue cells indicate the LDEV numbers that are selected for the V-VOLs in this dialog box.

- **CU number of another SLPR is used.** check box

  Allows you to select the CU numbers of the SLPR other than the SLPR you are now in.

- **Back** button

  Returns to the Create V-VOL wizard dialog box (1) while maintaining the settings in this dialog box.

- **Next** button

  Fixes the setting in this dialog box and moves to the Create V-VOL wizard dialog box (3).

  The Create V-VOL dialog box (3) appears only when SSID is not assigned to the boundary area that contains LDEV numbers you set in this dialog box. The Create V-VOL dialog box (4) appears when SSID is assigned.

- **Cancel** button

  Cancels the setting in the Create V-VOL wizard dialog box (2) and closes the dialog box.

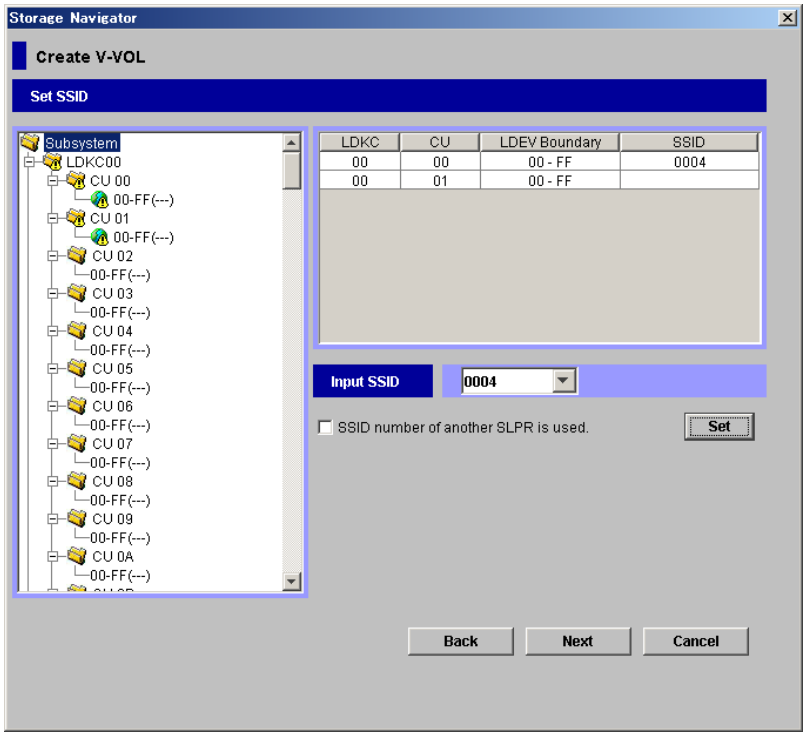

Figure 5-8 Create V-VOL Dialog Box (3)

- **Set SSID tree**

  Shows the LDKC numbers, CU numbers, SSID boundary, and SSID in hierarchical tree structure.

  The boundary area is a collection of LDEV numbers that SSID is assigned to. For example, using the boundary area 00-FF, you need to assign a SSID among the LDEV numbers from 00 to FF. A CU contains one or four boundary areas, which are fixed per CU by the factory settings.

  The parenthesized SSID is shown in the right side of the boundary area. When SSID is not assigned to the boundary area, an exclamation mark is added to the LDKC number, CU number, and boundary area icon, and "---" appears on the right side of the boundary area.

  – : LDKC number or CU number. Indicates that SSID is assigned to the all boundary areas.

  – : LDKC number or CU number. Indicates the boundary area with no SSID.

  – : Indicates that no SSID is assigned to the boundary area.

- **Set SSID list**

  Assigns SSID to the boundary area that contains LDEV numbers you set in this dialog box.

  Information about Set SSID list:

  – **LDKC:** LDKC number of CU number where SSID is not assigned.

  – **CU:** CU number where SSID is not assigned.

  – **LDEV boundary:** Boundary area of LDEV number where SSID is not assigned.

  – **SSID:** Assigned SSID. The initial value is blank.

- **Input SSID list**

  Select or enter an SSID.

  You can enter an SSID only when you are logged in as a storage administrator.

- **Set**

  – **Input SSID:** Sets the SSID you select or input from **Input SSID** list.

  – **Set SSID:** Updates the SSID you select or input from **Input SSID** list.

- **SSID number of another SLPR is used**

  When the **SSID number of another SLPR is used** check box is checked, you can enter the SSID excluding the SLPR that contains a parity group of your operation in the **Input SSID** list. When the check box is not checked, you can only select the SSID of the SLPR that contains a parity group of your operation.

  SSID number of another SLPR is used appears only when you are logged in as a storage administrator and more than two SLPRs exist. When the check box not checked, **Input SSID** is not accessible.

- **Back**

  Maintains the settings in this dialog box while returning you to the **Create V-VOL dialog box (2)**.

- **Next**

  Implements the settings in this dialog box and opens the **Create V-VOL dialog box (4)**.

- **Cancel**

  Cancels the operation and closes the dialog box.

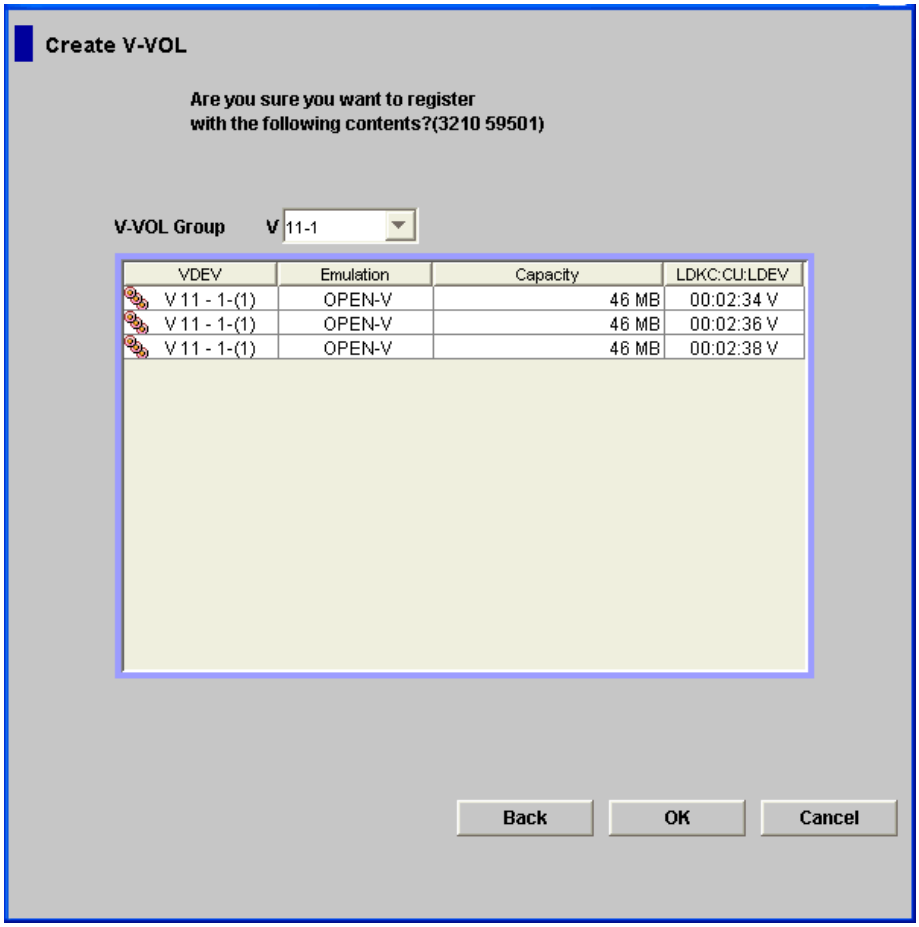

Figure 5-9 Create V-VOL Wizard Dialog Box (4)

The Create V-VOL wizard dialog box (4) displays the following items:

- **V-VOL Group** dropdown list

  You can select the V-VOL group number of the V-VOL you set. Note that you cannot enter the number.

- V-VOL information setting list (i.e., middle of the dialog box)

  Information about the V-VOL(s) whose V-VOL number you selected in the **V-VOL Group** dropdown list is displayed.

  – **VDEV**: V-VOL group number and VDEV number

  – **Emulation**: emulation type of the V-VOL

  – **Capacity**: capacity of the V-VOL

  – **LDKC:CU:LDEV**: LDKC number, CU number, and LDEV number of the V-VOL

- **Back** button

  Returns to the Create V-VOL wizard dialog box (2) while maintaining the settings in this dialog box.

- **OK** button

  Fixes the setting in the Create V-VOL wizard dialog box (4) and closes the dialog box.

- **Cancel** button

  Cancels the setting in the Create V-VOL wizard dialog box (4) and closes the dialog box.

Deleting Virtual Volume(s) and a Virtual Volume Group

To delete V-VOL(s) and a V-VOL group:

1. Change the mode of the Storage Navigator to **Modify**. If the mode is already changed to **Modify**, you can skip this step. For the information how to change the mode, see the *Storage Navigator User's Guide*.
2. In the V-VOL group tree in the V-VOL window, select and right-click the V-VOL group that contains the V-VOL(s) you want to delete. A menu is displayed.
3. Select the **Delete V-VOL Group** command from the menu. The confirmation message indicating if it is OK to delete the selected V-VOL group is displayed.
4. Click **OK**. The icon of the selected V-VOL group changes to the icon that indicates the deleting process.
5. Click **Apply**. The confirmation message indicating if it is OK to apply the setting to the storage system is displayed.
6. Click **OK**. The confirmation message closes, and the deletion of the V-VOL group is applied to the subsystem.

Caution: You cannot delete the V-VOL and its V-VOL group if the V-VOL is used as the S-VOL of the Copy-on-Write Snapshot pair. If you want to delete the V-VOL that is used as the S-VOL and its V-VOL group, first you need to delete that pair.

Deleting Multiple Virtual Volume Groups

To delete V-VOL(s) and multiple V-VOL groups:

Caution: You cannot delete the V-VOLs and its V-VOL groups if the V-VOLs are used as the S-VOLs of the Copy-on-Write Snapshot pairs. If you want to delete the V-VOLs that are used as the S-VOLs and its V-VOL groups, first you need to delete Copy-on-Write Snapshot pairs.

To delete V-VOLs and V-VOL groups:

1. Change the mode of the Storage Navigator to **Modify**. If the mode is already changed to **Modify**, you can skip this step. For information about how to change the mode, see the *Storage Navigator User's Guide*.
2. Right-click **C.O.W. Snapshot** in the V-VOL group tree of the V-VOL window. A menu is displayed.
3. Select the **Delete V-VOL Groups** command from the menu. The Delete V-VOL Groups dialog box (Figure 5-10) is displayed.

   Depending on your environment, it may take approximately 30 seconds to open the Delete V-VOL Groups dialog box.
4. In the V-VOL group's information setting list, in the Delete V-VOL Groups dialog box, select the V-VOL groups you want to delete.
   Specify a relevant CLPR from the CLPR dropdown list, and the list of V-VOL groups that are included in the CLPR is displayed in the V-VOL group's information setting list. To locate the V-VOL groups you want to delete, click the button in the page area under the list and display the page that includes the V-VOL groups you want to delete. Also, the list displays up to a maximum of 4,096 V-VOL groups at a time. If the number of V-VOL groups exceeds 4,096, the **Previous** and **Next** buttons allow you to display the remaining V-VOL groups.
5. Click **Set**. The specified V-VOL groups are displayed in blue italic fonts. Click the **Clear** button if you want to clear the specified V-VOL groups. If you want to specify more V-VOL groups, repeat step 4 and step 5.
6. Click **OK**. The Delete V-VOL Groups dialog box closes. A confirmation message indicating if it is **OK** to apply the setting to the storage system is displayed. Click the **Cancel** button if you want to cancel the setting.
7. Click **OK**. The confirmation message closes, and the deletion of the V-VOL groups is applied to the subsystem. If you click the **Cancel** button in this message, the Delete V-VOL Groups dialog box is displayed again. If the specified V-VOL groups are not deleted, a message dialog box is displayed.

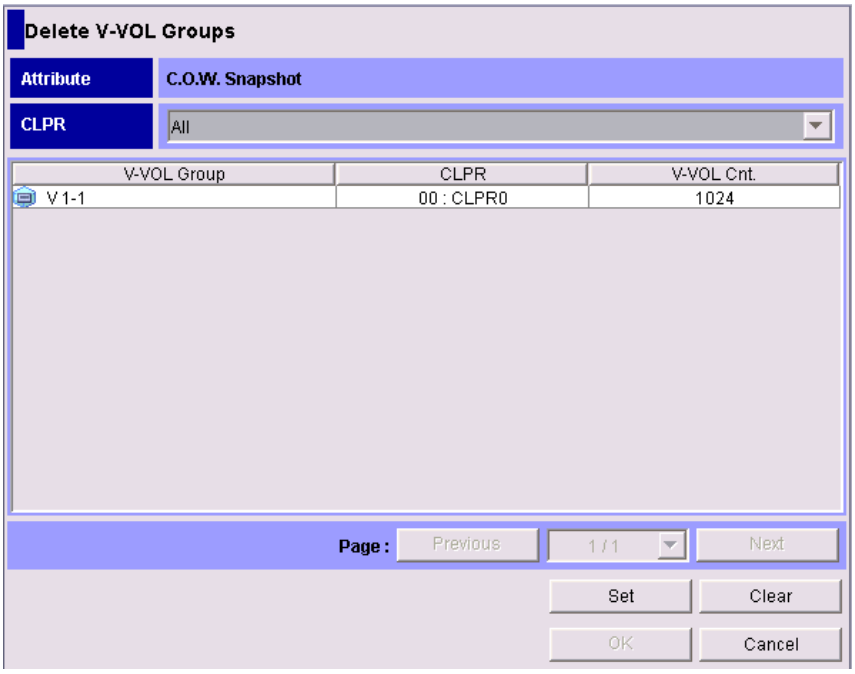

Figure 5-10 Delete V-VOL Groups Dialog Box

The Delete V-VOL Groups dialog box displays the following items.

- **Attribute**

  The name of the program product that is going to use the V-VOL groups is displayed. This is the name of the program product whose icon you right-clicked in order to display the Delete V-VOL Groups dialog box.

- **CLPR** dropdown list

  You can select the CLPR of the V-VOL group. If **All** is selected, all V-VOL groups in all CLPRs are displayed.

- V-VOL information setting list (i.e., center of the dialog box)

  Information about the V-VOL groups that you are going to delete is displayed.

  – **V-VOL Group.**: V-VOL group ID

  – **CLPR**: the number of the CLPR

  – **V-VOL Cnt.**: the number of the V-VOLs in the V-VOL groups

- Icons

  The following icons are displayed in the dialog box.

  – : V-VOL group

  – : V-VOL group (in the process of being deleted)

- The **Page:** area displays the number of the current page and the following items are used to change pages of the list.
  - **Previous** button allows you to display the previous 4,096 V-VOL groups.
  - ***N*/*M*** drop-down list: The ***N*** displays the number of the current page. The ***M*** displays total number of pages. You can click the drop-down list, and choose the number of the page you want to display.
  - **Next** button allows you to display the next 4,096 V-VOL groups.
- **Set** button specifies that the V-VOL groups selected in the V-VOL information setting list will be deleted. The V-VOL groups to be deleted are displayed as blue-italic fonts.
- **Clear** button clears the each setting in the V-VOL information setting list.
- **OK** button closes the Delete V-VOL Groups dialog box. A confirmation message indicating if it is OK to apply the setting to the storage system is displayed.
- **Cancel** button cancels all the settings in the Delete V-VOL Groups dialog box.

Creating Copy-on-Write Snapshot Pairs

Use the paircreate command of the Command Control Interface to create Copy-on-Write Snapshot pairs. To create Copy-on-Write Snapshot pairs, the following is required.

- Specify a volume that meets the requirements in Table 3-1 as a P-VOL
- Specify a volume that meets the requirements in Table 3-2 as an S-VOL
- Specify the same size volumes as a P-VOL and S-VOL
- When you use the volume that is already used as the P-VOL of another pair for the P-VOL of the new pair, specify the same pool for the pairs that share the P-VOL

For details about the paircreate command, see the *Command Control Interface (CCI) User and Reference Guide*.

Storing Snapshot Data

Use the pairsplit command of the Command Control Interface to store snapshot data in the pool. You can store 64 snapshot data at most per a P-VOL. To store snapshot data, the pair status must be PAIR.

When a P-VOL is paired with two or more volumes, make sure that none of the pairs is in COPY(RS-R) status. If some pairs are in the COPY(RS-R) status, the pairsplit command may end abnormally.

During execution of the pairsplit command to the Copy-on-Write Snapshot pair, do not execute the pairresync -restore command to the other Copy-on-Write Snapshot pair that shares P-VOL with the corresponding pair. The pairsplit command being executed may end abnormally. The causes of abnormal end are:

- Command rejection
- Timeout (Error code: EX_EWSTOT)
- Suspending the pair (Error code: EX_EWSUSE)

You can store one snapshot data at a time by using the pairsplit command, but you cannot specify the snapshot data ID. For details about the pairsplit command, see the *Command Control Interface (CCI) User and Reference Guide*.

Copy-on-Write Snapshot does not support Quick Split mode. If you specify Quick Split mode, Quick Split mode does not take effect.

Storing Snapshot Data by Consistency Group (At-Time Snapshot Function)

By using Command Control Interface, you can store snapshot data by a consistency group (At-Time Snapshot function).

Consistency group is defined with the pair creating option. Consistency groups have the following restrictions:

Table 5-1 Specifications of Consistency Group

Item	Description
Consistency group number	A number is assigned to each consistency group within a range of 0 to 255. You can specify a consistency group number when you create Copy-on-Write Snapshot pairs. If you do not specify a number, an unused number is assigned automatically. Use the Volume List of the C.O.W. Snapshot window or Pair Operation window of ShadowImage to view the list of the consistency group numbers. You can configure up to 256 consistency groups in a storage system, including ShadowImage consistency groups and ShadowImage for z/OS consistency groups.
Number of pairs	You can define up to 8,192 Copy-on-Write Snapshot pairs in a consistency group. ShadowImage pairs, ShadowImage for z/OS pairs, and Copy-on-Write Snapshot pairs cannot coexist in the same consistency group.

A summary of the steps to store snapshot data using At-Time Snapshot function of Command Control Interface is listed below. For details about the steps, see the *Command Control Interface (CCI) User and Reference Guide.*

1. Execute the paircreate command with the option specifying the consistency group number.

   The Copy-on-Write Snapshot pair that is the target of the At-Time Snapshot function is created.

   At-Time Snapshot function is enabled automatically by specifying consistency group number.

2. Execute the paircreate command again specifying the same consistency group number specified in step 1.

   You can add pairs into the same consistency group. Repeat this step for the number of pairs that you want to specify into the same consistency group.

3. Execute the pairsplit command to the consistency group that is a target of the At-Time Snapshot function.

   After USP V/VM accepts the pairsplit command, the snapshot data of the P-VOL is stored when the host issues an I/O request to each P-VOL in the corresponding consistency group.

Consistency group:

– You cannot specify the Copy-on-Write Snapshot pairs in the same consistency group if the pairs share the same volume as P-VOL. If you specify these pairs in the same consistency group, the paircreate command will be rejected.
– You should not mix pairs created with the At-Time Snapshot option and without the At-Time Snapshot option in the same group as the group that is defined in the Command Control Interface configuration file. This group differs from the consistency group. If you mix these two types of pairs, the pairsplit command may terminate abnormally. And it can not be ensured that the stored snapshot data is the P-VOL data when USP V/VM accepts the pairsplit command.
– You can specify only 1 consistency group for each group that is defined in the Command Control Interface configuration file.

  When you create a pair by using the group that is defined in the Command Control Interface configuration file, if some pairs specifying consistency group has been created in the group already, you should create a pair by specifying the same consistency group as the corresponding pairs. Even if you try to create a pair by specifying the other consistency group, the pair will be added to the same consistency group as the corresponding pairs.

  If you want to specify plural consistency groups, define as many groups as the consistency groups that you want to specify in the Command Control Interface configuration file.

Caution:

When storing snapshot data:

- When the pairsplit command is issued, if the corresponding consistency group includes the pairs that are not in the PAIR status, the pairsplit command processing may terminate abnormally. The causes of abnormal end are as follows:
  - Command rejection
  - Timeout (Error code: EX_EWSTOT)
  - Suspending the pair (Error code: EX_EWSUSE)
- During execution of the pairsplit command, if the other operation (deletion of snapshot data or deletion of Copy-on-Write Snapshot pairs, etc.) is executed to the pairs in the corresponding consistency group, the consistency of the stored snapshot data cannot be ensured. Therefore, the pairsplit command processing may terminate abnormally. The causes of abnormal end are as follows:
  - Timeout (Error code: EX_EWSTOT)
  - Suspending the pair (Error code: EX_EWSUSE)
- The restoration of the Copy-on-Write Snapshot pair sometimes ends abnormally for any of the following reasons:
  - The snapshot data of the Copy-on-Write Snapshot pair for restoration is being stored per consistency group.
  - The P-VOL of the Copy-on-Write Snapshot pair for restoration is used as the P-VOL of another Copy-on-Write Snapshot pair, and the snapshot data of the latter Copy-on-Write Snapshot pair is being stored per consistency group.

When the host server is down or has failed:

When the host server is down or has failed, a consistency group with no Copy-on-Write Snapshot pairs may be created. If you create pairs that are the target of the At-Time Split option from the Command Control Interface under such a condition, the command might be rejected. In this case, find the consistency group number by sorting the CTG column on the C.O.W. Snapshot window or Pair Operation window of ShadowImage, and create a pair specifying the consistency group number intentionally.

When the Copy-on-Write Snapshot pair P-VOL is shared with the TrueCopy pair or the Universal Replicator pair:

If the status of some Copy-on-Write Snapshot pairs belonging to a consistency group cannot be changed, the Pairsplit command processing by CCI may terminate abnormally with the error code EX_EWSTOT. This error indicates that a timeout has occurred. Probable reasons of why the pair status cannot be changed are as follows:

- When a Universal Replicator S-VOL is used as Copy-on-Write Snapshot P-VOL, the capacity of the journal volumes for this Universal Replicator pair is insufficient.
- The Copy-on-Write Snapshot license is invalid.
- Volumes of the Copy-on-Write Snapshot pair are blocked.
- The Copy-on-Write Snapshot pair is in the status where the pairsplit command cannot be executed. See Table 2-2.
- TrueCopy pair or Universal Replicator pair is in the status where the pairsplit command cannot be executed. See Interoperability with Other Products and Functions.

After these factors are removed, change all status of the pairs belonging to the consistency group into PAIR, and execute the pairsplit command again.

Restoring Copy-on-Write Snapshot Pairs

Use the pairresync -restore command of the Command Control Interface to restore Copy-on-Write Snapshot pairs. The Copy-on-Write Snapshot pair must be in PSUS status when you restore the pair.

When the restoration completes, the pair status changes to PAIR. For details about the pairresync -restore command, see the *Command Control Interface (CCI) User and Reference Guide*.

WARNING: If a failure occurs during the restoration, the pair status changes to PSUE. To recover the PSUE pair, you need to delete the snapshot data of the pair. When you recover the PSUE pair by deleting its snapshot data, data in the P-VOL will not be ensured. Therefore, you need to overwrite the P-VOL with the backup data or format the P-VOL.

Copy-on-Write Snapshot does not support Quick Restore mode. Therefore, even if you specify Quick Restore mode, Quick Restore mode does not take effect.

Deleting Snapshot Data

Use the pairresync command of the Command Control Interface to delete snapshot data. You can store up to 64 snapshot data per P-VOL. Therefore, if you want to store the new snapshot data of the P-VOL that already has 64 snapshot data, you need to delete the old snapshot data.

If you delete snapshot data, free area in the pool will increase. To increase the free area in the pool, delete snapshot data by issuing the pairresync command on the Copy-on-Write Snapshot pairs in PSUS status. However, if the snapshot data you try to delete shares data area with another snapshot data, only the snapshot ID will be deleted and the data will not be deleted from the pool.

For details about the pairresync command, see the *Command Control Interface (CCI) User and Reference Guide*.

Copy-on-Write Snapshot does not support Quick Resync mode. Therefore, even if you specify Quick Resync mode, Quick Resync mode does not take effect.

Deleting Copy-on-Write Snapshot Pairs

Use either the Command Control Interface pairsplit -S command or the Pairsplit-S dialog box to delete Copy-on-Write Snapshot pairs.

If you use the Command Control Interface pairsplit -S command to delete Copy-on-Write Snapshot pairs, you can delete only one pair at a time. For details about the pairsplit -S command, see the *Command Control Interface (CCI) User and Reference Guide*.

If you use the Pairsplit-S dialog box, you can delete multiple pairs at the same time. You can open the Pairsplit-S dialog box either from the ShadowImage Pair Operation window or the C.O.W. Snapshot window. If you want to select the pairs to be deleted by port or host group, open the Pairsplit-S dialog box from the Pair Operation window. If you want to select the pairs by pool, open the Pairsplit-S dialog box from the C.O.W. Snapshot window.

Deleting Copy-on-Write Snapshot Pairs by Selecting the Pairs per Port

To delete Copy-on-Write Snapshot pairs by selecting the pairs per port:

1. Change the mode of the Storage Navigator to **Modify**. If the mode is already changed to **Modify**, you can skip this step. For information about how to change the mode, see the *Storage Navigator User's Guide*.
2. Display the Pair Operation window.
3. In the tree, select the port or host group that contains the Copy-on-Write Snapshot pairs you want to delete. The list of the pairs or volumes is displayed in the volume list.
4. Select and right-click the Copy-on-Write Snapshot pairs you want to delete. A menu is displayed.

   You cannot delete a ShadowImage pair and a Copy-on-Write Snapshot pair at the same time.
5. Select the **Pairsplit-S** command from the menu. The Pairsplit-S dialog box (Figure 5-11) is displayed.
6. Click **OK**. The Pairsplit-S dialog box closes and the list of the Copy-on-Write Snapshot pairs that you are going to delete will be displayed in the **Preview** list of the Pair Operation window.
7. Click **Apply**. The confirmation message indicating if it is OK to apply the setting to the storage system is displayed.
8. Click **OK**. The confirmation message closes and the deletion of the pair is applied to the subsystem.

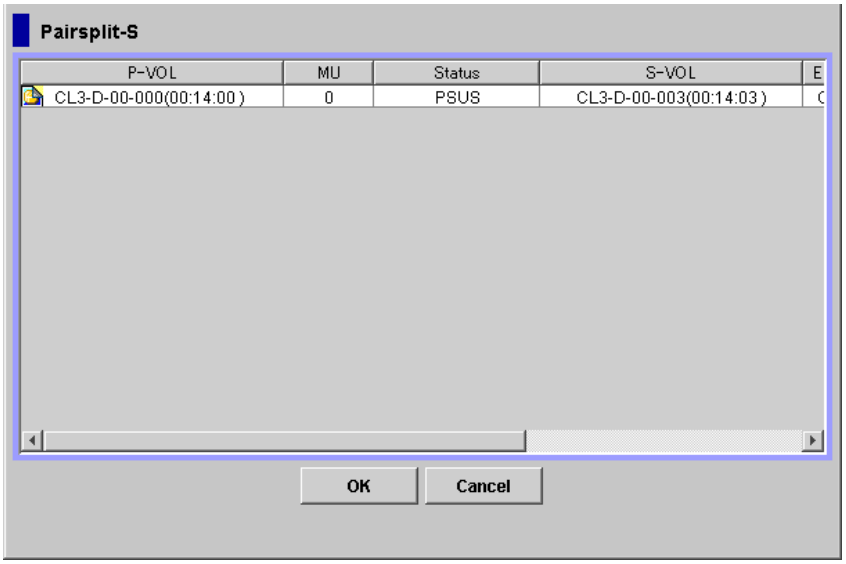

Figure 5-11 Pairsplit-S Dialog Box

When you select a Copy-on-Write Snapshot pair and display the Pairsplit-S dialog box, the dialog box displays the following items.

- Volume list

  Information about the Copy-on-Write Snapshot pairs you are going to delete is displayed.

  – **P-VOL**: Information about P-VOL is displayed in *AAA-BB-CCC(XX:YY:ZZ)* format.

    - AAA: The port ID (cluster and channel number)
    - BB: The group number of host group
    - CCC: LU number
    - XX:YY:ZZ: LDKC number:CU number:LDEV number

    An LDEV number that ends with a pound or gate (#) mark indicates that the LDEV is an external volume (e.g., 00:00:01#). An LDEV number that ends with a letter “X” indicates that the LDEV is a virtual volume used by Dynamic Provisioning (e.g., 00:00:00X). For details about external volumes, see the *Universal Volume Manager User’s Guide*. For information about Dynamic Provisioning, see the *Dynamic Provisioning User’s Guide*.

  – **MU**: snapshot ID

  – **Status**: status of the Copy-on-Write Snapshot pair

- **S-VOL**: Information about S-VOL is displayed in *AAA-BB-CCC(XX:YY:ZZ)* format.
  - AAA: The port ID (cluster and channel number)
  - BB: The group number of host group
  - CCC: LU number
  - XX:YY:ZZ: LDKC number:CU number:LDEV number

  An LDEV number that ends with a pound or gate (#) mark indicates that the LDEV is an external volume (e.g., 00:00:01#). An LDEV number that ends with a letter "X" indicates that the LDEV is a virtual volume used by Dynamic Provisioning (e.g., 00:00:00X). For details about external volumes, see the *Universal Volume Manager User's Guide*. For information about Dynamic Provisioning, see the *Dynamic Provisioning User's Guide*.
- **Emulation**: emulation type
- **Capacity(MB)**: storage capacity of the Copy-on-Write Snapshot pair
- **CLPR(P)**: cache logical partition of the P-VOL
- **CLPR(S)**: cache logical partition of the S-VOL

- **OK** button

  Closes the Pairsplit-S dialog box and displays the list of the Copy-on-Write Snapshot pairs in the **Preview** list.

- **Cancel** button

  Cancels the operation and closes the Pairsplit-S dialog box.

  For details about the Pairsplit-S dialog box that will be displayed when you selected ShadowImage pairs, see the *ShadowImage User's Guide*.

Deleting Copy-on-Write Snapshot Pairs by Selecting the Pairs per Pool

To delete Copy-on-Write Snapshot pairs by selecting the pairs per pool:

1. Start the Storage Navigator and display the Storage Navigator main window.
2. Change the mode of the Storage Navigator to **Modify**. If the mode is already changed to **Modify**, you can skip this step. For information about how to change the mode, see the *Storage Navigator User's Guide*.
3. Display the C.O.W. Snapshot window (Figure 4-5) of ShadowImage.
4. In the Tree, select the pool that contains the Copy-on-Write Snapshot pairs you want to delete. The list of the pairs or volumes is displayed in the volume list.
5. Select and right-click the Copy-on-Write Snapshot pairs you want to delete. A menu is displayed.
6. Select the Pairsplit-S command from the menu. The Pairsplit-S dialog box (Figure 5-11) is displayed.
7. Click **OK**. The Pairsplit-S dialog box closes and the list of the Copy-on-Write Snapshot pairs that you are going to delete will be displayed in the Preview list of the C.O.W. Snapshot window.
8. Click **Apply**. The confirmation message indicating if it is OK to apply the setting to the storage system is displayed.
9. Click **OK**. The confirmation message closes, and the deletion of the pair is applied to the subsystem.

Viewing Detailed Volume and Pair Information

To display the Detail dialog box:

1. Display the ShadowImage Pair Operation window.
2. Select and right-click a Copy-on-Write Snapshot pair on the volume list. A menu is displayed.
3. Select the **Detail** command from the menu. The Detail dialog box is displayed.

   If you select the **Detail** command in the menu when you are selecting a ShadowImage pair, the displayed Detail dialog box will be different from that of displayed when you select a Copy-on-Write Snapshot pair. For details, see the ShadowImage User's Guide.

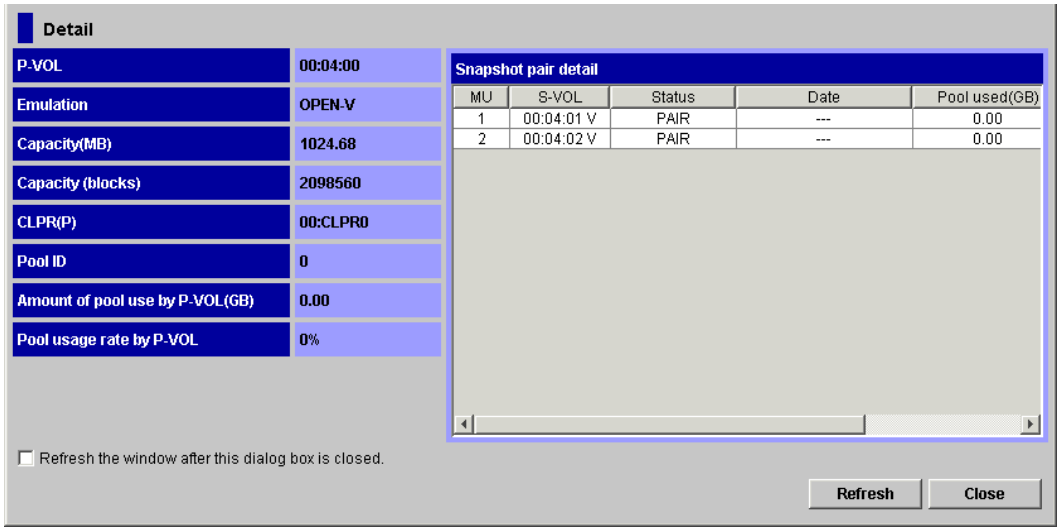

Figure 5-12 Detail Dialog Box for a Copy-on-Write Snapshot Pair

The Detail dialog box displays the following items.

- **P-VOL**

  LDKC number, CU number, and LDEV number of the P-VOL is displayed.

- **Emulation**

  Emulation type of the P-VOL is displayed.

- **Capacity(MB)**

  Capacity of the P-VOL is displayed. The unit is megabyte (MB).

- **Capacity(blocks)**

  The number of blocks used by the P-VOL is displayed.

- **CLPR(P)**

  The cache logical partition (CLPR) of the P-VOL is displayed.

- **Pool ID**

  Pool ID of the pool in which the P-VOL is registered is displayed.

- **Amount of pool use by P-VOL(GB)**

  Amount of the pool capacity that is used by the P-VOL is displayed.

- **Pool usage rate by P-VOL**

  Pool usage rate of the P-VOL is displayed.

- **Snapshot Pair Detail** list

  Following information items of snapshot data is displayed.

  – MU: snapshot ID

  – S-VOL: LDKC number, CU number, and LDEV number of the S-VOL

  – Status: status of the Copy-on-Write Snapshot pair

  – Date: time when the snapshot data is stored in the pool

  – Pool used(GB): capacity of the pool that is used by the S-VOL

  – Sync.: consistency rate of the data of the P-VOL and the S-VOL

  – CLPR(S): cache logical partition (CLPR) of the S-VOL

  – CTG: consistency group number of the Copy-on-Write Snapshot pair

    When the consistency group is not specified, dotted lines (**---**) will display.

- **Refresh the window after this dialog box is closed.** check box

  If you select the check box, the information displayed in the ShadowImage Pair Operation window will be updated after the Detail dialog box closes. If you do not select the check box, the information in the Pair Operation window will be the same before and after you close the Detail dialog box.

- **Refresh** button

  Updates the information in the Detail dialog box.

- **Close** button

  Closes the Detail dialog box.

Viewing S-VOL Path Information

To display the S-VOL Path dialog box:

1. Display the ShadowImage Pair Operation window.
2. Select and right-click a Copy-on-Write Snapshot pair on the volume list. A menu is displayed.
3. Select the S-VOL **Path** command from the menu. The S-VOL Path dialog box is displayed.

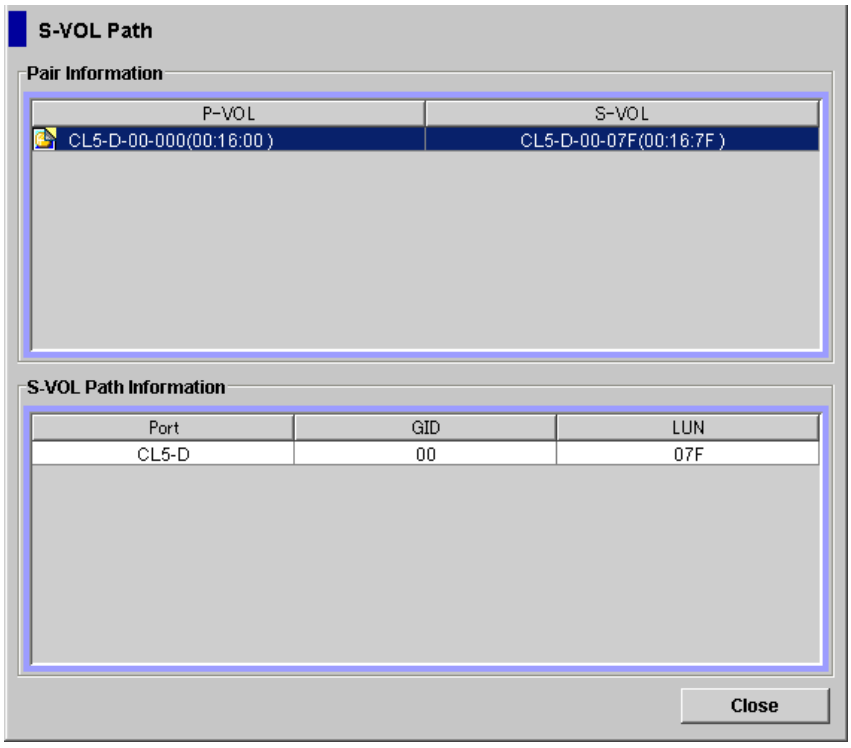

Figure 5-13 S-VOL Path Dialog Box

S-VOL Path dialog box displays the following items.

- The **Pair Information** box displays only the information of the paths that are used by the Copy-on-Write Snapshot pairs selected in the Pair Operation window Volume List. **P-VOL** displays the path information of the P-VOLs and **S-VOL** displays the path information of the S-VOLs in *AAA-BB-CCC(XX:YY:ZZ)* format.
  - AAA: The port ID (cluster name and channel number)
  - BB: The group number (G-ID) of host group
  - CCC: LU number
  - XX:YY:ZZ: LDKC number:CU number: LDEV number

An LDEV number that ends with a pound or gate (#) mark indicates that the LDEV is an external volume (e.g., 00:00:01#). An LDEV number that ends with a letter “X” indicates that the LDEV is a virtual volume used by Dynamic Provisioning (e.g., 00:00:00X). For details regarding the external volumes, see the Universal Volume Manager User’s Guide. For information about Dynamic Provisioning, see the *Dynamic Provisioning User’s Guide*.

- The **S-VOL Path Information** box displays all the path information including the alternate paths regarding the S-VOLs selected in the **Pair Information** box.
  - **Port**: The port ID
  - GID: The group number of host group
  - LUN: LU number
- **Close** button

  Closes the S-VOL Path dialog box.

Viewing the Number of Pairs and License Information

The Information dialog box displays information such as the number of pairs in the subsystem, the number of reserve volumes, and the license capacity.

To display the Information dialog box:

1. Right-click anywhere on the volume list of the ShadowImage Pair Operation window. A menu will be displayed.
2. Select the **Information** command in the menu. The Information dialog box will be displayed.

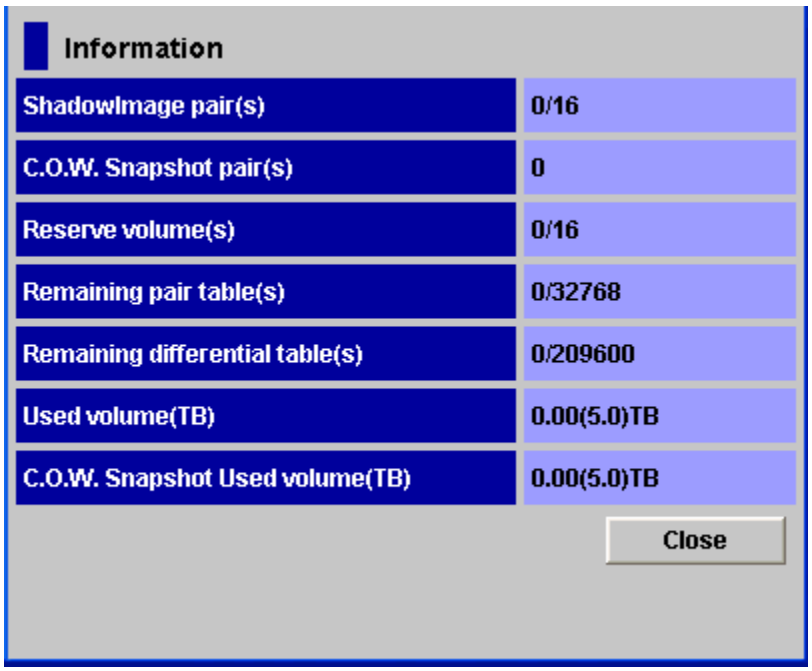

Figure 5-14 Information Dialog Box

The following information will be displayed in the Information dialog box:

- **ShadowImage pair(s)**

  The number of ShadowImage pairs will be displayed in the format of *XXXX / YYYY*. XXXX indicates the number of ShadowImage pairs. YYYY indicates the total number of ShadowImage pairs and ShadowImage for z/OS pairs.

- **C.O.W. Snapshot pair(s)**

  The number of Copy-on-Write Snapshot pairs will be displayed.

  The maximum number of pairs that can be created in one subsystem is 16,384, including migration plans and relationships. Therefore, if Copy-on-Write Snapshot pairs, migration plans of Volume Migration, and relationships of Compatible Mirroring for IBM FlashCopy Version 1 and Compatible Mirroring for IBM FlashCopy Version 2 are created in the same subsystem, the maximum number of pairs that you can create may be less than 16,384 minus YYYY. For information on using Volume Migration, contact the Hitachi Data Systems Support Center (see Calling the Hitachi Data Systems Support Center).

- **Reserved volume(s)**

  The number of reserved volumes of ShadowImage will be displayed in the format of *XXXX / YYYY.* XXXX indicates the number of reserved volumes of ShadowImage. YYYY indicates the total number of reserved volumes of ShadowImage and ShadowImage for z/OS.

  Reserved volumes include S-VOLs of ShadowImage and ShadowImage for z/OS pairs.

- **Remaining pair table(s)**

  The remaining number of usable pair tables in the storage system will be displayed in the format of *XXXXX / YYYYY.* XXXXX indicates the remaining number of usable pair table. YYYYY indicates the maximum number of pair tables. For details about the maximum number of pair tables, see Calculating Maximum Number of Pairs.

- **Remaining differential table(s)**

  The remaining number of usable differential tables in the storage system will be displayed in the format of *XXXXXX / YYYYYY.* XXXXXX indicates the remaining number of usable differential table. YYYYYY indicates the maximum number of differential tables. For details about the maximum number of differential tables, see Calculating Maximum Number of Pairs.

- **Used volume (TB)**

  License information of ShadowImage will be indicated in the format of *X(Y).* X indicates license capacity used by ShadowImage, and Y indicates total license capacity reserved for ShadowImage. **Unlimited** will be displayed when there is no limit on license capacity for ShadowImage.

- **C.O.W. Snapshot Used volume (TB)**

  License information of Copy-on-Write Snapshot will be indicated in the format of *X(Y).* X indicates license capacity used by Copy-on-Write Snapshot, and Y indicates total license capacity reserved for Copy-on-Write Snapshot. **Unlimited** will be displayed when there is no limit on license capacity for Copy-on-Write Snapshot.

- **Close** button

  Closes the Information dialog box.

Displaying the Operation History

The History window (Figure 4-4) displays the history of ShadowImage operations.

To refer to the history:

1. Display the History window. If you are already displaying the other window shown by a tab, click the **History** tab.

   If some of the pairs include LUSE volumes or if the total number of pairs and migration plans in the subsystem is 500 or more, you may need to wait for a while until the History window displays the operation history.

   - ShadowImage pairs
   - Copy-on-Write Snapshot pairs
   - ShadowImage for z/OS pairs
   - Compatible Mirroring for IBM FlashCopy Version 1 relationships
   - Compatible Mirroring for IBM FlashCopy Version 2 relationships
   - Migration plans of Volume Migration

2. Refer to the **C.O.W. Snapshot** list in the lower area of the History window.
3. To change the displaying order, click a column in the list. The list will be sorted based on the items in the clicked column.
   - If there are more than 16,384 records of operations, the list is divided into multiple pages and only the list that is currently displayed is sorted.
   - If you click the same column again, you can switch the sorting order (Ascending or Descending).
4. If the information on the list is not updated, click **File** and then **Refresh** on the menu bar of the Storage Navigator main window. The list is updated to the latest information.

   As for operations involving the copying process, the History window does not display information about the operations until the copying process starts. If you perform an operation on a pair before the copying process starts, the History window will not display information about the operation.
5. If there are many records of operations, click the scroll button to scroll the list and see all of the operation history records.

   To expand the display area of the list, click and drag down the frame border that divides the History window into upper and lower panes.
6. If there are more than 16,384 records of operations, click **Next**. The list displays subsequent records of operations.
   - If you click Previous, the list switches to the previous page.
   - If there are 16,384 or fewer records of operations, you cannot click Previous and Next.
   - The subsystem saves up to 524,288 records of latest operations.

6

Troubleshooting

This chapter provides troubleshooting information for Copy-on-Write Snapshot and instructions for calling technical support.

General Troubleshooting

If you have a problem with the Storage Navigator, see the *Storage Navigator User's Guide* for troubleshooting information.

Table 6-1 describes the problems that may occur when you are using Copy-on-Write Snapshot. The table also describes the causes of the problems and what you should do to solve the problems. If a problem cannot be resolved as described in Table 6-1, or if a problem that is not listed in Table 6-1 occurs, please call the Support Center.

Table 6-1 Troubleshooting for Copy-on-Write Snapshot

Problem	Causes and Solutions
Cannot install Copy-on-Write Snapshot.	Causes: ▪ Shared memory for the V-VOL management area is not installed. ▪ Shared memory is not set for the V-VOL management area. ▪ Shared memory for the differential tables is not installed. Solutions: ▪ Call the Support Center and check if the shared memory for the V-VOL management area and the differential tables is installed. ▪ Call the Support Center and check if the shared memory for the V-VOL management area is rightly set.
Pool information is not displayed.	Causes: ▪ The pool is blocked. Solutions: Implement the measures shown in Procedure to Recover a Blocked Pool.
A pool is blocked.	Causes: ▪ The pool-VOLs are blocked. Solutions: Implement the measures shown in Procedure to Recover a Blocked Pool. In addition, after the problems are solved, you need to complete the SIMs. If you keep the SIMs not completed, no new SIM can be occurred even if a pool is blocked again. For details about the procedure to complete SIMs, see Procedure to Complete the Pool Related SIMs.

Problem	Causes and Solutions
Pool usage rate exceeds the threshold.	Causes: ▪ Too much snapshot data is stored in the pool. ▪ Capacity of the pool is insufficient. ▪ Threshold of the pool is too low. Solutions: ▪ Delete the snapshot data which is less important or delete the old snapshot data to decrease the usage rate of the pool. ▪ Add some pool volumes to increase the capacity of the pool. ▪ Set a larger value to the threshold of the pool. In addition, after the problems are solved, you need to complete the SIMs. If you keep the SIMs not completed, no new SIM can be occurred even if the usage rate exceeds the threshold again. For details about the procedure to complete SIMs, see Procedure to Complete the Pool Related SIMs. ***Note:*** You need unused volumes to add the pool volumes. If there is no unused volume, you need to create new volumes or ask the Support Center to add the hard disks. Therefore, it may take time to solve the problem.
Cannot add pool-VOLs.	Causes: ▪ Already 1,024 pool-VOLs are set in the pool. ▪ Available pool management block in the V-VOL management area (which is in the shared memory) is insufficient. ▪ The requirements of the pool-VOLs are not fulfilled. Solutions: ▪ Add pool-VOLs to another pool. ▪ Initialize the V-VOL management area. ▪ Add the pool-VOLs that fulfill the requirements.
Cannot create Copy-on-Write Snapshot pairs.	Causes: ▪ There are not enough differential tables to create the pairs. ▪ The conditions to create the pair are not fulfilled. ▪ The volumes specified to create the pair is in SMPL(PD) status because the pair is being deleted. Solutions: ▪ Secure enough differential tables to create the Copy-on-Write Snapshot pairs. ▪ Fulfill the conditions to create the pair and try the pair creation again. ▪ See the ShadowImage Pair Operation window and verify that the status of the volume changes to SMPL, and then try the pair creation again. ▪ Execute CCI's inqraid command and verify that the volume is not used by Copy-on-Write Snapshot, and then try the pair creation again.
Copy-on-Write Snapshot pairs are not displayed in the volume list.	Causes: ▪ Copy-on-Write Snapshot pairs are not created. ▪ Displaying of the Copy-on-Write Snapshot pairs is prohibited by the filtering function. Solutions: ▪ Create Copy-on-Write Snapshot pairs. ▪ Change the settings in the Display Filter dialog box.

Problem	Causes and Solutions
An error occurred while restoring the pair.	Causes: ▪ A volume is blocked because a failure occurred in the hard disk drive. Solutions: ▪ Delete the Copy-on-Write Snapshot pair that is blocked, and call the Support Center.
A volume is blocked.	Causes: ▪ A failure occurred in two or more hard disk drives. ▪ The breaker was turned off once and then switch on the power supply. Solutions: ▪ Ask the Support Center to solve the problem.
Trouble occurs on the application software installed in the host computer in order to monitor the volumes.	Causes: ▪ Access to the volume is rejected. Solutions: ▪ Terminate the application software which monitors the volumes. ▪ Change all the Copy-on-Write Snapshot pair statuses to PSUS, then start the application software to monitor the volumes. For details about the relations between the pair status and host access, see Table 2-1.
When the host computer tries to access the port, error occurs and the host cannot access the port.	Causes: ▪ Some ports go offline because the access to the volume on the other port(s) is rejected. Solutions: ▪ Wait for a while, then try the operation again. ▪ If the application software is installed in the host to monitor the volume, terminate the application.
When you are operating Storage Navigator, time-out occurs frequently.	Causes: ▪ The load on the Storage Navigator computer is too heavy, so that the Storage Navigator computer cannot respond to the SVP. ▪ The period of time until when time-out occurs is set too short. Solutions: ▪ Wait for a while, then try the operation again. ▪ Verify the setting of the environment parameter of Storage Navigator **RMI time-out period**. For information about how to set **RMI time-out period**, see the *Storage* Navigator *User's Guide*.

Procedure to Recover a Blocked Pool

When a pool is blocked, you need to recover the pool-VOLs, pool, Copy-on-Write Snapshot pairs, and the V-VOLs in this order. This section describes the procedures to recover the blocked pool.

Recovery of the pool-VOLs. If the pool-VOL is blocked, please call the Support Center.

Recovery of the pool. To recover the pool:

1. Display the Pool window.
2. Select and right-click the blocked pool in the Pool tree in the Pool window. A menu is displayed.
3. Select the Restore Pool command from the menu. The confirmation message indicating if it is OK to restore the selected pool is displayed.
4. Click **OK**. The icon of the selected pool changes to the icon that indicates the normal status.
5. Click **Apply**. The confirmation message indicating if it is OK to apply the setting to the storage system is displayed.
6. Click **OK**. The confirmation message closes and the restoration of the pool is applied to the subsystem.

When there is more than one blocked pool, you may restore all the blocked pools at the same time by executing the following operation after you display the Pool window.

1. Select and right-click the C.O.W. Snapshot icon in the Pool tree in the Pool window. A menu is displayed.
2. Select the Restore Pool(s) command from the menu. The confirmation message indicating if it is OK to restore the pools is displayed.
3. Click **OK**. The icons of the blocked pools in the Pool tree change to the icons that indicate the normal status.
4. Click **Apply**. The confirmation message indicating if it is OK to apply the setting to the storage system is displayed.
5. Click **OK**. The confirmation message closes, and the restoration of the pools is applied to the subsystem.
6. You can check whether the pool is recovered from the blocked status in the Pool window. If Status of the Pool Information displays **Normal**, or if the icon in the Pool tree indicates the normal status, the blocked pool is restored successfully.

You can also recover the pool by performing one of the following operations.

- Adding some pool-VOLs
- Deleting snapshot data to decrease the usage rate of the pool
- Deleting Copy-on-Write Snapshot pairs to decrease the usage rate of the pool

Usage rate and status of the pool is displayed in the **Pool Information** box in the Pool window. Use this information to determine how many pool volumes to add or which snapshot data to delete.

Recovery of the Copy-on-Write Snapshot pair. When the pool is blocked, the status of all Copy-on-Write Snapshot pairs that have snapshot data stored in the pool changes to PSUE. To recover the PSUE pairs, delete those pairs.

Recovery of the V-VOL. When the V-VOL is blocked, please call the Support Center.

Procedure to Complete the Pool Related SIMs

When the usage rate of the pool exceeds the threshold, or when the pool becomes blocked, the following SIMs (Service Information Message) will occur.

- When the usage rate of the pool exceeds the threshold: Reference code 601XXX
- When the pool becomes blocked: Reference code 602XXX

XXX indicates the pool ID. For details about the SIM reference codes, please call the Support Center. You can reference the SIMs occurring in the storage system through the window of Storage Navigator. For details about the window, see the *Storage Navigator User's Guide*.

To complete the SIMs that occurred when the usage rate of the pool exceeds the threshold or when the pool becomes blocked:

If you complete a SIM, the status of the SIM changes to "completed". After the problem that caused the SIM is solved, complete the SIM and change its status to "completed".

1. Change the status of the pool whose usage rate exceeds the threshold to normal, and restore the blocked pool to change its status to normal. For information about the solutions when the pool usage rate exceeds the threshold and the pool becomes blocked, see Table 6-1.
2. Change the mode of the Storage Navigator to **Modify**. If the mode is already changed to **Modify**, you can skip this step. For information about how to change the mode, see the *Storage Navigator User's Guide*.
3. Display the Pool window.
4. Select the **SIM Complete Request** check box.
5. Click **Apply**. The confirmation message indicating if it is OK to apply the setting to the storage system is displayed.
6. Click **OK**. The confirmation message closes, and the SIM complete process begins. It takes time if there are many SIMs to be completed.

You can check whether the SIMs completed successfully in the Storage Navigator window. For details, see the *Storage Navigator User's Guide*.

Troubleshooting When Using Command Control Interface

When an error has occurred in the Snapshot Pair operation using CCI, refer to the log displayed on the CCI window or the CCI operation log file to see if you can identify the cause of the error. The CCI operation log file is stored in the following directory by default.

The log file is stored in: /HORCM/log*/curlog/horcmlog_HOST/horcm.log

Where:

- * is the instance number.
- HOST is the host name.

To identify the error code using the log file, follow the procedure below. For more information about CCI, please see the *Hitachi Command Control Interface (CCI) User and Reference Guide* (MK-90RD011).

1. Open the CCI log file, and find the error code.

   Example: 11:06:03-37897-10413- SSB = 0xB901,4A96

   Error codes appear on the right of the equal symbol (=).The alphanumeric characters of last four digits on the left of the comma (,) indicates SSB1 (e.g., B901), and the right of the comma (,) indicates SSB2 (e.g., 4A96).
2. See Table 6-2 and find the meaning of the error code.

   For details about the error codes that are not described in Table 6-2, contact the Hitachi Data Systems Support Center (see Calling the Hitachi Data Systems Support Center)

To identify the error code using the log displayed on the CCI window, follow the procedure below. For more information about CCI, please see the *Hitachi Command Control Interface (CCI) User and Reference Guide* (MK-90RD011).

1. Find the error code from the logs displayed on the CCI window.

   Figure 6-1 shows an example of a log displayed on the CCI window.

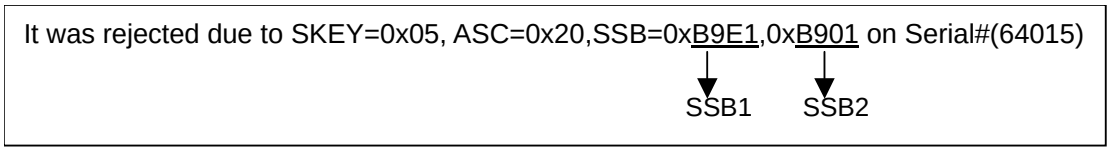

Figure 6-1 Example of a Log Displayed on the CCI Window

Error codes appear on the right of "SSB=". The alphanumeric characters of last four digits on the left of the comma (,) indicates SSB1 (e.g., B9E1), and the alphanumeric characters of last four digits on the right of the comma (,) indicates SSB2 (e.g., B901).

2. See Table 6-2 and find the meaning of the error code.

   For details about the error codes that are not described in Table 6-2, contact the Hitachi Data Systems Support Center (see Calling the Hitachi Data Systems Support Center).

Table 6-2 Cause of Error and the Result of CCI Command (SSB)

SSB1	SSB2	CCI Command	Cause of Error
B901 B9A8 B9A9 B9AD B9AE	9685	paircreate	Because of the shortage of the pair tables, Copy-on-Write Snapshot pair cannot be created.
	9686	paircreate	Because of the shortage of the differential tables, Copy-on-Write Snapshot pair cannot be created.
	9700	paircreate	Since the pool is not available, Copy-on-Write Snapshot pair cannot be created.
	9702	paircreate	When you create multiple Copy-on-Write Snapshot pairs by specifying multiple S-VOLs for one P-VOL, you specified the pool ID that is different from the pool ID used by the pairs that are already created. Therefore, Copy-on-Write Snapshot pair cannot be created.
	9703	paircreate	Since the volume you specified as the P-VOL is already used by other Copy-on-Write Snapshot S-VOL, the pair cannot be created.
	9704	paircreate	Since the volume you specified as the S-VOL is already used by other Copy-on-Write Snapshot P-VOL, the pair cannot be created.
	9705	paircreate	Since the volume you specified as the S-VOL is already used by other Copy-on-Write Snapshot S-VOL, the pair cannot be created.
	9706	paircreate	Since the specified snapshot ID is already used by other Copy-on-Write Snapshot pair, the pair cannot be created.
	9707	paircreate	Since the capacity of the pair exceeds the licensed capacity, the pair cannot be created.
	9718	All commands	The command ended abnormally because the command other than the paircreate command was issued for the volume in the pair other than the Copy-on-Write Snapshot pair. This error also may be reported when the command is executed with specifying an unsupported parameter.
	9719	All commands	The command ended abnormally because the pair is in the status that the corresponding command is not accepted at present. This error also may be reported when the command is executed with specifying an unsupported parameter.
	971a	paircreate	Since the capacity of shared memory is insufficient, the pair cannot be created.
	971b	paircreate	Since the attribute of the specified pool is other than Copy-on-Write Snapshot, Copy-on-Write Snapshot pair cannot be created.
	971f	pairresync -restore	Since the volume you specified as the P-VOL has an S-VOL Disable attribute, Copy-on-Write Snapshot pair cannot be restored.
	9720	All commands	Any errors have occurred because of the Copy-on-Write Snapshot operation.
	9721	paircreate pairsplit pairresync pairresync -restore	Since either Copy-on-Write Snapshot or ShadowImage is not installed, the command ends abnormally.
	9723	All commands	Because of no additional shared memory (FCV2, TPF, Extention1), the command ends abnormally.

SSB1	SSB2	CCI Command	Cause of Error
	9724	All commands	Because of no additional shared memory (more than COW1), the command ends abnormally.
	9725	All commands	Since the LDEV number of the volume you specified as the P-VOL is beyond the specified range, the command ends abnormally.
	9726	All commands	Since you specified the unmounted volume as the Copy-on-Write Snapshot P-VOL, the command ends abnormally.
	9727	paircreate pairsplit pairresync pairresync -restore	Since you specified the blocked volume as the Copy-on-Write Snapshot P-VOL, the command ends abnormally.
	9728	paircreate pairsplit pairresync pairresync -restore	Since you specified the volume that is in process of formatting as the Copy-on-Write Snapshot P-VOL, the command ends abnormally.
	9729	paircreate pairsplit pairresync pairresync -restore	Since you specified the volume whose emulation type is other than OPEN-V as the Copy-on-Write Snapshot P-VOL, the command ends abnormally.
	972a	paircreate	Since the volume you specified as the Copy-on-Write Snapshot P-VOL has the command device setting, the pair cannot be created.
	972c	paircreate	Since the capacity of the volume you specified as the Copy-on-Write Snapshot P-VOL exceeds the supported size (4TB), the pair cannot be created.
	972e	paircreate	Since the capacity of the volume you specified as the Copy-on-Write Snapshot S-VOL exceeds the supported size (4TB), the pair cannot be created.
	972f	paircreate	Since you specified a V-VOL as the Copy-on-Write Snapshot P-VOL, the pair cannot be created.
	9730	paircreate	Since you specified a pool-VOL as the Copy-on-Write Snapshot P-VOL, the pair cannot be created.
	9731	pairresync -restore	When Copy-on-Write Snapshot P-VOL and TrueCopy P-VOL share the volume, the status of the TrueCopy pair is other than PSUS or PSUE. Therefore, the Copy-on-Write Snapshot pair cannot be restored.
	9732	pairresync -restore	When Copy-on-Write Snapshot P-VOL and Universal Replicator P-VOL share the volume, the status of the Universal Replicator pair is other than PSUS or PSUE. Therefore, the Copy-on-Write Snapshot pair cannot be restored.
	9733	pairresync -restore	Since Copy-on-Write Snapshot P-VOL and TrueCopy S-VOL share the volume, the Copy-on-Write Snapshot pair cannot be restored.
	9734	pairresync -restore	Since Copy-on-Write Snapshot P-VOL and Universal Replicator S-VOL share the volume, the Copy-on-Write Snapshot pair cannot be restored.
	9735	paircreate	Since you specified Universal Replicator's journal volume as the Copy-on-Write Snapshot P-VOL, the pair cannot be created.
	9736	paircreate pairsplit pairresync pairresync -restore	Since the LUSE volumes you specified for the P-VOL and S-VOL do not have the same structure, the command ends abnormally.
	973a	paircreate	Since you specified the volume with the VMA setting as the Copy-on-Write Snapshot P-VOL, the pair cannot be created.
	973b	All commands	Since the LDEV number of the volume you specified as the S-VOL is beyond the specified range, the command ends abnormally.
	973c	All commands	Since you specified the unmounted volume as the Copy-on-Write Snapshot S-VOL, the command ends abnormally.

SSB1	SSB2	CCI Command	Cause of Error
	973d	paircreate pairsplit pairresync pairresync -restore	Since you specified the blocked volume as the Copy-on-Write Snapshot S-VOL, the command ends abnormally.
	973e	paircreate pairsplit pairresync pairresync -restore	Since you specified the volume that is in process of formatting as the Copy-on-Write Snapshot S-VOL, the command ends abnormally.
	973f	paircreate pairsplit pairresync pairresync -restore	Since you specified the volume whose emulation type is other than OPEN-V as the Copy-on-Write Snapshot S-VOL, the command ends abnormally.
	9740	paircreate	Since the volume you specified as the Copy-on-Write Snapshot S-VOL has the command device setting, the pair cannot be created.
	9742	paircreate	Since you specified an external volume as the Copy-on-Write Snapshot S-VOL, the pair cannot be created.
	9745	paircreate	Since you specified the volume other than V-VOLs as the Copy-on-Write Snapshot S-VOL, the pair cannot be created.
	9746	paircreate	Since you specified a pool-VOL as the Copy-on-Write Snapshot S-VOL, the pair cannot be created.
	9747	paircreate	Since you specified TrueCopy P-VOL as the Copy-on-Write Snapshot S-VOL, the pair cannot be created.
	9748	paircreate	Since you specified TrueCopy S-VOL as the Copy-on-Write Snapshot S-VOL, the pair cannot be created.
	9749	paircreate	Since you specified Universal Replicator data volume or journal volume in the intermediate site of 3DC cascading configuration as the Copy-on-Write Snapshot S-VOL, the Snapshot pair cannot be created.
	974a	paircreate	Since you specified Universal Replicator P-VOL as the Copy-on-Write Snapshot S-VOL, the pair cannot be created.
	974b	paircreate	Since you specified Universal Replicator S-VOL as the Copy-on-Write Snapshot S-VOL, the pair cannot be created.
	974c	paircreate	Since you specified Universal Replicator journal volume as the Copy-on-Write Snapshot S-VOL, the pair cannot be created.
	974f	All commands	Since the volume you specified as the S-VOL has an S-VOL Disable attribute, the command ends abnormally.
	9750	paircreate	Since you specified the volume with the VMA setting as the Copy-on-Write Snapshot S-VOL, the pair cannot be created.
	9752	paircreate pairsplit pairresync pairresync -restore	Since the Max LBA size of the volumes you specified as the Copy-on-Write Snapshot P-VOL and S-VOL is different, the command ends abnormally.
	9753	paircreate pairsplit pairresync pairresync -restore	Since the number of slots of the volumes you specified as the Copy-on-Write Snapshot P-VOL and S-VOL is different, the command ends abnormally.
	9754	paircreate	Since you specified the Dynamic Provisioning V-VOL as the Copy-on-Write Snapshot S-VOL, the pair cannot be created.

SSB1	SSB2	CCI Command	Cause of Error
	9756	All commands	Since you specified the ShadowImage reserved volume as the Copy-on-Write Snapshot P-VOL, the command ends abnormally.
	9757	All commands	Since you specified the Volume Migration source volume as the Copy-on-Write Snapshot P-VOL, the command ends abnormally. For information about using Volume Migration, contact the Hitachi Data Systems Support Center (see Calling the Hitachi Data Systems Support Center).
	9758	All commands	Since you specified the Volume Migration target volume as the Copy-on-Write Snapshot P-VOL, the command ends abnormally. For information about using Volume Migration, contact the Hitachi Data Systems Support Center (see Calling the Hitachi Data Systems Support Center).
	9759	All commands	Since you specified the Volume Migration reserved volume as the Copy-on-Write Snapshot P-VOL, the command ends abnormally. For information o about n using Volume Migration, contact the Hitachi Data Systems Support Center (see Calling the Hitachi Data Systems Support Center).
	975a	All commands	Since you specified the ShadowImage P-VOL as the Copy-on-Write Snapshot S-VOL, the command ends abnormally.
	975b	All commands	Since you specified the ShadowImage S-VOL as the Copy-on-Write Snapshot S-VOL, the command ends abnormally.
	975c	All commands	Since you specified the ShadowImage reserved volume as the Copy-on-Write Snapshot S-VOL, the command ends abnormally.
	975d	All commands	Since you specified the Volume Migration source volume as the Copy-on-Write Snapshot S-VOL, the command ends abnormally. For information about using Volume Migration, contact the Hitachi Data Systems Support Center (see Calling the Hitachi Data Systems Support Center).
	975e	All commands	Since you specified the Volume Migration target volume as the Copy-on-Write Snapshot S-VOL, the command ends abnormally. For information about using Volume Migration, contact the Hitachi Data Systems Support Center (see Calling the Hitachi Data Systems Support Center).
	975f	All commands	Since you specified the Volume Migration reserved volume as the Copy-on-Write Snapshot S-VOL, the command ends abnormally. For information about using Volume Migration, contact the Hitachi Data Systems Support Center (see Calling the Hitachi Data Systems Support Center).
	9763	paircreate	The Copy-on-Write Snapshot pair cannot be created for any of the following reasons: ▪ The shared memory is not increased. ▪ Initialization is in process.
	976a	paircreate	Unavailable parameter (unsupported parameter) is specified in the command.
	976c	pairsplit	Since the command was executed with the PSUE option, the snapshot data cannot be stored.
	976e	pairsplit	When Copy-on-Write Snapshot P-VOL and TrueCopy S-VOL share the volume, the status of the TrueCopy pair is COPY. Therefore, the snapshot data cannot be stored.

SSB1	SSB2	CCI Command	Cause of Error
	976f	pairsplit	When Copy-on-Write Snapshot P-VOL and Universal Replicator S-VOL share the volume, the status of the Universal Replicator pair is COPY. Therefore, the snapshot data cannot be stored.
	9771	paircreate	Since you specified Universal Replicator delta resync pair volume as the Copy-on-Write Snapshot P-VOL, the Copy-on-Write Snapshot pair cannot be created.
	9772	paircreate	Since you specified Universal Replicator delta resync pair volume as the Copy-on-Write Snapshot S-VOL, the Copy-on-Write Snapshot pair cannot be created.
	9774	paircreate	When the Copy-on-Write Snapshot P-VOL and ShadowImage P-VOL share the volume, the MU number you specified for the Copy-on-Write Snapshot pair is already used by the ShadowImage pair. Therefore, the Copy-on-Write Snapshot pair cannot be created.
	9776	paircreate	When the Copy-on-Write Snapshot P-VOL and ShadowImage P-VOL share the volume, the ShadowImage P-VOL you specified for the Copy-on-Write Snapshot P-VOL has consistency group settings. Therefore, the Copy-on-Write Snapshot pair cannot be created.
	9777	paircreate	When the Copy-on-Write Snapshot P-VOL and ShadowImage S-VOL share the volume, you specified MU number zero (0) for the Copy-on-Write Snapshot P-VOL. Therefore, the Copy-on-Write Snapshot pair cannot be created.
	9778	paircreate	When the Copy-on-Write Snapshot P-VOL and ShadowImage S-VOL share the volume, the ShadowImage S-VOL you specified for the Copy-on-Write Snapshot P-VOL has consistency group settings. Therefore, the Copy-on-Write Snapshot pair cannot be created.
	977a	paircreate pairsplit	When the Copy-on-Write Snapshot P-VOL and ShadowImage P-VOL share the volume, the ShadowImage pair was in the process of resynchronization. Therefore, the command ends abnormally.
	977b	paircreate pairsplit	When Copy-on-Write Snapshot P-VOL and ShadowImage S-VOL share the volume, the status of the ShadowImage pair is other than PSUS. Therefore, the command ends abnormally.
	977c	pairresync -restore	When Copy-on-Write Snapshot P-VOL and ShadowImage P-VOL share the volume, the status of the ShadowImage pair is other than PSUS or PSUE. Therefore, the Copy-on-Write Snapshot pair cannot be restored.
	977d	pairresync -restore	When Copy-on-Write Snapshot P-VOL and ShadowImage S-VOL share the volume, the status of the ShadowImage pair is other than PSUS. Therefore, the Copy-on-Write Snapshot pair cannot be restored.
	977e	pairsplit	Since the pool or the pool-VOL is blocked, the snapshot data cannot be stored.
	9783	pairresync -restore	The Copy-on-Write Snapshot pair cannot be restored for any of the following reasons: ▪ The snapshot data of the Copy-on-Write Snapshot pair for restoration is being stored per consistency group. ▪ The P-VOL of the Copy-on-Write Snapshot pair for restoration is used as the P-VOL of another Copy-on-Write Snapshot pair, and the snapshot data of the latter Copy-on-Write Snapshot pair is being stored per consistency group.
	9786	paircreate pairsplit pairresync pairresync -restore	Since quorum disks are specified as P-VOLs of Snapshot pairs, the command ends abnormally.

SSB1	SSB2	CCI Command	Cause of Error
	9787	paircreate pairsplit pairresync pairresync -restore	Since quorum disks are specified as S-VOLs of Snapshot pairs, the command ends abnormally.
	978a	paircreate	Since one of the following cases occurred, the Copy-on-Write Snapshot pair cannot be created by specifying the consistency number. ▪ The specified consistency group number is in use for ShadowImage. ▪ The number of pairs has already exceeded the maximum number of pairs that can be created for one consistency group. ▪ The pair that uses the same P-VOL exists already in the specified consistency group.
	978b	paircreate	The Copy-on-Write Snapshot pair cannot be created because the specified consistency group number is out of the range of the number that can be specified.
	978c	pairsplit	The snapshot data cannot be stored because the TrueCopy asynchronous pair status is other than PSUS or PSUE when Copy-on-Write Snapshot (P-VOL) and TrueCopy asynchronous (S-VOL) share the volume.
	978e	paircreate	The Copy-on-Write Snapshot pair for which the consistency group is specified cannot be created because the P-VOL or S-VOL of the ShadowImage pair is specified as the P-VOL of the Copy-on-Write Snapshot pair.
	9790	paircreate	The Dynamic Provisioning virtual volume, which is undergoing capacity expansion, is specified as the Copy on Write Snapshot P-VOL. Therefore, the Copy-on-Write Snapshot pair cannot be created.
	9793	paircreate	The Copy-on-Write Snapshot pair cannot be created because the Dynamic Provisioning V-VOL that is discarding zero data is specified as a P-VOL of the Copy-on-Write Snapshot pair.
	97a2	paircreate pairsplit pairresync pairresync -restore	The command ended abnormally because the specified S-VOL used two mirrors in a 3DC multi-target or 3DC cascade configuration, which is a delta resync configuration consisting of three Universal Replicator sites.
	97a3	paircreate pairsplit pairresync pairresync -restore	The command ended abnormally because the specified S-VOL used two mirrors in a 3DC multi-target or 3DC cascade configuration, which is a delta resync configuration consisting of three Universal Replicator sites.
	B912	paircreate pairsplit pairresync	The Copy-on-Write Snapshot pair operation failed because the specified S-VOL is wrong.
	B9A7	All commands	The consistency group information can not be obtained because the Copy-on-Write Snapshot is not installed.

Calling the Hitachi Data Systems Support Center

If you need to call the Hitachi Data Systems Support Center, make sure to provide as much information about the problem as possible, including:

- The circumstances surrounding the error or failure.
- The content of any error message(s) displayed on the host system(s).
- The exact content of any error messages displayed on Storage Navigator.
- The Storage Navigator configuration information (use the FD Dump Tool).
- The service information messages (SIMs), including reference codes and severity levels, displayed by Storage Navigator.

The Hitachi Data Systems customer support staff is available 24 hours a day, seven days a week. If you need technical support, log on to the Hitachi Data Systems Portal for contact information: https://hdssupport.hds.com

Acronyms and Abbreviations

CCI	Command Control Interface
CLPR	cache logical partition
COW	Copy-on-Write
CU	control unit
DP-VOL	Dynamic Provisioning
GB	gigabytes (see Convention for Storage Capacity Values)
KB	kilobytes (see Convention for Storage Capacity Values)
LAN	local-area network
LDEV	logical device
LDKC	logical DKC
LU	logical unit
LUN	logical unit number
LUSE	LUN Expansion
MB	megabytes (see Convention for Storage Capacity Values)
MU	mirror unit
PB	petabytes (see Convention for Storage Capacity Values)
P-VOL	primary volume
PSUE	pair suspended-error
PSUS	pair suspended-split
SMPL	simplex
SOM	system option mode
S-VOL	secondary volume
TB	terabytes (see Convention for Storage Capacity Values)
TC	TrueCopy
UR	Universal Replicator
USP V/VM	Hitachi Universal Storage Platform V/VM
VLL	Virtual LVI/LUN
V-VOL	virtual volume

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