VAX Volume Shadowing Manual

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Preface

The *VAX Volume Shadowing Manual* describes how to use the volume shadowing option.

Intended Audience

This manual is intended for VMS programmers, system managers, and general users.

Document Structure

The *VAX Volume Shadowing Manual* consists of four chapters and three appendixes.

Chapter 1 gives an introduction to volume shadowing.

Chapter 2 describes the VMS utilities and DCL commands used to mount, maintain, and dismount volume shadowing sets.

Chapter 3 describes the programming interface to VAX Volume Shadowing, which consists of modifications to three system service routines.

Chapter 4 briefly explains license registration and describes how to manage VAX Volume Shadowing.

Appendix A lists the mount verification messages and the Mount Utility messages related to volume shadowing.

Appendix B is a summary of the Mount Utility qualifiers for volume shadowing, designed to be inserted into the *VMS Mount Utility Manual.*

Appendix C is a summary of the system services item codes for volume shadowing, designed to be inserted into the *VMS System Services Reference Manual.*

Associated Documents

The following documents contain information related to this manual:

- *VMS License Management Utility Manual*
- *VMS VAXcluster Manual*
- *Guide to VMS Files and Devices*
- *Introduction to VMS System Management*
- *Guide to Setting Up a VMS System*
- *Guide to Maintaining a VMS System*
- *VMS DCL Dictionary*
- *VMS Mount Utility Manual*
- *VMS Backup Utility Manual*

- *VMS System Services Reference Manual*
- *VMS System Messages and Recovery Procedures Reference Volume*
- *VMS System Generation Utility Manual*

Conventions

Convention	Meaning
RET	In examples, a key name (usually abbreviated) shown within a box indicates that you press a key on the keyboard; in text, a key name is not enclosed in a box. In this example, the key is the RETURN key. (Note that the RETURN key is not usually shown in syntax statements or in all examples; however, assume that you must press the RETURN key after entering a command or responding to a prompt.)
CTRL/C	A key combination, shown in uppercase with a slash separating two key names, indicates that you hold down the first key while you press the second key. For example, the key combination CTRL/C indicates that you hold down the key labeled CTRL while you press the key labeled C. In examples, a key combination is enclosed in a box.
$ SHOW TIME 05-JUN-1988 11:55:22	In examples, system output (what the system displays) is shown in black. User input (what you enter) is shown in red.
$ TYPE MYFILE.DAT . . .	In examples, a vertical series of periods, or ellipsis, means either that not all the data that the system would display in response to a command is shown or that not all the data a user would enter is shown.
input-file, . . .	In examples, a horizontal ellipsis indicates that additional parameters, values, or other information can be entered, that preceding items can be repeated one or more times, or that optional arguments in a statement have been omitted.
[logical-name]	Brackets indicate that the enclosed item is optional. (Brackets are not, however, optional in the syntax of a directory name in a file specification or in the syntax of a substring specification in an assignment statement.)
quotation marks apostrophes	The term quotation marks is used to refer to double quotation marks ("). The term apostrophe (') is used to refer to a single quotation mark.

1 Introduction to VAX Volume Shadowing

1.1 Overview

Volume shadowing is a cooperative effort between the VMS operating system and a Hierarchical Storage Controller (HSC) to record data on more than one volume. This duplication of data provides greater data availability and faster data accessibility. When data is recorded on more than one volume, you have access to critical data even when one volume is unavailable. The system can also find the data more quickly because it can search more than one disk—it is as if there were additional read heads on a single disk drive. (Note, however, that due to the multiple write operations, write performance is slightly slower with volume shadowing.) In addition, when normal media deterioration renders a volume unreadable, systems with volume shadowing read the duplicate data and restore the data to the failed volume.

Volume shadowing allows you to unite compatible volumes into a shadow set. A shadow set generally consists of two or more compatible disk volumes (one is also allowed) referred to as shadow set members. After you create a shadow set, most users and most software regard it as a single virtual unit. A virtual unit is a software-created representation of a group of disks and disk drives that compose a shadow set.

From the command level, you can use the VMS Mount Utility (MOUNT) to create and add members to shadow sets, and the DCL commands SHOW DEVICES and DISMOUNT to maintain them. In software programs you can use the system service routines $MOUNT, $GETDVI, and $DISMOU to create and maintain shadow sets. In DCL command procedures, the lexical function F$GETDVI provides the same services as the $GETDVI system service.

You can mount shadow sets as private volumes or public volumes on systems operating alone or in VAXclusters. The VMS operating system provides volume shadowing for users of both Files–11 volumes and foreign volumes, but many of the functions provided with Files–11 volumes must be user supplied for foreign volumes.

To use VAX Volume Shadowing, you need a Hierarchical Storage Controller (HSC) and DIGITAL Storage Architecture (DSA) disk volumes in addition to one or more VAX processors.

1.2 Volume Shadowing Terms

Following are some important volume shadowing terms and their definitions.

$allocation-class$
$allocation-class$ is part of a naming convention for virtual units and physical devices. This convention is described in the *VMS VAXcluster Manual.* If your system connects devices by dual paths to two HSCs, you should specify those devices (and especially the shadow set virtual units) using the allocation class name *$allocation-class$* instead of the HSC name *hsc$* (described in this section).

HSC
The Hierarchical Storage Controller (HSC) is a self-contained, intelligent mass storage controller that communicates with VAX processors to implement volume shadowing on DIGITAL Storage Architecture (DSA) disks.

hsc$
hsc$ is part of a naming convention for virtual units and physical devices. Because volume shadowing requires an HSC, *hsc$* replaces *node$* for the node name format described in the *VMS VAXcluster Manual.* Physical devices (and the virtual unit that represents them) connected to the same HSC all use the same HSC name. For example, two devices connected to the HSC named TROLL might be named TROLL$DUA1 and TROLL$DUA2.

Mount verification
Mount verification is a VMS feature that suspends I/O with volumes while they are changing status. Mount verification also ensures that, following a suspension in disk I/O, the volume being accessed is the same as was previously mounted. When volume shadowing is installed, the mount verification feature also maintains and validates shadow set membership for Files–11 shadow sets.

MSCP
Mass Storage Control Protocol (MSCP) is the software protocol used to communicate between VAX processors and HSCs.

Remote server
Remote servers implement the MSCP protocol. They control disk operations separately from the host node and then communicate information back to it. The HSC is one example of a remote server.

Shadow set
A shadow set is one or more compatible physical disk volumes connected together for volume shadowing and represented by a virtual unit. Thus, the term shadow set refers to the physical units *and* the virtual unit.

Shadow set member
A shadow set member is a physical disk mounted as part of a shadow set. Typically, all shadow set members contain identical data in corresponding logical blocks.

Shadow set state change	A shadow set state change occurs when volumes are added to or removed from a Files–11 shadow set. During a shadow set state change, access to the virtual unit is temporarily suspended. The shadow set remains inaccessible until the host computer or VAXcluster accepts a membership change. For Files–11 volumes, mount verification controls this acceptance.
Virtual unit	A virtual unit is a software-created representation of a group of disks that compose a shadow set. Most users and system resources communicate with the virtual unit as if it were a physical device and disk volume. The HSC then manages I/O to the physical disks that are bound together as a shadow set.

1.3 Hardware Requirements

To use VAX Volume Shadowing, you need specific hardware in addition to the VMS operating system. Following are the hardware requirements.

Processors and Controllers

VAX Volume Shadowing requires a minimum of one VAX processor, one HSC intelligent mass storage controller, and two compatible disk drives and volumes.[1] This configuration provides protection against either failure of a single disk drive or deterioration of a single volume. Using two HSC controllers provides a further guarantee of data availability in the event of a single HSC failure. Using a VAXcluster and multiple HSCs provides the greatest data availability.

When setting up a system or VAXcluster with volume shadowing, you should do the following:

- Connect all disk drives chosen for a shadow set to the same HSC controller, if you are using single path connections.
- Connect all disk drives chosen for a shadow set to the same pair of HSC controllers, if you are using dual path connections.
- Connect disk drives to different HSC I/O channels, when possible.

Compatible Disk Drives and Volumes

Volume shadowing requires compatibility among the physical units (disk drives and volumes) that form a shadow set. For instance:

- Units must have the same geometry, including the same number of sectors per track, the same number of tracks per cylinder, and the same number of cylinders per volume.
- Units must have the same physical properties, including connections conforming to those described previously for HSC connections.
- Units must conform to the DIGITAL Storage Architecture (DSA), and Mass Storage Controller Protocol (MSCP). They must replace bad blocks without host intervention.

[1] A shadow set can consist of only one disk, but this configuration cannot provide the desired duplicate data.

1.3 Hardware Requirements

- Units should not have the hardware write-protection button pressed. Hardware write protection stops volume shadowing software from maintaining identical volumes.

For performance information related to system configurations, see Section 4.(

Figure 1–1 through Figure 1–3 show three possible system configurations for volume shadowing. In addition to the hardware components, these figures present how the virtual unit relates to the hardware.

Figure 1–1 Elements of a Shadow Set (One VAX — One HSC)

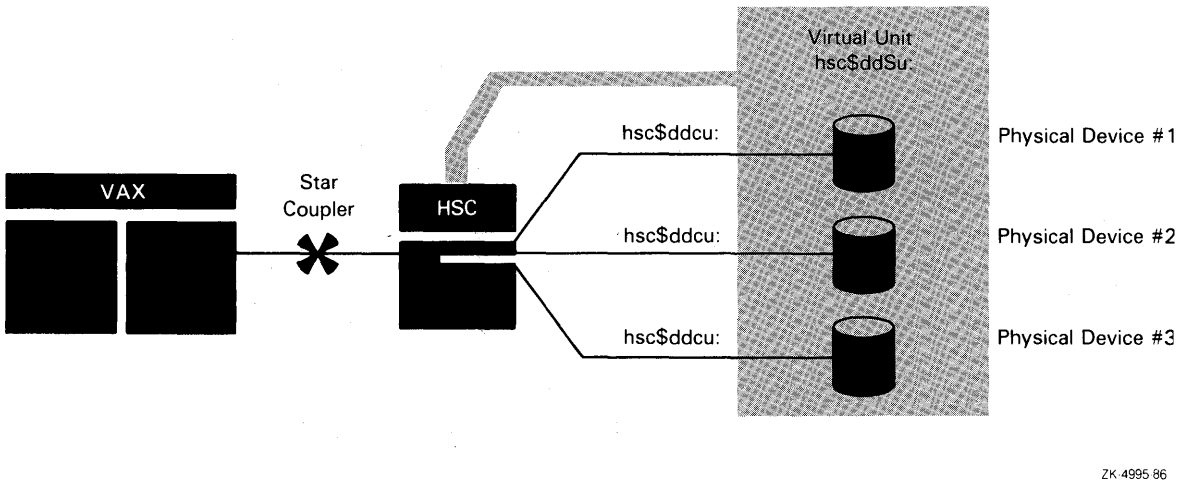


Figure 1–1 presents a system with one VAX processor and one HSC. In this configuration, the devices and virtual unit use the **hsc$** naming convention.

Figure 1–2 presents a system with one VAX processor and three units connected by dual paths to two HSCs. These devices and virtual unit all use the same allocation class name.

Figure 1–2 Elements of a Shadow Set (One VAX — Two HSCs)

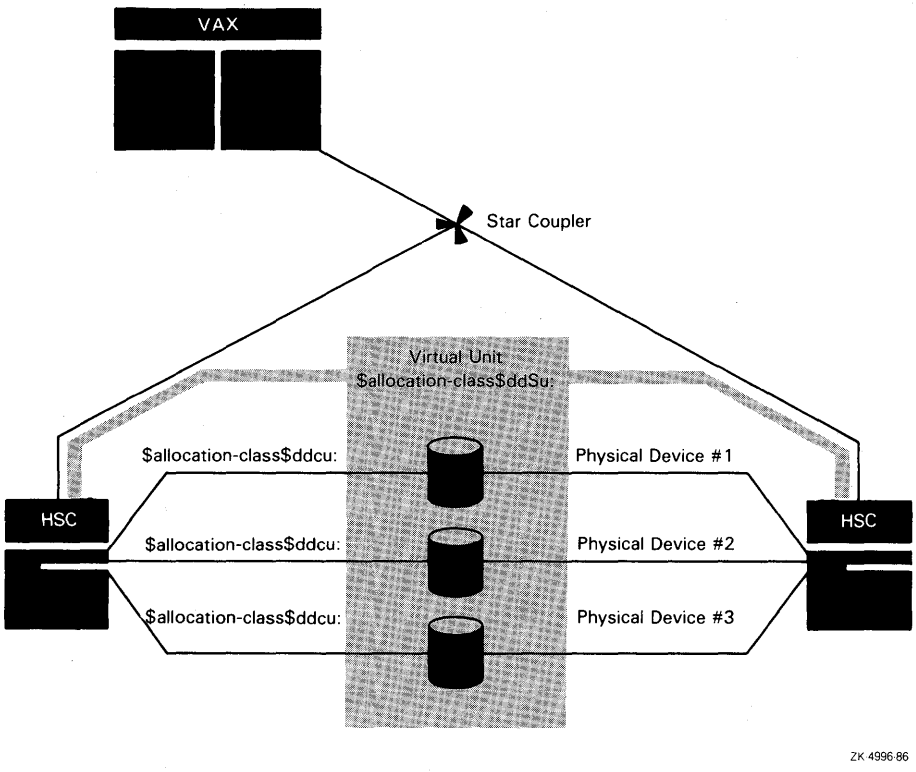


Figure 1–3 Elements of a Shadow Set (A VAXcluster — Two HSCs)

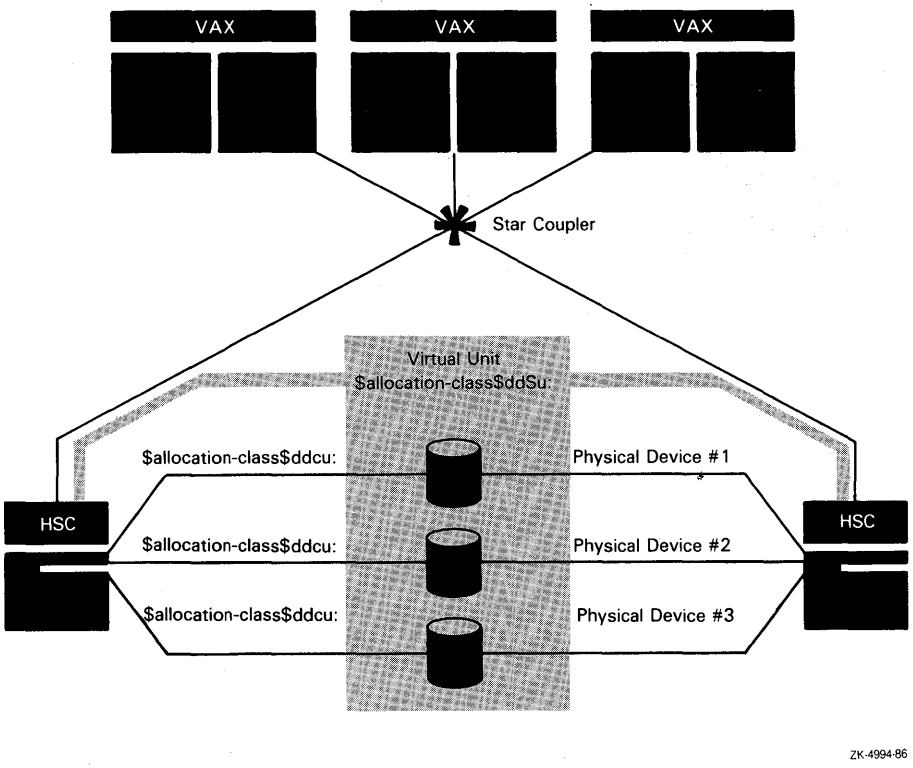


Figure 1–3 presents a system with three VAX processors and three units connected by dual paths to two HSCs. These devices and this virtual unit us the same allocation class name.

1.4 Mounting a Shadow Set

To mount a shadow set, you must perform the following steps:

1. Set up the VAX processors and HSC controllers to allow for the greatest protection against hardware failure. See the *VMS VAXcluster Manual* for details on VAXcluster configurations using multiple controllers.
2. Select compatible disk drive units and disk volumes properly ported according to your system configuration. Also, make sure the hardware write-protection buttons on the drives are in the out position (no write protection).

3 Prepare the selected volumes for mounting. This includes physically placing the volumes in the drives and allocating them (this is optional). Then you must consider the data on the volumes you have chosen to mount together, as follows:

- If you intend to mount a *new* shadow set with volumes that contain no useful data, you should initialize one volume. Initialize the volume in the drive that you will list as the *first* shadow set member in your mount operation. Give it a proper label that you will use for the shadow set. The other volumes are initialized automatically when they become shadow set members.
- If you intend to mount a shadow set that includes a volume with useful data, do not initialize the volumes.

4 Mount the shadow set using either the VMS Mount Utility or the $MOUNT system service. You must be careful of the default copy operations that overwrite data on shadow set members determined to be less current than others.

The following example uses the MOUNT command to create a single shadow set using RA80 disks:

```
$ MOUNT /CONFIRM❶ $2$DUS23:❷-
_$/SHADOW = ($2$DUA4:,❸ $2$DUA5:,❸ $2$DUA7:❸)-
_$ MYVOLUME❹   DISK$MYVOLUME❺
```

❶ /CONFIRM is an optional qualifier that stops *automatic* copy operations to disks determined to have the least correct data.

❷ 2DUS23 is the name of the virtual unit that represents the shadow set.

❸ 2DUA4, 2DUA5, and 2DUA7 are the physical units that are shadow set members. Note that they must be the same device type.

❹ MYVOLUME is the volume label of the shadow set virtual unit, and at least one of the shadow set members.

❺ DISK$MYVOLUME is the logical name of the shadow set virtual unit.

Chapter 2 describes more fully how to mount shadow sets using the Mount Utility. See Chapter 3 for information about how to mount shadow sets with the $MOUNT system service.

1.5 Shadow Set Changes

After a shadow set is mounted, volume shadowing must preserve the integrity of the data written to it. When you first mount and initialize the shadow set, each of the member volumes is identical and ready to receive identical data. However, changes in the composition of the shadow set are inevitable, because, for example:

- Disk drives fail or need routine maintenance.
- New disks are added to improve performance (or to replace other disks).

Volume shadowing responds to shadow set composition changes by doing the following:

- Maintaining identical data on current shadow set members by automatically detecting and replacing bad blocks on one shadow set member and rewriting those bad blocks with good data from another shadow set member.
- Bringing newly mounted volumes up to full shadow set membership through copy operations (see Section 2.1.4). Copying is automatic for Files–11 shadow sets; you must specify the copy operations for foreign shadow sets.
- Notifying the system operator when a member is removed from a shadow set.

1.6 Examining a Shadow Set

You can use the DCL command SHOW DEVICES, the system service $GETDVI, and the corresponding lexical function F$GETDVI to get information about a shadow set virtual unit and its corresponding physical volumes. You might enter the DCL command SHOW DEVICES, as in the following example:

```
$ SHOW DEVICES DUS1
```

Entering the virtual unit name DUS1 as a parameter produces a display such as the following:

```
Device                  Device           Error    Volume         Free  Trans Mnt
 Name                   Status           Count     Label        Blocks Count Cnt
$254$DUA39:     (HONOR) ShadowSetMember      0  (member of $254$DUS1:)
$254$DUA44:     (HONOR) ShadowSetMember      0  (member of $254$DUS1:)
$254$DUS1:      (HONOR) Mounted              0  SHD22AUG         99268    81   1
```

In this display the HSC is named HONOR.

Or you might enter a command such as this:

```
$ SHOW DEVICES DJS
```

Entering a generic virtual unit name DJS as a parameter produces a display o any virtual units representing shadow sets mounted on RA60 disks.

```
Device                  Device           Error    Volume         Free  Trans Mnt
 Name                   Status           Count     Label        Blocks Count Cnt
$254$DJS1:      (HONOR) Mounted              0  LURK1$           27060    35   7
$254$DJS2:      (HONOR) Mounted              0  LURKMASTER       85653     4   6
```

See Chapter 2 for a description of how to examine shadow sets using the SHOW DEVICES command, and Chapter 3 for information about using $GETDVI.

1.7 Adding and Removing Shadow Set Members

After a shadow set is mounted, you can add physical units to it with the VMS Mount Utility. You must use the same command syntax used to create the shadow set, except you do not need to list the physical units currently in the shadow set. Also, you do not need to add the /CLUSTER qualifier to add the units clusterwide. The /CLUSTER qualifier is implied; a virtual unit must represent the *same* shadow set members to every node on which it is mounted.

In the following example, the first command creates the shadow set with two shadow set members; the second command adds a third physical unit to the *same* shadow set. Note that any data on the third volume is lost to an automatic copy operation when the shadow set member is added.

```
$ MOUNT $6$DJS2: /SYSTEM /SHADOW=($6$DJA4:, $6$DJA5:) PHANTOMDISK DISK$PHANTOMDISK

$ MOUNT $6$DJS2: /SYSTEM /SHADOW=($6$DJA6:) PHANTOMDISK DISK$PHANTOMDISK
```

You can dismount shadow set virtual units and physical units with the DCL command DISMOUNT or the $DISMOU system service. If you dismount a virtual unit from one node, only the node from which you issued the command dismounts the shadow set. (For details, see Section 2.4.) You can dismount individual shadow set members directly as if they were not members of a shadow set. Dismounting a shadow set member removes it from the shadow set clusterwide; the membership of a shadow set must be consistent to every node on which it is mounted.

For example, to remove a physical unit 5DUA7 from a shadow set with the three members 5DUA4, 5DUA7, and 5DUA11, you might enter the following command:

```
$ DISMOUNT $5$DUA7:
```

Note: If you attempt to dismount all the physical units in a shadow set, mount verification requests that the operator restore a member to the shadow set.

1.8 Dissolving a Shadow Set

You can dismount the virtual unit from one node in a VAXcluster and leave the shadow set operational on the remaining nodes on which it is mounted. If you dismount the virtual unit of a shadow set from all the VAXcluster nodes, or from the only node with volume shadowing, you dissolve the shadow set.

After you dissolve a shadow set, each of the former shadow set members is available for use. Each volume, however, continues to be marked as having been part of a shadow set. Chapter 2 describes how to manage shadow sets, including how to dissolve and re-create shadow sets to your advantage.

1.9 Shadow Sets as System Disks and in VAXclusters

You can mount your system disk as a shadow set, but you must take special steps when creating the shadow set. When you install VAX Volume Shadowing in a VAXcluster, for example, you have to prepare each VAX processor the same way. Volume shadowing adds complications to software upgrade procedures on system disk shadow sets as well. Section 4.4 describe how to prepare a system disk shadow set and boot from it. Section 4.5 describes the upgrade procedure.

Shadow sets mounted in a VAXcluster require special considerations. Primarily, you should perform the volume shadowing procedures on each VAXcluster node even if the shadow set is fully constructed on one node. You should mount the shadow set exactly the same way on each node. Mounting a shadow set clusterwide provides the following advantages:

- The remote server informs each VAXcluster node of shadow set state changes.
- If an HSC fails in a VAXcluster with multiple HSCs, any VAXcluster nod can switch the shadow set to an alternate HSC.
- If the HSC fails in a VAXcluster with a single HSC, any VAXcluster nod can rebuild the shadow set when the HSC is available again.

Note that after you mount a shadow set clusterwide, you can dismount the shadow set from one VAXcluster node and leave it operational on the other cluster nodes.

Note: You cannot set up your quorum disk as a shadow set. A series of reques for the cluster quorum information would produce unpredictable results.

2 The Command-Level Interface

VAX Volume Shadowing provides enhancements to existing VMS utilities and DCL commands that let you create, maintain, and dissolve shadow sets. This chapter describes how to use the VMS Mount Utility, the VMS Backup Utility, and the DCL commands SHOW DEVICES and DISMOUNT with volume shadowing. The lexical function F$GETDVI is also described.

2.1 Creating a Shadow Set with the Mount Utility

You mount shadow sets with the Mount Utility using any valid MOUNT qualifiers[1] , the name of the virtual unit, and the required /SHADOW qualifier. You must name at least one physical device as a parameter to the /SHADOW qualifier.

If you specify more than one physical device, more current Files–11 disks are copied to less current Files–11 disks by default (see Section 2.1.4 for details). To disable the copy operations, use the /NOCOPY qualifier. If you are mounting a shadow set interactively, you can use the /CONFIRM qualifier, which instructs MOUNT to display the targets of copy operations and request permission before the copies are performed.

If you mount foreign volumes in a shadow set, to ensure identical data you must use the appropriate copy-type specifier for each physical device named (see Section 2.1.3 for details).

Restrictions

If the mount operation involves a copy operation, you must have override volume protection (VOLPRO) privilege or your user identification code (UIC) must match the owner UIC of the target volume.

Volume Shadowing Qualifier List

Following are the volume shadowing qualifiers and copy-type specifiers used with the VMS Mount Utility.

Files–11 Volume Qualifiers	Defaults
/SHADOW=(physical-device-name[:][, . . .])	None.
/[NO]CONFIRM	/NOCONFIRM
/[NO]COPY	/COPY

Foreign Volume Qualifier
/SHADOW=(copy-type=physical-device-name[:][, . . .])

[1] The /OVERRIDE=IDENTIFICATION and /NOMOUNT_VERIFICATION qualifiers are not recommended.

The following copy-type specifiers are used with the preceding foreign volume qualifier.

Foreign Volume Copy-Type Specifiers
NO_COPY=physical-device-name (default)
FULL_COPY=physical-device-name
MERGE_COPY=physical-device-name

The following qualifier, used with MOUNT, lets you remount a former shadow set member outside of a shadow set.

Qualifier	Default
/OVERRIDE=SHADOW_MEMBERSHIP	None.

2.1.1 Mounting a Files–11 Shadow Set

The format for mounting a Files–11 shadow set is as follows:

MOUNT virtual-unit-name[:]**/SHADOW =**
(physical-device-name[:][, . . .])[, . . .] [volume-label[, . . .]] [logical-name[:]]

virtual-unit-name[:][, . . .]

The required name for the software representation of a shadow set. Use the virtual unit naming formats **[$allocation-class$]ddSu[:]** or **[hsc$]ddSu[:]**.

If the allocation class is not zero, use the allocation class format. If you omit the HSC name or allocation class when you specify a virtual unit in a VAXcluster, MOUNT substitutes the HSC name or allocation class of the mos current shadow set member.

The **dd** describes the device type of the physical devices used. For example, an RA60 disk drive is device type **DJ**, and an RA80 or RA81 disk drive is device type **DU**. You must match the code for a virtual device name with the code for the type of physical devices proposed as shadow set members.

The **S** identifies the unit as a shadow set virtual unit.

The **u** is a unique number from 0 through 9999. This code is optional when you create a shadow set. If you omit this code, the system provides a virtual unit number. Numbering starts at 9999 and decrements to 0; the first virtual unit mounted is numbered 9999, the second 9998, and so forth.

If you are mounting a volume set of shadow sets and specify more than one shadow set virtual unit, separate each with either commas or plus signs. The shadow sets must be in the same volume set and the labels must be specifiec in ascending order according to relative virtual unit number.

/SHADOW=(physical-device-name[:][, . . .])

The required volume shadowing qualifier that directs the Mount Utility to bind the specified physical devices into a shadow set.

You must specify the name or names of the physical devices proposed as shadow set member devices. If you specify only one device, you can omit the parentheses.

physical-device-name[:][, . . .]

The name of a disk drive that contains a disk to be mounted in a shadow set. Use the standard HSC-mounted device naming formats **$allocation-class$ddcu[:]** or **hsc$ddcu[:]**. If your devices are dual ported to HSCs, use the allocation-class format. For example, 125DUA23 represents an RA80 or RA81 disk with unit number 23. The disk's allocation class is 125. The **c** part of the format is always A for HSC disks. An RA60 disk with unit number 12 might be named TROLL$DJA12. The device is connected to an HSC named TROLL. A named physical device becomes a *shadow set member* represented by the *virtual unit.*

volume-label[, . . .]

Specifies the label for a virtual unit (each of the shadow set members takes this label automatically). Labels can be from 1 to 12 characters. To add a shadow set member to an existing shadow set, specify only the label of the shadow set, not the label of the potential shadow set member.

If you do not specify a label, MOUNT selects the label for the shadow set from the first shadow set member listed. Note also that, if proposed members are not marked with shadow set information, MOUNT considers volumes with labels that match the shadow set label more current than volumes with labels that do not match. The less current volumes are targets of copy operations.

Note: DIGITAL recommends you do not mount a shadow set with the /OVERRIDE=IDENTIFICATION qualifier; see Section 2.1.5.4 for details.

If you are mounting a volume set of shadow sets and specify more than one volume label, separate the labels with either commas or plus signs. The shadow sets must be in the same volume set and the labels must be specified in ascending order according to relative virtual unit number.

logical-name[:]

Defines a 1- to 255-alphanumeric character string associated with the mounted shadow set. Follow the same command syntax as you would to mount any volume or volume set.

Note that most of the command format is the same as the format for mounting Files–11 disks for individual use. For information about mounting any disk, see the *VMS System Services Reference Manual.* The *Guide to VMS Files and Devices* and the *Guide to Maintaining a VMS System* also explain how to mount disks and disk sets.

2.1.2 MOUNT Examples

Example 1

This example forms the shadow set 45DUS23, which includes shadow set members 45DUA4, 45DUA5, and 45DUA7.

```
$ MOUNT   $45$DUS23: /SHADOW = ( $45$DUA4:, $45$DUA5:, $45$DUA7:) -
_$ LURKINGVOL  DISK$LURKINGVOL
```

Example 2

This example mounts a Files–11 volume set where each volume is a shadow set.

```
$ MOUNT  $7$DUS23:❶ /SHADOW = ($7$DUA4:,❷ $7$DUA5:, $7$DUA7:), -
_$ $7$DUS24:❶ /SHADOW = ($7$DUA9:,❷ $7$DUA10:, $7$DUA12:), -
_$ $42$DUS26:❶ /SHADOW = ($42$DUA20:,❷ $42$DUA21:, $42$DUA22:)
_$ LURKINGVOL1,❸ LURKINGVOL2,❸ LURKINGVOL3❸   DISK$LURKINGVOL❹
```

❶ These are the names of the virtual units that represent shadow sets mounted in a volume set. Each set uses either RA80 or RA81 disks (not mixed).

❷ 7DUA4, 7DUA5, and 7DUA7 . . . 42DUA22 are the physical units that are shadow set members. Note that one of the shadow sets uses disks from a different allocation class.

❸ LURKINGVOL1, LURKINGVOL2, and LURKINGVOL3 are the volume labels of the virtual units mounted in a Files–11 volume set.

❹ DISK$LURKINGVOL is the logical name that represents the volume set.

2.1.3 Mounting a Foreign Shadow Set

The format for mounting a foreign shadow set is as follows:

MOUNT/FOREIGN virtual-unit-name[:]**/SHADOW =**
(copy-type-specifier = physical-device-name[:][, . . .]) [, . . .]
[volume-label[, . . .]] [logical-name[:]]

Note: You cannot mount foreign shadow sets with the /CONFIRM and /COPY qualifiers.

The format for foreign shadow sets is the same as for Files–11 shadow sets, except for the addition of the **copy-type-specifier**. When you mount Files–1 volumes in a shadow set, MOUNT determines the correct copy operation to ensure identical data on each disk. When you mount foreign volumes in a shadow set, *you* must determine and specify the desired copy operation for each disk. There are three copy-type specifiers: FULL_COPY, MERGE_COPY, and NO_COPY. Note that MOUNT always uses the first shadow se member listed as the source of copies to the other members. Thus, you mus mount the first member with NO_COPY. You must determine the correct copy operation for any other shadow set members. The default copy-type specifier is NO_COPY.

FULL_COPY

Instructs MOUNT to copy data from other shadow set members to the specified volume. The specified volume should be a blank volume or a former shadow set member that is not as current as the other shadow set members.

MERGE_COPY

Instructs MOUNT to copy data from other shadow set members to the specified volume *and* to copy data from the specified volume to other shadow set members when the other shadow set members are unreadable. The specified volume should be one whose data is considered as current or as correct as any shadow set members, except for possible incomplete write operations. The volume listed with this specifier becomes a source of data for any volumes with unreadable blocks and is a target for data copying on all other blocks.

NO_COPY

Instructs MOUNT to mount the specified volume as a shadow set member with no copy operations. You must use this specifier with the first shadow set member listed. If you list this specifier with any other volume, you should know that the volume's contents are identical to all the current or potential shadow set members. Note that NO_COPY is the default copy-type specifier. If you mount foreign volumes with different data in a shadow set and do not specify a copy operation for each disk, the shadow set members will not have identical data. In this situation, a read request directed to the virtual unit produces unpredictable data.

You must supply your own methods of marking volumes and determining the correct copy operation for each shadow set member in a foreign shadow set.

Example

This example shows a command string for mounting a foreign shadow set.

```
$ MOUNT/FOREIGN $213$DJS5:❶ /SHADOW = -
_$ (NO_COPY❸ = $213$DJA2:,❷ -
_$ FULL_COPY❹ = $213$DJA10:,❷ -
_$ MERGE_COPY❺ = $213$DJA20:❷)
```

❶ 213DJS5 is the name of the virtual unit that represents a shadow set consisting of RA60-type disks.

❷ 213DJA2, 213DJA10, and 213DJA20 are the physical units that are shadow set members.

❸ NO_COPY is the specifier required to mount, with no copy operations, the foreign disk 213DJA2 in the shadow set.

❹ FULL_COPY is the specifier required to mount, with a full copy operation, the foreign disk 213DJA10 in the shadow set.

❺ MERGE_COPY is the specifier required to mount, with a merge copy operation, the foreign disk 213DJA20 in the shadow set.

2.1.4 Files–11 Copy Operations

Files–11 copy operations ensure that new shadow set members contain data identical to other members. Volume shadowing software brings newly mounted disks into full shadow set membership with full or merge copy operations.

To perform a MOUNT operation that involves a copy operation, you must have VOLPRO privilege or your user identification code (UIC) must match the owner UIC of the target volume.

2.1.4.1 Full Copy

The full copy operation assumes that the newly added disk is less current than, or unrelated to, the existing shadow set members. Data from the other members is written to the new member to make it identical and thus a full shadow set member. If you are re-creating a shadow set with former shadow set members, the volumes most recently in the shadow set (or processed with BACKUP/IMAGE) are considered the sources for full copy operations. For details, see Sections 2.7.3 and 2.8.

2.1.4.2 Merge Copy

The merge copy operation assumes that the newly added member differs from the existing shadow set members, only as a result of an incomplete write operation. Thus, the merge copy operation occurs only when a shadow set is rebuilt due to an HSC failure.

During the updating process, the new disk is regarded as a source of data when existing shadow set disks have unreadable data. If the merge copy operation cannot read the newly added disk either, then it declares the block in question to be identical on all shadow set members.

2.1.4.3 Determining the Correct Copy Operation

For Files–11 volumes, VAX Volume Shadowing performs the correct copy operation automatically when you mount or add to a shadow set. MOUNT interprets information recorded on current and potential shadow set volumes to determine the correct copy operation for each volume. Each volume needs either a full copy operation, a merge copy operation, or no copy operation.

Because every copy operation overwrites the data currently on the disk, you should mount and add to shadow sets carefully. If you are not sure which potential shadow set members are targets of copy operations, you can specify the /CONFIRM or /NOCOPY qualifier (see Sections 2.1.5.1 and 2.1.5.2 for details).

MOUNT checks the following Files–11 volume information to determine the correct copy operation.

Volume Label

MOUNT checks to see if the proposed shadow set disk volume label identifies the volume as a former shadow set member or an unrelated volume. If the volume labels are the same on volumes that have no volume shadowing information on them, MOUNT uses the label of the volume listed as the *first* shadow set member on the command line.

Proper Dismount

MOUNT checks to see if the proposed shadow set disk was correctly dismounted, assuring that the volume contains no incomplete write operations.

BACKUP Revision Number

A BACKUP/IMAGE restoration rearranges the location of data on a volume and sets a revision number to record this change. MOUNT checks the revision number of the proposed shadow set member against the numbers on current or other proposed shadow set members.

Volume Shadowing Generation Number

When a volume joins a shadow set, it is marked with a volume shadowing generation number. MOUNT checks this number on the newly mounted volume against the generation numbers of current shadow set members.

The volume shadowing generation number is a record of shadow set membership at a given time. Following the completion of each shadow set membership change, MOUNT records a new number on each shadow set member. This number is erased when you mount a former shadow set member outside of the shadow set.

Example

In this example, 1DUS0 is the virtual unit name, 1DUA10 and 1DUA11 are the names of the shadow set members, and HSC001 (with allocation class name 1) is the name of the HSC to which the disk drives are connected.

```
$ MOUNT $1$DUS0: /SHADOW=($1$DUA10:,$1$DUA11:) SHADOWDISK
%MOUNT-I-MOUNTED, SHADOWDISK    mounted on _$1$DUS0: (HSC001)
%MOUNT-I-SHDWMEMSUCC, _$1$DUA10: (HSC001) is now a valid member of
                      the shadow set
%MOUNT-I-SHDWMEMCOPY, _$1$DUA11: (HSC001) added to the shadow set
                      with a copy operation
```

This example shows how to create a shadow set where the software determines automatically the correct copy operation for the two shadow set members. MOUNT checks the volume shadowing generation numbers on the volumes, selects the most current shadow set member, and performs the appropriate copy operation. In this example, 1DUA10 is the most current volume and is the source of the copy operation to 1DUA11.

2.1.5 Qualifiers

You must use the /SHADOW qualifier when mounting all shadow sets. For Files–11 shadow sets, /COPY and /NOCONFIRM are the default qualifiers. Copying proceeds automatically using data on the shadow set members to determine the correct copy operation. If you are not sure of the contents of the specified shadow set members, you can specify either the /NOCOPY or the /CONFIRM qualifier in your Files–11 MOUNT command string.

2.1.5.1 The /CONFIRM Qualifier (Files–11 Shadow Sets)

The /CONFIRM qualifier controls whether the Mount Utility (MOUNT) issues a request to confirm a full copy operation when mounting a shadow set. The default is /NOCONFIRM. The format for mounting a shadow set with the /CONFIRM qualifier is as follows:

MOUNT /[NO]CONFIRM virtual-unit-name[:] **/SHADOW=**(physical-device-name[:][, . . .]) [, . . .] [volume-label[, . . .] [logical-name[:]]

You can specify /CONFIRM as a precaution to avoid erasing important data during copy operations. /CONFIRM stops automatic copying of targeted potential shadow set members. When you mount or add to a shadow set, members that contain data less current than other shadow set members are targets for full copy operations. Unless you specify the /CONFIRM or the /NOCOPY qualifier, MOUNT automatically overwrites the data of the targeted volumes.

MOUNT /CONFIRM displays the volume label and volume owner for any specified physical device that requires a full copy operation. MOUNT then stops and displays the following prompt:

```
Allow FULL shadow copy on the above member(s)? [N]:
```

If the targets of copy operations are as expected, type YES, and the MOUNT command proceeds automatically with full copy operations allowed. If not, type NO, press RETURN, or press CTRL/Z. The command quits without mounting any new shadow set members, including those that do not require a full copy operation. If you type a response other than these, the prompt is redisplayed. You can use any combination of upper- and lowercase letters, and abbreviate to one or more letters.

Section 2.1.4.3 describes how MOUNT determines the sources and targets of shadow set copy operations. In brief, the shadow set member with the most current volume shadowing generation number is the source for copy operations to potential shadow set members. Other potential shadow set members must have been marked with identical generation numbers or they are targets for full copy operations.

The /CONFIRM qualifier is similar to the /NOCOPY qualifier except that with /NOCOPY there is no interactive exchange. /NOCOPY also terminates the mount operation if there are any potential full copy operations. Use /CONFIRM to mount a shadow set interactively, and use /NOCOPY to mount shadow sets in the site-specific startup command procedure SYS$MANAGER:SYSTARTUP.COM. (See the /NOCOPY qualifier for information about using it with a system disk shadow set.)

Example 1

This example shows how to use the /CONFIRM qualifier to check the status of potential shadow set members before any data is erased.

```
$ MOUNT/CONFIRM DUS23: /SHADOW=($1$DUA4:,$1$DUA6:) SHADOWVOL❶

%MOUNT-F-SHDWCOPYREQ, shadow copy required
Virtual Unit - $1$DUS23 (HSC001)                  Volume Label - SHADOWVOL❷
     Member                    Volume Label Owner UIC❸
     $1$DUA6: (LOVE)           SCRATCH      [100,100]
Allow FULL shadow copy on the above member(s)? [N]: NO❹
$
```

❶ This command instructs MOUNT to build a shadow set, with the specified devices, and prompt for permission to perform any full copy operations.

❷ Because a full copy operation is necessary, the virtual unit name and the volume label are displayed.

❸ The display also includes the physical device name, the volume label, and the volume owner of the potential shadow set member that requires the copy operation.

❹ A response of **NO** instructs MOUNT to quit with no mounting or copying.

Example 2

This example shows how to use the /CONFIRM qualifier to check the status of potential shadow set members before any data is erased. This time a response of **YES** to the prompt instructs MOUNT to form the shadow set with a full copy operation.

```
$ MOUNT/CONFIRM DUS23: /SHADOW=($1$DUA4:,$1$DUA6:) SHADOWVOL

%MOUNT-F-SHDWCOPYREQ, shadow copy required
Virtual Unit - $1$DUS23 (HSC001)                    Volume Label - SHADOWVOL
     Member                     Volume Label Owner UIC
     $1$DUA6: (LOVE)            SCRATCH      [100,100]
Allow FULL shadow copy on the above member(s)? [N]: YES

%MOUNT-I-SHDWMEMSUCC, _$1$DUA4: (HSC001) is now a valid member of the
                      shadow set
%MOUNT-I-SHDWMEMCOPY, _$1$DUA6: (HSC001) added to the shadow set with
                      a copy operation
$
```

2.1.5.2 The /COPY Qualifier (Files–11 Shadow Sets)

The /COPY qualifier enables or disables copy operations on physical devices you name when mounting or adding to a shadow set. The default is /COPY. Section 2.1.4.3 describes how MOUNT determines the sources and targets of shadow set copy operations. Following is the format for the /COPY qualifier:

MOUNT /[NO]COPY virtual-unit-name[:] **/SHADOW=**(physical-device-name[:][, . . .])
[, . . .] [volume-label[, . . .] [logical-name[:]]

You can specify /NOCOPY as a precaution to avoid erasing important data during copy operations. /NOCOPY stops automatic copying of targeted potential shadow set members. When you mount or add to a shadow set, members that contain data less current than other shadow set members are targets for full copy operations. Unless you specify the /NOCOPY or the /CONFIRM qualifier, MOUNT automatically overwrites the data of the targeted volumes.

A MOUNT/NOCOPY operation fails if any of the specified potential shadow set members require full copy operations. Error messages identify the targets of full copy operations. If the targets are as expected, you can mount the shadow set with the /COPY qualifier. If not, you have not lost data and can enter a new command that specifies units that can be overwritten.

The /NOCOPY qualifier is similar to the /CONFIRM qualifier except that with /CONFIRM there is an interactive exchange in which you can continue a mount with copy operations. Use /CONFIRM to mount a shadow set interactively, and /NOCOPY to mount shadow sets in the site-specific startup command procedure SYS$MANAGER:SYSTARTUP.COM. (Using the /NOCOPY qualifier with a system disk shadow set either has no effect, as

in the case where the system boots from a virtual unit, or causes the mount operation to fail, which is not generally useful for a system disk.)

The /NOCOPY qualifier guards against accidental destruction of data when the system reboots and forms a shadow set using incorrect volumes (caused by different volumes being put into the drives, or drive unit plugs being accidentally switched while the system is down).

Example

This example shows how to use the /NOCOPY qualifier to check the status of potential shadow set members before any data is erased.

```
$ MOUNT/NOCOPY DUS2: /SHADOW=($1$DUA4:,$1$DUA6:,$1$DUA7:) -
_$ SHADOWVOL DISK$SHADOWVOL❶

%MOUNT-F-SHDWCOPYREQ, shadow copy required
%MOUNT-I-SHDWMEMFAIL, DUA7: failed as a member of the shadow set
%MOUNT-F-SHDWCOPYREQ, shadow copy required❷

$  MOUNT/COPY DUS2: /SHADOW=($1$DUA4:,$1$DUA6:,$1$DUA7:) -
_$ SHADOWVOL DISK$SHADOWVOL❸

%MOUNT-I-MOUNTED, SHADOWVOL    mounted on _$1$DUS2: (HSC001)
%MOUNT-I-SHDWMEMSUCC, _$1$DUA4: (HSC001) is now a valid member of
                      the shadow set
%MOUNT-I-SHDWMEMSUCC, _$1$DUA6: (HSC001) is now a valid member of
                      the shadow set
%MOUNT-I-SHDWMEMCOPY, _$1$DUA7: (HSC001) added to the shadow set
                      with a copy operation❹
```

❶ This command instructs MOUNT to build a shadow set with the specifiec devices, but only if no copy operations are required.

❷ MOUNT did not build the shadow set because the specified disk, loaded on device 1DUA7, was a target for a full copy operation. At this point you can verify that the volume in device 1DUA7 does not contain any useful data. You can then proceed using the /COPY qualifier.

❸ This command instructs MOUNT to build a shadow set providing the necessary copy operations.

❹ The shadow set is mounted. The volume in device 1DUA7 receives a full copy operation.

2.1.5.3 The /OVERRIDE=SHADOW_MEMBERSHIP Qualifier

The SHADOW_MEMBERSHIP option of the /OVERRIDE=option qualifier of the MOUNT command lets you remount former shadow set members for write operations outside of the shadow set. Use the following format:

MOUNT /OVERRIDE=SHADOW_MEMBERSHIP physical-device-name[:][, . . .] [volume-label[, . . .]] [logical-name[:]]

When you attempt to mount a former shadow set member outside of a shadow set, MOUNT automatically mounts the volume write-locked to prevent accidental alteration of data. To mount a former shadow set member for write operations, you must specify /OVERRIDE=SHADOW_MEMBERSHIP.

Note: When you use this qualifier, the shadow set generation number is erased from the volume. If you then remount the volume in the former shadow set, MOUNT considers it an unrelated volume and marks it for a full copy operation.

To use /OVERRIDE=SHADOW_MEMBERSHIP you must have VOLPRO privilege or your UIC must match the owner UIC of the volume. See the *VMS Mount Utility Manual* for a description of the /OVERRIDE=option qualifier.

Example

This example shows how to override the write protection and erase the volume shadowing generation number field, thus mounting a former shadow set member on 4DUA20.

```
$ MOUNT/OVERRIDE=SHADOW_MEMBERSHIP $4$DUA20: WORKDISK
```

2.1.5.4 Using MOUNT/OVERRIDE=IDENTIFICATION

Although any valid MOUNT qualifier is allowed, DIGITAL does not recommend using /OVERRIDE=IDENTIFICATION. If you mount a shadow set with this qualifier and individual shadow set members start with different volume labels, you can lose data. MOUNT automatically selects the label for the shadow set from the first shadow set member listed. For example, if you mount a shadow set with the /OVERRIDE=IDENTIFICATION qualifier and the first member listed is labeled SCRATCH (contains no useful data), SCRATCH becomes the label for the shadow set regardless of the labels and data on the other volumes. MOUNT considers shadow set members with labels that match the shadow set label more current than those with labels that do not match. Thus, the member labeled SCRATCH becomes the source of full copy operations to the other members whether or not it contains the most correct data.

2.1.5.5 Using MOUNT/NOMOUNT_VERIFICATION

Mount verification maintains and validates shadow set membership in Files–11 shadow sets. To avoid disabling important volume shadowing functions, do not mount a Files–11 shadow set with the /NOMOUNT_VERIFICATION qualifier.

If you specify the /NOMOUNT_VERIFICATION qualifier, the shadow set becomes unusable at the first shadow set state change.

2.2 Adding Members to a Shadow Set

Use the VMS Mount Utility to add physical units to a shadow set. For Files–11 volumes, use the same syntax as you used to create the shadow set except specify only the device names of the devices you intend to add; you do not need to specify all the current members of the shadow set. You *can* specify current members without changing their membership state.

For foreign volumes, you must specify the device names of the units you want to add and the type of copy operation needed to make the data on each shadow set member identical.

You must mount every member of the shadow set exactly the same way. This means any MOUNT qualifiers specified at the time of shadow set creation override any MOUNT qualifiers you specify when you add a shadow set member. Also, when you add volumes to an existing shadow set mounted across a VAXcluster, shadowing software automatically adds the new members on each VAXcluster node.

Example

This example shows two commands. The first command creates the Files–11 shadow set with two members; the next adds a volume to the same shadow set.

```
$ MOUNT/SYSTEM $3$DJS4: /SHADOW = ($3$DJA7:, $3$DJA8:)   FORMERSELF
%MOUNT-I-MOUNTED, FORMERSELF   mounted on _$3$DJS4: (HSC003)
%MOUNT-I-SHDWMEMSUCC, _$3$DJA7: (HSC003) is now a valid member of
                      the shadow set
%MOUNT-I-SHDWMEMSUCC, _$3$DJA8: (HSC003) is now a valid member of
                      the shadow set

$ MOUNT/SYSTEM $3$DJS4: /SHADOW = $3$DJA6:  FORMERSELF
%MOUNT-I-SHDWMEMCOPY, _$3$DJA6: (HSC003) added to the shadow set
                      with a copy operation
```

The disks 3DJA6 and 3DJA10 are mounted as system volumes in the shadow set identified by virtual unit 3DJS4. The shadow set now includes three shadow set members: 3DJA6, 3DJA7, and 3DJA8. In this example, when you add 3DJA6 after the shadow set already exists, the added volume receives full copy operations.

Section 2.8 describes how to maintain a shadow set with controlled adding c shadow set members.

2.3 Removing Members from a Shadow Set

Use the DCL command DISMOUNT to remove a shadow set member from a shadow set. Specify the physical device directly, just as you specify any device for dismounting. See the *VMS DCL Dictionary* for a description of the DISMOUNT command.

The format for dismounting a shadow set member is as follows:

DISMOUNT physical-device-name[:]

The **physical-device-name** specifies the name of the shadow set member to be dismounted. Use the standard HSC-mounted device naming formats **$allocation-class$ddcu[:]** or **hsc$ddcu[:]**. If your devices are dual ported to HSCs, use the allocation-class format. For example, 125DUA23 represent an RA80 or RA81 disk with unit number 23. The disk's allocation class is 125. The **c** part of the format is always A for HSC disks. GRUFF$DJA12 represents an RA60 disk with unit number 12. The device is connected to a HSC named GRUFF.

Although you dismount a shadow set member with standard DISMOUNT command syntax, the command produces the following behavior specific to volume shadowing:

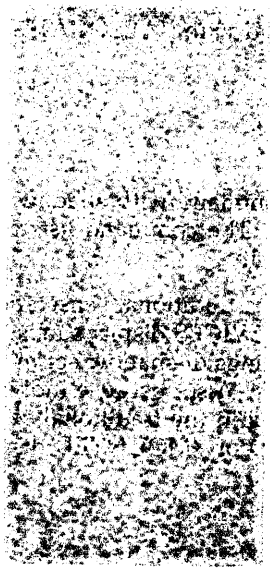
- Because you must dismount the shadow set member from each VAXcluster node, the /CLUSTER qualifier is assumed automatically.
- When you dismount a volume from a shadow set, you produce a situati similar to a hardware disk failure. The entire shadow set enters a shadc set state change under mount verification. This suspends I/O until eacl node accepts the new composition of the shadow set.

- Volumes are marked as *not* being properly dismounted (as they would be in the event of a hardware disk failure) due to the possibility of opened files or incomplete I/O operations. Thus, the volume is considered less current than other remaining shadow set members.
- After removal, shadow set members remain marked as having been members of a shadow set. This mark aids in determining the correct copy operation if you remount the volume in a Files–11 shadow set. A dismounted former shadow set member is automatically mounted write-locked if someone accidentally mounts it outside of a shadow set. To remount a former shadow set member outside of a shadow set, you must mount it with the /OVERRIDE=SHADOW_MEMBERSHIP qualifier.
- After every membership change in a Files–11 shadow set, the remaining shadow set members are marked with a number that identifies them as being more current than former shadow set members. This mark aids in determining the correct copy operation if you remount the volume in a Files–11 shadow set.
- You cannot dismount a shadow set member that is undergoing a copy operation. If you attempt such a dismount, you receive the following error message:

  ```
  %SYSTEM-F-DEVACTIVE,  device is active.
  ```

  You must wait until the copy operation is complete before you dismount the shadow set member. You can, however, abnormally terminate the copy operation if you dismount the entire shadow set.
- If you attempt to dismount all the physical units in a shadow set, mount verification sends a request to the operator to restore the last known valid member to the shadow set.

2.4 Dismounting and Dissolving a Shadow Set



Use the DCL command DISMOUNT to dismount shadow sets. In place of the **device-name** parameter, you specify the shadow set virtual unit name. If your shadow set is mounted on one node, a DISMOUNT command dissolves it; if your shadow set is mounted on several nodes in a VAXcluster, you can dismount the shadow set from each node separately. To dissolve a shadow set in a VAXcluster, you must specify the /CLUSTER qualifier or dismount the shadow set from every node. After a shadow set is dissolved, you can use the former members individually.

The format for dismounting or dissolving a shadow set is as follows:

DISMOUNT virtual-unit-name[:]

Dismounting a virtual unit is similar to dismounting a regular Files–11 physical unit. See the *VMS DCL Dictionary* for information about using DISMOUNT. If you specify /UNLOAD, the shadow set members are spun down *after* the shadow set is dissolved.

You might enter the following command to dissolve a shadow set:

```
$ DISMOUNT/CLUSTER $12$DJS9998:
```

This command dismounts the shadow set represented by the virtual unit 12DJS9998, from every VAXcluster node.

After you dissolve a shadow set, the volumes continue to be marked as being former shadow set members. Section 2.8 discusses some issues to consider when you remount former shadow set members.

2.5 Examining a Shadow Set with the DCL Command SHOW DEVICES

This section describes how to use SHOW DEVICES to examine volume shadowing virtual units and shadow set members. See the *VMS DCL Dictionary* for a full description of how to use the SHOW DEVICES command.

You can use any of the SHOW DEVICES qualifiers when you examine virtual units or shadow set members.

2.5.1 Listing Shadow Set Virtual Units

Use SHOW DEVICES in the following format to display information about virtual units:

SHOW DEVICES [virtual-unit-name[:]]

The **virtual-unit-name** replaces **device-name** as the SHOW DEVICES command parameter for virtual units. Use the **virtual-unit-name** format **ddSu**, **Hsc$ddSu**, or **$allocation-class$ddSu**.

The format for SHOW DEVICES changes only in the format for the virtual unit name. As with any SHOW DEVICES command, the colon is optional. Note also that you can specify a complete virtual unit name (or a portion of a virtual unit name) just as you can with device names. If you omit the virtual unit number, SHOW DEVICES lists all the shadow set virtual units representing shadow set member disks of the type specified. If you truncate a device name (for example, you specify D), SHOW DEVICES lists all the devices and all the virtual units that begin with the letter or letters you entered (in this case, D).

When you specify the virtual unit number, SHOW DEVICES displays the names of the shadow set members it represents. If you use the /FULL qualifier, SHOW DEVICES displays full information about the virtual unit and all the associated shadow set members.

Because individual shadow set members are not allocated or mounted in the traditional sense, a SHOW DEVICES command with /ALLOCATED or /MOUNTED displays only virtual units.

2.5.2 Listing Shadow Set Members

Use the same format for the SHOW DEVICES command with shadow set members as you use with other physical devices. The command lists all shadow set members of the device name you specify.

Because shadow set members are not mounted in a traditional sense and the all have the same device characteristics, SHOW DEVICES displays most of tl relevant data with the associated virtual unit. Listings of shadow set membe include information about current copy operations. Also, because individual shadow set members are not allocated or mounted in the traditional sense, a SHOW DEVICES command with /ALLOCATED or /MOUNTED displays only virtual units.

2.5.3 SHOW DEVICES Examples

Example 1

In this example the shadow set identified by the virtual unit DUS1 includes two shadow set members, 254DUA39 and 254DUA44, as well as the virtual unit 254DUS1. The listings for shadow set members do not include volume labels and other information, because the members are not mounted in the traditional sense.

```
$ SHOW DEVICES DUS1:

Device                  Device           Error    Volume         Free  Trans Mnt
 Name                   Status           Count     Label        Blocks Count Cnt
$254$DUA39:     (HONOR) ShadowSetMember      4  (member of $254$DUS1:)
$254$DUA44:     (HONOR) ShadowSetMember      4  (member of $254$DUS1:)
$254$DUS1:      (HONOR) Mounted              0  SHD22JUN         99268    81   1
```

Example 2

This example shows how the /FULL qualifier produces a display with more information.

```
$ SHOW DEVICES/FULL DUS

Disk $254$DUS1: (HONOR), device type RA80, is online, mounted, file-oriented
    device, shareable, available to cluster, shadow set virtual unit, error
    logging is enabled.

    Error count                    0    Operations completed             23517
    Owner process                 ""    Owner UIC                        [1,1]
    Owner process ID        00000000    Dev Prot    S:RWED,O:RWED,G:RWED,W:RWED
    Reference count                42    Default buffer size                512
    Total blocks               237212    Sectors per track                   31
    Total cylinders               274    Tracks per cylinder                 28
    Host name                  "HONOR"    Host type, available          HS50, yes
    Allocation class               254
    Volume label             "SHD22JUN"    Relative volume number               0.
    Cluster size                     1    Transaction count                   81
    Free blocks                  99268    Maximum files allowed            59303
    Extend quantity                  5    Mount count                          1
    Mount status                System    Cache name        "_$254$DUS1:XQPCACHE"
    Extent cache size              64    Maximum blocks in extent cache     9926
    File ID cache size             64    Blocks currently in extent cache   9383
    Quota cache size                0    Maximum buffers in FCP cache        508

  Volume status:  subject to mount verification, file high-water marking, write-
      through caching enabled.
  Members of shadow set $254$DUS1: are $254$DUA39:, $254$DUA44:.

Disk $254$DUS28: (SHEMP), device type RA81, is online, mounted, file-oriented
    device, shareable, available to cluster, shadow set virtual unit, error
    logging is enabled.
```

```
  Error count                    0    Operations completed                223
  Owner process                  ""   Owner UIC              [DEVO,SYSTEMGURU]
  Owner process ID        00000000    Dev Prot            S:RW,O:RWED,G:R,W:R
  Reference count                1    Default buffer size                 512
  Total blocks              891072    Sectors per track                    51
  Total cylinders             1248    Tracks per cylinder                  14
  Host name                "SHEMP"    Host type, available          HS50, yes
  Allocation class             254

  Volume label       "CASPER28JUL"    Relative volume number                0
  Cluster size                   1    Transaction count                     1
  Free blocks               885302    Maximum files allowed            222768
  Extend quantity                5    Mount count                           4
  Mount status              System    Cache name        "_$254$DUS1:XQPCACHE"
  Extent cache size             64    Maximum blocks in extent cache    88530
  File ID cache size            64    Blocks currently in extent cache      0
  Quota cache size               0    Maximum buffers in FCP cache        508

Volume status:  write-through caching enabled.
Volume is also mounted on LARRY, MOE, CURLEY.
Members of shadow set $254$DUS28: are $254$DUA52:, $254$DUA119:.
```

Example 3

This example shows how truncating the device name to D causes information about all devices and virtual units that begin with the letter D to be displayed.

```
$ SHOW DEVICES D
```

```
Device                  Device           Error    Volume         Free  Trans Mnt
 Name                   Status           Count     Label        Blocks Count Cnt
$7$DLA0:       (LARRY)  Online               0
$7$DMA0:       (LARRY)  Online               0
$7$DMA1:       (LARRY)  Mounted              0  DGR_D$            4266     1   4
$7$DRA2:         (MOE)  Online               0
$7$DRA5:         (MOE)  Online               0
$7$DRB6:       (LARRY)  Mounted              0  CLUSTERDUMP1    694938     1   4
$7$DRB7:       (LARRY)  Mounted              0  CLUSTERDUMP2    616281     1   4
$7$DYA0:       (LARRY)  Online              10
$7$DYA1:       (LARRY)  Online              10
$254$DJA1:      (LOVE)  Mounted              0  FOLKD$_I         52863    31   5
$254$DJA2:      (LOVE)  Mounted              0  PAGED$_I           486     3   4
$254$DJA38:     (LOVE)  Mounted              0  REGFACBLD       313587     1   4
$254$DJA149:    (LOVE)  Online               1
$254$DUA0:      (LOVE)  Mounted              0  VMS22MAY        481043     1   5
$254$DUA5:      (LOVE)  Mounted wrtlck       0  RES22JUL        124176     1   4
$254$DUA39:     (LOVE)  ShadowSetMember      4  (member of $254$DUS1:)
$254$DUA44:     (LOVE)  ShadowSetMember      4  (member of $254$DUS1:)
$254$DUA52:    (HONOR)  ShadowSetMember      8  (member of $254$DUS28:)
$254$DUA101:    (LOVE)  Mounted              0  WORK12$         302034     2   4
$254$DUA102:    (LOVE)  Mounted              0  WORK13$         395910     3   4
$254$DUA103:    (LOVE)  Mounted              0  WORK14$         541047     1   4
$254$DUA119:   (HONOR)  ShadowCopying        0  (being added to $254$DUS28:)❶
$254$DUA129:    (LOVE)  Mounted wrtlck       0  RES02JUL        133810     1   4
$254$DUS1:      (LOVE)  Mounted              0  SHD22JUL         99303    82   1
$254$DUS28:    (HONOR)  Mounted              0  CASPER28JUN     888919     1   4
```

❶ Device 254DUA119 is being added to the shadow set represented by 254DUS28. The addition of this device requires a copy operation.

2.6 Using the F$GETDVI Lexical Function

The F$GETDVI lexical function provides another method for obtaining information about shadow sets. Through the use of the shadow set item arguments, you can determine the following types of information:

- Whether a device is a shadow set virtual unit or a shadow set member
- Whether a copy operation is in progress on a device
- What type of copy operation is in progress on a device
- The name of the virtual unit that represents the shadow set of which the particular device is a member
- The entire membership of a shadow set, including the virtual unit and all of the members
- Whether or not a member has been removed from the shadow set by the remote server

The format for the F$GETDVI lexical function is as follows:

F$GETDVI(device-name,item)

The F$GETDVI function returns information about all items that you can specify with the $GETDVI system service. Table 2–1 lists the volume shadowing items you can specify with the F$GETDVI function, the type of information returned, and the data types of the return values.

See the *VMS DCL Dictionary* for additional information about the F$GETDVI lexical function. For information about the $GETDVI system service, see the *VMS System Services Reference Manual*; for information on using $GETDVI with volume shadowing, see Section 3.3.

Table 2–1 F$GETDVI Items for Volume Shadowing

Item	Information Returned
SHDW_CATCHUP_ COPYING	Returns the string "TRUE" or "FALSE" to indicate whether the device is a member that is receiving a full copy operation before joining a shadow set.
SHDW_FAILED_MEMBER	Returns the string "TRUE" or "FALSE" to indicate whether the device is a member that has been removed from the shadow set by the remote server.
SHDW_MASTER	Returns the string "TRUE" or "FALSE" to indicate whether the device is a virtual unit.
SHDW_MASTER_NAME	Returns as a string the device name of the virtual unit that represents the shadow set of which the specified device is a member. F$GETDVI returns a null string if the specified device is not a member, or is, itself, a virtual unit. The device name includes the allocation class if the allocation class is not zero; otherwise it includes the HSC name.

Table 2–1 (Cont.) F$GETDVI Items for Volume Shadowing

Item	Information Returned
SHDW_MEMBER	Returns the string "TRUE" or "FALSE" to indicate whether the device is a shadow set member.
SHDW_MERGE_COPYING	Returns the string "TRUE" or "FALSE" to indicate whether the device is a member that is receiving a merge copy operation before joining a shadow set
SHDW_NEXT_MBR_NAME	Returns as a string the device name of the next member in the shadow set. If you specify a virtual unit, F$GETDVI returns the device name of the lowest-numbered member. If you specify a member, F$GETDVI returns the device name of the member with the next highest number. If you specify the device name of the highest-numbered member, F$GETDVI returns a null string. If you specify the name of a device that is neither a virtual unit nor a member, F$GETDVI returns a null string. F$GETDVI returns the device name of the next member in the shadow set even if the next member has been removed from the shadow set by the remote server. The device name includes the allocation class if the allocation class is not zero; otherwise it includes the HSC name.

Example

To check a device for possible shadow set membership, you might include the following DCL command in a command procedure.

```
$ IF F$GETDVI("WRKD$:","SHDW_MEMBER") THEN GOTO SHADOW_MEMBER
```

If WRKD$ (a logical name for a disk) is a shadow set member, then F$GETDVI returns "TRUE" and directs the procedure to the label SHADOW_MEMBER.

2.7 Performing Backup Operations on a Shadow Set

The following subsections describe several approaches to shadow set backup operations. Standalone BACKUP restrictions are discussed in Section 4.7.

2.7.1 Using a Shadow Set Copy as a Backup

You can add a disk to an existing shadow set to produce a copy of the data on the shadow set. If you then dismount the shadow set, the disk is identical to the other disks of the former shadow set (see the following example). This is the recommended method for producing an identical copy of a shadow set. If you must maintain the shadow set on line, you can dismount the member without dismounting the shadow set. However, this marks the volume as *not* being properly dismounted due to the possibility of opened files and incomplete I/O operations.

Example

This example shows how to use volume shadowing copy operations to create an offline identical disk volume you can then use as a *backup* of your shadow set.

```
$ MOUNT/SYSTEM DUSO:/SHADOW=$1$DUA10: SHADOWFACTS
%MOUNT-I-MOUNTED, SHADOWFACTS  mounted on _$1$DUSO: (HSCOO1)
%MOUNT-I-SHDWMEMSUCC, _$1$DUA10: (HSCOO1) is now a valid member of
                      the shadow set
```

This command creates a shadow set with one shadow set member.

```
$ MOUNT/SYSTEM DUSO:/SHADOW=$1$DUA11: SHADOWFACTS
%MOUNT-I-SHDWMEMCOPY, _$1$DUA11: (HSCOO1) added to the shadow set with
                      a copy operation
```

This command adds a second member, 1DUA11, to the shadow set. At this point you must wait for the copy operation to complete before dismounting the shadow set. When the copy is completed, messages are sent to the system console and any operators enabled to receive them.

```
$ DISMOUNT $1$DUSO:
```

This command dismounts the shadow set leaving 1DUA10 and 1DUA11 with logically identical volumes. At this point you can re-create the shadow set with one of the volumes and keep the other as a backup.

2.7.2 Using the VMS Backup Utility

Generally you can use the VMS Backup Utility (BACKUP) with shadow sets as you do with regular volumes. (See the *VMS Backup Utility Manual* for a description of how to back up volumes.) You can *create* BACKUP save sets or copies from shadow sets by using the shadow set virtual unit name instead of a physical device name as the input specifier. However, you cannot always *restore* to a shadow set by listing the virtual unit name as an output specifier. The main restriction is to any backup *restoration* that requires you to mount the target volume with the /FOREIGN qualifier. If you mount your Files–11 shadow set as a foreign shadow set, you lose the automatic copy operations and error recovery normally provided. The proper procedure for a BACKUP /IMAGE restoration is described in Section 2.7.3.

Note: Standalone BACKUP is incompatible with shadow sets. See Section 4.7 for details.

The format for a BACKUP operation on a shadow set is as follows:

BACKUP input-specifier output-specifier

The format is the same as for any BACKUP operation.

The following command, for example, designates a virtual unit for the input specifier:

```
$ BACKUP/RECORD  $7$DUS2:[* . . .  ]/SINCE=BACKUP   MTAO:23OCT.BCK
```

This command saves all files on the shadow set 7DUS2 that have been created or modified since the last backup and records the current time as their new backup date.

2.7.3 Using BACKUP/IMAGE on a Shadow Set

You must take special precautions when you restore a shadow set from a BACKUP/IMAGE save set. (See the *VMS Backup Utility Manual* for a description of BACKUP/IMAGE operations with physical volumes.) A BACKUP/IMAGE operation marks the target volume as more current than the other shadow set members. This designates it as the source of copy operations if you re-create the shadow set with it.

Although you can create BACKUP save sets or copies from shadow set virtual units (not from active shadow set members), you should not mount your shadow set with the /FOREIGN qualifier to allow a BACKUP/IMAGE restoration. If you mount your Files–11 shadow set as a foreign shadow set, you lose the automatic copy operations and error recovery normally provided. DIGITAL does not support a restore operation from a BACKUP /IMAGE save set to a virtual unit. You should either restore to a physical disk and then re-create the shadow set with the restored disk as a shadow se member (example 2), or if the save was a copy to a compatible disk, re-creat the shadow set with that disk as a member (example 3). The target of the BACKUP/IMAGE operation becomes the source of copy operations if you re-create the shadow set with it.

Example 1

This example shows how to perform a backup on a former shadow set member after you rebuild the shadow set.

```
$ MOUNT $1$DUSO:/SHADOW = ($1$DUA10:, $1$DUA11:)  GHOSTVOL
%MOUNT-I-MOUNTED, GHOSTVOL     mounted on _$1$DUSO: (HSCOO1)
%MOUNT-I-SHDWMEMSUCC, _$1$DUA10: (HSCOO1) is now a valid member of
                      the shadow set
%MOUNT-I-SHDWMEMSUCC, _$1$DUA11: (HSCOO1) is now a valid member of
                      the shadow set
```

This command mounts the shadow set 1DUS0. Make sure all copy operations are finished before you dismount the shadow set with the following command:

```
$ DISMOUNT $1$DUSO:
```

This command dismounts the shadow set. Do not list an active shadow set member as the input specifier of a backup operation. You must dismount th shadow set first.

```
$ MOUNT/SYSTEM DUSO/SHADOW=$1$DUA10: GHOSTVOL
%MOUNT-I-MOUNTED, GHOSTVOL     mounted on _$1$DUSO: (HSCOO1)
%MOUNT-I-SHDWMEMSUCC, _$1$DUA10: (HSCOO1) is now a valid member of
                      the shadow set
```

This command puts the shadow set back on line without 1DUA11. You can now perform the backup to tape while the shadow set is on line.

```
$ MOUNT $1$DUA11: GHOSTVOL
%MOUNT-W-VOLSHDWMEM, mounting a shadow set member volume;
                     volume write locked
%MOUNT-I-MOUNTED, GHOSTVOL mounted on _$1$DUA11: (HSCOO1)

$ MOUNT/FOREIGN  MTAO:
%MOUNT-I-MOUNTED,  . . .
```

These two commands mount the former shadow set member and a magnetic tape in preparation for a BACKUP command.

```
$ BACKUP/IMAGE $1$DUA11: MTA0:SAVESET.BCK
```

This command produces a BACKUP/IMAGE save set from 1DUA11 while the shadow set is on line with 1DUA10.

Example 2

This example shows how to restore a shadow set from an image save set. DIGITAL does not support restoring an image save set *directly* to a shadow set because the BACKUP output medium (the shadow set) must be mounted as a foreign volume.

```
$ MOUNT/FOREIGN MTA0:
%MOUNT-I-MOUNTED,  . . .

$ MOUNT/FOREIGN/OVERRIDE=SHADOW_MEMBERSHIP $1$DUA10:
%MOUNT-I-MOUNTED,  . . .
```

These two commands mount the save set magnetic tape for input and the former shadow set member for output of the restore operation.

```
$ BACKUP/IMAGE MTA0:SAVESET.BCK $1$DUA10:
```

This command restores 1DUA10 from the save set.

```
$ DISMOUNT $1$DUA10:
```

This command dismounts the restored volume ready to be mounted in a shadow set.

```
$ MOUNT/SYSTEM DUS0/SHADOW=($1$DUA10:, $1$DUA11:) GHOSTVOL
%MOUNT-I-MOUNTED, GHOSTVOL    mounted on _$1$DUS0: (HSC001)
%MOUNT-I-SHDWMEMSUCC, _$1$DUA10: (HSC001) is now a valid member of
                      the shadow set
%MOUNT-I-SHDWMEMCOPY, _$1$DUA11: (HSC001) added to the shadow set
                      with a copy operation
```

This command mounts the shadow set with the restored shadow set member. The output of the image backup operation has a newer generation than other previous members of the shadow set. Therefore, 1DUA10 (the restored volume) is the source of a copy operation when you form the shadow set.

Example 3

This example illustrates a BACKUP/IMAGE copy operation on a shadow set. The image backup operation compacts the files and free space. Because you must mount the output device of such operations with the /FOREIGN qualifier, you must take the following special steps:

```
$ MOUNT $1$DUS0:/SHADOW = ($1$DUA10:, $1$DUA11:)  MEANDMY
%MOUNT-I-MOUNTED, MEANDMY     mounted on _$1$DUS0: (HSC001)
%MOUNT-I-SHDWMEMSUCC, _$1$DUA10: (HSC001) is now a valid member of
                      the shadow set
%MOUNT-I-SHDWMEMSUCC, _$1$DUA11: (HSC001) is now a valid member of
                      the shadow set

$ MOUNT/FOREIGN $1$DUA20:
%MOUNT-I-MOUNTED,  . . .
```

The first command mounts the shadow set 1DUS0. The second command mounts, on 1DUA20, the volume to be the output of the BACKUP/IMAGE operation. The /FOREIGN qualifier is required.

```
$ BACKUP/IMAGE  $1$DUS0: $1$DUA20:
```

This command performs the image backup using the virtual unit name as the input specifier. The image backup operation compacts the files and free space. Thus, the image backup copy of a shadow set has a newer generation than the existing members in the shadow set.

```
$ DISMOUNT $1$DUA20:
$ DISMOUNT $1$DUS0:
```

These commands dismount the target of the image backup and the shadow set, in preparation for re-creating the shadow set. Note that when you re-create the shadow set, you lose any data written to the shadow set between the start of the backup operation and dismounting.

```
$ MOUNT/SYSTEM DUS0/SHADOW=($1$DUA10:, $1$DUA11:, $1$DUA20:) MEANDMY
%MOUNT-I-MOUNTED, MEANDMY     mounted on _$1$DUS0: (HSC001)
%MOUNT-I-SHDWMEMSUCC, _$1$DUA20: (HSC001) is now a valid member of
                      the shadow set
%MOUNT-I-SHDWMEMCOPY, _$1$DUA10: (HSC001) added to the shadow set
                      with a copy operation
%MOUNT-I-SHDWMEMCOPY, _$1$DUA11: (HSC001) added to the shadow set
                      with a copy operation
```

This command rebuilds the shadow set with the image backup disk as one of the shadow set members. The other former shadow set members receive full copy operations.

2.8 Maintaining a Shadow Set

Generally, the user and the system access a shadow set through the virtual unit. Occasionally, you may want to change an individual shadow set member and then pass the changed data to the other shadow set members. For example, you can run the VMS Data Compression/Expansion (DCX) routines on a disk and then change the data on other shadow set members as well.

The following series of commands demonstrates how you can dissolve and re-create the shadow set to perform specialized processes on one shadow set member and transfer the change to the other shadow set members.

```
$ MOUNT $45$DUS9: /SHADOW=($45$DUA2:, $45$DUA4:, $45$DUA8:) LURK1
```

This command mounts a shadow set with three shadow set members.

```
$ DISMOUNT/NOUNLOAD $45$DUS9:
```

This command dissolves the shadow set mounted in the previous command, and makes the individual shadow set members available.

```
$ MOUNT /OVERRIDE=SHADOW_MEMBERSHIP $45$DUA2:   LURK1
```

This command mounts one former shadow set member as a Files–11 volume outside of the shadow set. To have write access, you must use the /OVERRIDE=SHADOW_MEMBERSHIP qualifier. At this point, you can process the volume as you would any physical disk. For example, you can run the DCX routines on 45DUA2. See the *VMS Utility Routines Manual* for information about these routines.

```
$ MOUNT  $45$DUS9: /SHADOW=$45$DUA2:   LURK1
```

This command re-creates the shadow set with only the processed volume as a shadow set member.

Note that mounting 45DUA2 with the /OVERRIDE=SHADOW_MEMBERSHIP qualifier automatically erases the volume shadowing generation number. If you mount *all* the former members of the shadow set at the same time, MOUNT copies to the processed volume, considering it an unrelated volume. The processing of 45DUA2 would be lost.

You then add the other two former shadow set members to the new shadow set producing automatic full copy operations on each.

```
$ MOUNT  $45$DUS9:  /SHADOW=($45$DUA4:, $45$DUA8:)  LURK1
```

In this command 45DUA4 and 45DUA8 are added to the shadow set 45DUS9. This re-creates the original shadow set, except that each shadow set member now has the benefits of processing that you cannot perform on an intact shadow set.

3 Performing Shadow Set Operations with System Services

Volume shadowing uses enhancements to three VMS system services to perform shadow set operations.

- $MOUNT—Creates, mounts, and adds members to shadow sets.
- $DISMOU—Dismounts, dissolves, and removes members from shadow sets.
- $GETDVI—Returns information about shadow set virtual units and members.

This chapter explains how to use these services to perform shadow set operations. It does not contain a detailed description of each service. For more information about the $MOUNT, $DISMOU, and $GETDVI services, see the *VMS System Services Reference Manual.*

3.1 Using $MOUNT to Create and Mount Shadow Sets

You can use the $MOUNT system service to create shadow sets, to mount shadow sets, and to add members to existing shadow sets. Calls to $MOUNT that create, mount, or add members to shadow sets share the same syntax. To direct the system to perform any of these mount operations, you construct a $MOUNT item list. The item list specifies the virtual unit that represents the shadow set and the members (physical devices) that the shadow set contains.

For example, to create and mount a new shadow set, your program calls $MOUNT and specifies an item list that contains the names of the virtual unit and the members. Later, if you want to add a member to the shadow set, you make another call to $MOUNT that specifies an item list that contains the name of the virtual unit and the name of the member you want to add to the shadow set.

The call to $MOUNT has the following format:

SYS$MOUNT itmlst

The sections that follow describe each of the four $MOUNT shadow set item codes in detail. They also explain how to construct a valid $MOUNT item list and give examples of three $MOUNT shadow set item lists.

For a complete description of the $MOUNT service and its argument, see the *VMS System Services Reference Manual.*

3.1.1 $MOUNT Shadow Set Item Codes

The list that follows explains the four $MOUNT shadow set item codes. The item code MNT$_SHANAM specifies the virtual unit. The other three, MNT$_SHAMEM, MNT$_SHAMEM_COPY, and MNT$_SHAMEM_MGCOPY, specify members. In addition, the MNT$_FLAGS item code contains two options that pertain to shadow set operations.

When you mount a Files–11 shadow set, the system determines the type of copy operation a member requires before it can join the shadow set. Therefore, you can use the MNT$_SHAMEM item code to specify any member, regardless of the copy operation the member requires.

When you mount a foreign shadow set (a shadow set mounted as a foreign volume), you must indicate the copy operation a member requires before it can join the shadow set. You indicate the required copy operation by specifying the member with one of the following item codes: MNT$_SHAMEM, MNT$_SHAMEM_COPY, or MNT$_SHAMEM_MGCOPY. The item code descriptions explain when to use the different item codes to add members to a foreign shadow set.

MNT$_SHANAM

The MNT$_SHANAM item code specifies the name of the virtual unit to be mounted. The buffer must contain a character string from 1 to 64 characters, which is the virtual unit name. The virtual unit name may be a logical name; if it is a logical name, it must translate to a virtual unit name. The name should include the controller letter *S*, which indicates that the device is a virtual unit.

Because every shadow set is represented by a virtual unit, you must include at least one MNT$_SHANAM item descriptor in the item list that you pass to $MOUNT to create and mount the shadow set. If you are mounting a Files–11 volume set containing more than one shadow set, you must include one MNT$_SHANAM item descriptor for each virtual unit included in the volume set.

The relative position of the item descriptors in the item list determines the membership of the shadow set. That is, it indicates which members should be bound to a specific virtual unit to form the shadow set. You must first specify the virtual unit by using the MNT$_SHANAM item code. Then, you can specify any number of members that are to be represented by that virtual unit by using one of the following item codes: MNT$_SHAMEM, MNT$_SHAMEM_MGCOPY, or MNT$_SHAMEM_COPY. If you specify one shadow set and want to specify a second, specify a second virtual unit item descriptor. The members you specify subsequently are bound to the shadow set represented by the virtual unit specified in the second virtual unit item descriptor.

MNT$_SHAMEM

The MNT$_SHAMEM item code specifies the name of a member (physical device) to be added to the shadow set represented by the most recently specified virtual unit, that is, the virtual unit name specified in the most recent MNT$_SHANAM item descriptor. The buffer must contain a character string from 1 to 64 characters, which is the device name. The device name may be a physical device name or a logical name; if it is a logical name, it must translate to a physical device name.

If you are mounting a foreign shadow set, the MNT$_SHAMEM item code indicates that the member specified in the item descriptor does not require a shadow copy before it joins the shadow set.

When you mount a foreign shadow set, the system considers the first member you specify after the virtual unit item descriptor to be the most current member of the shadow set. The system makes copies to other members based on this member. You must use the MNT$_SHAMEM item code to specify the first member of a foreign shadow set, because it can never require a copy operation before joining the shadow set.

To be valid, an item list must contain at least one item descriptor specifying a member; this item descriptor must appear after the MNT$_SHANAM item descriptor.

MNT$_SHAMEM_COPY

The MNT$_SHAMEM_COPY item code specifies the name of a member to be added to the shadow set represented by the most recently specified virtual unit, that is, the virtual unit name specified in the most recent MNT$_SHANAM item descriptor. The buffer must contain a character string from 1 to 64 characters, which is the device name. The device name may be a physical device name or a logical name; if it is a logical name, it must translate to a physical device name.

When mounting a foreign shadow set, use the MNT$_SHAMEM_COPY item code to indicate that the member specified in the item descriptor requires a full copy operation before it can join the shadow set.

MNT$_SHAMEM_MGCOPY

The MNT$_SHAMEM_MGCOPY item code specifies the name of a member to be added to the shadow set represented by the most recently specified virtual unit, that is, the virtual unit specified in the most recent MNT$_SHANAM item descriptor. The buffer must contain a character string from 1 to 64 characters, which is the device name. The device name may be a physical device name or a logical name; if it is a logical name, it must translate to a physical device name.

When mounting a foreign shadow set, use the MNT$_SHAMEM_MGCOPY item code to indicate that the member specified in the item descriptor requires a merge copy operation before it can join the shadow set.

MNT$_FLAGS

The MNT$_FLAGS item code specifies a longword bit vector wherein each bit specifies an option for the mount operation. The buffer must contain a longword, which is the bit vector.

The $MNTDEF macro defines symbolic names for each option (bit) in the bit vector. You construct the bit vector by specifying the symbolic names for the desired options in a logical OR operation. The following table describes the symbolic names for each shadow set option.

Option	Description
MNT$V_NOCOPY	Disables full copy operations on all physical devices being mounted or added to a shadow set. This option provides you with the opportunity to confirm the states of all of the members of a shadow set before proceeding with any full copy operation. This prevents any accidental loss of data that could occur if an unintended device is added to the shadow set. If you do not select this option, $MOUNT automatically overwrites the data on shadow set members that are not current. When you select this option, a $MOUNT operation fails if any of the specified potential shadow set members require full copy operations.
MNT$V_OVR_SHAMEM	Allows you to mount former shadow set members outside of the shadow set. If you do not specify this option, $MOUNT automatically mounts the volume write-locked to prevent accidental deletion of data. To specify this option, you must either own the volume or have VOLPRO privilege. When you use this option, the shadow set generatior number is erased from the volume. If you then remount the volume in the former shadow set, $MOUNT considers it an unrelated volume and marks it for a full copy operation.

3.1.2 Constructing the $MOUNT Item List

When you construct a $MOUNT item list to create, mount, or add a member to a shadow set, there are five important things to remember.

1. Every item list that mounts a shadow set must contain at least one item descriptor that specifies the virtual unit, and at least one item descriptor that specifies a member (most shadow sets have at least two members).
2. The item descriptor that specifies the virtual unit must come before the item descriptors that specify the members contained in the shadow set.
3. When mounting a Files–11 volume set, your item list must contain an item descriptor for each virtual unit. The virtual unit item descriptor mus be followed by item descriptors specifying the members to be represente by that virtual unit.
4. If you are mounting a foreign shadow set, the item descriptor that specifies the most current member of the shadow set must come after the virtual unit item descriptor, and before any other member item descriptors. The item descriptor must specify the MNT$_SHAMEM item code to indicate that the member does not require a copy operation befor joining the shadow set.
5. When you are specifying the members of a foreign shadow set, you mus use the item code that specifies the type of copy operation that each member must receive before it can join the shadow set. Following are th item codes and the copy operations they specify.

Item Code	Copy Operation
MNT$_SHAMEM	The member does not require a copy operation before it joins the shadow set.
MNT$_SHAMEM_COPY	The member requires a full copy operation before it joins the shadow set.
MNT$_SHAMEM_MGCOPY	The member requires a merge copy operation before it joins the shadow set.

3.1.3 Examples of $MOUNT Item Lists

The examples in this section show $MOUNT item lists for some typical shadow sets. The first example shows the type of item list you would construct to create and mount a Files–11 shadow set. The second example shows the type of item list you would construct to create and mount a Files–11 volume set that contains two shadow sets. The final example shows the type of item list you would construct to create and mount a foreign shadow set.

Item List for Files–11 Shadow Set

This example shows the MACRO-32 statements required to produce a $MOUNT system service item list to mount a Files–11 shadow set. A call to $MOUNT specifying the item list that follows performs the same action as the following DCL command MOUNT.

```
$ MOUNT $4$DUS23: /SHADOW = ( $4$DUA9:, $4$DUA5:, $4$DUA10: ) -
_$ MYVOLUME DISK$MYVOLUME
```

```
S_$4$DUS23:   .ASCII /$4$DUS23:/
S_$4$DUA9:    .ASCII /$4$DUA9:/
S_$4$DUA5:    .ASCII /$4$DUA5:/
S_$4$DUA10:   .ASCII /$4$DUA10:/
S_LABEL:    .ASCII /MYVOLUME/
S_LOGNM:    .ASCII /DISK$MYVOLUME/

        .MACRO    .ITEM, SIZE, CODE, BUFFER, RETURN=0
        .WORD     SIZE, CODE
        .ADDRESS BUFFER, RETURN
        .ENDM     .ITEM

ITMLST: .ITEM   9,  MNT$_SHANAM, S_$4$DUS23  (1)
        .ITEM   8,  MNT$_SHAMEM, S_$4$DUA9   (2)
        .ITEM   8,  MNT$_SHAMEM, S_$4$DUA5
        .ITEM   9,  MNT$_SHAMEM, S_$4$DUA10
        .ITEM   8,  MNT$_VOLNAM, S_LABEL  (3)
        .ITEM   13, MNT$_LOGNAM, S_LOGNM  (4)
        .LONG   0, 0, 0
```

1 Notice that the virtual unit item descriptor occurs first. This item descriptor specifies 4DUS23 as the name of the virtual unit. The controller letter *S* indicates that the device is a virtual unit.

2 The virtual unit item descriptor is followed by three member item descriptors. Because the system determines the type of copy operation necessary before Files–11 disks can join a Files–11 shadow set, all of the members are mounted with MNT$_SHAMEM item descriptors. These item descriptors specify that 4DUA9, 4DUA5, and 4DUA10 are to join the shadow set represented by 4DUS23.

3 The member item descriptors are followed by an item descriptor that specifies the volume label for the shadow set as MYVOLUME.

4 The last item descriptor specifies the logical name for the shadow set as DISK$MYVOLUME.

Item List for Files–11 Volume Set

This example shows the MACRO-32 statements required to produce a $MOUNT system service item to mount a Files–11 volume set that contains two shadow sets. A call to $MOUNT specifying the item list that follows performs the same action as the following DCL command MOUNT.

```
$  MOUNT     $4$DUS23: /SHADOW = ( $4$DUA9:,  $4$DUA5:, $4$DUA10: ),-
_$      $4$DUS51: /SHADOW = ( $4$DUA12:, $4$DUA3:, $4$DUA34: ) -
_$      WORK1,WORK2 WRKD$
```

```
     S_$4$DUS23:   .ASCII /$4$DUS23:/
     S_$4$DUS51:   .ASCII /$4$DUS51:/
     S_$4$DUA9:    .ASCII /$4$DUA9:/
     S_$4$DUA5:    .ASCII /$4$DUA5:/
     S_$4$DUA10:   .ASCII /$4$DUA10:/
     S_$4$DUA12:   .ASCII /$4$DUA12:/
     S_$4$DUA3:    .ASCII /$4$DUA3:/
     S_$4$DUA34:   .ASCII /$4$DUA34:/
     S_WORK1:    .ASCII /WORK1/
     S_WORK2:    .ASCII /WORK2/
     S_LOGNM:    .ASCII /WRKD$/

             .MACRO    .ITEM, SIZE, CODE, BUFFER, RETURN=0
             .WORD     SIZE, CODE
             .ADDRESS BUFFER, RETURN
             .ENDM     .ITEM

     ITMLST: .ITEM   9, MNT$_SHANAM, S_$4$DUS23  (1)
             .ITEM   8, MNT$_SHAMEM, S_$4$DUA9   (2)
             .ITEM   8, MNT$_SHAMEM, S_$4$DUA5
             .ITEM   9, MNT$_SHAMEM, S_$4$DUA10
             .ITEM   5, MNT$_VOLNAM, S_WORK1  (3)
             .ITEM   9, MNT$_SHANAM, S_$4$DUS51  (4)
             .ITEM   9, MNT$_SHAMEM, S_$4$DUA12  (4)
             .ITEM   8, MNT$_SHAMEM, S_$4$DUA3
             .ITEM   9, MNT$_SHAMEM, S_$4$DUA34
             .ITEM   5, MNT$_VOLNAM, S_WORK2   (4)
             .ITEM   5, MNT$_LOGNAM, S_LOGNM   (5)
             .LONG   0, 0, 0
```

1 Notice that the virtual unit item descriptor for the first volume in the volume set occurs first. This item descriptor specifies 4DUS23 as the name of the first virtual unit in the volume set.

2 The virtual unit item descriptor is followed by item descriptors for each of the members that are to be represented by the first virtual unit: 4DUA9, 4DUA5, and 4DUA10.

3 The member item descriptors are followed by an item descriptor that specifies the volume label for the first shadow set in the volume set as WORK1.

4 Following the descriptors for the first shadow set in the volume set are similar item descriptors for the second shadow set in the volume set. These item descriptors specify the second virtual unit as 4DUS51; the members as 4DUA12, 4DUA3, and 4DUA34; and the volume label as WORK2.

5 The last item descriptor specifies the logical name for the entire volume set as WRKD$.

Item List for Foreign Shadow Set

This example shows the MACRO-32 statements required to produce a $MOUNT system service item list to mount a foreign shadow set. A call to $MOUNT specifying the item list that follows performs the same action as the following DCL command MOUNT.

```
$ MOUNT /FOREIGN $4$DJS8: -
_$  /SHADOW = (NO_COPY=$4$DJA4:, MERGE_COPY=$4$DJA18:, COPY=$4$DJA12: )
```

```
FLAGS:     .LONG  MNT$M_FOREIGN
S_DJS8:    .ASCII /$4$DJS8:/
S_DJA4:    .ASCII /$4$DJA4:/
S_DJA18:   .ASCII /$4$DJA18:/
S_DJA12:   .ASCII /$4$DJA12:/

          .MACRO   .ITEM, SIZE, CODE, BUFFER, RETURN=0
          .WORD    SIZE, CODE
          .ADDRESS BUFFER, RETURN
          .ENDM    .ITEM

ITMLST:   .ITEM   4, MNT$_FLAGS,          FLAGS
          .ITEM   8, MNT$_SHANAM,         S_$4$DJS8  (1)
          .ITEM   8, MNT$_SHAMEM,         S_$4$DJA4  (2)
          .ITEM   9, MNT$_SHAMEM_MGCOPY,  S_$4$DJA18 (3)
          .ITEM   9, MNT$_SHAMEM_COPY,    S_$4$DJA12 (4)
          .LONG   0, 0, 0
```

1 The second item descriptor specifies the virtual unit 4DJS8.

2 The third item descriptor specifies the member that is considered the most current member of the shadow set. Because this member, 4DJA4, doesn't need to have any information copied to it, it is specified with a MNT$_SHAMEM item descriptor.

3 The fourth item descriptor specifies the member 4DJA18. It is specified with the MNT$_SHAMEM_MGCOPY item descriptor, because it needs a merge copy operation before it can join the shadow set.

4 The last item descriptor specifies the member 4DJA12. It is specified with the MNT$_SHAMEM_COPY item descriptor, because it needs a full copy operation before it can join the shadow set.

3.1.4 Evaluating Condition Values Returned by $DISMOU, $MOUNT, and $QIO

This section contains information about the condition values returned by $DISMOU, $MOUNT, and $QIO that pertain to mounting and using shadow sets. For a complete list of the condition values returned by these services, see the *VMS System Services Reference Manual*.

If $MOUNT returns the condition value SS$_BADPARAM, your item list probably contains one of the following errors:

- The virtual unit specified in one of your MNT$_SHANAM item descriptors contains a controller letter other than the letter *S*. The controller letter *S* designates that a device is a shadow set virtual unit.
- A MNT$_SHAMEM item descriptor appears in the item list before any MNT$_SHANAM item descriptor.
- Your item list contains a MNT$_SHANAM item descriptor, but it is not followed by any of the following three item descriptors: MNT$_SHAMEM, MNT$_SHAMEM_MGCOPY, or MNT$_SHAMEM_COPY.
- A MNT$_DEVNAM item descriptor appears in the item list in the middle of a series of item descriptors that specify a single shadow set. It is possible to construct a Files-11 volume set that contains one or more nonshadowed disks, as well as one or more shadow sets. However, when you use the MNT$_DEVNAM item descriptor to specify the nonshadowed disk, it must not appear in between the MNT$_SHANAM item descriptor that specifies a virtual unit and the item descriptors that specify the members of the shadow set that the virtual unit represents.

When you are mounting and using foreign shadow sets, your program must handle changes in shadow set membership. After making a call to $QIO, your program should check the $QIO I/O status block for the following condition values, which signal a change in shadow set membership:

SS$_VOLINV
SS$_SHACHASTA
SS$_MEDOFL

If you make a call to $DISMOU to dismount a device on which a copy operation is in progress, $DISMOU returns the condition value SS$_DEVACTIVE.

3.2 Using $DISMOU to Dismount Shadow Sets

You can use $DISMOU to perform the following three shadow set operations

- Remove a member from a shadow set.
- Dismount a shadow set on a single node.
- Dismount and dissolve a shadow set.

The call to $DISMOU has the following format:

SYS$DISMOU devnam ,flags

The action $DISMOU takes depends in part on whether you specify a shadow set virtual unit or a shadow set member in the **devnam** argument.

For a complete description of the $DISMOU service and its arguments, see the *VMS System Services Reference Manual.*

3.2.1 Removing Member Units from Shadow Sets

If you want to remove a single member from a shadow set, you must make a call to $DISMOU. In the **devnam** argument, you should specify the name of the shadow set member you want to remove. As a result of this call, all nodes in the cluster that have the shadow set mounted remove the member from the shadow set. This is the software-induced equivalent to a hardware failure that causes the remote server to remove a member from a shadow set.

When you remove a member from a shadow set, and the system is in the process of writing information to that member, the writing in progress at the time of removal may not be completed. Therefore, information contained in any files that are open when the member is removed is unreliable. The specified member is spun down unless you specify the DMT$M_NOUNLOAD option in the **flags** argument.

The following example demonstrates a call to $DISMOU that removes the member 2DUA9 from the shadow set represented by the virtual unit 2DUS34.

Removing a Member

```
$DMTDEF
FLAGS:   .LONG 0
S_$2$DUA9:       .ASCID /$2$DUA9:/
.
.
.
$DISMOU_S -
        devnam = S_$2$DUA9, -
        flags = FLAGS
.
.
.
.END
```

3.2.2 Dismounting and Dissolving Shadow Sets

If you want to dismount a shadow set on a single node, you must make a call to $DISMOU. In the **devnam** argument, you should specify the name of the virtual unit that represents the shadow set you want to dismount. If you only want to dismount the shadow set, you should not specify the DMT$M_CLUSTER option in the **flags** argument of the call.

When you dismount a shadow set on a single node in a VAXcluster and other nodes in the VAXcluster still have the shadow set mounted, none of the shadow members contained in the shadow set are spun down even if you have not specified the DMT$M_NOUNLOAD flag. After this call completes, the shadow set is unavailable on the node from which the call was made. The shadow set is still available to other nodes in the cluster that have the shadow set mounted.

If the node on which the shadow set is being dismounted is the only node that has the shadow set mounted, the HSC dissolves the shadow set. The shadow set members are spun down, unless you specify the DMT$M_NOUNLOAD flag.

In the following example, $DISMOU dismounts the shadow set represented by the virtual unit 4DUS23.

Dismounting a Shadow Set

```
$DMTDEF
FLAGS:      .LONG 0
S_$4$DUS23:   .ASCID /$4$DUS23:/
.
.
.
$DISMOU_S -
        devnam = S_$4$DUS23, -
        flags = FLAGS
.
.
.
.END
```

If you want to dissolve the shadow set, make a call to $DISMOU specifying the name of the virtual unit that represents the shadow set you want to dismount and dissolve. You must specify the DMT$M_CLUSTER option in the **flags** argument so that the shadow set is dismounted from every node in the cluster. When each node in the cluster has dismounted the shadow set (the count of hosts having the shadow set mounted reaches 0), the HSC dissolves the shadow set.

When a shadow set is dissolved, there is no longer any meaningful relationship between either the virtual unit and the shadow set members, or among the shadow set members. The member units can be mounted as single disks for other purposes. The virtual unit changes to a medium offline state. As a part of the dissolve operation, all shadow set members are spun down, unless you specify the DMT$M_NOUNLOAD option in the call to $DISMOU.

In the following example, $DISMOU dismounts the shadow set represented by the virtual unit 4DUS23. The call dismounts the shadow set clusterwide Therefore, when the shadow set is dismounted from the last node, the HSC dissolves the shadow set.

Dismounting and Dissolving a Shadow Set

```
$DMTDEF
FLAGS:      .LONG  DMT$M_CLUSTER
S_$4$DUS23:   .ASCID /$4$DUS23:/
.
.
.
$DISMOU_S -
        devnam = S_$4$DUS23, -
        flags = FLAGS
.
.
.
.END
```

3.2.3 Setting $DISMOU Flags in Shadow Set Operations

The following table lists the options for the $DISMOU **flags** argument and describes the shadow set operations that use these options. For a full description of each of these flag options, see the description of the $DISMOU service in the *VMS System Services Reference Manual.*

Option	Description
DMT$M_UNLOAD	Legal for all shadowing-related requests
DMT$M_CLUSTER	Legal for all shadowing-related requests
DMT$M_ABORT	Honored for virtual units; ignored for member units
DMT$M_UNIT	Ignored for virtual units and their members

3.3 Using $GETDVI to Obtain Information About Shadow Sets

The $GETDVI system service is useful for obtaining information about the shadow set devices on your system. Through the use of the shadow set item codes, you can determine the following types of information:

- Whether a device is a shadow set virtual unit or a shadow set member
- Whether a copy operation is in progress on a device
- What type of copy operation is in progress on a device
- The name of the virtual unit that represents the shadow set of which the particular device is a member
- The entire membership of a shadow set, including the virtual unit and all of the members
- Whether a member has been removed from the shadow set by the remote server

The call to $GETDVI has the following format:

SYS$GETDVI [efn] ,[chan] ,[devnam] ,itmlst ,[iosb]
,[astadr] ,[astprm] ,[nullarg]

For a complete description of the $GETDVI and $GETDVIW services and their arguments, see the *VMS System Services Reference Manual.*

3.3.1 $GETDVI Shadow Set Item Codes

This section contains a list that explains the information returned by the $GETDVI shadow set item codes.

DVI$_SHDW_CATCHUP_COPYING

When you specify DVI$_SHDW_CATCHUP_COPYING, $GETDVI returns a longword, which is interpreted as Boolean. The value 1 indicates that the device is a member receiving a full copy operation before joining a shadow set.

DVI$_SHDW_FAILED_MEMBER

When you specify DVI$_SHDW_FAILED_MEMBER, $GETDVI returns a longword, which is interpreted as Boolean. The value 1 indicates that the device is a member that has been removed from the shadow set by the remote server.

DVI$_SHDW_MASTER

When you specify DVI$_SHDW_MASTER, $GETDVI returns a longword, which is interpreted as Boolean. The value 1 indicates that the device is a virtual unit.

DVI$_SHDW_MASTER_NAME

When you specify DVI$_SHDW_MASTER_NAME and the specified device is a shadow set member, $GETDVI returns the device name of the virtual unit that represents the shadow set of which the specified device is a member. $GETDVI returns a null string if the specified device is not a member, or is, itself, a virtual unit.

When the shadow set members are dual pathed to two HSCs and, therefore, have a nonzero allocation class, the device name returned by $GETDVI contains the allocation class; the name has the form **$allocation-class$device**. For example, if a virtual unit has an allocation class of 255 and the device name DUS10, $GETDVI returns the following string: 255DUS10.

When the shadow set members have a zero allocation class, the device name contains the HSC node name; the name has the form **hsc$device**. For example, if the node name of the HSC is LAMONT and the device name is DUS10, $GETDVI returns the following string: LAMONT$DUS10.

Because the shadow set virtual unit name can include up to 64 characters, the buffer length field of the item descriptor should specify 64 (bytes).

DVI$_SHDW_MEMBER

When you specify DVI$_SHDW_MEMBER, $GETDVI returns a longword, which is interpreted as Boolean. The value 1 indicates that the device is a shadow set member.

DVI$_SHDW_MERGE_COPYING

When you specify DVI$_SHDW_MERGE_COPYING, $GETDVI returns a longword, which is interpreted as Boolean. The value 1 indicates that the device is a member receiving a merge copy operation before joining a shadow set.

DVI$_SHDW_NEXT_MBR_NAME

When you specify DVI$_SHDW_NEXT_MBR_NAME, $GETDVI returns the device name of the next member in the shadow set. If you specify a virtual unit, $GETDVI returns the device name of the lowest-numbered member. If you specify a member, $GETDVI returns the device name of the member with the next highest number. If you specify the device name of the highest-numbered member, $GETDVI returns a null string. If you specify the name of a device that is neither a virtual unit nor a member, $GETDVI returns a null string.

$GETDVI returns the device name of the next member in the shadow set even if the remote server has removed the next member from the shadow set.

When the shadow set members are dual pathed to two HSCs and therefore have a nonzero allocation class, the device name returned by $GETDVI contains the allocation class; the name has the form **$allocation-class$device**. For example, if a shadow set has an allocation class of 255 and the device name is DUS10, $GETDVI returns the following string: 255DUS10.

When the shadow set members have a zero allocation class, the device name contains the HSC node name; the name has the form **hsc$device**. For example, if the node name of the HSC is LAMONT and the device name is DUS10, $GETDVI returns the following string: LAMONT$DUS10.

Because a device name can include up to 64 characters, the buffer length field of the item descriptor should specify 64 (bytes).

3.3.2 Obtaining the Names of All Members of a Shadow Set

To obtain the names of all members of a shadow set, you must make a series of calls to $GETDVI. In your first call to $GETDVI you can specify either the device name of the virtual unit that represents the shadow set whose membership you want to determine, or the device name of a member of the shadow set.

Starting with the Shadow Set Virtual Unit

If your first call specifies the name of the virtual unit, the item list should contain a DVI$_SHDW_NEXT_MBR_NAME item descriptor into which $GETDVI returns the name of the lowest-numbered member of the shadow set. The **devnam** argument of the next call to $GETDVI should specify the device name returned in the previous call's DVI$_SHDW_NEXT_MBR_NAME item descriptor. This second call's item list should contain a DVI$_SHDW_NEXT_MBR_NAME item descriptor to receive the name of the next highest-numbered unit in the shadow set. You should repeat these calls to $GETDVI until $GETDVI returns a null string, which means that there are no more members in the shadow set.

Starting with a Shadow Set Member Unit

If your first call specifies the name of a shadow set member, you must determine the name of the virtual unit that represents the shadow set before you can obtain the names of all members contained in the shadow set. Therefore, if your first call specifies a member, it should also specify an item list that contains a DVI$_SHDW_MASTER_NAME item descriptor. $GETDVI returns the name of the virtual unit that represents the shadow set into this descriptor. Now, you are ready to make the series of calls to $GETDVI described previously. The **devnam** argument of each call specifies the name of the device returned in the previous call's DVI$_SHDW_NEXT_MBR_NAME item descriptor. You repeat these calls until $GETDVI returns a null string, indicating that there are no more members in the shadow set.

The DVI$_SHDW_NEXT_MBR_NAME item code returns the names of all members of the shadow set, even if the remote server has removed the members from the shadow set. If you want to determine the names of all the current members of the shadow set, you should use the DVI$_SHDW_FAILED_MEMBER item code to identify and ignore members that have been removed from the shadow set.

4 Licensing, Enabling, and Managing VAX Volume Shadowing

This chapter briefly explains license registration, which authorizes the use of VAX Volume Shadowing. It also describes system management issues related to volume shadowing in a VAXcluster and on a system disk.

4.1 Registering the Volume Shadowing Product Authorization Key (PAK)

After you install and license VMS Version 5.0 by registering a VMS Product Authorization Key (PAK), you must license VAX Volume Shadowing with a separate Volume Shadowing PAK. Obtain a PAK, generally a paper certificate similar to the one shown in Example 4–1, from a DIGITAL representative. The PAK provides information that defines the VAX Volume Shadowing license contract you have with DIGITAL. When you enter this information into the online LICENSE database, the VMS License Management Facility (LMF) authorizes use of volume shadowing. In some cases, a PAK may be registered automatically when you install VMS or an update to VMS. See the installation kit cover letter and the VMS release notes for the correct license registration method.

Example 4–1 Example of a Product Authorization Key (PAK)

```
 - - - - - - -
| | | | | | | |
|d|i|g|i|t|a|l|    Product Authorization Key (PAK)
| | | | | | | |
 - - - - - - -
Digital Equipment Corporation
Maynard, MA.

 ------------------------------------
| LICENSE ADMINISTRATION LOCATION:   |  ORDERED BY: Casper Friendly
|                                    |              Data Twice, Inc.
| Digital Equipment Corporation      |              Shady Hill, CT. 20010
| Maynard, Ma.                       |
| Address                            |
|                                    |
 ------------------------------------

********************************************************************************
 PAK ID:
                     Issuer: DEC
       Authorization Number: USA00326

 PRODUCT ID:
                Product Name: VOLSHAD
                    Producer: DEC

 NUMBER OF UNITS:
             Number of Units: 1234
```

Example 4–1 Cont'd. on next page

Example 4–1 (Cont.) Example of a Product Authorization Key (PAK)

```
KEY LEVEL:
                    Version: 5.0
      Product Release Date:

KEY TERMINATION DATE:
      Key Termination Date:

RATING:
   Availability Table Code: E
       Activity Table Code:

MISCELLANEOUS:
                Key Options:  MOD_UNITS
              Product Token:
                Hardware-Id:
                   Checksum: 1-MJLI-JEKC-GHBB-JGKB
*******************************************************************************
```

After a Product Authorization Key is registered but before you can use VAX Volume Shadowing, you must also set the System Generation Utility (SYSGEN) SHADOWING parameter as descibed in Section 4.2.

4.2 Setting the SYSGEN Parameter for Volume Shadowing

After registering the volume shadowing Product Authorization Key (PAK), you must invoke the System Generation Utility (SYSGEN) to set the SHADOWING SYSGEN parameter. Invoke SYSGEN by typing the following:

```
$ RUN SYS$SYSTEM:SYSGEN
SYSGEN>
```

Then, set the system parameter SHADOWING to 1 (volume shadowing), as follows:

```
SYSGEN> SET SHADOWING 1
SYSGEN> WRITE CURRENT
```

Type EXIT or press CTRL/Z to return to the DCL level.

Finally, you must reboot the system.

Note: To ensure volume shadowing is enabled each time Autogen executes, edit the file SYS$SYSTEM:MODPARAMS.DAT to use the DCL assignment statement SHADOWING=1. See the *Guide to Setting Up a VMS System* for more information about editing the MODPARAMS.DAT file.

4.3 Using Volume Shadowing on the System Disk

To use volume shadowing on the system disk, you must copy the new primary bootstrap program, VMB, to your console device CSA1. If you are using a VAXcluster, you *must* copy VMB to the console device of *each* node in the cluster. Use the following commands:

```
$  RUN SYS$SYSTEM:SYSGEN
SYSGEN>  CONNECT CONSOLE
SYSGEN>  CTRL/Z
$  EXCHANGE COPY /LOG SYS$SYSTEM:VMB.EXE CSA1:
```

After copying VMB to the console device, you must also modify DEFBOO.CMD[1] as described in Section 4.4.

4.4 Booting from a System Disk Shadow Set

You can mount your system disk as a shadowed set, but you must take special steps when creating the shadow set. If no system disk shadow set currently exists, as it might if you have VAXcluster nodes booting from a common disk, then the system must boot from one of the physical disks that would typically be in a shadow set.

Normally, when you boot from an HSC disk, you deposit the unit number of your system disk into boot register R3 (see the processor installation or operations manual for details). For a system disk shadow set, however, you must deposit in R3 both the virtual unit number *and* the unit number of one of the shadow set members. You must convert the unit numbers of both the virtual unit and the physical unit that is normally a shadow set member into hexadecimal. You then deposit the unit number (in hexadecimal) of the virtual unit number into the high word (bits <30:16>) of boot R3, and deposit the physical unit number (in hexadecimal) into the low word (bits <15:0>) of R3. You must also set the sign bit (bit 31) to indicate that you are using a shadow set virtual unit. Thus, if the system disk shadow set uses a virtual unit number of 000C (12 decimal) and a physical unit number of 0000, the deposit command line for a VAX 8600 should be like this:

```
>>> DEPOSIT R3 800C0000
```

The same procedure on a VAX 8200 should look like this:

```
BOOT58> D/G  3 800C0000
```

Note: You must deposit the *same* physical unit number into R3 of every VAXcluster member. If VAXcluster members specify different shadow set members for booting, you risk the loss of system crash information.

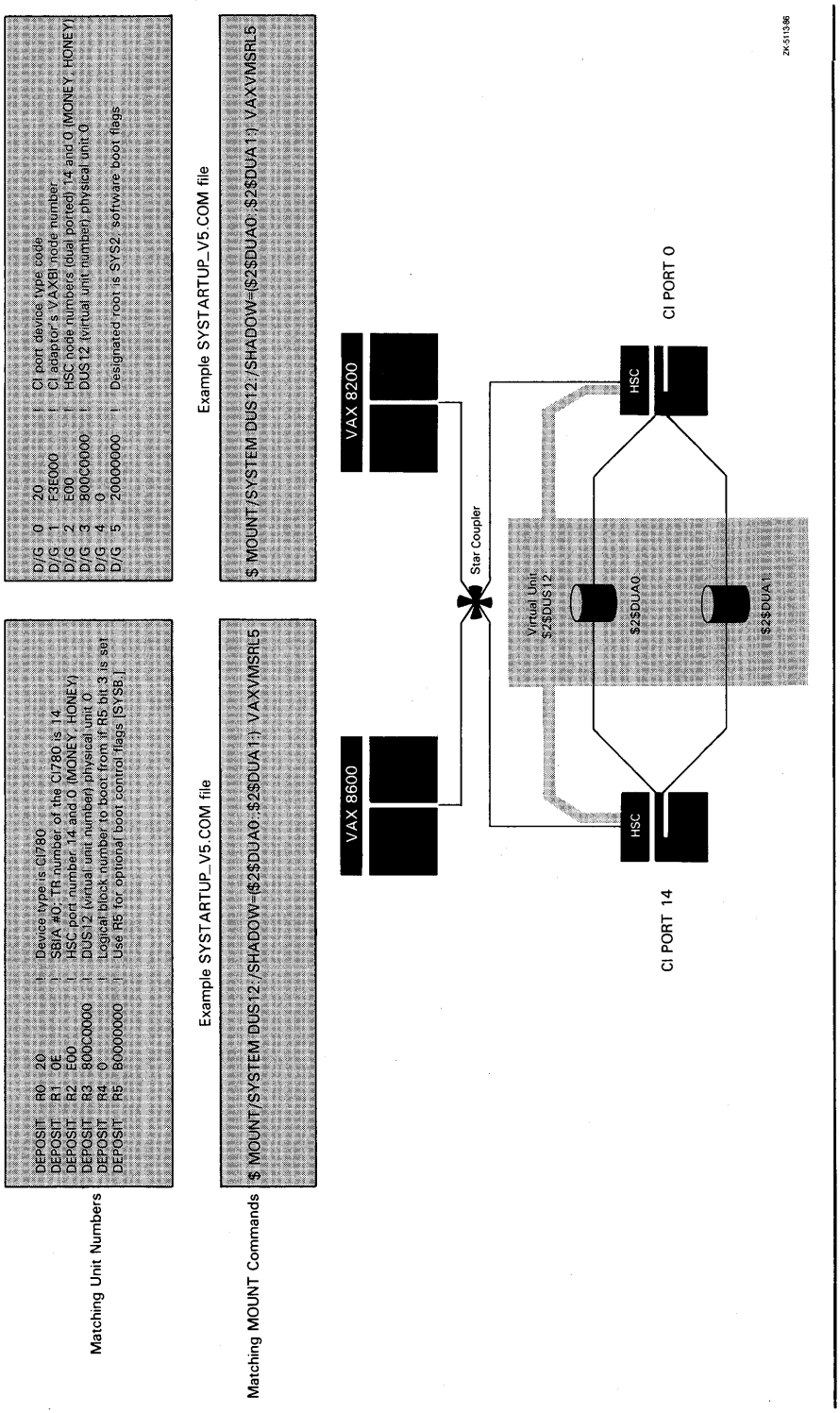
Also, you must deposit the physical unit number of the last existing shadow set member. Do not identify as the boot member a physical unit that is less current than another shadow set member. The system creates a new shadow set by copying data from the identified boot member without regard to which former member is most current. You can lose data during the automatic copy operation.

Figure 4–1 presents a system configuration of a VAX 8600 and a VAX 8200 in a VAXcluster with a system disk shadow set dual ported to a pair of HSCs. The VAX CPUs have corresponding default boot command files. They specify the location of the system disk shadow set and a physical device that is normally one of the shadow set members.

This figure also illustrates matching site-specific system startup command files, named SYSTARTUP_V5.COM. To have the system create a complete shadow set at bootstrap time, a system manager must add a MOUNT command to each SYSTARTUP_V5.COM that completely describes the desired system disk shadow set.

[1] This command file has different names, depending on the type of processor you are using. See Table 4–1 for more information.

Figure 4–1 Booting from a System Disk Shadow Set



Note that different processors use different names for the default boot command procedure. Table 4–1 provides the names of the files by processor type.

Table 4–1 Names of Default Boot Command Procedures

Processor Names	Boot Command File Name
VAX 8800, VAX 8700, VAX 8550, VAX 8530	DEFBOO.COM[1]
VAX 8840, VAX 8830, VAX 8820	DEFBOO.CMD[1]
VAX 8650, VAX 8600	DEFBOO.COM
VAX 8350, VAX 8300, VAX 8250, VAX 8200	DEFBOO.CMD
VAX–11/785, VAX–11/780	DEFBOO.CMD
VAX–11/750	DEFBOO.CMD
VAX–11/730, VAX–11/725	DEFBOO.CMD

[1]For volume shadowing, you must also edit BCIBOO.COM, BCIGEN.COM, BCIXDT.COM, BDABOO.COM, BDAGEN.COM, BDAXDT.COM, UDABOO.COM, UDAGEN.COM, and UDAXDT.COM. See the documentation for your specific processor.

4.5 Upgrading a System That Uses a System Disk Shadow Set

You *cannot* upgrade a shadowed system disk while it is in use as a shadow set. The upgrade procedure must reboot at times when the necessary shadowing support would not be available. Therefore, the upgrade procedure terminates abnormally if a system disk shadow set is active.

When you are using a shadowed system disk, you must modify the procedure to upgrade to a new version of VMS that is described in the VMS release notes. First, you must create a nonshadowed system disk to be upgraded. You can use standalone BACKUP to create a compressed copy of the shadow set on a single scratch disk (a disk with no useful data), or you can remove a current member from the system disk shadow set. Next, you perform the upgrade on the copy of the system disk shadow set. Finally, you build a new system disk shadow set using the updated disk as the source for shadow copies to other members.

The Procedure

This procedure is divided into three parts. In Part 1, you convert the system disk shadow set to a nonshadowed system disk.

Part 1

1. Select a VAXcluster member and a scratch disk (or current member of the current shadowed system disk) with which to perform the upgrade.
2. Prepare a DEFBOO.CMD boot command file that boots from the selected disk without shadowing (does not name a virtual unit in boot register 3). Store this command procedure on the console media of the system selected to perform the upgrade.

3 On the VAXcluster member selected to perform the upgrade, invoke the System Generation Utility (SYSGEN) by typing the following:

```
$ RUN SYS$SYSTEM:SYSGEN
SYSGEN>
```

If you are running a system previous to Version 5.0, disable volume shadowing by setting system parameter VMS7 to 0, as follows:

```
SYSGEN> SET  VMS7 0
SYSGEN> WRITE CURRENT
```

If you are running a system with Version 5.0 or later instead, disable volume shadowing by setting system parameter SHADOWING to 0, as follows:

```
SYSGEN> SET  SHADOWING 0
SYSGEN> WRITE CURRENT
```

Type EXIT or press CTRL/Z to return to the DCL level.

4 Shut down all systems that boot from the system disk shadow set, including the one chosen to perform the upgrade. Dismount the shadow set from any remaining VAXcluster members that have it mounted.

Note: At this point the shadow set should be dissolved; no VAXcluster members should have it mounted.

5 If you have selected a scratch disk for the upgrade, read the restrictions on standalone BACKUP described in Section 4.7. Then back up, with standalone BACKUP, a former shadow set member from the old system disk shadow set (that you just dissolved) to the selected scratch disk. Your processor installation or operations manual describes how to use standalone BACKUP on a system disk. If you are not using a scratch di for the upgrade, go to Part 2 of the procedure.

In Part 2 you perform the upgrade.

Part 2

1 Using the upgraded DEFBOO.CMD file prepared in step 2, boot the system chosen for the upgrade from the disk chosen to be upgraded.

2 Perform the upgrade on this single disk, as outlined in the VMS release notes.

3 Register the VAX Volume Shadowing Product Authorization Key (PAK) or keys, as described in the release notes and cover letter with your installation kit.

4 Invoke the System Generation Utility (SYSGEN) by typing the followin

```
$ RUN SYS$SYSTEM:SYSGEN
SYSGEN>
```

To enable volume shadowing on a Version 5.0 system, set system parameter SHADOWING to 1 (before Version 5.0, you set system parameter VMS7), as follows:

```
SYSGEN> SET  SHADOWING 1
SYSGEN> WRITE CURRENT
```

Note: To ensure volume shadowing is enabled each time Autogen executes, edit the file SYS$SYSTEM:MODPARAMS.DAT to use

the DCL assignment statement SHADOWING=1. See the *Guide to Setting Up a VMS System* for more information about editing the MODPARAMS.DAT file.

Type EXIT or press CTRL/Z to return to the DCL level.

5 Restore the DEFBOO.CMD file to its original contents for shadow set booting (see Section 4.4 for details).

6 Shut down the system performing the upgrade.

7 Exchange the unit plug of the physical unit normally named in boot register R3 of the shadowing DEFBOO.CMD file with the unit plug of the unit with the upgraded disk. This makes the VAXcluster members that normally boot from the system disk shadow set use the newly upgraded disk as the first member of a new system disk shadow set. At this point, you may leave the disk formerly named as the first member off line to preserve its contents.

In Part 3 you rebuild a system disk shadow set from the upgraded disk.

Part 3

1 Boot the VAXcluster members that boot from the system disk shadow set and remount the shadow set on any remaining VAXcluster members.

Each VAXcluster node must use a DEFBOO.CMD file that selects the upgraded system disk as the physical unit in boot R3. This ensures that the upgraded disk becomes the source of a new system disk shadow set. The site-specific startup command procedures name additional members that are added to the new shadow set with full copy operations.

2 Copy the file SYS$SYSTEM:VMB.EXE from the upgraded system to *all* console media of each VAXcluster member. See Section 4.3 for details.

3 If the VMS upgrade procedure directs you to use AUTOGEN, you must do so on all the VAXcluster members. Edit the file SYS$SYSTEM:MODPARAMS.DAT, as described in Part 2 of this procedure.

4 Back up your new system disk shadow set. If you normally use online BACKUP for this task, you can use a procedure described in Section 2.7. If you normally use standalone BACKUP at this point, read the restrictions described in Section 4.7. You must dismount the system disk shadow set, and remove one member to use as the source of standalone BACKUP. You can then remount the system disk shadow set without the member designated for use with standalone BACKUP. Mount that volume outside the shadow set.

4.6 Performance Information for Volume Shadowing

This section offers some general recommendations and information related to the performance characteristics of shadow sets.

- Always connect individual members of a shadow set to different K.sdi boards within the HSC. This hardware configuration rule has the greatest positive effect on the overall shadow set performance.
- For write operations, a shadow set suffers only minor performance loss compared to a single unshadowed disk. Thus, if you are using volume shadowing primarily for data availability in the event of disk drive failure, you do not suffer significant performance loss. However, if your primary goal is to improve data accessibility, the rate of data transfer increases only in shadow sets with I/O operations that are less than 25% write operations.
- For read operations, a two-member shadow set can satisfy nearly twice as many transfer requests per unit time than a single unshadowed disk. Three member shadow sets can satisfy nearly 2.5 times as many transfer requests per unit time as a single unshadowed disk. However, this is possible *only* when there are at least as many transfer requests queued to the shadow set as there are members in the shadow set. You gain no increased data accessibility by shadowing a disk that never has more than one request active at a time.
- Recovering from loss of a shadow set member takes about five to ten seconds when at least one working member remains in the shadow set.
- Moving a shadow set from a broken HSC to the alternate working HSC can take 75 to 120 seconds. It may not take that long, however.

4.7 Standalone BACKUP and Volume Shadowing

Because of its very limited system environment, standalone BACKUP contains no support for shadow sets. The following subsections describe the limitations for using standalone BACKUP on systems that have shadow sets, and provide information about how to use standalone BACKUP on former shadow set members.

4.7.1 Incompatiblities Between Shadow Sets and Standalone BACKUP

DIGITAL does not support accessing shadow sets from standalone BACKUP. The DIGITAL-supplied command procedures for building standalone BACKUP kits make every effort to prevent standalone BACKUP from using volume shadowing improperly. However, these checks can easily be overridden by a well-informed and sufficiently privileged user.

The following limitations exist for standalone BACKUP on systems that use volume shadowing:

- Do not bootstrap standalone BACKUP from an alternate root on a shadowed system disk. If you try this, you will crash the system that is attempting to boot standalone BACKUP.
- Standalone BACKUP does not configure virtual units. This makes access to virtual units impossible from standalone BACKUP.

- Do not assume that standalone BACKUP prevents you from accessing a shadow set member unit. You must prevent standalone BACKUP from sending output to a disk mounted on any other VAXcluster member, either as a directly accessible disk or as the member of a shadow set.

4.7.2 Using Standalone BACKUP on Disks That Are Former Shadow Set Members

To use standalone BACKUP on disks that have been members of a shadow set, you must rebuild your standalone BACKUP console media or alternate root on your system disk. Your processor installation or operations manual describes this process.

4.8 Volume Shadowing in Mixed-Interconnect Clusters

As of VMS Version 5.0, you can use VAX Volume Shadowing in a mixed-interconnect VAXcluster configuration which consists of CI-connected nodes *and* satellite nodes. Although you can use shadowing with such a configuration, you must take special precautions described in this section. See *VMS VAXcluster Manual* for full information about VAXcluster configurations and terminology.

If shadowing is to be used anywhere in a mixed-interconnect cluster, all CI-connected VAX nodes *must* have the SYSGEN parameter SHADOWING set to 1. This setting causes them to use the shadowing driver, DSDRIVER. The MSCP Server serves the shadow set virtual unit to the satellites.

Example 4–2 shows how the shadow set appears when you enter the DCL command SHOW DEVICES D on a boot server. In this example VOYGR1 is the name of an HSC.

Example 4–2 Shadow Set as Seen from Boot Server

```
Device                  Device           Error    Volume         Free  Trans Mnt
 Name                   Status           Count     Label        Blocks Count Cnt
$1$DUA111:     (VOYGR1) ShadowSetMember      0  (member of $1$DUS111:)
$1$DUA151:     (VOYGR1) ShadowSetMember      0  (member of $1$DUS111:)
$1$DUS111:     (VOYGR1) Mounted              0  VMS08JUL       244688   118  21
```

Satellites must have the SHADOWING parameter set to 0. This setting causes them to use the non-shadowing driver, DUDRIVER. Satellites access the shadow set by mounting the virtual unit, and they can see the virtual unit through the MSCP Server. The shadow set appears to have the same characteristics as any other disk device, as shown in Example 4–3. However, while satellites can see shadow set member units, they cannot access them individually. In this example SATURN is the name of the VAX serving the shadow set.

Example 4–3 Shadow Set as Seen from Satellite

```
Device                  Device          Error    Volume         Free  Trans Mnt
 Name                   Status          Count     Label        Blocks Count Cnt
$1$DUA111:    (SATURN)  Online              0  (remote shadow member)
$1$DUA151:    (SATURN)  Online              0  (remote shadow member)
$1$DUS111:    (SATURN)  Mounted             0  VMS08JUL       244688   121  21
```

In mixed-interconnect clusters it is recommended that at least two boot servers should serve the shadow set, so that if one server should fail, another is available to keep the shadow set intact.

4.8.1 Mounting Shadow Sets in a Mixed-Interconnect VAXcluster Configuration

Satellites have no knowlege of shadow set configuration, and they cannot issue any shadow set maintenance commands using the /SHADOW qualifier. All commands that create, modify, and dissolve shadow sets must be entered on a CI-connected node. For example, you must enter a command like the following on a CI-connected node:

```
$ MOUNT/CLUSTER $1$DUS111:/SHADOW=($1$DUA111,$1$DUA151) VMS08JUL
```

This command performs the following operations:

- Creates the virtual unit and forms the shadow set on the current node
- Mounts the shadow set on the other CI-connected nodes
- Mounts the virtual unit on the satellite nodes

4.8.2 Dismounting Shadow Sets in a Mixed-Interconnect VAXcluster Configuration

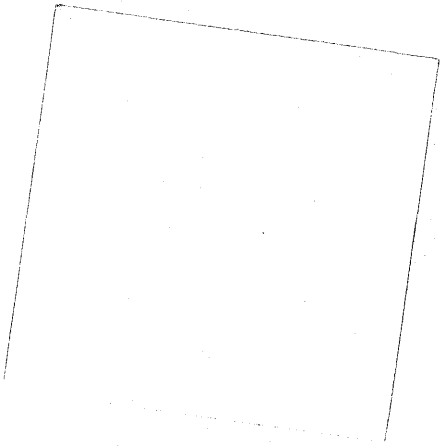
Be careful when dismounting shadow sets. The shadow set virtual unit must always be dismounted on all satellites before being dismounted (and possibly dissolved) on the CI-connected VAX nodes. If these nodes dismount the shadow set before satellites do, the shadow set will be dissolved. The satellites will then have the virtual unit mounted, but will have no path (through a CI-connected node) to the member units. The satellites will therefore place the virtual unit in mount verification. This condition can result in suspended operations, and require a cluster reboot, because satellites may hold locks that must be released before the CI-connected node can rebuild the shadow set.

If this condition occurs, you can remount the shadow set on a CI-connected serving node. When that node reforms the shadow set, the satellites can once again access the volume—provided that the CI-connected node has been able to rebuild the shadow set.

In general, you should use the command DISMOUNT/SYSTEM, rather than DISMOUNT/CLUSTER, to dismount shadow sets in mixed-interconnect clusters.

4.8.3 Using Shadow Sets as Satellite System Disks

A satellite system disk can be a served shadow set. The system device parameter in the DECnet database for satellites must be the device name of the shadow set virtual unit (for example, 1DUS111). No description of shadow set member units is needed.



A Messages

A.1 Mount Verification Status Messages

Mount verification operations on a shadow set display the following status messages on the system console, OPA0, and terminals enabled to receive disk operator messages.

- **<shadow-set-member> : shadow copy has been started.**

  This indicates the start of a shadow copy operation.

- **<shadow-set-member> : shadow copy has been completed.**

  This indicates the completion of a shadow copy operation.

- **<virtual-unit> : all shadow set copy operations are completed.**

  This indicates the completion of all pending shadow set copy operations; all shadow set members contain logical blocks of the same data.

- **<virtual-unit> : shadow set has changed state. Mount verification in progress.**

  This indicates a shadow set state change. The size of the shadow set may be increasing or decreasing. Further messages give details if a change occurs.

- **<shadow-set-member> : has been removed from shadow set.**

  This indicates that the specified unit is no longer a member of the shadow set.

- **<virtual-unit> : shadow set has been reduced.**

  This indicates the completion of shadow set member removal. Preceding messages list the removed shadow set members.

- **<shadow-set-member> : is an incorrect shadow set member volume.**

  This indicates that mount verification has rejected the specified Files–11 shadow set member during a shadow set rebuild. Unless this is the only available shadow set member, the volume is removed from the shadow set. The rejected member was probably altered improperly.

- **<virtual-unit> : contains zero working members.**

  This indicates that mount verification cannot find a working member for the named shadow set. Subsequent messages name shadow set members that are not operating. A system operator must restore one of the named shadow set members to operational status before MVTIMEOUT (mount verification timeout) expires; otherwise, mount verification aborts for the shadow set.

- **<shadow-set-member> : is a possible shadow set member.**

Messages

A.1 Mount Verification Status Messages

This indicates the named shadow set member is a failed member of a zero-member shadow set. The operator must restore to operational status this or another named shadow set member before MVTIMEOUT expires; otherwise, mount verification aborts for the shadow set.

- **<virtual-unit> : does not contain member named to VMB. System may not reboot.**

  This indicates that the system disk shadow set member named in the R3 input to VMB is no longer a member of the system disk shadow set. If this condition exists, mount verification displays this warning message at the completion of each mount verification operation. Unless you add to the system disk shadow set the unit named in the R3 input to VMB, the system may not reboot.

A.2 Mount Verification Messages That Apply to Shadow Sets

In addition to the messages listed previously, the following mount verification messages can apply to shadow sets. These messages have approximately the same meaning for shadow sets as they do for regular disks. They are sent to the system console OPA0 and to any operator terminals enabled to receive disk operator messages.

- **<virtual-unit> : is offline. Mount verification in progress.**
- **<virtual-unit> : has completed mount verification.**
- **<virtual-unit> : has aborted mount verification.**

A.3 MOUNT Messages That Apply to Shadow Sets

The following messages are provided by the VMS Mount Utility or the $MOUNT system service in response to shadow set operations.

BADSHADOW, invalid syntax on /SHADOW qualifier

Explanation: The MOUNT command contains an invalid shadow set syntax.

User Action: Correct the syntax and reenter the command, or correct the program that caused the error.

NOSHDWMEM, no eligible shadow set members to mount the shadow set

Explanation: There are no valid volumes to create the shadow set. This error message is followed by the failed status code for each proposed member.

User Action: Examine the status codes, correct the situation, and reenter the command.

A.3 MOUNT Messages That Apply to Shadow Sets

NOTSHDWDEV, not a shadowing device

Explanation: There are two possible causes for this error message: (1) you did not use the form DUS or DJS to specify the virtual unit name in the MOUNT command (in this case the MOUNT command fails), or (2) you attempted to mount, in a shadow set, a volume that does not support volume shadowing (for example, a magnetic tape cannot become a shadow set member).

User Action: Correct the command syntax and enter the command again.

INVSHDWMEM, shadow set member ddcu: is 'newer' than the shadow set

Explanation: When you attempted to add a volume to an existing shadow set, the volume to be added had a higher generation number than the shadow set.

User Action: Determine which volume should be the target of the shadow copy operation. Re-create the shadow set, and add the target of the copy operations to it.

SHDWCOPYREQ, shadow copy required

Explanation: A shadow set member requires a shadow copy operation, but you specified that no copy operations are allowed.

User Action: Verify that the volume can be initialized (that is, contains no useful data) and reenter the command allowing shadow copy operations.

SHADOWFAIL, failed to create (or add to) the shadow set

Explanation: The shadow set cannot be created, or proposed shadow set members cannot be added to the shadow set. The cause of the failed operation follows this error message.

User Action: Examine the status code of the failed operation and correct the error.

SHDWINCVOL, shadow set member device contains the wrong volume

Explanation: The proposed shadow set member device contains a different volume than expected. Rather than adding this volume to the shadow set and initializing it, this volume is not being added to the shadow set.

User Action: Examine this volume and verify that the volume can be initialized (that is, contains useful data) and reenter the command to add this volume to the shadow set.

VOLSHDWMEM, mounting a shadow set member volume; volume write locked

Explanation: This informational message indicates that the volume being mounted is a former shadow set member. To prevent accidental destruction of data, this volume is being mounted write-locked.

User Action: To allow write access to this volume, dismount the volume and remount it with the /OVERRIDE=SHADOW_MEMBERSHIP qualifier.

SHDWMEMSUCC, ddcu: is now a valid member of the shadow set

Explanation: This informational message indicates that device **ddcu:** is a f shadow set member.

User Action: None.

SHDWMEMCOPY, ddcu: added to the shadow set with a copy operation

Explanation: This informational message indicates that device **ddcu:** is bei added to the shadow set with a copy operation. When the copy operation complete, the device is a full shadow set member.

User Action: None.

SHDWMEMFAIL, ddcu: failed as a member of the shadow set

Explanation: This informational message indicates that device **ddcu:** cann be made a shadow set member. The failure status code follows this messa

User Action: Examine the failure status codes, correct the situation, and reenter the command.

B MOUNT Qualifiers for Volume Shadowing

This appendix presents the MOUNT command qualifiers that you can use with VAX Volume Shadowing. This material is presented to allow insertion into the *VMS Mount Utility Manual*.

/CONFIRM

Controls whether the Mount Utility (MOUNT) issues a request to confirm a full copy operation when mounting a shadow set. The default is /NOCONFIRM.

FORMAT

/CONFIRM *virtual-unit-name[:]*
/SHADOW=*(physical-device-name[:][, . . .]*

/NOCONFIRM *virtual-unit-name[:]* **/SHADOW=**
(physical-device-name[:][, . . .])

DESCRIPTION

You can specify /CONFIRM as a precaution to avoid erasing important data during full copy operations. /CONFIRM stops automatic copying of targeted potential shadow set members. When you mount or add to a shadow set, members that contain data less current than that in other shadow set members are targets for full copy operations. Unless you specify the /CONFIRM or the /NOCOPY qualifier, MOUNT automatically overwrites the data of the targeted volumes.

The MOUNT/CONFIRM command displays the volume label and volume owner for any specified physical device that requires a full copy operation. MOUNT then stops the full copy operation and displays the following prompt:

```
Allow FULL shadow copy on the above member(s)? [N]:
```

If the targets of copy operations are as expected, type YES, and the MOUNT command proceeds automatically with full copy operations allowed. If not, type NO, press RETURN, or press CTRL/Z. The command quits without mounting any new shadow set members, including those that do not require a full copy operation. If you type a response other than these, the prompt is redisplayed. You can use any combination of upper- and lowercase letters, and abbreviate to one or more letters.

Section 2.1.4.3 of the *VAX Volume Shadowing Manual* describes how MOUNT determines the sources and targets of shadow set copy operations. In brief, the shadow set member with the most current volume shadowing generation number is the source for copy operations to potential shadow set members. Other potential shadow set members must have been marked with identical generation numbers or they are targets for full copy operations.

The /CONFIRM qualifier is similar to the /NOCOPY qualifier except that with /NOCOPY there is no interactive exchange. /NOCOPY also terminates the mount operation if there are any potential full copy operations. Use /CONFIRM to mount a shadow set interactively, and use /NOCOPY to mount shadow sets in the site-specific startup command procedure SYS$MANAGER:SYSTARTUP.COM. (See the /NOCOPY qualifier for information about using it with a system disk shadow set.)

EXAMPLES

1

```
$ MOUNT/CONFIRM DUS23: /SHADOW=($1$DUA4:,$1$DUA6:) SHADOWVOL❶

%MOUNT-F-SHDWCOPYREQ, shadow copy required
Virtual Unit - $1$DUS23 (HSC001)                Volume Label - SHADOWVOL❷
     Member                    Volume Label Owner UIC❸
     $1$DUA6: (LOVE)           SCRATCH      [100,100]
Allow FULL shadow copy on the above member(s)? [N]: NO❹
$
```

This example shows how to use the /CONFIRM qualifier to check the status of potential shadow set members before any data is erased.

❶ This command instructs MOUNT to build a shadow set, with the specified devices, and prompt for permission to perform any full copy operations.

❷ Because a full copy operation is necessary, the virtual unit name and the volume label is displayed.

❸ The display also includes the physical device name, the volume label, and the volume owner of the potential shadow set member that requires the copy operation.

❹ A response of **NO** instructs MOUNT to quit with no mounting or copying.

2

```
$ MOUNT/CONFIRM DUS23: /SHADOW=($1$DUA4:,$1$DUA6:) SHADOWVOL

%MOUNT-F-SHDWCOPYREQ, shadow copy required
Virtual Unit - $1$DUS23 (HSC001)                Volume Label - SHADOWVOL
     Member                    Volume Label Owner UIC
     $1$DUA6: (LOVE)           SCRATCH      [100,100]
Allow FULL shadow copy on the above member(s)? [N]: YES

%MOUNT-I-SHDWMEMSUCC, _$1$DUA4: (HSC001) is now a valid member of the
                      shadow set
%MOUNT-I-SHDWMEMCOPY, _$1$DUA6: (HSC001) added to the shadow set with
                      a copy operation
$
```

This example shows how to use the /CONFIRM qualifier to check the status of potential shadow set members before any data is erased. A response of **YES** to the prompt instructs MOUNT to form the shadow set with a full copy operation.

/COPY

Enables or disables copy operations on physical devices named when mounting or adding to a shadow set. The default is /COPY.

FORMAT

/COPY *virtual-unit-name[:]*
/SHADOW=*(physical-device-name[:][, . . .])*
/NOCOPY *virtual-unit-name[:]*
/SHADOW=*(physical-device-name[:][, . . .])*

DESCRIPTION

You can specify /NOCOPY as a precaution to avoid erasing important data during copy operations. /NOCOPY stops automatic copying of targeted potential shadow set members. When you mount or add to a shadow set, members that contain data less current than other shadow set members are targets for full copy operations. Unless you specify the /NOCOPY or the /CONFIRM qualifier, MOUNT automatically overwrites the data of the targeted volumes.

A MOUNT/NOCOPY operation fails if any of the specified potential shadow set members require full copy operations. Error messages identify the targets of full copy operations. If the targets of full copy operations are as expected, you can mount the shadow set with the /COPY qualifier. If not, you have not lost data, and should enter a new command that specifies units that can be overwritten.

Section 2.1.4.3 of the *VAX Volume Shadowing Manual* describes how MOUNT determines the sources and targets for shadow set copy operations. In brief, the shadow set member with the most current volume shadowing generation number is the source for copy operations to potential shadow set members. Other potential shadow set members must have been marked with identical generation numbers or they are targets for full copy operations.

The /NOCOPY qualifier is similar to the /CONFIRM qualifier except that with /CONFIRM there is an interactive exchange in which you can continue a mount with copy operations. Use /CONFIRM to mount a shadow set interactively, and /NOCOPY to mount shadow sets in the site-specific startup command procedure SYS$MANAGER:SYSTARTUP.COM. (Using the /NOCOPY qualifier with a system disk shadow set either has no effect, as in the case where the system boots from a virtual unit, or causes the mount operation to fail, which is not generally useful for a system disk.)

The /NOCOPY qualifier guards against accidental destruction of data when the system reboots and forms a shadow set using incorrect volumes (caused by different volumes being put into the drives or drive unit plugs being accidentally switched when the system is down).

EXAMPLE

```
$ MOUNT/NOCOPY DUS2: /SHADOW=($1$DUA4:,$1$DUA6:,$1$DUA7:) -
_$ SHADOWVOL DISK$SHADOWVOL❶

%MOUNT-F-SHDWCOPYREQ, shadow copy required
%MOUNT-I-SHDWMEMFAIL, DUA7: failed as a member of the shadow set
%MOUNT-F-SHDWCOPYREQ, shadow copy required❷

$  MOUNT/COPY DUS2: /SHADOW=($1$DUA4:,$1$DUA6:,$1$DUA7:) -
_$ SHADOWVOL DISK$SHADOWVOL❸

%MOUNT-I-MOUNTED, SHADOWVOL    mounted on _$1$DUS2: (HSC001)
%MOUNT-I-SHDWMEMSUCC, _$1$DUA4: (HSC001) is now a valid member of
                      the shadow set
%MOUNT-I-SHDWMEMSUCC, _$1$DUA6: (HSC001) is now a valid member of
                      the shadow set
%MOUNT-I-SHDWMEMCOPY, _$1$DUA7: (HSC001) added to the shadow set
                      with a copy operation❹
```

This example shows how to use the /NOCOPY qualifier to check the status of potential shadow set members before any data is erased.

❶ This command instructs MOUNT to build a shadow set, with the specified devices, only if no copy operations are required.

❷ MOUNT did not build the shadow set because the specified disk, loaded on device 1DUA7, was a target for a full copy operation. At this point you can verify that the volume in device 1DUA7 does not contain any useful data. You can than proceed using the /COPY qualifier.

❸ This command instructs MOUNT to build a shadow set providing the necessary copy operations.

❹ The shadow set is mounted. The volume in device 1DUA7 receives a full copy operation.

/OVERRIDE

Inhibits one or more protection checks performed by the MOUNT command.

FORMAT

/OVERRIDE=*(option[, . . .]) device-name:*

QUALIFIER VALUE

option

The following protection check option is available for mounting disks formerly mounted in a Files–11 shadow set.

SHADOW_MEMBERSHIP

Disks that have been mounted as shadow set members on a system can use the volume shadowing option. Use /OVERRIDE=SHADOW_MEMBERSHIP to mount a former shadow set member for write operations outside of a shadow set. If you do not use /OVERRIDE=SHADOW_MEMBERSHIP, MOUNT automatically mounts the volume write-locked to prevent accidental alteration of data.

When you use this qualifier, the shadow set generation number is erased from the volume. If you then remount the volume in the former shadow set, MOUNT considers it an unrelated volume and marks it for a full copy operation.

To use /OVERRIDE=SHADOW_MEMBERSHIP, you must have VOLPRO privilege or your UIC must match the owner UIC of the volume.

Note: DIGITAL recommends that you do not mount a shadow set with the /OVERRIDE=IDENTIFICATION qualifier; see Section 2.1.5.4 of the *VAX Volume Shadowing Manual* for details.

EXAMPLE

```
$ MOUNT/OVERRIDE=SHADOW_MEMBERSHIP $4$DUA20: WORKDISK
```

This command overrides the write protection and erases the volume shadowing generation number field, thus mounting a former shadow set member on 4DUA20.

/SHADOW

Directs the Mount Utility to bind the specified physical devices into a shadow set represented by the specified virtual unit.

FORMAT

virtual-unit-name[:]/**SHADOW=**
(physical-device-name[:][, . . .])

QUALIFIER VALUES

virtual-unit-name[:]

The required name for the software representation of a shadow set. Use the virtual unit naming formats **[$allocation-class$]ddSu[:]** or **[hsc$]ddSu[:]**.

If the allocation class is not zero, use the allocation class format. If you omit the HSC name or allocation class when you specify a virtual unit in a VAXcluster, MOUNT substitutes the HSC name or allocation class of the most current shadow set member.

The **dd** describes the device type of the physical devices used, **S** identifies the unit as a shadow set, and **u** is a unique number from 0 through 9999.

physical-device-name[:][, . . .]

The name of a disk drive that contains a disk to be mounted in a shadow set. If you specify only one device, you can omit the parentheses. Use the standard HSC-mounted device naming formats **$allocation-class$ddcu[:]** or **hsc$ddcu[:]**. If your devices are dual ported to HSCs, use the **$allocation-class$ddcu[:]** format. A named disk becomes a *shadow set member* represented by the *virtual unit*.

DESCRIPTION

Use the /SHADOW qualifer to mount a shadow set or a volume set of shadow sets. You must specify at least one physical device. If you specify more than one physical device, more current Files–11 disks are copied to less current Files–11 disks by default. To disable the copy operations, use the /NOCOPY qualifier. If you are mounting a shadow set interactively, you can use the /CONFIRM qualifier. /CONFIRM instructs MOUNT to display the targets of copy operations and request permission before the copies are performed.

Foreign volumes require special treatment to be mounted in a shadow set. When you mount a foreign shadow set, you must specify the desired copy operation: FULL_COPY=ddcu, MERGE_COPY=ddcu, or NO_COPY=ddcu for each physical device you list with the /SHADOW qualifier. See the *VAX Volume Shadowing Manual*.

EXAMPLE

```
$ MOUNT DUSO: /SHADOW=($1$DUA10:,$1$DUA11:) SHADOWDISK
%MOUNT-I-MOUNTED, SHADOWDISK    mounted on _$1$DUSO: (HSCOO1)
%MOUNT-I-SHDWMEMSUCC, _$1$DUA10: (HSCOO1) is now a valid member of
                      the shadow set
%MOUNT-I-SHDWMEMCOPY, _$1$DUA11: (HSCOO1) added to the shadow set
                      with a copy operation
```

This example shows how to create a Files–11 shadow set wherein the software determines automatically the correct copy operation for the two shadow set members. MOUNT checks the volume shadowing generation numbers on the volumes, selects the more current shadow set member, and performs the appropriate copy operation. In this example, 1DUA10 is the more current volume and becomes the source of the copy operation to 1DUA11.

C System Services Item Codes for Volume Shadowing

This appendix presents the $GETDVI and $MOUNT system service item codes that you can use with VAX Volume Shadowing. This material is presented to allow insertion into the descriptions of the $GETDVI and $MOUNT system services contained in the *VMS System Services Reference Manual*.

System Services Item Codes for Volume Shadowing

$GETDVI Volume Shadowing Item Codes

DVI$_SHDW_CATCHUP_COPYING

When you specify DVI$_SHDW_CATCHUP_COPYING, $GETDVI returns a longword, which is interpreted as Boolean. The value 1 indicates that the device is a member receiving a full copy operation before joining a shadow set.

DVI$_SHDW_FAILED_MEMBER

When you specify DVI$_SHDW_FAILED_MEMBER, $GETDVI returns a longword, which is interpreted as Boolean. The value 1 indicates that the device is a member that has been removed from the shadow set by the remote server.

DVI$_SHDW_MASTER

When you specify DVI$_SHDW_MASTER, $GETDVI returns a longword, which is interpreted as Boolean. The value 1 indicates that the device is a virtual unit.

DVI$_SHDW_MASTER_NAME

When you specify DVI$_SHDW_MASTER_NAME and the specified device is a shadow set member, $GETDVI returns the device name of the virtual un that represents the shadow set of which the specified device is a member. $GETDVI returns a null string if the specified device is not a member or is itself a virtual unit.

When the shadow set members are dual-pathed to two HSCs and therefore have a nonzero allocation class, the device name returned by $GETDVI contains the allocation class; the name has the form **$allocation-class$devic** For example, if a virtual unit has an allocation class of 255 and the device name DUS10, $GETDVI returns the following string: 255DUS10.

When the shadow set members have a zero allocation class, the device name contains the HSC node name; the name has the form **hsc$device**. For example, if the node name of the HSC is LAMONT and the device name is DUS10, $GETDVI returns the following string: LAMONT$DUS10.

Because the shadow set virtual unit name can include up to 64 characters, th buffer length field of the item descriptor should specify 64 (bytes).

DVI$_SHDW_MEMBER

When you specify DVI$_SHDW_MEMBER, $GETDVI returns a longword, which is interpreted as Boolean. The value 1 indicates that the device is a shadow set member.

DVI$_SHDW_MERGE_COPYING

When you specify DVI$_SHDW_MERGE_COPYING, $GETDVI returns a longword, which is interpreted as Boolean. The value 1 indicates that the device is a member receiving a merge copy operation before joining a shado set.

DVI$_SHDW_NEXT_MBR_NAME

When you specify DVI$_SHDW_NEXT_MBR_NAME, $GETDVI returns th device name of the next member in the shadow set. If you specify a virtual unit, $GETDVI returns the device name of the lowest-numbered member. If you specify a member, $GETDVI returns the device name of the member

with the next highest number. If you specify the device name of the highest-numbered member, $GETDVI returns a null string. If you specify the name of a device that is neither a virtual unit nor a member, $GETDVI returns a null string.

$GETDVI returns the device name of the next member in the shadow set even if the remote server has removed the next member from the shadow set.

When the shadow set members are dual pathed to two HSCs and therefore have a nonzero allocation class, the device name returned by $GETDVI contains the allocation class; the name has the form **$allocation-class$device**. For example, if a shadow set has an allocation class of 255 and the device name is DUS10, $GETDVI returns the following string: 255DUS10.

When the shadow set members have a zero allocation class, the device name contains the HSC node name; the name has the form **hsc$device**. For example, if the node name of the HSC is LAMONT and the device name is DUS10, $GETDVI returns the following string: LAMONT$DUS10.

Because a device name can include up to 64 characters, the buffer length field of the item descriptor should specify 64 (bytes).

$MOUNT Volume Shadowing Item Codes

MNT$_SHANAM

The MNT$_SHANAM item code specifies the name of the virtual unit to be mounted. The buffer must contain a character string from 1 to 64 characters, which is the virtual unit name. The virtual unit name may be a logical name if it is a logical name, it must translate to a virtual unit name. The name should include the controller letter *S*, which indicates that the device is a virtual unit.

Because every shadow set is represented by a virtual unit, you must include at least one MNT$_SHANAM item descriptor in the item list that you pass to $MOUNT to create and mount the shadow set. If you are mounting a Files–11 volume set containing more than one shadow set, you must include one MNT$_SHANAM item descriptor for each virtual unit included in the volume set.

The relative position of the item descriptors in the item list determines the membership of the shadow set. That is, it indicates which members should be bound to a specific virtual unit to form the shadow set. You must first specify the virtual unit by using the MNT$_SHANAM item code. Then, you can specify any number of members that are to be represented by that virtual unit by using one of the following item codes: MNT$_SHAMEM, MNT$_SHAMEM_MGCOPY, or MNT$_SHAMEM_COPY. If you specify one shadow set and want to specify a second, specify a second virtual unit item descriptor. The members you specify subsequently are bound to the shadow set represented by the virtual unit specified in the second virtual uni item descriptor.

MNT$_SHAMEM

The MNT$_SHAMEM item code specifies the name of a member (physical device) to be added to the shadow set represented by the most recently specified virtual unit, that is, the virtual unit name specified in the most recent MNT$_SHANAM item descriptor. The buffer must contain a characte string from 1 to 64 characters, which is the device name. The device name may be a physical device name or a logical name; if it is a logical name, it must translate to a physical device name.

If you are mounting a foreign shadow set, the MNT$_SHAMEM item code indicates that the member specified in the item descriptor does not require a shadow copy before it joins the shadow set.

When you mount a foreign shadow set, the system considers the first membe you specify after the virtual unit item descriptor to be the most current member of the shadow set. The system makes copies to other members base on this member. You must use the MNT$_SHAMEM item code to specify the first member of a foreign shadow set, because it can never require a copy operation before joining the shadow set.

To be valid, an item list must contain at least one item descriptor specifying a member; this item descriptor must appear after the MNT$_SHANAM item descriptor.

MNT$_SHAMEM_COPY

The MNT$_SHAMEM_COPY item code specifies the name of a member to be added to the shadow set represented by the most recently specified virtual unit, that is, the virtual unit name specified in the most recent MNT$_SHANAM item descriptor. The buffer must contain a character string from 1 to 64 characters, which is the device name. The device name may be

a physical device name or a logical name; if it is a logical name, it must translate to a physical device name.

When mounting a foreign shadow set, use the MNT$_SHAMEM_COPY item code to indicate that the member specified in the item descriptor requires a full copy operation before it can join the shadow set.

MNT$_SHAMEM_MGCOPY

The MNT$_SHAMEM_MGCOPY item code specifies the name of a member to be added to the shadow set represented by the most recently specified virtual unit, that is, the virtual unit specified in the most recent MNT$_SHANAM item descriptor. The buffer must contain a character string from 1 to 64 characters, which is the device name. The device name may be a physical device name or a logical name; if it is a logical name, it must translate to a physical device name.

When mounting a foreign shadow set, use the MNT$_SHAMEM_MGCOPY item code to indicate that the member specified in the item descriptor requires a merge copy operation before it can join the shadow set.

MNT$_FLAGS

The MNT$_FLAGS item code specifies a longword bit vector wherein each bit specifies an option for the mount operation. The buffer must contain a longword, which is the bit vector.

The $MNTDEF macro defines symbolic names for each option (bit) in the bit vector. You construct the bit vector by specifying the symbolic names for the desired options in a logical OR operation. The following table describes the symbolic names for each shadow set option.

Option	Description
MNT$V_NOCOPY	Disables full copy operations on all physical devices being mounted or added to a shadow set. This option provides you with the opportunity to confirm the states of all of the members of a shadow set before proceeding with any full copy operation. This prevents any accidental loss of data that could occur if an unintended device is added to the shadow set. If you do not select this option, $MOUNT automatically overwrites the data on shadow set members that are not current. When you select this option, a $MOUNT operation fails if any of the specified potential shadow set members require full copy operations.

System Services Item Codes for Volume Shadowing

Option	Description
MNT$V_OVR_SHAMEM	Allows you to mount former shadow set members outside of the shadow set. If you do not specify this option, $MOUNT automatically mounts the volume write-locked to prevent accidental deletion of data. To specify this option, you must either own the volume or have VOLPRO privilege. When you use this option, the shadow set generation number is erased from the volume. If you then remount the volume in the former shadow set, $MOUNT considers it an unrelated volume and marks it for a full copy operation.

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