Veritas™ Dynamic Multi-Pathing Administrator's Guide

Solaris

DMP 5.1 Rolling Patch 1 Patch 0

Symantec

Veritas™ Dynamic Multi-Pathing Administrator's Guide

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Chapter 1

Understanding DMP

This chapter includes the following topics:

About Veritas Dynamic Multi-Pathing

Veritas Dynamic Multi-Pathing (DMP) provides multipathing functionality for the operating system native devices configured on the system. DMP creates DMP metadevices (also known as DMP nodes) to represent all the device paths to the same physical LUN.

In previous Veritas releases, DMP was only available as a feature of Veritas Volume Manager (VxVM). DMP supported VxVM volumes and Veritas File System (VxFS) file systems on the DMP metadevices.

This release extends DMP metadevices to support ZFS. You can create ZFS pools on DMP metadevices.

In this release, Veritas Dynamic Multi-Pathing does not support Veritas File System (VxFS) on DMP devices.

Veritas Volume Manager (VxVM) volumes and disk groups can co-exist with ZFS pools, but each device can only support one of the types. If a disk has a VxVM label, then the disk is not available to ZFS. Similarly, if a disk is in use by ZFS, then the disk is not available to VxVM.

How DMP works

Veritas Dynamic Multi-Pathing (DMP) provides greater availability, reliability, and performance by using path failover and load balancing. This feature is available for multiported disk arrays from various vendors.

Multiported disk arrays can be connected to host systems through multiple paths. To detect the various paths to a disk, DMP uses a mechanism that is specific to each supported array. DMP can also differentiate between different enclosures of a supported array that are connected to the same host system.

See "Discovering and configuring newly added disk devices" on page 84.

The multipathing policy that is used by DMP depends on the characteristics of the disk array.

DMP supports the following standard array types:

Active/Active (A/A)	Allows several paths to be used concurrently for I/O. Such arrays allow DMP to provide greater I/O throughput by balancing the I/O load uniformly across the multiple paths to the LUNs. In the event that one path fails, DMP automatically routes I/O over the other available paths.
Asymmetric Active/Active (A/A-A)	A/A-A or Asymmetric Active/Active arrays can be accessed through secondary storage paths with little performance degradation. Usually an A/A-A array behaves like an A/P array rather than an A/A array. However, during failover, an A/A-A array behaves like an A/A array. An ALUA array behaves like an A/A-A array.

Active/Passive (A/P)	Allows access to its LUNs (logical units; real disks or virtual disks created using hardware) via the primary (active) path on a single controller (also known as an access port or a storage processor) during normal operation. In implicit failover mode (or autotrespass mode), an A/P array automatically fails over by scheduling I/O to the secondary (passive) path on a separate controller if the primary path fails. This passive port is not used for I/O until the active port fails. In A/P arrays, path failover can occur for a single LUN if I/O fails on the primary path. This policy supports concurrent I/O and load balancing by having multiple primary paths into a controller. This functionality is provided by a controller with multiple ports, or by the insertion of a SAN switch between an array and a controller. Failover to the secondary (passive) path occurs only if all the active primary paths fail.
Active/Passive in explicit failover mode or non-autotrespass mode (A/P-F)	The appropriate command must be issued to the array to make the LUNs fail over to the secondary path. This policy supports concurrent I/O and load balancing by having multiple primary paths into a controller. This functionality is provided by a controller with multiple ports, or by the insertion of a SAN switch between an array and a controller. Failover to the secondary (passive) path occurs only if all the active primary paths fail.

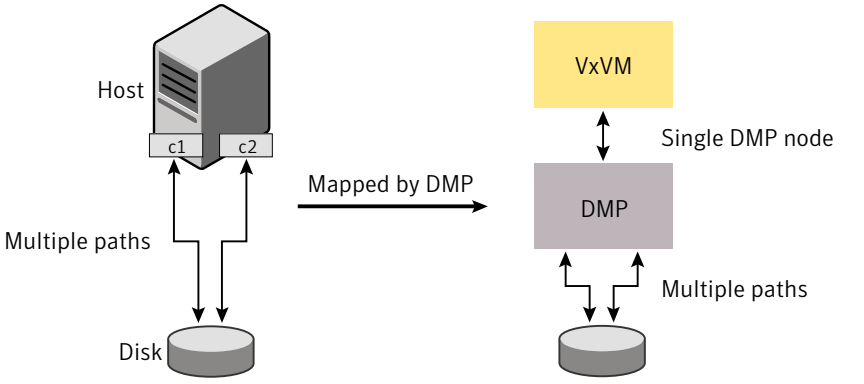
Active/Passive with LUN group failover (A/P-G)	For Active/Passive arrays with LUN group failover (A/PG arrays), a group of LUNs that are connected through a controller is treated as a single failover entity. Unlike A/P arrays, failover occurs at the controller level, and not for individual LUNs. The primary controller and the secondary controller are each connected to a separate group of LUNs. If a single LUN in the primary controller's LUN group fails, all LUNs in that group fail over to the secondary controller. This policy supports concurrent I/O and load balancing by having multiple primary paths into a controller. This functionality is provided by a controller with multiple ports, or by the insertion of a SAN switch between an array and a controller. Failover to the secondary (passive) path occurs only if all the active primary paths fail.

An array policy module (APM) may define array types to DMP in addition to the standard types for the arrays that it supports.

VxVM uses DMP metanodes (DMP nodes) to access disk devices connected to the system. For each disk in a supported array, DMP maps one node to the set of paths that are connected to the disk. Additionally, DMP associates the appropriate multipathing policy for the disk array with the node. For disks in an unsupported array, DMP maps a separate node to each path that is connected to a disk. The raw and block devices for the nodes are created in the directories `/dev/vx/rdmp` and `/dev/vx/dmp` respectively.

Figure 1-1 shows how DMP sets up a node for a disk in a supported disk array.

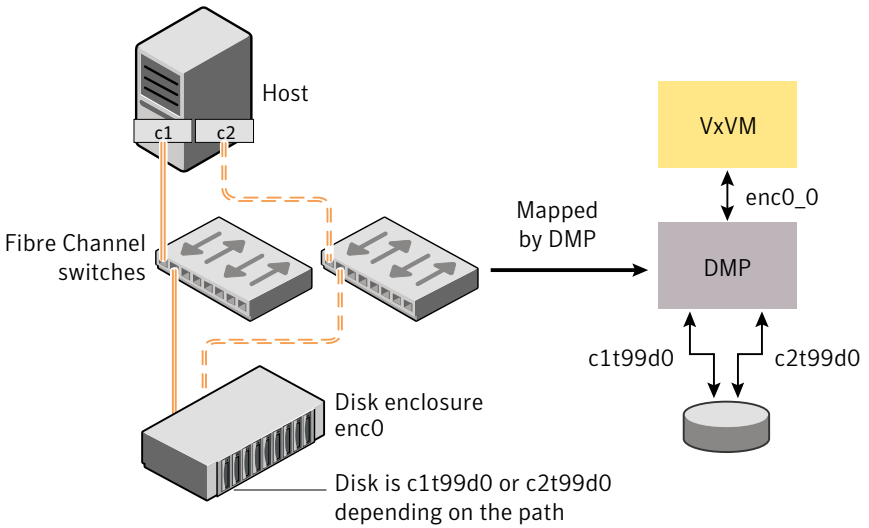
Figure 1-1 How DMP represents multiple physical paths to a disk as one node



VxVM implements a disk device naming scheme that allows you to recognize to which array a disk belongs.

Figure 1-2 shows an example where two paths, `c1t99d0` and `c2t99d0`, exist to a single disk in the enclosure, but VxVM uses the single DMP node, `enc0_0`, to access it.

Figure 1-2 Example of multipathing for a disk enclosure in a SAN environment



See "About enclosure-based naming" on page 21.

See "Changing the disk-naming scheme" on page 102.

See "Discovering and configuring newly added disk devices" on page 84.

How DMP monitors I/O on paths

In older releases of VxVM, DMP had one kernel daemon (`errord`) that performed error processing, and another (`restored`) that performed path restoration activities.

From release 5.0, DMP maintains a pool of kernel threads that are used to perform such tasks as error processing, path restoration, statistics collection, and SCSI request callbacks. The `vxdmpadm stat` command can be used to provide information about the threads. The names `errord` and `restored` have been retained for backward compatibility.

One kernel thread responds to I/O failures on a path by initiating a probe of the host bus adapter (HBA) that corresponds to the path. Another thread then takes

the appropriate action according to the response from the HBA. The action taken can be to retry the I/O request on the path, or to fail the path and reschedule the I/O on an alternate path.

The restore kernel task is woken periodically (typically every 5 minutes) to check the health of the paths, and to resume I/O on paths that have been restored. As some paths may suffer from intermittent failure, I/O is only resumed on a path if the path has remained healthy for a given period of time (by default, 5 minutes). DMP can be configured with different policies for checking the paths.

See "Configuring DMP path restoration policies" on page 79.

The statistics-gathering task records the start and end time of each I/O request, and the number of I/O failures and retries on each path. DMP can be configured to use this information to prevent the SCSI driver being flooded by I/O requests. This feature is known as I/O throttling.

If an I/O request relates to a mirrored volume, VxVM specifies the FAILFAST flag. In such cases, DMP does not retry failed I/O requests on the path, and instead marks the disks on that path as having failed.

See "Path failover mechanism" on page 16.

See "I/O throttling" on page 17.

Path failover mechanism

DMP enhances system reliability when used with multiported disk arrays. In the event of the loss of a path to a disk array, DMP automatically selects the next available path for I/O requests without intervention from the administrator.

DMP is also informed when a connection is repaired or restored, and when you add or remove devices after the system has been fully booted (provided that the operating system recognizes the devices correctly).

If required, the response of DMP to I/O failure on a path can be tuned for the paths to individual arrays. DMP can be configured to time out an I/O request either after a given period of time has elapsed without the request succeeding, or after a given number of retries on a path have failed.

See "Configuring the response to I/O failures" on page 74.

Subpaths Failover Group (SFG)

An SFG represents a group of paths which could fail and restore together. When an I/O error is encountered on a path in an SFG group, DMP does proactive path probing on the other paths of that SFG as well. This behavior adds greatly to the performance of path failover thus improving IO performance. Currently the criteria followed by DMP to form the subpath failover groups is to bundle the

paths with the same endpoints from the host to the array into one logical storage failover group.

See "Configuring Subpaths Failover Groups (SFG)" on page 77.

Low Impact Path Probing (LIPP)

The restore daemon in DMP keeps probing the LUN paths periodically. This behavior helps DMP to keep the path states up-to-date even though IO activity is not there on the paths. Low Impact Path Probing adds logic to the restore daemon to optimize the number of the probes performed while the path status is being updated by the restore daemon. This optimization is achieved with the help of the logical subpaths failover groups. With LIPP logic in place, DMP probes only limited number of paths within an SFG, instead of probing all the paths in an SFG. Based on these probe results, DMP determines the states of all the paths in that SFG.

See "Configuring Low Impact Path Probing" on page 77.

I/O throttling

If I/O throttling is enabled, and the number of outstanding I/O requests builds up on a path that has become less responsive, DMP can be configured to prevent new I/O requests being sent on the path either when the number of outstanding I/O requests has reached a given value, or a given time has elapsed since the last successful I/O request on the path. While throttling is applied to a path, the new I/O requests on that path are scheduled on other available paths. The throttling is removed from the path if the HBA reports no error on the path, or if an outstanding I/O request on the path succeeds.

See "Configuring the I/O throttling mechanism" on page 75.

Load balancing

By default, the DMP uses the Minimum Queue policy for load balancing across paths for Active/Active, A/P, A/PF and A/PG disk arrays. Load balancing maximizes I/O throughput by using the total bandwidth of all available paths. I/O is sent down the path which has the minimum outstanding I/Os.

For Active/Passive disk arrays, I/O is sent down the primary path. If the primary path fails, I/O is switched over to the other available primary paths or secondary paths. As the continuous transfer of ownership of LUNs from one controller to another results in severe I/O slowdown, load balancing across paths is not performed for Active/Passive disk arrays unless they support concurrent I/O.

Both paths of an Active/Passive array are not considered to be on different controllers when mirroring across controllers (for example, when creating a volume using `vxassist make` specified with the `mirror=ctlr` attribute).

For A/P, A/PF and A/PG arrays, load balancing is performed across all the currently active paths as is done for Active/Active arrays.

You can use the `vxdmpadm` command to change the I/O policy for the paths to an enclosure or disk array.

See "Specifying the I/O policy" on page 65.

Dynamic Reconfiguration

Dynamic Reconfiguration (DR) is a feature that is available on some high-end enterprise systems. It allows some components (such as CPUs, memory, and other controllers or I/O boards) to be reconfigured while the system is still running. The reconfigured component might be handling the disks controlled by VxVM.

See "About enabling and disabling I/O for controllers and storage processors" on page 37.

About booting from DMP devices

When the root disk is placed under VxVM control, it is automatically accessed as a DMP device with one path if it is a single disk, or with multiple paths if the disk is part of a multiported disk array. By encapsulating and mirroring the root disk, system reliability is enhanced against loss of one or more of the existing physical paths to a disk.

Note: The SAN bootable LUN must be controlled by DMP. PowerPath and MPXIO control of SAN bootable LUNs is not supported.

Multiple paths to disk arrays

Some disk arrays provide multiple ports to access their disk devices. These ports, coupled with the host bus adaptor (HBA) controller and any data bus or I/O processor local to the array, make up multiple hardware paths to access the disk devices. Such disk arrays are called multipathed disk arrays. This type of disk array can be connected to host systems in many different configurations, (such as multiple ports connected to different controllers on a single host, chaining of the ports through a single controller on a host, or ports connected to different hosts simultaneously).

See "How DMP works" on page 12.

Device discovery

Device discovery is the term used to describe the process of discovering the disks that are attached to a host. This feature is important for DMP because it needs to support a growing number of disk arrays from a number of vendors. In conjunction with the ability to discover the devices attached to a host, the Device Discovery service enables you to add support dynamically for new disk arrays. This operation, which uses a facility called the Device Discovery Layer (DDL), is achieved without the need for a reboot.

This means that you can dynamically add a new disk array to a host, and run a command which scans the operating system's device tree for all the attached disk devices, and reconfigures DMP with the new device database.

See "How to administer the Device Discovery Layer" on page 89.

Disk devices

When performing disk administration, it is important to understand the difference between a disk name and a device name.

The disk name (also known as a disk media name) is the symbolic name assigned to a VM disk. When you place a disk under VxVM control, a VM disk is assigned to it. The disk name is used to refer to the VM disk for the purposes of administration. A disk name can be up to 31 characters long. When you add a disk to a disk group, you can assign a disk name or allow VxVM to assign a disk name. The default disk name is *diskgroup##* where *diskgroup* is the name of the disk group to which the disk is being added, and *##* is a sequence number. Your system may use device names that differ from those given in the examples.

The device name (sometimes referred to as devname or disk access name) defines the name of a disk device as it is known to the operating system.

Such devices are usually, but not always, located in the `/dev/dsk` and `/dev/rdsk` directories. Devices that are specific to hardware from certain vendors may use their own path name conventions.

VxVM uses the device names to create metadevices in the `/dev/vx/[r]dmp` directories. Dynamic Multi-Pathing (DMP) uses these metadevices (or DMP nodes) to represent disks that can be accessed by one or more physical paths, perhaps via different controllers. The number of access paths that are available depends on whether the disk is a single disk, or is part of a multiported disk array that is connected to a system.

You can use the `vxdisk` utility to display the paths that are subsumed by a DMP metadevice, and to display the status of each path (for example, whether it is enabled or disabled).

See "How DMP works" on page 12.

Device names may also be remapped as enclosure-based names.

See "Disk device naming in VxVM" on page 20.

Disk device naming in VxVM

Device names for disks are assigned according to the naming scheme which you specify to VxVM. The format of the device name may vary for different categories of disks.

See "Disk categories" on page 86.

Device names can use one of the following naming schemes:

- Operating system-based naming
- Enclosure-based naming

Devices with device names longer than 31 characters always use enclosure-based names.

You can change the disk-naming scheme if required.

See "Changing the disk-naming scheme" on page 102.

Operating system-based naming

In the OS-based naming scheme, all disk devices are named using the `c#t#d#s#` format.

The syntax of a device name is *`c#t#d#s#`*, where `c#` represents a controller on a host bus adapter, `t#` is the target controller ID, `d#` identifies a disk on the target controller, and `s#` represents a partition (or slice) on the disk.

Note: For non-EFI disks, the slice `s2` represents the entire disk. For both EFI and non-EFI disks, the entire disk is implied if the slice is omitted from the device name.

DMP assigns the name of the DMP meta-device (disk access name) from the multiple paths to the disk. DMP sorts the names by controller, and selects the smallest controller number. For example, c1 rather than c2. If multiple paths are

seen from the same controller, then DMP uses the path with the smallest target name. This behavior make it easier to correlate devices with the underlying storage.

If a CVM cluster is symmetric, each node in the cluster accesses the same set of disks. This naming scheme makes the naming consistent across nodes in a symmetric cluster.

The boot disk (which contains the root file system and is used when booting the system) is often identified to VxVM by the device name `c0t0d0`.

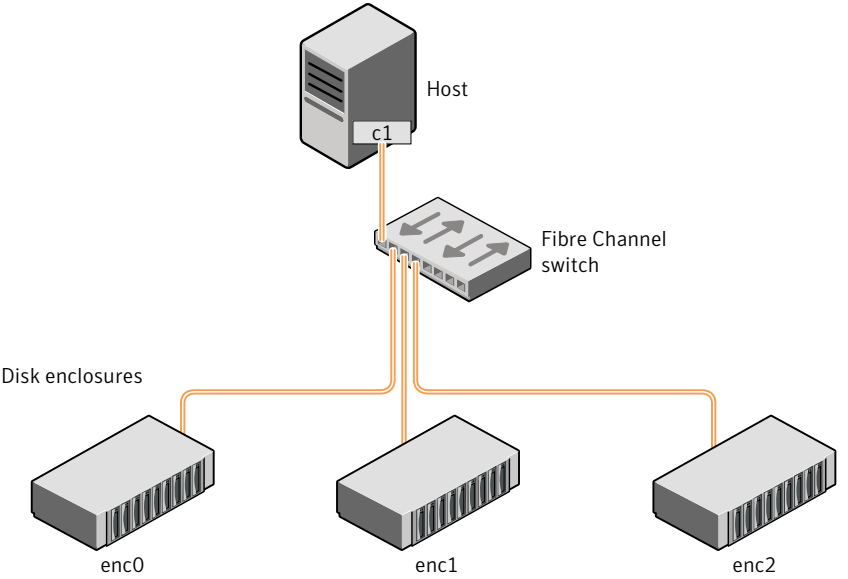
OS-based names can be made persistent, so that they do not change after reboot. By default, OS-based names are not persistent, and are regenerated if the system configuration changes the device name as recognized by the operating system.

About enclosure-based naming

Enclosure-based naming provides an alternative to operating system-based device naming. This allows disk devices to be named for enclosures rather than for the controllers through which they are accessed. In a Storage Area Network (SAN) that uses Fibre Channel switches, information about disk location provided by the operating system may not correctly indicate the physical location of the disks. For example, c#t#d#s# naming assigns controller-based device names to disks in separate enclosures that are connected to the same host controller.
Enclosure-based naming allows VxVM to access enclosures as separate physical entities. By configuring redundant copies of your data on separate enclosures, you can safeguard against failure of one or more enclosures.

Figure 1-3 shows a typical SAN environment where host controllers are connected to multiple enclosures through a Fibre Channel switch.

Figure 1-3 Example configuration for disk enclosures connected via a fibre channel switch



In such a configuration, enclosure-based naming can be used to refer to each disk within an enclosure. For example, the device names for the disks in enclosure `enc0` are named `enc0_0`, `enc0_1`, and so on. The main benefit of this scheme is that it allows you to quickly determine where a disk is physically located in a large SAN configuration.

In most disk arrays, you can use hardware-based storage management to represent several physical disks as one LUN to the operating system. In such cases, VxVM also sees a single logical disk device rather than its component disks. For this reason, when reference is made to a disk within an enclosure, this disk may be either a physical disk or a LUN.

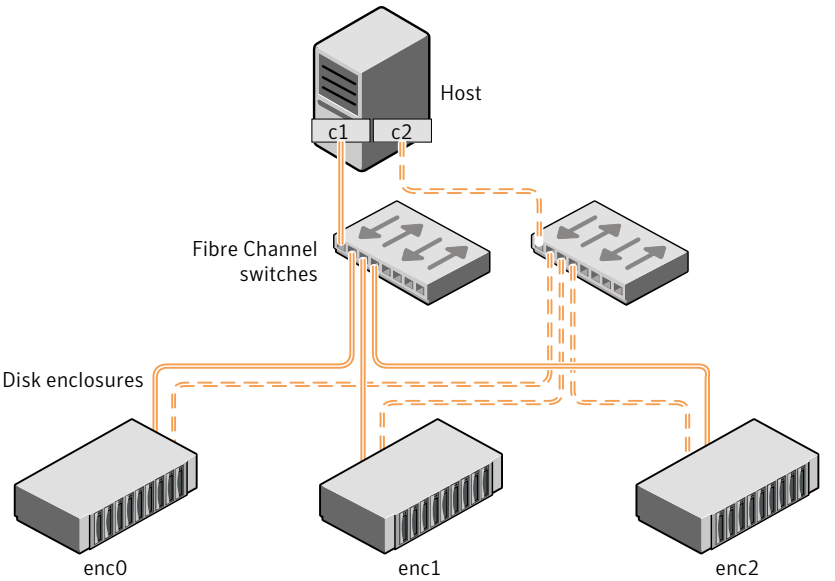
Another important benefit of enclosure-based naming is that it enables VxVM to avoid placing redundant copies of data in the same enclosure. This is a good thing to avoid as each enclosure can be considered to be a separate fault domain. For example, if a mirrored volume were configured only on the disks in enclosure `enc1`, the failure of the cable between the switch and the enclosure would make the entire volume unavailable.

If required, you can replace the default name that VxVM assigns to an enclosure with one that is more meaningful to your configuration.

See "Renaming an enclosure" on page 73.

Figure 1-4 shows a High Availability (HA) configuration where redundant-loop access to storage is implemented by connecting independent controllers on the host to separate switches with independent paths to the enclosures.

Figure 1-4 Example HA configuration using multiple switches to provide redundant loop access



Such a configuration protects against the failure of one of the host controllers (`c1` and `c2`), or of the cable between the host and one of the switches. In this example, each disk is known by the same name to VxVM for all of the paths over which it can be accessed. For example, the disk device `enc0_0` represents a single disk for which two different paths are known to the operating system, such as `c1t99d0` and `c2t99d0`.

See "Disk device naming in VxVM" on page 20.

See "Changing the disk-naming scheme" on page 102.

To take account of fault domains when configuring data redundancy, you can control how mirrored volumes are laid out across enclosures.

Enclosure-based naming

By default, VxVM and DMP use enclosure-based naming.

Enclosure-based naming operates as follows:

- All fabric or non-fabric disks in supported disk arrays are named using the *enclosure_name_#* format. For example, disks in the supported disk array, enggdept are named enggdept_0, enggdept_1, enggdept_2 and so on.
  You can use the vxdmpadm command to administer enclosure names.
  See "Renaming an enclosure" on page 73.
  See the vxdmpadm(1M) manual page.
- Disks in the DISKS category (JBOD disks) are named using the Disk_# format.
- Disks in the OTHER_DISKS category (disks that are not multipathed by DMP) are named using the c#t#d#s# format.

By default, enclosure-based names are persistent, so they do not change after reboot.

If a CVM cluster is symmetric, each node in the cluster accesses the same set of disks. Enclosure-based names provide a consistent naming system so that the device names are the same on each node.

To display the native OS device names of a VM disk (such as mydg01), use the following command:

```
# vxdisk path | grep diskname
```

See "Renaming an enclosure" on page 73.

See "Disk categories" on page 86.

Enclosure based naming with the Array Volume Identifier (AVID) attribute

By default, DMP assigns enclosure-based names to DMP meta-devices using an array-specific attribute called the Array Volume ID (AVID). The AVID provides a unique identifier for the LUN that is provided by the array. The ASL corresponding to the array provides the AVID property. Within an array enclosure, DMP uses the Array Volume Identifier (AVID) as an index in the DMP metanode name. The DMP metanode name is in the format *enclosureID_AVID*.

With the introduction of AVID to the EBN naming scheme, identifying storage devices becomes much easier. The array volume identifier (AVID) enables you to have consistent device naming across multiple nodes connected to the same storage. The disk access name never changes, because it is based on the name defined by the array itself.

Note: DMP does not support AVID with PowerPath names.

If DMP does not have access to a device's AVID, it retrieves another unique LUN identifier called the LUN serial number. DMP sorts the devices based on the LUN Serial Number (LSN), and then assigns the index number. All hosts see the same set of devices, so all hosts will have the same sorted list, leading to consistent device indices across the cluster. In this case, the DMP metanode name is in the format *enclosureID_index*.

DMP also supports a scalable framework, that allows you to fully customize the device names on a host by applying a device naming file that associates custom names with cabinet and LUN serial numbers.

If a CVM cluster is symmetric, each node in the cluster accesses the same set of disks. Enclosure-based names provide a consistent naming system so that the device names are the same on each node.

The VxVM utilities such as `vxdisk list` display the DMP metanode name, which includes the AVID property. Use the AVID to correlate the DMP metanode name to the LUN displayed in the array management interface (GUI or CLI) .

For example, on an EMC CX array where the enclosure is emc_clariion0 and the array volume ID provided by the ASL is 91, the DMP metanode name is emc_clariion0_91. The following sample output shows the DMP metanode names:

```
$ vxdisk list
emc_clariion0_91  auto:cdsdisk  emc_clariion0_91   dg1  online shared
emc_clariion0_92  auto:cdsdisk  emc_clariion0_92   dg1  online shared
emc_clariion0_93  auto:cdsdisk  emc_clariion0_93   dg1  online shared
emc_clariion0_282 auto:cdsdisk  emc_clariion0_282  dg1  online shared
emc_clariion0_283 auto:cdsdisk  emc_clariion0_283  dg1  online shared
emc_clariion0_284 auto:cdsdisk  emc_clariion0_284  dg1  online shared

# vxddladm get namingscheme
NAMING_SCHEME       PERSISTENCE    LOWERCASE      USE_AVID
============================================================
Enclosure Based     Yes            Yes            Yes
```

Chapter 2

Setting up DMP to manage native devices

This chapter includes the following topics:

About setting up DMP to manage native devices

You can use DMP instead of third-party drivers for advanced storage management. This section describes how to set up DMP to manage ZFS pools and any ZFS file systems that operate on those pools.

After you install DMP, set up DMP for use with ZFS. To set up DMP for use with ZFS, turn on the dmp_native_support tunable. When this tunable is turned on, DMP enables support for ZFS on any device that does not have a VxVM label and is not in control of any third party multipathing (TPD) software. In addition, turning on the dmp_native_support tunable migrates any ZFS pools that are not in use onto DMP devices.

The dmp_native_support tunable enables DMP support for ZFS, as follows:

ZFS pools	If the ZFS pools are not in use, turning on native support migrates the devices to DMP devices. If the ZFSpools are in use, perform steps to turn off the devices and migrate the devices to DMP.
Veritas Volume Manager (VxVM) devices	Native support is not enabled for any device that has a VxVM label. To make the device available for ZFS, remove the VxVM label. VxVM devices can coexist with native devices under DMP control.
Devices that are multipathed with Third-party drivers (TPD)	If a disk is already multipathed with a third-party driver (TPD), DMP does not manage the devices unless you remove TPD support. After you remove TPD support, turning on the `dmp_native_support` tunable migrates the devices. If you have ZFS pools constructed over TPD devices, then you need to follow specific steps to migrate the ZFS pools onto DMP devices.

After you install DMP, set up DMP for use with ZFS. To set up DMP for use with ZFS, turn on the `dmp_native_support` tunable. When this tunable is turned on, DMP enables support for ZFS on any device that does not have a VxVM label and is not in control of any third party multipathing (TPD) software. In addition, turning on the `dmp_native_support` tunable migrates any ZFS pool that are not in use onto DMP devices.

```
# vxdmpadm settune dmp_native_support=on

# vxdmpadm gettune dmp_native_support
         Tunable               Current Value  Default Value
------------------------------    ----------------    -----------------
dmp_native_support                on              off
```

This operation reports if a pool is in use, and does not migrate those devices. To migrate the pool onto DMP, stop the pool. Then execute the settune command to migrate the pool onto DMP.

Migrating ZFS pools to DMP

You can use DMP instead of third-party drivers for advanced storage management. This section describes how to set up DMP to manage ZFS poolsand the file systems operating on them.

To set up DMP, migrate the devices from the existing third-party device drivers to DMP.

Table 2-1 shows the supported native solutions and migration paths.

Table 2-1 Supported migration paths

Operating system	Native solution	Migration procedure
Solaris 10	EMC PowerPath	
Solaris 10	Hitachi Data Link Manager (HDLM)	See "Migrating to DMP from Hitachi Data Link Manager (HDLM)" on page 30.
Solaris 10	Sun Multipath IO (MPxIO)	See "Migrating to DMP from Sun Multipath IO (MPxIO)" on page 31.

Migrating to DMP from EMC PowerPath

This procedure describes removing devices from EMC PowerPath control and enabling DMP on the devices.

Plan for system downtime for the following procedure.

The migration steps involve system downtime on a host due to the following:

- Need to stop applications
- Need to stop the VCS services if using VCS

To remove devices from EMC PowerPath control and enable DMP

1. Turn on the DMP support for the ZFS pool.

   ```
   # vxdmpadm settune dmp_native_support=on
   ```

2. Stop the applications that use the PowerPath meta-devices.

   In a VCS environment, stop the VCS service group of the application, which will stop the application.

3. Unmount any file systems that use the volume group on the PowerPath device.
4. Export the ZFS pools that use the PowerPath device.

   ```
   # zpool export poolname
   ```

5. Remove the disk access names for the PowerPath devices from VxVM.

   ```
   # vxdisk rm emcpowerXXXX
   ```

   Where *emcpowerXXXX* is the name of the device.

6 Take the device out of PowerPath control:

```
# powermt unmanage dev=pp_device_name
# powermt unmanage class=array_class
```

7 Verify that the PowerPath device has been removed from PowerPath control.

```
# powermt display dev=all
```

8 Run a device scan to bring the devices under DMP control:

```
# vxdisk scandisks
```

9 Mount the file systems.

10 Restart the applications.

Migrating to DMP from Hitachi Data Link Manager (HDLM)

This procedure describes removing devices from HDLM control and enabling DMP on the devices.

Note: DMP cannot co-exist with HDLM; HDLM must be removed from the system.

Plan for system downtime for the following procedure.

The migration steps involve system downtime on a host due to the following:

- Need to stop applications
- Need to stop the VCS services if using VCS
- The procedure involves one or more host reboots

To remove devices from Hitachi Data Link Manager (HDLM) and enable DMP

1 Stop the applications using the HDLM meta-device

2 Unmount any file systems that use the volume group on the HDLM device.

3 Export the ZFS pools that use the HDLM device.

```
# zpool export poolname
```

4 Uninstall the HDLM package.

5 Reboot the system.

6 Turn on the DMP support for the ZFS pool.

```
# vxdmpadm settune dmp_native_support=on
```

7 After the reboot, DMP controls the devices. If there were any ZFS pools on HDLM devices they are migrated onto DMP devices.

8 Mount the file systems.

9 Restart the applications.

Migrating to DMP from Sun Multipath IO (MPxIO)

This procedure describes removing devices from MPxIO control and enabling DMP on the devices.

Plan for system downtime for the following procedure.

The migration steps involve system downtime on a host due to the following:

- Need to stop applications
- Need to stop the VCS services if using VCS
- The procedure involves one or more host reboots

To take devices out of MPxIO control and enable DMP on the devices

1 Stop the applications that use MPxIO devices.

2 Unmount all the file systems that use MPxIO devices.

3 Deactivate the ZFS pools operating on MPxIO devices.

4 Turn on the DMP support for the ZFS pools.

```
# vxdmpadm settune dmp_native_support=on
```

5 Disable MPxIO using the following command.

```
# stmsboot -d
```

6 Reboot the system.

7 After the reboot, DMP controls the ZFS pools. Any ZFS pools are migrated onto DMP devices.

8 Mount the file systems.

9 Restart the applications.

Adding DMP devices to an existing ZFS pool or creating a new ZFS pool

When the dmp_native_support is ON, you can create a new ZFS pool on an available DMP device. You can also add an available DMP device to an existing ZFS pool. After the ZFS pools are on DMP devices, you can use any of the ZFS commands to manage the pools.

To create a new ZFS pool on a DMP device or add a DMP device to an existing ZFS pool

1 Choose disks that are available for use by ZFS. The `vxdisk list` command displays disks that are not in use by VxVM with the TYPE auto:none and the STATUS Online invalid.

```
# vxdisk list


DEVICE               TYPE      DISK    GROUP    STATUS
. . .
tagmastore-usp0_0079 auto:none -       -        online invalid
tagmastore-usp0_0080 auto:none -       -        online invalid
```

2 Create a new ZFS pool on a DMP device.

```
# zpool create newpool tagmastore-usp0_0079s2
# zpool status newpool
  pool: newpool
 state: ONLINE
 scrub: none requested
config:

        NAME                       STATE     READ WRITE CKSUM
        newpool                    ONLINE       0     0     0
          tagmastore-usp0_0079s2   ONLINE       0     0     0

errors: No known data errors
```

3 Add a DMP device to an existing ZFS pool.

```
# zpool add newpool tagmastore-usp0_0080s2
# zpool status newpool
  pool: newpool
 state: ONLINE
 scrub: none requested
config:

        NAME                       STATE     READ WRITE CKSUM
        newpool                    ONLINE       0     0     0
          tagmastore-usp0_0079s2   ONLINE       0     0     0
          tagmastore-usp0_0080s2   ONLINE       0     0     0

errors: No known data errors
```

4 Run the following command to trigger DMP discovery of the devices:

```
# vxdisk scandisks
```

5 After the discovery completes, the disks are shown as in use by ZFS:

```
# vxdisk list

. . .
tagmastore-usp0_0079 auto:ZFS    -        -        ZFS
tagmastore-usp0_0080 auto:ZFS    -        -        ZFS
```

Displaying the native multipathing configuration

When DMP is enabled for native devices, the dmp_native_support attribute displays as ON. When the tunable is ON, all DMP disks are available for native volumes except:

- Devices that have a VxVM label
  If you initialize a disk for VxVM use, then the native multipathing feature is automatically disabled for the disk. When the VxVM label is removed, the native multipathing is enabled.
- Devices that are multipathed with Third-party drivers
  If a disk is already multipathed with a third-party driver (TPD), DMP does not manage the devices unless TPD support is removed.

To display whether DMP is enabled

1 Display the attribute `dmp_native_support`.

```
# vxdmpadm gettune dmp_native_support
```

2 When the `dmp_native_support` tunable is ON, use the `vxdisk list` to display available volumes. Volumes available to ZFS display with the TYPE auto:none. Volumes that are already in use by ZFS display with the TYPE auto:ZFS.

Removing DMP support for native devices

The dmp_native_support tunable is persistent across reboots and package upgrades.

You can remove an individual device from control by ZFS if you initialize it for VxVM, or if you set up TPD multipathing for that device.

To remove support for native devices from all DMP devices, turn off the dmp_native_support tunable.

```
# vxdmpadm settune dmp_native_support=off

# vxdmpadm gettune dmp_native_support
         Tunable               Current Value  Default Value
------------------------------   -----------------    ------------------
dmp_native_support                 off              off
```

Chapter 3

Administering DMP

This chapter includes the following topics:

Disabling multipathing and making devices invisible to VxVM

Use this procedure to prevent a device from being multipathed by the VxVM DMP driver (`vxdmp`), or to exclude a device from the view of VxVM.

To disable multipathing and make devices invisible to VxVM

1. Run the `vxdiskadm` command, and select `Prevent multipathing/Suppress devices from VxVM's view` from the main menu. You are prompted to confirm whether you want to continue.
2. Select the operation you want to perform from the following options:

Option 1	Suppresses all paths through the specified controller from the view of VxVM.
Option 2	Suppresses specified paths from the view of VxVM.
Option 3	Suppresses disks from the view of VxVM that match a specified Vendor ID and Product ID combination. The root disk cannot be suppressed. The operation fails if the VID:PID of an external disk is the same VID:PID as the root disk and the root disk is encapsulated under VxVM.
Option 4	Suppresses all but one path to a disk. Only one path is made visible to VxVM.
Option 5	Prevents multipathing for all disks on a specified controller by VxVM.
Option 6	Prevents multipathing of a disk by VxVM. The disks that correspond to a specified path are claimed in the OTHER_DISKS category and are not multipathed.
Option 7	Prevents multipathing for the disks that match a specified Vendor ID and Product ID combination. The disks that correspond to a specified Vendor ID and Product ID combination are claimed in the OTHER_DISKS category and are not multipathed.
Option 8	Lists the devices that are currently suppressed or not multipathed.

Enabling multipathing and making devices visible to VxVM

Use this procedure to re-enable multipathing for a device, or to make a device visible to VxVM again.

To enable multipathing and make devices visible to VxVM

1. Run the `vxdiskadm` command, and select `Allow multipathing/Unsuppress devices from VxVM's view` from the main menu. You are prompted to confirm whether you want to continue.
2. Select the operation you want to perform from the following options:

Option 1	Unsuppresses all paths through the specified controller from the view of VxVM.
Option 2	Unsuppresses specified paths from the view of VxVM.
Option 3	Unsuppresses disks from the view of VxVM that match a specified Vendor ID and Product ID combination.
Option 4	Removes a pathgroup definition. (A pathgroup explicitly defines alternate paths to the same disk.) Once a pathgroup has been removed, all paths that were defined in that pathgroup become visible again.
Option 5	Allows multipathing of all disks that have paths through the specified controller.
Option 6	Allows multipathing of a disk by VxVM.
Option 7	Allows multipathing of disks that match a specified Vendor ID and Product ID combination.
Option 8	Lists the devices that are currently suppressed or not multipathed.

About enabling and disabling I/O for controllers and storage processors

DMP allows you to turn off I/O for a controller or the array port of a storage processor so that you can perform administrative operations. This feature can be used for maintenance of HBA controllers on the host, or array ports that are attached to disk arrays supported by VxVM. I/O operations to the controller or array port can be turned back on after the maintenance task is completed. You can accomplish these operations using the `vxdmpadm` command provided with VxVM.

For Active/Active type disk arrays, after disabling the I/O through an HBA controller or array port, the I/O continues on the remaining paths. For Active/Passive type disk arrays, if disabling I/O through an HBA controller or

array port resulted in all primary paths being disabled, DMP will failover to active secondary paths and I/O will continue on them.

After the operation is over, you can use `vxdmpadm` to re-enable the paths through the controllers.

See "Disabling I/O for paths, controllers or array ports" on page 71.

See "Enabling I/O for paths, controllers or array ports" on page 73.

Note: From release 5.0 of VxVM, these operations are supported for controllers that are used to access disk arrays on which cluster-shareable disk groups are configured.

You can also perform certain reconfiguration operations dynamically online.

See "About online dynamic reconfiguration" on page 111.

About displaying DMP database information

You can use the `vxdmpadm` command to list DMP database information and perform other administrative tasks. This command allows you to list all controllers that are connected to disks, and other related information that is stored in the DMP database. You can use this information to locate system hardware, and to help you decide which controllers need to be enabled or disabled.

The `vxdmpadm` command also provides useful information such as disk array serial numbers, which DMP devices (disks) are connected to the disk array, and which paths are connected to a particular controller, enclosure or array port.

See "Administering DMP using vxdmpadm" on page 44.

Displaying the paths to a disk

The `vxdisk` command is used to display the multipathing information for a particular metadevice. The metadevice is a device representation of a particular physical disk having multiple physical paths from one of the system's HBA controllers. In VxVM, all the physical disks in the system are represented as metadevices with one or more physical paths.

To display the multipathing information on a system

- Use the `vxdisk path` command to display the relationships between the device paths, disk access names, disk media names and disk groups on a system as shown here:

```
# vxdisk path

SUBPATH      DANAME     DMNAME     GROUP    STATE
c1t0d0s2     c1t0d0s2   mydg01     mydg     ENABLED
c4t0d0s2     c1t0d0s2   mydg01     mydg     ENABLED
c1t1d0s2     c1t1d0s2   mydg02     mydg     ENABLED
c4t1d0s2     c1t1d0s2   mydg02     mydg     ENABLED
     .
     .
     .
```

  This shows that two paths exist to each of the two disks, `mydg01` and `mydg02`, and also indicates that each disk is in the `ENABLED` state.

To view multipathing information for a particular metadevice

1 Use the following command:

```
# vxdisk list devicename
```

For example, to view multipathing information for `c2t0d0s2`, use the following command:

```
# vxdisk list c2t0d0s2
```

Typical output from the `vxdisk list` command is as follows:

```
Device     c2t0d0
devicetag  c2t0d0
type       sliced
hostid     aparajita
disk       name=mydg01 id=861086917.1052.aparajita
group      name=mydg id=861086912.1025.aparajita
flags      online ready autoconfig autoimport imported
pubpaths   block=/dev/vx/dmp/c2t0d0s4 char=/dev/vx/rdmp/c2t0d0s4
privpaths  block=/dev/vx/dmp/c2t0d0s3 char=/dev/vx/rdmp/c2t0d0s3
version    2.1
iosize     min=512 (bytes) max=2048 (blocks)
public     slice=4 offset=0 len=1043840
private    slice=3 offset=1 len=1119
update     time=861801175 seqno=0.48
headers    0 248
configs    count=1 len=795
logs       count=1 len=120
Defined regions
config     priv 000017-000247[000231]:copy=01 offset=000000
enabled
config     priv 000249-000812[000564]:copy=01 offset=000231
enabled
log        priv 000813-000932[000120]:copy=01 offset=000000
enabled
Multipathing information:
numpaths:       2
c2t0d0s2        state=enabled       type=primary
c1t0d0s2        state=disabled      type=secondary
```

In the `Multipathing information` section of this output, the `numpaths` line shows that there are 2 paths to the device, and the following two lines show that one path is active (`state=enabled`) and that the other path has failed (`state=disabled`).

The `type` field is shown for disks on Active/Passive type disk arrays such as the EMC CLARiiON, Hitachi HDS 9200 and 9500, Sun StorEdge 6xxx, and Sun StorEdge T3 array. This field indicates the primary and secondary paths to the disk.

The `type` field is not displayed for disks on Active/Active type disk arrays such as the EMC Symmetrix, Hitachi HDS 99xx and Sun StorEdge 99xx Series, and IBM ESS Series. Such arrays have no concept of primary and secondary paths.

2 Alternately, you can use the following command to view multipathing information:

```
# vxdmpadm getsubpaths dmpnodename=devicename
```

For example, to view multipathing information for `eva4k6k0_6`, use the following command:

```
# vxdmpadm getsubpaths dmpnodename=eva4k6k0_6
```

Typical output from the `vxdmpadm getsubpaths` command is as follows:

```
NAME                      STATE[A]    PATH-TYPE[M] CTLR-NAME ENCLR-TYPE ENCLR-NAME ATTRS
================================================================================
c0t50001FE1500A8F08d7s2 ENABLED(A) PRIMARY      c0        EVA4K6K    eva4k6k0      -
c0t50001FE1500A8F09d7s2 ENABLED(A) PRIMARY      c0        EVA4K6K    eva4k6k0      -
c0t50001FE1500A8F0Cd7s2 ENABLED    SECONDARY    c0        EVA4K6K    eva4k6k0      -
c0t50001FE1500A8F0Dd7s2 ENABLED    SECONDARY    c0        EVA4K6K    eva4k6k0      -
```

Setting customized names for DMP nodes

The DMP node name is the meta device name which represents the multiple paths to a disk. The DMP node name is generated from the device name according to the VxVM naming scheme.

See "Disk device naming in VxVM" on page 20.

You can specify a customized name for a DMP node. User-specified names are persistent even if names persistence is turned off.

You cannot assign a customized name that is already in use by a device. However, if you assign names that follow the same naming conventions as the names that the DDL generates, a name collision can potentially occur when a device is added. If the user-defined name for a DMP device is the same as the DDL-generated name for another DMP device, the `vxdisk list` command output displays one of the devices as 'error'.

To specify a custom name for a DMP node

- Use the following command:

```
# vxdmpadm setattr dmpnode dmpnodename name=name
```

You can also assign names from an input file. This enables you to customize the DMP nodes on the system with meaningful names.

To assign DMP nodes from a file

1. Use the script `vxgetdmpnames` to get a sample file populated from the devices in your configuration. The sample file shows the format required and serves as a template to specify your customized names.
2. To assign the names, use the following command:

```
# vxddladm assign names file=pathname
```

To clear custom names

- To clear the names, and use the default OSN or EBN names, use the following command:

```
# vxddladm -c assign names
```

DMP coexistence with native multipathing

Dynamic Multi-Pathing (DMP) supports using multipathing with raw devices. The `dmp_native_multipathing` tunable controls the behavior. If the `dmp_native_multipathing` tunable is set to on, DMP intercepts I/O requests, operations such as open, close, and ioctls sent on the raw device path.

If the `dmp_native_multipathing` tunable is set to off, these requests are sent directly to the raw device. In A/PF arrays, the format command on Solaris platform does not show the extra attributes (like vendor ID, product ID and geometry information) of the passive paths. To avoid this issue, enable the `dmp_native_multipathing` tunable. DMP intercepts the request and routes it on the primary path.

For A/P arrays, turning on the `dmp_native_multipathing` feature enables the commands to succeed without trespassing. The feature has no benefit for A/A or A/A-A arrays.

DMP Native Multipathing should not be enabled if one of the following tools are already managing multipathing:

- EMC PowerPath
- Sun StorEdge Traffic Manager (also called MPxIO)

If EMC PowerPath is installed first, the command to set `dmp_native_multipathing` to on fails. If VxVM is installed first, ensure that `dmp_native_multipathing` is set to off before installing EMC PowerPath.

Administering DMP using vxdmpadm

The `vxdmpadm` utility is a command line administrative interface to the DMP.

You can use the `vxdmpadm` utility to perform the following tasks:

- Retrieve the name of the DMP device corresponding to a particular path.
- Display the members of a LUN group.
- List all paths under a DMP device node, HBA controller or array port.
- Display information about the HBA controllers on the host.
- Display information about enclosures.
- Display information about array ports that are connected to the storage processors of enclosures.
- Display information about devices that are controlled by third-party multipathing drivers.
- Gather I/O statistics for a DMP node, enclosure, path or controller.
- Configure the attributes of the paths to an enclosure.
- Set the I/O policy that is used for the paths to an enclosure.
- Enable or disable I/O for a path, HBA controller or array port on the system.
- Upgrade disk controller firmware.
- Rename an enclosure.
- Configure how DMP responds to I/O request failures.
- Configure the I/O throttling mechanism.
- Control the operation of the DMP path restoration thread.
- Get or set the values of various tunables used by DMP.

The following sections cover these tasks in detail along with sample output.

See “DMP tunable parameters” on page 123.

See the `vxdmpadm`(1M) manual page.

Retrieving information about a DMP node

The following command displays the DMP node that controls a particular physical path:

```
# vxdmpadm getdmpnode nodename=c0t5006016041E03B33d0s2
```

The physical path is specified by argument to the `nodename` attribute, which must be a valid path listed in the `/dev/rdsk` directory.

The command displays output similar to the following:

```
NAME               STATE     ENCLR-TYPE   PATHS  ENBL  DSBL  ENCLR-NAME
=============================================================================
emc_clariion0_162  ENABLED   EMC_CLARiiON 6      6     0     emc_clariion0
```

Use the `-v` option to display the LUN serial number and the array volume ID.

```
# vxdmpadm -v getdmpnode nodename=c0t5006016041E03B33d0s2
```

```
NAME               STATE   ENCLR-TYPE   PATHS ENBL DSBL ENCLR-NAME   SERIAL-NO            ARRAY
=============================================================================================================
emc_clariion0_162 ENABLED EMC_CLARiiON 6     6    0    emc_clariion0 600601606D121B007C778BC48
```

Use the `enclosure` attribute with `getdmpnode` to obtain a list of all DMP nodes for the specified enclosure.

```
# vxdmpadm getdmpnode enclosure=enc0
```

```
NAME     STATE    ENCLR-TYPE  PATHS     ENBL    DSBL   ENCLR-NAME
=================================================================
c2t1d0s2 ENABLED  T300        2         2       0       enc0
c2t1d1s2 ENABLED  T300        2         2       0       enc0
c2t1d2s2 ENABLED  T300        2         2       0       enc0
c2t1d3s2 ENABLED  T300        2         2       0       enc0
```

Use the `dmpnodename` attribute with `getdmpnode` to display the DMP information for a given DMP node.

```
# vxdmpadm getdmpnode dmpnodename=emc_clariion0_158
```

```
NAME               STATE    ENCLR-TYPE    PATHS  ENBL  DSBL  ENCLR-NAME
=============================================================================
emc_clariion0_158 ENABLED  EMC_CLARiiON  1      1     0     emc_clariion0
```

Displaying consolidated information about the DMP nodes

The `vxdmpadm list dmpnode` command displays the detail information of a DMP node. The information includes the enclosure name, LUN serial number, port id information, device attributes, etc.

The following command displays the consolidated information for all of the DMP nodes in the system:

```
# vxdmpadm list dmpnode all
```

Use the `enclosure` attribute with `list dmpnode` to obtain a list of all DMP nodes for the specified enclosure.

```
# vxdmpadm list dmpnode enclosure=enclosure name
```

For example, the following command displays the consolidated information for all of the DMP nodes in the `enc0` enclosure.

```
#vxdmpadm list dmpnode enclosure=enc0
```

Use the `dmpnodename` attribute with `list dmpnode` to display the DMP information for a given DMP node. The DMP node can be specified by name or by specifying a path name. The detailed information for the specified DMP node includes path information for each subpath of the listed dmpnode.

The path state differentiates between a path that is disabled due to a failure and a path that has been manually disabled for administrative purposes. A path that has been manually disabled using the `vxdmpadm disable` command is listed as `disabled(m)`.

```
# vxdmpadm list dmpnode dmpnodename=dmpnodename
```

For example, the following command displays the consolidated information for the DMP node emc_clariion0_158.

```
# vxdmpadm list dmpnode dmpnodename=emc_clariion0_158
```

```
dmpdev          = emc_clariion0_158
state       = enabled
enclosure   = emc_clariion0
cab-sno     = CK200070400359
asl         = libvxCLARiiON.so
vid         = DGC
pid         = DISK
array-name  = EMC_CLARiiON
array-type  = CLR-A/PF
```

```
iopolicy    = MinimumQ
avid        = 158
lun-sno     = 600601606D121B008FB6E0CA8EDBDB11
udid        = DGC%5FDISK%5FCK200070400359%5F600601606D121B008FB6E0CA8EDBDB11
dev-attr    = lun
###path     = name state type transport ctlr hwpath aportID aportWWN attr
path        = c0t5006016141E03B33d1s2 enabled(a) primary FC c0
/pci@1e,600000/SUNW,emlxs@3/fp@0,0 A5 50:06:01:61:41:e0:3b:33 -
path        = c0t5006016041E03B33d1s2 enabled(a) primary FC c0
/pci@1e,600000/SUNW,emlxs@3/fp@0,0 A4 50:06:01:60:41:e0:3b:33 -
path        = c0t5006016841E03B33d1s2 enabled secondary FC c0
/pci@1e,600000/SUNW,emlxs@3/fp@0,0 B4 50:06:01:68:41:e0:3b:33 -
path        = c1t5006016141E03B33d1s2 enabled(a) primary FC c1
/pci@1e,600000/SUNW,emlxs@3,1/fp@0,0 A5 50:06:01:61:41:e0:3b:33 -
path        = c1t5006016841E03B33d1s2 enabled secondary FC c1
/pci@1e,600000/SUNW,emlxs@3,1/fp@0,0 B4 50:06:01:68:41:e0:3b:33 -
path        = c1t5006016041E03B33d1s2 enabled(a) primary FC c1
/pci@1e,600000/SUNW,emlxs@3,1/fp@0,0 A4 50:06:01:60:41:e0:3b:33 -
```

Displaying the members of a LUN group

The following command displays the DMP nodes that are in the same LUN group as a specified DMP node:

```
# vxdmpadm getlungroup dmpnodename=c11t0d10s2
```

The above command displays output such as the following:

```
NAME        STATE    ENCLR-TYPE  PATHS    ENBL    DSBL    ENCLR-NAME
=============================================================
c11t0d8s2   ENABLED  ACME        2        2       0        enc1
c11t0d9s2   ENABLED  ACME        2        2       0        enc1
c11t0d10s2  ENABLED  ACME        2        2       0        enc1
c11t0d11s2  ENABLED  ACME        2        2       0        enc1
```

Displaying paths controlled by a DMP node, controller, enclosure, or array port

The `vxdmpadm getsubpaths` command lists all of the paths known to DMP. The `vxdmpadm getsubpaths` command also provides options to list the subpaths through a particular DMP node, controller, enclosure, or array port. To list the paths through an array port, specify either a combination of enclosure name and array port id, or array port WWN.

To list all subpaths known to DMP:

```
# vxdmpadm getsubpaths
```

```
NAME      STATE[A]    PATH-TYPE[M] DMPNODENAME  ENCLR-NAME  CTLR  ATTRS
==========================================================================
c1t65d0s2 ENABLED(A)  -            Disk_1       Disk        c1    -
c1t66d0s2 ENABLED(A)  -            Disk_2       Disk        c1    -
c2t65d0s2 ENABLED(A)  -            Disk_1       Disk        c2    -
c2t66d0s2 ENABLED(A)  -            Disk_2       Disk        c2    -
c3t2d0s2  ENABLED(A)  -            EMC0_1       EMC0        c3    -
c3t2d1s2  ENABLED(A)  -            EMC0_2       EMC0        c3    -
c4t2d0s2  ENABLED(A)  -            EMC0_1       EMC0        c4    -
c4t2d1s2  ENABLED(A)  -            EMC0_2       EMC0        c4    -
```

The `vxdmpadm getsubpaths` command combined with the `dmpnodename` attribute displays all the paths to a LUN that are controlled by the specified DMP node name from the `/dev/vx/rdmp` directory:

```
# vxdmpadm getsubpaths dmpnodename=c2t66d0s2
```

```
NAME      STATE[A]   PATH-TYPE[M] CTLR-NAME ENCLR-TYPE ENCLR-NAME ATTRS
==========================================================================
c2t66d0s2 ENABLED(A) PRIMARY      c2        ACME       enc0       -
c1t66d0s2 ENABLED    PRIMARY      c1        ACME       enc0       -
```

For A/A arrays, all enabled paths that are available for I/O are shown as `ENABLED(A)`.

For A/P arrays in which the I/O policy is set to `singleactive`, only one path is shown as `ENABLED(A)`. The other paths are enabled but not available for I/O. If the I/O policy is not set to `singleactive`, DMP can use a group of paths (all primary or all secondary) for I/O, which are shown as `ENABLED(A)`.

See "Specifying the I/O policy" on page 65.

Paths that are in the DISABLED state are not available for I/O operations.

A path that was manually disabled by the system administrator displays as DISABLED(M). A path that failed displays as DISABLED.

You can use `getsubpaths` to obtain information about all the paths that are connected to a particular HBA controller:

```
# vxdmpadm getsubpaths ctlr=c2
```

```
NAME      STATE[-] PATH-TYPE[-] CTLR-NAME  ENCLR-TYPE ENCLR-NAME ATTRS
```

```
=============================================================================
c2t1d0s2 ENABLED  PRIMARY      c2t1d0s2   ACME       enc0       -
c2t2d0s2 ENABLED  PRIMARY      c2t2d0s2   ACME       enc0       -
c2t3d0s2 DISABLED SECONDARY    c2t3d0s2   ACME       enc0       -
c2t4d0s2 ENABLED  SECONDARY    c2t4d0s2   ACME       enc0       -
```

You can also use `getsubpaths` to obtain information about all the paths that are connected to a port on an array. The array port can be specified by the name of the enclosure and the array port ID, or by the worldwide name (WWN) identifier of the array port:

```
# vxdmpadm getsubpaths enclosure=enclosure portid=portid
# vxdmpadm getsubpaths pwwn=pwwn
```

For example, to list subpaths through an array port through the enclosure and the array port ID:

```
# vxdmpadm getsubpaths enclosure=HDS9500-ALUA0 portid=1A

NAME      STATE[A]   PATH-TYPE[M] DMPNODENAME ENCLR-NAME    CTLR ATTRS
=============================================================================
c1t65d0s2 ENABLED(A) PRIMARY      c1t65d0s2   HDS9500-ALUA0 c1   -
c1t66d0s2 ENABLED(A) PRIMARY      c1t66d0s2   HDS9500-ALUA0 c1   -
```

For example, to list subpaths through an array port through the WWN:

```
# vxdmpadm getsubpaths pwwn=20:00:00:E0:8B:06:5F:19

NAME      STATE[A]   PATH-TYPE[M] DMPNODENAME ENCLR-NAME    CTLR ATTRS
=============================================================================
c1t65d0s2 ENABLED(A) PRIMARY      c1t65d0s2   HDS9500-ALUA0 c1   -
c1t66d0s2 ENABLED(A) PRIMARY      c1t66d0s2   HDS9500-ALUA0 c1   -
```

You can use `getsubpaths` to obtain information about all the subpaths of an enclosure.

```
# vxdmpadm getsubpaths enclosure=enclosure_name [ctlr=ctlrname]
```

To list all subpaths of an enclosure:

```
# vxdmpadm getsubpaths enclosure=Disk
NAME      STATE[A]    PATH-TYPE[M] DMPNODENAME ENCLR-NAME CTLR ATTRS
=============================================================================
c1t65d0s2 ENABLED(A)  -            Disk_1      Disk       c1   -
c1t66d0s2 ENABLED(A)  -            Disk_2      Disk       c1   -
c2t65d0s2 ENABLED(A)  -            Disk_1      Disk       c2   -
c2t66d0s2 ENABLED(A)  -            Disk_2      Disk       c2   -
```

To list all subpaths of a controller on an enclosure:

```
# vxdmpadm getsubpaths enclosure=Disk ctlr=c1
```

```
NAME      STATE[A]    PATH-TYPE[M] DMPNODENAME ENCLR-NAME CTLR ATTRS
==========================================================================
c1t65d0s2 ENABLED(A)  -            Disk_1      Disk       c1   -
c1t66d0s2 ENABLED(A)  -            Disk_2      Disk       c1   -
```

By default, the output of the `vxdmpadm getsubpaths` command is sorted by enclosure name, DMP node name, and within that, path name. To sort the output based on the pathname, the DMP node name, the enclosure name, or the host controller name, use the `-s` option.

To sort subpaths information, use the following command:

```
# vxdmpadm -s {path | dmpnode | enclosure | ctlr} getsubpaths \
[all | ctlr=ctlr_name | dmpnodename=dmp_device_name | \
enclosure=enclr_name [ctlr=ctlr_name | portid=array_port_ID] | \
pwwn=port_WWN | tpdnodename=tpd_node_name]
```

Displaying information about controllers

The following command lists attributes of all HBA controllers on the system:

```
# vxdmpadm listctlr all
```

```
CTLR-NAME       ENCLR-TYPE        STATE          ENCLR-NAME
=============================================================
c1              OTHER             ENABLED        other0
c2              X1                ENABLED        jbod0
c3              ACME              ENABLED        enc0
c4              ACME              ENABLED        enc0
```

This output shows that the controller `c1` is connected to disks that are not in any recognized DMP category as the enclosure type is `OTHER`.

The other controllers are connected to disks that are in recognized DMP categories.

All the controllers are in the ENABLED state which indicates that they are available for I/O operations.

The state DISABLED is used to indicate that controllers are unavailable for I/O operations. The unavailability can be due to a hardware failure or due to I/O operations being disabled on that controller by using the `vxdmpadm disable` command.

The following forms of the command lists controllers belonging to a specified enclosure or enclosure type:

```
# vxdmpadm listctlr enclosure=enc0
```

or

```
# vxdmpadm listctlr type=ACME
```

```
CTLR-NAME         ENCLR-TYPE          STATE        ENCLR-NAME
=============================================================
c2                ACME                ENABLED      enc0
c3                ACME                ENABLED      enc0
```

The `vxdmpadm getctlr` command displays HBA vendor details and the Controller ID. For iSCSI devices, the Controller ID is the IQN or IEEE-format based name. For FC devices, the Controller ID is the WWN. Because the WWN is obtained from ESD, this field is blank if ESD is not running. ESD is a daemon process used to notify DDL about occurance of events. The WWN shown as 'Controller ID' maps to the WWN of the HBA port associated with the host controller.

```
# vxdmpadm getctlr c5
```

```
LNAME     PNAME HBA-VENDOR  CTLR-ID
=============================================================================
c5        c5    qlogic      20:07:00:a0:b8:17:e1:37
```

Displaying information about enclosures

To display the attributes of a specified enclosure, including its enclosure type, enclosure serial number, status, array type, and number of LUNs, use the following command:

```
# vxdmpadm listenclosure enc0
```

```
ENCLR_NAME ENCLR_TYPE  ENCLR_SNO            STATUS  ARRAY_TYPE    LUN_COUNT
=============================================================================
enc0       T3          60020f20000001a90000 CONNECTED  A/P        30
```

The following command lists attributes for all enclosures in a system:

```
# vxdmpadm listenclosure all
```

```
ENCLR_NAME ENCLR_TYPE  ENCLR_SNO            STATUS  ARRAY_TYPE    LUN_COUNT
=============================================================================
Disk       Disk        DISKS                CONNECTED   Disk       6
```

```
SENA0       SENA         5080020000001d660     CONNECTED   A/A         57
enc0        T3           60020f20000001a90000 CONNECTED   A/P         30
```

Displaying information about array ports

Use the commands in this section to display information about array ports. The information displayed for an array port includes the name of its enclosure, and its ID and worldwide name (WWN) identifier.

To display the attributes of an array port that is accessible via a path, DMP node or HBA controller, use one of the following commands:

```
# vxdmpadm getportids path=path-name
# vxdmpadm getportids dmpnodename=dmpnode-name
# vxdmpadm getportids ctlr=ctlr-name
```

The following form of the command displays information about all of the array ports within the specified enclosure:

```
# vxdmpadm getportids enclosure=enclr-name
```

The following example shows information about the array port that is accessible via DMP node `c2t66d0s2`:

```
# vxdmpadm getportids dmpnodename=c2t66d0s2

NAME        ENCLR-NAME   ARRAY-PORT-ID pWWN
============================================================
c2t66d0s2   HDS9500V0    1A            20:00:00:E0:8B:06:5F:19
```

Displaying information about TPD-controlled devices

The third-party driver (TPD) coexistence feature allows I/O that is controlled by third-party multipathing drivers to bypass DMP while retaining the monitoring capabilities of DMP. The following commands allow you to display the paths that DMP has discovered for a given TPD device, and the TPD device that corresponds to a given TPD-controlled node discovered by DMP:

```
# vxdmpadm getsubpaths tpdnodename=TPD_node_name
# vxdmpadm gettpdnode nodename=TPD_path_name
```

See “Changing device naming for TPD-controlled enclosures” on page 105.

For example, consider the following disks in an EMC Symmetrix array controlled by PowerPath, which are known to DMP:

```
# vxdisk list

DEVICE          TYPE           DISK       GROUP    STATUS
emcpower10s2    auto:sliced    disk1      ppdg     online
emcpower11s2    auto:sliced    disk2      ppdg     online
emcpower12s2    auto:sliced    disk3      ppdg     online
emcpower13s2    auto:sliced    disk4      ppdg     online
emcpower14s2    auto:sliced    disk5      ppdg     online
emcpower15s2    auto:sliced    disk6      ppdg     online
emcpower16s2    auto:sliced    disk7      ppdg     online
emcpower17s2    auto:sliced    disk8      ppdg     online
emcpower18s2    auto:sliced    disk9      ppdg     online
emcpower19s2    auto:sliced    disk10     ppdg     online
```

The following command displays the paths that DMP has discovered, and which correspond to the PowerPath-controlled node, `emcpower10s2`:

```
# vxdmpadm getsubpaths tpdnodename=emcpower10s2

NAME    TPDNODENAME  PATH-TYPE[-]DMP-NODENAME  ENCLR-TYPE ENCLR-NAME
=============================================================================
c7t0d10s2emcpower10s2-           emcpower10s2  EMC        EMC0
c6t0d10s2emcpower10s2-           emcpower10s2  EMC        EMC0
```

Conversely, the next command displays information about the PowerPath node that corresponds to the path, `c7t0d10s2`, discovered by DMP:

```
# vxdmpadm gettpdnode nodename=c7t0d10s2

NAME          STATE    PATHS  ENCLR-TYPE    ENCLR-NAME
=============================================================================
emcpower10s2 ENABLED  2      EMC           EMC0
```

Displaying extended device attributes

Device Discovery Layer (DDL) extended attributes are attributes or flags corresponding to a VxVM LUN or Disk which are discovered by DDL. These attributes identify a LUN to a specific hardware category.

The list of categories includes:

Hardware RAID types	Displays what kind of Storage RAID Group the LUN belongs to

Thin Provisioning Discovery and Reclamation	Displays the LUN's thin reclamation abilities
Device Media Type	Displays the type of media –whether SSD (solid state disk)
Storage-based Snapshot/Clone	Displays whether the LUN is a SNAPSHOT or a CLONE of a PRIMARY LUN
Storage-based replication	Displays if the LUN is part of a replicated group across a remote site
Transport	Displays what kind of HBA is used to connect to this LUN (FC, SATA, iSCSI)

Each LUN can have one or more of these attributes discovered during device discovery. ASLs furnish this information to DDL through the property DDL_DEVICE_ATTR. The `vxdisk -p list` command displays DDL extended attributes. For example, the following command shows attributes of "std", "fc", and "RAID_5" for this LUN:

```
# vxdisk -p list
DISK           : tagmastore-usp0_0e18
DISKID         : 1253585985.692.rx2600h11
VID            : HITACHI
UDID           : HITACHI%5FOPEN-V%5F02742%5F0E18
REVISION       : 5001
PID            : OPEN-V
PHYS_CTLR_NAME : 0/4/1/1.0x50060e8005274246
LUN_SNO_ORDER  : 411
LUN_SERIAL_NO  : 0E18
LIBNAME        : libvxhdsusp.sl
HARDWARE_MIRROR: no
DMP_DEVICE     : tagmastore-usp0_0e18
DDL_THIN_DISK  : thick
DDL_DEVICE_ATTR: std fc RAID_5
CAB_SERIAL_NO  : 02742
ATYPE          : A/A
ARRAY_VOLUME_ID: 0E18
ARRAY_PORT_PWWN: 50:06:0e:80:05:27:42:46
ANAME          : TagmaStore-USP
TRANSPORT      : FC
```

The `vxdisk -x attribute -p list` command displays the one-line listing for the property list and the attributes. The following example shows two Hitachi LUNs that support Thin Reclamation via the attribute `hdprclm`:

```
# vxdisk -x DDL_DEVICE_ATTR -p list
DEVICE                  DDL_DEVICE_ATTR
tagmastore-usp0_0a7a    std fc RAID_5
tagmastore-usp0_065a    hdprclm fc
tagmastore-usp0_065b    hdprclm fc
```

User can specify multiple -x options in the same command to display multiple entries. For example:

```
# vxdisk -x DDL_DEVICE_ATTR -x VID -p list

DEVICE               VID          DDL_DEVICE_ATTR
tagmastore-usp0_0a7a HITACHI      std fc RAID_5
tagmastore-usp0_0a7b HITACHI      std fc RAID_5
tagmastore-usp0_0a78 HITACHI      std fc RAID_5
tagmastore-usp0_0a79 HITACHI      std fc RAID_5
tagmastore-usp0_065a HITACHI      hdprclm fc
tagmastore-usp0_065b HITACHI      hdprclm fc
tagmastore-usp0_065c HITACHI      hdprclm fc
tagmastore-usp0_065d HITACHI      hdprclm fc
```

Use the `vxdisk -e list` command to show the DLL_DEVICE_ATTR property in the last column named ATTR.

```
# vxdisk -e list
DEVICE               TYPE  DISK  GROUP  STATUS  OS_NATIVE_NAME  ATTR
tagmastore-usp0_0a7a auto  -     -      online  c10t0d2         std fc RAID_5
tagmastore-usp0_0a7b auto  -     -      online  c10t0d3         std fc RAID_5
tagmastore-usp0_0a78 auto  -     -      online  c10t0d0         std fc RAID_5
tagmastore-usp0_0655 auto  -     -      online  c13t2d7         hdprclm fc
tagmastore-usp0_0656 auto  -     -      online  c13t3d0         hdprclm fc
tagmastore-usp0_0657 auto  -     -      online  c13t3d1         hdprclm fc
```

For a list of ASLs that supports Extended Attributes, and descriptions of these attributes, refer to the hardware compatibility list at the following URL:

http://seer.entsupport.symantec.com/docs/330441.htm

Suppressing or including devices for VxVM or DMP control

The `vxdmpadm exclude` command suppresses devices from VxVM based on the criteria that you specify. The devices can be added back into VxVM control by

using the `vxdmpadm include` command. The devices can be included or excluded based on VID:PID combination, paths, controllers, or disks. You can use the bang symbol (!) to exclude or include any paths or controllers except the one specified.

The root disk cannot be suppressed. The operation fails if the VID:PID of an external disk is the same VID:PID as the root disk and the root disk is encapsulated under VxVM.

Note: The ! character is a special character in some shells. The following syntax shows how to escape it in a bash shell.

```
# vxdmpadm exclude [vxvm | vxdmp] { all | product=VID:PID |
ctlr=[\!]ctlr | dmpnodename=diskname [ path=\!pathname] }

# vxdmpadm include [vxvm | vxdmp] { all | product=VID:PID |
ctlr=[\!]ctlr | dmpnodename=diskname [ path=\!pathname] }
```

where:

all – all devices

product=*VID:PID* – all devices with the specified VID:PID

ctlr=*ctlr* – all devices through the given controller

dmpnodename=*diskname* - all paths under the DMP node

dmpnodename=*diskname* path=\!*pathname* - all paths under the DMP node except the one specified.

Gathering and displaying I/O statistics

You can use the `vxdmpadm iostat` command to gather and display I/O statistics for a specified DMP node, enclosure, path or controller.

To enable the gathering of statistics, enter this command:

```
# vxdmpadm iostat start [memory=size]
```

To reset the I/O counters to zero, use this command:

```
# vxdmpadm iostat reset
```

The `memory` attribute can be used to limit the maximum amount of memory that is used to record I/O statistics for each CPU. The default limit is `32k` (32 kilobytes) per CPU.

To display the accumulated statistics at regular intervals, use the following command:

```
# vxdmpadm iostat show {all | dmpnodename=dmp-node | \
  enclosure=enclr-name | pathname=path-name | ctlr=ctlr-name} \
  [interval=seconds [count=N]]
```

This command displays I/O statistics for all paths (`all`), or for a specified DMP node, enclosure, path or controller. The statistics displayed are the CPU usage and amount of memory per CPU used to accumulate statistics, the number of read and write operations, the number of kilobytes read and written, and the average time in milliseconds per kilobyte that is read or written.

The `interval` and `count` attributes may be used to specify the interval in seconds between displaying the I/O statistics, and the number of lines to be displayed. The actual interval may be smaller than the value specified if insufficient memory is available to record the statistics.

To disable the gathering of statistics, enter this command:

```
# vxdmpadm iostat stop
```

Examples of using the vxdmpadm iostat command

The following is an example session using the `vxdmpadm iostat` command. The first command enables the gathering of I/O statistics:

```
# vxdmpadm iostat start
```

The next command displays the current statistics including the accumulated total numbers of read and write operations and kilobytes read and written, on all paths:

```
# vxdmpadm iostat show all
                    cpu usage = 7952us    per cpu memory = 8192b
              OPERATIONS              KBYTES              AVG TIME(ms)
PATHNAME     READS     WRITES      READS     WRITES     READS    WRITES
c0t0d0        1088          0     557056          0      0.00      0.00
c2t118d0        87          0      44544          0      0.00      0.00
c3t118d0         0          0          0          0      0.00      0.00
c2t122d0        87          0      44544          0      0.00      0.00
c3t122d0         0          0          0          0      0.00      0.00
c2t115d0        87          0      44544          0      0.00      0.00
c3t115d0         0          0          0          0      0.00      0.00
c2t103d0        87          0      44544          0      0.00      0.00
c3t103d0         0          0          0          0      0.00      0.00
c2t102d0        87          0      44544          0      0.00      0.00
c3t102d0         0          0          0          0      0.00      0.00
c2t121d0        87          0      44544          0      0.00      0.00
c3t121d0         0          0          0          0      0.00      0.00
```

```
c2t112d0       87          0      44544          0      0.00     0.00
c3t112d0        0          0          0          0      0.00     0.00
c2t96d0        87          0      44544          0      0.00     0.00
c3t96d0         0          0          0          0      0.00     0.00
c2t106d0       87          0      44544          0      0.00     0.00
c3t106d0        0          0          0          0      0.00     0.00
c2t113d0       87          0      44544          0      0.00     0.00
c3t113d0        0          0          0          0      0.00     0.00
c2t119d0       87          0      44544          0      0.00     0.00
c3t119d0        0          0          0          0      0.00     0.00
```

The following command changes the amount of memory that vxdmpadm can use to accumulate the statistics:

```
# vxdmpadm iostat start memory=4096
```

The displayed statistics can be filtered by path name, DMP node name, and enclosure name (note that the per-CPU memory has changed following the previous command):

```
# vxdmpadm iostat show pathname=c3t115d0s2
                    cpu usage = 8132us    per cpu memory = 4096b
               OPERATIONS             BYTES             AVG TIME(ms)
PATHNAME     READS     WRITES      READS     WRITES     READS   WRITES
c3t115d0s2       0          0          0          0      0.00     0.00

# vxdmpadm iostat show dmpnodename=c0t0d0s2
                    cpu usage = 8501us    per cpu memory = 4096b
               OPERATIONS             BYTES             AVG TIME(ms)
PATHNAME     READS     WRITES      READS     WRITES     READS   WRITES
c0t0d0  s2    1088          0     557056          0      0.00     0.00

# vxdmpadm iostat show enclosure=Disk
                    cpu usage = 8626us    per cpu memory = 4096b
               OPERATIONS             BYTES             AVG TIME(ms)
PATHNAME     READS     WRITES      READS     WRITES     READS   WRITES
c0t0d0  s2    1088          0     557056          0      0.00     0.00
```

You can also specify the number of times to display the statistics and the time interval. Here the incremental statistics for a path are displayed twice with a 2-second interval:

```
$vxdmpadm iostat show dmpnodename=emc_clariion0_342 interval=1 count=2
                     cpu usage = 164687us    per cpu memory = 409600b
                        OPERATIONS       BLOCKS       AVG TIME(ms)
```

```
PATHNAME                READS   WRITES   READS   WRITES READS     WRITES
c0t5006016041E03B33d6s2 3       0        33      0        0.02      0.00
c0t5006016141E03B33d6s2 3       0        3       0        0.16      0.00
c0t5006016841E03B33d6s2 0       0        0       0        0.00      0.00
c1t5006016041E03B33d6s2 1       0        16      0        0.02      0.00
c1t5006016141E03B33d6s2 2       0        2       0        0.18      0.00
c1t5006016841E03B33d6s2 0       0        0       0        0.00      0.00

c0t5006016041E03B33d6s2 0       0        0       0        0.00      0.00
c0t5006016141E03B33d6s2 0       0        0       0        0.00      0.00
c0t5006016841E03B33d6s2 0       0        0       0        0.00      0.00
c1t5006016041E03B33d6s2 0       0        0       0        0.00      0.00
c1t5006016141E03B33d6s2 0       0        0       0        0.00      0.00
c1t5006016841E03B33d6s2 0       0        0       0        0.00      0.00
```

Displaying statistics for queued or erroneous I/Os

Use the `vxdmpadm iostat show` command with the `-q` option to display the I/Os queued in DMP for a specified DMP node, or for a specified path or controller. For a DMP node, the `-q` option displays the I/Os on the specified DMP node that were sent to underlying layers. If a path or controller is specified, the `-q` option displays I/Os that were sent to the given path or controller and not yet returned to DMP.

See the `vxdmpadm`(1m) manual page for more information about the `vxdmpadm iostat` command.

To display queued I/O counts on a DMP node:

```
# vxdmpadm -q iostat show [filter]
[interval=n [count=m]]
```

For example:

```
# vxdmpadm -q iostat show dmpnodename=c5t2d1s2

QUEUED I/Os            Pending I/Os
DMPNODENAME  READS  WRITES
c5t2d1s2     2     15           30
```

To display the count of I/Os that returned with errors on a DMP node, path or controller:

```
# vxdmpadm -e iostat show [filter]
[interval=n [count=m]]
```

For example, to show the I/O counts that returned errors on a path:

```
# vxdmpadm -e iostat show pathname=c1t5006016041E03B33d6s2 interval=1

cpu usage = 168144us    per cpu memory = 409600b
                                  ERROR I/Os
PATHNAME             READS    WRITES
c1t5006016041E03B33d6s2            0         0
c1t5006016041E03B33d6s2            0         0
```

Displaying cumulative I/O statistics

Use the `groupby` clause of the `vxdmpadm iostat` command to display cumulative I/O statistics listings per DMP node, controller, array port id, or host-array controller pair and enclosure. If the `groupby` clause is not specified, then the statistics are displayed per path.

To group by DMP node:

```
# vxdmpadm iostat show groupby=dmpnode [all | dmpnodename=dmpnodename
| enclosure=enclr-name]
```

For example:

```
# vxdmpadm iostat show groupby=dmpnode dmpnodename=c5t0d1s2

                  OPERATIONS              BLOCKS              AVG TIME(ms)
DMPNODENAME     READS      WRITES       READS      WRITES      READS    WRITES
c5t0d1s2         0           0           0           0         0.00      0.00
```

To group by controller:

```
# vxdmpadm iostat show groupby=ctlr [ all | ctlr=ctlr ]
```

For example:

```
# vxdmpadm iostat show groupby=ctlr ctlr=c5

             OPERATIONS         BLOCKS        AVG TIME(ms)
CTLRNAME   READS    WRITES   READS   WRITES   READS    WRITES
c5         224       14      54       7       4.20     11.10
```

To group by arrayport:

```
# vxdmpadm iostat show groupby=arrayport [ all | pwwn=array port wwn
 | enclosure=enclr portid=array-port-id ]
```

For example:

```
# vxdmpadm iostat show groupby=arrayport enclosure=HDS9500-ALUA0 portid=1A
```

```
            OPERATIONS        BLOCKS       AVG TIME(ms)
PORTNAME  READS   WRITES  READS  WRITES  READS   WRITES
1A        224      14     54      7       4.20    11.10
```

To group by enclosure:

```
# vxdmpadm iostat show groupby=enclosure [ all | enclosure=enclr ]
```

For example:

```
# vxdmpadm iostat show groupby=enclosure enclosure=EMC_CLARiiON0

               OPERATIONS        BLOCKS       AVG TIME(ms)
ENCLRNAME    READS  WRITES  READS  WRITES  READS   WRITES
EMC_CLARiiON 0      0       0      0        0.00     0.00
```

You can also filter out entities for which all data entries are zero. This option is especially useful in a cluster environment which contains many failover devices. You can display only the statistics for the active paths.

To filter all zero entries from the output of the `iostat show` command:

```
# vxdmpadm -z iostat show [all|ctlr=ctlr_name |
dmpnodename=dmp_device_name | enclosure=enclr_name [portid=portid] |
pathname=path_name|pwwn=port_WWN][interval=seconds [count=N]]
```

For example:

```
# vxdmpadm -z iostat show dmpnodename=c2t16d4s2

              OPERATIONS        BLOCKS        AVG TIME(ms)
PATHNAME   READS  WRITES    READS   WRITES  READS   WRITES
c3t16d4s2  10     110       2       25      12.00    27.96
c2t17d4s2  20     126       4       29       9.50    19.41
```

You can now specify the units in which the statistics data is displayed. By default, the read/write times are displayed in milliseconds up to 2 decimal places. The throughput data is displayed in terms of 'BLOCKS' and the output is scaled, meaning that the small values are displayed in small units and the larger values are displayed in bigger units, keeping significant digits constant.The `-u` option accepts the following options:

`k`	Displays throughput in kiloblocks.
`m`	Displays throughput in megablocks.
`g`	Displays throughput in gigablocks.

`bytes`	Displays throughput in exact number of bytes.
`us`	Displays average read/write time in microseconds.

For example: To display average read/write times in microseconds.

```
# vxdmpadm -u us iostat show pathname=c2t17d4s2

                OPERATIONS        BLOCKS        AVG TIME(microsec)
PATHNAME    READS  WRITES    READS   WRITES  READS     WRITES
c2t17d4s2   20     126       4       29    9500.00  19413.79
```

Setting the attributes of the paths to an enclosure

You can use the `vxdmpadm setattr` command to set the attributes of the paths to an enclosure or disk array.

You can set the following attributes:

`active`	Changes a standby (failover) path to an active path. The following example specifies an active path for an array: `# vxdmpadm setattr path c2t10d0s2 pathtype=active`
`nomanual`	Restores the original primary or secondary attributes of a path. This example restores the path to a JBOD disk: `# vxdmpadm setattr path c3t10d0s2 \ pathtype=nomanual`
`nopreferred`	Restores the normal priority of a path. The following example restores the default priority to a path: `# vxdmpadm setattr path c1t20d0s2 \ pathtype=nopreferred`

`preferred [priority=N]`

Specifies a path as preferred, and optionally assigns a priority number to it. If specified, the priority number must be an integer that is greater than or equal to one. Higher priority numbers indicate that a path is able to carry a greater I/O load.

See "Specifying the I/O policy" on page 65.

This example first sets the I/O policy to `priority` for an Active/Active disk array, and then specifies a preferred path with an assigned priority of 2:

```
# vxdmpadm setattr enclosure enc0 \
  iopolicy=priority
# vxdmpadm setattr path c1t20d0s2 \
  pathtype=preferred priority=2
```

`primary`

Defines a path as being the primary path for a JBOD disk array. The following example specifies a primary path for a JBOD disk array:

```
# vxdmpadm setattr path c3t10d0s2 \
  pathtype=primary
```

`secondary`

Defines a path as being the secondary path for a JBOD disk array. The following example specifies a secondary path for a JBOD disk array:

```
# vxdmpadm setattr path c4t10d0s2 \
  pathtype=secondary
```

`standby`

Marks a standby (failover) path that it is not used for normal I/O scheduling. This path is used if there are no active paths available for I/O. The next example specifies a standby path for an A/P-C disk array:

```
# vxdmpadm setattr path c2t10d0s2 \
  pathtype=standby
```

Displaying the redundancy level of a device or enclosure

Use the `vxdmpadm getdmpnode` command to list the devices with less than the required redundancy level.

To list the devices on a specified enclosure with fewer than a given number of active paths, use the following command:

```
# vxdmpadm getdmpnode enclosure=encl_name redundancy=value
```

For example, to list the devices with fewer than 3 active paths, use the following command:

```
# vxdmpadm getdmpnode enclosure=EMC_CLARiiON0 redundancy=3

NAME               STATE    ENCLR-TYPE   PATHS ENBL DSBL ENCLR-NAME
=============================================================================
emc_clariion0_162 ENABLED  EMC_CLARiiON 6     5    1    emc_clariion0
emc_clariion0_182 ENABLED  EMC_CLARiiON 6     6    0    emc_clariion0
emc_clariion0_184 ENABLED  EMC_CLARiiON 6     6    0    emc_clariion0
emc_clariion0_186 ENABLED  EMC_CLARiiON 6     6    0    emc_clariion0
```

To display the minimum redundancy level for a particular device, use the `vxdmpadm getattr` command, as follows:

```
# vxdmpadm getattr enclosure|arrayname|arraytype component-name redundancy
```

For example, to show the minimum redundancy level for the enclosure HDS9500-ALUA0:

```
# vxdmpadm getattr enclosure HDS9500-ALUA0 redundancy

ENCLR_NAME  DEFAULT  CURRENT
============================================
 HDS9500-ALUA0    0      4
```

Specifying the minimum number of active paths

You can set the minimum redundancy level for a device or an enclosure. The minimum redundancy level is the minimum number of paths that should be active for the device or the enclosure. If the number of paths falls below the minimum redundancy level for the enclosure, a message is sent to the system console and also logged to the DMP log file. Also, notification is sent to `vxnotify` clients.

The value set for minimum redundancy level is stored in the `dmppolicy.info` file, and is persistent. If no minimum redundancy level is set, the default value is 0.

You can use the `vxdmpadm setattr` command to set the minimum redundancy level.

To specify the minimum number of active paths

- Use the `vxdmpadm setattr` command with the redundancy attribute as follows:

  ```
  # vxdmpadm setattr enclosure|arrayname|arraytype component-name
   redundancy=value
  ```

  where *value* is the number of active paths.

  For example, to set the minimum redundancy level for the enclosure HDS9500-ALUA0:

  ```
  # vxdmpadm setattr enclosure HDS9500-ALUA0 redundancy=2
  ```

Displaying the I/O policy

To display the current and default settings of the I/O policy for an enclosure, array or array type, use the `vxdmpadm getattr` command.

The following example displays the default and current setting of `iopolicy` for JBOD disks:

```
# vxdmpadm getattr enclosure Disk iopolicy

ENCLR_NAME        DEFAULT         CURRENT
----------------------------------------
Disk              MinimumQ        Balanced
```

The next example displays the setting of `partitionsize` for the enclosure `enc0`, on which the `balanced` I/O policy with a partition size of 2MB has been set:

```
# vxdmpadm getattr enclosure enc0 partitionsize
ENCLR_NAME     DEFAULT         CURRENT
----------------------------------------
enc0           512             4096
```

Specifying the I/O policy

You can use the `vxdmpadm setattr` command to change the I/O policy for distributing I/O load across multiple paths to a disk array or enclosure. You can set policies for an enclosure (for example, `HDS01`), for all enclosures of a particular type (such as `HDS`), or for all enclosures of a particular array type (such as `A/A` for Active/Active, or `A/P` for Active/Passive).

Warning: Starting with release 4.1 of VxVM, I/O policies are recorded in the file `/etc/vx/dmppolicy.info`, and are persistent across reboots of the system.

Do not edit this file yourself.

The following policies may be set:

`adaptive` This policy attempts to maximize overall I/O throughput from/to the disks by dynamically scheduling I/O on the paths. It is suggested for use where I/O loads can vary over time. For example, I/O from/to a database may exhibit both long transfers (table scans) and short transfers (random look ups). The policy is also useful for a SAN environment where different paths may have different number of hops. No further configuration is possible as this policy is automatically managed by DMP.

In this example, the adaptive I/O policy is set for the enclosure `enc1`:

```
# vxdmpadm setattr enclosure enc1 \
  iopolicy=adaptive
```

`balanced [partitionsize=size]`

This policy is designed to optimize the use of caching in disk drives and RAID controllers. The size of the cache typically ranges from 120KB to 500KB or more, depending on the characteristics of the particular hardware. During normal operation, the disks (or LUNs) are logically divided into a number of regions (or partitions), and I/O from/to a given region is sent on only one of the active paths. Should that path fail, the workload is automatically redistributed across the remaining paths.

You can use the size argument to the partitionsize attribute to specify the partition size. The partition size in blocks is adjustable in powers of 2 from 2 up to 231. A value that is not a power of 2 is silently rounded down to the nearest acceptable value.

Specifying a partition size of 0 is equivalent to specifying the default partition size.

The default value for the partition size is 512 blocks (256k). Specifying a partition size of 0 is equivalent to the default partition size of 512 blocks (256k).

The default value can be changed by adjusting the value of the `dmp_pathswitch_blks_shift` tunable parameter.

See "DMP tunable parameters" on page 123.

Note: The benefit of this policy is lost if the value is set larger than the cache size.

For example, the suggested partition size for an Hitachi HDS 9960 A/A array is from 32,768 to 131,072 blocks (16MB to 64MB) for an I/O activity pattern that consists mostly of sequential reads or writes.

The next example sets the balanced I/O policy with a partition size of 4096 blocks (2MB) on the enclosure enc0:

```
# vxdmpadm setattr enclosure enc0 \
  iopolicy=balanced partitionsize=4096
```

`minimumq`

This policy sends I/O on paths that have the minimum number of outstanding I/O requests in the queue for a LUN. No further configuration is possible as DMP automatically determines the path with the shortest queue.

The following example sets the I/O policy to `minimumq` for a JBOD:

```
# vxdmpadm setattr enclosure Disk \
  iopolicy=minimumq
```

This is the default I/O policy for all arrays.

`priority` This policy is useful when the paths in a SAN have unequal performance, and you want to enforce load balancing manually. You can assign priorities to each path based on your knowledge of the configuration and performance characteristics of the available paths, and of other aspects of your system.

See "Setting the attributes of the paths to an enclosure" on page 62.

In this example, the I/O policy is set to `priority` for all SENA arrays:

```
# vxdmpadm setattr arrayname SENA \
  iopolicy=priority
```

`round-robin` This policy shares I/O equally between the paths in a round-robin sequence. For example, if there are three paths, the first I/O request would use one path, the second would use a different path, the third would be sent down the remaining path, the fourth would go down the first path, and so on. No further configuration is possible as this policy is automatically managed by DMP.

The next example sets the I/O policy to `round-robin` for all Active/Active arrays:

```
# vxdmpadm setattr arraytype A/A \
  iopolicy=round-robin
```

`singleactive` This policy routes I/O down the single active path. This policy can be configured for A/P arrays with one active path per controller, where the other paths are used in case of failover. If configured for A/A arrays, there is no load balancing across the paths, and the alternate paths are only used to provide high availability (HA). If the current active path fails, I/O is switched to an alternate active path. No further configuration is possible as the single active path is selected by DMP.

The following example sets the I/O policy to `singleactive` for JBOD disks:

```
# vxdmpadm setattr arrayname Disk \
  iopolicy=singleactive
```

Scheduling I/O on the paths of an Asymmetric Active/Active array

You can specify the `use_all_paths` attribute in conjunction with the `adaptive`, `balanced`, `minimumq`, `priority` and `round-robin` I/O policies to specify whether I/O requests are to be scheduled on the secondary paths in addition to the primary paths of an Asymmetric Active/Active (A/A-A) array. Depending on the

characteristics of the array, the consequent improved load balancing can increase the total I/O throughput. However, this feature should only be enabled if recommended by the array vendor. It has no effect for array types other than A/A-A.

For example, the following command sets the `balanced` I/O policy with a partition size of 4096 blocks (2MB) on the enclosure `enc0`, and allows scheduling of I/O requests on the secondary paths:

```
# vxdmpadm setattr enclosure enc0 iopolicy=balanced \
      partitionsize=4096 use_all_paths=yes
```

The default setting for this attribute is `use_all_paths=no`.

You can display the current setting for `use_all_paths` for an enclosure, arrayname or arraytype. To do this, specify the `use_all_paths` option to the `vxdmpadm gettattr` command.

```
# vxdmpadm getattr enclosure HDS9500-ALUA0 use_all_paths

ENCLR_NAME  DEFAULT  CURRENT
============================================
HDS9500-ALUA0 no   yes
```

The `use_all_paths` attribute only applies to A/A-A arrays. For other arrays, the above command displays the message:

```
Attribute is not applicable for this array.
```

Example of applying load balancing in a SAN

This example describes how to configure load balancing in a SAN environment where there are multiple primary paths to an Active/Passive device through several SAN switches. As can be seen in this sample output from the `vxdisk list` command, the device `c3t2d15s2` has eight primary paths:

```
# vxdisk list c3t2d15s2

Device: c3t2d15s2
    .
    .
    .
numpaths: 8
c2t0d15s2 state=enabled type=primary
c2t1d15s2 state=enabled type=primary
c3t1d15s2 state=enabled type=primary
```

```
c3t2d15s2 state=enabled type=primary
c4t2d15s2 state=enabled type=primary
c4t3d15s2 state=enabled type=primary
c5t3d15s2 state=enabled type=primary
c5t4d15s2 state=enabled type=primary
```

In addition, the device is in the enclosure `ENC0`, belongs to the disk group `mydg`, and contains a simple concatenated volume `myvol1`.

The first step is to enable the gathering of DMP statistics:

```
# vxdmpadm iostat start
```

Next the `dd` command is used to apply an input workload from the volume:

```
# dd if=/dev/vx/rdsk/mydg/myvol1 of=/dev/null &
```

By running the `vxdmpadm iostat` command to display the DMP statistics for the device, it can be seen that all I/O is being directed to one path, `c5t4d15s2`:

```
# vxdmpadm iostat show dmpnodename=c3t2d15s2 interval=5 count=2
    .
    .
    .
cpu usage = 11294us per cpu memory = 32768b
              OPERATIONS           KBYTES           AVG TIME(ms)
PATHNAME    READS   WRITES   READS     WRITES   READS      WRITES
c2t0d15s2   0       0        0         0         0.00        0.00
c2t1d15s2   0       0        0         0         0.00        0.00
c3t1d15s2   0       0        0         0         0.00        0.00
c3t2d15s2   0       0        0         0         0.00        0.00
c4t2d15s2   0       0        0         0         0.00        0.00
c4t3d15s2   0       0        0         0         0.00        0.00
c5t3d15s2   0       0        0         0         0.00        0.00
c5t4d15s2   10986   0        5493      0         0.41        0.00
```

The `vxdmpadm` command is used to display the I/O policy for the enclosure that contains the device:

```
# vxdmpadm getattr enclosure ENC0 iopolicy

ENCLR_NAME        DEFAULT         CURRENT
============================================
ENC0              MinimumQ        Single-Active
```

This shows that the policy for the enclosure is set to `singleactive`, which explains why all the I/O is taking place on one path.

To balance the I/O load across the multiple primary paths, the policy is set to `round-robin` as shown here:

```
# vxdmpadm setattr enclosure ENC0 iopolicy=round-robin
# vxdmpadm getattr enclosure ENC0 iopolicy

ENCLR_NAME    DEFAULT         CURRENT
============================================
ENC0          MinimumQ        Round-Robin
```

The DMP statistics are now reset:

```
# vxdmpadm iostat reset
```

With the workload still running, the effect of changing the I/O policy to balance the load across the primary paths can now be seen.

```
# vxdmpadm iostat show dmpnodename=c3t2d15s2 interval=5 count=2
    .
    .
    .
cpu usage = 14403us per cpu memory = 32768b
             OPERATIONS            KBYTES          AVG TIME(ms)
PATHNAME   READS   WRITES    READS     WRITES   READS      WRITES
c2t0d15s2  2041    0         1021      0         0.39        0.00
c2t1d15s2  1894    0         947       0         0.39        0.00
c3t1d15s2  2008    0         1004      0         0.39        0.00
c3t2d15s2  2054    0         1027      0         0.40        0.00
c4t2d15s2  2171    0         1086      0         0.39        0.00
c4t3d15s2  2095    0         1048      0         0.39        0.00
c5t3d15s2  2073    0         1036      0         0.39        0.00
c5t4d15s2  2042    0         1021      0         0.39        0.00
```

The enclosure can be returned to the single active I/O policy by entering the following command:

```
# vxdmpadm setattr enclosure ENC0 iopolicy=singleactive
```

Disabling I/O for paths, controllers or array ports

Disabling I/O through a path, HBA controller or array port prevents DMP from issuing I/O requests through the specified path, or the paths that are connected

to the specified controller or array port. The command blocks until all pending I/O requests issued through the paths are completed.

Note: From release 5.0 of VxVM, this operation is supported for controllers that are used to access disk arrays on which cluster-shareable disk groups are configured.

Before detaching a system board, stop all I/O to the HBA controllers that are located on the board. To do this, execute the `vxdmpadm disable` command, and then run the Dynamic Reconfiguration (DR) facility provided by Sun.

To disable I/O for a path, use the following command:

```
# vxdmpadm [-c|-f] disable path=path_name
```

To disable I/O for multiple paths, use the following command:

```
# vxdmpadm [-c|-f] disable path=path_name1,path_name2,path_nameN
```

To disable I/O for the paths connected to an HBA controller, use the following command:

```
# vxdmpadm [-c|-f] disable ctlr=ctlr_name
```

To disable I/O for the paths connected to an array port, use one of the following commands:

```
# vxdmpadm [-c|-f] disable enclosure=enclr_name portid=array_port_ID
# vxdmpadm [-c|-f] disable pwwn=array_port_WWN
```

where the array port is specified either by the enclosure name and the array port ID, or by the array port's worldwide name (WWN) identifier.

The following are examples of using the command to disable I/O on an array port:

```
# vxdmpadm disable enclosure=HDS9500V0 portid=1A
# vxdmpadm disable pwwn=20:00:00:E0:8B:06:5F:19
```

You can use the -c option to check if there is only a single active path to the disk. If so, the `disable` command fails with an error message unless you use the `-f` option to forcibly disable the path.

The `disable` operation fails if it is issued to a controller that is connected to the root disk through a single path, and there are no root disk mirrors configured on alternate paths. If such mirrors exist, the command succeeds.

Enabling I/O for paths, controllers or array ports

Enabling a controller allows a previously disabled path, HBA controller or array port to accept I/O again. This operation succeeds only if the path, controller or array port is accessible to the host, and I/O can be performed on it. When connecting Active/Passive disk arrays, the `enable` operation results in failback of I/O to the primary path. The `enable` operation can also be used to allow I/O to the controllers on a system board that was previously detached.

Note: From release 5.0 of VxVM, this operation is supported for controllers that are used to access disk arrays on which cluster-shareable disk groups are configured.

To enable I/O for a path, use the following command:

```
# vxdmpadm enable path=path_name
```

To enable I/O for multiple paths, use the following command:

```
# vxdmpadm enable path=path_name1,path_name2,path_nameN
```

To enable I/O for the paths connected to an HBA controller, use the following command:

```
# vxdmpadm enable ctlr=ctlr_name
```

To enable I/O for the paths connected to an array port, use one of the following commands:

```
# vxdmpadm enable enclosure=enclr_name portid=array_port_ID
# vxdmpadm [-f] enable pwwn=array_port_WWN
```

where the array port is specified either by the enclosure name and the array port ID, or by the array port's worldwide name (WWN) identifier.

The following are examples of using the command to enable I/O on an array port:

```
# vxdmpadm enable enclosure=HDS9500V0 portid=1A
# vxdmpadm enable pwwn=20:00:00:E0:8B:06:5F:19
```

Renaming an enclosure

The `vxdmpadm setattr` command can be used to assign a meaningful name to an existing enclosure, for example:

```
# vxdmpadm setattr enclosure enc0 name=GRP1
```

This example changes the name of an enclosure from `enc0` to `GRP1`.

Note: The maximum length of the enclosure name prefix is 25 characters.

The following command shows the changed name:

```
# vxdmpadm listenclosure all

ENCLR_NAME    ENCLR_TYPE    ENCLR_SNO                 STATUS
============================================================
other0        OTHER         OTHER_DISKS               CONNECTED
jbod0         X1            X1_DISKS                  CONNECTED
GRP1          ACME          60020f20000001a90000      CONNECTED
```

Configuring the response to I/O failures

You can configure how DMP responds to failed I/O requests on the paths to a specified enclosure, disk array name, or type of array. By default, DMP is configured to retry a failed I/O request up to 5 times for a single path.

To display the current settings for handling I/O request failures that are applied to the paths to an enclosure, array name or array type, use the `vxdmpadm getattr` command.

See "Displaying recovery option values" on page 78.

To set a limit for the number of times that DMP attempts to retry sending an I/O request on a path, use the following command:

```
# vxdmpadm setattr \
  {enclosure enc-name|arrayname name|arraytype type} \
  recoveryoption=fixedretry retrycount=n
```

The value of the argument to `retrycount` specifies the number of retries to be attempted before DMP reschedules the I/O request on another available path, or fails the request altogether.

As an alternative to specifying a fixed number of retries, the following version of the command specifies how long DMP should allow an I/O request to be retried on a path:

```
# vxdmpadm setattr \
  {enclosure enc-name|arrayname name|arraytype type} \
  recoveryoption=timebound iotimeout=seconds
```

The value of the argument to `iotimeout` specifies the time in seconds that DMP waits for an outstanding I/O request to succeed before it reschedules the request on another available path, or fails the I/O request altogether. The effective number of retries is the value of `iotimeout` divided by the sum of the times taken for each retry attempt. DMP abandons retrying to send the I/O request before the specified time limit has expired if it predicts that the next retry will take the total elapsed time over this limit.

The default value of `iotimeout` is 10 seconds. For some applications, such as Oracle, it may be desirable to set `iotimeout` to a larger value, such as 60 seconds.

Note: The `fixedretry` and `timebound` settings are mutually exclusive.

The following example configures time-bound recovery for the enclosure `enc0`, and sets the value of `iotimeout` to 60 seconds:

```
# vxdmpadm setattr enclosure enc0 recoveryoption=timebound \
  iotimeout=60
```

The next example sets a fixed-retry limit of 10 for the paths to all Active/Active arrays:

```
# vxdmpadm setattr arraytype A/A recoveryoption=fixedretry \
  retrycount=10
```

Specifying `recoveryoption=default` resets DMP to the default settings corresponding to `recoveryoption=fixedretry retrycount=5`, for example:

```
# vxdmpadm setattr arraytype A/A recoveryoption=default
```

The above command also has the effect of configuring I/O throttling with the default settings.

See "Configuring the I/O throttling mechanism" on page 75.

Note: The response to I/O failure settings is persistent across reboots of the system.

Configuring the I/O throttling mechanism

By default, DMP is configured with I/O throttling turned off for all paths. To display the current settings for I/O throttling that are applied to the paths to an enclosure, array name or array type, use the `vxdmpadm getattr` command.

See "Displaying recovery option values" on page 78.

If enabled, I/O throttling imposes a small overhead on CPU and memory usage because of the activity of the statistics-gathering daemon. If I/O throttling is disabled, the daemon no longer collects statistics, and remains inactive until I/O throttling is re-enabled.

To turn off I/O throttling, use the following form of the `vxdmpadm setattr` command:

```
# vxdmpadm setattr \
  {enclosure enc-name|arrayname name|arraytype type} \
  recoveryoption=nothrottle
```

The following example shows how to disable I/O throttling for the paths to the enclosure `enc0`:

```
# vxdmpadm setattr enclosure enc0 recoveryoption=nothrottle
```

The `vxdmpadm setattr` command can be used to enable I/O throttling on the paths to a specified enclosure, disk array name, or type of array:

```
# vxdmpadm setattr \
  {enclosure enc-name|arrayname name|arraytype type}\
  recoveryoption=throttle {iotimeout=seconds|queuedepth=n}
```

If the `iotimeout` attribute is specified, its argument specifies the time in seconds that DMP waits for an outstanding I/O request to succeed before invoking I/O throttling on the path. The default value of `iotimeout` is 10 seconds. Setting `iotimeout` to a larger value potentially causes more I/O requests to become queued up in the SCSI driver before I/O throttling is invoked.

If the `queuedepth` attribute is specified, its argument specifies the number of I/O requests that can be outstanding on a path before DMP invokes I/O throttling. The default value of `queuedepth` is 20. Setting `queuedepth` to a larger value allows more I/O requests to become queued up in the SCSI driver before I/O throttling is invoked.

Note: The `iotimeout` and `queuedepth` attributes are mutually exclusive.

The following example sets the value of `iotimeout` to 60 seconds for the enclosure `enc0`:

```
# vxdmpadm setattr enclosure enc0 recoveryoption=throttle \
  iotimeout=60
```

The next example sets the value of `queuedepth` to 30 for the paths to all Active/Active arrays:

```
# vxdmpadm setattr arraytype A/A recoveryoption=throttle \
  queuedepth=30
```

Specify `recoveryoption=default` to reset I/O throttling to the default settings, as follows:

```
# vxdmpadm setattr arraytype A/A recoveryoption=default
```

The above command configures the default behavior, corresponding to `recoveryoption=nothrottle`. The above command also configures the default behavior for the response to I/O failures.

See "Configuring the response to I/O failures" on page 74.

Note: The I/O throttling settings are persistent across reboots of the system.

Configuring Subpaths Failover Groups (SFG)

The Subpaths Failover Groups (SFG) feature can be turned on or off using the tunable `dmp_sfg_threshold`.

To turn off the feature, set the tunable `dmp_sfg_threshold` value to 0:

```
# vxdmpadm settune dmp_sfg_threshold=0
```

To turn on the feature, set the `dmp_sfg_threshold` value to the required number of path failures which triggers SFG. The default is 1.

```
# vxdmpadm settune dmp_sfg_threshold=N
```

The default value of the tunable is "1" which represents that the feature is on.

To see the Subpaths Failover Groups ID, use the following command:

```
# vxdmpadm -v getportids
```

Configuring Low Impact Path Probing

The Low Impact Path Probing (LIPP) feature can be turned on or off using the `vxdmpadm settune` command:

```
# vxdmpadm settune dmp_low_impact_probe=[on|off]
```

Path probing will be optimized by probing a subset of paths connected to same HBA and array port. The size of the subset of paths can be controlled by the `dmp_probe_threshold` tunable. The default value is set to 5.

```
# vxdmpadm settune dmp_probe_threshold=N
```

Displaying recovery option values

To display the current settings for handling I/O request failures that are applied to the paths to an enclosure, array name or array type, use the following command:

```
# vxdmpadm getattr \
  {enclosure enc-name|arrayname name|arraytype type} \
  recoveryoption
```

The following example shows the `vxdmpadm getattr` command being used to display the `recoveryoption` option values that are set on an enclosure.

```
# vxdmpadm getattr enclosure HDS9500-ALUA0 recoveryoption
ENCLR-NAME      RECOVERY-OPTION  DEFAULT[VAL]    CURRENT[VAL]
============================================================
HDS9500-ALUA0   Throttle         Nothrottle[0]   Queuedepth[60]
HDS9500-ALUA0   Error-Retry      Fixed-Retry[5]  Timebound[20]
```

This shows the default and current policy options and their values.

Table 3-1 summarizes the possible recovery option settings for retrying I/O after an error.

Table 3-1 Recovery options for retrying I/O after an error

Recovery option	Possible settings	Description
recoveryoption=fixedretry	Fixed-Retry (retrycount)	DMP retries a failed I/O request for the specified number of times if I/O fails.
recoveryoption=timebound	Timebound (iotimeout)	DMP retries a failed I/O request for the specified time in seconds if I/O fails.

Table 3-2 summarizes the possible recovery option settings for throttling I/O.

Table 3-2 Recovery options for I/O throttling

Recovery option	Possible settings	Description
recoveryoption=nothrottle	None	I/O throttling is not used.
recoveryoption=throttle	Queuedepth (queuedepth)	DMP throttles the path if the specified number of queued I/O requests is exceeded.
recoveryoption=throttle	Timebound (iotimeout)	DMP throttles the path if an I/O request does not return within the specified time in seconds.

Configuring DMP path restoration policies

DMP maintains a kernel thread that re-examines the condition of paths at a specified interval. The type of analysis that is performed on the paths depends on the checking policy that is configured.

Note: The DMP path restoration thread does not change the disabled state of the path through a controller that you have disabled using `vxdmpadm disable`.

When configuring DMP path restoration policies, you must stop the path restoration thread, and then restart it with new attributes.

See "Stopping the DMP path restoration thread" on page 81.

Use the `vxdmpadm start restore` command to configure one of the following restore policies. The policy will remain in effect until the restore thread is stopped or the values are changed using `vxdmpadm settune` command.

- `check_all`

  The path restoration thread analyzes all paths in the system and revives the paths that are back online, as well as disabling the paths that are inaccessible. The command to configure this policy is:

  ```
  # vxdmpadm start restore [interval=seconds] policy=check_all
  ```

- `check_alternate`

  The path restoration thread checks that at least one alternate path is healthy. It generates a notification if this condition is not met. This policy avoids inquiry commands on all healthy paths, and is less costly than `check_all` in cases where a large number of paths are available. This policy is the same as

check_all if there are only two paths per DMP node. The command to configure this policy is:

```
# vxdmpadm start restore [interval=seconds] \
  policy=check_alternate
```

- check_disabled

  This is the default path restoration policy. The path restoration thread checks the condition of paths that were previously disabled due to hardware failures, and revives them if they are back online. The command to configure this policy is:

  ```
  # vxdmpadm start restore [interval=seconds] \
    policy=check_disabled
  ```

- check_periodic

  The path restoration thread performs check_all once in a given number of cycles, and check_disabled in the remainder of the cycles. This policy may lead to periodic slowing down (due to check_all) if there is a large number of paths available. The command to configure this policy is:

  ```
  # vxdmpadm start restore interval=seconds \
    policy=check_periodic [period=number]
  ```

  The interval attribute must be specified for this policy. The default number of cycles between running the check_all policy is 10.

The interval attribute specifies how often the path restoration thread examines the paths. For example, after stopping the path restoration thread, the polling interval can be set to 400 seconds using the following command:

```
# vxdmpadm start restore interval=400
```

Starting with the 5.0MP3 release, you can also use the vxdmpadm settune command to change the restore policy, restore interval, and restore period. This method stores the values for these arguments as DMP tunables. The settings are immediately applied and are persistent across reboots. Use the vxdmpadm gettune to view the current settings.

See "DMP tunable parameters" on page 123.

If the vxdmpadm start restore command is given without specifying a policy or interval, the path restoration thread is started with the persistent policy and interval settings previously set by the administrator with the vxdmpadm settune command. If the administrator has not set a policy or interval, the system defaults

are used. The system default restore policy is `check_disabled`. The system default interval is 300 seconds.

Warning: Decreasing the interval below the system default can adversely affect system performance.

Stopping the DMP path restoration thread

Use the following command to stop the DMP path restoration thread:

```
# vxdmpadm stop restore
```

Warning: Automatic path failback stops if the path restoration thread is stopped.

Displaying the status of the DMP path restoration thread

Use the following command to display the status of the automatic path restoration kernel thread, its polling interval, and the policy that it uses to check the condition of paths:

```
# vxdmpadm stat restored
```

This produces output such as the following:

```
The number of daemons running : 1
The interval of daemon: 300
The policy of daemon: check_disabled
```

Displaying information about the DMP error-handling thread

To display information about the kernel thread that handles DMP errors, use the following command:

```
# vxdmpadm stat errord
```

One daemon should be shown as running.

Configuring array policy modules

An array policy module (APM) is a dynamically loadable kernel module (plug-in for DMP) for use in conjunction with an array. An APM defines array-specific procedures and commands to:

- Select an I/O path when multiple paths to a disk within the array are available.

- Select the path failover mechanism.
- Select the alternate path in the case of a path failure.
- Put a path change into effect.
- Respond to SCSI reservation or release requests.

DMP supplies default procedures for these functions when an array is registered. An APM may modify some or all of the existing procedures that are provided by DMP or by another version of the APM.

You can use the following command to display all the APMs that are configured for a system:

```
# vxdmpadm listapm all
```

The output from this command includes the file name of each module, the supported array type, the APM name, the APM version, and whether the module is currently loaded and in use. To see detailed information for an individual module, specify the module name as the argument to the command:

```
# vxdmpadm listapm module_name
```

To add and configure an APM, use the following command:

```
# vxdmpadm -a cfgapm module_name [attr1=value1 \
      [attr2=value2 ...]]
```

The optional configuration attributes and their values are specific to the APM for an array. Consult the documentation that is provided by the array vendor for details.

Note: By default, DMP uses the most recent APM that is available. Specify the `-u` option instead of the `-a` option if you want to force DMP to use an earlier version of the APM. The current version of an APM is replaced only if it is not in use.

Specifying the `-r` option allows you to remove an APM that is not currently loaded:

```
# vxdmpadm -r cfgapm module_name
```

See the `vxdmpadm`(1M) manual page.

Chapter 4

Administering disks

This chapter includes the following topics:

About disk management

Veritas Volume Manager (VxVM) allows you to place LUNs and disks under VxVM control, to initialize or encapsulate disks, and to remove and replace disks.

Note: Most VxVM commands require superuser or equivalent privileges.

Disks that are controlled by the Sun Microsystems Solaris Volume Manager software cannot be used directly as VxVM disks, but the disks can be converted so that their volumes become VxVM volumes.

For detailed information about migrating volumes, see the *Veritas Storage Foundation Advanced Features Administrator's Guide*.

Veritas Dynamic Multi-Pathing (DMP) is used to administer multiported disk arrays.

See "How DMP works" on page 12.

Discovering and configuring newly added disk devices

The `vxdiskconfig` utility scans and configures new disk devices attached to the host, disk devices that become online, or fibre channel devices that are zoned to host bus adapters connected to this host. The command calls platform specific interfaces to configure new disk devices and brings them under control of the operating system. It scans for disks that were added since VxVM's configuration daemon was last started. These disks are then dynamically configured and recognized by VxVM.

`vxdiskconfig` should be used whenever disks are physically connected to the host or when fibre channel devices are zoned to the host.

`vxdiskconfig` calls `vxdctl enable` to rebuild volume device node directories and update the DMP internal database to reflect the new state of the system.

You can also use the `vxdisk scandisks` command to scan devices in the operating system device tree, and to initiate dynamic reconfiguration of multipathed disks.

If you want VxVM to scan only for new devices that have been added to the system, and not for devices that have been enabled or disabled, specify the `-f` option to either of the commands, as shown here:

```
# vxdctl -f enable
# vxdisk -f scandisks
```

However, a complete scan is initiated if the system configuration has been modified by changes to:

- Installed array support libraries.
- The list of devices that are excluded from use by VxVM.
- DISKS (JBOD), SCSI3, or foreign device definitions.

See the `vxdctl`(1M) manual page.

See the `vxdisk`(1M) manual page.

Partial device discovery

Dynamic Multi-Pathing (DMP) supports partial device discovery where you can include or exclude sets of disks or disks attached to controllers from the discovery process.

The `vxdisk scandisks` command rescans the devices in the OS device tree and triggers a DMP reconfiguration. You can specify parameters to `vxdisk scandisks` to implement partial device discovery. For example, this command makes VxVM discover newly added devices that were unknown to it earlier:

```
# vxdisk scandisks new
```

The next example discovers fabric devices:

```
# vxdisk scandisks fabric
```

The above command discovers devices with the characteristic `DDI_NT_FABRIC` property set on them.

The following command scans for the devices `c1t1d0` and `c2t2d0`:

```
# vxdisk scandisks device=c1t1d0,c2t2d0
```

Alternatively, you can specify a ! prefix character to indicate that you want to scan for all devices except those that are listed.

Note: The ! character is a special character in some shells. The following examples show how to escape it in a bash shell.

```
# vxdisk scandisks \!device=c1t1d0,c2t2d0
```

You can also scan for devices that are connected (or not connected) to a list of logical or physical controllers. For example, this command discovers and configures all devices except those that are connected to the specified logical controllers:

```
# vxdisk scandisks \!ctlr=c1,c2
```

The next command discovers devices that are connected to the specified physical controller:

```
# vxdisk scandisks pctlr=/pci@1f,4000/scsi@3/
```

The items in a list of physical controllers are separated by + characters.

You can use the command `vxdmpadm getctlr all` to obtain a list of physical controllers.

You should specify only one selection argument to the `vxdisk scandisks` command. Specifying multiple options results in an error.

See the `vxdisk`(1M) manual page.

Discovering disks and dynamically adding disk arrays

DMP uses array support libraries (ASLs) to provide array-specific support for multipathing. An array support library (ASL) is a dynamically loadable shared library (plug-in for DDL). The ASL implements hardware-specific logic to discover

device attributes during device discovery. DMP provides the device discovery layer (DDL) to determine which ASLs should be associated to each disk array

In some cases, DMP can also provide basic multipathing and failover functionality by treating LUNs as disks (JBODs).

How DMP claims devices

For fully optimized support of any array and for support of more complicated array types, DMP requires the use of array-specific array support libraries (ASLs), possibly coupled with array policy modules (APMs). ASLs and APMs effectively are array-specific plugins that allow close tie-in of DMP with any specific array model.

See the Hardware Compatibility List for the complete list of supported arrays.

http://entsupport.symantec.com/docs/330441

During device discovery, the DDL checks the installed ASL for each device to find which ASL claims the device. If no ASL is found to claim the device, the DDL checks for a corresponding JBOD definition. You can add JBOD definitions for unsupported arrays to enable DMP to provide multipathing for the array. If a JBOD definition is found, the DDL claims the devices in the DISKS category, which adds the LUNs to the list of JBOD (physical disk) devices used by DMP. If the JBOD definition includes a cabinet number, DDL uses the cabinet number to group the LUNs into enclosures.

See "Adding unsupported disk arrays to the DISKS category" on page 96.

DMP can provide basic multipathing to ALUA-compliant arrays even if there is no ASL or JBOD definition. DDL claims the LUNs as part of the aluadisk enclosure. The array type is shown as ALUA. Adding a JBOD definition also enables you to group the LUNs into enclosures.

Disk categories

Disk arrays that have been certified for use with Veritas Volume Manager are supported by an array support library (ASL), and are categorized by the vendor ID string that is returned by the disks (for example, "HITACHI").

Disks in JBODs which are capable of being multipathed by DMP, are placed in the DISKS category. Disks in unsupported arrays can also be placed in the DISKS category.

See "Adding unsupported disk arrays to the DISKS category" on page 96.

Disks in JBODs that do not fall into any supported category, and which are not capable of being multipathed by DMP are placed in the OTHER_DISKS category.

Adding support for a new disk array

You can dynamically add support for a new type of disk array. The support comes in the form of Array Support Libraries (ASLs) that are developed by Symantec. Symantec provides support for new disk arrays though updates to the `VRTSaslapm` package. To determine if an updated `VRTSaslapm` package is available for download, refer to the hardware compatibility list tech note. The hardware compatibility list provides a link to the latest package for download and instructions for installing the `VRTSaslapm` package. You can upgrade the `VRTSaslapm` package while the system is online; you do not need to stop the applications.

To access the hardware compatibility list, go to the following URL:

http://entsupport.symantec.com/docs/330441

The new disk array does not need to be already connected to the system when the package is installed. If any of the disks in the new disk array are subsequently connected, and if `vxconfigd` is running, `vxconfigd` immediately invokes the Device Discovery function and includes the new disks in the VxVM device list.

If you need to remove the latest `VRTSaslapm` package, you can revert to the previously installed version. For the detailed procedure, refer to the *Veritas Volume Manager Troubleshooting Guide*.

Enabling discovery of new disk arrays

The `vxdctl enable` command scans all of the disk devices and their attributes, updates the VxVM device list, and reconfigures DMP with the new device database. There is no need to reboot the host.

Warning: This command ensures that Dynamic Multi-Pathing is set up correctly for the array. Otherwise, VxVM treats the independent paths to the disks as separate devices, which can result in data corruption.

To enable discovery of a new disk array

- Type the following command:

```
# vxdctl enable
```

Third-party driver coexistence

The third-party driver (TPD) coexistence feature of VxVM allows I/O that is controlled by some third-party multipathing drivers to bypass DMP while retaining the monitoring capabilities of DMP. If a suitable ASL is available and installed,

devices that use TPDs can be discovered without requiring you to set up a specification file, or to run a special command. In previous releases, VxVM only supported TPD coexistence if the code of the third-party driver was intrusively modified. Now, the TPD coexistence feature maintains backward compatibility with such methods, but it also permits coexistence without requiring any change in a third-party multipathing driver.

See "Changing device naming for TPD-controlled enclosures" on page 105.

See "Displaying information about TPD-controlled devices" on page 52.

Autodiscovery of EMC Symmetrix arrays

In VxVM 4.0, there were two possible ways to configure EMC Symmetrix arrays:

- With EMC PowerPath installed, EMC Symmetrix arrays could be configured as foreign devices.
  See "Foreign devices" on page 100.
- Without EMC PowerPath installed, DMP could be used to perform multipathing.

On upgrading a system to VxVM 4.1 or later release, existing EMC PowerPath devices can be discovered by DDL, and configured into DMP as autoconfigured disks with DMP nodes, even if PowerPath is being used to perform multipathing. There is no need to configure such arrays as foreign devices.

Table 4-1 shows the scenarios for using DMP with PowerPath.

The ASLs are all included in the ASL-APM package, which is installed when you install Storage Foundation products.

Table 4-1 Scenarios for using DMP with PowerPath

PowerPath	DMP	Array configuration mode
Installed.	The `libvxpp` ASL handles EMC Symmetrix arrays and DGC CLARiiON claiming internally. PowerPath handles failover.	EMC Symmetrix - Any DGC CLARiiON - Active/Passive (A/P), Active/Passive in Explicit Failover mode (A/P-F) and ALUA Explicit failover
Not installed; the array is EMC Symmetrix.	DMP handles multipathing. The ASL name is `libvxemc`.	Active/Active

Table 4-1 Scenarios for using DMP with PowerPath *(continued)*

PowerPath	DMP	Array configuration mode
Not installed; the array is DGC CLARiioN (CXn00).	DMP handles multipathing. The ASL name is `libvxCLARiiON`.	Active/Passive (A/P), Active/Passive in Explicit Failover mode (A/P-F) and ALUA

If any EMCpower disks are configured as foreign disks, use the `vxddladm rmforeign` command to remove the foreign definitions, as shown in this example:

```
# vxddladm rmforeign blockpath=/dev/dsk/emcpower10 \
  charpath=/dev/rdsk/emcpower10
```

To allow DMP to receive correct inquiry data, the Common Serial Number (C-bit) Symmetrix Director parameter must be set to enabled.

How to administer the Device Discovery Layer

The Device Discovery Layer (DDL) allows dynamic addition of disk arrays. DDL discovers disks and their attributes that are required for VxVM and DMP operations.

The DDL is administered using the `vxddladm` utility to perform the following tasks:

- List the hierarchy of all the devices discovered by DDL including iSCSI devices.
- List all the Host Bus Adapters including iSCSI
- List the ports configured on a Host Bus Adapter
- List the targets configured from a Host Bus Adapter
- List the devices configured from a Host Bus Adapter
- Get or set the iSCSI operational parameters
- List the types of arrays that are supported.
- Add support for an array to DDL.
- Remove support for an array from DDL.
- List information about excluded disk arrays.
- List disks that are supported in the `DISKS` (JBOD) category.
- Add disks from different vendors to the `DISKS` category.
- Remove disks from the `DISKS` category.

- Add disks as foreign devices.

The following sections explain these tasks in more detail.

See the `vxddladm`(1M) manual page.

Listing all the devices including iSCSI

You can display the hierarchy of all the devices discovered by DDL, including iSCSI devices.

To list all the devices including iSCSI

- Type the following command:

  ```
  # vxddladm list
  ```

  The following is a sample output:

```
HBA c2 (20:00:00:E0:8B:19:77:BE)
     Port c2_p0 (50:0A:09:80:85:84:9D:84)
          Target c2_p0_t0 (50:0A:09:81:85:84:9D:84)
               LUN c2t0d0s2
. . .
HBA c3 (iqn.1986-03.com.sun:01:0003ba8ed1b5.45220f80)
     Port c3_p0 (10.216.130.10:3260)
          Target c3_p0_t0 (iqn.1992-08.com.netapp:sn.84188548)
               LUN c3t0d0s2
               LUN c3t0d1s2
          Target c3_t1 (iqn.1992-08.com.netapp:sn.84190939)
. . .
```

Listing all the Host Bus Adapters including iSCSI

You can obtain information about all the Host Bus Adapters configured on the system, including iSCSI adapters. This includes the following information:

Driver	Driver controlling the HBA.
Firmware	Firmware version.
Discovery	The discovery method employed for the targets.
State	Whether the device is Online or Offline.
Address	The hardware address.

To list all the Host Bus Adapters including iSCSI

- Use the following command to list all of the HBAs, including iSCSI devices, configured on the system:

```
# vxddladm list hbas
```

Listing the ports configured on a Host Bus Adapter

You can obtain information about all the ports configured on an HBA. The display includes the following information:

HBA-ID	The parent HBA.
State	Whether the device is Online or Offline.
Address	The hardware address.

To list the ports configured on a Host Bus Adapter

- Use the following command to obtain the ports configured on an HBA:

```
# vxddladm list ports

PortID   HBA-ID    State      Address
-------------------------------------------------------------------
c2_p0    c2        Online     50:0A:09:80:85:84:9D:84
c3_p0    c3        Online     10.216.130.10:3260
```

Listing the targets configured from a Host Bus Adapter or a port

You can obtain information about all the targets configured from a Host Bus Adapter or a port. This includes the following information:

Alias	The alias name, if available.
HBA-ID	Parent HBA or port.
State	Whether the device is Online or Offline.
Address	The hardware address.

To list the targets

- To list all of the targets, use the following command:

  ```
  # vxddladm list targets
  ```

  The following is a sample output:

```
TgtID      Alias  HBA-ID   State      Address
-----------------------------------------------------------------
c2_p0_t0   -      c2       Online     50:0A:09:80:85:84:9D:84
c3_p0_t1   -      c3       Online     iqn.1992-08.com.netapp:sn.84190939
```

To list the targets configured from a Host Bus Adapter or port

- You can filter based on a HBA or port, using the following command:

  ```
  # vxddladm list targets [hba=hba_name|port=port_name]
  ```

  For example, to obtain the targets configured from the specified HBA:

  ```
  # vxddladm list targets hba=c2

  TgtID      Alias  HBA-ID   State      Address
  -----------------------------------------------------------------
  c2_p0_t0   -      c2       Online     50:0A:09:80:85:84:9D:84
  ```

Listing the devices configured from a Host Bus Adapter and target

You can obtain information about all the devices configured from a Host Bus Adapter. This includes the following information:

Target-ID	The parent target.
State	Whether the device is Online or Offline.
DDL status	Whether the device is claimed by DDL. If claimed, the output also displays the ASL name.

To list the devices configured from a Host Bus Adapter

- To obtain the devices configured, use the following command:

```
# vxddladm list devices

Device    Target-ID    State    DDL status (ASL)
-------------------------------------------------------------
c2t0d2s2  c2_p0_t0     Online   CLAIMED (libvxemc.so)
c3t1d2s2  c3_p0_t1     Online   SKIPPED
c4t1d2s2  c4_p0_t1     Offline  ERROR
c4t1d2s2  c4_p0_t2     Online   EXCLUDED
c4t5d2s2  c4_p0_t5     Offline  MASKED
```

To list the devices configured from a Host Bus Adapter and target

- To obtain the devices configured from a particular HBA and target, use the following command:

```
# vxddladm list devices target=target_name
```

Getting or setting the iSCSI operational parameters

DDL provides an interface to set and display certain parameters that affect the performance of the iSCSI device path. However, the underlying OS framework must support the ability to set these values. The `vxddladm set` command returns an error if the OS support is not available.

Table 4-2 Parameters for iSCSI devices

Parameter	Default value	Minimum value	Maximum value
DataPDUInOrder	yes	no	yes
DataSequenceInOrder	yes	no	yes
DefaultTime2Retain	20	0	3600
DefaultTime2Wait	2	0	3600
ErrorRecoveryLevel	0	0	2
FirstBurstLength	65535	512	16777215
InitialR2T	yes	no	yes
ImmediateData	yes	no	yes

Table 4-2 Parameters for iSCSI devices *(continued)*

Parameter	Default value	Minimum value	Maximum value
MaxBurstLength	262144	512	16777215
MaxConnections	1	1	65535
MaxOutStandingR2T	1	1	65535
MaxRecvDataSegmentLength	8182	512	16777215

To get the iSCSI operational parameters on the initiator for a specific iSCSI target

- Type the following commands:

```
# vxddladm getiscsi target=tgt-id {all | parameter}
```

You can use this command to obtain all the iSCSI operational parameters. The following is a sample output:

```
# vxddladm getiscsi target=c2_p2_t0
```

```
PARAMETER                 CURRENT        DEFAULT         MIN           MAX
--------------------------------------------------------------------------------
DataPDUInOrder            yes            yes             no            yes
DataSequenceInOrder       yes            yes             no            yes
DefaultTime2Retain        20               20            0            3600
DefaultTime2Wait           2               2             0            3600
ErrorRecoveryLevel         0               0             0               2
FirstBurstLength          65535         65535           512         16777215
InitialR2T                yes             yes            no            yes
ImmediateData             yes             yes            no            yes
MaxBurstLength            262144       262144           512         16777215
MaxConnections            1                1             1            65535
MaxOutStandingR2T         1                1             1            65535
MaxRecvDataSegmentLength  8192           8182           512         16777215
```

To set the iSCSI operational parameters on the initiator for a specific iSCSI target

- Type the following command:

```
# vxddladm setiscsi target=tgt-id
   parameter=value
```

Listing all supported disk arrays

Use this procedure to obtain values for the `vid` and `pid` attributes that are used with other forms of the `vxddladm` command.

To list all supported disk arrays

- Type the following command:

```
# vxddladm listsupport all
```

Excluding support for a disk array library

To exclude support for a disk array library

- Type the following command:

```
# vxddladm excludearray libname=libvxenc.so
```

This example excludes support for disk arrays that depends on the library `libvxenc.so`. You can also exclude support for disk arrays from a particular vendor, as shown in this example:

```
# vxddladm excludearray vid=ACME pid=X1
```

See the `vxddladm` (1M) manual page.

Re-including support for an excluded disk array library

To re-include support for an excluded disk array library

- If you have excluded support for all arrays that depend on a particular disk array library, you can use the `includearray` keyword to remove the entry from the exclude list, as shown in the following example:

```
# vxddladm includearray libname=libvxenc.so
```

This command adds the array library to the database so that the library can once again be used in device discovery. If `vxconfigd` is running, you can use the `vxdisk scandisks` command to discover the arrays and add their details to the database.

Listing excluded disk arrays

To list all disk arrays that are currently excluded from use by VxVM

- Type the following command:

```
# vxddladm listexclude
```

Listing supported disks in the DISKS category

To list disks that are supported in the DISKS (JBOD) category

- Type the following command:

```
# vxddladm listjbod
```

Displaying details about a supported array library

To display details about a supported array library

- Type the following command:

```
# vxddladm listsupport libname=library_name.so
```

This command displays the vendor ID (VID), product IDs (PIDs) for the arrays, array types (for example, A/A or A/P), and array names. The following is sample output.

```
# vxddladm listsupport libname=libvxfujitsu.so
ATTR_NAME            ATTR_VALUE
==============================================
LIBNAME              libvxfujitsu.so
VID                  vendor
PID                  GR710, GR720, GR730
                     GR740, GR820, GR840
ARRAY_TYPE           A/A, A/P
ARRAY_NAME           FJ_GR710, FJ_GR720, FJ_GR730
                     FJ_GR740, FJ_GR820, FJ_GR840
```

Adding unsupported disk arrays to the DISKS category

Disk arrays should be added as JBOD devices if no ASL is available for the array.

JBODs are assumed to be Active/Active (A/A) unless otherwise specified. If a suitable ASL is not available, an A/A-A, A/P or A/PF array must be claimed as an Active/Passive (A/P) JBOD to prevent path delays and I/O failures. If a JBOD is ALUA-compliant, it is added as an ALUA array.

See "How DMP works" on page 12.

Warning: This procedure ensures that Dynamic Multi-Pathing (DMP) is set up correctly on an array that is not supported by Veritas Volume Manager. Otherwise, Veritas Volume Manager treats the independent paths to the disks as separate devices, which can result in data corruption.

To add an unsupported disk array to the DISKS category

1 Use the following command to identify the vendor ID and product ID of the disks in the array:

```
# /etc/vx/diag.d/vxscsiinq device_name
```

where *device_name* is the device name of one of the disks in the array. Note the values of the vendor ID (VID) and product ID (PID) in the output from this command. For Fujitsu disks, also note the number of characters in the serial number that is displayed.

The following example shows the output for the example disk with the device name `/dev/rdsk/c1t20d0s2`

```
# /etc/vx/diag.d/vxscsiinq /dev/rdsk/c1t20d0s2

Vendor id (VID)      : SEAGATE
Product id (PID)     : ST318404LSUN18G
Revision             : 8507
Serial Number        : 0025T0LA3H
```

In this example, the vendor ID is `SEAGATE` and the product ID is `ST318404LSUN18G`.

2 Stop all applications, such as databases, from accessing VxVM volumes that are configured on the array, and unmount all file systems and checkpoints that are configured on the array.

3 If the array is of type A/A-A, A/P or A/PF, configure it in autotrespass mode.

4 Enter the following command to add a new JBOD category:

```
# vxddladm addjbod vid=vendorid [pid=productid] \
[serialnum=opcode/pagecode/offset/length]
[cabinetnum=opcode/pagecode/offset/length] policy={aa|ap}]
```

where *vendorid* and *productid* are the VID and PID values that you found from the previous step. For example, *vendorid* might be `FUJITSU`, `IBM`, or `SEAGATE`. For Fujitsu devices, you must also specify the number of characters in the serial number as the argument to the `length` argument (for example, 10). If the array is of type A/A-A, A/P or A/PF, you must also specify the `policy=ap` attribute.

Continuing the previous example, the command to define an array of disks of this type as a JBOD would be:

```
# vxddladm addjbod vid=SEAGATE pid=ST318404LSUN18G
```

5 Use the `vxdctl enable` command to bring the array under VxVM control.

```
# vxdctl enable
```

See "Enabling discovery of new disk arrays" on page 87.

6 To verify that the array is now supported, enter the following command:

```
# vxddladm listjbod
```

The following is sample output from this command for the example array:

```
VID      PID                SerialNum               CabinetNum        Policy
                          (Cmd/PageCode/off/len)  (Cmd/PageCode/off/len)
==============================================================================
SEAGATE  ALL PIDs       18/-1/36/12            18/-1/10/11             Disk
SUN      SESS01         18/-1/36/12            18/-1/12/11             Disk
```

7 To verify that the array is recognized, use the `vxdmpadm listenclosure` command as shown in the following sample output for the example array:

```
# vxdmpadm listenclosure
ENCLR_NAME ENCLR_TYPE ENCLR_SNO            STATUS    ARRAY_TYPE LUN_COU
==========================================================================
Disk       Disk       DISKS                CONNECTED Disk       2
```

The enclosure name and type for the array are both shown as being set to `Disk`. You can use the `vxdisk list` command to display the disks in the array:

```
# vxdisk list
DEVICE   TYPE       DISK     GROUP      STATUS
Disk_0   auto:none  -        -          online invalid
Disk_1   auto:none  -        -          online invalid
...
```

8 To verify that the DMP paths are recognized, use the `vxdmpadm getdmpnode` command as shown in the following sample output for the example array:

```
# vxdmpadm getdmpnode enclosure=Disk
NAME   STATE   ENCLR-TYPE PATHS ENBL DSBL ENCLR-NAME
=====================================================
Disk_0 ENABLED Disk       2     2    0    Disk
Disk_1 ENABLED Disk       2     2    0    Disk
...
```

This shows that there are two paths to the disks in the array.

For more information, enter the command `vxddladm help addjbod`.

See the `vxddladm`(1M) manual page.

See the `vxdmpadm`(1M) manual page.

Removing disks from the DISKS category

To remove disks from the `DISKS` category

- Use the `vxddladm` command with the `rmjbod` keyword. The following example illustrates the command for removing disks which have the vendor id of SEAGATE:

```
# vxddladm rmjbod vid=SEAGATE
```

Foreign devices

DDL may not be able to discover some devices that are controlled by third-party drivers, such as those that provide multipathing or RAM disk capabilities. For these devices it may be preferable to use the multipathing capability that is provided by the third-party drivers for some arrays rather than using Dynamic Multi-Pathing (DMP). Such foreign devices can be made available as simple disks to VxVM by using the `vxddladm addforeign` command. This also has the effect of bypassing DMP for handling I/O. The following example shows how to add entries for block and character devices in the specified directories:

```
# vxddladm addforeign blockdir=/dev/foo/dsk \
  chardir=/dev/foo/rdsk
```

By default, this command suppresses any entries for matching devices in the OS-maintained device tree that are found by the autodiscovery mechanism. You can override this behavior by using the `-f` and `-n` options as described on the `vxddladm`(1M) manual page.

After adding entries for the foreign devices, use either the `vxdisk scandisks` or the `vxdctl enable` command to discover the devices as simple disks. These disks then behave in the same way as autoconfigured disks.

The foreign device feature was introduced in VxVM 4.0 to support non-standard devices such as RAM disks, some solid state disks, and pseudo-devices such as EMC PowerPath.

Foreign device support has the following limitations:

- A foreign device is always considered as a disk with a single path. Unlike an autodiscovered disk, it does not have a DMP node.
- It is not supported for shared disk groups in a clustered environment. Only standalone host systems are supported.
- It is not supported for Persistent Group Reservation (PGR) operations.
- It is not under the control of DMP, so enabling of a failed disk cannot be automatic, and DMP administrative commands are not applicable.
- Enclosure information is not available to VxVM. This can reduce the availability of any disk groups that are created using such devices.
- The I/O Fencing and Cluster File System features are not supported for foreign devices.

If a suitable ASL is available and installed for an array, these limitations are removed.

See “Third-party driver coexistence” on page 87.

VxVM coexistence with SVM and ZFS

Solaris Volume Manager (SVM) is a logical volume manager software provided by Sun. ZFS is a type of file system presenting a pooled storage model that Sun developed. File systems can directly draw from a common storage pool (zpool). Veritas Volume Manager (VxVM) can be used on the same system as SVM and ZFS disks.

VxVM protects devices in use by SVM or ZFS from any VxVM operations that may overwrite the disk. These operations include initializing the disk for use by VxVM or encapsulating the disk. If you attempt to perform one of these VxVM operations a device that is in use by SVM or ZFS, VxVM displays an error message.

Before you can manage an SVM disk or a ZFS disk with VxVM, you must remove it from SVM or ZFS control. Similarly, to begin managing a VxVM disk with SVM or ZFS, you must remove the disk from VxVM control.

To determine if a disk is in use by SVM or ZFS

- Use the `vxdisk list` command:

```
# vxdisk list
DEVICE                  TYPE            DISK    GROUP   STATUS
c1t0d0s2                auto:none       -       -       online invalid
c1t1d0s2                auto:none       -       -       online invalid
c2t5006016130603AE5d2s2 auto:ZFS        -       -       ZFS
c2t5006016130603AE5d3s2 auto:SVM        -       -       SVM
c2t5006016130603AE5d4s2 auto:cdsdisk    -       -       online
c2t5006016130603AE5d5s2 auto:cdsdisk    -       -       online
```

To reuse a VxVM disk as a ZFS disk or an SVM disk

1. If the disk is in a disk group, remove the disk from the disk group or destroy the disk group.

   To remove the disk from the disk group:

   ```
   # vxdg [-g diskgroup] rmdisk diskname
   ```

   To destroy the disk group:

   ```
   # vxdg destroy diskgroup
   ```

2. Remove the disk from VxVM control

   ```
   # /usr/lib/vxvm/bin/vxdiskunsetup diskname
   ```

3. You can now initialize the disk as a SVM/ZFS device using ZFS/SVM tools.

   See the Sun documentation for details.

   You must perform step 1 and step 2 in order for VxVM to recognize a disk as SVM or ZFS device.

To reuse a ZFS disk or an SVM disk as a VxVM disk

1. Remove the disk from the zpool or SVM metadevice, or destroy the zpool or SVM metadevice.

   See the Sun documentation for details.

2. Clear the signature block using the `dd` command:

   ```
   # dd if=/dev/zero of=/dev/rdsk/c#t#d#s# oseek=16 bs=512 count=1
   ```

   Where c#t#d#s# is the disk slice on which the ZFS device or the SVM device is configured. If the whole disk is used as the ZFS device, clear the signature block on slice 0.

3. You can now initialize the disk as a VxVM device using the **vxdiskadm** command or the **vxdisksetup** command.

Changing the disk-naming scheme

You can either use enclosure-based naming for disks or the operating system's naming scheme. ProductNameShort commands display device names according to the current naming scheme.

The default naming scheme is enclosure-based naming (EBN). When you use DMP with native volumes, the disk naming scheme must be EBN, and the use_avid attribute must be on.

Note: Devices with very long device names (longer than 31 characters) are represented by enclosure-based names regardless of the naming scheme. If the OS-based names include WWN identifiers, the device name displays with the WWN identifier as long as the device name is less than 31 characters. If any device name is longer than 31 characters, that device name displays with an enclosure name.

To change the disk-naming scheme

- Select `Change the disk naming scheme` from the `vxdiskadm` main menu to change the disk-naming scheme that you want VxVM to use. When prompted, enter `y` to change the naming scheme.

  Alternatively, you can change the naming scheme from the command line. Use the following command to select enclosure-based naming:

  ```
  # vxddladm set namingscheme=ebn [persistence={yes|no}] \
  [use_avid=yes|no] [lowercase=yes|no]
  ```

  Use the following command to select operating system-based naming:

  ```
  # vxddladm set namingscheme=osn [persistence={yes|no}] \
  [lowercase=yes|no]
  ```

  The optional `persistence` argument allows you to select whether the names of disk devices that are displayed by VxVM remain unchanged after disk hardware has been reconfigured and the system rebooted. By default, enclosure-based naming is persistent. Operating system-based naming is not persistent by default.

  By default, the names of the enclosure are converted to lowercase, regardless of the case of the name specified by the ASL. The enclosure-based device names are therefore in lower case. Set the `lowercase=no` option to suppress the conversion to lowercase.

  For enclosure-based naming, the `use_avid` option specifies whether the Array Volume ID is used for the index number in the device name. By default, `use_avid=yes`, indicating the devices are named as *enclosure_avid*. If `use_avid` is set to `no`, DMP devices are named as *enclosure_index*. The index number is assigned after the devices are sorted by LUN serial number.

  The change is immediate whichever method you use.

  See "Regenerating persistent device names" on page 105.

Displaying the disk-naming scheme

VxVM disk naming can be operating-system based naming or enclosure-based naming. This command displays whether the VxVM disk naming scheme is currently set. It also displays the attributes for the disk naming scheme, such as whether persistence is enabled.

To display the current disk-naming scheme and its mode of operations, use the following command:

```
# vxddladm get namingscheme
```

See "Disk device naming in VxVM" on page 20.

Regenerating persistent device names

The persistent device naming feature makes the names of disk devices persistent across system reboots. DDL assigns device names according to the persistent device name database.

If operating system-based naming is selected, each disk name is usually set to the name of one of the paths to the disk. After hardware reconfiguration and a subsequent reboot, the operating system may generate different names for the paths to the disks. Therefore, the persistent device names may no longer correspond to the actual paths. This does not prevent the disks from being used, but the association between the disk name and one of its paths is lost.

Similarly, if enclosure-based naming is selected, the device name depends on the name of the enclosure and an index number. If a hardware configuration changes the order of the LUNs exposed by the array, the persistent device name may not reflect the current index.

To regenerate persistent device names

- To regenerate the persistent names repository, use the following command:

  ```
  # vxddladm [-c] assign names
  ```

  The `-c` option clears all user-specified names and replaces them with autogenerated names.

  If the `-c` option is not specified, existing user-specified names are maintained, but OS-based and enclosure-based names are regenerated.

  The disk names now correspond to the new path names.

Changing device naming for TPD-controlled enclosures

By default, TPD-controlled enclosures use pseudo device names based on the TPD-assigned node names. If you change the device naming to native, the devices are named in the same format as other VxVM devices. The devices use either operating system names (OSN) or enclosure-based names (EBN), depending on which naming scheme is set.

See "Displaying the disk-naming scheme" on page 104.

To change device naming for TPD-controlled enclosures

- For disk enclosures that are controlled by third-party drivers (TPD) whose coexistence is supported by an appropriate ASL, the default behavior is to assign device names that are based on the TPD-assigned node names. You can use the `vxdmpadm` command to switch between these names and the device names that are known to the operating system:

  ```
  # vxdmpadm setattr enclosure enclosure tpdmode=native|pseudo
  ```

  The argument to the `tpdmode` attribute selects names that are based on those used by the operating system (`native`), or TPD-assigned node names (`pseudo`).

  The use of this command to change between TPD and operating system-based naming is illustrated in the following example for the enclosure named `EMC0`. In this example, the device-naming scheme is set to OSN.

  ```
  # vxdisk list

  DEVICE          TYPE             DISK       GROUP      STATUS
  emcpower10s2    auto:sliced      disk1      mydg       online
  emcpower11s2    auto:sliced      disk2      mydg       online
  emcpower12s2    auto:sliced      disk3      mydg       online
  emcpower13s2    auto:sliced      disk4      mydg       online
  emcpower14s2    auto:sliced      disk5      mydg       online
  emcpower15s2    auto:sliced      disk6      mydg       online
  emcpower16s2    auto:sliced      disk7      mydg       online
  emcpower17s2    auto:sliced      disk8      mydg       online
  emcpower18s2    auto:sliced      disk9      mydg       online
  emcpower19s2    auto:sliced      disk10     mydg       online

  # vxdmpadm setattr enclosure EMC0 tpdmode=native

  # vxdisk list

  DEVICE          TYPE             DISK       GROUP      STATUS
  c6t0d10s2       auto:sliced      disk1      mydg       online
  c6t0d11s2       auto:sliced      disk2      mydg       online
  c6t0d12s2       auto:sliced      disk3      mydg       online
  c6t0d13s2       auto:sliced      disk4      mydg       online
  c6t0d14s2       auto:sliced      disk5      mydg       online
  c6t0d15s2       auto:sliced      disk6      mydg       online
  c6t0d16s2       auto:sliced      disk7      mydg       online
  c6t0d17s2       auto:sliced      disk8      mydg       online
  c6t0d18s2       auto:sliced      disk9      mydg       online
  c6t0d19s2       auto:sliced      disk10     mydg       online
  ```

If `tpdmode` is set to `native`, the path with the smallest device number is displayed.

Simple or nopriv disks with enclosure-based naming

If you change from OS-based naming to enclosure-based naming, simple or nopriv disks may be put in the `error` state and cause VxVM objects on those disks to fail.

You can use the `vxdarestore` command to handle simple and nopriv disk failures that arise from changing to the enclosure-based naming scheme. You do not need to use this command if your system does not have any simple or nopriv disks, or if the devices on which any simple or nopriv disks are present are not automatically configured by VxVM (for example, non-standard disk devices such as ramdisks).

Note: You cannot run `vxdarestore` if OS-based naming is in use. Additionally, `vxdarestore` does not handle failures on simple or nopriv disks that are caused by renaming enclosures, by hardware reconfiguration that changes device names, or by changing the naming scheme on a system that includes persistent sliced disk records.

See "Removing the error state for simple or nopriv disks in the boot disk group" on page 107.

See "Removing the error state for simple or nopriv disks in non-boot disk groups" on page 108.

See the `vxdarestore`(1M) manual page.

Removing the error state for simple or nopriv disks in the boot disk group

If the boot disk group (usually aliased as `bootdg`) is comprised of only simple and/or nopriv disks, the `vxconfigd` daemon goes into the disabled state after the naming scheme change.

To remove the error state for simple or nopriv disks in the boot disk group

1. Use `vxdiskadm` to change back to c#t#d#s# naming.
2. Enter the following command to restart the VxVM configuration daemon:

   ```
   # vxconfigd -kr reset
   ```

3. If you want to use enclosure-based naming, use `vxdiskadm` to add a sliced disk to the `bootdg` disk group, change back to the enclosure-based naming scheme, and then run the following command:

   ```
   # vxdarestore
   ```

Removing the error state for simple or nopriv disks in non-boot disk groups

If an imported disk group, other than `bootdg`, is comprised of only simple and/or nopriv disks, the disk group is in the "`online dgdisabled`" state after the change to the enclosure-based naming scheme.

To remove the error state for simple or nopriv disks in non-boot disk groups

1. Deport the disk group using the following command:

   ```
   # vxdg deport diskgroup
   ```

2. Use the `vxdarestore` command to restore the failed disks, and to recover the objects on those disks:

   ```
   # vxdarestore
   ```

3. Re-import the disk group using the following command:

   ```
   # vxdg import diskgroup
   ```

Discovering the association between enclosure-based disk names and OS-based disk names

If you enable enclosure-based naming, the `vxprint` command displays the structure of a volume using enclosure-based disk device names (disk access names) rather than OS-based names.

To discover the association between enclosure-based disk names and OS-based disk names

- To discover the operating system-based names that are associated with a given enclosure-based disk name, use either of the following commands:

```
# vxdisk list enclosure-based_name
# vxdmpadm getsubpaths dmpnodename=enclosure-based_name
```

For example, to find the physical device that is associated with disk `ENC0_21`, the appropriate commands would be:

```
# vxdisk list ENC0_21
# vxdmpadm getsubpaths dmpnodename=ENC0_21
```

To obtain the full pathname for the block disk device and the character disk device from these commands, append the displayed device name to `/dev/vx/dmp` or `/dev/vx/rdmp`.

Chapter 5

Online dynamic reconfiguration

This chapter includes the following topics:

About online dynamic reconfiguration

You can perform the following kinds of online dynamic reconfigurations:

- Reconfiguring a LUN online that is under DMP control
- Replacing a host bus adapter (HBA) online
- Updating the array controller firmware, also known as a nondisruptive upgrade

Reconfiguring a LUN online that is under DMP control

System administrators and storage administrators may need to modify the set of LUNs provisioned to a server. You can change the LUN configuration dynamically, without performing a reconfiguration reboot on the host.

Dynamic LUN reconfigurations require array configuration commands, operating system commands, and Veritas Volume manager commands. To complete the operations correctly, you must issue the commands in the proper sequence on the host.

The operations are as follows:

- Dynamic LUN removal from an existing target ID
  See "Removing LUNs dynamically from an existing target ID" on page 112.
- Dynamic new LUN addition to a new target ID
  See "Adding new LUNs dynamically to a new target ID" on page 114.

Removing LUNs dynamically from an existing target ID

In this case, a group of LUNs is unmapped from the host HBA ports and an operating system device scan is issued. The device scan recognizes the LUNs and adds them to DMP control. To add subsequent LUNs seamlessly, perform additional steps to cleanup the operating system device tree.

The high-level procedure and the VxVM commands are generic. However, the operating system commands may vary depending on the Solaris version. For example, the following procedure uses Solaris 10 with the Leadville stack.

See "Reconfiguring a LUN online that is under DMP control" on page 111.

To remove LUNs dynamically from an existing target ID

1. Identify which LUNs to remove from the host. Do one of the following:
   - Use Storage Array Management to identify the Array Volume ID (AVID) for the LUNs.
   - If the array does not report the AVID, use the LUN index.
2. For LUNs under VxVM, perform the following steps:
   - Evacuate the data from the LUNs using the `vxevac` command.
     See the `vxevac`(1M) online manual page.
     After the data has been evacuated, enter the following command to remove the LUNs from the disk group:

     ```
     # vxdg -g diskgroup rmdisk da-name
     ```

   - If the data has not been evacuated and the LUN is part of a subdisk or disk group, enter the following command to remove the LUNs from the disk group. If the disk is part of a shared disk group, you must use the `-k` option to force the removal.

     ```
     # vxdg -g diskgroup -k rmdisk da-name
     ```

3. Using the AVID or LUN index, use Storage Array Management to unmap or unmask the LUNs you identified in step 1.

4 Remove the LUNs from the `vdisk` list. Enter the following command on all nodes in a cluster:

```
# vxdisk rm da-name
```

This is a required step. If you do not perform this step, the DMP device tree shows ghost paths.

5 Clean up the Solaris SCSI device tree for the devices that you removed in step 4.

See "Cleaning up the operating system device tree after removing LUNs" on page 116.

This is a required step. You must clean up the operating system SCSI device tree to release the SCSI target ID for reuse if a new LUN is added to the host later.

6 Scan the operating system device tree.

See "Scanning an operating system device tree after adding or removing LUNs" on page 115.

7 Use Volume Manager to perform a device scan. You must perform this operation on all nodes in a cluster. Enter one of the following commands:

- `# vxdctl enable`
- `# vxdisk scandisks`

8 Verify that the LUNs were removed cleanly by answering the following questions:

- Is the device tree clean?
  Verify that the operating system metanodes are removed from the `/dev` directory.
- Were all the appropriate LUNs removed?
  Use the DMP disk reporting tools such as the `vxdisk list` command output to determine if the LUNs have been cleaned up successfully.
- Is the `vxdisk list` output correct?
  Verify that the `vxdisk list` output shows the correct number of paths and does not include any ghost disks.

If the answer to any of these questions is "No," return to step 3 and perform the required steps.

If the answer to all of the questions is "Yes," the LUN remove operation is successful.

Adding new LUNs dynamically to a new target ID

In this case, a new group of LUNs is mapped to the host via multiple HBA ports. An operating system device scan is issued for the LUNs to be recognized and added to DMP control.

The high-level procedure and the VxVM commands are generic. However, the operating system commands may vary depending on the Solaris version. For example, the following procedure uses Solaris 10 with the Leadville stack.

To add new LUNs dynamically to a new target ID

1. If DMP co-exists with EMC PowerPath, make sure the `dmp_monitor_osevent` parameter is set to `off`. The `vxesd` daemon will not monitor operating system events.

   If you install DMP on a system that already has PowerPath installed, DMP sets the `dmp_monitor_osevent` to `off` by default.

   ```
   # vxdmpadm gettune dmp_monitor_osevent
   ```

   If required, turn off the `dmp_monitor_osevent` parameter explicitly:

   ```
   # vxdmpadm settune dmp_monitor_osevent=off
   ```

2. Identify which LUNs to add to the host. Do one of the following:
   - Use Storage Array Management to identify the Array Volume ID (AVID) for the LUNs.
   - If the array does not report the AVID, use the LUN index.
3. Map/mask the LUNs to the new target IDs on multiple hosts.
4. Scan the operating system device.

   See "Scanning an operating system device tree after adding or removing LUNs" on page 115.

   Repeat step 2 and step 3 until you see that all the LUNs have been added.
5. Use Volume Manager to perform a device scan. You must perform this operation on all nodes in a cluster. Enter one of the following commands:
   - `# vxdctl enable`
   - `# vxdisk scandisks`
6. Verify that the LUNs were added correctly by answering the following questions:

- Do the newly provisioned LUNs appear in the `vxdisk list` output?
- Are the configured paths present for each LUN?

If the answer to any of these questions is "No," return to step 2 and begin the procedure again.

If the answer to all of the questions is "Yes," the LUNs have been successfully added. You can now add the LUNs to a disk group, create new volumes, or grow existing volumes.

If the dmp_native_support is ON and the new LUN does not have a VxVM label or is not claimed by a TPD driver then it is available for use by ZFS.

About detecting target ID reuse if the operating system device tree is not cleaned up

If you try to reprovision a LUN or set of LUNs whose previously-valid operating system device entries are not cleaned up, the following messages are displayed. Also, DMP reconfiguration during the DMP device scan and DMP reconfiguration are temporarily inhibited.

See "Cleaning up the operating system device tree after removing LUNs" on page 116.

```
VxVM vxdisk ERROR V-5-1-14519 Data Corruption Protection Activated
- User Corrective Action Needed

VxVM vxdisk INFO V-5-1-14521 To recover, first ensure that the OS
device tree is up to date (requires OS specific commands).

VxVM vxdisk INFO V-5-1-14520 Then, execute 'vxdisk rm' on the
following devices before reinitiating device discovery. <DA names>
```

The message above indicates that a new LUN is trying to reuse the target ID of an older LUN. The device entries have not been cleaned, so the new LUN cannot use the target ID. Until the operating system device tree is cleaned up, DMP prevents this operation.

Scanning an operating system device tree after adding or removing LUNs

After you add or remove LUNs, scan the operating system device tree to verify that the operation completed successfully.

The operating system commands may vary, depending on the Solaris version. The following procedure uses Solaris 10 with the Leadville stack.

To scan an operating system device tree after adding or removing LUNs

1 Enter the following command:

```
# cfgadm -c configure c2
```

where `c2` is the controller ID 2.

2 Enter the following command:

```
# devfsadm -Cv
```

Cleaning up the operating system device tree after removing LUNs

After you remove LUNs, you must clean up the operating system device tree. The operating system commands may vary, depending on the Solaris version. The following procedure uses Solaris 10 with the Leadville stack. If any of these steps do not produce the desired result, contact Sun support.

To clean up the operating system device tree after removing LUNs

1 Run the `format` command. In the command output, a device that has been removed includes the text `<drive not available>`.

```
413. c3t5006048ACAFE4A7Cd252 <drive not available>
/pci@1d,700000/SUNW,qlc@1,1/fp@0,0/ssd@w5006048acafe4a7c,fc
```

2 Use Storage Array Management or the command line to unmap the LUNs. After they are unmapped, Solaris indicates the devices are either `unusable` or `failing`.

```
# cfgadm -al -o show_SCSI_LUN | grep -i unusable
c2::5006048acafe4a73,256 disk connected configured unusable
c3::5006048acafe4a7c,255 disk connected configured unusable
# cfgadm -al -o show_SCSI_LUN | grep -i failing
c2::5006048acafe4a73,71 disk connected configured failing
c3::5006048acafe4a7c,252 disk connected configured failing
```

See "Reconfiguring a LUN online that is under DMP control" on page 111.

3 If the output indicates the LUNs are `failing`, you must force an LIP on the HBA.

```
# luxadm -e forcelip /devices/pci@1d,700000/SUNW,qlc@1,1/fp@0,0:devctl
```

This operation probes the targets again, so that output indicates the devices are `unstable`. To remove a device from the operating system device tree, it must be `unstable`.

4 Remove the device from the `cfgadm` database. On the HBA, enter the following commands:

```
# cfgadm -c unconfigure -o unusable_SCSI_LUN c2::5006048acafe4a73
# cfgadm -c unconfigure -o unusable_SCSI_LUN c3::5006048acafe4a7c
```

5 To verify that the LUNs have been removed, repeat step 2.

6 Clean up the device tree. The following command removes the `/dev/dsk` links to `/devices`.

```
# devfsadm -Cv
```

Upgrading the array controller firmware online

Storage array subsystems need code upgrades as fixes, patches, or feature upgrades. You can perform these upgrades online when the file system is mounted and I/Os are being served to the storage.

Legacy storage subsystems contain two controllers for redundancy. An online upgrade is done one controller at a time. DMP fails over all I/O to the second controller while the first controller is undergoing an Online Controller Upgrade. After the first controller has completely staged the code, it reboots, resets, and comes online with the new version of the code. The second controller goes through the same process, and I/O fails over to the first controller.

Note: Throughout this process, application I/O is not affected.

Array vendors have different names for this process. For example, EMC calls it a nondisruptive upgrade (NDU) for CLARiiON arrays.

A/A type arrays require no special handling during this online upgrade process. For A/P, A/PF, and ALUA type arrays, DMP performs array-specific handling through vendor-specific array policy modules (APMs) during an online controller code upgrade.

When a controller resets and reboots during a code upgrade, DMP detects this state through the SCSI Status. DMP immediately fails over all I/O to the next controller.

If the array does not fully support NDU, all paths to the controllers may be unavailable for I/O for a short period of time. Before beginning the upgrade, set the `dmp_lun_retry_timeout` tunable to a period greater than the time that you expect the controllers to be unavailable for I/O. DMP retries the I/Os until the end of the `dmp_lun_retry_timeout` period, or until the I/O succeeds, whichever happens first. Therefore, you can perform the firmware upgrade without interrupting the application I/Os.

For example, if you expect the paths to be unavailable for I/O for 300 seconds, use the following command:

```
# vxdmpadm settune dmp_lun_retry_timeout=300
```

DMP retries the I/Os for 300 seconds, or until the I/O succeeds.

To verify which arrays support Online Controller Upgrade or NDU, see the hardware compatibility list (HCL) at the following URL:

http://entsupport.symantec.com/docs/330441

Chapter 6

Event monitoring

This chapter includes the following topics:

About the event source daemon (vxesd)

The event source daemon (`vxesd`) is a Veritas Dynamic Multi-Pathing (DMP) component process that receives notifications of any device-related events that are used to take appropriate actions. The benefits of `vxesd` include:

- Monitoring of SAN fabric events and proactive error detection (SAN event)
- Logging of DMP events for troubleshooting (DMP event)
- Automated device discovery (OS event)
- Discovery of SAN components and HBA-array port connectivity (Fibre Channel and iSCSI)

Fabric Monitoring and proactive error detection

In previous releases, DMP handled failed paths reactively, by only disabling paths when active I/O failed on the storage. Using the Storage Networking Industry Association (SNIA) HBA API library, `vxesd` now is able to receive SAN fabric events

from the HBA. This information allows DMP to take a proactive role by checking suspect devices from the SAN events, even if there is no active I/O. New I/O is directed to healthy paths while the suspect devices are verified.

During startup, `vxesd` queries the HBA (by way of the SNIA library) to obtain the SAN topology. The `vxesd` daemon determines the Port World Wide Names (PWWN) that correspond to each of the device paths that are visible to the operating system. After the `vxesd` daemon obtains the topology, `vxesd` registers with the HBA for SAN event notification. If LUNs are disconnected from a SAN, the HBA notifies `vxesd` of the SAN event, specifying the PWWNs that are affected. The `vxesd` daemon uses this event information and correlates it with the previous topology information to determine which set of device paths have been affected.

The `vxesd` daemon sends the affected set to the `vxconfigd` daemon (DDL) so that the device paths can be marked as suspect. When the path is marked as suspect, DMP does not send new I/O to the path unless it is the last path to the device. In the background, the DMP restore daemon checks the accessibility of the paths on its next periodic cycle using a SCSI inquiry probe. If the SCSI inquiry fails, DMP disables the path to the affected LUNs, which is also logged in the event log.

By default, the DMP restore daemon uses check_disabled mode. The check_disabled mode indicates that the restore daemon checks disabled, suspect, and idle paths. If the LUNs are reconnected at a later time, the HBA informs `vxesd` of the SAN event. When the DMP restore daemon runs its next test cycle, the disabled paths are checked with the SCSI probe and re-enabled if successful.

Note: If `vxesd` receives an HBA LINK UP event, the DMP restore daemon is restarted and the SCSI probes run immediately, without waiting for the next periodic cycle. When the DMP restore daemon is restarted, it starts a new periodic cycle. If the disabled paths are not accessible by the time of the first SCSI probe, they are re-tested on the next cycle (300s by default).

The fabric monitor functionality is enabled by default. The value of the `dmp_monitor_fabric` tunable is persistent across reboots.

To disable the Fabric Monitoring functionality, use the following command:

```
# vxdmpadm settune dmp_monitor_fabric=off
```

To enable the Fabric Monitoring functionality, use the following command:

```
# vxdmpadm settune dmp_monitor_fabric=on
```

To display the current value of the `dmp_monitor_fabric` tunable, use the following command:

```
# vxdmpadm gettune dmp_monitor_fabric
```

Automated device discovery

In releases before VxVM 4.0, VxVM device discovery required manual invocation of commands such as `vxdisk scandisks` or `vxdctl enable`. `vxesd` automates the discovery process by interfacing with the Reconfiguration Coordination Manager (RCM) framework.

The `vxesd` daemon registers the script `es_devfs.pl` with the Solaris `syseventd` daemon for device arrival events. In the event that `cfgadm` is invoked to attach a new device to the system, the `syseventd` daemon executes the scripts that are registered for device arrival events, including `es_devfs.pl`. The `es_devfs.pl` script establishes a socket with `vxesd` and transfers the event parameter (physical path of device) to the daemon. The `vxesd` daemon in turn connects to the `vxconfigd` daemon to initiate DDL device discovery for the device that had arrived. The whole operation takes place asynchronously so that the `cfgadm` command returns after the event has been added to the `syseventd` queue.

In the event that a device is removed with `cfgadm`, a similar process exists which uses the `es_rcm.pl` script to disable the relevant DMP paths. The removal operation is synchronous so that the `cfgadm` command waits until all the registered detach scripts have completed execution.

Note: On systems with EMC PowerPath, a slow PowerPath discovery process may lead to a device being automatically claimed and controlled by DMP control. In such scenarios, the `vxesd` daemon may be stopped before the addition of the disk and restart after PowerPath has claimed control of the device.

Discovery of iSCSI and SAN Fibre Channel topology

The `vxesd` builds a topology of iSCSI and Fibre Channel devices that are visible to the host. On Solaris, the `vxesd` daemon uses the iSCSI management API (IMA) to build the topology.

To display the hierarchical listing of Fibre Channel and iSCSI devices, use the following command:

```
# vxddladm list
```

See the `vxddladm(1M)` manual page.

DMP event logging

DMP notifies `vxesd` of major events, and `vxesd` logs the event in a log file (/etc/vx/dmpevents.log). These events include:

- Marking paths or dmpnodes enabled
- Marking paths or dmpnodes disabled
- Throttling of paths i/o error analysis HBA/SAN events

The log file is located in `/var/adm/vx/dmpevents.log` but is symbolically linked to `/etc/vx/dmpevents.log`. When the file reaches 10,000 lines, the log is rotated. That is, dmpevents.log is renamed dmpevents.log.X and a new dmpevents.log file is created.

You can change the level of detail in the event log file using the tunable `dmp_log_level`. Valid values are 1 through 4.

```
# vxdmpadm settune dmp_log_level=X
```

The current value of dmp-log_level can be displayed with:

```
# vxdmpadm gettune dmp_log_level
```

For details on the various log levels, see the `vxdmpadm`(1M) manual page.

Starting and stopping the event source daemon

By default, VxVM starts `vxesd` at boot time.

To stop the `vxesd` daemon, use the `vxddladm` utility:

```
# vxddladm stop eventsource
```

To start the `vxesd` daemon, use the `vxddladm` utility:

```
# vxddladm start eventsource [logfile=logfilename]
```

To disable `vxesd` from starting at boot, modify the start script to comment out the command:

```
# vxddladm start eventsource
```

Chapter 7

Performance monitoring and tuning

This chapter includes the following topics:

DMP tunable parameters

DMP tunables are set online (without requiring a reboot) by using the `vxdmpadm` command as shown here:

```
# vxdmpadm settune dmp_tunable=value
```

The values of these tunables can be displayed by using this command:

```
# vxdmpadm gettune [dmp_tunable]
```

Table 7-1 shows the DMP parameters that can be tuned by using the `vxdmpadm settune` command.

Table 7-1 DMP parameters that are tunable

Parameter	Description
`dmp_cache_open`	If this parameter is set to `on`, the first open of a device that is performed by an array support library (ASL) is cached. This caching enhances the performance of device discovery by minimizing the overhead that is caused by subsequent opens by ASLs. If this parameter is set to `off`, caching is not performed. The default value is `on`.

Table 7-1 DMP parameters that are tunable *(continued)*

Parameter	Description
`dmp_daemon_count`	The number of kernel threads that are available for servicing path error handling, path restoration, and other DMP administrative tasks. The default number of threads is 10.
`dmp_delayq_interval`	How long DMP should wait before retrying I/O after an array fails over to a standby path. Some disk arrays are not capable of accepting I/O requests immediately after failover. The default value is 15 seconds.
`dmp_enable_restore`	If this parameter is set to `on`, it enables the path restoration thread to be started. See "Configuring DMP path restoration policies" on page 79. If this parameter is set to `off`, it disables the path restoration thread. If the path restoration thread is currently running, use the `vxdmpadm stop restore` command to stop the process. The default is `on`. See "Stopping the DMP path restoration thread" on page 81.
`dmp_fast_recovery`	Whether DMP should try to obtain SCSI error information directly from the HBA interface. Setting the value to `on` can potentially provide faster error recovery, provided that the HBA interface supports the error enquiry feature. If this parameter is set to `off`, the HBA interface is not used. The default setting is `on`.

Table 7-1 DMP parameters that are tunable *(continued)*

Parameter	Description
dmp_health_time	DMP detects intermittently failing paths, and prevents I/O requests from being sent on them. The value of dmp_health_time represents the time in seconds for which a path must stay healthy. If a path's state changes back from enabled to disabled within this time period, DMP marks the path as intermittently failing, and does not re-enable the path for I/O until dmp_path_age seconds elapse. The default value is 60 seconds. A value of 0 prevents DMP from detecting intermittently failing paths.
dmp_log_level	The level of detail that is displayed for DMP console messages. The following level values are defined: 1 — Displays all DMP log messages that existed in releases before 5.0. 2 — Displays level 1 messages plus messages that relate to path or disk addition or removal, SCSI errors, IO errors and DMP node migration. 3 — Displays level 1 and 2 messages plus messages that relate to path throttling, suspect path, idle path and insane path logic. 4 — Displays level 1, 2 and 3 messages plus messages that relate to setting or changing attributes on a path and tunable related changes. The default value is 1.
dmp_low_impact_probe	Determines if the path probing by restore daemon is optimized or not. Set it to on to enable optimization and off to disable. Path probing is optimized only when restore policy is check_disabled or during check_disabled phase of check_periodic policy. The default value is on.

Table 7-1 DMP parameters that are tunable *(continued)*

Parameter	Description
dmp_lun_retry_timeout	Retry period for handling transient errors. The value is specified in seconds. When all paths to a disk fail, there may be certain paths that have a temporary failure and are likely to be restored soon. The I/Os may be failed to the application layer even though the failures are transient, unless the I/Os are retried. The dmp_lun_retry_timeout tunable provides a mechanism to retry such transient errors. If the tunable is set to a non-zero value, I/Os to a disk with all failed paths are retried until dmp_lun_retry_timeout interval or until the I/O succeeds on one of the path, whichever happens first. The default value of tunable is 0, which means that the paths are probed only once.
dmp_monitor_fabric	Determines whether the Event Source daemon (vxesd) uses the Storage Networking Industry Association (SNIA) HBA API. This API allows DDL to improve the performance of failover by collecting information about the SAN topology and by monitoring fabric events. If this parameter is set to on, DDL uses the SNIA HBA API. (Note that the HBA vendor specific HBA-API library should be available to use this feature.) If this parameter is set to off, the SNIA HBA API is not used. The default setting is off for releases before 5.0 that have been patched to support this DDL feature. The default setting is on for 5.0 and later releases.

Table 7-1 DMP parameters that are tunable *(continued)*

Parameter	Description
dmp_monitor_osevent	Determines whether the Event Source daemon (vxesd) monitors operating system events such as reconfiguration operations. If this parameter is set to on, vxesd monitors operations such as attaching operating system devices. If this parameter is set to off, vxesd does not monitor operating system operations. When DMP co-exists with EMC PowerPath, Symantec recommends setting this parameter to off to avoid any issues. The default setting is on, unless EMC PowerPath is installed. If you install DMP on a system that already has PowerPath installed, DMP sets the dmp_monitor_osevent to off.
dmp_native_multipathing	Determines whether DMP will intercept the I/Os directly on the raw OS paths or not. Set the tunable to on to have DMP do multipathing of IOs done directly on raw paths, otherwise set it to off. The default value is off.
dmp_native_support	Determines whether DMP will do multipathing for native devices. Set the tunable to on to have DMP do multipathing for native devices. The default value is off.
dmp_path_age	The time for which an intermittently failing path needs to be monitored as healthy before DMP again tries to schedule I/O requests on it. The default value is 300 seconds. A value of 0 prevents DMP from detecting intermittently failing paths.

Table 7-1 DMP parameters that are tunable *(continued)*

Parameter	Description
dmp_pathswitch_blks_shift	The default number of contiguous I/O blocks that are sent along a DMP path to an array before switching to the next available path. The value is expressed as the integer exponent of a power of 2; for example 9 represents 512 blocks. The default value of this parameter is set to 9. In this case, 512 blocks (256k) of contiguous I/O are sent over a DMP path before switching. For intelligent disk arrays with internal data caches, better throughput may be obtained by increasing the value of this tunable. For example, for the HDS 9960 A/A array, the optimal value is between 15 and 17 for an I/O activity pattern that consists mostly of sequential reads or writes. This parameter only affects the behavior of the balanced I/O policy. A value of 0 disables multipathing for the policy unless the vxdmpadm command is used to specify a different partition size for an array. See "Specifying the I/O policy" on page 65.
dmp_probe_idle_lun	If DMP statistics gathering is enabled, set this tunable to on (default) to have the DMP path restoration thread probe idle LUNs. Set this tunable to off to turn off this feature. (Idle LUNs are VM disks on which no I/O requests are scheduled.) The value of this tunable is only interpreted when DMP statistics gathering is enabled. Turning off statistics gathering also disables idle LUN probing. The default value is on.
dmp_probe_threshold	If the dmp_low_impact_probe is turned on, dmp_probe_threshold determines the number of paths to probe before deciding on changing the state of other paths in the same subpath failover group. The default value is 5.

Table 7-1 DMP parameters that are tunable *(continued)*

Parameter	Description
dmp_queue_depth	The maximum number of queued I/O requests on a path during I/O throttling. The default value is 32. A value can also be set for paths to individual arrays by using the vxdmpadm command. See "Configuring the I/O throttling mechanism" on page 75.
dmp_restore_cycles	If the DMP restore policy is check_periodic, the number of cycles after which the check_all policy is called. The default value is 10. The value of this tunable can also be set using the vxdmpadm start restore command. See "Configuring DMP path restoration policies" on page 79.
dmp_restore_interval	The interval attribute specifies how often the path restoration thread examines the paths. Specify the time in seconds. The default value is 300. The value of this tunable can also be set using the vxdmpadm start restore command. See "Configuring DMP path restoration policies" on page 79.
dmp_restore_policy	The DMP restore policy, which can be set to one of the following values: ■ check_all ■ check_alternate ■ check_disabled ■ check_periodic The default value is check_disabled. The value of this tunable can also be set using the vxdmpadm start restore command. See "Configuring DMP path restoration policies" on page 79.

Table 7-1 DMP parameters that are tunable *(continued)*

Parameter	Description
dmp_retry_count	If an inquiry succeeds on a path, but there is an I/O error, the number of retries to attempt on the path. The default value is 5. A value can also be set for paths to individual arrays by using the vxdmpadm command. See "Configuring the response to I/O failures" on page 74.
dmp_scsi_timeout	Determines the timeout value to be set for any SCSI command that is sent via DMP. If the HBA does not receive a response for a SCSI command that it has sent to the device within the timeout period, the SCSI command is returned with a failure error code.
dmp_sfg_threshold	Determines the minimum number of paths that should be failed in a failover group before DMP starts suspecting other paths in the same failover group. The value of 0 disables the failover logic based on subpath failover groups. The default value is 1.
dmp_stat_interval	The time interval between gathering DMP statistics. The default and minimum value are 1 second.

Glossary

Active/Active disk arrays	This type of multipathed disk array allows you to access a disk in the disk array through all the paths to the disk simultaneously, without any performance degradation.
Active/Passive disk arrays	This type of multipathed disk array allows one path to a disk to be designated as primary and used to access the disk at any time. Using a path other than the designated active path results in severe performance degradation in some disk arrays.
associate	The process of establishing a relationship between VxVM objects; for example, a subdisk that has been created and defined as having a starting point within a plex is referred to as being associated with that plex.
associated plex	A plex associated with a volume.
associated subdisk	A subdisk associated with a plex.
atomic operation	An operation that either succeeds completely or fails and leaves everything as it was before the operation was started. If the operation succeeds, all aspects of the operation take effect at once and the intermediate states of change are invisible. If any aspect of the operation fails, then the operation aborts without leaving partial changes. In a cluster, an atomic operation takes place either on all nodes or not at all.
attached	A state in which a VxVM object is both associated with another object and enabled for use.
block	The minimum unit of data transfer to or from a disk or array.
boot disk	A disk that is used for the purpose of booting a system.
boot disk group	A private disk group that contains the disks from which the system may be booted.
bootdg	A reserved disk group name that is an alias for the name of the boot disk group.
clean node shutdown	The ability of a node to leave a cluster gracefully when all access to shared volumes has ceased.
cluster	A set of hosts (each termed a node) that share a set of disks.
cluster manager	An externally-provided daemon that runs on each node in a cluster. The cluster managers on each node communicate with each other and inform VxVM of changes in cluster membership.

cluster-shareable disk group A disk group in which access to the disks is shared by multiple hosts (also referred to as a shared disk group).

column A set of one or more subdisks within a striped plex. Striping is achieved by allocating data alternately and evenly across the columns within a plex.

concatenation A layout style characterized by subdisks that are arranged sequentially and contiguously.

configuration copy A single copy of a configuration database.

configuration database A set of records containing detailed information on existing VxVM objects (such as disk and volume attributes).

DCO (data change object) A VxVM object that is used to manage information about the FastResync maps in the DCO volume. Both a DCO object and a DCO volume must be associated with a volume to implement Persistent FastResync on that volume.

data stripe This represents the usable data portion of a stripe and is equal to the stripe minus the parity region.

DCO volume A special volume that is used to hold Persistent FastResync change maps and dirty region logs. See also see dirty region logging.

detached A state in which a VxVM object is associated with another object, but not enabled for use.

device name The device name or address used to access a physical disk, such as `c0t0d0s2`. The `c#t#d#s#` syntax identifies the controller, target address, disk, and slice (or partition).

In a SAN environment, it is more convenient to use enclosure-based naming, which forms the device name by concatenating the name of the enclosure (such as `enc0`) with the disk's number within the enclosure, separated by an underscore (for example, `enc0_2`). The term disk access name can also be used to refer to a device name.

dirty region logging The method by which the VxVM monitors and logs modifications to a plex as a bitmap of changed regions. For a volumes with a new-style DCO volume, the dirty region log (DRL) is maintained in the DCO volume. Otherwise, the DRL is allocated to an associated subdisk called a log subdisk.

disabled path A path to a disk that is not available for I/O. A path can be disabled due to real hardware failures or if the user has used the `vxdmpadm disable` command on that controller.

disk A collection of read/write data blocks that are indexed and can be accessed fairly quickly. Each disk has a universally unique identifier.

disk access name An alternative term for a device name.

disk access records Configuration records used to specify the access path to particular disks. Each disk access record contains a name, a type, and possibly some type-specific information, which is used by VxVM in deciding how to access and manipulate the disk that is defined by the disk access record.

disk array A collection of disks logically arranged into an object. Arrays tend to provide benefits such as redundancy or improved performance.

disk array serial number This is the serial number of the disk array. It is usually printed on the disk array cabinet or can be obtained by issuing a vendor- specific SCSI command to the disks on the disk array. This number is used by the DMP subsystem to uniquely identify a disk array.

disk controller In the multipathing subsystem of VxVM, the controller (host bus adapter or HBA) or disk array connected to the host, which the operating system represents as the parent node of a disk.

For example, if a disk is represented by the device name `/dev/sbus@1f,0/QLGC,isp@2,10000/sd@8,0:c` then the path component `QLGC,isp@2,10000` represents the disk controller that is connected to the host for disk `sd@8,0:c`.

disk enclosure An intelligent disk array that usually has a backplane with a built-in Fibre Channel loop, and which permits hot-swapping of disks.

disk group A collection of disks that share a common configuration. A disk group configuration is a set of records containing detailed information on existing VxVM objects (such as disk and volume attributes) and their relationships. Each disk group has an administrator-assigned name and an internally defined unique ID. The disk group names `bootdg` (an alias for the boot disk group), `defaultdg` (an alias for the default disk group) and `nodg` (represents no disk group) are reserved.

disk group ID A unique identifier used to identify a disk group.

disk ID A universally unique identifier that is given to each disk and can be used to identify the disk, even if it is moved.

disk media name An alternative term for a disk name.

disk media record A configuration record that identifies a particular disk, by disk ID, and gives that disk a logical (or administrative) name.

disk name A logical or administrative name chosen for a disk that is under the control of VxVM, such as `disk03`. The term disk media name is also used to refer to a disk name.

dissociate The process by which any link that exists between two VxVM objects is removed. For example, dissociating a subdisk from a plex removes the subdisk from the plex and adds the subdisk to the free space pool.

dissociated plex	A plex dissociated from a volume.
dissociated subdisk	A subdisk dissociated from a plex.
distributed lock manager	A lock manager that runs on different systems in a cluster, and ensures consistent access to distributed resources.
enabled path	A path to a disk that is available for I/O.
encapsulation	A process that converts existing partitions on a specified disk to volumes. If any partitions contain file systems, `/etc/vfstab` entries are modified so that the file systems are mounted on volumes instead.
enclosure	See disk enclosure.
enclosure-based naming	See device name.
fabric mode disk	A disk device that is accessible on a Storage Area Network (SAN) via a Fibre Channel switch.
FastResync	A fast resynchronization feature that is used to perform quick and efficient resynchronization of stale mirrors, and to increase the efficiency of the snapshot mechanism.
Fibre Channel	A collective name for the fiber optic technology that is commonly used to set up a Storage Area Network (SAN).
file system	A collection of files organized together into a structure. The UNIX file system is a hierarchical structure consisting of directories and files.
free space	An area of a disk under VxVM control that is not allocated to any subdisk or reserved for use by any other VxVM object.
free subdisk	A subdisk that is not associated with any plex and has an empty `putil[0]` field.
hostid	A string that identifies a host to VxVM. The host ID for a host is stored in its `volboot` file, and is used in defining ownership of disks and disk groups.
hot-relocation	A technique of automatically restoring redundancy and access to mirrored and RAID-5 volumes when a disk fails. This is done by relocating the affected subdisks to disks designated as spares and/or free space in the same disk group.
hot-swap	Refers to devices that can be removed from, or inserted into, a system without first turning off the power supply to the system.
initiating node	The node on which the system administrator is running a utility that requests a change to VxVM objects. This node initiates a volume reconfiguration.
JBOD (just a bunch of disks)	The common name for an unintelligent disk array which may, or may not, support the hot-swapping of disks.
log plex	A plex used to store a RAID-5 log. The term log plex may also be used to refer to a Dirty Region Logging plex.

log subdisk A subdisk that is used to store a dirty region log.

master node A node that is designated by the software to coordinate certain VxVM operations in a cluster. Any node is capable of being the master node.

mastering node The node to which a disk is attached. This is also known as a disk owner.

mirror A duplicate copy of a volume and the data therein (in the form of an ordered collection of subdisks). Each mirror consists of one plex of the volume with which the mirror is associated.

mirroring A layout technique that mirrors the contents of a volume onto multiple plexes. Each plex duplicates the data stored on the volume, but the plexes themselves may have different layouts.

multipathing Where there are multiple physical access paths to a disk connected to a system, the disk is called multipathed. Any software residing on the host, (for example, the DMP driver) that hides this fact from the user is said to provide multipathing functionality.

node One of the hosts in a cluster.

node abort A situation where a node leaves a cluster (on an emergency basis) without attempting to stop ongoing operations.

node join The process through which a node joins a cluster and gains access to shared disks.

Non-Persistent FastResync A form of FastResync that cannot preserve its maps across reboots of the system because it stores its change map in memory.

object An entity that is defined to and recognized internally by VxVM. The VxVM objects are: volume, plex, subdisk, disk, and disk group. There are actually two types of disk objects—one for the physical aspect of the disk and the other for the logical aspect.

parity A calculated value that can be used to reconstruct data after a failure. While data is being written to a RAID-5 volume, parity is also calculated by performing an exclusive OR (XOR) procedure on data. The resulting parity is then written to the volume. If a portion of a RAID-5 volume fails, the data that was on that portion of the failed volume can be recreated from the remaining data and the parity.

parity stripe unit A RAID-5 volume storage region that contains parity information. The data contained in the parity stripe unit can be used to help reconstruct regions of a RAID-5 volume that are missing because of I/O or disk failures.

partition The standard division of a physical disk device, as supported directly by the operating system and disk drives.

path When a disk is connected to a host, the path to the disk consists of the HBA (Host Bus Adapter) on the host, the SCSI or fibre cable connector and the controller on the disk or disk array. These components constitute a path to a disk. A failure on

	any of these results in DMP trying to shift all I/O for that disk onto the remaining (alternate) paths.
pathgroup	In the case of disks which are not multipathed by `vxdmp`, VxVM will see each path as a disk. In such cases, all paths to the disk can be grouped. This way only one of the paths from the group is made visible to VxVM.
Persistent FastResync	A form of FastResync that can preserve its maps across reboots of the system by storing its change map in a DCO volume on disk).
persistent state logging	A logging type that ensures that only active mirrors are used for recovery purposes and prevents failed mirrors from being selected for recovery. This is also known as kernel logging.
physical disk	The underlying storage device, which may or may not be under VxVM control.
plex	A plex is a logical grouping of subdisks that creates an area of disk space independent of physical disk size or other restrictions. Mirroring is set up by creating multiple data plexes for a single volume. Each data plex in a mirrored volume contains an identical copy of the volume data. Plexes may also be created to represent concatenated, striped and RAID-5 volume layouts, and to store volume logs.
primary path	In Active/Passive disk arrays, a disk can be bound to one particular controller on the disk array or owned by a controller. The disk can then be accessed using the path through this particular controller.
private disk group	A disk group in which the disks are accessed by only one specific host in a cluster.
private region	A region of a physical disk used to store private, structured VxVM information. The private region contains a disk header, a table of contents, and a configuration database. The table of contents maps the contents of the disk. The disk header contains a disk ID. All data in the private region is duplicated for extra reliability.
public region	A region of a physical disk managed by VxVM that contains available space and is used for allocating subdisks.
RAID (redundant array of independent disks)	A disk array set up with part of the combined storage capacity used for storing duplicate information about the data stored in that array. This makes it possible to regenerate the data if a disk failure occurs.
read-writeback mode	A recovery mode in which each read operation recovers plex consistency for the region covered by the read. Plex consistency is recovered by reading data from blocks of one plex and writing the data to all other writable plexes.
root configuration	The configuration database for the root disk group. This is special in that it always contains records for other disk groups, which are used for backup purposes only. It also contains disk records that define all disk devices on the system.
root disk	The disk containing the root file system. This disk may be under VxVM control.

root file system The initial file system mounted as part of the UNIX kernel startup sequence.

root partition The disk region on which the root file system resides.

root volume The VxVM volume that contains the root file system, if such a volume is designated by the system configuration.

rootability The ability to place the `root` file system and the `swap` device under VxVM control. The resulting volumes can then be mirrored to provide redundancy and allow recovery in the event of disk failure.

secondary path In Active/Passive disk arrays, the paths to a disk other than the primary path are called secondary paths. A disk is supposed to be accessed only through the primary path until it fails, after which ownership of the disk is transferred to one of the secondary paths.

sector A unit of size, which can vary between systems. Sector size is set per device (hard drive, CD-ROM, and so on). Although all devices within a system are usually configured to the same sector size for interoperability, this is not always the case.

A sector is commonly 512 bytes.

shared disk group A disk group in which access to the disks is shared by multiple hosts (also referred to as a cluster-shareable disk group).

shared volume A volume that belongs to a shared disk group and is open on more than one node of a cluster at the same time.

shared VM disk A VM disk that belongs to a shared disk group in a cluster.

slave node A node that is not designated as the master node of a cluster.

slice The standard division of a logical disk device. The terms partition and slice are sometimes used synonymously.

snapshot A point-in-time copy of a volume (volume snapshot) or a file system (file system snapshot).

spanning A layout technique that permits a volume (and its file system or database) that is too large to fit on a single disk to be configured across multiple physical disks.

sparse plex A plex that is not as long as the volume or that has holes (regions of the plex that do not have a backing subdisk).

SAN (storage area network) A networking paradigm that provides easily reconfigurable connectivity between any subset of computers, disk storage and interconnecting hardware such as switches, hubs and bridges.

stripe A set of stripe units that occupy the same positions across a series of columns.

stripe size The sum of the stripe unit sizes comprising a single stripe across all columns being striped.

stripe unit Equally-sized areas that are allocated alternately on the subdisks (within columns) of each striped plex. In an array, this is a set of logically contiguous blocks that exist on each disk before allocations are made from the next disk in the array. A stripe unit may also be referred to as a stripe element.

stripe unit size The size of each stripe unit. The default stripe unit size is 64KB. The stripe unit size is sometimes also referred to as the stripe width.

striping A layout technique that spreads data across several physical disks using stripes. The data is allocated alternately to the stripes within the subdisks of each plex.

subdisk A consecutive set of contiguous disk blocks that form a logical disk segment. Subdisks can be associated with plexes to form volumes.

swap area A disk region used to hold copies of memory pages swapped out by the system pager process.

swap volume A VxVM volume that is configured for use as a swap area.

transaction A set of configuration changes that succeed or fail as a group, rather than individually. Transactions are used internally to maintain consistent configurations.

VM disk A disk that is both under VxVM control and assigned to a disk group. VM disks are sometimes referred to as VxVM disks.

volboot file A small file that is used to locate copies of the boot disk group configuration. The file may list disks that contain configuration copies in standard locations, and can also contain direct pointers to configuration copy locations. The `volboot` file is stored in a system-dependent location.

volume A virtual disk, representing an addressable range of disk blocks used by applications such as file systems or databases. A volume is a collection of from one to 32 plexes.

volume configuration device The volume configuration device (`/dev/vx/config`) is the interface through which all configuration changes to the volume device driver are performed.

volume device driver The driver that forms the virtual disk drive between the application and the physical device driver level. The volume device driver is accessed through a virtual disk device node whose character device nodes appear in `/dev/vx/rdsk`, and whose block device nodes appear in `/dev/vx/dsk`.

volume event log The device interface (`/dev/vx/event`) through which volume driver events are reported to utilities.

vxconfigd The VxVM configuration daemon, which is responsible for making changes to the VxVM configuration. This daemon must be running before VxVM operations can be performed.

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