Sun Enterprise Server Alternate Pathing User's Guide

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Preface

The *Sun Enterprise Server Alternate Pathing User's Guide* describes the Alternate Pathing (AP) component of the Sun™ Enterprise™ server product line. Some AP features apply only to the Sun Enterprise 10000 server. These features are noted throughout this guide.

How This Book Is Organized

This guide contains the following chapters:

Chapter 1 introduces AP.

Chapter 2 covers the AP database operations.

Chapter 3 describes meta-disks and disk pathgroups, and explains how to use them.

Chapter 4 covers unattended system boot issues.

Chapter 5 describes meta-networks and network pathgroups, and explains how to use them.

Chapter 6 describes how Dynamic Reconfiguration (DR) and AP work together.

Appendix A provides a list of all AP commands.

Appendix B provides an overview of the underlying AP architecture.

Appendix C provides an overview of the underlying AP drivers.

Before You Read This Book

This manual is intended for the Sun Enterprise system administrator, who should have a working knowledge of UNIX® systems, particularly those based on the Solaris™ operating environment. If you do not have such knowledge, you should first read the Solaris User and System Administrator AnswerBook™ documentation provided with this system, and consider UNIX system administration training.

Using UNIX Commands

This document does not contain information on basic UNIX commands and procedures such as shutting down the system, booting the system, and configuring devices.

See one or more of the following for this information:

- AnswerBook online documentation for the Solaris software environment, particularly those dealing with Solaris system administration
- Other software documentation that you received with your system

Typographic Conventions

TABLE P-1 Typographic Conventions

Typeface orSymbol	Meaning	Examples
`AaBbCc123`	The names of commands, files, and directories; on-screen computer output.	Edit your `.login` file. Use `ls -a` to list all files. `% You have mail`.

`AaBbCc123`	What you type, when contrasted with on-screen computer output.	`%` **`su`**
		`Password:`

AaBbCc123	Book titles, new words or terms, words to be emphasized. Command-line variable; replace with a real name or value.	Read Chapter 6 in the *User's Guide*. These are called *class* options. You *must* be `root` to do this. To delete a file, type `rm` *filename*.

Shell Prompts

TABLE P-2 Shell Prompts

Shell	Prompt
C shell	*machine_name*%
C shell superuser	*machine_name*#
Bourne shell and Korn shell	$
Bourne shell and Korn shell superuser	#

Related Documentation

TABLE P-3 Related Documentation

Application	Title
Installation	*Solaris 7 5/99 Sun Hardware Platform Guide*
Reference (man pages)	*Sun Enterprise Server Alternate Pathing 2.2 Reference Manual*
Release Notes	*Release Notes Supplement Solaris 7 5/99*
Other	*Sun Enterprise 10000 Dynamic Reconfiguration User's Guide* *Sun Enterprise 6x00, 5x00, 4x00, 3x00 Dynamic Reconfiguration User's Guide* *Sun Enterprise 10000 Dynamic Reconfiguration Reference Manual* *Sun Enterprise 10000 SSP 3.1.1 User's Guide* *Sun Enterprise 10000 SSP 3.1.1 Reference Manual*

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CHAPTER 1

Introduction to Alternate Pathing

This chapter describes the basic purpose of Alternate Pathing and provides an overview of Alternate Pathing concepts and terminology.

Purpose of Alternate Pathing

Alternate Pathing (AP) supports high availability of I/O controllers—the hardware components that reside on system boards and enable the Sun Enterprise server to communicate with I/O devices such as disks and networks. With AP, each I/O device connects to *two* I/O controllers.

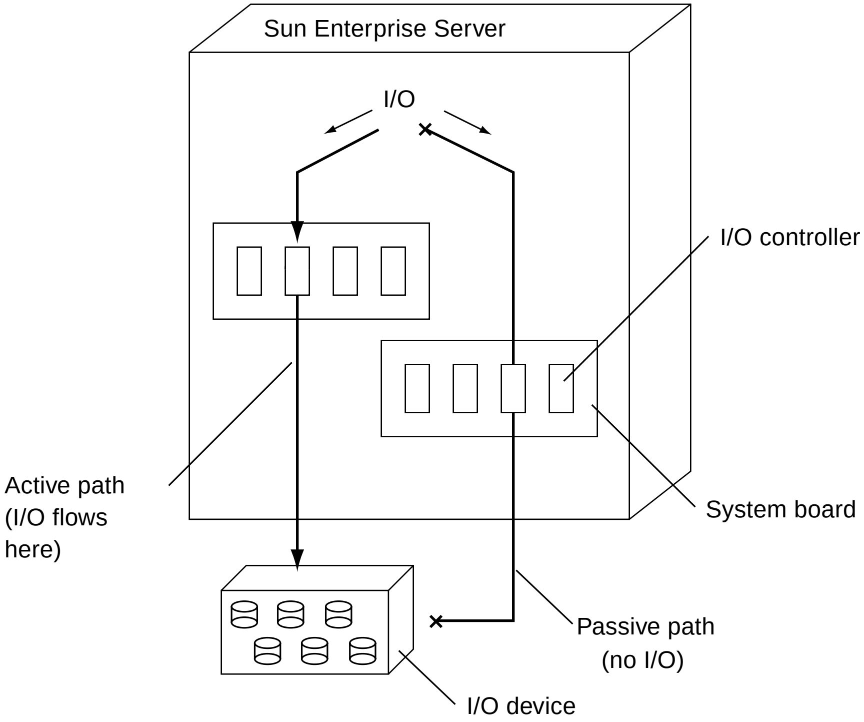


FIGURE 1-1 Alternately Pathed I/O Device

The I/O controllers are part of two separate electrical pathways to the I/O device, known as *alternate paths*. AP enables you to set up and use alternate paths on the Sun Enterprise servers.

There are two purposes for AP. One purpose is to help protect against I/O controller failures. With AP, if one I/O controller fails, you can switch to the alternate controller.

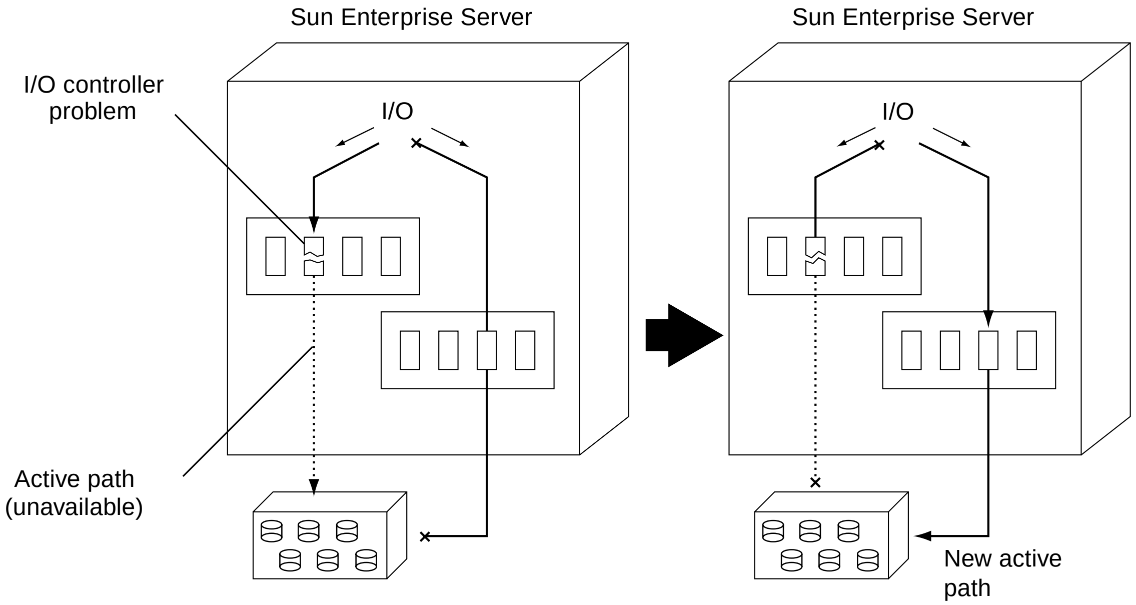


FIGURE 1-2 Switching Paths After an I/O Controller Failure

For disk controllers, this switch occurs *automatically* whenever a path failure is detected during normal operation. For network controllers, you must manually switch paths (using a single AP command).

The second purpose of AP is to support Dynamic Reconfiguration (DR). DR is used to logically attach and detach system boards from the operating system without having to halt and reboot. For example, with DR you can detach a board from the operating system, physically remove and service the board, and then re-insert the board and attach it to the operating system again. You can do all of this without halting the operating system or terminating any user applications.

If you want to detach a board that is connected to an I/O device, and if that I/O device is alternately pathed, you can first use AP to redirect the I/O flow to a controller on a different board. You can then use DR to detach the system board without interrupting the I/O flow. On the Sun Enterprise 10000, the switch occurs automatically during the DR operation (for both disk and network devices), assuming a viable alternate controller exists on another board. The following figure shows the relationship between AP and DR.

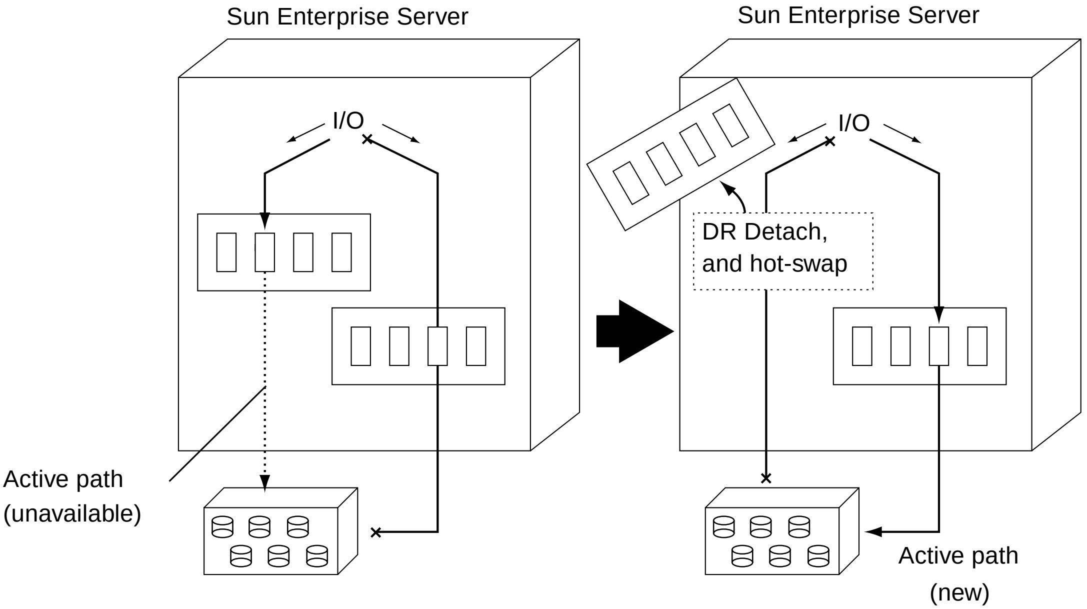


FIGURE 1-3 Switching Paths for a DR Detach Operation

Basic Alternate Pathing Concepts

This section discusses basic AP concepts and introduces the terminology that is used throughout this chapter.

Physical Path

For the purposes of AP, an *I/O device* is either a disk or network. An *I/O controller* is the controller card for an I/O device. An *I/O port* is a connector on a controller card. (Often there are two ports per controller card.) A *device node* is a path in the devices directory that is used to specify a physical device, for example, `/dev/dsk/c0t0d1s0`. The term *physical path* refers to the electrical path from the host to a disk or network.

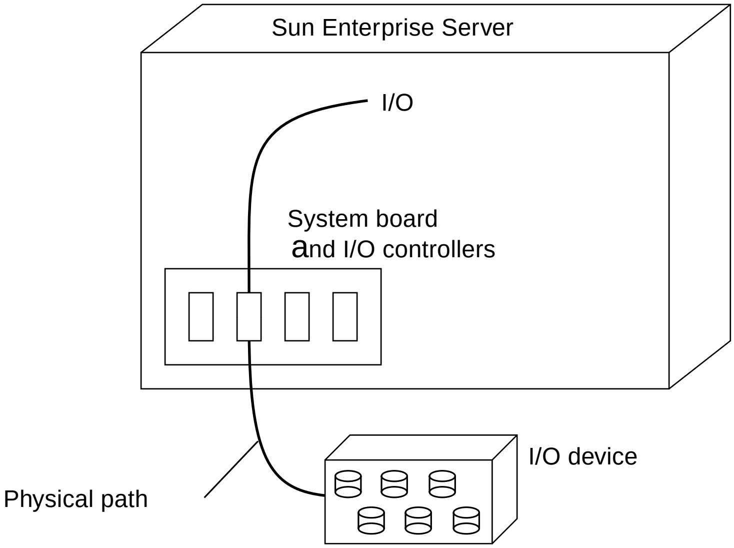


FIGURE 1-4 Physical Path

You reference a physical device by means of a device node, for example, `/dev/dsk/c0t1d1s0`.

Meta-Disk

A *meta-disk*, as illustrated in FIGURE 1-5, is a construct that enables you to access a disk by using either of two physical paths without having to reference either path explicitly within your scripts and programs. You reference a meta-disk (in your scripts and programs) using an AP-specific device node such as `/dev/ap/dsk/mc0t1d1s0`. (See "Device Nodes for Meta-Disks" on page 19 for more information.)

In the following figure, an AP-specific device node is used to perform disk I/O, regardless of which `pln` port (`pln2` or `pln9`) is currently handling I/O.

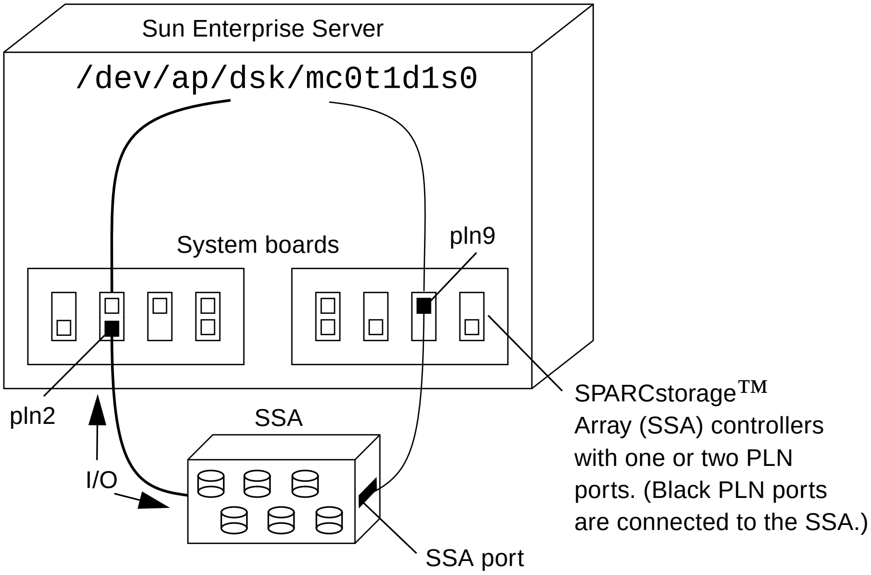


FIGURE 1-5 Meta-Disk Example

Meta-Network

A *meta-network*, as illustrated in FIGURE 1-6, is a construct that enables you to access a network by using either of two physical paths without having to reference either path explicitly within your scripts and programs. You reference a meta-network (in your scripts and programs) using a *meta-network interface* name such as `mle1`. (See "Meta-Network Interfaces" on page 43 for more information.)

In the following figure, `mle1` is used to access a meta-network, regardless of which controller (`le1` or `le6`) is currently processing I/O for the meta-network.

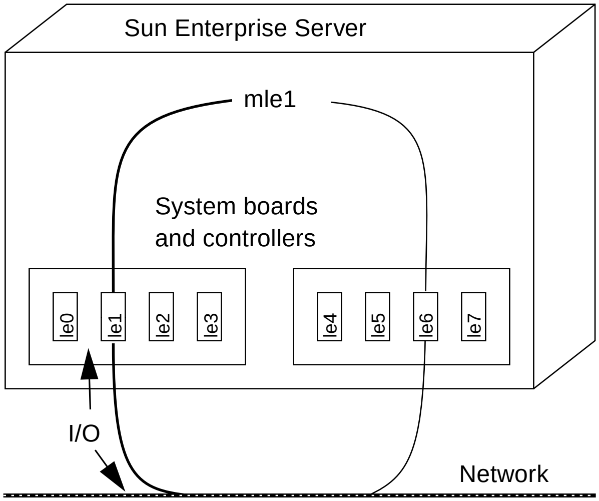


FIGURE 1-6 Meta-Network

Disk Pathgroup

A *disk pathgroup*, as illustrated in FIGURE 1-7, consists of two physical paths leading to the same disk array. When a physical path is part of a pathgroup, it is called an *alternate path*. An alternate path to a disk can be uniquely identified by the `pln` port or `sf` port that the alternate path uses. Only one alternate path at a time handles disk I/O. The alternate path that is currently handling I/O is called the *active alternate*.

Note that whereas a meta-disk provides a means for you to access a *disk* (in your scripts and programs), a disk pathgroup provides a means for you to manipulate the *path* to that disk (when you run AP commands). For example, to perform a *switch* operation (that is, change the active alternate from one alternate path to another), you reference a disk pathgroup within an `apconfig(1M)` command.

One of the alternate paths is designated as the *primary path*. The primary path is initially the active alternate. Although the active alternate changes when you perform a switch operation, the primary path remains constant. You reference a disk pathgroup by specifying the `pln` port (for example, `pln1`) or `sf` port (for example, `sf1`) that corresponds to the primary path. (For information about determining the `pln` or `sf` port name, see “Device Nodes for Meta-Disks” on page 19.)

For example, the following figure shows the results of using the `apconfig(1M)` command to switch the active alternate of a disk pathgroup.

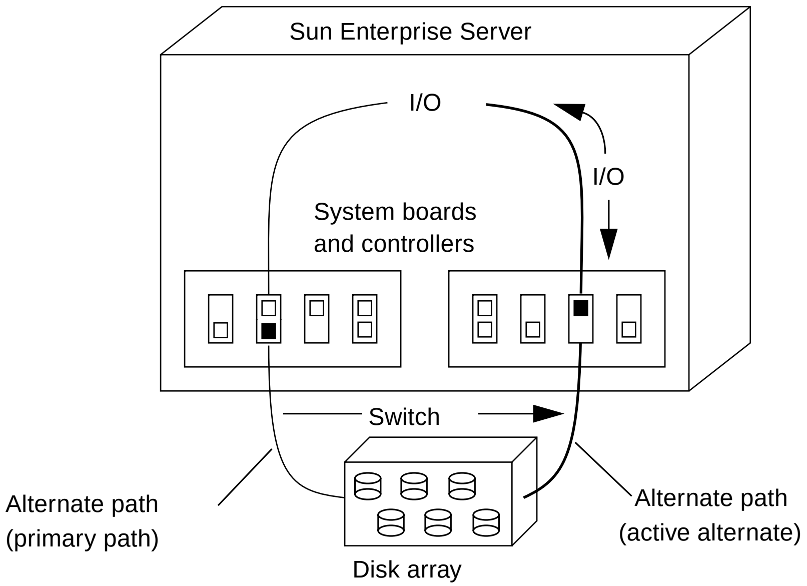


FIGURE 1-7 Disk Pathgroup

You reference a disk pathgroup (for example, to switch from one path to another) by specifying the primary path, for example, `apconfig -P pln2 -a pln9`.

Network Pathgroup

A *network pathgroup*, as illustrated in the following figure, consists of two network controllers connected to the same physical network. The terms *alternate path*, *active alternate*, *primary path*, and *switch* have basically the same meaning as they do for disk pathgroups.

To specify a network pathgroup, reference the corresponding meta-network interface name, for example, `mle1`. (Meta-network interface names are described in "Meta-Network Interfaces" on page 43.) For example, FIGURE 1-8 shows the results of using the `apconfig(1M)` command to switch the active alternate of a network pathgroup.

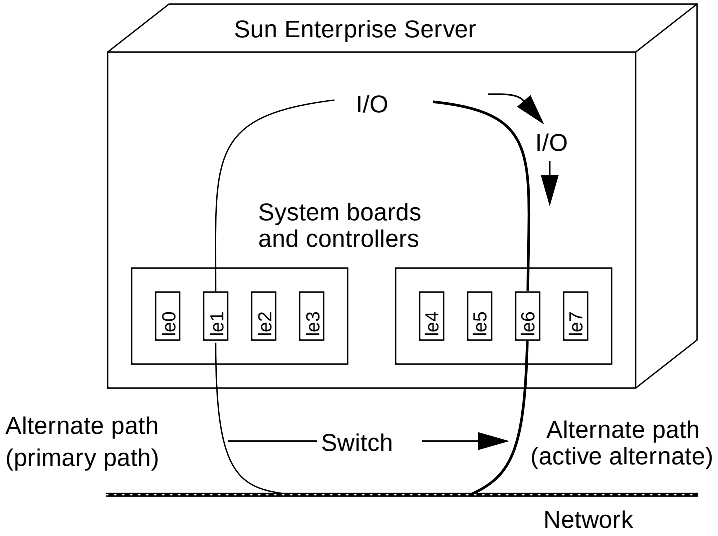


FIGURE 1-8 Network Pathgroup

You reference a network pathgroup (for example, to switch from one path to another) by specifying the meta-network interface, for example, `apconfig -P mle1 -a le6`.

Supported Devices and Software Versions

AP 2.2 supports the Solaris 7 operating environment (32-bit and 64-bit modes).

AP supports the following disk arrays:

- Sun StorEdge™ A5000 and A7000 disk arrays attached to `sf` ports
- SPARCStorage Array™ (SSA) disk arrays attached to `pln` ports on FC-AL SBus Host Adapters (SOC controllers)

The network devices and third party software products supported by AP are listed in the *Release Notes Supplement Solaris 7 5/99*.

If you alternately path disks, and you also use a volume manager with those disks, the disks must be known to the volume manager by their AP meta-disk names. This requirement enables AP to switch the active path without interfering with the volume manager.

You can place the boot disk and the primary network interface under AP control. AP makes it possible for the system to boot unattended even if the primary network or boot disk controller is not accessible, as long as viable alternate paths for these devices are defined.

Example AP Configurations

FIGURE 1-9 shows how you can use AP to support an Ethernet network and a disk array.

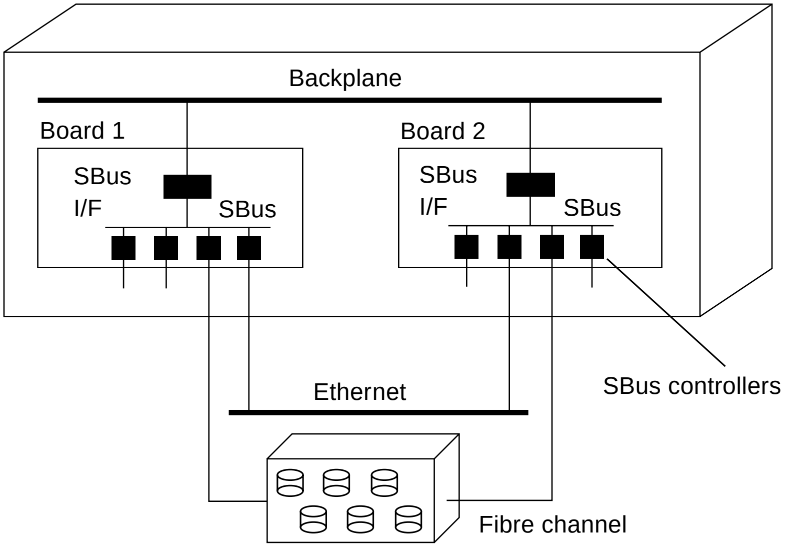


FIGURE 1-9 Typical AP Configuration

In this example, two network controllers—one each on Board 1 and Board 2—are connected to the same network. Similarly, two SSA controllers on the two boards are connected to the same SSA. In this situation, if Board 1 is detached with a DR Detach operation, AP can switch usage to Board 2 without interfering with any I/O operations that may be in progress.

AP is not equivalent to disk mirroring. Disk mirroring primarily achieves *data* redundancy although two paths are available, one for each side of the mirror. AP achieves true *pathing* redundancy, by making two paths available for each side of the mirror. To use AP and disk mirroring together, you must configure your volume manager software (such as Sun Enterprise Volume Manager™) so that it uses the AP meta-disk paths.

The following figure shows an example of how AP can be used in conjunction with disk mirroring.

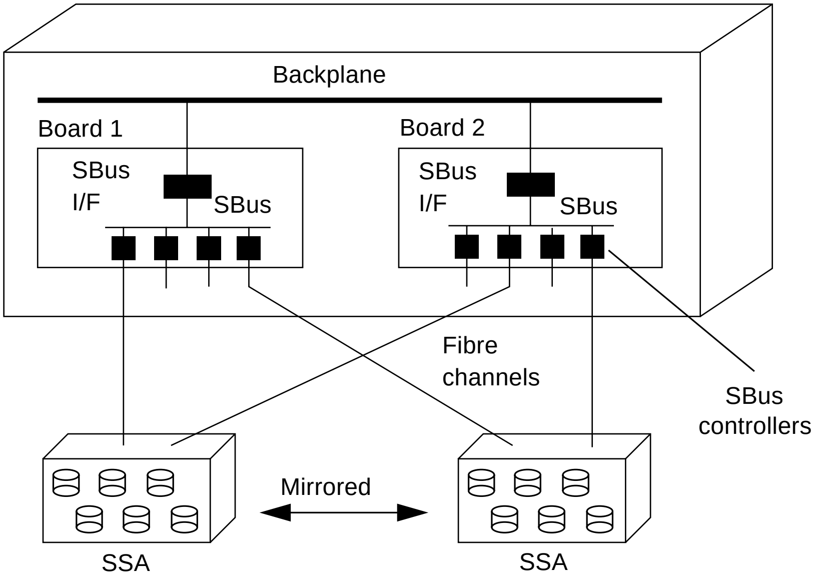


FIGURE 1-10 AP and Disk Mirroring

This type of configuration enables you to switch the paths used to implement the mirror from one board to another board, without disrupting the disk mirroring or any active I/O.

AP and Domains

The Sun Enterprise 10000 server supports Dynamic System Domains, or simply "domains." AP cannot be used across two domains. For example, suppose a board contains a controller that is part of a pathgroup, and you move that board into a different domain using DR. (You can do this only if the alternate path on that board is not currently active.) In this case, you can no longer switch to the alternate path on that board.

CHAPTER 2

Alternate Pathing Database

This chapter describes how to create and manage the AP database which maintains the state of the AP configuration.

Managing Copies of the Database

AP maintains a database that contains information about all defined meta-disks and meta-networks, and their corresponding alternate paths and properties. One set of data is maintained for each domain on the Sun Enterprise 10000 server. On other Sun Enterprise servers, one set of data is maintained for the entire machine. You should always set up multiple copies of the database. In this way, if a given database copy is not accessible or becomes corrupted, AP can automatically begin to use a current, noncorrupted database copy.

You must dedicate an entire disk partition, one that has at least 300 Kbytes, to each database copy. You can use larger partitions, but doing so wastes disk space. Keep the following information in mind when selecting disk partitions for the AP database:

- You should set up three to five database copies.
- As configured at the factory, partition four of the root disk is appropriately sized for the AP database and is not allocated for any other purposes. This partition is a good choice for an AP database copy, assuming you are not using it for other purposes.
- The database copies should have no I/O controllers in common with each other. Following this rule allows maximum availability in case of controller failure.
- If you have configured your system to make use of Dynamic Reconfiguration (DR), the database copies should be hosted by I/O controllers on different system boards so that a database copy is accessible if one of the system boards is detached.

- If you want to place an AP database copy in a partition of an alternately pathed disk, create two copies of the database using each of the *physical path*s utilized by the AP meta-disk to access the partition. AP behaves as if two copies of the database exist, when actually there is only one, since the disk is accessible via two paths. The behavior does not result in database inconsistencies, however, since AP always updates and accesses database copies sequentially. This behavior does not result in performance problems since the AP database is not accessed frequently.

On the Sun Enterprise 10000 server, a subset of the information in the AP database is automatically maintained on the SSP for use at boot time. This database contains AP information for the boot disk.

Locating Databases to Maximize RAS

You should consider how you expect to use the system boards that host the I/O controllers for the disks where the AP databases will be stored. If you expect to detach a board often, perhaps because you intend to migrate it between domains, you should probably not place an AP database on any disk attached to a controller hosted by that board. If you do find it necessary to detach such a board, error messages will be sent to the console whenever AP attempts to write to the unavailable database. This does not pose a serious problem. You can re-attach the board at any time, and the stale database is re-synchronized immediately. However, if you attach the board to other domains in the mean time, those domains may write data to the slice that is reserved for the database.

Creating and Deleting Databases

Note – The following AP command examples assume that your command search path includes the directory where the commands are installed. See “Using Single-User Mode” on page 41.

▼ To Create a Copy of the AP Database

- **Use** apdb(1M) **as follows:**

```
# apdb -c /dev/rdsk/c0t1d0s4 -f
```

The -c option specifies the raw disk slice (under /dev/rdsk) where you want to create the database copy. You must dedicate an entire disk partition to each database copy. The disk partition must have at least 300 Kbytes.

The -f (force) option is only necessary to create the first AP database copy.

▼ To Delete a Copy of the AP Database

- **Use** apdb(1M) **as follows:**

```
# apdb -d /dev/rdsk/c0t1d0s4 -f
# apconfig -D
#
```

The -d option specifies the raw disk slice (under /dev/rdsk) where the copy of the database that you want to delete is located.

The -f (force) option is only necessary to delete the second-to-last copy and the last copy of the database.

In this example, apconfig -D is used after the deletion operation to view information about the existing AP database copies. Since no information is returned, the apdb(1M) command must have deleted the last database copy.

Note – If you delete the last copy of the AP database, the contents of the database still resides in memory (including all committed and uncommitted entries). If you then create a new copy of the AP database, without rebooting in the interim, the new database contains the same information as the previous database. However, if you reboot after deleting the last copy of the database, the database information in memory is lost. In this case, if you create a new copy of the database, it contains no data.

Viewing Database Information

You can view information in the database, including information about the database copies, the disk entries within the database, and the network entries within the database.

To View Information About Database Copies

- **Use** `apconfig -D` **as follows:**

```
# apconfig -D

path: /dev/rdsk/c0t1d0s4
major: 32
minor: 12
timestamp: Thu Jul 27 16:24:27 1995
checksum: 687681819
corrupt: No
inaccessible: No
```

In this example, there is only one AP database. The command shows the path to this database, along with its major number, minor number, timestamp, and checksum. The `corrupt` field indicates whether the database is corrupt. (If `corrupt` is set to `Yes`, the data did not validate properly against the checksum.) The `inaccessible` field indicates whether the device that holds the database can be accessed.

Viewing Pathgroup Information

The AP database contains information about disk and network pathgroups. When a pathgroup is initially defined (as described in Chapter 3 and Chapter 5), its pathgroup definition is an *uncommitted* database entry. The meta-disk or meta-network associated with an uncommitted entry is not available until the pathgroup definition is *committed*. Conversely, when a pathgroup definition is deleted, the deletion must be committed before it takes effect. The two states (uncommitted and committed) enable you to review the effects of an operation before allowing the operation to proceed. To commit the uncommitted database entries, use the `apdb -C` command. Note that uncommitted entries remain in the database indefinitely, until you either commit them or remove them.

▼ To View Uncommitted Disk Entries

- **Use** `apconfig(1M)` **with the** `-S` **and** `-u` **options as follows, where** `S` **stands for storage and** `u` **stands for uncommitted:**

```
# apconfig -S -u

c1      sf0  P A
c2      sf1
        metadiskname(s):
                mc1t5d0  U
                mc1t4d0  U
                mc1t3d0  U
                mc1t2d0  U
                mc1t1d0  U
                mc1t0d0  U
```

For more information see Chapter 3.

▼ To View Committed Disk Entries

- **Use** `apconfig(1M)` **with the** `-S` **option, as follows, where** `S` **stands for storage:**

```
# apconfig -S

c1      pln0  P A
c2      pln1
        metadiskname(s):
                mc1t5d0  R
                mc1t4d0
                mc1t3d0
                mc1t2d0
                mc1t1d0
                mc1t0d0
```

For more information see Chapter 3.

▼ To View Uncommitted Network Entries

- **Use** apconfig(1M) **with the** -N **and** -u **options, as follows, where** N **stands for network and** u **stands for uncommitted**:

```
# apconfig -N -u

metanetwork:    mle0  U
physical devices:
                le2
                le0  P A
```

For more information see Chapter 5.

▼ To View Committed Network Entries

- **Use** apconfig(1M) **with the** -N **option, as follows:**

```
# apconfig -N

metanetwork:    mle3
physical devices:
                le4
                le3  P A
```

For more information see Chapter 5.

CHAPTER 3

Using Meta-Disks and Disk Pathgroups

You can create meta-disks and disk pathgroups only for disks that are accessible through two paths. You should generally use two separate controllers on different system boards.

Note – AP does not modify the data on a disk when that disk is placed under AP control or when a pathgroup is deleted (except for the data on the slices that contain AP database copies). AP does not repartition a disk. If a pathgroup is deleted, you can continue to access the data by using its physical device name.

Device Nodes for Meta-Disks

Here are two examples of *physical* device nodes for disk devices:

- `/dev/dsk/c0t0d0s0`
- `/dev/rdsk/c0t0d0s0`

where:

`c` references the I/O port on the host (not the disk array)
`t` is the bus within the disk array
`d` is the target ID of the disk on that bus
`s` is the slice number on the disk

These physical device nodes represent a particular physical path to a partition on a disk.

For SCSI disks:

- The c number is the host adapter number.
- The t number is the target number of a disk tray.
- The d number is the disk number.
- The s number is the slice number on the disk.

Each controller port has both a port number (such as c0) and a port name (such as pln2 or sf3). The port name consists of the port type and *instance* number. See /etc/path_to_inst for more information.

When a disk array is connected to two ports, it can potentially be accessed from either path by using the physical device node, for example, /dev/dsk/c0t0d0s0 or /dev/dsk/c1t0d0s0.

The device node for a meta-disk is derived from the physical device node of the primary path for a pathgroup. Here are two examples of meta-disk device nodes:

- /dev/ap/dsk/mc0t0d0s0
- /dev/ap/rdsk/mc0t0d0s0

As you can see, an ap directory has been added, and an m (for “meta”) is prepended to the device specification. The device node for a meta-disk has the ability to access the underlying physical disk drive from multiple paths.

Automatic Switching of Meta-Disks

Meta-disks can be automatically switched from the active path to the alternate path in two situations:

- The active path fails.
- The board containing the controller for the active path is detached by using a DR Detach operation. (Automatic switching during a DR detach is available only on the Sun Enterprise 10000 server.)

When the active path fails, an automatic switch is attempted only if an alternate path is available. The failed path is then marked unavailable, or *tried*. You can identify the tried paths with `apconfig -S`:

```
# apconfig -S

c1      pln0  P A
c2      pln1  T
        metadiskname(s):
                mc1t5d0
                mc1t4d0
                mc1t3d0
                mc1t2d0
                mc1t1d0
                mc1t0d0
```

In this example, the currently inactive path, `pln1`, is marked with a `T`, which indicates that path was tried but failed.

The tried flag is only significant for automatic switch operations (not for manual switch operations). AP never attempts to automatically switch to a tried path. (This prevents thrashing in the case that both paths may have failed.)

You can reset the tried flag with any of the following actions:

- Rebooting the corresponding domain.
- Performing a DR detach followed by a DR attach of a board that contains the controller marked as tried.
- Manually resetting the tried flag for a particular controller.

You can manually reset the tried flag as shown in this example:

```
# apdisk -w pln1
```

In this example, `pln1` is a controller with the tried flag set to true. The `apdisk -w` feature should be used judiciously. This command merely clears the tried flag; it does not address any potential problems with the controller or device. This command should only be used in situations where the failed path has been restored without an intervening DR operation or reboot. Note that you can attempt to perform a manual switch to a path that is marked as tried.

Disk Availability and Performance Trade-Offs

Before you configure your disk arrays and controllers, you need to establish your disk usage priorities. You may be able to achieve greater availability of your disk resources by trading off performance, or perhaps by investing in more hardware.

Consider a dual-ported SSA disk array. This type of device can be connected to either one or two Fibre Channel disk controllers (SOC controllers). Within an SSA, there are multiple targets. Each target contains multiple disks. And each disk is divided into multiple slices. Depending upon how you set up your system, there can be several different levels of contention for these disk I/O resources.

- Disk contention
- Target contention (I/O bus contention)
- Controller contention

For example, suppose you divide a disk into four slices, and create a file system out of the four slices. Although the file system spans several slices, those slices reside on the same disk and you may as well have simply placed the file system on a single slice. This is generally a poor configuration and it results in disk-level contention since every read or write to that file system requires access to the same disk.

You can place a file system across several disks in the same target. In this situation you have target-level contention, since each read or write to the file system must access the same target. Target-level contention is not as severe as disk-level contention, but it is still a poor configuration in most cases.

If you create a file system across too many targets in the same SSA, you will have controller-level contention. This is because each read or write to the file system must use the same controller.

Generally, it is best to create a file system across multiple SSA disk arrays (using multiple controllers). However, there is a trade-off between disk access speed and system availability. The more disk arrays that you use for your file systems, the faster your disk access times will be. (This is true up to a point, which can be determined empirically.) However, if any component fails in any of the disk arrays, your file systems will become unavailable. If you limit the number of disk arrays for a file system, perhaps to a single disk array, performance will decrease, but overall system availability should increase. This is because there are fewer components that could fail for a given file system.

Suppose you have six disk controllers connected to three dual-ported SSA disk arrays.

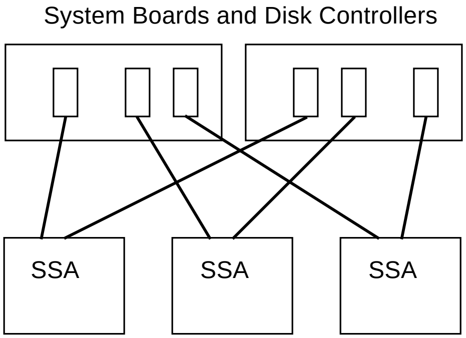


FIGURE 3-1 System Boards and Disk Controllers

If you want to maximize availability, you can alternately path each SSA using AP. The advantage of this is that you can use DR to attach and detach system boards (possibly to service or upgrade those boards) without losing access to the file systems on the SSAs. Of course, you would want to place the alternate disk controllers (SOC controllers) on different system boards. One arrangement is to use two system boards with three disk controllers on each board. This is a simple and clean arrangement, and it enables you to switch to the controllers on one of the boards when you need to detach the other board. It also enables you to migrate the disk resources among domains fairly easily (by detaching and attaching a single board).

Note that two SOC controllers must be purchased for each SSA. Also, in very large installations, it is possible to run into limitations in terms of the number of SBus slots that are available to host all the SOC controllers needed to dual path a large number of SSAs.

Disk Mirroring Considerations

If you use a product such as Sun Enterprise Volume Manager (SEVM) to mirror your disks, and you also want to detach system boards with Dynamic Reconfiguration (DR), you must configure your volumes and mirrors so that they will work properly with AP and DR.

For example, suppose you have 12 system boards, each of which has one host adapter (called a “controller” in the following diagram):

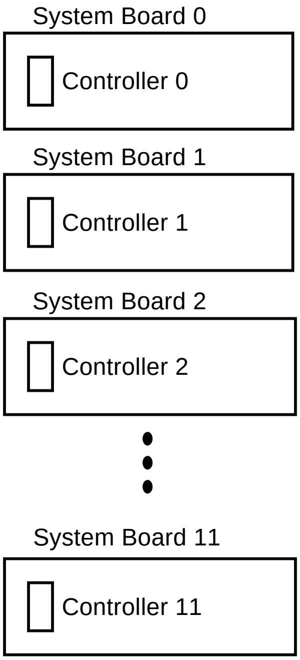
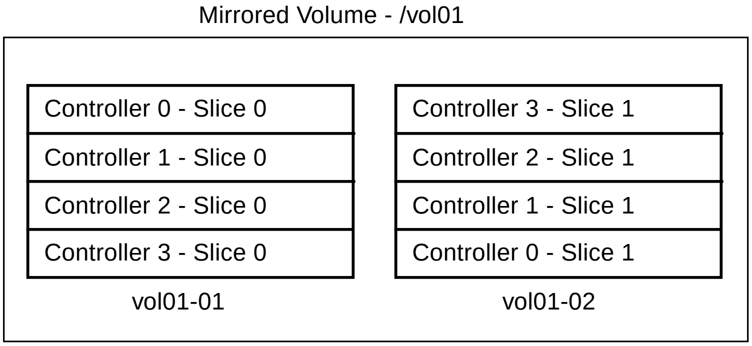


FIGURE 3-2 System Boards and Controllers

You may need to create a mirrored volume. Consider the following configuration:



Controller 0 - Slice 0	Controller 3 - Slice 1
Controller 1 - Slice 0	Controller 2 - Slice 1
Controller 2 - Slice 0	Controller 1 - Slice 1
Controller 3 - Slice 0	Controller 0 - Slice 1
vol01-01	vol01-02

FIGURE 3-3 Mirrored Volumes Example 1

In this configuration, vol01-01 consists of a four-way slice that is accessed through four separate controllers which reside on four separate system boards. vol01-01 is mirrored to vol01-02 which also consists of a four-way slice. For example, Controller 0 Slice 0 is mirrored to Controller 3 Slice 1, and so forth.

Consider the situation where you need to detach a board that contains one of these four controllers. Before you can detach the board, you must deactivate the half of the mirror that uses controllers on that board. This is impossible with the configuration shown above. For example, if you wish to detach Board 0 (which contains Controller 0), you would have to deactivate *both* sides of the mirror, which makes the file system inaccessible. The result is that you cannot use DR on any of the boards in the configuration shown above.

One way around this situation is to mirror your volumes so that controllers from the same system board do not appear on both sides of the mirror, for example:

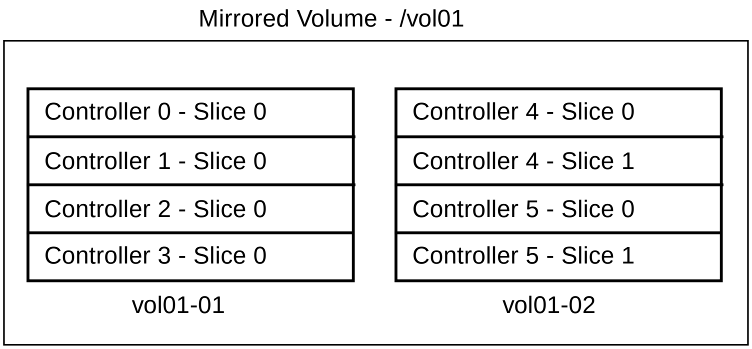


FIGURE 3-4 Mirrored Volumes Example 2

In the configuration above, you can detach any board (Board 0 through Board 5), by first deactivating the half of the mirror that uses a controller on that board. For example, to detach Board 4 (which hosts Controller 4), simply deactivate vol01-02 first. You do not lose access to the file system, since it is still available through vol01-01. Later when you re-attach Board 4, you can add vol01-02 to the mirror again.

The problem with this solution is that your system is vulnerable to single points of failure while the mirror is down. If a disk fails, there is no mirrored backup disk. You can protect against this by using AP. You might set up the following AP meta-devices:

- `mc0` is the meta-device for Controller 0 and Controller 6
- `mc1` is the meta-device for Controller 1 and Controller 7
- `mc2` is the meta-device for Controller 2 and Controller 8
- `mc3` is the meta-device for Controller 3 and Controller 9
- `mc4` is the meta-device for Controller 4 and Controller 10
- `mc5` is the meta-device for Controller 5 and Controller 11

Abbreviations are used above to simplify this discussion. For example, the full meta-device name may be `mc0t0d0s0`, and it may encapsulate the physical devices `c0t0d0s0` and `c6t0d0s0` as the alternate paths.

Now consider the following configuration:

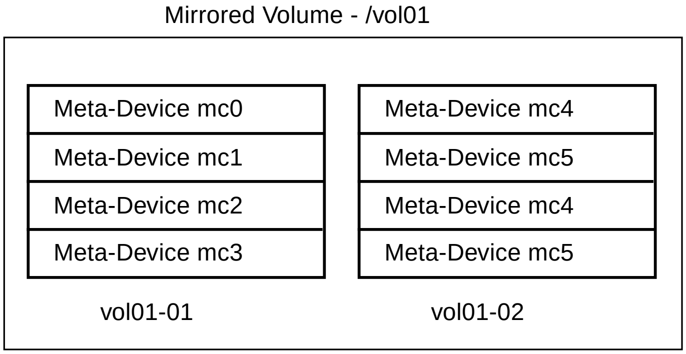


FIGURE 3-5 Mirrored Volumes Example 3

In this configuration, you can detach any of the boards (Board 0 to Board 11) without taking down the mirror. This reduces your exposure to single points of failure. For example, to detach Board 4, which contains Controller 4, you would first switch the meta-device `mc4` so that it uses Controller 10 on Board 10. (You do this with a single AP command, `apconfig -P`.)

In this example, as you increase the level of RAS support (that is, the availability of disk I/O resources and the level of protection against single points of failure), you have to increase the number of controllers and boards in the configuration. This amounts to an increase in the cost of the system to provide greater support for RAS features.

This is a hypothetical example. The main point is that you must consider AP and DR when you set up your volumes and mirrors. Otherwise, you may end up in a situation where you cannot use AP and DR. If you use Sun Enterprise Volume Manager (SEVM), keep track of the *physical* controllers and slices that make up your volumes. SEVM can be used in such a way that it chooses the physical components automatically, but this selection process is not aware of AP and DR considerations. You should explicitly choose the physical components that make up your volumes if you want to assure compatibility with AP and DR.

Working With Disk Pathgroups and Meta-Disks

Note – The example commands in this section use `pln` ports (for SSA disk arrays). If you have Sun StorEdge™ A5000 disk arrays, you specify `sf` ports wherever `pln` ports are shown. If you have Sun StorEdge A7000 disk arrays, you specify `isp` ports wherever `pln` ports are shown.

▼ To Create a Disk Pathgroup and Meta-Disk

1. **Decide which two ports will make up the alternate paths for the pathgroup.**

   a. **You can use the** `apinst(1M)` **command to display all ports (for example,** `pln0` **and** `pln1`**) and their disk device nodes (for example,** `/dev/dsk/c1t0d0`**):**

```
# apinst
pln0
        /dev/dsk/c1t0d0
        /dev/dsk/c1t1d0
        /dev/dsk/c1t2d0
        /dev/dsk/c1t3d0
        /dev/dsk/c1t4d0
        /dev/dsk/c1t5d0
pln1
        /dev/dsk/c2t0d0
        /dev/dsk/c2t1d0
        /dev/dsk/c2t2d0
        /dev/dsk/c2t3d0
        /dev/dsk/c2t4d0
        /dev/dsk/c2t5d0
```

   b. **You must know your system hardware configuration to recognize when two ports are connected to the same disk array.**

   In this example, it is assumed that the SSA contains six disks and two SSA ports. One SSA port is connected to `pln` port `c1`, and the other SSA port is connected to `pln` port `c2`.

2. **Use** apdisk(1M) **with the** -c **,** -p**, and** -a **options to create an uncommitted disk pathgroup:**

   ```
   # apdisk -c -p pln0 -a pln1
   ```

   where:

   -p specifies the primary path
   -a specifies the alternate path
   -c specifies that this information is to be created.

   This apdisk(1M) command creates a meta-disk name, as well as all of the necessary information in the AP database for maintaining the two alternate paths for all six disks.

3. **Verify the results:**

   ```
   # apconfig -S -u

   c1      pln0  P A
   c2      pln1
           metadiskname(s):
                   mc1t5d0  U
                   mc1t4d0  U
                   mc1t3d0  U
                   mc1t2d0  U
                   mc1t1d0  U
                   mc1t0d0  U
   ```

   The apconfig -S -u command lists the uncommitted meta-disks. -S lists storage devices only (that is, disks rather than networks). -u lists uncommitted devices only. The U next to each meta-disk name indicates that the meta-disk entry is uncommitted.

   The P next to pln0 indicates that pln0 is the primary path, and the A indicates that pln0 is the active alternate. Although you can change the active alternate, the primary path always remains constant. The significance of the primary path is that it is initially the active alternate, it is used when the meta-disk is named, and it is used to identify the meta-disk. In this case, c1t0d0 from the primary path name becomes part of mc1t0d0 in the meta-disk name.

4. **If you are satisfied with the results shown in the previous step, use** apdb(1M) **with the** -C **option to commit the uncommitted database entries:**

   ```
   # apdb -C
   ```

5. **Before continuing, verify the results by using** `apconfig -S` **to view the committed storage entries in the database:**

```
# apconfig -S

c1      pln0  P A
c2      pln1
        metadiskname(s):
                mc1t5d0
                mc1t4d0
                mc1t3d0
                mc1t2d0
                mc1t1d0
                mc1t0d0
```

If a partition is currently mounted under a physical path name, it should be unmounted and remounted under the meta-disk path name.

If you do not want to unmount a partition, perhaps because it is heavily used, you can delay placing the partition under AP control until you are ready to bring the system down for maintenance and then reboot. In this scenario, you modify the `/etc/vfstab` file so that when the system is rebooted, the partition comes up under an AP device. (If you are placing the boot disk under AP control, you also need to modify `/etc/vfstab` using `apboot(1M)` as described in Chapter 4.)

The `apconfig -S` command lists the committed storage entries in the database. As shown in the example, this listing is exactly the same as the previous listing, except the `U` no longer appears after the meta-disk names, indicating that the meta-disks are no longer uncommitted.

6. **Use drvconfig(1M):**

```
# drvconfig -i ap_dmd
```

The `drvconfig` command rebuilds the devices directory, which represents the device tree in the kernel. The AP disk meta-driver is a pseudo-device.

7. **Use the following command to verify the results:**

```
# ls /devices/pseudo/ap_dmd*
/devices/pseudo/ap_dmd@0:128,blk
/devices/pseudo/ap_dmd@0:128,raw
/devices/pseudo/ap_dmd@0:129,blk
/devices/pseudo/ap_dmd@0:129,raw
/devices/pseudo/ap_dmd@0:130,blk
/devices/pseudo/ap_dmd@0:130,raw
...
```

   As you can see from the listing, `drvconfig` created minor nodes for the alternately pathed device.

8. **Use `apconfig(1M)` with the `-R` option to create symbolic links from the devices directories, `/dev/ap/dsk and /dev/ap/rdsk`, to the meta-disk special files under `/devices/pseudo`:**

```
# apconfig -R
```

9. **Use the following command to view the symbolic links and verify the results:**

```
# ls -l /dev/ap/dsk
total 8
lrwxrwxrwx  1 root           40 Jul 27 16:47 mc1t0d0s0 ->
     ../../../devices/pseudo/ap_dmd@0:128,blk
lrwxrwxrwx  1 root           40 Jul 27 16:47 mc1t0d0s1 ->
     ../../../devices/pseudo/ap_dmd@0:129,blk
lrwxrwxrwx  1 root           40 Jul 27 16:47 mc1t0d0s2 ->
     ../../../devices/pseudo/ap_dmd@0:130,blk
```

   The device nodes that you need—under `/dev/ap/dsk` as well as `/dev/ap/rdsk`—are now ready to be used.

10. **Modify every reference that uses a physical device node (that is, a path that begins with `/dev/dsk` or `/dev/rdsk`) to use the corresponding meta-disk device node (that is, a path that begins with `/dev/ap/dsk` or `/dev/ap/rdsk`).**

To Switch From the Primary Path to the Alternate Path

Note – You can perform a switch at any time, even while I/O is occurring on the device. It is a good idea to experiment with the switching process to verify that you understand it and that your system is set up properly, rather than wait until a critical situation occurs.

Caution – When you switch paths, AP does not check to verify that data can be transferred over the path to which you are switching (although it does determine whether or not that path is detached or offline). You can verify the status of the path before switching to it by performing an I/O operation such as `prtvtoc(1M)`. AP does not produce any error or warning messages if you switch to a path that is not functioning properly. If you switch to a non-functioning path for your boot disk, your system may crash if the path is not switched back immediately.

---

1. **Use the** `apconfig -S` **command to view the current configuration:**

```
# apconfig -S

c1      pln0  P A
c2      pln1
        metadiskname(s):
                mc1t5d0
                mc1t4d0
                mc1t3d0
                mc1t2d0
                mc1t1d0
```

In this example, `pln0` is the active alternate since it is followed by an `A`. (It is also the primary path, since it is followed by a `P`.)

2. **To perform the switch, use** `apconfig(1M)` **with the** `-P` **and** `-a` **options:**

```
# apconfig -P pln0 -a pln1
```

`-P` specifies the primary path and thereby *identifies the pathgroup* for which you want to change the active alternate. Thus, `-P pln0` in the example above identifies the pathgroup for which `pln0` is the primary path. `-a` specifies the alternate that you want to make active.

3. **You can verify the results using** apconfig(1M) **with the** -S **option to view the committed meta-disks in the database:**

```
# apconfig -S

c1      pln0  P
c2      pln1  A
        metadiskname(s):
                mc1t5d0
                mc1t4d0
                mc1t3d0
                mc1t2d0
                mc1t1d0
```

The active alternate has been switched to pln1.

Note that you do not have to commit a switch operation.

To Switch Back to the Primary Path

- **You can switch back to the primary path using the following commands:**

```
# apconfig -P pln0 -a pln0
# apconfig -S

c1      pln0  P A
c2      pln1
        metadiskname(s):
                mc1t5d0
                mc1t4d0
                mc1t3d0
                mc1t2d0
                mc1t1d0
```

The first apconfig command, above, switches the active alternate for the pathgroup that has the primary controller pln0. The active alternate becomes pln0.

To Delete Disk Pathgroups and Meta-Disks

1. **Convert meta-disk references to physical device references.**

a. **If your boot disk is under AP control, use** `apboot(1M)` **to remove it from AP control, as described in "To Remove the Boot Disk From AP Control" on page 40.**

   You do not need to unmount any file systems mounted from the boot disk, since `apboot(1M)` places those file systems on top of physical devices without requiring you to unmount them.

b. **Unmount any file systems that are built on top of AP meta-disks (other than file systems mounted from the boot disk).**

c. **Your scripts and programs may contain references to meta-disks of the form** `/dev/ap/dsk/mc?t?d?s?` **and** `/dev/ap/rdsk/mc?t?d?s?`**. These references must be converted to references of the form** `/dev/dsk/c?t?d?s?` **and** `/dev/rdsk/c?t?d?s?`**, respectively.**

   Typically, references to meta-disks exist in the following locations:

   - `/etc/vfstab`
   - `/etc/system`
   - `/etc/dumpadm.conf`
   - Any application or script that references disks

2. **Use** `apdisk(1M)` **with the** `-d` **option to specify the primary path of the path group you intend to delete:**

```
# apdisk -d pln0
```

3. **To verify the results, use** `apconfig(1M)` **with the** `-S` **option to view the committed disk entries in the database:**

```
# apconfig -S

c1      pln0  P A
c2      pln1
        metadiskname(s):
                mc1t5d0  D
                mc1t4d0  D
                mc1t3d0  D
                mc1t2d0  D
                mc1t1d0  D
                mc1t0d0  D
```

If the pathgroup was not previously committed, the `apdisk -d` command deletes it from the database. However, if the pathgroup was previously committed, the `apdisk -d` command simply marks it as deleted, but the deletion is not completed until the next time you commit the entries in the database. In the example above, the pln0 pathgroup was previously committed, so the letter D indicates that it is marked for deletion.

4. **Use** apdb(1M) **to commit the database entries, thereby completing the deletion:**

```
# apdb -C
```

5. **You can verify the deletion with** apconfig -S:

```
# apconfig -S
```

Note – You can undo a deletion if the deletion is uncommitted. To undo a deletion, use apdisk -z, specifying the same port that you previously specified.

▼ To Deconfigure a Meta-Disk

- **Your scripts and programs may contain references to meta-disks of the form** /dev/ap/dsk/mc?t?d?s? **and** /dev/ap/rdsk/mc?t?d?s?**. These references must be converted to references of the form** /dev/dsk/c?t?d?s? **and** /dev/rdsk/c?t?d?s?**, respectively.**

  Typically, references to meta-disks exist in the following locations:

  - /etc/vfstab
  - /etc/system
  - /etc/dumpadm.conf
  - Any application or script that references disks

▼ To Reconfigure a Meta-Disk

- **Convert physical device references back into meta-disk references.**

Note – This procedure assumes that you previously created a disk pathgroup and meta-disk, and subsequently deconfigured the meta-disk references. If you simply want to reconfigure the meta-disk interface, use this procedure.

Your scripts and programs may contain references to physical devces of the form `/dev/ap/dsk/mc?t?d?s?` and `/dev/ap/rdsk/mc?t?d?s?`, respectively.

Typically, references to disk devices exist in the following locations:

- `/etc/vfstab`
- `/etc/system`
- `/etc/dumpadm.conf`
- Any application or script that references disks

CHAPTER 4

Using AP Boot Devices

This chapter describes how you can alternately path the boot disk.

Placing the Boot Disk Under AP Control

On the Sun Enterprise 10000 server, you can allow for unattended system boot, even if the controller for the boot disk fails, by placing your the boot disk under AP control.

On all Sun Enterprise servers, you can make it possible to use Dynamic Reconfiguration (DR) to detach a system board, even if that system board hosts a controller for the boot disk. To do this, you must alternately path the boot disk using controllers from two different system boards. Note, however, if a controller for the primary network is hosted on the same system board as a controller for the boot disk, you must alternately path the primary network as well. Otherwise, you will not be able to use DR to detach that board.

▼ To Place a Boot Disk under AP Control

1. **Create an AP pathgroup for the boot disk.**

   This process is described in Chapter 3.

2. **Use apboot(1M) to define the new AP boot device.**

   apboot(1M) modifies /etc/vfstab and /etc/system. For example:

   ```
   # apboot mc2t0d0
   ```

   where mc2t0d0 is the meta-disk name of the boot disk. The apboot(1M) command examines /etc/vfstab and replaces the physical device name of the disk (for example, /dev/dsk/c2t0d0* or /dev/dsk/c1t0d0*) with the meta-disk name (for example, /dev/dsk/mc2t0d0*). The apboot(1M) command also edits /etc/system so that the kernel drivers required for AP boot disk usage are loaded at the proper time.

   Do not manually replace the physical devices in /etc/vfstab with meta-disks for the boot disk. Instead, use apboot(1M) to ensure that all required changes are made.

   In addition, apboot(1M) checks /etc/vfstab to determine if the swap device is to be changed to a meta-device. If so, it issues the appropriate apboot(1M) commands. Similarly, apboot(1M) checks the configuration of the dump device, and calls dumpadm(1M) if necessary to configure the dump device as a metadevice.

3. **Set the OpenBoot™ PROM (OBP) devalias variable boot-device to the physical path most likely to be used for booting.**

   For example:

   ```
   ok setenv boot-device \
   /sbus@68,0/SUNW,soc@0,0/SUNW,pln@a0000000,78cab4/ssd@0,2
   ```

4. **Define a devalias for the alternate boot device path as a convenience in case you need to perform a manual boot.**

   At this point, reboot the system to begin using the AP boot device.

   Normally, the file systems that are mounted as part of the boot process are split across two separate disks (because of disk space requirements). If you place the boot disk under AP control (using apboot(1M)), you must manually edit the /etc/vfstab file to also place other file systems that are mounted during the boot process under AP control. In the /etc/vfstab file, you must change the device to mount and device to fsck paths for all other mount points that you want to place under AP control.

   If you want to create a new AP database copy *after* you have placed the boot disk under AP control, and that database copy is to be located on a partition controlled by a controller port that does not control any of the current AP database partitions, you must first remove the boot disk from AP control. Make sure that the new AP database has been created. Then, place the boot disk under AP control again. Failure to follow this procedure may cause the database to become inaccessible during boot.

▼ To Alternately Path a Mirrored Boot Disk

Mirroring the boot disk is primarily a function of your disk management software. The purpose of this procedure is to notify AP about a mirrored boot disk. When you use mirrored boot disks that are also alternately pathed, you have four potential physical paths to the boot disk, two for each side of the mirror. (This is the suggested configuration if you want to maximize protection against controller failure.) There are two benefits to performing the following procedure:

- Once you perform the following procedure, AP assures that the appropriate alternate path is always designated as the active path, even if you boot using a different boot device path.
- On the Sun Enterprise 10000 server (which supports automatic switching of the boot device path at boot time when an error is detected with the currently active boot device path), the following procedure assures that all four paths are available as alternates should an automatic switch be required at boot time.

1. **Place the boot disk under AP control, as described in “To Place a Boot Disk under AP Control.**

2. **Create an AP pathgroup for the mirror of the boot disk.**

   This process is described in Chapter 3.

3. **Notify AP about the boot disk mirror.**

```
# apboot -m mc3t0d0
```

   In this example, `mc3t0d0` is the meta-disk for the mirror of the boot disk.

4. **Create a mirror of your boot disk (using the two meta-disks) with your disk management software.**

▼ To Remove a Mirrored Boot Disk From AP Control

- **Use** `apboot(1M)` **to undefine the AP mirrored boot device.**

```
# apboot -u mc3t0d0
```

▼ To Remove the Boot Disk From AP Control

- **Use** `apboot(1M)` **to specify an appropriate physical device node.**

```
# apboot c2t0d0
```

In the above command, `c2t0d0` is the physical device node of an alternate path for the boot disk (as currently specified in `/etc/vfstab`). *apboot* also edits the `/etc/system` file to remove force loading of AP kernel driver modules, since they are no longer needed when the boot disk is not an AP device. In addition, `apboot(1M)` reconfigures swap and dump devices to use appropriate alternate paths if necessary.

Caution – If you place the boot disk under AP control, and later decide to remove the AP package (using `pkgrm(1M)`), you must first use `apboot(1M)` to remove the boot disk from AP control. If you do not first remove the boot disk from AP control, the configuration using that disk becomes unbootable.

AP Boot Sequence

This subsection briefly describes the flow of events that occur when the Sun Enterprise 10000 server is booted on an alternately pathed boot disk. This sequence of events illustrates how auto-switching of the boot disk controller is achieved during the boot process, if such a switch is necessary. The boot sequence proceeds as follows:

1. By default, the system is booted from the device specified by the OBP devalias `boot-device`. Note that this device may be different from the last active alternate for the boot disk.

2. OBP stores the path to the boot disk on the SSP.
3. If a failure occurs, it is detected after a few minutes. (The default is 10 minutes.) Then, the AP Reboot Host program is executed.

Note – Several minutes may pass before action is taken, so do not immediately enter new commands if you notice that the boot process has failed. If you attempt a manual recovery from a boot failure, be aware that the automatic reboot recovery process will still be executing and may override your manual recovery command.

---

4. AP Reboot Host retrieves the path stored earlier by OBP, and communicates the path to the AP SSP daemon.
5. The AP SSP daemon looks up the alternate path for the boot disk in the AP SSP database, and retries the boot process with that alternate path.
6. After the reboot succeeds, AP determines the alternate from which the system was booted, and makes it the active alternate.

Using Single-User Mode

Normally, when the Sun Enterprise server is fully booted, you use the AP command versions located in `/usr/sbin`. However, if your server comes up in single-user mode because the boot process did not fully complete, you can use the commands in `/sbin`. The command versions under `/sbin` do not rely on the AP daemon services (which are not available in single-user mode). If the system enters single-user mode because of a problem related to AP, you may be able to resolve the problem by using the `/sbin` commands to perform needed AP operations.

Two AP-related problems may cause the system to come up in single-user mode:

- If two paths are supposed to lead to the same disk (according to the AP SSP database) but those paths actually lead to different disks, and if that disk needs to be mounted during the boot process. (This can only happen if you change the physical configuration of the pathgroup without running AP commands to update the database.)
- If an active alternate for a disk turns out to be inaccessible and that disk is required during the boot process. A disk is required during the boot process if it has file systems that are mounted during the boot process (that is, it has entries in the `/etc/vsftab` file).

These situations arise only with respect to disks, not networks. In either case, you may be able to use the AP commands under `/sbin` to resolve the problem.

CHAPTER 5

Using Meta-Networks and Network Pathgroups

To use AP, both physical networks within a network pathgroup must be of the same type. For example, a network pathgroup could consist of two `le` networks or two `qe` networks, but not one of each.

Both alternates in a network pathgroup should be physically connected to the same network. For example, Ethernet controllers should be connected to the same subnet.

While multiple physical network connections exist, only one controller at a time is active. The controllers should be on different system boards so that DR operations (such as DR Detach) can be performed without affecting all potential active alternates.

The AP switch procedures in this section show how to switch the active alternate.

Meta-Network Interfaces

A meta-network interface name is derived from the name of the primary alternate for that meta-network. A meta-network interface name has the form `m`*xxx*, where *xxx* is the primary interface name such as `le0`.

You must use two network interfaces of the same type when creating a meta-network interface. For example, you can use `le0` and `le4`, or `nf0` and `nf1`. However, you can not use `le0` and `nf1`. Some examples follow:

- LE Ethernet meta-network names have the form `mle`*#*, where *#* is the instance number. For example, assume the network controllers `le0` and `le1` connect to the same Ethernet subnet. A meta-network `mle0` can encompass these two controllers (if the primary controller is le0). Similarly, QE Ethernet meta-network names have the form mqe#. Note that you cannot mix le and qe networks within the same pathgroup.

- FDDI meta-network names have the form mf# and mnf#. nf networks can be either SAS or DAS. SAS and DAS configurations may be mixed when creating a meta-network interface.

Working With Network Pathgroups

▼ To Create a Network Pathgroup and Meta-Network

Note – This procedure should *not* be used for the primary network. To alternately path the primary network, see “Alternately Pathing the Primary Network Interface” on page 51.

1. **Use** apnet(1M) **with the** -c **option:**

```
# apnet -c -p le0 -a le2
# apconfig -N -u

metanetwork:    mle0  U
physical devices:
                le2
                le0  P A
```

This apnet(1M) command creates the network pathgroup as well as the meta-network interface name mle0 for the two physical devices le0 and le2. The meta-network interface name is derived from the primary controller name (specified by -p).

The apconfig(1M) command lists the uncommitted network entries in the database. -N specifies that network database entries should be listed. -u specifies that uncommitted entries should be listed.

2. **If you are satisfied with the network pathgroup, commit the entry:**

```
# apdb -C
# apconfig -N

metanetwork:    mle0
physical devices:
                le2
                le0  P A
```

`apdb -C` commits the database entries. `apconfig -N` lists the committed network entries in the database. The listing appears exactly as it did before, except that the `U` no longer appears after `mle0`.

3. **Remove all direct usage of both members of the pathgroup (see `ifconfig(1M)`).**

   a. **If the physical interface is currently plumbed, and it is not the primary network interface, and it is not the interface that you will be using as you run commands to configure the meta-network, unplumb the physical interface.**

Note – If the interface you will be configuring down is the primary network interface, or if it is the interface that you will be using as you use commands to configure the meta-network, follow one of the procedures in "Alternately Pathing the Primary Network Interface" on page 51.

You can unplumb the physical interface as shown in the following example:

```
# ifconfig le0 down; ifconfig le0 unplumb
```

Usually network interfaces are configured during system boot via the file `/etc/hostname.`*xxx*, where *xxx* is the interface name (such as `le0`). This file contains the IP address or the hostname associated with the interface. You should remove or rename the `/etc/hostname.`*xxx* for all interfaces that have been made AP alternates, since direct usage of the alternate must not occur.

   b. **Create an `/etc/hostname.m`*xxx* file (such as `/etc/hostname.mle0`) for any meta-networks that you want to configure at system reboot.**

   This file should contain the meta-network IP address or the hostname for the interface. You can simply rename `/etc/hostname.le0` to `/etc/hostname.mle0`.

The normal operating state of a network interface is plumbed up when in use, and unplumbed when not in use. When you automatically configure network interfaces through `/etc/hostname.*`, the interfaces are left in one of these states. It is possible to leave a network interface in a transitory state of plumbed when you manually configure your network interface. As this is not a normal operational mode, it is unlikely that network interfaces will be left in this state. Do not leave meta-networks in this state during AP network configuration. A network meta-device may be deleted only if it and all other network meta-devices of that device type are either in the unplumbed state or the plumbed up state. Otherwise, AP ignores the delete request, and depending on your configuration, may display warning messages of the following form:

```
WARNING:mnf_setphyspath: APUNSET busy
WARNING:ap_db_commit: mnf3 not deleted, metadevice returned error
16
```

Note – If you are using FDDI, you must specify a unique MACID for the meta-network. The MACID is set through the `ether` parameter to the `ifconfig(1M)` command. First examine the MACID for each of the alternates. You can do this by bringing up each alternate and examining the `ether` field. Then, fabricate a MACID that does not match any of the alternates.

The allocation of Media Access Control Identifiers (MACIDs) is described in RFC1340, “Assigned Numbers”, July 1992. When generating a MACID for your AP network interface, the new 48-bit hardware address should be acquired from the IEEE Standards Office, 345 East 47th Street, New York, N.Y. 10017. However, it is possible to “create” a number by transposing digits on an existing MACID of one of the meta-interface alternate elements. After creating a number, it is important to verify that there is no other hardware on the same subnet that is a legitimate user of the created address.

This meta-network MACID is used to configure the active physical interface of the meta-network. The use of this MACID is necessary to prevent duplication of MACIDs on the network when combining AP switching of interfaces and DR board insertion activities. The meta-network defaults to the MACID of the active alternate at boot time. To ensure that the MACID is set properly at boot time, place `ifconfig(1M)` commands in the `/etc/rcs.d/S30rootusr.sh` start-up script. The following is an example. Note that the ## characters are used to indicate the lines to be added; the leading ## characters should *not* be added. You should replace *MACID_mnf2* and *MACID_mle0* with the actual numbers (for example, `8:0:20:68:6d:62`).

```
/etc/rcS.d/S30rootusr.sh:
[....]

interface_names="`echo /etc/hostname.*[0-9] 2>/dev/null`"
if [ "$interface_names" != '/etc/hostname.*[0-9]' ]; then
     (
        echo 'configuring network interfaces:\c'
        IFS="${IFS}."
        set -- $interface_names
        while test $# -ge 2; do
           shift
           if [ "$1" != "xx0" ]; then
       addr=`shcat /etc/hostname\.$1`
                /sbin/ifconfig $1 plumb

##             #
##             # Set the MACid for AP
##             #
##             if [ "$1" = "mnf2" ] ; then
##                  /sbin/ifconfig $1 ether MACID_mnf2
##              fi
##              if [ "$1" = "mle0" ] ; then
##                 /sbin/ifconfig $1 ether MACID_mle0
##              fi
##
                if [ -n "$addr" ]; then
                    /sbin/ifconfig $1 inet "$addr" \
                        netmask + broadcast + -trailers up \
                        2>&1 >/dev/null
                fi
                echo " $1\c"
            fi
            shift
       done
        echo '.'
     )
fi
[....]
```

4. **Bring up the meta-network in the usual manner, but use the meta-network name instead of the physical network name. You can do this by either rebooting the machine or manually configuring the network as in the following example:**

```
# ifconfig mle0 plumb
# ifconfig mle0 inet 136.162.65.30 up netmask + broadcast +
Setting netmask of mle0 to 255.255.255.0
# ifconfig -a
lo0: flags=849<UP,LOOPBACK,RUNNING,MULTICAST> mtu 8232
    inet 127.0.0.1 netmask ff000000
mle0: flags=843<UP,BROADCAST,RUNNING,MULTICAST> mtu 4352
    inet 136.162.65.30 netmask ffffff00 broadcast 136.162.65.255
    ether 0:0:be:0:8:c5
```

At this point, the device node, such as `/dev/mle`, can be used to access the network from Solaris commands such as `snoop(1M)`.

To Switch a Network Pathgroup

You can switch a network pathgroup even while the network sustains traffic.

Caution – This procedure requires that you reboot the machine. If you are not ready to reboot the machine, do not perform this procedure.

- **Use the** `apconfig(1M)` **command:**

```
# apconfig -P mle0 -a le2
# apconfig -N

metanetwork:    mle0
physical devices:
                le2  A
                le0  P
```

The `-P` option specifies the pathgroup and `-a` specifies the alternate that you want to become active. The listing above shows that the active alternate has been switched to `le2`, as indicated by the `A` following `le2`.

You do not have to commit a switch operation.

▼ To Delete a Network Pathgroup and Meta-Network

1. **Remove all usage of the corresponding meta-network, and use** `apnet -d`**:**

```
# ifconfig mle0 down unplumb
# apnet -d mle0
# apconfig -N

metanetwork:    mle0  D
physical devices:
                le2  A
                le0  P
```

In the listing produced by `apconfig -N`, a `D` follows `mle0`, indicating that the pathgroup is marked as deleted.

2. **Commit the entries in the database using** `apdb -C`**:**

```
# apdb -C
# apconfig -N
#
```

The `apconfig -N` command produces no listing, indicating that the network pathgroup (the only one that existed previously in this example) has been deleted.

You can undo a deletion if the deletion is uncommitted. To undo a deletion, use `apnet -z`, specifying the same meta-network interface that you previously deleted.

When an `apnet -m -r` or `apnet -m -a` command is used, AP marks the current pathgroup configuration as deleted and creates a new uncommitted pathgroup definition. Once the database change is committed with `apdb -C`, the new definition replaces the old.

3. **Remove the** `/etc/hostname.m`*xxx* **file, as described in "To Deconfigure a Meta-Network.**

▼ To Deconfigure a Meta-Network

Caution – This procedure requires you to reboot the machine. If you are not ready to reboot the machine, do not perform this procedure.

1. **Verify that the primary network interface is** `mqe0` **(in this example):**

```
# cat /etc/nodename
hmb
# cat /etc/hostname.mqe0
hmb
#
```

2. **Create the new** `hostname.`*xxx* **file so the network will be automatically configured at boot time:**

```
# cat > /etc/hostname.qe0
hmb
^D
# cat /etc/hostname.qe0
hmb
```

3. **Remove the configuration files for the meta-network interface:**

```
# rm -f /etc/hostname.mqe0
```

4. **Reboot.**

▼ To Reconfigure a Meta-Network

Caution – This procedure requires you to reboot the machine. If you are not ready to reboot the machine, do not perform this procedure.

1. **Verify that the primary network interface is** `qe0` **(in this example):**

```
# cat /etc/nodename
hmb
# cat /etc/hostname.qe0
hmb
#
```

2. **Create the new `hostname.`*xxxx* file so the network will be automatically configured at boot time:**

```
# cat > /etc/hostname.mqe0
hmb
^D
# cat /etc/hostname.mqe0
hmb
```

3. **Remove the configuration file for the meta network interface:**

```
# rm -f /etc/hostname.qe0
```

4. **Reboot.**

Alternately Pathing the Primary Network Interface

The primary network interface between your Sun Enterprise server and the other machines on the network is the Ethernet interface that is on the same subnet as the SSP. One way to identify the primary network is to look in the `/etc/hostname.`*xxx* files until you find the one that contains the IP name that matches the IP name found in the file `/etc/nodename`. The corresponding *xxx* network (for example, `qe0`) is the primary network.

You can alternately path the primary network, if you want. The primary network is the only network interface that can be auto-switched at boot-time. During the boot process on the Sun Enterprise 10000 server (but not on other Sun Enterprise servers), if the active alternate for the primary network fails, the system attempts to find a working alternate. Note that the AP database on your SSP is used for this purpose. A subset of the AP database that resides on the SSP is used at boot time to automatically switch to a functional path for the primary network. By the time the system is ready to start using the network, the file systems on the host are already up and running, so the main AP database can be used.

When you configure an alternately pathed network, you must not configure the meta-network while the underlying driver is still active. When you configure AP for a network that you are currently using, the transition period between configuring the physical interface down and the AP interface up generates a loss of network service for your Sun Enterprise server. To perform this transition, you should use one of the following procedures, which are shown in order of preference:

- Create the appropriate AP database entries, create a new `/etc/hostname.m`*xxx* file, remove (or rename) the corresponding `/etc/hostname.`*xxx* file, and then reboot your Sun Enterprise server.
- Set up a script file to perform the transition on your Sun Enterprise server.
- Log into your Sun Enterprise server via another network interface to enable commands to be issued when the network service is lost on the network interface that you are bringing up under AP.

The following example shows how to reconfigure the primary network using the first approach. This example assumes you have an Sun Enterprise server named `hmb` with a primary network interface on `qe0`, and that you want to have a meta-network interface composed of `qe0` and `qe4`. (If you are unsure which network interfaces should be combined into a meta-network, you can use `snoop -d` to determine which of your configured networks are on the same subnet.)

▼ To Create a Network Pathgroup and Meta-Network for the Primary Network

---

Caution – This procedure requires you to reboot the machine. If you are not ready to reboot the machine, do not perform this procedure.

---

1. Verify that the primary network interface is `qe0`**:**

```
# cat /etc/nodename
hmb
# cat /etc/hostname.qe0
hmb
#
```

2. Create the new network pathgroup and commit the changes:

```
# apnet -c -p qe0 -a qe4
# apdb -C
```

3. **Verify the new pathgroup by looking at committed network entries in the AP database:**

```
# apconfig -N
metanetwork:    mqe0
physical devices:
                                 qe4
                                 qe0  P A
```

4. **Create the new** `hostname.m`*`xxx`* **file so the network will be automatically configured at boot time:**

```
# cat > /etc/hostname.mqe0
hmb
^D
# cat /etc/hostname.mqe0
hmb
```

5. **Remove the configuration files for the physical network interfaces:**

```
# rm -f /etc/hostname.qe0 /etc/hostname.qe4
```

6. **Bring down the physical network interfaces and bring up the meta-network interface by rebooting the machine.**

To Delete the Network Pathgroup and Meta-Network for the Primary Network

Caution – This procedure requires you to reboot the machine. If you are not ready to reboot the machine, do not perform this procedure.

1. **Verify that the primary network interface is** `mqe0` **(in this example):**

```
# cat /etc/nodename
hmb
# cat /etc/hostname.mqe0
hmb
#
```

2. **Create the new** hostname.*xxx* **file so the network will be automatically configured at boot time:**

```
# cat > /etc/hostname.qe0
hmb
^D
# cat /etc/hostname.qe0
hmb
```

3. **Remove the configuration files for the meta network interface:**

```
# rm -f /etc/hostname.mqe0
```

4. **Reboot.**

5. **Delete the entry in the AP database:**

```
# apnet -d mqe0
# apdb -C
# apconfig -N
#
```

▼ To Deconfigure the Meta-Network for the Primary Network

Caution – This procedure requires you to reboot the machine. If you are not ready to reboot the machine, do not perform this procedure.

1. **Verify that the primary network interface is** mqe0 **(in this example):**

```
# cat /etc/nodename
hmb
# cat /etc/hostname.mqe0
hmb
#
```

2. **Create the new `hostname.`*xxx* file so the network will be automatically configured at boot time:**

```
# cat > /etc/hostname.qe0
hmb
^D
# cat /etc/hostname.qe0
hmb
```

3. **Remove the configuration files for the meta network interface:**

```
# rm -f /etc/hostname.mqe0
```

4. **Reboot.**

▼ To Reconfigure the Meta-Network for the Primary Network

Caution – This procedure requires you to reboot the machine. If you are not ready to reboot the machine, do not perform this procedure.

1. **Verify that the primary network interface is `qe0` (in this example):**

```
# cat /etc/nodename
hmb
# cat /etc/hostname.qe0
hmb
#
```

2. **Create the new `hostname.`*xxxx* file so the network will be automatically configured at boot time:**

```
# cat > /etc/hostname.mqe0
hmb
^D
# cat /etc/hostname.mqe0
hmb
```

3. **Remove the configuration file for the meta network interface:**

```
# rm -f /etc/hostname.qe0
```

4. **Reboot.**

CHAPTER 6

Interaction Between AP and DR

This chapter describes the relationship between AP and DR.

Using AP and DR Together

Dynamic Reconfiguration (DR) and Alternate Pathing (AP) are designed to work closely together. DR enables you to attach and detach system boards without halting the operating system, as described in the *Sun Enterprise 10000 Dynamic Reconfiguration User's Guide*. AP enables you to switch usage *away from* a controller on a board that is being detached or possibly *to* a controller on a board that has been attached.

On the Sun Enterprise 10000 server, AP *automatically* switches each disk and network meta-device that has an active controller on a board being detached (assuming a viable alternate path exists on another board). Also, on the Sun Enterprise 10000 server, AP prevents you from manually switching to controllers on a board that is in the drain state of a DR detach operation.

On Sun Enterprise servers other than the Sun Enterprise 10000 server, you must *manually* switch disk and network meta-devices (if necessary) before detaching a board.

The following AP command shows that the `pln1` controller is on a board that is detached (as indicated by the `DE` flag) and, thus, you cannot switch to that controller:

```
# apconfig -S

c1      pln0  P A
c2      pln1  DE
        metadiskname(s):
                mc1t5d0
                mc1t4d0
                mc1t3d0
                mc1t2d0
                mc1t1d0
```

Similarly, the following AP command shows that the `pln1` controller is on a board that is in the drain state (as indicated by the `DR` flag) and, thus, you cannot switch to that controller:

```
# apconfig -S

c1      pln0  P A
c2      pln1  DR
        metadiskname(s):
                mc1t5d0
                mc1t4d0
                mc1t3d0
                mc1t2d0
                mc1t1d0
```

AP is notified that a board is in the DR drain state only on the Sun Enterprise 10000 server.

When you plan to detach a board that hosts the active controller of a pathgroup, you can manually switch to a controller on another board before the DR Detach operation, or even during the DR Detach operation. On machines other than the Sun Enterprise 10000 server, however, you *must* perform any such switch before the detach operation attempts to complete, or the detach operation will fail. In this case, you can perform the switch and then retry the detach operation.

For more information about DR, see the *Sun Enterprise 10000 Dynamic Reconfiguration User's Guide* or the *Sun Enterprise 6x00, 5x00, 4x00, and 3x00 Systems Dynamic Reconfiguration User's Guide*.

Maintaining the Correct AP State

On machines other than the Sun Enterprise 10000 server, if you attach or detach a board that hosts an I/O controller for a disk or network pathgroup, you must run `apconfig -F`. This command sets or clears the the detach flag (DE) for that board so that it correctly indicates whether the board is attached or detached. (On the Sun Enterprise 10000 server, you do not need to use `apconfig -F` after an attach or detach operation, since the DE flag is automatically set or cleared after the DR operation completes.)

If you detach a board that hosts a network controller, and that network device has not been used since the previous boot, you must run `apconfig -F` to notify the system that the network device is no longer available.

The `apconfig -N` command may incorrectly indicate that a network controller resides on a board that is detached (or incorrectly indicate that it resides on a board that is present) if the corresponding AP meta-driver has not been loaded. Use `apconfig -F` to ensure the correct information is shown by `apconfig -N`.

APPENDIX **A**

AP Commands

The AP man pages are in the *Alternate Pathing Reference Manual* portion of your Sun Enterprise server documentation set, and online as well (once you have installed the AP packages). This chapter introduces the AP commands and files. Unless noted otherwise, AP commands are executable on the Sun Enterprise server, not in the SSP environment. (The SSP is part of the Sun Enterprise 10000 system, and is not available with other Sun Enterprise servers.) Following is a list of the AP man pages:

- `ap(1M)` – alternate pathing overview
- `ap_reboot_host(1M)` – fast alternate path boot. This command is executed on the SSP by other commands. Do not execute it manually. (The SSP is part of the Sun Enterprise 10000 system, and is not available with other Sun Enterprise servers.)
- `ap_daemon(1M)` – alternate pathing daemon
- `ap_ssp_daemon(1M)` – AP SSP daemon. This daemon runs on the SSP. (The SSP is part of the Sun Enterprise 10000 system, and is not available with other Sun Enterprise servers.)
- `apboot(1M)` – define an AP boot device
- `apcheck(1M)` – determine accessibility of AP SCSI meta–device
- `apconfig(1M)` – display and manage AP configuration
- `apdb(1M)` – manage replicas of AP database
- `apdisk(1M)` – manage AP for SCSI disks
- `apinst(1M)` – identify SCSI bus controller
- `apnet(1M)` – manage AP for networks
- `apssp(1M)` – client of AP SSP daemon. This command is executed on the SSP by other commands. Do not execute it manually. (The SSP is part of the Sun Enterprise 10000 system, and is not available with other Sun Enterprise servers.)
- `ap(7)` – AP driver
- `ap_dmd(7)` – AP disk meta-driver
- `ap_nmd(7)` – AP network meta-driver

APPENDIX **B**

AP Components

AP consists of the following components:

- AP daemon – ap_daemon(1M) runs on the Sun Enterprise server and receives user requests through the AP commands executed on the server. The daemon acts as an intermediary between the commands and the AP librarian, ap(7). It passes requests received through RPCs to the librarian by invoking ioctls. The actual work of maintaining the database is performed by the librarian.
- AP librarian – ap(7) manages the AP database and interacts with the meta-drivers as necessary. It receives requests through ioctls and acts on them by updating the database or calling entry points in the meta-drivers.
- AP meta-drivers – The low-level capability for re-routing I/O accesses to alternate paths is implemented in the meta-drivers.

All application I/O requests that use the appropriate meta-disk go through a meta-driver that passes them to the physical device drivers. As a result, the meta-drivers can decide which physical path to use, whether a given path is no longer functioning, and so forth. The information on which the meta-drivers base their decisions comes from the AP librarian and AP database.

- AP SSP daemon – ap_ssp_daemon(1M) executes on the SSP and receives RPC requests from the AP daemon whenever the AP database changes. (Note that the SSP is part of the Sun Enterprise 10000 system; the SSP is not available with any other Sun Enterprise servers.) This daemon is responsible for maintaining a file on the SSP containing alternate pathing information for booting.

APPENDIX **C**

Driver Layers

The following figure illustrates the driver layers that are used when AP controls disk devices.

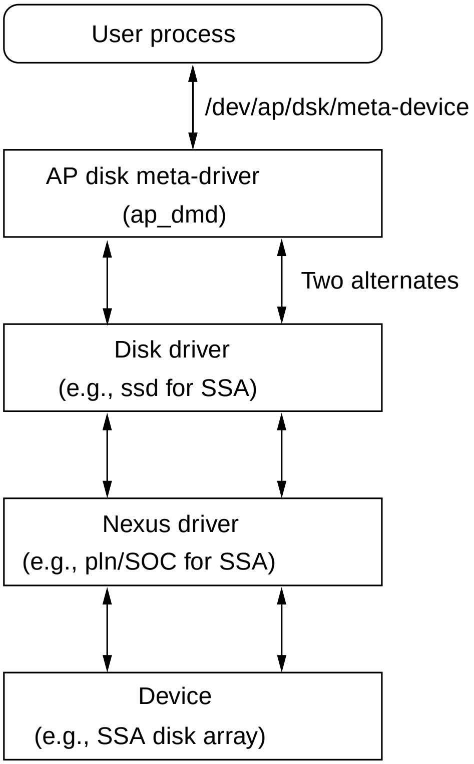


FIGURE C-1 AP Disk Driver Layers

A user process references a meta-disk, which provides access to the AP disk meta-driver. The AP disk meta-driver controls two instances of the physical disk driver which, in turn, controls two instances of the nexus driver (or controller driver). The nexus driver controls the physical device.

FIGURE C-2 illustrates the driver layers that are used when AP controls networks.

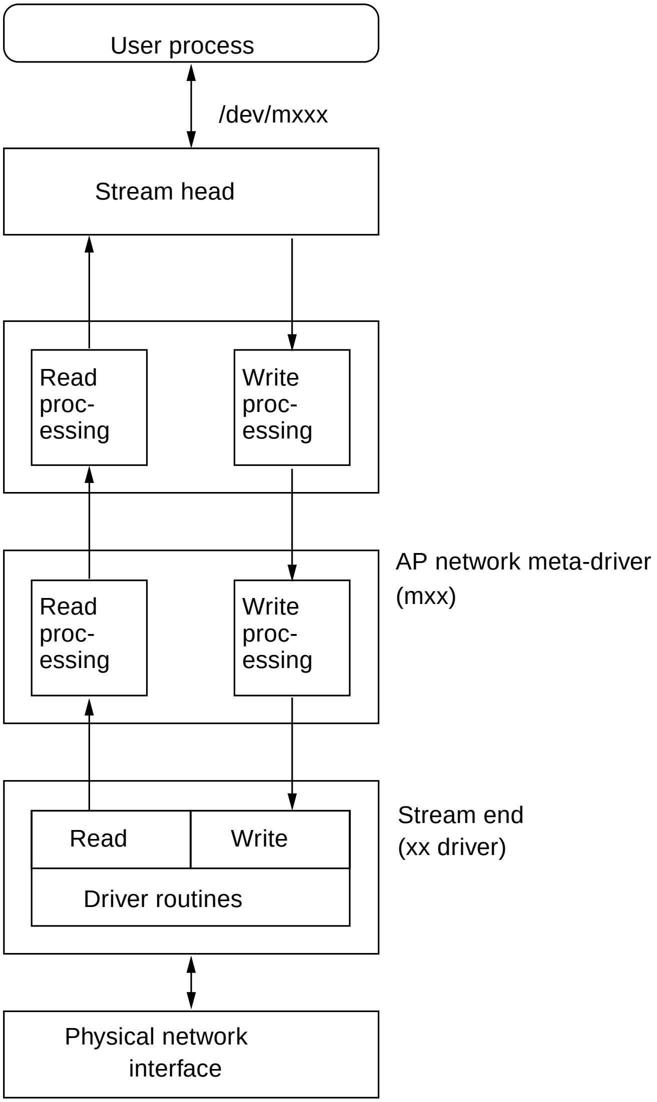


FIGURE C-2 AP Network Driver Layers

A user process references a meta-network, which provides access to the stream head. The AP network meta-driver is inserted into the stream between the high-level read / write processing components and the physical driver routines.

Glossary

active alternate The alternate path that is currently handling I/O for a pathgroup.

AP database (or simply database) A database that is maintained by the AP subsystem. The AP database contains all of the information needed to maintain the configuration alternate paths.

alternate path One of the physical paths within a pathgroup.

committed database entry An entry in the AP database that is currently being used by AP to manage access to a disk or network. (Compare with *uncommitted database entry*.)

meta-disk A disk abstraction that provides access to an underlying group of two physical paths to a disk.

meta-network A network abstraction that provides access to an underlying group of two physical paths to a network.

pathgroup A set of two alternate paths that provide access to the same device or set of devices.

physical path The electrical path from the host to a disk or network.

pln port An optical link connection (OLC) module on an SSA controller that can be connected to an SSA port.

primary path The alternate path in a pathgroup that is initially the active alternate. The name of the primary path is used when constructing the name of the meta-disk or meta-network. The primary path does not change when a switch occurs.

SSA A SPARCstorage Array, a collection of disks within a hardware peripheral. The SSA provides access to each of its housed disks via two ports.

SSA port An optical link connection (OLC) module on an SSA that can be connected to a `pln` port.

SSA controller A controller that resides on the host system and has one or two `pln` ports (also called a SOC controller).

switch The act of establishing a new active path as the path to be used for a given pathgroup. Note that switching does not change the primary path.

uncommitted database entry An entry in the AP database that has not been committed and is therefore not currently in effect. If a pathgroup has been created but the database entry has not been committed, that pathgroup is not currently used by AP to manage access to a disk or network. If a previously committed pathgroup has been deleted, but that database entry has not been committed, that pathgroup is still being used by AP to manage access to the disk or network.

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