# AIX Storage Management

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Austin Center

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## First Edition (October 24, 1994)

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# Abstract

This document provides a general introduction to storage management using AIX on the RISC System/6000. Concepts and terminology are covered before describing in more detail the operating system components: the Logical Volume Manager, and file systems. Using this foundation, it then describes the additional features and functions provided with AIX Version 4; useful commands are also detailed, as well as a guide to designing storage subsystems. In order to illustrate the topics covered, and provide examples of common practical application, a section containing detailed step by step information on a variety of storage management tasks is included.

This document is intended for customers and systems engineers who require a more detailed understanding of storage management with AIX on the RISC System/6000, particularly the additional features provided with AIX Version 4, and who wish to have access to practical examples.  Some knowledge of AIX Version 3 is assumed.

(367 pages)

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# Special Notices

This publication is intended to help customers and systems engineers understand the basics of AIX storage management and the additional features and functions provided by AIX Version 4. It also provides various examples to illustrate and help explain various storage scenarios. The information in this publication is not intended as the specification of any programming interfaces that are provided by AIX Version 4. See the PUBLICATIONS section of the IBM Programming Announcement for AIX Version 4 for more information about what publications are considered to be product documentation.

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# Preface

This document is intended to assist customers and systems engineers in understanding and utilizing storage management with AIX Version 4 on the RISC System/6000. The concepts and terminology of AIX storage management are explained first, providing a foundation for a more detailed examination of the elements involved. This will allow less experienced readers to reach the level of understanding necessary to appreciate the new features and functions provided with AIX Version 4. Examples in the use of various storage management commands are provided, as well as an overview of the issues involved in organizing and managing storage with AIX Version 4 on the RISC System/6000. In order to more effectively convey the information, a comprehensive set of detailed scenarios provide step by step practical examples.

## How This Document is Organized

The document is organized as follows:

- Chapter 1, "Storage Management Related Concepts"

  This chapter describes general concepts relating to storage. It is designed to bring those readers with little or no knowledge of storage management under AIX to a level sufficient to appreciate the latter parts of this book. This chapter can be skipped by those readers who already have a good grasp of general storage management concepts.

- Chapter 2, "Hardware Storage Components"

  This chapter discusses in more detail, the hardware components available for use by AIX storage management products. Basic operation and functions are outlined to provide a context for understanding the functions and options provided by the storage management products. This chapter may be used as reference to specific hardware types, or skipped by those readers who are already familiar with the operation of all AIX hardware storage devices.

- Chapter 3, "Operating System Software Components"

  This chapter describes the operating system software components involved in AIX storage management. Specifically, the following areas are covered:

  1. Device Drivers. An overview of the function and operation of device drivers is included, as these provide the basic interface to storage products.
  2. Paging Space. The operating system management of paging space will be covered, as it relates to storage management.
  3. The AIX Logical Volume Manager. The part of AIX responsible for managing storage for higher level processes will also be covered here.
  4. File systems. The creation of a directory structure for file storage on areas of disk managed by the Logical Volume Manager will be discussed here too.

  This chapter can be skipped by readers who are already familiar with these elements of AIX storage management.

- Chapter 4, "AIX Version 4 Storage Management Enhancements"

This chapter contains descriptions of all of the new features and functions that enhance AIX storage management, as included in AIX Version 4. This information is new, and should be read by anyone who is planning to manage storage on a RISC System/6000 using AIX Version 4; it may be skipped by those readers who will not be moving to AIX Version 4 at this time.

- Chapter 5, “Storage Subsystem Design”

  This chapter discusses the various issues involved in designing, configuring, and managing storage under AIX Version 4 on the RISC System/6000. This information is meant to allow readers to gain an insight into the considerations involved in creating efficient storage resources and should be viewed by any reader not familiar with designing efficient storage resource.

- Chapter 6, “General AIX Storage Management”

  This chapter explores more practical aspects of storage management, investigating the procedures necessary for successfully maintaining the storage elements of a system. This chapter contains information applicable to Version 3 and Version 4 users, though readers familiar with management at Version 3 need only look at those sections pertaining to the Version 4 enhancements.

- Chapter 7, “Storage Management Files and Commands Summary”

  This chapter provides examples of the usage of a variety of AIX commands for the management of storage. The chapter is split into two sections, pre-Version 4 commands and post-Version 4 commands. Those commands included in the former section are still relevant under Version 4, while the latter section contains examples of new commands. Readers already familiar with Version 3 commands may therefore wish to skip the first section.

- Chapter 8, “Practical Examples”

  This chapter consists of a number of practical examples of storage management under AIX Version 4. The examples include topics such as reducing page space utilization, common storage errors/recovery, setting backup/restore policy, utilization of new Version 4 features, and many more. Each example contains step by step details and explanations. This chapter should be used by all readers for reference as required.

- Appendix A, “Overview of Hardware Components”

  This appendix will provide an overview of the various hardware storage devices available for attachment to the RISC System/6000. The emphasis is on the basic features provided by the devices, and the mechanisms for attaching them to the RS/6000.

- Appendix B, “Higher Level Storage Management Products”

  This appendix contains a brief overview of the higher level storage management products available. This redbook is primarily intended to cover AIX Version 4 storage management, and as such this information is included for reference only.

- Appendix C, “General Volume Group Recovery”

  This appendix will provide several examples of techniques for recovering from disk failures. These examples have not been tested in this project and are presented as is.

## Related Publications

The publications listed in this section are considered particularly suitable for a more detailed discussion of the topics covered in this document.

- *IBM RISC System/6000 Technology*, SA23-2619
- *RISC System/6000 System Overview*, GC23-2406
- *AIX Version 4.1 Installation Guide*, SC23-2550
- *AIX Version 4.1 Network Installation Management Guide and Reference*, SC23-2627
- *AIX Version 4.1 Getting Started*, SC23-2527
- *AIX Version 4.1 System User's Guide: Operating System and Devices*, SC23-2544
- *AIX Version 4.1 Messages Guide and Reference*, SC23-2641
- *AIX Version 4.1 Problem Solving Guide and Reference*, SC23-2606
- *AIX V3.2 Performance Monitoring and Tuning Guide*, SC23-2365
- *AIX Version 4.1 Commands Reference, Volume 1*, SC23-2537
- *AIX Version 4.1 Commands Reference, Volume 2*, SC23-2538
- *AIX Version 4.1 Commands Reference, Volume 3*, SC23-2539
- *AIX Version 4.1 Commands Reference, Volume 4*, SC23-2540
- *AIX Version 4.1 Commands Reference, Volume 5*, SC23-2639
- *AIX Version 4.1 Commands Reference, Volume 6*, SC23-2640
- *AIX Version 3.2 Files Reference*, GC23-2200
- *AIX Documentation Overview*, SC23-2456

## International Technical Support Organization Publications

- *AIX V3.2 System Management Tips and Techniques*, GG24-4161
- *ADSM Presentation Guide*, GG24-4146
- *ADSM Implementation Examples*, GG24-4034
- *ADSM Advanced Implementation Experiences*, GG24-4221
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> *Bibliography of International Technical Support Organization Technical Bulletins,* GG24-3070.

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# Chapter 1. Storage Management Related Concepts

This chapter examines the basic elements involved in storage subsystems, and explains basic concepts related to the hardware and software involved.

## 1.1 Overview

Storage subsystems may contain a variety of hardware and software products, but primarily exist to supplement the relatively expensive main memory of a computer with less expensive non-volatile storage. Secondary functions include information exchange via removable storage media, backup of vital information for recovery in the event of failure, and short term storage of frequently accessed information. This overview will explain the rationale and some of the concepts involved in the development and usage of the elements of storage subsystems.

### 1.1.1 General Concepts

A computer system is composed of a number of different subsystems that cooperate to carry out tasks on behalf of a user. Generally speaking, the process works as follows. A user wishes to run an application to take some input, operate on it, and produce some output. The application exists as a series of instructions to the Central Processing Unit (CPU) of the computer system that tell it where to get information, what to do with it, and where to put the results. For the CPU to load these instructions and execute them, they must be located in the main memory of the computer system. The first problem is that main memory is volatile, which means that without power, it will lose whatever was stored in it. Thus when the computer is first powered on, it must load its instructions from a non-volatile source, and this is the first function of the storage subsystem, to provide the CPU with it's operating system, and then access to applications and data for processing. This function is usually provided by magnetic disks which are relatively fast, and allow direct access to required information, although a brand new system may load it's instructions initially from diskette, or more commonly magnetic tape.

Now the CPU has access to the required instructions and data, and can go ahead and do useful work for a user. So much so however, that pretty soon the user wants more work done, in parallel, and to support other users workloads. Clever operating system design allows this multitasking, enabling many things to be done at once, but the next problem is that there is not enough volatile main memory to contain all the different applications and data that are in concurrent use. One solution would be to keep purchasing more memory to enable all required applications and data to be maintained in main memory, but this quickly becomes prohibitively expensive. A better solution is to use a system called paging which utilizes reasonably fast, much cheaper magnetic disk as an extension to the main memory. An area of the disk is set aside as paging space, and those applications and data, or parts of applications and data, that are not currently in use, are stored in this space, or swapped out. When an instruction calls for a piece of this data, or the next instruction exists in the page space, the page containing the required information is swapped in, or copied from the disk back into main memory, and something else temporarily not required is copied out. Page space is so named because the main memory is divided into sections known as pages, and these form the units of exchange.

Soon there are large amounts of vital data being produced by the computer, which immediately develops a fault causing everything to be lost, and creating a great many angry people. Not so. The third function of a storage subsystem is to provide inexpensive non-volatile storage for copies of vital information that can be restored to the system in the event of failure. Removable media, such as magnetic tape, diskette, or optical disks are generally used for this, as transfer to and from the devices is easy (though much slower than disk or main memory), and the media can then be stored safely in a secure place for use in the event of failure.

With the advent of faster and faster low cost, high capacity devices such as tape and optical, a fourth usage of storage subsystems is emerging. Space management is the monitoring of information usage, so that less frequently accessed information can be moved to lower cost, slower storage, thereby maximizing the use of the higher cost, faster devices.

One final use of storage devices is for information exchange. Applications, data, and even large directories of information can be stored on removable media, such as optical, tape, diskette, or disk pack. The media can then be removed and replaced for access on a different system, thereby allowing simple transfer for common access to information. With the increase in performance and reduction in the cost of communications networks, this function is becoming less necessary.

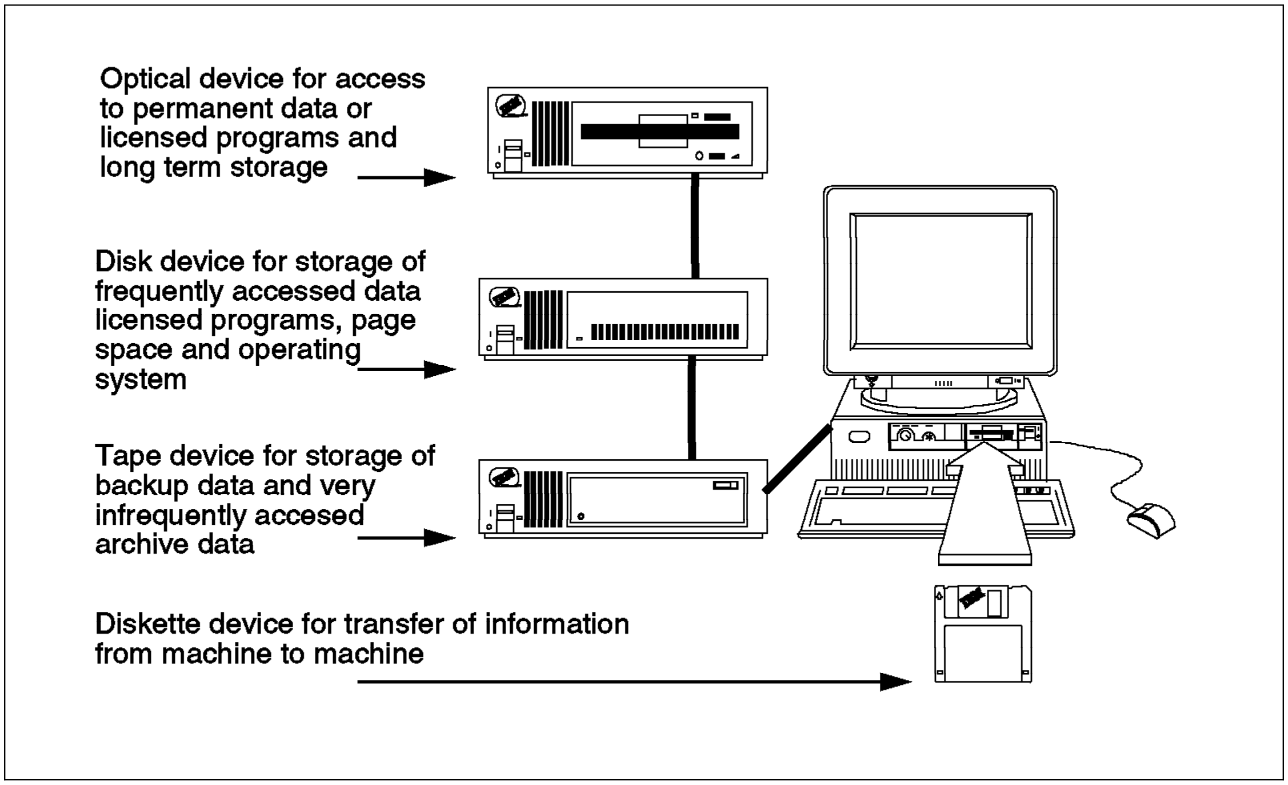

Optical device for access to permanent data or licensed programs and long term storage
Disk device for storage of frequently accessed data licensed programs, page space and operating system
Tape device for storage of backup data and very infrequently accesed archive data
Diskette device for transfer of information from machine to machine

*Figure 1. Storage Subsystem Component Usage*

## 1.1.2 Hardware Concepts

As has been described in the previous section, storage subsystems components have evolved to meet specific requirements within the computer system, and each have different characteristics that enable these requirements to be met. A storage subsystem may contain any or all of the following types of device.

1. Diskette Storage

   Diskettes, or floppy disks, were among the first permanent storage devices developed. Information can be written to and read from a diskette via a diskette drive unit attached to the computer system. The diskette can then be removed and reinserted into a drive on another computer, where the information can be utilized. Information can be accessed directly from anywhere on the diskette so individual files can be quickly located and accessed if required.

   There are quite a few different standards for diskettes, both in terms of physical specifications, and information capacities. In size, diskettes range from 8-inch diskettes, as used on the IBM System/36* for example, to the 5.25-inch and more recently the 3.5-inch diskettes which are the most commonly used today. Information capacity ranges from the earliest 320KB 5.25-inch diskettes to 2.8MB 3.5-inch diskettes today. Performance is relatively slow, and coupled with the low maximum capacities, diskettes tend to be used mostly for transferring small amounts of information between computers, and sometimes for backing up information from small personal computers.

   The 5.25 and 3.5-inch standards are common to most manufacturers machines, as are certain data formats used; this means that diskettes are still one of the simplest mechanisms for exchanging information between computers of different types.

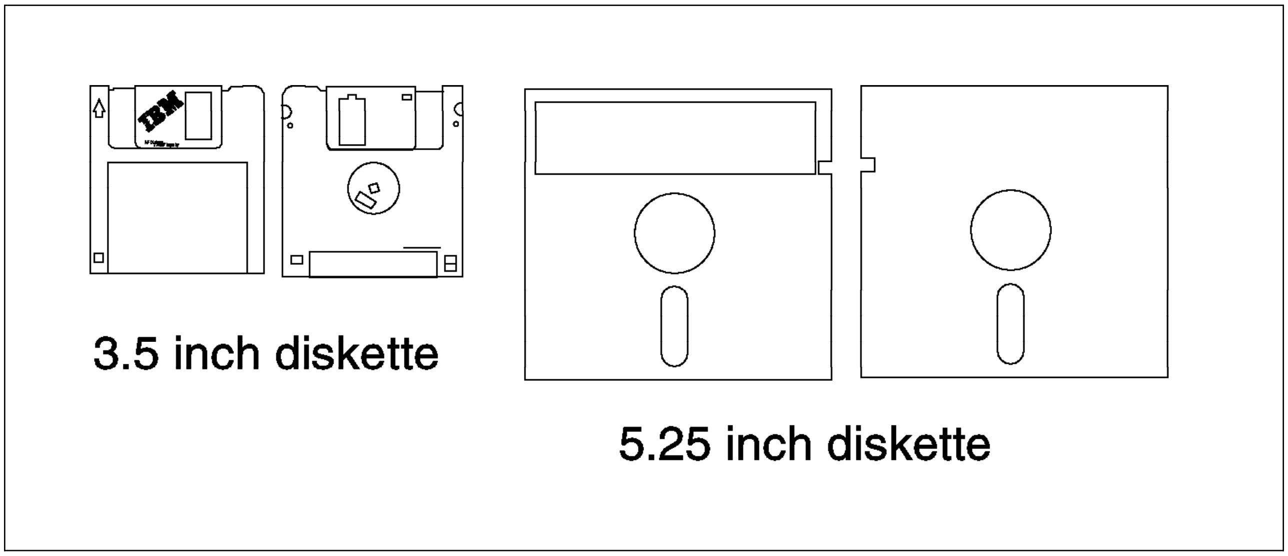


*Figure 2. Diskette Types. 3.5 inch diskettes are the most commonly used diskettes on the RS/6000, though the lower capacity 5.25 inch diskettes are still available.*

2. Tape Storage

   Tape storage technology has also been in existence for some time. The earliest computers would utilize tape in much the same way that disk is used today for storage of programs and data. The main difference between tape and other forms of storage device is that information is read and written sequentially. This means that random access to information on a tape is slow, as the tape must be sequentially searched from the beginning. The read/write speed can be very fast, and the information capacity very high - up to 10GB per tape - which means that tapes are currently best suited for backing up large amounts of data, or for infrequent access to archived information.

There are two main types of tape device. Tape cartridges contain all of the tape inside a case which is inserted into a drive in much the same way as a diskette. Tape reels contain the tape wrapped around a single spool, and tend to require more complex mounting operations.

There are many different sizes and types of tape device, as well as an equal variety of recording formats. This means that tapes are not as easily interchangeable as diskettes.

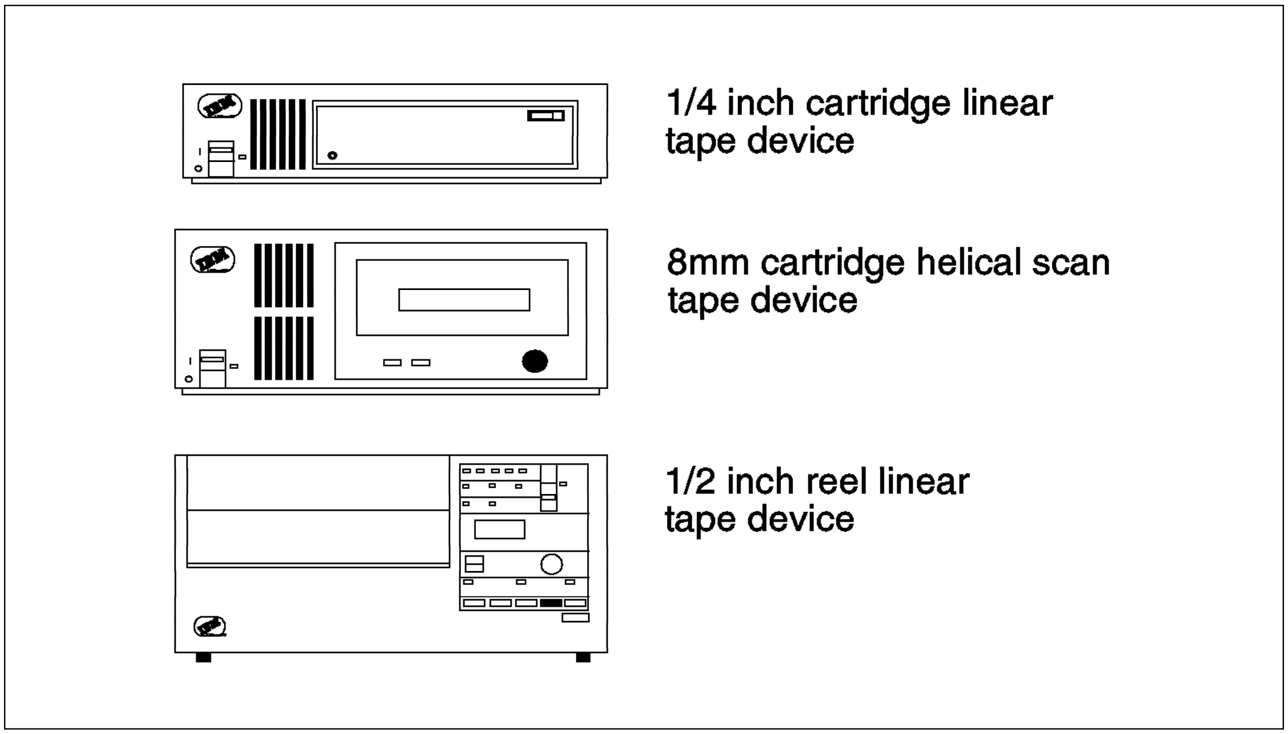
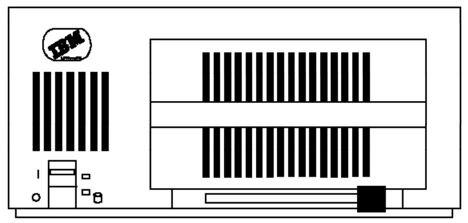

1/4 inch cartridge linear tape device
8mm cartridge helical scan tape device
1/2 inch reel linear tape device

*Figure 3. Tape Device Types. These are some of the different tape devices available for use on the RS/6000.*

3. Disk Storage

   Magnetic disk, or Direct Access Storage Devices (DASD), are similar to diskette in design. Also known as fixed disk, magnetic disk is not however generally removable, and allows much higher read/write speeds and information capacity. Single units are now capable of storing up to 2GB and the technology is improving all the time. Disk also allows direct access to information, and coupled with the capacity and performance, makes an ideal device for loading information to, and saving from main memory.

   There are models of disk drive that do allow the removal of the internal fixed disks. The removed disk packs can then be transferred to and utilized by other computers, although due to the proprietary nature of most disk information organization, compatibility is usually only ensured between computers of the same model.


355MB SCSI attached external disk device. This drive allows the removal of the disk pack.

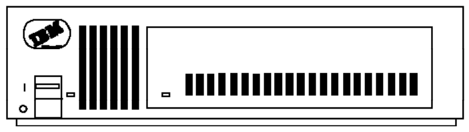

320MB SCSI attached external disk device. The disk platters are fixed inside this unit.

*Figure 4. Disk Device Types. These are some of the different disk devices available for external attachment to the RS/6000.*

4. Optical Storage

   A relatively recent technology, optical storage is based on Compact Disc technology, though there are several different mechanisms and formats in use. The simplest utilizes standard CD technology providing a Read Only Memory (ROM) capability, surprisingly known as CD-ROM. Later, more complex evolutions allow the disk to be written to once and then read from as a normal CD-ROM; this is known as Write Once, Read Many (WORM). The latest products allow complete read write capability.

   All of these products allow direct access to information, though the access time is somewhat slower than for DASD. The capacities range from 640MB for a CD-ROM to several GB in the latest products. Optical storage products are improving all the time, and the latest products are best utilized as secondary storage for less frequently accessed information, either working in parallel with DASD, or as part of a storage management system. Many optical devices allow for removable media, which make them ideal for software distribution on CD-ROM; the extraordinarily long life of information recorded on optical media (up to one hundred years) also makes this a good medium for information archive.

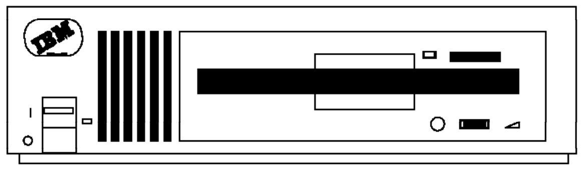

This CD-ROM device is for external SCSI attachment. The standard CD is loaded into a caddy before insertion into the drive.

*Figure 5. Optical Device Type*

This covers the various storage media available in overview. These devices also require software to drive and utilize them to their fullest potential, as well as hardware attachment methods. Both these topics will be discussed later in this chapter.

### 1.1.3 Software Concepts

So far, the purpose of the various hardware elements comprising a storage subsystem, as well as their place in the overall scheme have been discussed. In order to make these devices perform, some form of software is required to drive them. In actuality, several levels of software products are involved, and this section outlines the hierarchy.

1. Operating System

   As is fairly common knowledge, the key player in a computer system is the operating system. This complex piece of software is responsible for making the resources of the computer available to applications in a reasonably fair and effective manner. Looking solely from the perspective of storage, the first component involved is the device driver. This piece of software is written specifically for the hardware device it provides an interface to. Essentially, it understands how to talk to the device and obtain the best performance from it. When an application wishes to communicate with the device (read or write some information), the request is made ultimately to the device driver which manages the device and executes the required function. Applications can communicate directly with the device driver, known as raw device handling, or through an intermediate software product which usually provides additional capabilities. The commands made to a device driver are usually standard (read, write, control commands) so applications need not be aware of differences in the hardware devices they are using. This does mean that a specific device driver must be provided for every device.

   Utilizing device drivers to access the devices, a number of other operating system components provide useful functions.

   - Logical Volume Manager

     This piece of software provides a number of convenience and protection functions transparently to an application. The specifics of the LVM will be discussed in a later chapter, but include the ability to generate multiple copies of information (mirroring) for protection in the event of failure, relocation of information in the event of damage to an area of disk, and the implementation of information location policies to enable frequently accessed information to be located more quickly.

   - File Systems

     File systems provide the user with a hierarchical view of the space available to them for application and data storage. Generally the view is organized as a tree structure of directories for organizational convenience. Operating system commands are provided to open, close, read, write and control files within the structure. File systems use the LVM, which in turn uses device drivers to access the hardware.

   - Backup/Restore commands

     These operating system commands allow selected information, or even entire systems to be saved to a storage device. In the event of failure, the information can then be restored to the system from the device.

   - Miscellaneous

There are a number of operating system commands that allow reading and writing of information to a storage device. Some of these are designed for specific devices, others generic, but they all use device drivers to communicate with the device.

These components will be discussed in more detail in Chapter 3, "Operating System Software Components" on page 45.

2. Higher Level Tools

   Higher level tools are generally applications that are designed to provide more complex storage management functions such as scheduled backup of files, disk space management, and data archive for example. These tools will usually employ many of the operating system functions to provide a more convenient interface to managing storage, which means that some of the capabilities of these products can be achieved with a good knowledge of the lower level operating system functions. Although beyond the scope of this book, some of these tools will be discussed in outline in Appendix B, "Higher Level Storage Management Products" on page 341.

3. Applications

   Most applications will require access to information as part of their function. Many of them will access files through the file systems mentioned earlier, thus gaining the benefits of the more complex functions provided by this part of the operating system. Some applications will use storage devices directly through device drivers, which while being more complex in implementation, allows a more flexible approach to the management of their information. Databases are typical examples of applications that access storage devices in this way.

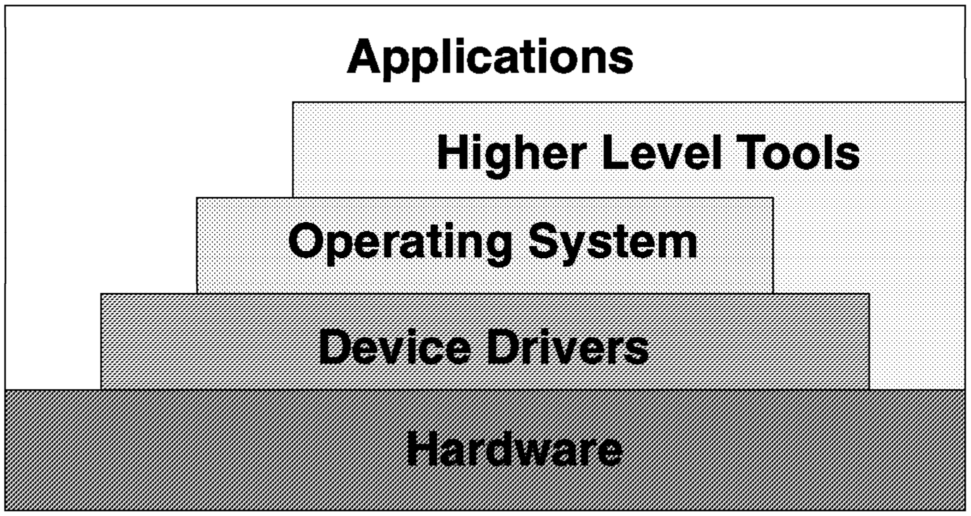


*Figure 6. Storage Software Organization. The various levels of software used in storage subsystems make use of lower levels of software as well as sometimes utilizing the hardware directly.*

## 1.2 Storage Management

So far, the computing environment in general has been described in order to allow the storage elements of the system to be positioned and discussed generally. This section will focus on storage management; what are the issues that this area addresses, and what aspects of a storage subsystem does it focus on.

## 1.2.1 Hardware Management

From the hardware point of view, all of the devices that can constitute a storage subsystem have been briefly discussed, and will be explored in more detail in the next chapter. The intention here is to look at what aspects of their operation are critical to overall system operation, and therefore form the focus of storage management. This should put into context the discussion in later chapters of the operating system commands and higher level tools available.

There are three main considerations, performance, availability, and capacity.

### 1.2.1.1 Performance

Performance is usually all about providing access to a resource such that particular criteria are met. The resources in a storage subsystem all have different characteristics and intended uses, and therefore the criteria applied are also different. In general though, it is safe to say that performance in storage products is about maximizing the throughput of information to and from the device.

As has been said, there are different criteria for each device and some examples follow, though a more complete discussion of maximizing performance for storage subsystems can be found in Chapter 5, "Storage Subsystem Design" on page 77 and Chapter 6, "General AIX Storage Management" on page 93.

- System bus

  All information passed to I/O devices must at some stage cross the system bus. The performance of this device is a common factor for all devices, though rarely a bottleneck.

- Hardware attachment adapter

  The physical attachment of all I/O devices to the system is via some sort of adapter. There are various types including SCSI, Serial, Optical, and Channel. Some of the issues which affect performance at the adapter are the data rate, the number of devices supported, and the command capability of the adapter. For example, some adapters are capable of overlapping commands, duplex communication, and sorting of requests for best performance.

- Disk Devices

  Throughput to a disk depends on a number of things, the most basic of which is the maximum read/write capability of the disk for sequential operations, which is fixed by the disk technology; the maximum possible data rate from a single disk cannot be higher than this. The intended usage of the disk will also affect performance. Random access requests, where the disk read/write head has to move around the disk a great deal will take longer than sequential requests which involve only the initial search for the data. There are other facilities such as mirroring, where multiple copies of data are maintained in parallel. This can provide higher throughput when access to the data occurs in parallel, as well as increased availability due to the multiple copies, though at the cost of increased disk space requirements.

The design of a storage subsystem will involve considering these options and more. As will be seen after the section on availability, many of these possibilities involve trade-offs with performance and cost, the final decision often being one of compromise. Actual subsystem design is covered in more detail in Chapter 5, “Storage Subsystem Design” on page 77, and disk function in 2.2.2.1, “Disk Technology” on page 25.

- Tape Devices

  Throughput to tape devices is also limited to the maximum read/write capability of the drive. Tape devices access information sequentially by their nature, information being read and written on a sequential medium. As such, random access to information is slow, and tape devices are not normally called upon for this requirement. Some tape devices provide for data compression when writing and decompression when reading, thereby increasing the volume of data and therefore the throughput. Some tape subsystems provide autochangers with access to a library of tapes; in these instances, tape selection and load time also become a throughput issue.

  Performance in tape devices is therefore generally a straightforward consideration of the physical specifications: features provided (for example compression and libraries), throughput, and perhaps compatibility with other tape media. Again, these issues will be discussed in Chapter 5, “Storage Subsystem Design” on page 77. Tape function is covered in 2.2.3, “Tape Storage” on page 34.

- Optical Devices

  Throughput to optical devices involves elements from both disk and tape devices. Optical devices operate in a similar fashion to disks, allowing sequential and random access, and therefore present similar design considerations; optical devices do generally possess a lower data rate than magnetic disk though.

  In common with tape devices, it is possible to have optical libraries which again present similar considerations to tape library access.

  Performance of optical technology is also therefore dependent upon the intended environment, as well as the basic characteristics of the media. Design issues will be covered in more detail in Chapter 5, “Storage Subsystem Design” on page 77, and the technology itself is discussed in 2.2.4, “Optical Storage” on page 39.

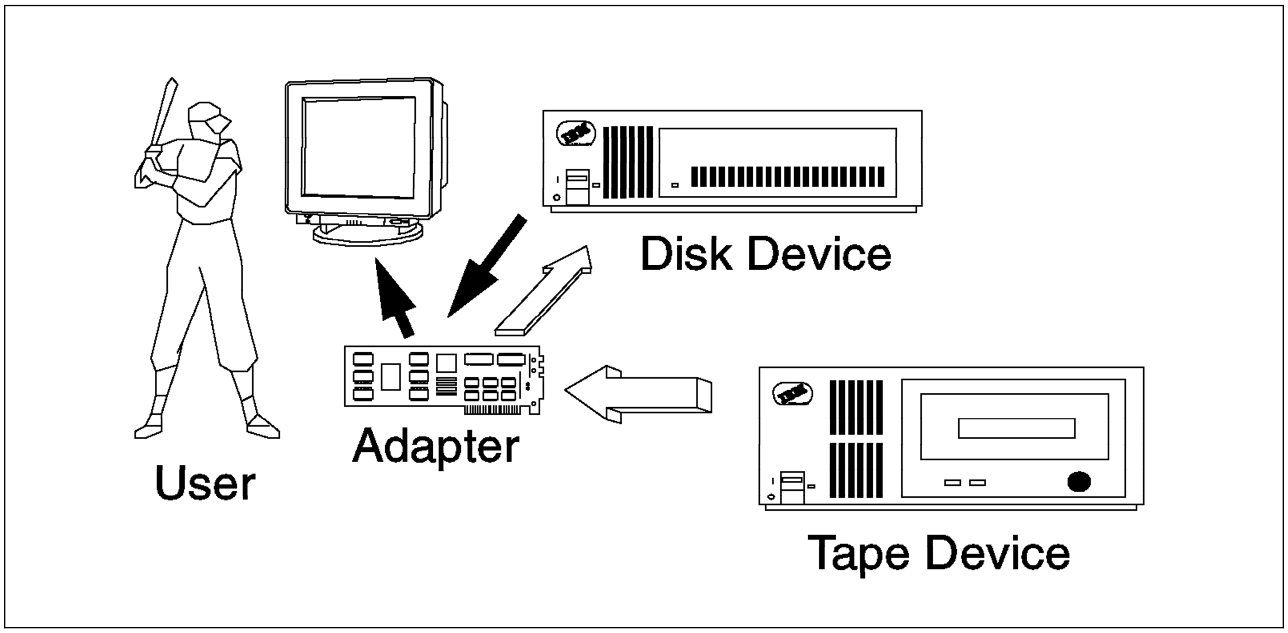


*Figure 7. Importance of Performance Management. Users can become a trifle irritable if information is not quickly forthcoming from their computer systems.*

#### 1.2.1.2 Availability

Availability concerns designing the storage subsystem to minimize the effects of failure in any of the elements. Every environment will have different requirements in this area, but essentially the intention is to ensure the continued operation of the system despite failure in certain components. The level of redundancy, or replication of devices for replacement purposes in the event of failure, is again a trade-off with price and performance.

- Tape Devices

  As has been explained in the previous section on performance, tape devices are generally used for backup/restore operations, which means that they do not tend to be a critical part of the subsystem (unless failure occurs during restore after a crash, or during usage of the device itself), and as such, having an alternative device to use may be sufficient for most situations.

- Optical Devices

  Optical devices again do not tend to be used for primary data storage, due to their slower access times, rather being used for archive or less frequently accessed information. As such, providing a replacement device may also be sufficient protection against failure. As with tape devices though, the exact requirements will vary with the environment in question, and a more comprehensive account of the design considerations can be found in the section on storage subsystem design.

- Disk Devices

  Disk devices constitute the most vital element of a storage subsystem, indeed of the computer system. Processors and memory can be replaced, but a disk crash can cause the loss of irreplaceable information. Furthermore, disk devices are in continuous use as extensions to main memory, and as storage for frequently accessed data; as such, availability of these devices is of prime concern.

Availability in this context has several connotations. The first and most obvious, relates to ensuring that required information is always available, and that corruption or problems with access to this data can be compensated for. Techniques for ensuring this include file journaling and mirroring, which are discussed in the section on file systems and AIX* Storage Management respectively. These techniques ensure access to data can be maintained continuously, even in the event of a hardware disk failure. Generally, though, some time will need to be spent with the system not operational to allow rebuilding of file systems, or replacement of damaged parts; this activity should of course be scheduled to minimize its impact, but is nevertheless a requirement.

The second connotation relates to not only ensuring that data is always available, but that any repairs can be effected whilst the system remains operational. The main technique for ensuring this function, is utilizing some form of RAID (Redundant Array of Independent Disks). RAID is beyond the scope of this book, but basically involves providing an intelligent array of disks that allows mirroring, parallel access to data, on-line replacement of failing components, and high performance.

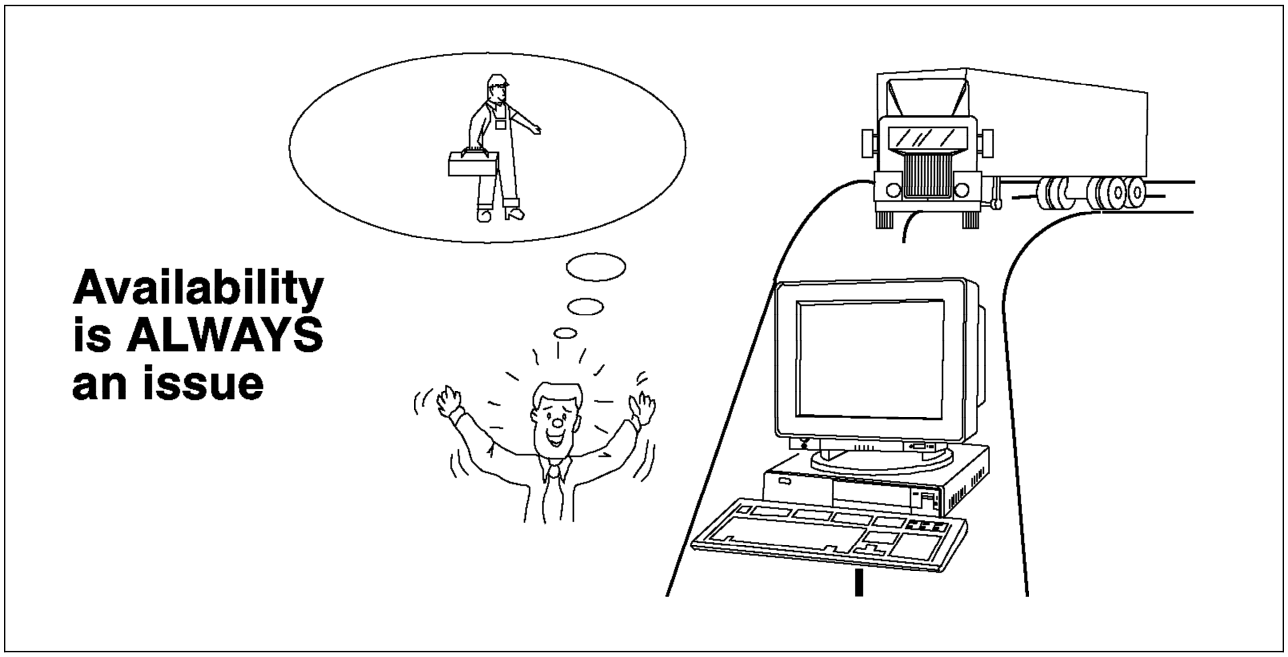


*Figure 8. Importance of Availability. However carefully managed a computer system is, there will always be unforeseen circumstances when information is lost.*

#### 1.2.1.3 Capacity

The last main consideration is that of the capacity of the devices. Capacity is generally related to performance, the more space that a device has, the longer the average access time will be. This tends to be more important for devices that will be used to access data for interactive use (such as disk or optical), and it can sometimes be more prudent to utilize more lower capacity devices than fewer larger capacity devices. This will be a trade-off between cost and performance again, and there are other solutions to increasing performance through parallel access to devices.

In the main, increasing capacity with disk devices involves purchasing either larger, or more devices. With optical and tape devices there is another option, and that is the library. Optical and tape libraries provide the capability to store many tapes or optical cartridges within a managed library, such that when a request for a particular piece of data arrives, the library knows which tape or optical cartridge the information is on, and can then utilize robotics to select the item and load it into the tape or optical device. Libraries are discussed in more detail in 2.2.3.2, “Selecting the Correct Tape Storage Devices” on page 37 and 2.2.4.2, “Selecting the Correct Optical Storage Devices” on page 42.

Thus the three major criteria from a hardware point of view, are the performance of the storage subsystem, or more generally, it's throughput, the maintenance of the required level of availability of the information stored, and the quantity of data that can be kept, or capacity.

## 1.2.2 Software Management

From the point of view of software in storage management, the main elements have been described in overview, and will be covered in detail in the section on Operating System Software Components. The intent of this section is to examine the main issues that software management aims to address, in order to provide a context for the discussion of the features currently available for storage management, as well as the new features provided in AIX Version 4.

There are three considerations, space, recovery, and administration.

### 1.2.2.1 Space

As has been discussed, in any computer system, there is a finite amount of fast main system memory. This, coupled with the requirement for non-volatile storage, leads to the necessity for the provision of cheaper, auxiliary storage. It is a truism to say that anything grows to fill the available resource, and this is particularly true of information stored in computer systems; thus the cheaper disk storage devices used for accessing frequently used data will also become full over time, particularly when availability designs are taken into account. Whilst cheap, disk devices are not *that* cheap, and so some sort of plan for managing available disk space must be developed.

Managing disk space usually involves moving less frequently accessed information out to slower, larger capacity, and cheaper per unit of information, storage devices. Optical storage devices supporting read and write capability are an ideal medium for this less frequently accessed information. Optical storage can be treated in the same way as disk, with only access time being slower. Using statistics on data access, less frequently used information can be moved to the optical media, the slightly longer delay in retrieval being acceptable for this type of information.

There is also a large amount of information that is very infrequently, if ever, accessed; tax information must be kept for five years for example, in case an inspection is required. This kind of information can be moved to even slower, massive capacity devices, such as tape libraries.

Again, this process is a trade-off between space and access time, and is usually called data archiving. Policies can be defined, and operating system tools used to manage disk space, as will be shown in the chapters on operating system software. There are also higher level tools designed specifically to provide automatic management, and some examples of these can be found in Appendix B, “Higher Level Storage Management Products” on page 341.

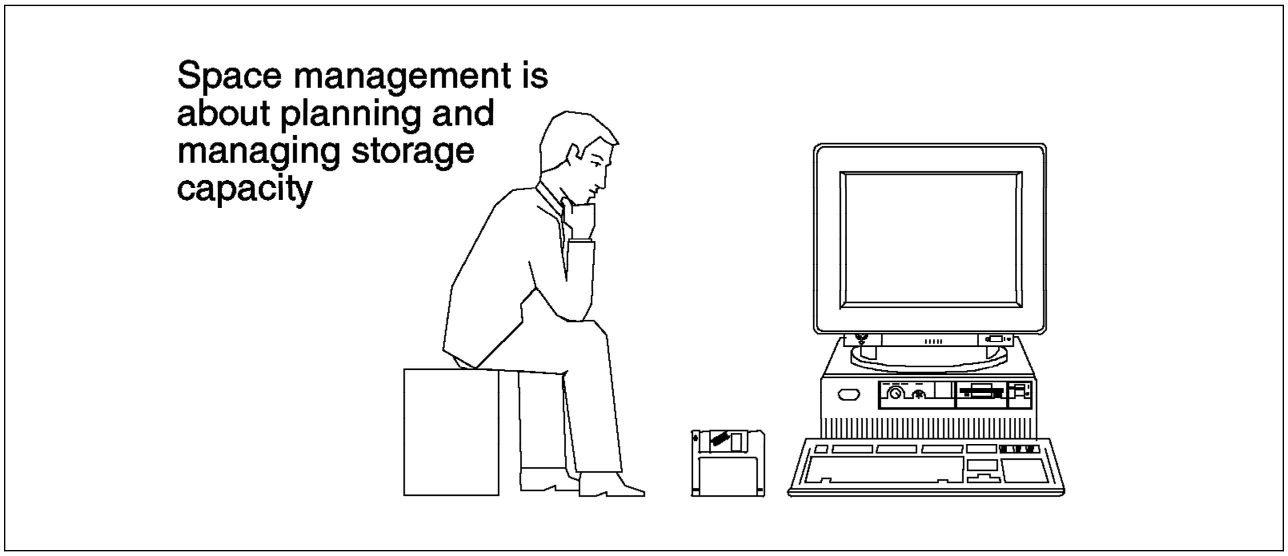

Space management is about planning and managing storage capacity

*Figure 9. Space Management. Organization of the available storage space on the computer system is very important to ensure sufficient room for all of the currently required information, as well as projected growth.*

#### 1.2.2.2 Recovery

The second consideration is concerned with making provisions for failures in the storage subsystem. Disk devices can fail for a variety of reasons including mechanical faults such as head crashes, electronic failures, and corrupted data on the disk itself; optical storage can suffer from mechanical problems, tape devices can fail, and information written to tape can be unreadable due to problems with the tape media. Users of the system are also prone, on occasion, to accidentally erase vital components of the system, operating system files, or data. There is also the possibility of natural disasters such as fires, floods, or even lightning.

When a failure occurs, and it will, it would be fairly useful to be able to restore the system to its state prior to the problem. This is what recovery management is all about. There are several different strategies that can be employed, and these will be discussed in detail in the chapters on storage management, but the main point is to ensure that a current copy of the information stored in the system is available to reload from. This copy is usually stored on tape, and its currency reflects the amount of data that an organization can afford to lose. For example, if losing more than a days worth of information would be fatal to a company, then copies of at least the vital data need to be made daily. There are various ways to minimize the amount of information that needs to be copied each time, as well as high level tools to assist in managing the process. Some of the high level tools will be briefly discussed in Appendix B, “Higher Level Storage Management Products” on page 341. Again, the operating system provides the basic tools to manage this process, and this area will be examined in more detail in the chapters on storage management.

Recovery is about being able to restore the system to its original state

*Figure 10. Recovery Management. The effects of disaster can be minimized if sensible backup precautions have been taken. Having the right tools and procedures for the job eases the task of recovery.*

#### 1.2.2.3 Administration

In order to make use of the devices constituting a storage subsystem, the operating system needs to made aware of them, their capabilities, and how they are to be used. Furthermore, in the event of failure, or for general maintenance, there are tasks that need doing, such as making devices temporarily unavailable so that they can be replaced, or reconfigured. Additionally, performance and usage statistics may need to be gathered so that informed planning and management can take place.

The operating system therefore provides administrative commands and tools that enable these processes to be performed. Devices can be defined to the system, made available or unavailable, configured, and monitored for performance and usage. One other useful administrative tool gives the ability to define and manage quotas for disk usage, thereby allowing a modicum of control to be exercised over usage, and thereby ease the task of managing the subsystem. These activities are examined in more detail in the chapters on operating system software components and storage management.

Diskette devices have not been mentioned in this section on storage management, mainly because their major usage is for simple transfer of small amounts of information between computer systems that are not connected via a network. In the past, when the quantity of information stored on computers (and still today for some smaller personal computers), diskette devices were used for backup purposes. Whilst remaining very inexpensive per diskette, and although the capacity has grown to several megabytes, the sheer volume of information contained in a general system backup precludes the use of diskettes for this purpose.

## 1.3 Summary

This chapter has looked at the basic concepts of storage management.

The first section examined the rationale behind storage subsystems, explaining at a high level, the reasons why auxiliary storage is required. The components that comprise storage subsystems:

- Diskette devices
- Tape devices
- Disk devices
- Optical devices

were looked at individually, and their basic capabilities discussed. Finally, the software components used with storage subsystems were discussed:

- Logical Volume Manager
- File systems
- Device drivers
- Higher level tools
- Applications

again at a high level, in order to demonstrate the levels of function provided by the various parts.

The second section looked at the rationale behind storage management. The considerations involved in hardware management:

- Performance
- Availability
- Capacity

were discussed, along with an examination of the impact that particular devices have in these areas. The issues addressed by software management:

- Space
- Recovery
- Administration

were explained in overview to put into context discussion in later chapters of these processes, and the tools and commands that enable them.

# Chapter 2. Hardware Storage Components

This chapter is intended to overview the capabilities and functions of the hardware storage devices available to AIX. This will help to provide a context for understanding more clearly the rationale behind some of the storage management policies and the options and features of storage management software, as well as enabling more informed decisions to be made when selecting hardware devices.

## 2.1 Selecting the Hardware Components

Selection of the components that will make up the storage subsystem ranges from very easy to being a complex trade-off. First of all, the application requirements need to be considered in terms of their storage necessities, the mix of storage device types then needs to be decided, and finally specific products need to be chosen.

### 2.1.1 Points to Consider

Selecting the correct products for inclusion into a storage management subsystem involves consideration of a number of points:

- Cost per megabyte

  The cost per megabyte of storing information on a device is always important. This cost is usually proportional to the speed of access to data on the device, and generally also proportional to the capacity. If rapid access to data is essential, then the cost will be higher.

- Access frequency

  This figure represents the number of times data on the device will be accessed in a given period. The higher this figure, the higher the data rate, access times, and reliability usually need to be. Devices supporting frequent access are usually required for interactive types of applications.

- Access density

  This value describes the number of I/O requests per gigabyte of data. This value needs to be considered in conjunction with the access frequency. High access density and low frequency suggests using optical storage; high density and high frequency suggests disk; low density and low frequency suggests tape; low density and high frequency may involve other decision points such as cost.

- Access type

  This describes the required method for access to the data on the device, and can be sequential or random. Random access means accessing small amounts of data at many points on the device, whilst sequential access means accessing large amounts of data from relatively few points. The difference is mainly to do with just how easy it is to locate specific data elements on the device. If it takes a long time to search for the required information, then random access is not recommended. Database applications tend to involve random requests, whilst backups or restores would be good examples of sequential operations.

- Data rate

This describes how rapidly the data can be obtained from the device (once located). Interactive applications tend to require a high data rate, whilst batch applications can usually tolerate lower data rates.

- Online life

  This describes how long data will need to be accessible on the device, and is sometimes known as data age. Data age is usually inversely proportional to access frequency, and therefore high values here usually imply the use of low cost, low speed, high capacity devices.

- Interchange requirements

  Will the information stored on this device be exchanged with other systems? If this is the case, then some form of removable media will be required.

- Longevity

  If archive, backup or even reference information is to be stored for long periods of time, then the integrity of the media used is important. Most media have a shelf life, after which degradation of stored information is likely.

- Reliability

  This is an extremely important consideration, particularly when mission critical information is being considered.

- Regulatory requirements

  Some industries are under legal restrictions with regard to data management. Restrictions can apply, among other things, to access security and length of time that records must be retained for.

## 2.1.2 How to Make the Decision

The decision as to which storage device is best for a given environment can be represented using a Venn diagram as in Figure 11 on page 19.

### 2.1.2.1 The Simple Case

This example shows the case where the decision is not complicated; examination of the points discussed in 2.1.1, “Points to Consider” on page 17 has placed the solution completely into one of the shaded areas:

- Disk

  Disk would be selected when the environment requires high performance and response times are critical.

- Tape

  Tape would be the choice where low cost archive of information, high speed sequential access to data, and/or backup/interchange of data is required.

- Optical

  Optical should be used if long term archive of information is the primary requirement.

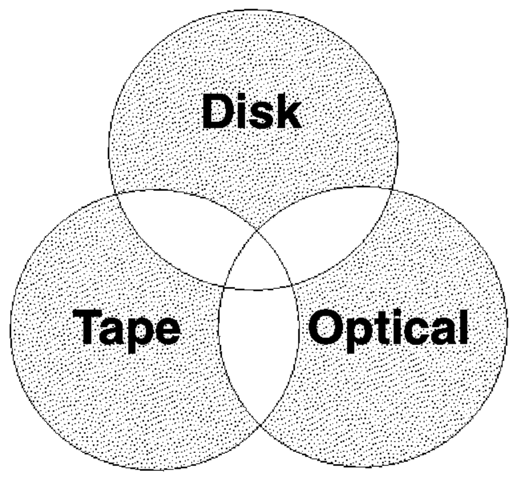


*Figure 11. Simple Storage Component Selection*

It is not always this easy however, and requirements often generate a case for more than one device type.

### 2.1.2.2 Things Become More Complicated

In these examples, the decision points in 2.1.1, "Points to Consider" on page 17 have resulted in requirements for more than one device type, as can be seen in Figure 12 on page 20.

- Disk/Optical

  In this case, the requirements present arguments for both disk and optical devices. Reasons for this include:

  – Random access to information with medium to high performance requirements

  – Use of non-traditional applications such as image, which require medium access frequency to large amounts of sequential data

  – Long term storage of information is sometimes necessary

  – Data usage allows migration of less frequently accessed information to slower speed devices

  – High availability and/or fault tolerance is required

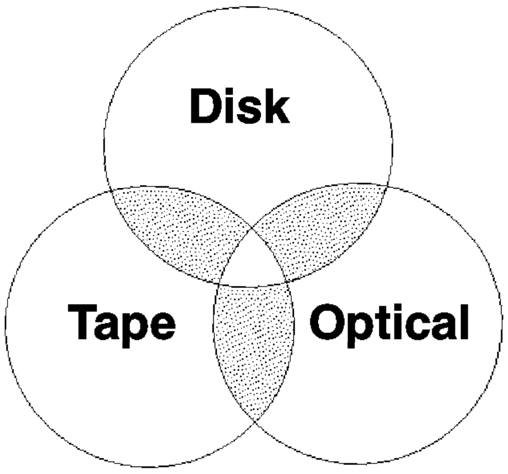


*Figure 12. Requirements Suggest Several Components*

- Disk/Tape

  Here, the requirements include benefits from using both tape and disk. Some of the reasons for this include:

  - Access to large amounts of sequential data is required, with medium to low performance
  - Large amounts of space are required
  - Time to access first byte of data is not significant, though the performance requirements are then high

- Tape/Optical

  In this situation, it can be seen that there are requirements for both tape and optical storage devices. This state of affairs may have arisen as a result of the following points:

  - Bulk of access to data will be low speed sequential
  - Requirements for random access to information
  - Time to access first byte of information is not important
  - Migration of less frequently accessed information from reasonably fast media to slower speed media is acceptable
  - Data life is important

Sometimes the decision can be even more difficult though.

#### 2.1.2.3 The Worst Case

The worst case is not terrible in the sense that it is a disaster, but it does mean that the requirements are complex enough to merit selection of devices of all three types (see Figure 13 on page 21). Some of the reasons that may have led to these decisions include:

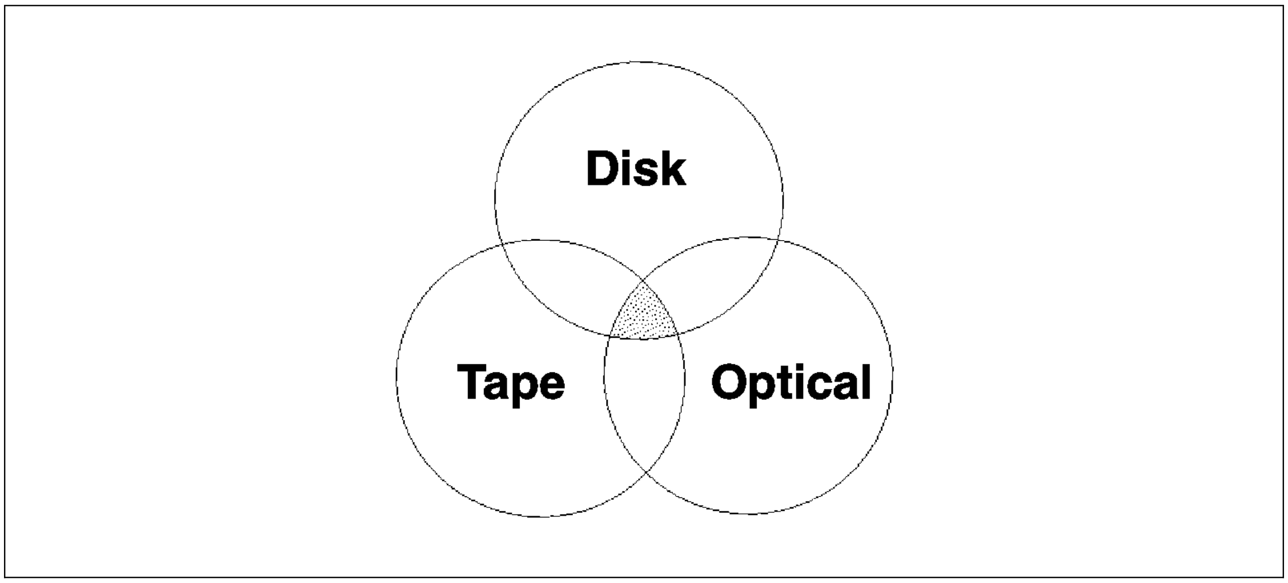
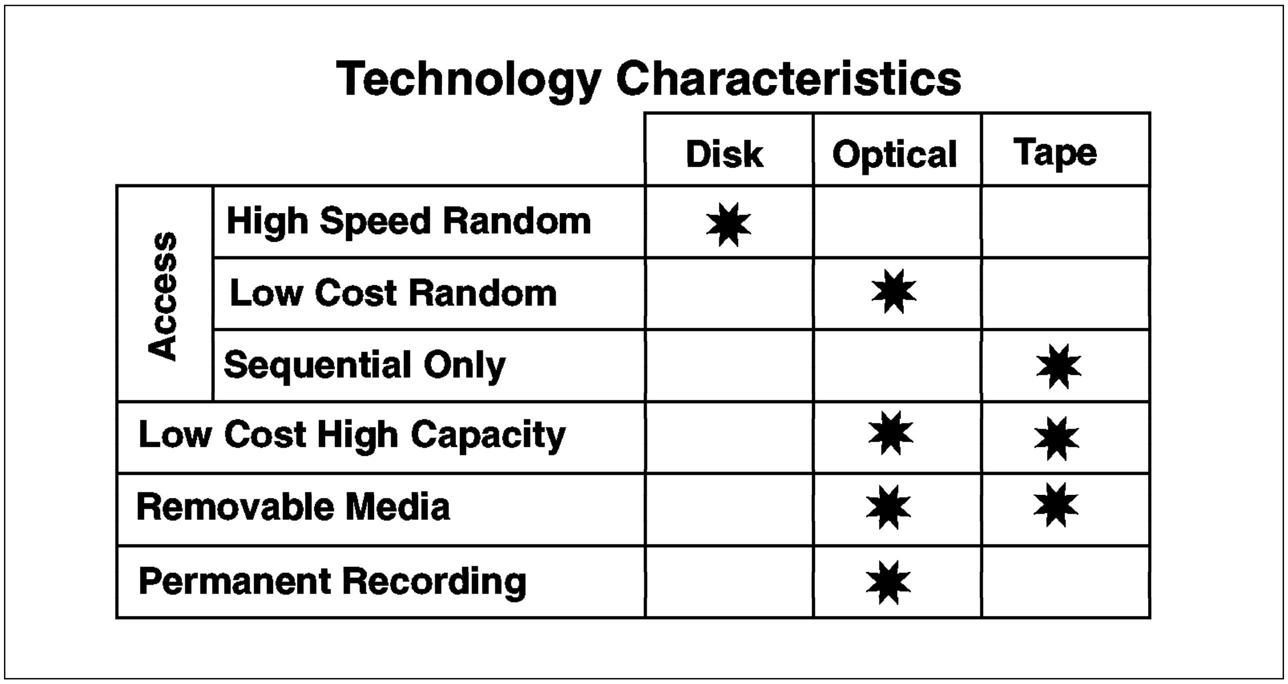


*Figure 13. Complex Storage Component Selection*

- Strong requirements for high performance random access to information
- Large amounts of information need to be stored, though not all access will be concurrent
- There is a need to store archive information, and data life is an issue
- Fault tolerance and high availability are important
- Capacity is likely to grow

The chart in Figure 14 summarizes the advantages of each of the device types.



**Technology Characteristics**

| | | Disk | Optical | Tape |
|---|---|---|---|---|
| Access | High Speed Random | ✱ | | |
| | Low Cost Random | | ✱ | |
| | Sequential Only | | | ✱ |
| Low Cost High Capacity | | | ✱ | ✱ |
| Removable Media | | | ✱ | ✱ |
| Permanent Recording | | | ✱ | |

*Figure 14. Summary of Device Attributes*

Selection of the correct devices for the storage subsystem does, therefore, involve careful consideration of the types of information that will be stored, as well as the access requirements. Once the correct mix of devices has been selected, it is then necessary to choose specific devices from within each device class. Within each class, the basic functions of the device (disk, optical or tape) can be implemented in a number of different ways, with different costs associated, and different levels of function provided. Selection of the actual device to be used is also a matter for consideration, and the following sections endeavor to assist in this process by discussing the features, functions and technologies involved in each class.

## 2.2 Selecting the Physical Hardware Devices

This section will look at the different physical implementations of the various devices available, and explain some of the advantages and disadvantages involved in their selection.

### 2.2.1 Hardware Attachment Adapters

As has been mentioned in the previous chapter (see 1.2.1, "Hardware Management" on page 8), the adapter forms the primary interface between storage devices and the rest of the computer system. The adapter is responsible for communicating instructions and data between a controlling process and the storage device. There are a number of different adapters available, each utilizing differing communications protocols, and each with subsequent pros and cons. Each storage device also supports different combinations of adapters, so it is well worth understanding the difference in order to enable sensible decisions to be taken.

There are five main things to consider when looking at adapters:

1. Cabling requirements

   Every adapter technology places limitations upon the length of cable supported between the adapter and a device, and then device to device (if supported). This can have implications in terms of the amount of disk that can be attached for example (the physical sizes of the devices may be greater than the cable length allowed for connection). The size of the cable may also cause problems if routing though ducting is necessary.

2. Performance/Reliability

   The maximum sustainable and burst data transfer rates govern how fast information can be sent to and retrieved from the devices. This has implications in the number and type of devices that can be attached to a particular adapter. The reliability of the technology will also affect performance (some methods are less error prone than others).

3. Addressability

   This governs both how many devices can be physically attached to an adapter, as well as the type of device. Some adapter technologies allow attachment of multiple systems; this means that more than one processor can share storage devices using this mechanism.

4. Device support

   Obviously, the adapter selected must be capable of supporting the devices required for attachment now, but consideration should also be given to future requirements, as well as range of devices supported (some standards are more open than others).

5. Cost

   Both the cost of the adapter and the average cost of devices supporting attachment to the adapter should be considered. Some technologies are more expensive than others.

The following sections look at the various adapter options available.

#### 2.2.1.1 Small Computer System Interface Adapter

The Small Computer System Interface or SCSI is one of the most common mechanisms for attaching both IBM* and non-IBM peripherals. SCSI originated from the selector channel on IBM System/360* computers, and was later scaled down by the Shutgart Associates Company to make a universal, intelligent disk drive interface. After around four years of discussions, in 1986, SCSI became an ANSI standard, expanded to support other kinds of devices as well.

This standard, now referred to as SCSI-1, allows a maximum of seven devices to be attached, and provides a one byte wide parallel bus. Each attached device has a unique address to allow the operating system to communicate with it. Data can be transmitted either synchronously, or asynchronously, depending upon the capabilities of the device used; both asynchronous and synchronous devices can share the same SCSI bus, and in fact, all devices must start up in asynchronous mode initially to enable this compatibility. Asynchronous transfer rates are typically around 1 to 2.5MB per second, while synchronous devices can communicate faster, from 4 to 10MB per second. This original standard defined optional synchronous clock speed of up to 5MHz, giving a maximum data rate of 5MB per second on the one byte wide bus.

With the release of the SCSI-1 standard in 1986, work started on a new standard, predictably called SCSI-2. This standard is still in the process of being officially approved as an ANSI standard, though many vendors, including IBM, have implemented most of the features in the draft standard. Among the new features are the following improvements.

- Command Tag Queuing

  This provides the ability to queue multiple commands to devices understanding the SCSI-2 protocol, which improves performance by making more efficient use of the available bandwidth.

- Fast SCSI

  The standard now defines permissible clock speeds of from 5 to 10MHz, which increases the data rate to 10MB per second on a one byte wide bus.

- Wide SCSI

  The standard now also allows bus widths of up to four bytes, though in practice, physical design limitations have meant that two byte wide buses are generally used. With 10MHz clock speeds, a two byte wide bus gives burst data rates of 20MB per second.

Downward compatibility is maintained so that SCSI-1 devices can be attached to SCSI-2 buses. SCSI-1 will be used when communicating with these devices, and SCSI-2 to devices on the same bus supporting the new functions.

There are two alternative electrical configurations possible for the SCSI-1 and SCSI-2 standards.

1. Single Ended

   The single ended interface comprises a ground and single signal line for each of the SCSI data and control functions. This is the simplest configuration possible, but is prone to electrical interference, and therefore has recommended cable lengths of from three to six meters.

2. Differential

   The differential interface comprises positive and negative signal lines for each of the data and control functions. The binary value of the transmitted signal is determined from the difference between the voltages of these two signals. Interference will affect both signals equally, hence not changing the difference between them; this provides for far more reliable communication, with correspondingly greater cable lengths of up to 19 meters allowed.

There is a third SCSI standard currently being discussed, not surprisingly known as SCSI-3. This standard will provide for even higher data rates, larger numbers of addresses, and greater cable lengths between devices. This will be possible through the utilization of serial buses and packetized protocols. New media will be supported, such as fiber optics, twisted pair, or even wireless.

SCSI also supports the attachment of multiple processors to the SCSI bus, which allows implementation of device sharing.

#### 2.2.1.2 High Performance Disk Drive Subsystem Adapter

The High Performance Disk Drive Subsystem adapter provides for attachment of up to four serially attached disk subsystems, each of which may address up to four disk devices, giving a total addressability of 16 devices. The distances between adapter and subsystem can be up to 10 meters using copper twisted pair cables. The serial link uses full duplex packetized communications to the disk subsystems, and can support a maximum total data transfer rate of 80MB per second.

#### 2.2.1.3 High Performance Parallel Interface Adapter

The High Performance Parallel Interface (HiPPI) adapter provides an ANSI standard parallel interface to other computers and to storage devices. The adapter provides simplex or duplex point to point communication at burst data rates of up to 800Mb per second (in each direction) over copper cable at distances of up to 25 meters. This cable distance can be extended using fiber optic extenders or OEM HiPPI switches. The adapter consists of three cards on the RS/6000*, requiring five slots for power consumption reasons; only one is installable per Micro Channel* bus. These points limit the environments that the HiPPI interface can be used in as they restrict the possible configurations of the system.

#### 2.2.1.4 ESCON Channel Adapter

The ESCON channel adapter supports the transfer of data between an RS/6000 and the ESCON channel at a maximum rate of 17MB per second. The adapter supports connections over fiber optic links using LED or LASER technologies. The link between control units, directors and systems can be up to three kilometers with LED technology, and up to 20 kilometers using LASER.

#### 2.2.1.5 System/370 Channel Emulator Adapter

The System/370 channel emulator adapter provides parallel channel attachment capability via the block multiplexor channel, and supports data transfer at rates of up to 4.5MB per second. The block multiplexor channel cable length can be up to 61 meters in length, and up to four control units can be supported.

#### 2.2.1.6 Serial Storage Architecture

Serial Storage Architecture, or SSA, is an emerging standard defining a new connection mechanism for peripheral devices. The architecture specifies a serial interface that has the benefits of more compact cables and connectors, higher performance and reliability, and ultimately, a lower subsystem cost. A general purpose transport layer provides for 20MB per second full duplex communications over 10 meter copper cables. Devices are connected together in strings, with up to 128 nodes (devices) allowed per string. Information is transmitted in 128 byte frames that are multiplexed to allow concurrent operations. In addition, the full duplex communications allows simultaneous reading and writing of data.

#### 2.2.1.7 Other Adapters

There are a number of devices that can be connected via local area networks. In the main, these devices support some form of networking protocol, such as TCP/IP and NFS, that allow the computer system to access the device as though it were local. In these cases, the computer system would be attached to the LAN using a token ring or Ethernet adapter.

### 2.2.2 Disk Storage

This section will look at disk technology generally, before going on to examine the decision process necessary to select the correct disk subsystems for the environment.

#### 2.2.2.1 Disk Technology

All disk devices are constructed in basically the same way (see Figure 15 on page 26). A number of disk *platters* fixed to a central hub are rotated at high speed by a motor. Both surfaces of each platter are coated with a thin film of magnetic material where the data will be stored. Information is written to and read from the magnetic surface via small read and write heads that are located at the end of mechanical arms known as *actuators* The actuators move the heads back and forth from the outer edge of the platters to the inner edge. Data is written to the disk surface in concentric *tracks* , so the movement of the actuator locates the head over the required track, and the rotation of the platter moves the track past the heads allowing information to be read or written. Each platter surface has read and write heads associated with it, though all heads are usually attached to the same actuator assembly, moving in concert, with data read from one platter surface and one track at a time. The length of time it takes for the actuator to move the head to the required track is known as the *seek time*, while the time taken for the rotation of the platter to bring the correct part of the track under the heads is known as the *rotational latency*. Once correctly positioned, data is read or written in a continuous stream, and the rate at which this occurs is called the *data transfer rate*. The combination of the averages of seek time, rotational latency, and data transfer rate define the performance of the disk device.

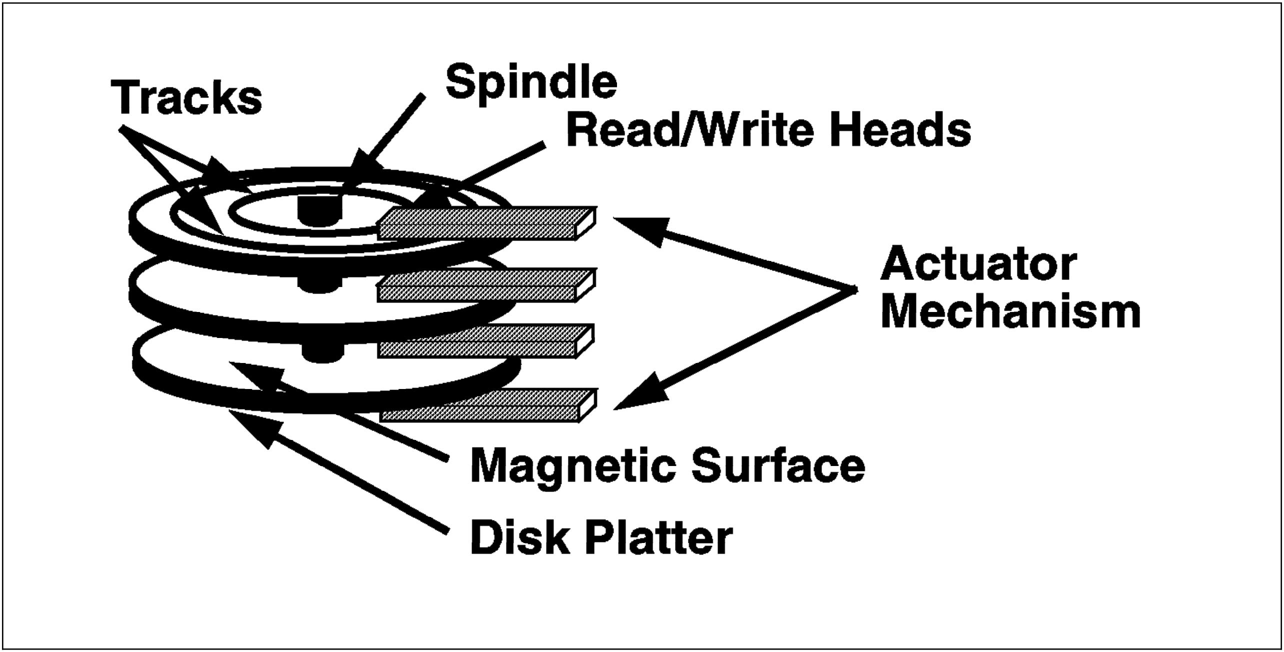


*Figure 15. Anatomy of a Disk Device*

The technology used for the read and write heads, as well as the composition of the magnetic material used on the platter surface, defines the *areal density* or how much information per unit area can be stored on the disk device. The earliest mechanisms used small coils that generated a magnetic field when current was passed through them, thereby changing the magnetic polarity of a small area of the disk; the polarity of the area defining the binary value stored. Passing the coil back over the surface causes it to intersect with the magnetic fields generated by each area. When a magnetic field moves through a coil, it causes a current to flow, the direction dependent upon the polarity of the field, thus allowing the information to be read back. Greater areal densities and hence correspondingly greater capacities per drive have since been achieved with new head technologies, such as thin film heads which utilize the coil principle, and more recently *magneto resistive* or MR heads (used for reading only). MR heads use a different principle for reading the state of the magnetic domains, sensing the variation in electrical resistance of the platter surface rather than using induction. This also gives much improved performance.

Locating the information and passing it to the requesting processor is accomplished by electronics in the drive assembly. The design and capabilities here also affect the overall performance of the device. In the simplest case, requests arrive for information located at a particular disk address, so the actuator is positioned at the correct track and the required number of blocks are read and passed to the requestor. The next request arrives, the actuator is repositioned and the request again fulfilled. This involves much seeking back and forth, as well as waiting for the correct parts of the track to arrive, thus introducing significant delay. In order to minimize these periods of inactivity, some devices utilize a mechanism known as *elevator seeking* where the incoming requests are sorted so that the actuator can fulfill a sequential series of requests on an inward pass, and then again on the outward pass. This minimizes seek delay. Some devices also utilize a mechanism called *read ahead* whereby the remaining blocks in a track (after a read has been satisfied) are read and cached locally in the device in anticipation of a sequential request. If this occurs, the information can be supplied directly from cache with no costly seek or rotational latency delays.

One other hardware technique used is known as banding. This takes advantage of the fact that if data is written at a fixed rate, then there will be larger gaps between bits the further out from the center that writes occur. Banding therefore partitions the disk into radial sections and raises the bit density as the heads move outwards through them. This ensures an even data density, and consequently increases the overall capacity of the device.

Disk devices vary enormously in their capacities and performance, with the highest single drive capacities currently around 4GB.

#### 2.2.2.2 Selecting the Correct Disk Storage Devices

The preceding section explained the basic technology utilized in disk storage devices; this section will focus on selecting the right solution in terms of the drives and subsystems currently available. There are three main considerations (as outlined in 1.2.1, "Hardware Management" on page 8), performance, availability, and capacity. In some situations, fault tolerance, or the ability to continue in the event of component failure, is important. This consideration is really a subset of availability, but is separated out in Table 1 for clarity. This table provides a guide for various application types as to which of the above attributes are required, and should therefore assist in the selection of the correct storage hardware.

*Table 1. Application Requirements for Disk Storage*

| Application | Random Performance | Sequential Performance | Capacity | Availability | Fault Tolerance |
|---|---|---|---|---|---|
| CAD/CAM | I | I | I | O | - |
| CASE | I | I | I | I | O |
| Communications Routing | I | E | - | O | O |
| Database | C | E | I | I | O |
| Fileserver | I | O | I | I | I |
| Multimedia Server | I | C | I | I | O |
| Scientific/NIC | I | C | I | O | - |
| Transaction Processing | C | - | I | I | I |

**Note:**

- C - critical
- I - important
- O - optionally important
- E - emerging

:2 refid=idiskd.application requirements

Having looked at which elements are important on a per application basis, requirements for each attribute can now be examined in terms of specific device type selection.

1. Capacity

   If increased internal disk storage is required, then the choice is restricted by the number of internal drives supported within the system itself, and then by the capacities of the drives selected. The following table shows the maximum capacities for each of the currently available systems.

*Table 2. Maximum Internal Storage Capacities*

| RS/6000 System | Maximum Number of Drives | Maximum Drive Capacity (GB) | Maximum Total Capacity (GB) |
|---|---|---|---|
| 2xx Series | 1 | 2 | 2 |
| 3xx Series | 2 | 2 | 4 |
| Models 41T/41W | 1 + 1 | 1 + 2 | 3 |
| Model C10 | 2 | 2 | 4 |
| Model 52H | 3 | 2 | 6 |
| 5xx Series | 6 | 2 | 12 |
| Model R10/R20 | 2 | 2 | 4 |
| 970B/980B/990/R24 | 4 | 2 | 8 |

Internal disks will generally be attached to a SCSI adapter, and may well share the bus with other slower, asynchronous devices such as tape. This will affect performance. Furthermore designing a highly available solution using only internal disks can be difficult, as the maximum number of drives allowed is not high. If either of these points is important, or just that more capacity than supportable internally is required, then the considerations become slightly more complex. In terms of maximizing storage capacity, Table 3 and Table 4 on page 29 show the maximum sizes for all drives and subsystems that can be attached to the RS/6000.

*Table 3. Maximum External Storage Capacities*

| RS/6000 System Configuration | 9334 Single-ended Capacity (GB) | 9334 Single-ended Max Drawers | 9334 Differential Capacity (GB) | 9334 Differential Max Drawers | 7134 Capacity (GB) | 7134 Max Subsystems |
|---|---|---|---|---|---|---|
| Model 250 | 18.5 | 2 | 28 | 4 | NS | NS |
| Rest of 2xx series | 9.2 | 1 | NS | NS | NS | NS |
| Models 41T/41W | 18.5 | 2 | 28 | 4 | NS | NS |
| Model C10 | 27.7 | 3 | 42 | 6 | 42 | 1.5 |
| Models 355/365/375 | 9.2 | 1 | 14 | 2 | 14 | 0.5 |
| Models 360/370/380/390 | 36.9 | 4 | 28 | 4 | 28 | 1 |
| Models 3AT/3BT | 27.7 | 3 | 28 | 4 | 28 | 1 |
| Model 52H | 36.9 | 4 | 56 | 8 | 56 | 2 |
| Model 550L | 36.9 | 4 | 56 | 8 | 56 | 2 |
| Rest of 5xx series | 64.6 | 7 | 98 | 14 | 98 | 3.5 |
| Models 950/R10/R20 | 64.6 | 7 | 98 | 14 | 98 | 3.5 |
| Models 970B/980B/990 R24 | 129.2 | 14 | 196 | 28 | 196 | 7 |

**Note:**

- 7135 RAIDiant array capacities are for RAID 3 or 5 with five disk drives in a bank
- All 9334 drives are 2GB except for single ended
- Differential 9334s are attached two per adapter
- NS is Not Supported

*Table 4. Maximum External Storage Capacities (continued)*

| RS/6000 System Configuration | 9333 Capacity (GB) | 9333 Max Drawers | 3514 Capacity (GB) | 3514 Max Subsystems | 7135 Capacity (GB) | 7135 Max Subsystems |
|---|---|---|---|---|---|---|
| Model 250 | NS | NS | 55.1 | 4 | NS | NS |
| Rest of 2xx series | NS | NS | NS | NS | NS | NS |
| Models 41T/41W | NS | NS | 55.1 | 4 | NS | NS |
| Model C10 | 64 | 8 | 82.6 | 6 | 288 | 6 |
| Models 355/365/375 | NS | NS | 55.1 | 4 | 192 | 4 |
| Models 360/370/380/390 | 32 | 4 | 27.5 | 2 | 96 | 2 |
| Models 3AT/3BT | NS | NS | 55.1 | 4 | 192 | 4 |
| Model 52H | 64 | 8 | 27.5 | 2 | 96 | 2 |
| Model 550L | 128 | 16 | 110.2 | 8 | 384 | 8 |
| Rest of 5xx series | 192 | 24 | 110.2 | 8 | 384 | 8 |
| Models R10/R20 | 192 | 24 | NS | NS | 384 | 8 |
| Models 970B/980B/990 R24 | 224 | 28 | NS | NS | 672 | 14 |

**Note:**

- All drives are 2GB
- Capacities of 7135 RAIDiant Array are for RAID 3 or RAID 5 configurations with 5 disk drives
- The 3514 Array capacity is calculated with 8 drives as 7 + P. Some capacity is used by the array subsystem so its actual capacity is 13.77GB rather than 14GB.
- NS is Not Supported

This gives an indication of the capacity that can be expected when selecting particular devices, but should be used in conjunction with the sections on performance and availability before making any final decisions. Furthermore, it must be noted that multiples and mixes of these subsystems and devices can be attached, though there are limits on the total due to technology constraints.

- Cable lengths restrict the number of devices attachable in some cases. See 2.2.1, “Hardware Attachment Adapters” on page 22 for details.
- Addressing limitations restrict the number of devices attachable to an adapter. See 2.2.1, “Hardware Attachment Adapters” on page 22 for details.
- Micro Channel can support a maximum of four differential SCSI adapters due to power considerations. See Table 5 for more information.

The following table shows the maximum numbers of external storage devices that can be attached to a Micro Channel bus.

*Table 5 (Page 1 of 2). Maximum External Storage per Micro Channel*

| System | Maximum Capacity (GB) | Number of Drawers or Subsystems | Single Processor Max Capacity (GB) | Dual Processor Max Capacity (GB) |
|---|---|---|---|---|
| 9334 Single Ended Deskside | 9.2 | 1 | 9.2 | 8.8 |
| 9334 Single Ended Rack | 9.2 | 1 | 9.2 | Not Supported |
| 9334 Differential Deskside | 8 | 2 | 14 | 12 |

*Table 5 (Page 2 of 2). Maximum External Storage per Micro Channel*

| System | Maximum Capacity (GB) | Number of Drawers or Subsystems | Single Processor Max Capacity (GB) | Dual Processor Max Capacity (GB) |
|---|---|---|---|---|
| 9334 Differential Rack | 8/6 | 2 | 14 | 12 |
| 9333 High Performance | 8 | 4 | 32 | 32 |
| 3514 Disk Array (RAID 0) | 15.77 | 2 | 31.5 | 31.5 |
| 3514 Disk Array (RAID 5) | 13.77 | 2 | 27.5 | 27.5 |
| 7134 Disk Subsystem | 28 | 0.5 | 14 | 12 |
| 7135 RAIDiant Model 010 | 24 | 1 | 12 | 12 |
| 7135 Model 110 RAID 0 | 60 | 2 | 120 | 120 |
| 7135 Model 110 RAID 3/5 | 48 | 2 | 96 | 96 |
| 7135 Model 110 RAID 1 | 28 | 2 | 56 | 56 |

**Note:**

- The second drawer on a 9334 differential SCSI is limited to three drives in a single processor configuration, and two drives with dual processors.
- The single processor configurations of a single ended 9334 use seven SCSI ids with three 2.4GB and one 2GB drive.
- The dual processor configuration of a single ended 9334 uses six SCSI ids with two 2.4GB drives and two 2GB drives.
- The 7135 model 010 can contain a maximum of 12 disk drives with six on each of two SCSI buses. A separate Micro Channel adapter is required for each bus.

2. Performance

   With regard to the disk devices themselves, the major performance issue is application related; that is to say, whether large numbers of small accesses will be made (random), or smaller numbers of large accesses (sequential). For random access, performance will generally be better using larger numbers of smaller capacity drives; the opposite applying for sequential access. If the overall capacity requirements are large however, then larger capacity disk drives should be used, as there will be sufficient drives to enable performance benefits to be gained from concurrent access. Individual disk drive performance information can be found in Table 6.

*Table 6. Individual Disk Drive Characteristics*

| Drive | Capacity | Random Performance 4K ops/sec | Sequential Performance 4KB (MB/s) | Sequential Performance 64KB (MB/s) | Sequential Performance 512KB (MB/s) | Interface Speed (MB/s) |
|---|---|---|---|---|---|---|
| SCSI 3.5" | 0.2 | 26 | 0.204 | 1.16 | 1.476 | 5 |
| SCSI 3.5" | 0.4 | 27 | 0.225 | 1.141 | 1.472 | 5 |
| SCSI 3.5" | 0.54 | 44 | 0.357 | 2.152 | 2.932 | 10 |
| SCSI 3.5" | 1.0 | 33 | 0.271 | 1.604 | 2.189 | 10 |
| SCSI 3.5" | 2.0 | 39 | 0.319 | 2.153 | 3.218 | 10 |
| SCSI 5.25" | 0.857 | 31 | 0.255 | 1.301 | 1.709 | 4 |
| SCSI 5.25" | 1.37 | 35 | 0.286 | 1.634 | 2.245 | 5 |
| SCSI 5.25" | 2.4 | 66 | 0.271 | 1.604 | 2.189 | 10 |
| Serial | 1.07 | 31 | 0.255 | 1.301 | 1.709 | 8 |
| Serial | 2.0 | 39 | 0.319 | 2.153 | 3.218 | 8 |

**Note:**

- Random performance is measured as the number of 4KB blocks a drive can sustain at a utilization of 50%. As the utilization approaches 100% the response time increases significantly.
- Sequential performance is measured as the number of bytes per second that can be read from the drive. A random seek is done, a number of bytes are read (4KB, 64KB, or 512KB), and then another random seek is done.
- Interface speeds shown are the burst data rates, and as such not sustainable for long periods of time. The serial drives are full duplex, and can read and write data simultaneously.

Generally speaking, when performance is the major issue, the best approach is to benchmark the application set. If the applications spend most of their time waiting for data from disk, then much benefit will be attained from selecting faster storage subsystems. The quickest access to data can be achieved through concurrency, which means being able to read/write from/to multiple disk drives simultaneously in order to satisfy an application request. This functionality is provided with RAID (Redundant Array of Independent Disks) support, which a number of disk subsystems can utilize. Actual performance characteristics will vary from subsystem to subsystem, but in the main, the following points hold true for each of the RAID modes of operation.

a. RAID 0

   RAID 0 is also known as data striping. Conventionally, a file is written out to (or read from) a disk in blocks of data. With striping, the information is split into chunks (a fixed amount of data) and the chunks written to (or read from) a series of disks in parallel. There are two main performance advantages to this.

   - Data transfer rates are higher for sequential operations due to the overlapping of multiple I/O streams.
   - Random access throughput is higher because access pattern skew is eliminated due to the distribution of the data. This means that with data distributed evenly across a number of disks, random accesses will most likely find the required information spread across multiple disks and thus benefit from the increased throughput of more than one drive.

   RAID 0 is well suited for program libraries requiring rapid loading of large tables, or more generally, applications requiring fast access to read-only data, or fast writing. RAID 0 is only designed to increase performance, there is no redundancy, so any disk failures will require reloading from backups.

b. RAID 1

   RAID 1 is also known as disk mirroring. In this implementation, duplicate copies of each chunk of data are kept on separate disks, or more usually, each disk has a twin that contains an exact replica (or mirror image) of the information. If any disk in the array fails, then the mirrored twin can take over. Read performance can be enhanced as the disk with its actuator closest to the required data is always used thereby minimizing seek times. The response time for writes can be somewhat slower than for a single disk, depending on the write policy; the writes can either be executed in parallel for speed, or serially for safety (see “Logical Volume Manager Policies” on page 54 for a complete explanation of mirroring policies). This technique improves response time for read-mostly applications, and improves availability at the cost of price (twice as many disks as disk space required are required).

   RAID 1 is most suited to applications that require high data availability, good read response times, and where cost is a secondary issue.

c. RAID 2/3

   RAID 2 and RAID 3 are parallel process arrays, where all drives in the array operate in unison. Similar to data striping, information to be written to disk is split into chunks and each chunk written out to the same physical position on separate disks (in parallel). When a read occurs, simultaneous requests for the data can be sent to each disk, which then retrieve the data from the same place and return it for assembly and presentation to the requesting application. More advanced versions of RAID 2 and 3 synchronize the disk spindles so that the reads and writes can truly occur simultaneously (minimizing rotational latency buildups between disks). This architecture requires parity information to be written for each stripe of data, the difference between RAID 2 and RAID 3 being that RAID 2 can utilize multiple disk drives for parity, whilst RAID 3 uses only one. If a drive should fail, the system can reconstruct the missing data from the parity and remaining drives. Performance is very good for large amounts of data, but poor for small requests as every drive is always involved, and there can be no overlapped or independent operation.

RAID 2 is rarely used, but RAID 3 is well suited for large data objects such as CAD/CAM or image files, or applications requiring sequential access to large data files.

d. RAID 4

   RAID 4 addresses some of the disadvantages of RAID 3 by using larger chunks of data and striping the data across all of the drives except the one reserved for parity. Using disk striping means that I/O requests need only reference the drive that the data required is actually on. This means that simultaneous as well as independent reads are possible. Write requests however, require a read/modify/update cycle that creates a bottleneck at the single parity drive. This bottleneck means that RAID 4 is not used as often as RAID 5, which implements the same process, but without the bottleneck.

e. RAID 5

   RAID 5, as has been mentioned, is very similar to RAID 4. The difference is that the parity information is distributed across the same disks used for the data, thereby eliminating the bottleneck. Parity data is never stored on the same drive as the chunk that it protects. This means that concurrent read and write operations can now be performed, and there are performance increases due to the availability of an extra disk (the disk previously used for parity). There are other enhancements possible to further increase data transfer rates, such as caching simultaneous reads from the disks, then transferring that information whilst reading the next blocks. This can generate data transfer rates at up to the adapter speed. Similar to RAID 3, in the event of disk failure, the information can be rebuilt from the remaining drives.

   RAID 5 is best used in environments requiring high availability and fewer writes than reads.

Disk subsystems that support RAID include:

- IBM 7135 RAIDiant array
- IBM 3514 High Availability External Disk Array
- IBM 9570 Disk Array Subsystem

To summarize, the key performance issues are listed below:

- Quantity of code executed per block of data (I/O ratio)
- Number of disks containing data
- Disk drive performance
- Disk drive data path performance (adapter to disk)

- Size of data blocks accessed
- Pattern of data access (random/sequential/locality of reference)
- Ability to pipeline data (caching)
- Importance of response time

3. Availability and Fault Tolerance

   The key assessment with regard to availability is how severe the impact of losing data (however temporarily) would be to the business. If, for example, being without access to vital information for two hours would cause unacceptable loss of business, then the system must be designed in such a way that any failures can be remedied within this period. Standard availability usually means that the system is designed in such a way as to minimize the risk of failure, but not prevent it altogether; choosing highly reliable devices for example. High availability generally implies introducing some redundancy into the system design, so that the system can continue (albeit usually at reduced performance) while the failing component is replaced. If all vital components in a subsystem have a back up in case of failure (total redundancy), then the system is fault tolerant; this means duplication of all critical components, including power supplies and cooling fans for example, as well as allowing replacement of failing parts during continuing subsystem operation.

   The price of redundancy for high availability or fault tolerance is usually the increased cost.

   Highly availability solutions include mirroring (RAID 1), as well as RAID 3 and RAID 5 parity. Automatic recovery can be built into some of the RAID supporting subsystems as well. Additionally, some subsystems allow redundancy in power supplies, controllers, and cooling to provide fault tolerant, highly available subsystems.

The various advantages and disadvantages of the disk devices and subsystems available are summarized in Table 7, which can be used to compare disk solutions, and select the most appropriate for the required environment.

*Table 7 (Page 1 of 2). Comparison of Disk Device and Subsystem Features*

| Configuration | Availability Mechanism | Maximum Capacity (GB) | Performance | Cost | Applications | Fault Tolerance |
|---|---|---|---|---|---|---|
| Internal Disk | Mirroring | System Dependent | Medium | Low | General, OLTP | No |
| 7204-215 | Mirroring | 2 | Medium | Low | General, OLTP | Yes (#) |
| 9334 Deskside | Mirroring | 8 | Medium | Medium | General, OLTP | Yes (#) |
| 9334-011 8 Drawers | Mirroring | 32 | Medium | Medium | General, OLTP | Yes (#) |
| 9333 Deskside | Mirroring | 8 | High | Medium | Fast Response | Yes (#) |
| 9333 32 Drawers | Mirroring | 128 | High | Medium | Fast Response | Yes (#) |
| 7135-110 (RAID 0) | None | 56 | High | Medium | Fast Response | Yes |
| 7135-110 (RAID 1) | Mirroring | 28 | Medium | High | General, OLTP | Yes |
| 7135-110 (RAID 3) | Parity | 48 | Medium | Medium | NIC, Sequential | Yes |
| 7135-110 (RAID 5) | Parity | 48 | Medium | Medium | General | Yes |
| 3514 (RAID 0) | None | 14 | High | Low | General | Some |

*Table 7 (Page 2 of 2). Comparison of Disk Device and Subsystem Features*

| Configuration | Availability Mechanism | Maximum Capacity (GB) | Performance | Cost | Applications | Fault Tolerance |
|---|---|---|---|---|---|---|
| 3514 (RAID 5) | Parity | 13.77 | Medium | Low | General | Some |
| 9570 (RAID 1) | Mirroring | 116.2 | High | High | Fast Response | Yes |
| 9570 (RAID 5) | Parity | 232.4 | High | High | Fast Response | Yes |

**Note:**

- (#) indicates that fault tolerance is achieved through using duplicate devices
- Capacities are based upon the usage of 2GB drives

## 2.2.3 Tape Storage

This section will look at tape technology, before continuing to examine the decision process necessary to enable the best tape subsystems for the environment to be selected.

### 2.2.3.1 Tape Technology

There are two basic technologies incorporated into tape devices, and the specifics of these will be discussed shortly. Both though, utilize the same essential mechanism for writing and reading data: however it is packaged, and whatever materials are used in its construction, tape consists of a long strip of material ranging from 4mm wide, to half an inch. The strip is coated (in much the same way as disk) with a magnetic material, and wound onto spools of some kind. Using a transport mechanism dependant on the technology, the tape is moved past read and write heads that utilize similar technology to those used in disk devices to alter or sense the polarity of magnetic domains on the tape, thereby writing or reading data.

It is at this point that the technologies differ, both in the methods used for tape transport, and in the way in which the data is written onto the tape surface.

1. Helical Scan

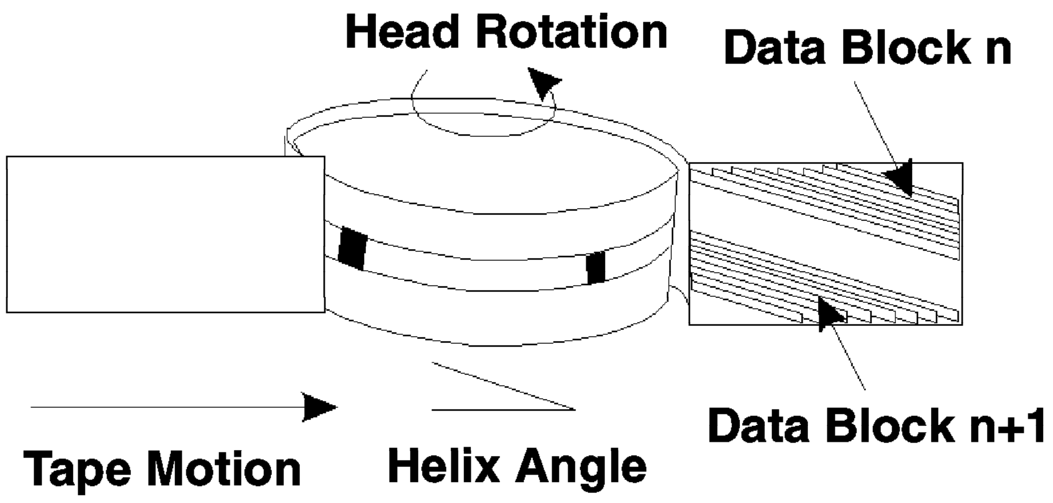


*Figure 16. Helical Scan Principles*

Helical scan technology has its origins in consumer analog video devices, and though there are a number of different formats, the basic principles are the same in each case. As can be seen from Figure 16, the tape surface is wound around a large cylindrical head inclined at an angle of some four to five degrees. The tape moves relative to the head, which is itself spinning at high speed. This results in data tracks written at an angle across the tape width as well as being slightly overlapped. This makes very efficient use of the tape capacity, and gives a good data rate for continuous writing of data (*streaming*). This capacity is at the cost of start/stop performance, as synchronization problems slow down the initial access. Additionally, helical scan is a destructive process in the sense that the tape surface is in contact with the read/write head and hence wears more rapidly. Tape is normally contained within a cartridge and extracted to be wound around the head as shown in Figure 17. This winding process also takes time and must be performed every time the device is loaded or idle, as tape cannot be left in contact with the head for too long as this would again cause excessive wear. Head replacement is also difficult, due to the complexity of the transport mechanism.

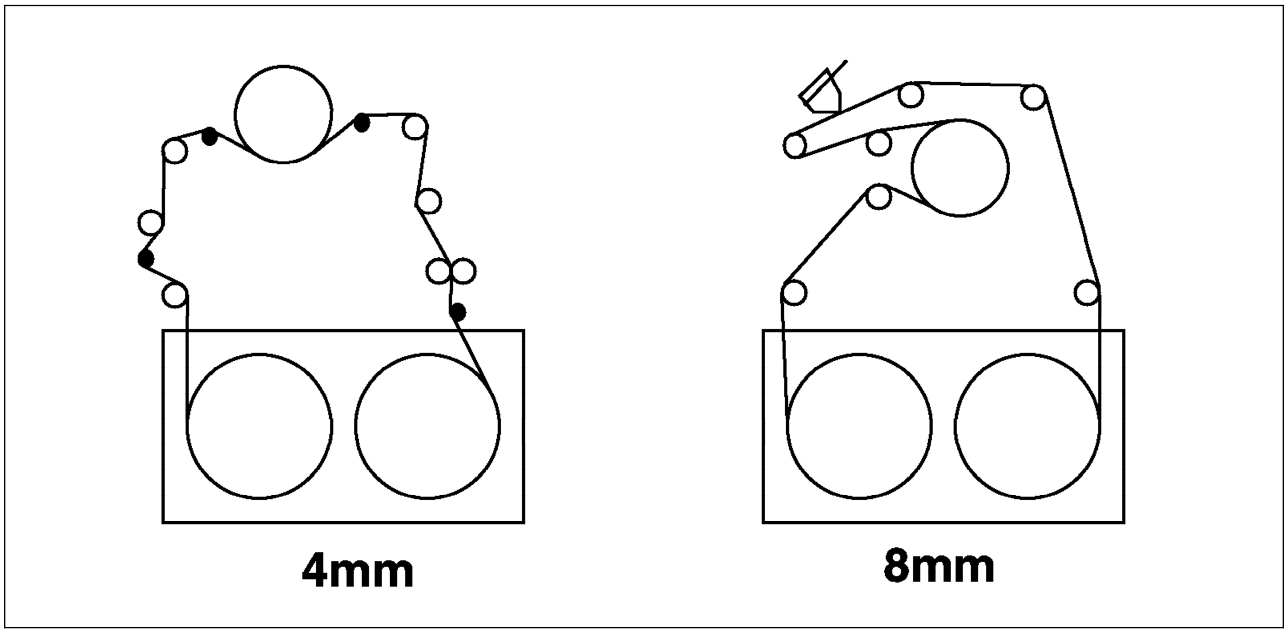


*Figure 17. Helical Scan Tape Paths*

2. Longitudinal Recording

   Longitudinal recording was specifically designed for computer data storage. Again there are a number of variations, though all utilize the same basic ideas. As can be seen from Figure 18 on page 36, the tape is moved past stationary read and write heads causing the data tracks to be recorded linearly along the tape's length. In order to make full use of the tape, the heads normally contain multiple elements allowing several tracks to be written or read concurrently. In addition, when a continuous series of tracks has been written along the length of the tape, the direction of motion can be switched, and the heads stepped perpendicular to the movement of the tape, thereby allowing another series of tracks to be written. This process can be repeated until the entire tape width is used, and is known as *serpentine track interleaving*.

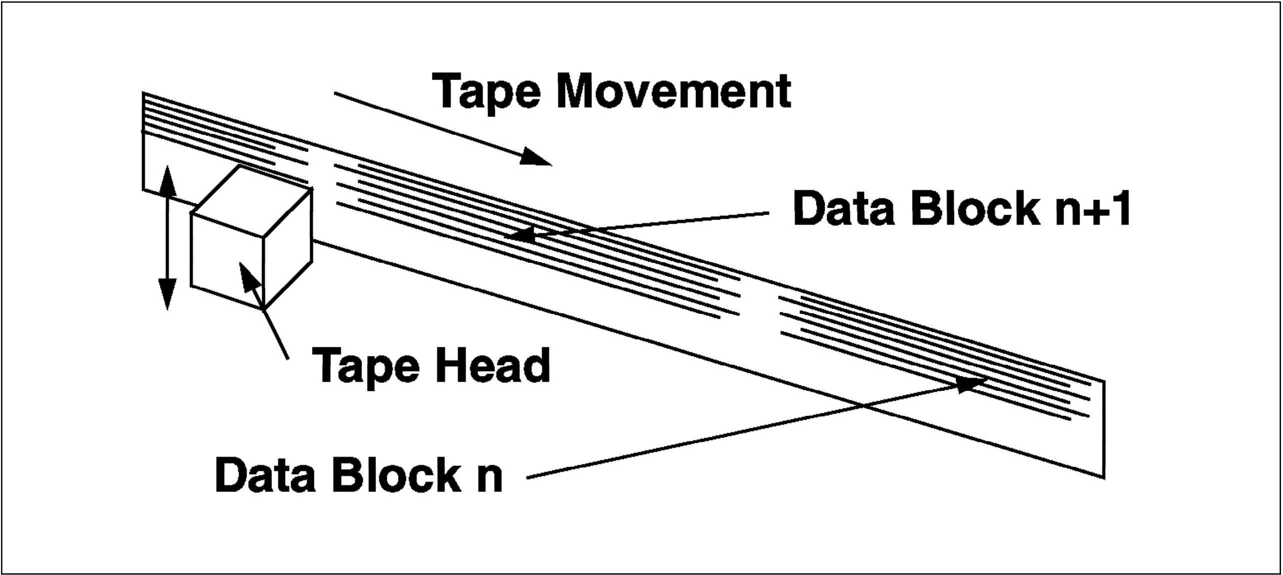


*Figure 18. Longitudinal Recording Principles*

Longitudinal recording is a non-destructive process with a consequently longer media life. Performance is good for both streaming and start/stop activity, and the data rate is high. Maintenance is a simpler process, and as can be seen from Figure 19, the tape transport path and mechanism are generally simpler.

Two types of spooling method are common. Cartridges similar to helical scan cartridges can be used, though with longitudinal recording, the tape transport path can remain entirely within the cartridge. This makes load and unload operations much faster, and the entire design much simpler. The other mechanism utilizes a single reel within the cartridge, and requires the free end of the tape to be threaded onto a spool within the tape device itself. This does result in a slightly more complex design, and consequently longer load and unload times.

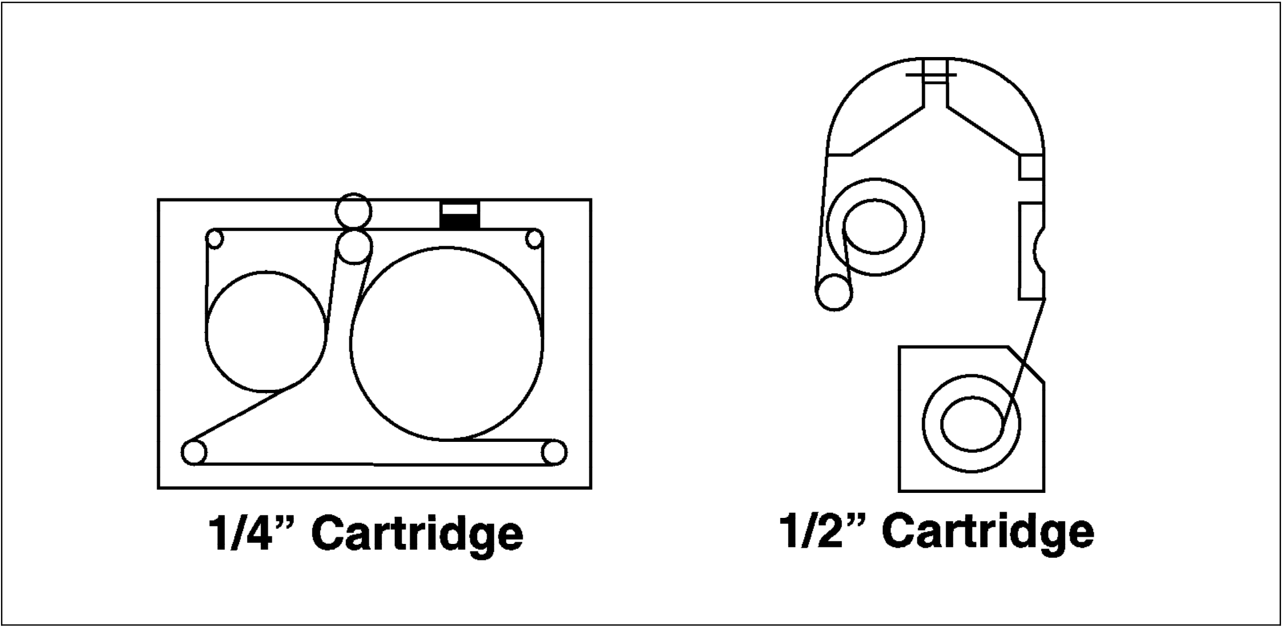


*Figure 19. Longitudinal Recording Tape Paths*

The simpler design of longitudinal devices generally results in greater reliability, though for a given media size, helical scan will provide greater capacity. Start/stop performance and load/unload times are also better with the longitudinal technology.

Both helical scan and longitudinal recording devices can make use of hardware compression before writing data to the tape. In some cases (with the latest Intelligent Data Recording Capability, or IDRC), this can result in up to a fourfold increase in capacity, depending upon the characteristics of the data to be compressed. Currently, maximum capacities for both technologies are at around 5GB per cartridge without compression.

The latest longitudinal devices now have such rapid load times, which when coupled with new recording strategies, give access times to data anywhere on the tape that are beginning to enter the acceptable range for interactive use. The next section will look at specific product types with a view to selecting the best tape devices for the environment.

#### 2.2.3.2 Selecting the Correct Tape Storage Devices

The preceding section has looked at tape devices from the technical point of view. This section will now examine the criteria that should be used to choose the correct devices for an environment, as well as the devices available. As in the case of disk devices, there are three main considerations, performance, availability, and capacity.

1. Capacity

   The capacity of a tape drive refers to how much information can be stored on the media that it uses. This varies as a function of the tape drive technology, and the compression techniques used (see 2.2.3.1, “Tape Technology” on page 34 for details). If the required capacity should exceed that of any single tape available, and either time constraints exist, or there is a requirement for unattended backup, then a tape library should be used. The various capacities available from the individual tape devices are shown in Table 7 on page 33. As can be seen, capacities are generally higher for the devices using helical scan technology. Tape Libraries are discussed at the end of this section.

   Most tape drives support some form of compression which can increase the amount of data that can be stored on a tape. The degree of compression depends upon the data to be compressed, so the figures shown in Table 8 on page 38 are the maximum ratios. In order to arrive at a maximum compressed capacity for a particular tape, the ratio should be multiplied with the uncompressed capacity (for example a 5GB tape with a compression ratio of 2:1 would give 10GB of data). The tape device automatically uncompresses the data when reading back from tape. There is a small overhead involved (small because the compression is usually performed in hardware). As some types of data do not benefit greatly from compression, and to remove the small overhead, most devices allow compression to be turned off if required. Generally though, it is of benefit to leave compression enabled.

2. Performance

   In the case of tape drives, performance mostly refers to the data rates to and from the device. This is usually not limited by the attachment mechanism, but by the device itself, though there are a number of adapters supported (see Table 8 on page 38). In the case of tape libraries, the time taken to read the first byte of data is usually also a performance measurement, and includes the time taken to load and unload tapes from/to the library; this is discussed at the end of this section. Data rates and attachment methods are detailed in Table 7 on page 33. Note that although the data rates are generally comparable, start/stop performance is usually superior with longitudinal technology.

3. Availability

   Availability in this sense usually means reliability, and can be measured as the Mean Time Between Failures for the device (MTBF), and the reliability of the media. As was mentioned in 2.2.3.1, “Tape Technology” on page 34, media life is greater for longitudinally recorded tapes, with correspondingly fewer errors; additionally, the simpler transport mechanisms employed normally extend the MTBF significantly.

*Table 8. Tape Drive Specifications*

| Drive | Uncompressed Capacity (GB) | Maximum Compression Ratio | Data Rate (KB/s uncompressed) | Time to Write One Cartridge (hrs) | Save Rate (GB/hr uncompressed) | Interface | Technology |
|---|---|---|---|---|---|---|---|
| 7208-011 (8mm) | 5 | 2:1 | 500 | 2.78 | 1.8 | SCSI-2 | Helical |
| 7208-001 (8mm) | 2.3 | N/A | 245 | 2.61 | 0.88 | SCSI-1 | Helical |
| 7206-001 (4mm) | 2 | 2:1 | 183 | 3.04 | 0.66 | SCSI-1 | Helical |
| 7206-005 (4mm) | 4 | 2:1 | 400 | 2.78 | 1.44 | SCSI-2 | Helical |
| 7207-012 (1/4") | 1.2 | N/A | 300 | 1.11 | 1.08 | SCSI | Longitudinal |
| 9348-012 (1/2") | 0.16 | N/A | 768 | 0.06 | 2.76 | SCSI | Longitudinal |
| 3490-C10 (1/2") | 4.8 | 3:1 | 3000 | 0.5 | 10.8 | S/370 or ESCON | Longitudinal |
| 3490-C22 (1/2") | 9.6 | 3:1 | 3000 | 0.5 | 10.8 | S/370 or ESCON or SCSI-2 Diff F/W | Longitudinal |
| 3490-E01 (1/2") | 5.6 | 3:1 | 3000 | 0.5 | 10.8 | SCSI-2 Diff F/W | Longitudinal |

**Note:**

- The figures for the 9348-012 are using 6250 bpi

Tape libraries have been described in 2.2.3.1, “Tape Technology” on page 34, and generally utilize automation to load/unload one of the drives in Table 8 from a library. The library management software must usually be provided by an application and needs to be written to understand the interface to the library. It is important therefore, to confirm that the tape library selected is in fact supported by the applications required. The intended usage is important too. If the library will be used for backing up fileservers, or workstation clients overnight, then it is necessary to ensure that the data rate is sufficient to do this. A comparison of current tape library products can be seen in Table 9.

*Table 9 (Page 1 of 2). Tape Library Specifications*

| Library | Number of Tapes | Maximum Capacity (GB) | Compression Ratio | Number of Drives | Data Rate (MB/s un-compressed) | Time to Fill All Media (hrs) | Average Exchange Time (secs) | Technology |
|---|---|---|---|---|---|---|---|---|
| 0840-001 (8mm) | 10 | 50 | 2:1 | 1 | 0.5 | 27.8 | 49 | Helical |

*Table 9 (Page 2 of 2). Tape Library Specifications*

| Library | Number of Tapes | Maximum Capacity (GB) | Compression Ratio | Number of Drives | Data Rate (MB/s un-compressed) | Time to Fill All Media (hrs) | Average Exchange Time (secs) | Technology |
|---|---|---|---|---|---|---|---|---|
| 0572-001 (8mm) | 54 | 270 | N/A | 2 | 1.0 | 75 | 49 | Helical |
| 3494-L10 | 210+ | 168+ | 3:1 | 1-8 | 3.0 | 42+ | 7-17 | Long-itudinal |
| 3495-L20 (1/2") | 6440 | 5152 | 3:1 | 4-16 | 2.5 | days | 7-17 | Long-itudinal |

**Note:**

- Average exchange times do not include access to first byte of data
- The 3490 supports the OEMI adapter at 2.5MB/s data rate

## 2.2.4 Optical Storage

This section will look at optical storage technology, before going on to examine the decision process required to choose the right optical storage devices for the environment.

### 2.2.4.1 Optical Technology

There are three basic optical technologies, each providing for different capabilities. Some devices will cope with more than one kind of technology, though this is not always so. In all three cases, information is stored in tracks on the media surface. Each mechanism then uses different methods to read and write information on these tracks.

1. Compact Disk Read Only Memory

   With Compact Disk Read Only Memory, or CD-ROM, information is molded into the media during the manufacturing process as a series of pits in the surface. The existence or absence of a pit determines the binary state at each point. The information is read back by shining a laser onto the disk surface and measuring the reflected intensity. The compact disk is spun at high speed inside the device and the laser assembly moved radially in and out to give access to the required blocks of information. CD-ROMs are cheap to make and provide an excellent distribution medium. The only potential issue is that there is no recording capability.

2. Rewritable

   Rewritable media uses magneto-optic technology to store information. As can be seen from Figure 20 on page 40, the media surface is comprised of concentric tracks of magnetic material. With this technique, the read/write head consists of two components, an electromagnet and a laser. The media is first prepared by heating each magnetic domain with a high powered laser in the presence of a magnetic field. This causes the domains to adopt a common polarity. Writing is accomplished by again heating up a domain with the laser while applying a magnetic field of reverse polarity to flip its state. Reading back information is achieved using the reflected light from a lower powered laser to detect the original polarity domains (zeros) and the reversed polarity domains (ones), through a polarization effect. Erasing is implemented by again heating up the domains with a high powered laser and simultaneously using the electromagnet to reset the polarity to its original state.

While providing the benefits of read, write and erase, this technology still manages to be very stable, giving a shelf life of around 10,000 years, and archival life of around 150 years.

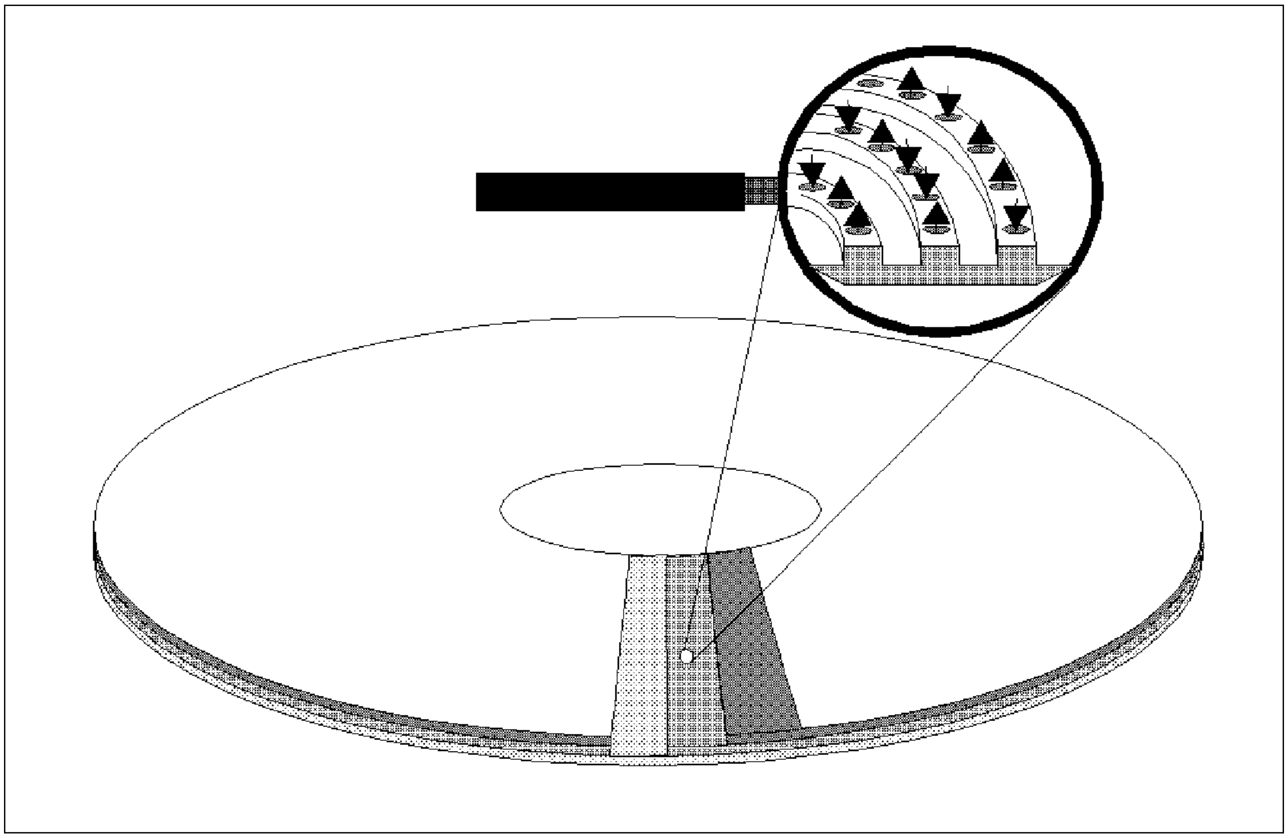


*Figure 20. Rewritable Optical Media Technology*

3. Write Once Read Many

   Write Once Read Many, or WORM technology is also implemented in a number of different ways. The purpose in each case is the same, to allow information to be recorded for permanent copy, that is to say once written, it cannot be erased.

   - Ablative

     The ablative WORM technique uses a higher powered laser to actually physically alter the media surface by burning away material to create pits similar to those used in CD-ROM. In the same way, a lower powered laser is then used to read back information through reflected intensity. Erasing of information so recorded is clearly not possible.

   - Continuous Composite Write-Once

     Continuous Composite Write-Once, or CCW uses the magneto-optic technology described earlier to record and read back information. Erasure of data is prevented by simply not allowing this function in the device firmware.

   - Phase Change

     This technology operates in a similar fashion to ablative. A higher powered laser beam alters the physical properties of the material used to form the disk surface, causing it to adopt its crystalline form at the high temperature induced by the laser. The crystalline form is lighter in color than the original form, and the resulting lighter dots can be read as variations in reflected intensity by a lower powered laser.

- Dye-Polymer

  Again similar to ablative, this technology uses a high powered laser to alter the physical properties of an organic dye that is coated on the media surface. When exposed to the high energy beam, the dye absorbs energy and becomes darker. A lower powered laser can then be used to read back information as differences in reflected intensity.

WORM media is also stable, giving the benefits of extremely long archival life of over 500 years, with the additional advantage of allowing the initial information recording.

4. Multifunction

   A fourth technology combines the capabilities of WORM and magneto-optical to give drives that support both functions.

These optical technologies also come in a number of different form factors including 5.25 inch and 12 inch media, both single and double sided. The optical disk is normally housed in a cartridge, and typical capacities per cartridge are currently around 1.3GB for double sided, double density, 5.25 inch media.

Currently, lasers operating in the red light frequency range are being used; in the future, switching to blue light frequency range lasers will increase the density fourfold and consequently enlarge capacity. The binary state is currently read as a function of the position of the element on the media (known as Pulse Position Modulation, or PPM). In the future, Pulse Width Modulation, or PWM will be used. This is also known as edge detection, where a state change is interpreted as one level, and no state change as the other (binary 1 and 0). This allows up to a 50% increase in density (see Figure 21), with a corresponding increase in capacity. Lastly, banding as described in the section on disk technology will be used, the overall capacity increase including banding being around 24 times.

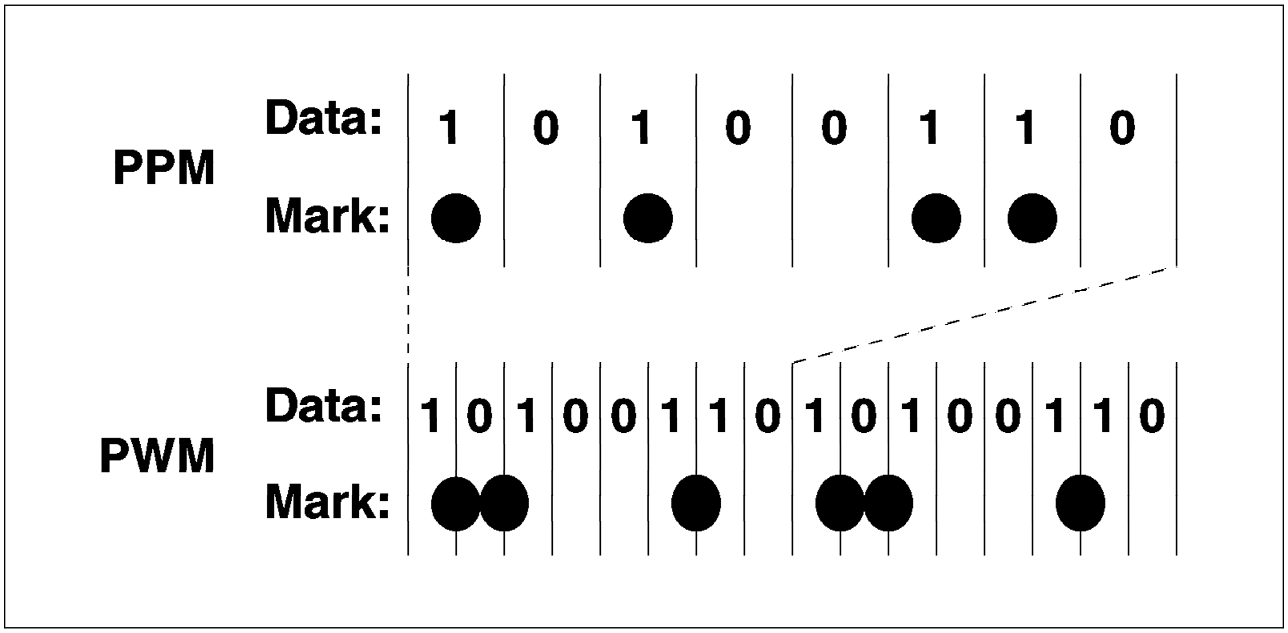


*Figure 21. Pulse Position Modulation Vs Pulse Width Modulation*

### 2.2.4.2 Selecting the Correct Optical Storage Devices

Having looked at the technology used in optical storage devices in the previous section, this section will now discuss the selection of the physical devices. Once again, performance and capacity are important differentiators, and should be considered; in addition, with optical media, the technology used is also important.

1. Capacity

   The capacity of optical media is mainly dependent upon the technology, but within that, also varies with the number of bytes per sector supported. It is important to ensure that the application that will be using the optical device supports the sector size that gives the capacity required. The capacities (for the different bytes per sector supported) are shown in Table 10. If the capacities available are insufficient for the environment, then an optical library should be considered; these are discussed at the end of this section.

2. Performance

   With optical devices, performance involves (similar to disk) a combination of the read and write data rates, as well as access times (themselves a combination of seek times and rotational latencies). The attachment method will not affect the performance significantly, as the maximum data rates do not come close to the data rates of the adapters; this does mean that optical devices can share adapters with other devices without performance implications (the total data rate should be calculated to be below the maximum adapter data rate). The performance characteristics of the various optical devices available are compared in Table 10.

3. Technology

   As was described in 2.2.4, “Optical Storage” on page 39, there are several different optical technologies currently in use: CD-ROM, WORM, and Rewritable. If the requirement is for distribution or reading only, at relatively low data rates, then CD-ROM is adequate; higher data rates would require WORM or rewritable media devices. WORM is ideal if there is a requirement for long term storage of infrequently accessed information, or for distribution. Rewritable media is more suitable for interactive use when performance is not critical.

*Table 10. Optical Device Specifications*

| Drive | Technology | Capacity (GB) | Read Data Rate (KB/s) | Write Data Rate (KB/s) | Average Access Time (ms) | Interface |
|---|---|---|---|---|---|---|
| 7210-001 | CD-ROM | 0.6 | 150 | N/A | 325 | SCSI |
| 7210-005 | CD-ROM | 0.6 | 330 | N/A | 200 | SCSI |
| 7209-001 | Rewritable | 0.65 (0.595) | 680 (620) | 227 (207) | 82.5 | SCSI |
| 7209-002 | Rewritable | 1.3 (1.19) | 1600 (1400) | 533 (467) | 67.5 | SCSI |

**Note:**

- The figures for the 7209 models were measured at 1024 bytes per sector, the figures in brackets are for 512 bytes per sector media

Although generally slower than disk, optical storage is cheaper. Therefore, if there is a requirement for large amounts of secondary storage, and performance is not critical, then optical storage should be considered. If the storage capacity required exceeds that of the optical drives available, then a library should be considered. Using similar technology to that employed in tape libraries, optical libraries utilize automation to load/unload optical drives from magazines of optical media. The same performance, capacity, and technology considerations apply as in the case of optical drives; similar to tape libraries though, library management software needs to be provided that understands how to control the optical library. A comparison of the optical libraries currently available can be found in Table 11 on page 43.

*Table 11. Optical Library Specifications*

| Library | Number of Cartridges | Technology | Maximum Capacity (GB) | Number of Drives | Average Read Data Rate (MB/s) | Average Write Data Rate (MB/s) | Average Exchange Time | Interface |
|---|---|---|---|---|---|---|---|---|
| 3995-A63 | 16 | Rewritable & WORM | 20 (19) | 1 | 1.05 (0.96) | 350 (320) | 10 | SCSI-2 & SCSI-2 Diff |
| 3995-063 | 32 | Rewritable & WORM | 40 (38) | 2 | 1.05 (0.96) | 0.35 (0.32) | 10 | SCSI-2 & SCSI-2 Diff |
| 3995-163 | 144 | Rewritable & WORM | 188 (171) | 4 | 1.05 (0.96) | 0.35 (0.32) | 10 | SCSI-2 & SCSI-2 Diff |

**Note:**

- The 3995 models support both 1024 and 512 bytes per sector media. The first figures are 1024 bytes per sector, the figures in brackets are 512 bytes per sector

In addition to the directly attachable library devices shown in Table 11, there are also a number of LAN attached optical libraries that can be utilized via NFS. These libraries utilize the same technologies as discussed in this section, the difference being in the method of access. See 3.1.4, “File Systems” on page 57 for a discussion of NFS. The models of the 3995 that can be attached in this fashion are:

- 3995-A23
- 3995-023
- 3995-123

The capacities are the same as for the equivalent x63 models for direct attachment.

## 2.3 Summary

This chapter has discussed in more detail the hardware components available for use by AIX storage management products.

The first section looked at the considerations involved in choosing the types of components appropriate for a particular environment:

- Costs per megabyte
- Access frequency
- Access density
- Access type
- Data rates
- Online life
- Interchange requirements
- Longevity of data
- Reliability
- Regulatory requirements

Various decision scenarios were examined, including:

- Simple cases for just disk, tape, or optical

- More complicated environments where combinations of disk, tape, and optical may be required
- The most complex cases where disk, tape, and optical are all required

The second section examined the characteristics of the hardware devices themselves with a view to selecting from the various products currently available.

Adapters were looked at from the points of view of:

- Technology
- Cabling requirements
- Performance/reliability
- Addressability
- Device support
- Cost

Disks were looked at from the points of view of:

- Technology
- Capacity
- Subsystem performance, including RAID levels
- Availability and fault tolerance

Tape devices were looked at from the points of view of:

- Helical and longitudinal technologies
- Device and library capacities
- Availability
- Device and library performance

Optical devices were looked at from the points of view of:

- ROM, Rewritable, and WORM technologies
- Device and library capacities
- Device and library performance

# Chapter 3.  Operating System Software Components

This chapter is intended to discuss the various software components within the Operating System that are used to enable storage management. A brief overview of the higher level software components available for storage management is also included.

## 3.1  The Operating System

The operating system of a computer has been defined in many ways, but essentially it is a set of software interfaces and functions designed to provide an environment in which the hardware resources of the system can be utilized easily to do work. Within this definition there can be arbitrary levels of complexity, ranging from simple operating systems that allow a single process to execute at a time for a single user, to those that manage multiple processors, large arrays of disk, huge amounts of real memory, as well as many different devices on behalf of hundreds of users, each running several processes concurrently.

The operating system can be subdivided into a number of components, each of which perform essential tasks. This section will focus on those elements related to storage management.

### 3.1.1  Page Space

An application consists of four main elements:

1. Library

   The library segment contains shared instructions that perform common functions that will be used by many processes.

2. Text

   The text segment contains any static information such as text strings, tables, and instructions to the processor.

3. Data

   The data segment contains variable information that the application will use and modify during the course of its operation.

4. Files

   Files contain the information that the application will actually process to produce output that the user requires.

The text and data segments form an entity known as the executable and are stored in a file system (file systems and the organization of disk space for their support are described in more detail in 3.1.3, “Logical Volume Manager” on page 49, and 3.1.4, “File Systems” on page 57), usually on disk. When the user wishes to run the application, the operating system must locate the executable in the file system, and load it into real memory. Any shared libraries required, if not already being used by other applications, and therefore already loaded, must also be loaded.

Memory under AIX is managed by the *Virtual Memory Manager*, which provides a 52 bit virtual address space (4 petabytes). This space is divided into segments, each of 256MB. Segments can be of several different types:

1. Working Segments

   Working segments are those pages of memory that contain transient information, such as application data, and shared library code.

2. Persistent Segments

   Persistent segments are those pages of memory that contain longer term information, such as data files, or application text.

3. Client Segments

   Client segments are used for NFS files, or data from remote systems.

4. Log Segments

   Log segments contain meta information used by the journaled file system (see 3.1.4, "File Systems" on page 57 for more information on logs).

When the application is loaded, the VMM loads the various elements into virtual memory segments (see Figure 22 on page 47). Application text and file data are loaded into persistent segments, whilst application data and shared libraries are loaded into working segments. If any of the libraries required have already been loaded, then they obviously need not be loaded again.

Virtual memory segments are themselves divided into pages of 4096 bytes each, and the VMM manages the mapping of these pages between real memory, paging space, and disk. The first element of the application loaded is the text segment, and the first few pages of this working segment are mapped to real memory locations. This means that when the operating system loader issues instructions to load the text segment to the required virtual memory segment, the VMM translates the addresses of the first few pages, so that they actually correspond to real memory *page frames*, and the corresponding pages are therefore loaded into real memory.

As was described in 1.1.1, "General Concepts" on page 1, real memory is also logically divided into pages frames, where each frame is a fixed number of bytes of data (again 4096 bytes). When the application is loaded into memory, the virtual memory pages are placed in real memory page frames, which is where they must be for the processor to access information from them. The other pages in real memory will contain other applications including those parts of the operating system currently in use, also mapped by the VMM from the virtual memory locations where they are actually addressed. The VMM maintains a *free list* of currently unused real memory page frames; frames from this list are used for mapping the incoming virtual memory pages to.

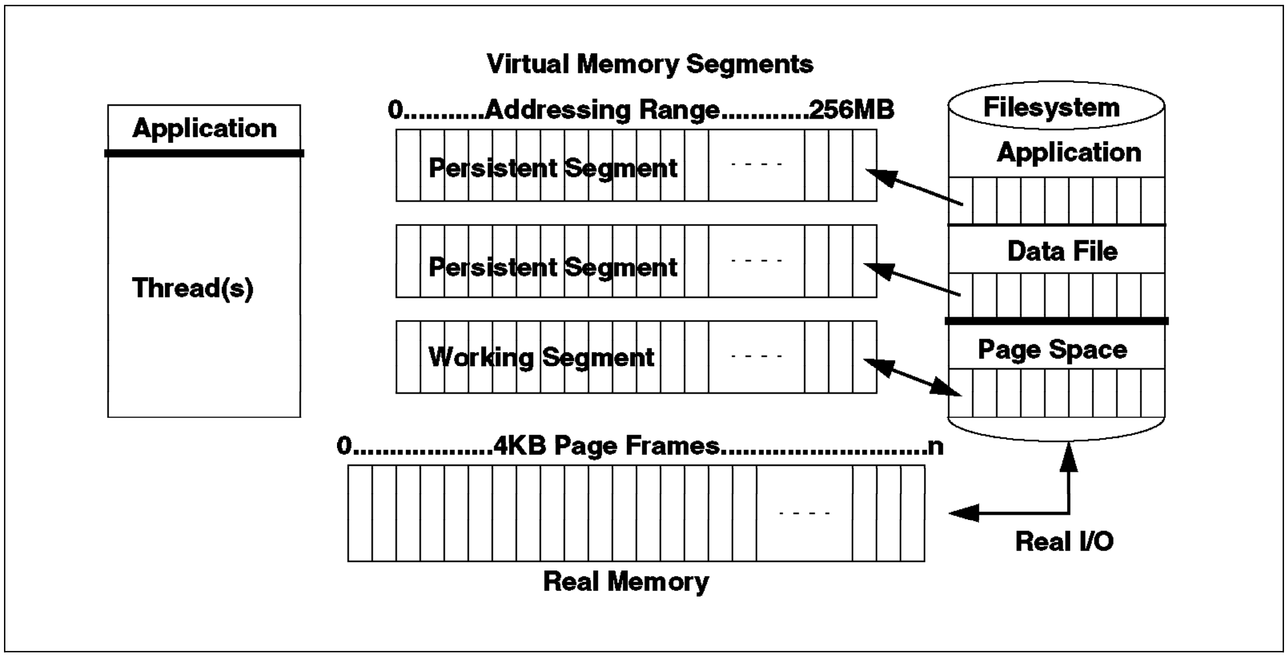


Figure 22. Virtual Memory Manager Disk Usage

An entry in the process table is created containing essential information regarding the application, such as the address of the current instruction, locks held, and other application specific information. An entry is also put on a process dispatch queue which is used by the operating system scheduler to select the application which will run next.

The code segment, and shared libraries (if necessary) are also loaded in the same manner.

The application eligible to run next is dispatched, which means that the address of the next instruction in the process table is loaded into the processor, and the application is now running. If at some point the application makes a jump to an instruction contained in a page not currently in real memory (or requests a piece of data on such a page,, or calls a library function whose instructions are on a page not currently in real memory) a *page fault* occurs. In this case, the operating system must copy the page required into real memory for use.

Sooner or later, the application will need to access information from a data file. When the request to open the file is made, the physical file on disk is loaded into a persistent virtual memory segment in the same manner as has been described for the executable.

Each application also has a fixed time slice during which it can use the processor, and once this expires the process is put to the back of the dispatch queue and the next process scheduled. The next process may be part of the operating system loading a new application that a user has started, in which case the new executable is loaded into memory pages.

Relatively quickly, the memory pages will become full, and when a certain threshold is reached, the VMM must act to maintain the number of pages in the free list. To do this, it uses an algorithm to determine which of the in use pages are not likely to be required in the near future. The criteria include:

- Whether the page frame belongs to a persistent or working segment
- If persistent, whether it contains program text, or file data
- Whether the page frame has caused page faults before (page faults are explained shortly)
- If so, whether the faults were new faults, or repages (a repage is a page of information that has been required more than once)
- If repages, how many
- User tunable threshold parameters

Pages selected in this way (enough to bring the number of used pages back below the threshold) are *paged out*, and page frames thus freed added to the free list. The decisions are designed to favor those types of segment most likely to be required in the near future, such as program text data, working segments, and highly accessed information.

The actions taken for paging out (or swapping) vary depending upon the type of segment from which the page comes, as well as its current state. If the page is from a working segment, then it is copied to an area of disk reserved for this purpose known as *page space*. The VMM changes the mapping to reflect that the page is no longer in real memory, so that if a jump to an address (or request for data at an address) on this page occurs, a page fault will result causing the page to be reloaded. This is the case for any working segment page out. The page is then added to the free list.

If the page is from a persistent segment, then the VMM will check to see whether the page has been altered since it was first loaded, if not then the page is just added to the free list; if a change has happened, then the page is first written out to its original location on disk (usually in a file system). Again, the VMM changes the virtual memory mapping to point to the pages new location back on disk, and then adds the freed real memory page to the free list. Utilization of disk in this fashion is known as *single level storage*.

Thus page space is used as an extension to real memory for situations where more real memory than is available for *working segments* is necessary. Persistent memory segments use their original locations on disk as overflow. In this way, the VMM is able to effectively use more real memory than is physically available on the system, as well as provide a huge address space.

There are certain mechanisms for file access such as the mmap() subroutine, or accessing files via shared memory segments that will cause the file to be loaded into a working segment in virtual memory. In these cases, the file information will be treated in the same way as data or libraries and page faults may result in parts being paged out to page space. Applications using these mechanisms will require much more page space, particularly if large files are to be accessed.

The operating system monitors the number of free pages in paging space, and when this falls below a certain level, all applications currently running on the system are informed of the situation via a SIGDANGER signal. If the number of free pages should then fall further, below a second threshold, those processes using the most paging space will be sent the SIGKILL signal. This will continue until the number of free pages has risen above the danger level. Well behaved applications will trap the

SIGDANGER signal, and upon receipt, free up as much page space as they can by releasing resources.

As can be seen, the allocation of paging space is critical to the operation of the computer system. Furthermore, the design of the storage subsystems generally will have a big impact due to the concept of single level storage. These considerations are taken into account in Chapter 6, “General AIX Storage Management” on page 93 and Chapter 5, “Storage Subsystem Design” on page 77, which cover design and management.

### 3.1.2 Device Drivers

Whenever an operating system component or an application needs to interact with a physical device, such as a disk or tape, it does so through services provided by another element of the operating system known as a device driver. Device drivers provide a common mechanism for accessing the devices that they support.

Device drivers are treated as though they are ordinary files; thus when a process needs to communicate with a device, it uses the open subroutine to initialize the interface, and can then use the read and write calls to access data. Control of the device is accomplished using the ioctl calls, and when the task requiring the device is complete, the interface is ended with the close subroutine.

There are two main types of device driver; those designed for character oriented devices, such as terminals, and printers, and those designed for block devices, such as disks or tapes. Storage management devices are usually block devices, as this is more efficient for transfer of larger quantities of information.

Device drivers normally consist of two parts:

1. The top half

   This half is responsible for interacting with requestors, blocking and buffering data, queuing up requests for service, and handling error recovery and logging.

2. The bottom half

   This half is responsible for the actual I/O to and from the device, and can perform some preprocessing on requests, such as sorting reads from disks for maximum efficiency.

Device drivers provide the primary interface to devices. The logical volume manager, which is discussed in the next section also provides a device driver interface to higher level software, and makes use of the services provided by device drivers to communicate with the physical devices themselves. A fuller understanding of device drivers is really only necessary for those readers who intend to develop applications that will interact directly with storage devices, such as tape or optical library managers. More information can be found in the "Device Driver Concepts Overview" in the InfoExplorer* online hypertext documentation.

### 3.1.3 Logical Volume Manager

The logical volume concept defines a higher level interface transparent to applications and users, that allows the division, allocation, and management of fixed disk storage space. This concept is implemented as a set of operating system commands, subroutines, device drivers, and tools that are collectively known as the

Logical Volume Manager (LVM). This section is relevant to both AIX Version 3 and AIX Version 4, though any differences will be highlighted.

#### 3.1.3.1 Logical Volume Manager Terminology

There are a number of specialized terms used to describe the various entities that comprise Logical Volume Management.

***Physical Volumes:*** The physical disk drive itself forms the basis of Logical Volume Management. Before a disk can be used by the system, it must be defined. Each disk is assigned certain configuration and identification information that together define the disk as a *Physical Volume* (PV). This information is physically recorded on the disk and includes a *Physical Volume Identifier* (PVid) that uniquely identifies it. The disk is also assigned a physical volume name, typically hdisk*x* where *x* is a system unique number. This physical volume name is also used for the low level device driver interface to the disk (for example /dev/hdisk0).

***Volume Groups::*** A collection of between 1 and 32 physical volumes is known as a *Volume Group* (VG). When physical volumes are created, they must be added to a volume group in order to be used. A physical volume can only be in one volume group on a system, though there can be multiple volume groups. Volume group information includes a unique *Volume Group Identifier* (VGid), and the PVids of all physical volumes in the volume group, as well as various status information. Each disk in the volume group has an area on disk known as the VGDA or *Volume Group Descriptor Area*, where this information is stored. The VGDA also contains information describing all of the logical volumes (discussed later in this section) that exist in the volume group.

If more than 32 physical volumes are attached to a system then more than one volume group will definitely be required. It is usually sensible to design the system such that different types of information are stored in different volume groups though. For example, operating system information contained in one volume group, and user information in a separate one, can assist in management and in particular recovery; should a disk fault occur in a physical volume from one volume group, then only information from that volume group will be affected.

Under AIX Version 3 and AIX Version 4, up to 255 volume groups can be defined.

***Physical Partitions:*** When a physical volume is added into a volume group, the space on the physical volume is divided up into equal chunks known as *Physical Partitions* (PPs). The physical partition size is set when a volume group is created, and all physical volumes that are added to the volume group inherit the value. The physical partition size can range from 1 to 256MB, and must be a power of 2, the AIX default being 4MB. Up to 1016 physical partitions can be defined per physical volume under AIX Version 3 and AIX Version 4.

This is the smallest unit of disk space allocation in the logical volume paradigm. Smaller units increase allocation flexibility at the cost of increased management overhead.

***Logical Partitions:*** A *Logical Partition* (LP) is effectively a pointer to from 1 to 3 physical partitions, this number specified when a logical volume (see next section) is created. Information written to a logical partition will be physically written to the physical partitions pointed to. Thus the number of physical partitions mapped to a logical partition defines the number of copies of that partition, or the level of mirroring.

Up to 35,512 logical partitions can be defined per logical volume under AIX Version 3 and AIX Version 4.

***Logical Volumes:*** Once a volume group has been created, and physical volumes added to it, logical volumes can be created. A *Logical Volume* (LV) defines a number of logical partitions, and therefore an area of disk that can be used to store information. With AIX Version 3, the maximum size of a logical volume was 2GB, with AIX Version 4, this limit has been raised to 256GB. The maximum number of user-definable logical volumes in a volume group is 256.

Logical volumes are used to store such things as file systems, log volumes, page space, boot data, and dump storage. The section on logical partitions explained that a logical partition can be mapped to up to three physical partitions, which means that up to two copies of the information contained in a logical volume can be maintained; this is called mirroring, and is explained in more detail in “Logical Volume Manager Policies” on page 54.

A logical volume can have its size changed by adding or removing logical partitions, the number of copies can be increased or reduced, and even the physical location of the logical volume on disk can be changed.

Further information on creating and managing volume groups, physical volumes, logical volumes, physical partitions, and logical partitions can be found in Chapter 6, “General AIX Storage Management” on page 93. The diagram in Figure 23 on page 52, shows the relationship between these components.

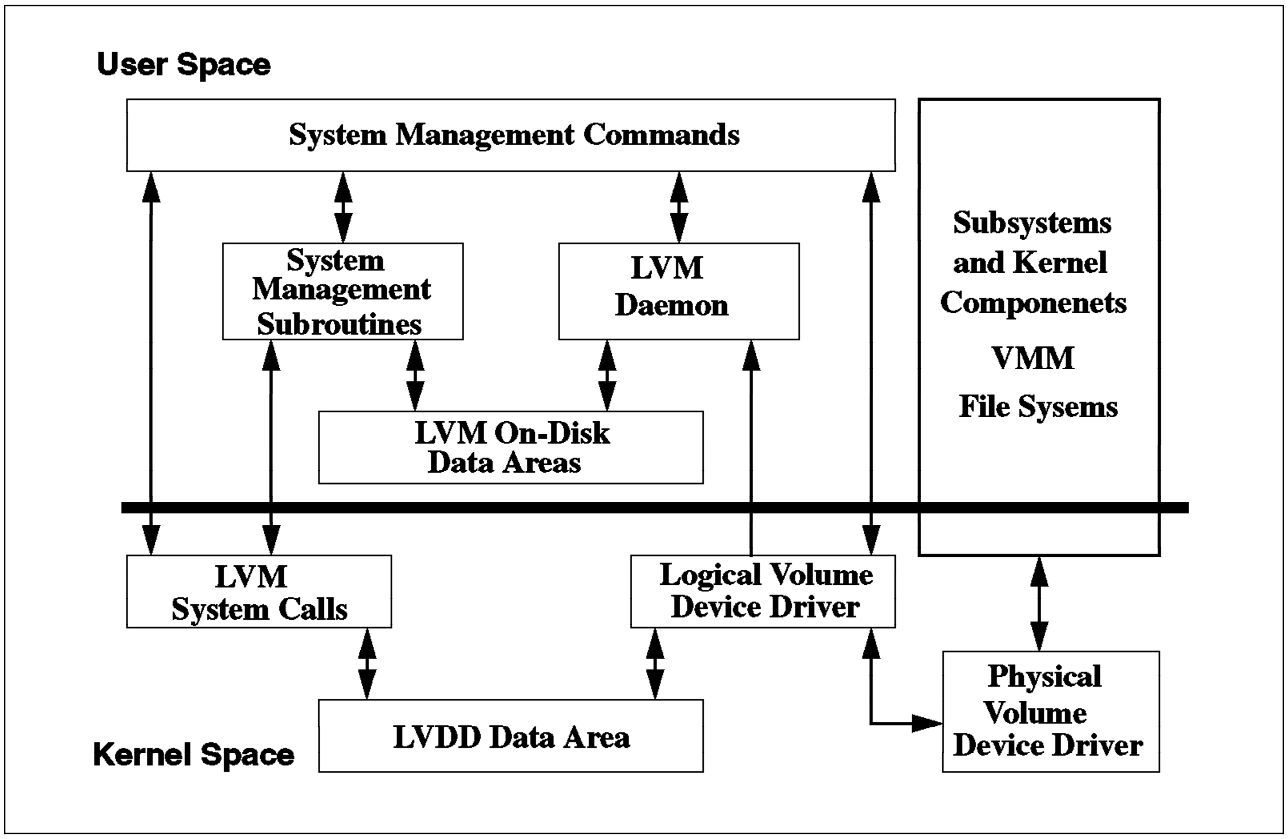

User Space
System Management Commands
System Management Subroutines
LVM Daemon
LVM On-Disk Data Areas
Subsystems and Kernel Componenets
VMM
File Sysems
LVM System Calls
Logical Volume Device Driver
Physical Volume Device Driver
LVDD Data Area
Kernel Space

*Figure 23. Components of the Logical Volume Manager*

The logical volume manager provides the tools to create and manage these entities. Structuring access to the physical disks in this manner provides the following benefits.

- Transparent Control of Physical Storage

  Data contained in a logical volume appears to be contiguous, but can in fact be located on disk partitions that are not side by side, or even on the same physical disk. This allows efficient usage of available disk space, particularly when logical volumes require expanding.

- Mirrored Copies of Logical Volumes

  Through being able to assign multiple physical partitions to each logical partition, copies of vital information can be transparently maintained, even on separate physical disks for additional security.

- Capacity Greater than Physical Disk Sizes

  The logical partitions comprising a logical volume can span multiple disks, which means that logical volumes are not limited to the sizes of the individual physical disks attached to the system.

- Physical Partition Flexibility

  The sizes of physical partitions can be defined when a volume group is created. This gives flexibility in the use of disk resources. For example, logical volumes can be increased in size by smaller increments, thereby utilizing the available disk space more effectively.

### 3.1.3.2 Logical Volume Manager Operation

***General Operation:*** As has already been discussed, the logical volume manager consists of a set of operating system commands, library subroutines, and other tools that allow logical volumes to be established and controlled. The operating system commands are discussed in detail in Chapter 6, “General AIX Storage Management” on page 93, and Chapter 7, “Storage Management Files and Commands Summary” on page 137. These commands use the library subroutines to perform management and control tasks for the logical volumes, physical volumes, and volume groups in a system. The interface to the logical volumes is called the *Logical Volume Device Driver* (LVDD), and this is a pseudo device driver that manages and processes all I/O to logical volumes. The logical volume device driver is designed and utilized in the same way as any other device driver in the system, consisting of two halves. In this case, the lower half is responsible for mapping the logical addresses to actual physical disk addresses, for handling any mirroring, and for maintaining *Mirror Write Consistency* (MWC). Mirror Write Consistency uses a cache in the device driver where blocks that are mirrored are stored until all copies have been updated. This ensures data consistency between mirrors. The lower half also manages bad block detection and relocation if necessary. If the physical disk is capable of this function, then the logical volume device driver will make use of the hardware support, otherwise it will be done in software. Both mirror write consistency and bad block relocation can be disabled on a logical volume basis.

The list of data blocks to be written (or read) is finally passed by the logical volume device driver to the physical disk device drivers, who interact directly with the disks. In order for the logical volume manager to work with a disk device driver, it must adhere to a number of criteria, the most significant of which is a fixed disk block size of 512 bytes.

The relationship between the various software layers involved in disk access with the logical volume manager is shown in Figure 24 on page 54.

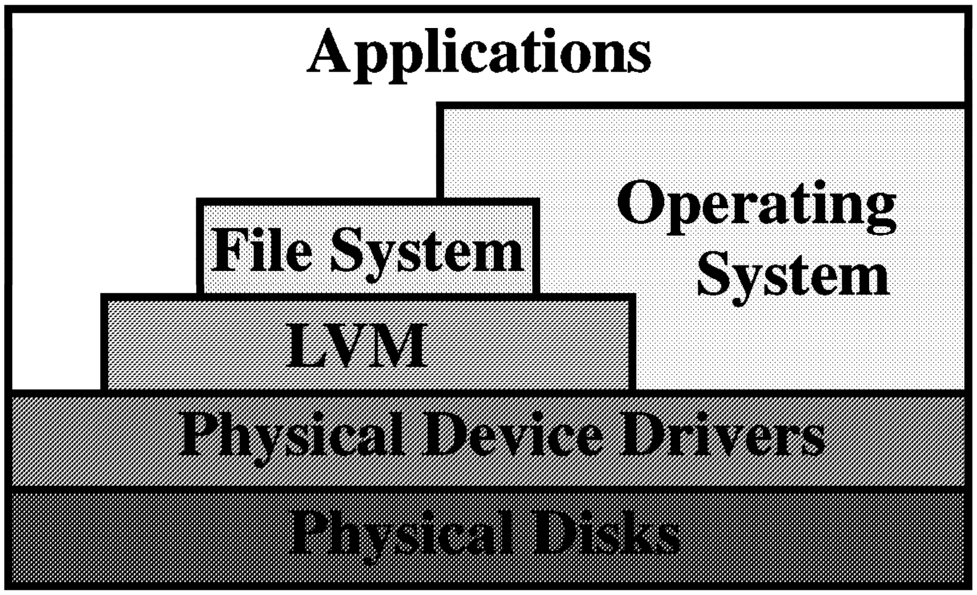


*Figure 24. Relationship Between the LVM and other Components*

***Quorum Checking:*** In order for a volume group to be accessible to the system, it must be varied on. The process of varying on a volume group is discussed in 6.3.4, “Varying On and Varying Off Volume Groups” on page 106. During this process, the logical volume manager reads management information from the physical volumes in the volume group. This information includes the volume group descriptor area already mentioned in 3.1.3.1, “Logical Volume Manager Terminology” on page 50, and another on-disk information repository known as the *Volume Group Status Area* (VGSA), which is also stored on all physical volumes in the volume group. The VGSA contains information regarding the state of physical partitions and volumes in the volume group, such as whether physical partitions are stale (used for mirroring, but not reflecting the latest information), and whether physical volumes are accessible or not. The VGDA is managed by the subroutine library, and the VGSA is maintained by the LVDD. If the vary on command cannot access a physical volume in the volume group it will mark it as missing in the VGDA. For the command to succeed, a *quorum* of physical volumes must be available. A quorum is defined as a majority of VGDAs and VGSAs (more than half of the total number available). The only situation where this is slightly different is in the case where there are one or two physical volumes in a volume group. In this case two VGDAs and VGSAs will be written to one disk, and one (or none if only one disk) to the other. If the disk with two sets is inaccessible, then a quorum will not be achieved and the vary on will fail. For techniques to recover from quorum failure, see Appendix C, “General Volume Group Recovery” on page 349.

***Logical Volume Manager Policies:*** When logical volumes are created, there are a number of attributes that can be defined for them that govern their subsequent operation in terms of performance and availability. These attributes are really policies that the logical volume manager enforces for the logical volume and include the following:

1. Bad-Block Relocation Policy

As was mentioned in "General Operation" on page 53, the logical volume manager will perform bad-block relocation if required. This is the process of redirecting read/write requests from a disk block that has become damaged to one that is functional, transparently to an application.

2. Intra-Physical Volume Allocation Policy

   The logical volume manager defines five concentric areas on a disk where physical partitions can be located. These regions are shown in Figure 25, and are combined into the following three policy choices for data location:

   a. Edge and Inner Edge

      These regions generally have the longest seek times, resulting in the slowest average access times. Logical volumes containing relatively infrequently accessed data are best located here.

   b. Middle and Inner Middle

      These regions provide lower average seek times, and consequently lower average access times. Reasonably frequently accessed data should be positioned here.

   c. Center

      This region provides the lowest average seek times, and hence the best response times. Information which is accessed regularly, and needs high performance should be situated here.

   The different average seek times are based upon the supposition that there is a uniform distribution of disk I/O, meaning the disk head will spend more time crossing the center section of the disk than any of the other regions.

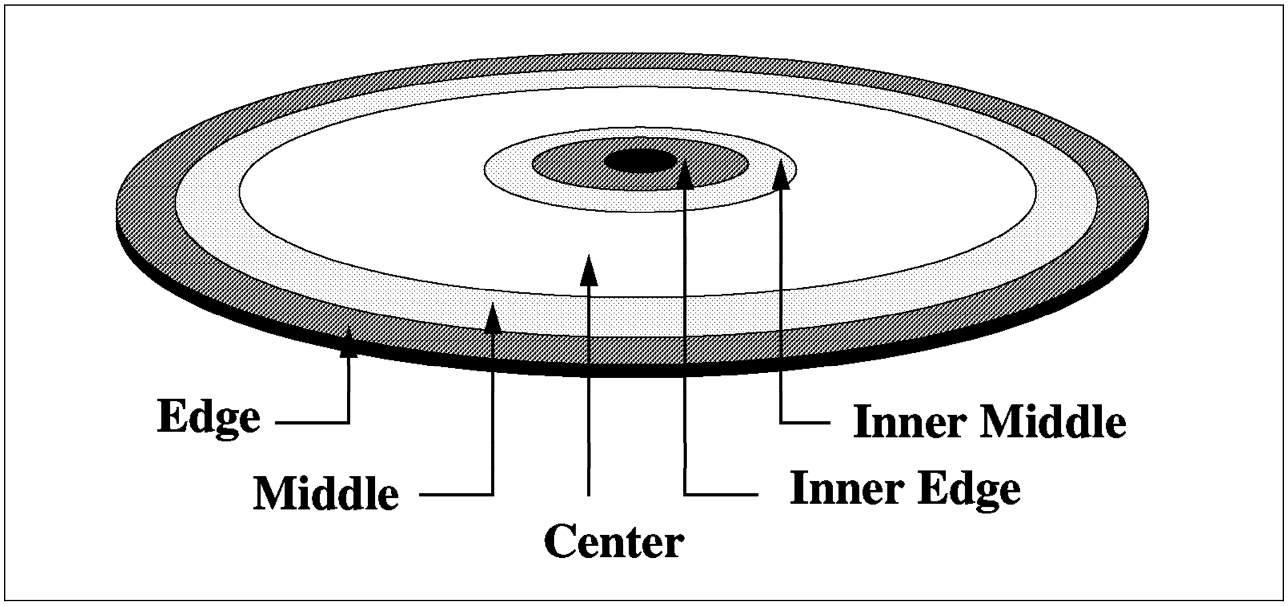


*Figure 25. Physical Disk Partition Location*

   When a logical volume is created, the preferred location policy for the logical volume can be defined. The logical volume manager will then do its utmost to locate the volume as closely to the required position as is possible.

3. Mirroring

The logical volume manager allows each logical partition in a logical volume to be mapped to from one to three physical partitions. This means that up to two copies of a logical volume can be transparently maintained for performance and availability purposes. The scheduling policy explained below determines how information is actually written. Should a disk with one of the copies of the logical volume fail, or should some of the physical partitions in the copy become damaged, then another copy can be transparently used while repairs are effected. Furthermore, the copy that has the required partitions closest to a read/write head will be used for reading, improving performance. The benefits here are somewhat dependent upon the inter-physical volume allocation policy which is explained next.

4. Inter-Physical Volume Allocation Policy

   When the logical volume manager allocates partitions for a logical volume, the partitions can be spread across multiple disks. The inter-physical volume allocation policy governs how this will actually be implemented in terms of numbers of physical volumes. There are two options:

   a. Minimum

      The minimum option indicates that if mirroring is being used, then the minimum number of physical volumes should be used per copy, and that each copy should use separate physical volumes. If mirroring is not being used, then just the minimum number of physical volumes necessary to hold all of the required physical partitions should be used.

   b. Maximum

      The maximum option predictably enough, attempts to spread the required physical partitions over as many physical volumes as possible, thereby improving performance. If mirroring is not used here, then this approach is highly sensitive to physical volume failure.

5. Scheduling Policy

   When mirroring is being used, there are two ways in which the logical volume manager can schedule I/O for the physical volumes:

   a. Sequential-write copy

      When this option is selected for a logical volume, write requests are performed to each copy successively, in the order primary, secondary, and tertiary. A write to a copy must complete before the next copy can be updated, thus ensuring maximum availability in the event of failure.

      Read requests will be initially directed to the primary copy, and if this fails, to the secondary, and then tertiary if necessary (and defined). While the data is being read from the next copy, the failing copy (or copies) is repaired by turning the read into a write with bad-block relocation switched on.

   b. Parallel-write copy

      In this case, write requests are scheduled for each of the copies simultaneously. The write request returns when the copy that takes the longest to update completes. This method provides the best performance.

      Read requests are scheduled to the copy that can be most rapidly accessed, thereby minimizing response time. If the read fails, repairs are accomplished using the same mechanism as for sequential-write copy.

There is a great deal of additional information on all aspects of the logical volume manager in InfoExplorer online hypertext documentation, if required. Further information on planning and managing the elements of the logical volume manager can be found in Chapter 5, “Storage Subsystem Design” on page 77, and Chapter 6, “General AIX Storage Management” on page 93.

### 3.1.4 File Systems

One further level of abstraction is provided at the operating system level, and this is the file system. A file system is essentially a hierarchical structure of directories, each directory containing files, or further directories (known as subdirectories). The diagram in Figure 26 shows the standard AIX journaled file system structure as of AIX Version 4; the differences between this and AIX Version 3 structure are organizational. The main purpose of a file system is to provide for improved management of data by allowing different types of information to be organized and maintained separately. As will be shown later in this section however, file systems also provide many more facilities.

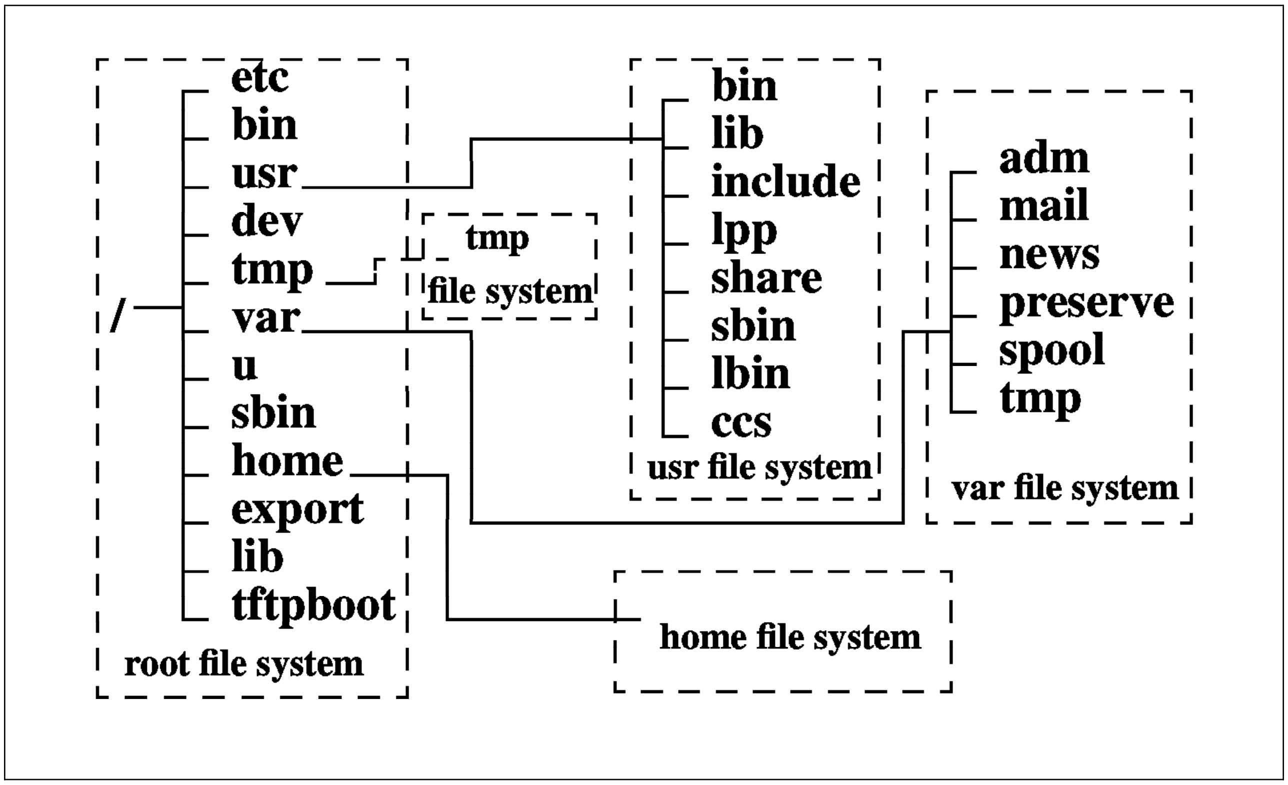


*Figure 26. Standard AIX Version 4.1 JFS Organization*

There many different types of file systems in existence, including the following:

- Journaled File System (JFS)

  This is the native AIX file system, providing the full range of supported file system operations for organizing and managing physical files. The JFS is explored in more detail later in this section.

- Network File System (NFS)

  This type of file system allows a remote file system (or part of a file system) to be accessed as if it were part of a local file system.

- CD-ROM File System

This type of file system allows the contents of a CD-ROM to be accessed as if they were part of a local file system.

However there must be at least one base (or *root*) file system within which other file systems can be accessed, on the local machine.

### 3.1.4.1 Journaled File System

Journaled file systems are implemented through a set of operating system commands that allow creation, management, and deletion, and a set of subroutines that allow lower level access such as open, read, write, and close to files in the file system. A JFS is created inside a logical volume and is organized as shown in Figure 27.

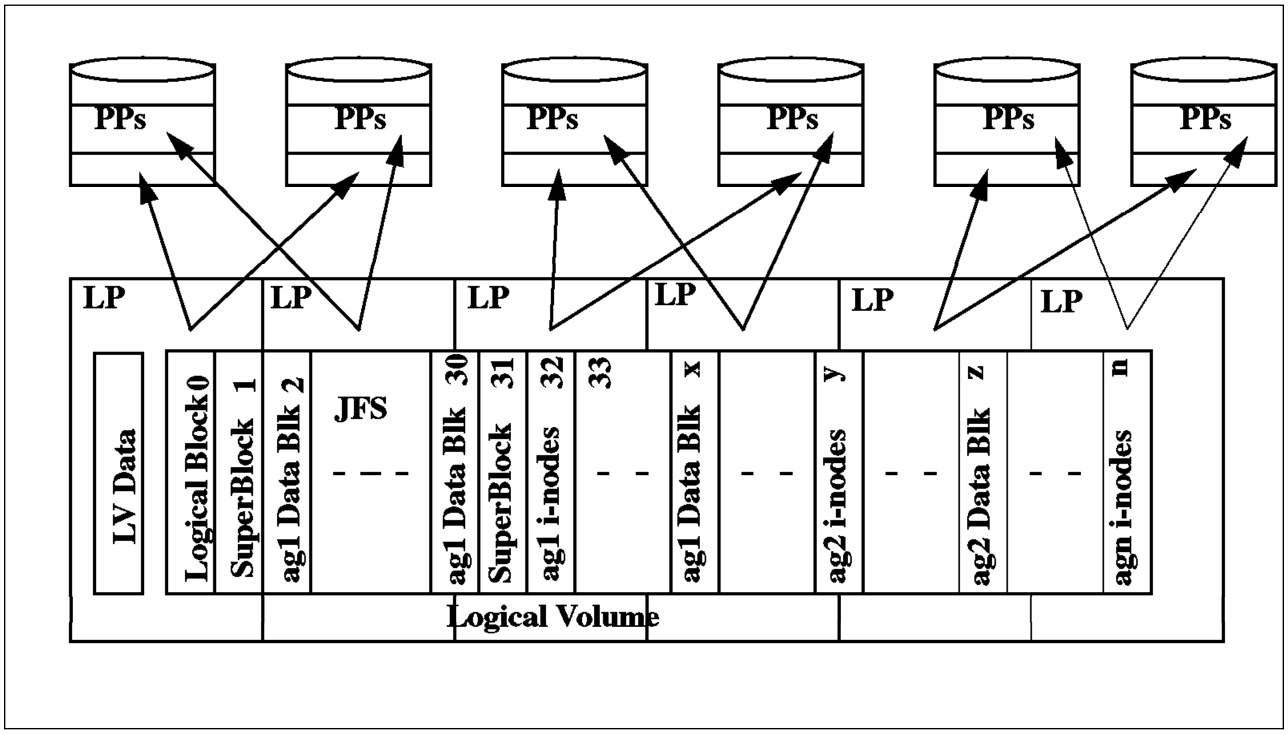


*Figure 27. JFS Physical Organization*

As can be seen, the JFS divides the logical volume into a number of fixed size units or *Logical Blocks*. The logical block size is the block size used for I/O at the file system interface - this means that the file system passes data to be written or receives data that has been read in blocks of 4096 bytes to/from the LVM. The block size was selected to be 4KB to be the same as memory page size for maximum transfer efficiency, and to minimize free space fragmentation on the disk. The logical blocks in the file system are organized as follows:

***Logical Block 0:*** The first logical block in the file system is reserved and available for a bootstrap program or any other required information; this block is unused by the file system.

***Superblock:*** The first and thirty first logical blocks are reserved for the superblock (logical block 31 being a backup copy). The super block contains information such as the overall size of the file system in 512 byte blocks, the file system name, file system log device address (logs will be covered later in this section), version number, and file system state.

***Allocation Groups:*** The rest of the logical blocks in the file system are divided into a number of allocation groups. An allocation group consists of data blocks and i-nodes to reference those data blocks when they are allocated to directories or files. The purpose behind this extra level of abstraction is as follows:

1. Improve locality of reference

   Files created within a directory will be maintained in an allocation group with that directory. As allocation groups consist of contiguous logical blocks, this should assist in maintaining locality of reference for the disk head.

2. Ease file system extension

   Extending a file system is easier as a new allocation group of i-nodes and data blocks can be added, maintaining the relationship between i-nodes and file system size simply. Without allocation groups, the file system would either have to be reorganized to increase the number of i-nodes, or the extension could only increase the number of data blocks available, thereby conceivably limiting the number of files and directories in the file system.

I-nodes are explained in the next section. For a pictorial representation of this organization, please refer to Figure 27 on page 58.

***Disk i-nodes:*** When the file system is created, files and directories within the file system are located via i-nodes. An i-node is an on-disk structure that contains information regarding the file and its physical location on disk. Under AIX Version 3, an i-node is created for every 4KB of file system space, so for a 32MB file system, 8000 i-nodes would be created, and these i-nodes would be divided between the allocation groups. This then defines the maximum number of files and directories that can be created in the file system. The structure of an i-node is depicted in Figure 28. The first part contains information such as the owner, and permissions for the directory or file, the second part contains an array of 8 pointers to the actual disk addresses of the 4KB logical blocks that make up the file or directory.

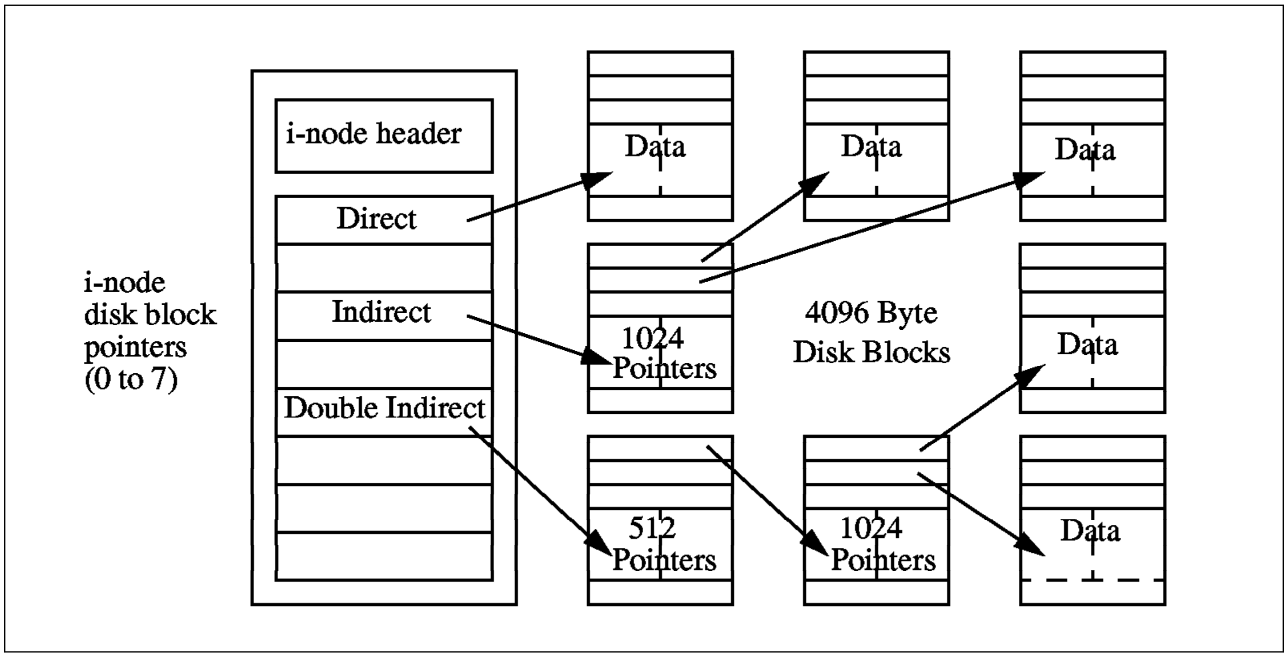


*Figure 28. Anatomy of an I-node*

For files that can fit within the array storage area, such as most links, the file is actually stored in the i-node itself, thus saving disk space.

For a file of size up to 32KB, each i-node pointer will directly reference a logical block on the disk. For example, if the file is of size 27KB, then the first seven pointers will be required, the last pointer referencing a 4KB logical block containing the last 3KB of the file.

For files up to 4MB, the i-node points to a logical block that contains 1024 pointers to logical blocks that will contain the files data; this gives a file size of up to 1024 x 4096 or 4MB.

For files greater in size than this, the i-node points to a logical block that contains 512 pointers to logical blocks that each contain 1024 pointers to the logical blocks that will actually contain the files data; this gives a maximum file size of 512 x 1024 x 4096 or 2GB.

The mapping of file names to i-node numbers is stored within directory files.

The maximum size of the file system under AIX Version 3 is limited to 2GB. This is due to limitations in the size of the internal pointer used by some system calls to navigate the file system; the pointer is defined as a signed integer which means there are 31 bits available for addressing. This gives a maximum range of 2 to the power 31, or 2GB.

#### *AIX Version 4 Enhancements to the JFS*

1. Fragments

   While generally efficient from the point of view of loading into memory and preventing physical disk fragmentation, having a fixed logical block size can have drawbacks. If the majority of files stored in the file system are small (less than 1 logical block in size), then there will be a great deal of wasted disk space in the accumulation of those portions of the logical blocks that remain unused by the smaller files. If all files are less than half of a logical block in size, for example, then half of the total file system space will be unused, even though the file system is full.

   In order to address this type of situation, AIX Version 4 introduces the concept of the *fragment*. A fragment is the smallest unit of file system disk space allocation, and can be 512, 1024, 2048, or 4096 bytes in size. The fragment size is defined at JFS creation time and is stored in the superblock.

2. Number of Bytes Per i-node

   Under AIX Version 3, the number of i-nodes created for a file system was fixed, as discussed in the section on i-nodes. With AIX Version 4, it is now possible to vary the number of i-nodes created within a file system, and therefore the amount of space required by the i-node structures can be tailored to maximize utilization of the file system. If only a few very large files are going to be created in a file system, then it is a waste of space to generate 8000 i-node structures, and therefore the value of the *Number of Bytes Per i-node* or NBPI, should be increased. For example, if the NBPI is set to 16KB, then in a file system of size 32MB, 2000 i-nodes would be created rather than 8000 as in AIX Version 3.

3. Compression

Another new feature in AIX Version 4 is JFS compression. This facility provides for compression of regular files (as opposed to directories or links). The compression is implemented on a logical block basis which means that when a logical block of file data is to be written, an entire logical block is allocated for it; the logical block is then compressed and the number of fragments now required as a result of the compression, actually allocated. Thus in contrast to a fragment file system which only allocates fragments for the final logical blocks of files less than 32KB in size, compressed file systems allocate fragments for every logical block in every file.

Compression is done block by block in order to fulfill the requirements for efficient random I/O. The algorithm used by default is LZ1, although user-defined compression algorithms are also supported.

4. File System Size

   As discussed previously, the maximum size of a file system under AIX Version 3 was 2GB. With AIX Version 4, this maximum has been increased to 256GB. This increase has been achieved by changing the file system pointers and data types to 64 bits; the limitations restricting the maximum size are now JFS data structure and algorithm related.

These enhancements are described in more detail in Chapter 4, "AIX Version 4 Storage Management Enhancements" on page 67.

### 3.1.4.2 Network File System

NFS allows files and directories located on other systems to be incorporated into a local file system and accessed as though they were a part of that file system. NFS provides its services on a client-server basis. Server systems can make selected files and directories available for access by client systems. NFS provides a number of services, including the following:

- Mount Service

  This service allows clients to mount the portion of the remote file system that they wish to access into a local file system. Mounting is discussed in more detail later in this section.

- Remote File Access

  This service fulfills requests for file activity from the client to server (such as opens, reads, and writes).

- Remote Execution Service

  This service provides authorized clients with the ability to execute commands on the server.

- Remote System Statistics Service

  This service provides statistics on the recent availability of the server.

- Remote User Listing Service

  This service provides information to clients on users of the server system.

NFS installation, configuration and management are covered in detail in the InfoExplorer online hypertext documentation.

NFS operation is stateless, which means that the server does not maintain any transaction information on behalf of clients. Each file operation is atomic, which means that once complete, no information on the operation is retained. Thus if a connection should fail, it is up to the client to maintain any synchronization or transaction logging to ensure consistency.

#### 3.1.4.3 Other File Systems

As has been explained in this section, file systems provide an interface that simplifies management and access to information. The native file system under AIX is the JFS, but there are other types such as NFS for remote files, as well as the following:

- CD-ROM File System

  This file system provides access to information stored on a CD-ROM, such as the infoExplorer hypertext information. Once created (see InfoExplorer for details) a CD-ROM file system can be mounted and accessed like any other.

- File Storage Facility/6000 MFS

  The File Storage Facility product (FSF) is discussed in overview in B.2, “AIX File Storage Facility/6000” on page 344. This product provides a cache file system on the client machine where files currently being accessed reside. Viewing the contents of this file system can show more files than could actually fit within the physical space on the client. This is accomplished through the provision of another file system type known as MFS. The MFS intercepts requests for file operations and works out whether the required file is currently in local cache or stored remotely at the server; if remotely stored, the file is transparently copied to the local cache for use. The MFS also manages the removal from cache to the server of files that have not been accessed for a defined period, or the largest files, so as to maintain enough working space in the cache.

  The MFS is created automatically when FSF/6000 is configured. For more information on FSF/6000, see the documentation.

- Andrew File System** (AFS**)

  The Andrew File System, or AFS, provides a similar basic service to NFS in that it allows machines to access remote file systems as though they were local. The major difference is that AFS defines its own hierarchy, where many machines can participate in mounting sections of their local file systems into the hierarchy. Client machines that are authorized can then mount the entire AFS hierarchy into their local file system structure, and thereby access information on a wide range of machines and file systems as though it were local.

  For more information on AFS, please refer to the product manuals.

#### 3.1.4.4 Accessing File Systems

Once a file system of whatever type has been created, it must be mounted in order to access the information within it. The process of mounting creates the connection between an existing and accessible local file system *mount point* and the root directory of the directory structure to be accessed. A mount point can be either a directory or a file in the local file system. If a new local file system, or remote directory structure (using NFS for example) is to be accessed, then it must be mounted over a directory. If only a single file is to be accessed then it must be mounted over a local file. As shown in Figure 26 on page 57, the AIX operating system starts with a root file system into which the /usr, /var, /tmp, and /home file systems are mounted at boot time. Any other file systems required can then be mounted wherever required (assuming relevant permissions).

## 3.2 Higher Level Tools

So far in this chapter the basic operating system support providing access to information stored on physical media (such as disk) has been discussed. This next section will look briefly at some higher level functions provided either by the operating system, or by applications designed to enhance storage management capabilities.

### 3.2.1 Backup/Restore

Backup facilities, as provided by the operating system, enable all information (including both user and operating system data) to be copied (generally to removable media such as tape), so that in the event of a major problem the information can be easily restored.

There are three main areas to consider when designing a backup strategy:

1. Which information should be backed up

   There is usually a large amount of information stored in a computer system. Copying this information can take time, and there will usually be information that is not important enough to warrant concern (such as temporary files, or data that has already been archived).

2. What technology should be used for the backups

   This will depend on the quantity of information, length of time available for backup, length of time information needs to be stored on backup media, and the cost of the technology used. As has been discussed in previous sections, optical storage is generally faster and has longer potential shelf life, whilst tapes are cheaper and generally larger capacity.

3. When and how often should backups occur

   There are several strategies that can be used, depending on the nature of the information produced by the business. For example, sites where there is a great deal of static reference information with little day to day change, and maybe monthly updates to the static information could benefit from an incremental policy. This would mean taking full backups on a monthly basis, and only backing up the changed information daily. Organizations processing large amounts of information on a daily basis may choose to backup the data daily.

   The strategy chosen should reflect the business information cycles, but will also be strongly tied to the criticality of the information. The decision is simply: how long can the business survive without key information. If the answer is one day, then backups of the information must be scheduled at least once a day.

Designing a backup strategy is an essential task, as however well maintained a system is, the unexpected, by definition can always happen. Backup and recovery planning and techniques are discussed in more detail in 5.5, “Planning Backup Strategies” on page 87.

### 3.2.2 Hierarchical Storage Management

Thus far, storage subsystems have been discussed from the point of view of operating system level access. That is to say, covering the various storage devices available, their pros and cons, and the way in which they can be made available to higher level user applications. There are also many intermediate and higher level applications that themselves provide services, both for system administrators, and for higher level management of storage on behalf of users. These types of application fall into the category of *Hierarchical Storage Management*.

The premise behind hierarchical storage management is to categorize storage devices in terms of their basic properties and provide automatic mechanisms to utilize them most efficiently within this context, usually in a networked environment. For example, as has been discussed in 2.1.2, “How to Make the Decision” on page 18, the basic property classifications shown in Figure 14 on page 21, apply. This implies that frequently accessed information, or information that requires high performance access (such as databases), should be located on fast disk devices. Older, less frequently accessed information, or information with less restrictive performance requirements, can be stored on optical media. Backup, archive, or long term information that is rarely accessed, can be stored on tape. The process of classifying information in this way, is however, really a dynamic one, and therefore best done on a reasonably continuous basis. This is where hierarchical storage managers can be useful.

ADSTAR* Distributed Storage Manager (ADSM) for example, can manage disk, optical and tape storage in just this way. ADSM provides backup/restore and archive/retrieve services to client systems in a distributed environment. Storage pools are maintained on the server machine that ADSM uses to fulfill client requests. These pools can be defined to form a hierarchy and information can be automatically migrated between pools. For example, the first pool may be composed of fast disk devices to support rapid satisfaction of client requests. However, if this pool becomes full, then information can be automatically migrated to another storage pool. Generally, the information so migrated will be the less frequently accessed information, and so the lower level pool will be composed of lower cost, slower, higher capacity devices, such as optical. The hierarchy so defined is arbitrary, and can contain pools of tape devices lower in the hierarchy, to which backup information can be directly (and automatically) written on behalf of clients, or to which even less regularly accessed archive data can be migrated.

ADSM also has many other capabilities, and for a fuller description of these, please refer to Appendix B, “Higher Level Storage Management Products” on page 341.

Some tools manage disk space at the client machine as well. FSF/6000 is an example of such an application. In this case, the client fast disk space is maintained merely as a cache (or window onto the real storage space). When information is created or changed in any way, it is stored in the cache at the local machine, but a copy is made and this is maintained at the server. When the cache approaches a predefined *high water mark*, or percentage utilization, data is automatically migrated to the server storage space, and a pointer to it left in the cache. Subsequent requests for this information will result in the information being transparently moved back (a copy is still maintained). In this way, the small client storage space can be made to seem much larger than it really is; in addition, the server storage pool can be managed by a tool such as ADSM (at the server) to provide automatic backup, archive and migration.

Using such tools additionally enhances storage management by providing a centralized mechanism for information management, which can be useful, not only from resource utilization management, but also from security, general availability, and ease of use.

General information on some of the applications available in this area is available in Appendix B, "Higher Level Storage Management Products" on page 341.

### 3.2.3 Media Management

Media management refers to the control of the attached storage devices. This chapter has already looked at the operating system supplied mechanisms to enable this, including device drivers, the LVM, and file systems. In the previous two sections, backup and restore, and hierarchical storage managers have also been discussed, which provide higher level functions for storage. The capabilities of the devices are thus made available through the operating system components, and through higher level tools. Generally, the higher level applications make use of the operating system provided components to access the required devices. There are some device types that cannot currently be managed by the operating system, including tape and optical libraries. In these cases an alternative mechanism must be found to control the devices, if required; ADSM for example provides the necessary support to control a range of libraries (both tape and optical). It is not always the case that the complete functionality of a higher level tool be required, merely just the ability to manage a tape library for a discrete system. In this case an alternative solution may be necessary in order to provide the library management component.

## 3.3 Summary

This chapter has discussed in detail the operating system software components that enable access and management of the physical storage devices, as well as those aspects that require storage space for system operation. Higher level functions provided by tools such as hierarchical storage managers, backup/restore operations, and management of the physical media were also briefly discussed.

1. Operating system

   The components of the operating system discussed were:

   - Paging

     This section explained paging and the requirement for paging space as a means to maximize the usage of available real memory. The complete mechanism used to execute an application was outlined illustrating how secondary storage can be used to supplement real memory and thereby greatly increase the address space of the system.

   - Device drivers

     This section discussed the components of the operating system that provide the low level management and access to physical devices. The structure and capabilities of device drivers was briefly explained.

   - Logical Volume Manager

     The main component of storage management under AIX, the LVM was explained in reasonable detail in this section. LVM concepts such as:

     – Physical Volumes

    - Volume Groups
    - Physical Partitions
    - Logical Partitions
    - Logical Volumes

    were explained, as well as their interrelationships. LVM operations and services were also described, including:

    - Quorum checking
    - Bad block relocation
    - Intra-physical allocation policy
    - Mirroring
    - Inter-physical allocation policy
    - Scheduling policy

  - File systems

    The concept of file systems was then covered. The relationship of file systems to the LVM as well as their general function were outlined. The native AIX file system, the JFS was then described in detail, including the AIX Version 3 implementation, and the enhancements provided with AIX Version 4:

    - Fragments
    - Number of bytes per i-node
    - Compression
    - File system size increase

    The NFS and other file systems were then briefly discussed, followed by a concise outline of subsequent operating system procedures for accessing file systems.

2. Higher level tools

   The higher level tools discussed were:

   - Backup/restore

     The purpose and basic considerations involved in backing up a system to ensure recovery in the event of failure were discussed in this section.

   - Hierarchical Storage Management

     The principles of hierarchical storage management as a means to make the most effective use of available storage devices, as well as provide backup/restore and archive/retrieve services, were discussed in this section. Several high level applications (including ADSM, and FSF/6000) were used as examples.

   - Media Management

     Certain devices provide extra capabilities that are not currently directly supported by the operating system. Examples of this are tape and optical library support. This section looks at the alternative methods available for utilizing such functionality.

# Chapter 4. AIX Version 4 Storage Management Enhancements

AIX Version 4 provides enhanced functional capabilities in the area of the storage management. This chapter will examine these enhancements, in some detail.

## 4.1 Fragmentation

Fragmentation is a concept introduced in BSD UNIX** which enables system administrators to manage file systems in such a way that they make more efficient use of the disk storage space available to them.

Research conducted in the area of disk space utilization has revealed that up to 45% of disk space is wasted by file systems that use a 4KB block as the allocation unit. In AIX releases prior to AIX Version 4, the disk space allocation unit is in fact 4KB and not tunable, potentially giving rise to much wasted disk space. In AIX Version 4 it is now possible to create journaled file systems with an allocation unit or *fragment* size specified as one of 512, 1024, 2048 or 4096 bytes.

Although there is a distinct advantage in providing this enhancement for ensuring optimal disk space utilization this can sometimes be at the expense of performance.

In AIX Version 4, as many whole fragments as necessary are used to store a file or directory's data. Consider that we have chosen to use a JFS fragment size of 4KB and we are attempting to store file data which only partially fills a JFS fragment. Potentially, the amount of unused or *wasted* space in the partially filled fragment can be quite high. For example, if only 500 bytes are stored in this fragment then 3596 bytes will be wasted. However, if a smaller JFS fragment size, say 512 bytes, was used, the amount of wasted disk space would be greatly reduced to only 12 bytes. It is, therefore, better to use small fragment sizes if efficient use of available disk space is required.

Although small fragment sizes can be beneficial in reducing disk space wastage, this can have an adverse effect on disk I/O activity. For a file with a size of 4KB stored in a single fragment of 4KB, only one disk I/O operation would be required to either read or write the file. If the choice of the fragment size was 512 bytes, eight fragments would be allocated to this file and for a read or write to complete, several additional disk I/O operations (disk seeks, data transfers and allocation activity) would be required. Therefore, for file systems which use a fragment size of 4KB, the number of disk I/O operations will be far less than for file systems which employ a smaller fragment size.

For files of greater than 32KB in size, whatever the fragment size, allocation is performed in logical blocks of 4KB. The i-node pointers will therefore point to 4KB logical blocks as before (indirection will also be the same). For those files of up to 32KB in size, fragments come in to play. Consider a file of 17KB in size. The first 16KB of this file will be allocated logical blocks as before, the disk addresses of these blocks pointed to by the first four pointers in the i-node. The last 1KB of the file will be allocated sufficient contiguous fragments to contain the remaining data, if available. Assuming a fragment size of 512 bytes, two fragments in this case. The fifth pointer in the i-node points to the disk address of the first fragment. In AIX Version 3, the first four bits of the disk block addresses were unused and therefore zeros. In AIX Version 4, when fragmentation is used, the last three of these bits are used to indicate the number of fragments from the disk address that are required. To ensure compatibility with previous releases, all zeros in these bits implies a full block of fragments (which means that the disk address references a 4KB logical block), and therefore in this example eight fragments (using logic 8 - 0 = 8 fragments). So, for the final data in the example file, two fragments are required, so the number in the four bits should be 0110 (this is 6 in binary: 8 - 6 = 2 fragments). The JFS will always subtract the first four bits from eight to see if there are fragments at the disk address in the remainder of the pointer, and if so, how many. The next file that is to be written is exactly 4KB in size. This is one complete logical block, and will be written immediately after the two fragments from the previous example, thus wasting no space. The first four bits will be zeros, indicating eight fragments. If there had not been eight contiguous fragments free anywhere in the file system, this write would have failed. See Figure 29 on page 69 for a diagram of the allocation for this first file (file X). Now a third file is to be written (file Y). File Y is four fragments (or 2048 bytes) in length. There are four fragments free after file X, so file Y is written immediately after the fragments for file X. If there had not been four contiguous fragments available, this write would have failed. File X is now extended by three fragments (or 1536 bytes). There are three contiguous fragments available after file Y, so the extension is written there (as shown in Figure 29 on page 69). Note that both the pointer for file Ys fragments, as well as for the second block of file Xs indicate partial blocks of fragments in the first four bits of the address (file X: 0101 = 5; 8 - 5 = 3 fragments. File Y: 0100 = 4; 8 - 4 = 4 fragments).

It is very important to note the following:

1. Fragments are allocated contiguously or not at all

   If the JFS cannot find sufficient contiguous fragments (up to 4KB worth), allocation and therefore the write will fail. To elaborate, if 11 fragments needed writing (following on from the preceding example), and there were eight free contiguous fragments after file Y, and three free contiguous fragments before file X, then file Z could be written. Having nine free fragments after, and two before would not be sufficient.

2. Fragments will lead to free space fragmentation

   As files are extended, reduced, and deleted, small groups of free fragments will begin to become available (for example if file X in Figure 29 on page 69 is reduced in size to six fragments, two free fragments will appear between files X and Y. This will be used if another file should be created of size one or two fragments, or if a file is extended by two fragments beyond a 4KB boundary, otherwise it will remain unused). In order to reclaim this fragmented free space, a tool is provided that will reorganize the file system to coalesce this space as far as possible. The *defragfs* command is described in Chapter 7, "Storage Management Files and Commands Summary" on page 137.

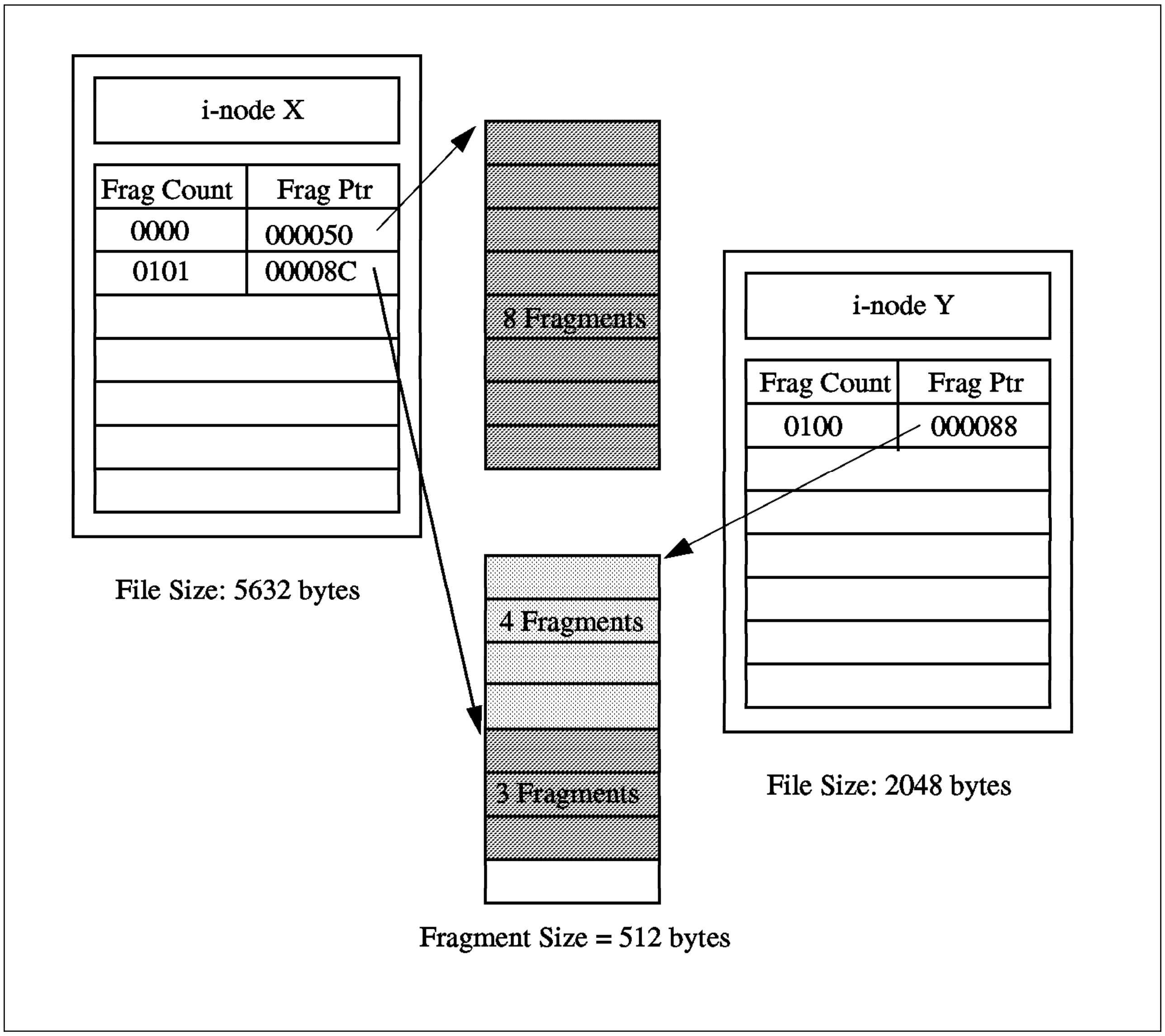


*Figure 29. Fragmentation Example*

To expand on fragment allocation one step further, *only* the last 4KB block of a file can be *partially allocated*, that is to say allocated as fragments of the logical block size, and the file must be directly referenced by the i-node, not indirect. When blocks (4KB) or partial blocks (a fragment multiple) are allocated, contiguous space *must* be available for them. Hence the statement in the last example relating to extending a file 2 fragments beyond a 4K boundary. If the file was 9 fragments, and is extended to 18 fragments, then this is the case: 2 full blocks of 8 contiguous fragments, and 2 contiguous fragments must be found for the write to succeed.

## 4.1.1 Disk Space Allocation

For file systems with a fragment size smaller than 4KB, there is likely to be an increase in allocation activity when the size of existing files or directories are extended.

As an example, assume that a file is extended by 500 bytes, and the file system fragment size is 512 bytes, this will result in one allocation to this file of a 512 byte fragment. If the file is extended by another 500 bytes, another allocation of a 512 byte fragment will be made to this file. So far, two allocation operations have already been performed. However, with a file system fragment size of 4KB, the first file extension operation would have involved one allocation to this file of a 4KB fragment and the second file extension operation would not have resulted in an allocation as there would have been sufficient space from the first allocation. The number of allocations made in the file system using a 512 byte fragment could have been minimized if the two separate file extension operations were performed as one extension of 1024 bytes. Although two 512 byte fragments would still be allocated, this would involve only one file system operation to complete.

### 4.1.2 Free Space Fragmentation

As has been mentioned, free space fragmentation can occur much more within a file system that uses smaller fragment sizes. To clarify, assume that there is a portion of the disk consisting of 8 contiguous 512 byte fragments and that four files, each 500 bytes in size, have written to these fragments in a non-contiguous manner. The free disk space within this area of the disk (four 512 byte fragments) are unallocated fragments which also reside in a non-contiguous manner. A file extension operation which would require 2048 bytes would not be allocated these free fragments as they would have to be contiguous for a single allocation to succeed.

It is quite possible for a file system using a fragment size smaller than 4KB, particularly 512 bytes, to reach high levels of free space fragmentation.

### 4.1.3 Fragment Allocation Map

The fragment allocation map, used to hold information about the state of each fragment for each file system, is held on the disk and in virtual memory. The use of smaller fragment sizes in file systems results in an increase in the length of these maps and therefore requires more resources to hold.

## 4.2 Compression

Compression, like fragmentation, is provided for journaled file systems in AIX Version 4 for the better utilization of available disk space. The disk space savings made by using compression on average increase by about a factor of two. Unlike the JFS fragment support, which treats logical blocks of files and directories less than 32K bytes in size differently to those that are larger, the JFS data compression support will use the same data compression technique for all logical blocks of files, irrespective of file size and fragment size. It does however, enforce that the fragments used for the files logical blocks are contiguous.

The obvious advantage of the use of data compression supplemental to fragmentation, is that there is no restriction to the file size, and so compression will be efficient for both small and large files.

AIX Version 4 JFS data compression is supplemental to JFS fragment support, and requires the installation of the data compression software package.

Only regular files and long symbolic links can be compressed in file systems supporting compression. The *fragment sizes* supported in a *compressed* file system are *512, 1024 and 2048* bytes only. A compressed file system *cannot* have a fragment size of 4KB.

The choice of the fragment size for compressed file systems must be made after evaluating the size of files to be stored and the amount of compression that is actually achieved. Where high amounts of compression are possible, higher disk space savings can be achieved by using a small fragment size like 512 bytes. However, at the same time performance will degrade quite substantially.

### 4.2.1 Implementation of Data Compression

In AIX Version 4, data is compressed at the level of individual files logical blocks. To compress data in large units (all the logical blocks of a file together for example), would result in the loss of more available disk space. By individually compressing a files logical blocks, random seeks and updates are carried out much more rapidly.

After compression of a logical block of a file takes place, the compressed logical block is written to disk using only the number of fragments required for it. After compression, it is likely that the data in the files logical block will occupy less than 4K bytes of disk space. However, if the data does not compress, then it is written to disk in the uncompressed format and allocated the full 4KB of contiguous fragments.

When a file or directory's logical block is first modified, 4KB of disk space are allocated to it to guarantee that the write to disk of that logical block will be successful. If this allocation fails, then an appropriate system error message is returned.

In addition to increased disk I/O activity and free space fragmentation problems, file systems using data compression have the following performance considerations:

**1)** Degradation in file system usability arising as a direct result of the data compression/decompression activity. If the time to compress and decompress data is quite lengthy, it may not always be possible to use a compressed file system, particularly in a busy commercial environment where data needs to be available immediately.

**2)** All logical blocks in a compressed file system, when modified for the first time, will be allocated 4096 bytes of disk space, and this space will subsequently be reallocated when the logical block is written to disk. Performance costs are therefore associated with this allocation, which does not occur in non-compressed file systems.

**3)** In order to perform data compression, approximately 50 CPU cycles per byte are required, and about 10 CPU cycles per byte for decompression. Data compression therefore places a load on the processor by increasing the number of processor cycles.

### 4.2.2 Compression Algorithm

An IBM version of the Lempel Zev (LZ) algorithm is used to perform data compression. The LZ algorithm compresses data by representing the second and subsequent occurrences of a given string with a pointer, identifying the position of the first occurrence of the string and its length. At the start of the compression process the first byte of data is represented as the raw character using a pointer-byte pair (0, byte). The algorithm then processes a fixed amount of data, say N bytes, for compression. Normally, the value of N is one of 512, 1024 or 2048. Every time a string in the N bytes is replicated it is replaced by a pointer-length pair as described above. After compression of N bytes of data, the algorithm searches for the string starting at the next unprocessed byte in the N bytes previously compressed. If the longest match found has a length of zero or one, it represents the first byte in the unprocessed string as a raw character as mentioned previously. If, on the other hand, the length of the matching string is greater than one, the compression algorithm will represent the string using a pointer-length pair and continue to process a further N bytes of data starting from that string.

## 4.3 Disk Striping

AIX allows the placement of logical volumes on a specific area of one or more physical volumes. For example, the center of the disk may be chosen for the placement of logical volumes when rapid access to data is required. Even though this placement strategy can provide fast access to data, it is still restricted by the fact that a disk I/O operation is performed to retrieve each data block.

In Part 1 of Figure 30, the numbered disk blocks for the file represent the sequence of the data in the file. To read the entire file sequentially will involve reading each disk block in turn.

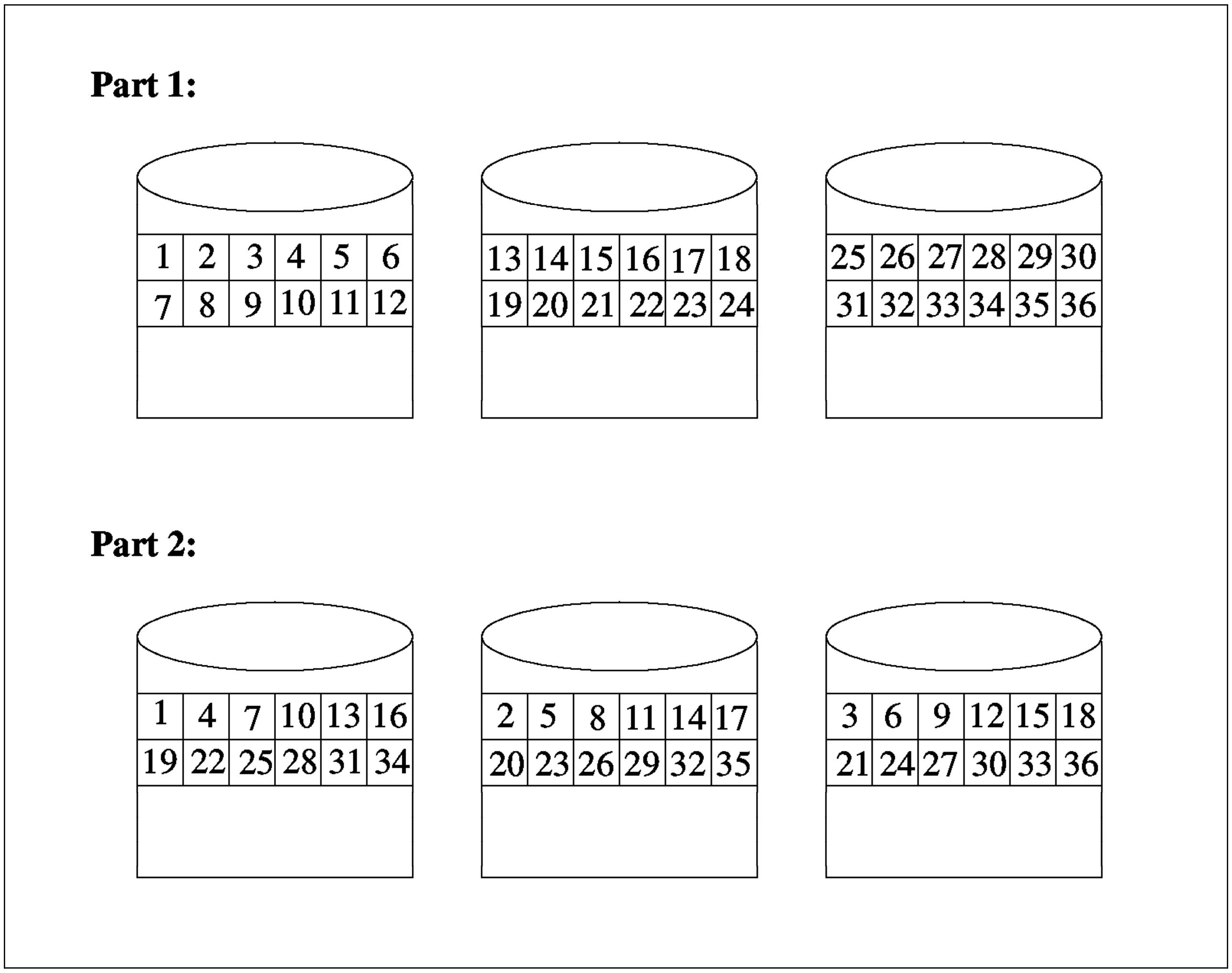


*Figure 30. Striping Example*

However, if we place the data in a logical volume over all available disks in a specific manner to enable parallel access to that data then this would further improve sequential access to that data (see Figure 30).

In user environments where sequential access to large data files is very frequent, this technique will prove extremely efficient. In fact, AIX Version 4 provides for this technique with a mechanism known as *striping*.

In non-striped logical volumes, data is accessed using addresses to data blocks within physical partitions. In a striped logical volume, data is accessed using addresses to stripe units. Consecutive stripe units are created on different physical volumes. A single stripe consists of a stripe unit on each physical volume. The size of a stripe unit must be specified at creation time and can be any power of 2 in the range 4K to 128K bytes. As data in a striped logical volume is no longer accessed using data block addresses, the LVM will track which blocks on which physical drives actually hold the data being accessed. If the data being accessed resides on more than one physical volume, the appropriate number of simultaneous disk I/O operations will be scheduled for all drives concerned.

### 4.3.1 Usage Implications

Disk striping definitely appears to provide very high-performance access to large sequential files. However, to get optimal performance for sequential I/O, there should be little or no other I/O activity on the physical volumes.

To make the most efficient use of striped logical volumes, some operating system parameters must be tuned and application requirements for memory must also be minimized. Results of a benchmark comparing the relative performance of striped logical volumes against non-striped logical volumes are provided in section 8.5.1.3, “Benchmark Results for an I/O Bound Test Using Striping” on page 275.

The constraints imposed by striping of logical volumes are:

- For striping to be possible, at least two physical volumes are required.
- Mirroring is not possible. Increased I/O activity resulting from mirror-writes would impact performance.

## 4.4 Using Page Space for System Dumps

A collection of one or more logical volumes, used solely for providing a mechanism for storing data temporarily not required to be in real memory, is known as *Paging Space*. A description of how paging actually works can be found in 3.1.1, “Page Space” on page 45. Unlike non-paging logical volumes, which are used to store data permanently when a computer is powered on or rebooted, there is no guarantee that data which previously resided in paging space would still remain there.

In AIX Version 4, paging space is additionally used as a primary dump device for system dumps. During installation of AIX Version 4, */dev/hd6*, (the paging logical volume), is automatically configured as the primary dump device. However, for AIX systems being migrated to AIX Version 4, */dev/hd7* is still being maintained as the primary dump device.

After a system dump to the paging space (primary dump device) has taken place, the system boot process has to move the dump data from this area to an appropriate area on the disk. This has to be carried out since the paging space will become re-activated and all data previously residing there is likely to become over-written. By default, the dump is copied to the directory */var/adm/ras*. The `sysdumpdev` command now has an optional flag which can be used to specify a different directory for the dump to be copied to.

The advantages of using paging space for the primary dump device are:

1. It makes better utilization of storage space by using an existing logical volume as opposed to reserving one specifically for this purpose. A dedicated dump device like */dev/hd7*, as used in AIX Version 3, can be quite wasteful, particularly within a stable system.
2. Since paging space is normally configured to be of the same size or larger than RAM this would guarantee that it is has sufficient space for a dump.
3. The I/O operations, particularly when writing dump data to disk, are improved if the paging logical volumes are strategically placed for fast access to data. For example, at the center of the disk and also over as many physical volumes within the volume group as possible.

## 4.5 Variable I-nodes

In all UNIX implementations, when a file system is created, several data structures known as i-nodes are written to the disk. For each file or directory one such data structure is used which describes information pertaining to it. The sort of information which is stored in the i-node includes file type, permissions, size, user and group owner ids. Other critical pieces of information that are held in the i-node are the disk addresses at which the files data is stored.

AIX, like other UNIX implementations, reserves a number of i-nodes for files and directories in each file system that is created. In releases prior to AIX Version 4, an i-node is generated for every 4KB of disk space that is allocated to the file system being created.

In a 4MB file system this would result in 1024 i-nodes being generated. For earlier releases this figure would probably suffice, since a file or directory is allocated at minimum 4KB of disk space anyway. In AIX Version 4, since disk space is allocated in fragments allowing better utilization of disk space 1024 i-nodes in a 4MB file system can quickly become exhausted if a large number of small files are written (assuming a fragment size of 512 bytes). In a file system created using a 512 byte fragment size, 8192 files, at maximum, can be written if the largest file size is 512 bytes.

AIX Version 4 JFS provides a parameter to tune the number of i-nodes generated at file system creation time. This parameter, better known as number-of-bytes-per-i-node (NBPI), can be any power of 2 in the range 512 through 16384 (examples include 512, 1024, 2048, 4096).

When NBPI is used in conjunction with the fragment size it can allow better storage management, particularly when it is known beforehand the number and size of files to be stored in the file system. See 3.1.4, “File Systems” on page 57 for more information on i-nodes.

## 4.6 File System Maximum Size Increase

In releases of AIX prior to Version 4, the maximum size a journaled file system or logical volume can grow to is 2GB. The limitation is due to the usage of a 32 bit signed integer value giving maximum file system addressability of 2GB: 2 raised to the power of 31, the most significant bit giving the sign. With the growing needs of commercial and scientific environments, this limit can be reached quite quickly. In fact it is now becoming more commonplace for database application environments to need to access larger volumes of data.

In AIX Version 4, the maximum size a journaled file system or logical volume can grow to is 256GB. This is now possible since a 64 bit variable is used as for the pointer.

However, note that the maximum file size is still limited to 2GB. This is because no change has been implemented to the i-node structures used to reference the data blocks. See 3.1.4, “File Systems” on page 57 for more information on file systems.

### 4.6.1 JFS Log Considerations

For *journaled* file systems, a transaction log is maintained which provides file system recovery in case the system abnormally terminates. One JFS log, with a default size of one logical partition, maintains log data for all the file systems within a volume group. For file systems that are no larger than 2GB, the default log size is sufficient. However, for file systems that are larger than 2GB, it may be necessary for the log size to be increased proportionately.

## 4.7 Summary

This chapter covers the latest enhancements to storage management made available in AIX Version 4. These enhancements include:

- Fragmentation

  The basic unit of file system allocation is now the fragment, which can be 512, 1024, 2048, or 4096 bytes.

- Compression

  The JFS now supports compression which can result in a space saving of a factor of 2.

- Striping

  The logical volume manager now support striping which can radically improve performance.

- Page Space for System Dumps

  Page space can now be allocated as a dump device.

- Variable i-nodes

  The number of i-nodes created within a file system can now be varied allowing for improved management of disk resources.

- File System Size Increase

  The maximum file system size is no longer limited to 2GB.

# Chapter 5. Storage Subsystem Design

This chapter covers the issues and considerations involved in designing storage subsystems. Guidance on actually implementing the ideas set out here can be found in Chapter 6, "General AIX Storage Management" on page 93, and Chapter 8, "Practical Examples" on page 185.

## 5.1 Introduction

Designing storage subsystems involves evaluating the requirements that the business processes that will be executed on the machine have, in terms of data access and availability. Systems will generally be used for more than one purpose (database applications may compete for resource with word processing and image based applications for example), and it is important to attempt to configure the environment in such a way that each process can perform within required tolerances (these are usually performance and availability related - user response time, and recovery in the event of error or failure for example). As each process will have differing requirements, this task will of necessity involve some compromise. The design of the AIX storage management components, as has been covered in Chapter 3, "Operating System Software Components" on page 45, does allow great flexibility in organization. The logical volume manager allows the physical disks to be partitioned and the space thus created organized in different ways to enable performance requirements to be met in one logical volume, and availability requirements in another for example.

The first task is therefore to evaluate the storage requirements of the application set that will be executed on the system in terms of:

1. Performance requirements
2. Availability requirements
3. Recovery requirements
4. Disk utilization

Each of these areas will now be examined in more detail.

## 5.2 Planning Disk Utilization

The design of the volume group and logical volume organization has a major impact upon performance, availability, and recovery. The first consideration in the process is volume group allocation.

### 5.2.1 Volume Groups

The most common hardware failure in a storage subsystem is disk failure, followed by failure of adapters and power supplies. When failures of this type occur, recovery will be easier if a sensible volume group design has been implemented. Multiple volume groups should generally be implemented for the following reasons:

- Maintenance

  - Maintaining only operating system information in the root volume group is a good decision because operating system updates, reinstallations, and crash recoveries can be effected without danger to user data.
  - System updates or reinstallation generally only affect the root volume group, so these regular and important processes can occur more quickly, as only operating system or application data is included in the changes.

- Physical Partition Size

  All physical volumes within a volume group must have the same physical partition size. In some cases greater granularity may be required in allocation of physical partitions to logical volumes, and the only way to implement this is to place those logical volume with differing physical partition requirements into separate volume groups. An example of when this might be necessary would be an environment where many small logical volumes need to be created for specialized file systems of a size that may entail much wasted space with 4MB partitions (2MB file systems say). The greater flexibility afforded by the smaller partition is offset by increased performance overhead to the LVM.

- Quorum Characteristics

  If there is a requirement for implementing a file system in a non-quorum volume group, then a separate volume group that does not utilize quorum checking needs to be created.

- Security

  In order to allow important confidential data to be removed and stored in a secure place when required, a volume group including physical volumes on removable disks should be created. At night, for example, the volume group can be exported and the disks with the sensitive data removed and kept in a secure place.

- Multiple JFS Logs

  In order to reduce bottlenecks in a volume group with many journaled file systems, multiple JFS logs may be required.

- Switching Physical Volumes Between Systems

  In some cases there may be a requirement to share a physical volume between systems, for availability or shared access for example. If the physical volumes so utilized are maintained in a separate volume group, then this volume group can be exported and varied off line for reuse on a second system (import, vary on), without interrupting the normal operation of either system.

The number of volume groups created should therefore be decided based upon consideration of these points.

### 5.2.2 Physical Volumes

The next consideration should be the number of physical volumes per volume group. This affects quorum checking and mirroring. A volume group with two disks and quorum checking will fail to vary on if the disk with two VGDAs fails (see “Quorum Checking” on page 54 for a description of this process). With more than two disks, 51% or more of the VGDAs must become unavailable for the vary on to fail, and data to become inaccessible. This is particularly true in a two disk mirrored system, failure of the two VGDA disk will result in no access, even though a good copy of the data is still available.

Enough physical disks must also be included to support the mirroring strategy required, both in terms of space for the mirrored copies, and number of disks for the policies. If mirroring is to be done across the maximum number of physical volumes possible, for availability purposes, then it makes sense to have at least enough space to ensure the copies are stored on separate physical volumes. A disk failure in this scenario will not impact access to the data.

### 5.2.3 Logical Volumes

The delineating factors for deciding upon the number of logical volumes to create are basically performance and availability. As many logical volumes should be created as there are different performance and availability requirements. The design of the logical volumes themselves to satisfy these requirements is covered in 5.3, “Planning for Performance” on page 80, and 5.4, “Planning for Availability” on page 84. Within this however, there is the consideration of disk space utilization. Depending upon the intended purpose of file systems that will be created within logical volumes, different fragment sizes may be required to optimally utilize the available disk space in the logical volumes. As has been described in 4.1, “Fragmentation” on page 67, choosing different fragment sizes can significantly improve disk space use. If there is a need for file systems containing many small files, then a logical volume for each file system with different requirements should be created.

### 5.2.4 File Systems

The primary considerations when creating file systems are as follows:

- Fragment size

  Fragment size should be considered only if there will be many files in the file system less than 32KB in size, or compression will be used. In the former case, the fragment size should be selected based upon the average size of the files, in order to minimize wasted space. For example, file less than 512 bytes or that will grow in chunks less than 512 bytes would be more economically stored in a file system with a fragment size of 512. Compression is discussed later in this section. This is an AIX Version 4 facility.

- Number of bytes per i-node (NBPI)

  The number of bytes per i-node is described in 4.5, “Variable I-nodes” on page 74. This parameter controls the number of i-nodes created in the file system. The main consideration will be the number of expected files; if only a few large files will be stored, then increase the NBPI to reduce the number of i-nodes created, and hence free up disk resource that would have be used by the extra i-nodes. The NBPI and fragment size together directly affect the maximum possible size of the file system, and this is therefore a further consideration. File system size is discussed later in this section. This is an AIX Version 4 facility.

- Compression

  Compression is discussed in 4.2, “Compression” on page 70. If disk space is at a premium, and performance is not the major issue, then file system compression should be considered. Using compression can reduce the amount of storage space required by files enormously, at the cost of the overhead required for the compression. The algorithm is performed on a fragment basis, and its effectiveness is dependent upon the type of information contained in the file. Larger fragment sizes will help to offset the performance overhead, by reducing the number of allocation requests and physical I/O. This is an AIX Version 4 facility.

- File system size

  The size of the file system should be chosen to be large enough to accommodate the required files. It is better to err on the small side, as file systems can be easily expanded as the limit approaches, while reducing (which can be done) is more work. Recovering free space within file systems lost due to fragmentation can be accomplished using the `defragfs` command which is discussed in Chapter 7, "Storage Management Files and Commands Summary" on page 137.

Having created volume groups and added the required number of physical volumes, the logical volumes and file systems need to be created. There are two basic considerations: performance and availability. Generally, designing for high performance will impact availability, and vice versa. The next two sections look at design from these perspectives.

## 5.3 Planning for Performance

The performance of a disk subsystem is a combination of factors that includes:

- Adapters

  This includes the physical performance capabilities of the adapter, as well as the organization of devices using the adapter. In order to maximize performance to high speed disk devices on an adapter, the characteristics of the adapter should be considered. For example, SCSI adapters can support multiple devices operating in either synchronous or asynchronous modes (see 2.2.1.1, "Small Computer System Interface Adapter" on page 23 for information on SCSI technology). To achieve maximum throughput for a synchronous disk device, only other synchronous devices should be attached to the adapter, and the total bandwidth (or throughput) of these devices should not exceed the capabilities of the adapter itself.

  The same considerations apply to adapters of other types. If multiple devices are supported on the adapter, the total bandwidth available should not be exceeded.

  Finally, obviously the fastest adapter that meets the environmental requirements of the site (in terms of cable lengths, and devices supported) should be selected to maximize performance. Other functions like command tag queuing (for some SCSI adapters), and differential communications (to reduce errors) will also improve performance.

- Physical disk devices

  Physical disk drives themselves support different levels of function in their hardware. Some drives support bad block relocation and elevator seek functions internally for example (see 2.2.2, "Disk Storage" on page 25 for a discussion of disk technology). Off-loading these functions from the LVM will increase performance.

  Some subsystems, such as the 7135, support striping within the subsystem (RAID 0) which will also increase performance.

  Again, selecting disks with the fastest overall read/write performance figures should be the policy for maximizing performance.

- Logical Volume Manager

  Selecting the highest performance hardware goes a long way to maximizing the performance of a disk subsystem, but the software implementation in terms of data placement on the disks and access methods (random or sequential) are also vital to the overall result.

  Under AIX Version 4, the LVM supports striping, which means that the logical partitions of a logical volume can be spread across multiple disks and therefore accessed concurrently (see 4.3, “Disk Striping” on page 72 for a discussion of striping). Striping will maximize performance for sequential reads and writes, where the LVM can schedule consecutive reads and writes simultaneously to blocks on different disks. Performance will be further enhanced when the disks are on different adapters, thereby allowing full concurrency. Setting up striping is discussed in 8.5.1, “Striped Logical Volumes” on page 272.

  Whether striping is to be used or not, the placement of the data on the disk surface itself affects the performance of the subsystem. The LVM provides a number of parameters at logical volume setup that govern the policies it will enforce in terms of data placement and access. These policies are explained in “Logical Volume Manager Policies” on page 54. In order to maximize performance, the following policies should be adopted:

  – Intra-physical volume allocation policy

    For maximum performance logical partitions should be selected in the center of the disk.

  – Inter-physical volume allocation policy

    For maximum performance the maximum number of physical volumes available should be used for the logical volumes logical partitions. This will allow the LVM to schedule requests for long sequential reads or writes across physical disks in parallel.

  – Mirroring

    Mirroring should generally be disabled for maximum performance. If it is required however, then the scheduling policy should be set to parallel and the allocation policy to strict. This will cause the LVM to place copies on separate physical volumes, and to perform writes in parallel, thereby maximizing performance. In addition, reads will be scheduled to the copy of the data required that is closest to a disk head, improving read performance. Write verification and mirror write consistency should also be set to no. This will prevent the LVM from wasting a disk revolution on every write to read back the data for validity, and also stop the LVM waiting for all writes to copies to succeed before returning successful completion of the write.

  Adopting these policy settings in the LVM will maximize performance, but at the expense of availability. If availability is an equally great issue, then compromises will be necessary, such as using mirroring with reduced efficacy (as described in this section).

- File System

  With regard to maximizing performance from the file system point of view, there are several configuration options that can be taken at file system creation time:

  – Fragment size

  Using the largest fragment size of 4096KB will minimize allocation operations and maximize throughput from the file system. This could be at the expense of space utilization within the file system, depending upon the sizes of files within (see 5.2, “Planning Disk Utilization” on page 77 for a discussion of maximizing disk space utilization).

  – Compression

  Using compression increases the overheads of reads and writes to the file system, and therefore to maximize performance, compression should not be used.

  – Log devices

  If many file systems are using the same log device, then this can introduce a bottleneck. Reducing the number of file systems that will be concurrently accessing a log device will avoid this problem. In order to do this, multiple log devices should be created within the volume group. To maximize performance, the log device should be on a different physical volume, and preferably a different adapter to the file systems sharing the log.

The JFS uses 4KB buffers for reading and writing, and returns success to a requesting application on receipt of the data. The actual physical write is not done until the buffer is full. This means that just using the JFS can improve disk I/O performance.

**Warning**

Some applications (some databases for example), rely on the fact that when a write is requested, it is actually done immediately. In these cases, using the JFS may speed up performance, but can introduce inconsistencies if a crash should occur before a write actually took place - the database logs would be out of sync with the JFS logs, resulting in an inconsistent state. These type of applications should write directly to a logical volume. For ordinary applications this would not be the case, and recovery to a stable state should be possible from replaying the JFS log. In all cases, checking with the application provider makes good sense.

Fragmentation of the file system will have an adverse effect on I/O performance as it will increase the number of seeks required to access information. The smaller the fragment size selected, the worse this problem can become. Regular defragmentation of the file system, will alleviate this problem, and is can be accomplished using the `defragfs` command, discussed in Chapter 7, “Storage Management Files and Commands Summary” on page 137.

- Operating System Parameters

  There are a number of operating system parameters that affect the performance of I/O subsystems. These parameters should be adjusted with caution as they have system wide scope; this means that though they may radically improve performance for one application using one logical volume, they may have a detrimental effect on others:

  – Sequential Read Ahead

  This is a Virtual Memory Manager feature that allows the VMM to read in pages of information from disk before they are required. If the VMM suspects that a large sequential read is about to take place, it will use the values set in *minpgahead* and *maxpgahead* to decide on how many extra pages ahead of the current one to read in. This means that when requests for subsequent pages arrive, the required pages are already in memory and time is saved. More detail on the setting of these parameters is available in the InfoExplorer section *Tuning Sequential Read Ahead*.

  - Disk I/O Pacing

    This feature is intended to prevent those programs that generate very large amounts of I/O from saturating the I/O queues with requests, and thereby causing the response time of less demanding applications to deteriorate. Disk I/O pacing enforces high and low water mark values on the number of I/O requests that can be outstanding for any memory segment (this effectively means for any file). When the number of outstanding I/O requests for a segment reaches the high water mark, the process making the requests is put to sleep until the number of requests has reached the low water mark.

    This feature is set to off by default. See the InfoExplorer article on *Use of Disk-I/O Pacing* for further details on tuning these parameters.

  - SCSI Device Driver max_coalesce Parameter

    When there are multiple requests in a SCSI device drivers queue, it attempts to coalesce these requests into a smaller number of larger requests. The largest request size (in terms of data actually transmitted) that the device driver will build, is limited by the max_coalesce parameter. See the InfoExplorer section on *Modifying the SCSI Device Driver max_coalesce Parameter* for details on adjusting this setting.

  - Setting SCSI Adapter and Disk Device Queue Limits

    It is possible to enforce a limit on the maximum number of outstanding requests on a queue for a given SCSI bus or disk drive. Setting these parameters can improve performance for those devices that do not provide sophisticated queue handling algorithms. See the InfoExplorer section on *Setting the SCSI-Adapter and Disk-Device Queue Limits* for further information on adjusting these parameters.

  - Controlling the Number of System pbufs

    The LVM uses a construct called a *pbuf* to control pending disk I/O. In AIX Version 3, a pbuf is required for each page being read or written, which for applications with heavy I/O can result in pbuf pool depletion. In AIX Version 4, a pbuf is used for every sequential I/O request, regardless of the number of pages involved, thereby reducing the load on the pbuf pool. It is possible to tune the number of pbufs available, and in some cases this can improve performance. See the section in InfoExplorer on *Controlling the Number of System pbufs*, for further information.

- Applications

  The final performance considerations are at the actual application level. The design of the application can have a major effect upon performance. It is not always possible to affect the way in which application operate, but on those occasions where it is, the following considerations should be taken into account:

  - Asynchronous Disk I/O

    Applications can use asynchronous disk I/O, which means that control returns to the application from the read/write as soon as the request has been queued. The application can then continue working while the physical disk operation takes place. Obviously not all applications will be able to take advantage of this feature, but for those that can, the performance benefits are significant. More information on this feature can be found in InfoExplorer in the section on *Performance Implications of Asynchronous Disk I/O*.

  – sync and fsync

    In a similar fashion to asynchronous disk I/O, the sync() system call schedules a write of all modified memory data pages to disk, but returns immediately. Conversely, the fsync() call will not return until the writing is complete. Those application which must know whether the write was successful will not be able to take advantage of this, but for those that can, again the performance benefits can be significant. For more information, see the InfoExplorer section on *Performance Implications of sync/fsync*.

Examples of using LVM and file system configuration commands to maximize performance are detailed in 8.3.4, “A Design Example for Improved Performance” on page 220.

## 5.4 Planning for Availability

Designing a disk subsystem for availability also involves a number of considerations, including:

- Adapters

  From an availability standpoint, it is better to design a storage system using more rather than less adapters. This is really of benefit in the case where mirroring is to be used; having mirrored copies on separate adapters means that failure of one adapter will still leave the information accessible from the copy on the other adapter.

- Redundancy

  Redundancy is one of the most important mechanisms for ensuring availability. This entails having backups for all vital system components in much the same way as multiple adapters and mirroring above; within storage subsystem components, this really means having backup power supplies, cooling fans, adapters, data paths, and spare disk drives that can be automatically switched in when required, with no service or information loss.

  At a pure operating system level, redundancy is limited to mirroring and multiple adapters. Much greater availability guarantees can be achieved using the features of external devices providing many of the backup features discussed. Devices available that support these kinds of features include the IBM 7135 and the 9570. Details of these and other similar devices can be found in A.2, “Disk Storage Products” on page 330.

- RAID

  This set of performance and availability features is discussed in 2.2.2.2, “Selecting the Correct Disk Storage Devices” on page 27. RAID levels 1, 3, and 5 provide increasing levels of high availability and performance external to the operating system. The attached subsystem performs all of the RAID functionality under the covers, and presents an ordinary disk drive interface to the operating system. Subsystems which support RAID to varying degrees include the IBM 7135, IBM 3514, and IBM 9570. A brief discussion of these and other devices can be found in A.2, “Disk Storage Products” on page 330.

- Logical Volume Manager

  As in the case of performance, there are several options that can be taken at logical volume creation time to maximize availability of data. These options include policies governing the placement of data on the physical disks and mirroring. Data can be divided into two categories, operating system data, and user data, and the mirroring setup is slightly different for each case:

  – Mirroring the root volume group

    This procedure will maximize availability of the operating system. At least three physical disks should be in the rootvg to ensure that a quorum will always be available in the event of a single disk failure.

    **Note**

    A full system backup should be taken before performing any disk reorganization procedures.

    Mirroring the root volume group involves setting up one or two copies of each logical volume in the volume group; the procedure for actually implementing this is explained in 8.2, “rootvg Mirroring - Implementation and Recovery” on page 187.

    **Warning**

    The mirrored copies must each be on a bootable physical volume or else a failure in the main bootable copy will not be easily recoverable. The boot logical volume should not be mirrored, as this can cause problems, rather a new boot logical volume should be created on each physical disk containing a mirror copy.

    The Non-Volatile RAM must be updated to reflect the new disks available as boot devices, so that in the event of failure of the main copy of the rootvg, a reboot can be effected from another copy.

  – Mirroring user data

    Mirroring user data also involves creating copies of all of those logical volumes requiring high availability. For maximum availability, the following policies should be selected:

    - Number of mirrored copies

      The number of copies of a logical volume maintained by the LVM can be one, two, or three. Maximum protection against failure is provided using three copies, though at increased overhead. Again, availability is mainly achieved at the cost of performance, though this will depend on the intended usage of the mirrored logical volume. If the volume will mainly be used for reading, then performance can be enhanced, as the LVM will schedule reads to the disk head closest to the required data.

    - Inter-physical allocation policy

      Having the logical partitions comprising the mirrored logical volume spread across the minimum number of disks will optimize availability. Ideally, each copy should be on a separate physical volume which is itself on a separate adapter. To enable this, the range parameter should be set to minimum, and the strict parameter to yes; this will force the LVM to restrict each copy of the logical volume to as few disks as possible, and to maintain the copies separate (no copy may share a disk). Prior planning to ensure space on the physical disks to hold the entire logical volume will ensure each copy can be successfully kept on a single physical volume.

  - Intra-physical allocation policy

    The actual location of the data on each physical disk will have no direct impact on availability. If however, a center policy is selected for example, then although the LVM will try and fulfill the request on all of the mirrored copies, the inter-disk allocation policy will take preference. This means essentially, that if there are not enough center located logical partitions on a disk, then rather than look at spreading the logical volume to another disk, edge or middle located partitions will be used instead.

  - Scheduling policy

    For maximum availability, a sequential policy should be adopted. This means that writes will be scheduled one after the other to all copies of the logical volume, each write having to complete before the next occurs. This maximizes the chances of at least one copy surviving in the event of a system crash during the process.

  - Write verification

    This feature should be switched on for maximum availability. Write verification means that after every write to a disk, the data written is read back to ensure its validity. This does have performance implications as every write will involve one extra disk revolution for the read verify.

- File System

  Using the JFS provides some availability features over writing to raw logical volumes, or using NFS for example. The JFS records all changes to the meta-data of a file system into a log (file systems are explained in 3.1.4, “File Systems” on page 57). If there should be a system crash, on reboot, the log is replayed and the file system returned to its last consistent state. This prevents corruption of the file system and thereby assists in maintaining higher availability.

- Application

  Applications themselves can be designed to be availability aware. In the reverse of the requirements for high performance, applications should avoid asynchronous I/O to ensure that any data written is committed to disk before continuing and risking inconsistencies. In addition, the fsync() system call should be used rather than sync(), so that the application can be sure that all modified pages in memory have been written before continuing.

  The section on application oriented performance considerations earlier in this section gives more details on these operating system calls.

## 5.5 Planning Backup Strategies

The rest of this chapter looks at backup strategies, and the elements involved in planning them.

### 5.5.1 Backup Overview

As soon as the system has been set up and the operating environment configured as required, a backup strategy should be immediately implemented. From this point on, valuable data will be created and stored within the storage subsystem that represents time and effort, and in most cases that supports the business. The organization of the system (operating system data and applications), and the user information created (files and directories) are subject to misadventure, however carefully managed; files can be accidentally erased, and hardware or software faults can destroy some information or even the entire system. For these reasons, it is important to be able to recover the system back to a point at which work can continue. Backing up the system involves making copies of all the information contained in it on a some medium that can be stored separately. The copies can then be used to recreate the system after a failure has been repaired, or information accidentally lost. The information in the system is usually highly dynamic, and therefore frequent copies or updates to the copies (also known as *incremental* backups) should be taken. The frequency and content of the updates or full backups is unique for each business, and depends upon the rate of change of information and the relative importance of that information. Evaluating this is the process of developing a backup strategy. The following points should be considered:

- Ensure recovery from major losses

  Consider every potential catastrophe, however unlikely, and determine whether recovery would be possible. If the backup media was lost in some natural disaster, would recovery be possible? Obviously, it is necessary to factor in the likelihood of a particular disaster, but this must be done in conjunction with consideration of the value of the data. It's not much comfort to reflect how unlikely the ball of lightning that destroyed the backup media inside a safe was, when the business is ruined as a result.

- Check backups periodically

  There are many different types of backup media, each with varying degrees of reliability and longevity (see 2.2.3, “Tape Storage” on page 34 for a comparison of backup media). Check the condition of backups on a regular basis to ensure that they are still usable.

- Keep old backups

  Although it is a good policy to develop a regular cycle for reusing backup media, complete copies should be maintained for some time as it can often be a while before it is noticed that a particular file is damaged or unusable, by which time the backup copies may contain copies of the damage. It is therefore a good plan to implement a recycling policy such as the following:

  – Recycle all media except Friday backups weekly

  – Recycle all Friday media except the last in the month monthly

  – Recycle all monthly media except the last in the quarter quarterly

  Keep the quarterly backups indefinitely. This will always ensure the ability to access information up to three months old at various levels of currency.

- Check file systems before backing up

  Making a backup of a damaged file system will result in the ability to restore that damaged file system in the event of failure. It is therefore a good idea to check file systems before backing up to ensure integrity.

- Ensure files are not in use during backup

  Files that are in use during a backup will be different to the backed up copy. Backups should therefore be taken while the system, or files being backed up, are not in use.

- Backup the system before implementing any major changes

  Major changes introduce the possibility of errors and hence loss of data. It is always sensible to take a backup prior to any such activity.

### 5.5.2 Backup Planning

There are two main types of backup:

- Complete system backup

  In a complete system backup, a copy is made of everything on the system. this can then be used to completely restore the system in the event of a failure. The complete backup can contain operating system and user data, although it is more sensible to maintain these two separately for the following reasons:

  1. User data changes more regularly than system data, and the backup will be smaller if the two are kept separate.
  2. It is quicker and easier to restore user data when kept separate from the operating system. Crashes only affecting the operating system, only require the operating system backup to be restored, and vice versa.

- Incremental backup

  In an incremental backup, only the data that has changed since the last backup is backed up.

A complete system backup policy should be used when data does not change too often. The backups should be scheduled at a frequency that allows complete recovery of business critical information. For example, if database update runs are done weekly, then a backup after the run each week is sensible.

An incremental policy should be used when information is extremely dynamic. Full system backups are taken at a fixed interval, within which backups of changed information are taken at shorter intervals. The frequency of the incremental backups depends upon the criticality of the information, as in the complete system backup policy. The frequency of the incremental backups depend upon the volumes of data that have changed. As recovery with incremental backup requires reloading the last full backup followed by application of the incremental backups up until the point of failure, the frequency of incremental backups should be set at a value which is a balance between criticality of information and number of incremental backups that will need applying.

## 5.5.3 Backup Methods

There are several ways of backing up information:

- Backing up by name

  This method is also called *file name archive*, and should be used to backup individual files or directories, if required. This mechanism is most commonly used by users to make backups of their own files.

- Back up by file system

  This method is also known as *backup by i-node*, and is used to backup entire file systems. This mechanism should be used by the system administrator to back up large groups of files. It is also used for incremental backups.

- Backup by volume group

  This method allows complete volume groups to be backed up. There are separate commands for the root volume group and for user volume groups.

The following commands can be used to implement the backup policy created:

| | |
|---|---|
| `backup` | This command allows backup by file name or by file system. |
| `mksysb` | This command creates an installable image of the root volume group. |
| `savevg` | This command backs up a user volume group. |
| `cpio` | This command copies files into and out of archive storage. The `cpio` format is common across many platforms, and so can be used for exchange of information between systems. |
| `dd` | This command will convert and copy information from one device to another. The `dd` command does not group multiple files in any particular format, it just streams the data, performing any supported conversion from the source to the target device. |
| `tar` | This command manipulates archives of files and directories. The `tar` command will create an archive on the output device, write files and directories to it, and extract them when required. |
| `rdump` | This command backs up files by file system to a device on a remote machine. |
| `pax` | This POSIX conformant command will read and write `tar` and `cpio` compliant archives. |

These commands are described in detail in Chapter 7, “Storage Management Files and Commands Summary” on page 137. Examples of backing up a system are detailed in 8.4, “Managing Backup and Restore” on page 247.

## 5.5.4 Backup Media

So far, backup purposes, policies, and commands have been discussed. This leaves the important topic of the actual media that the backup will be stored on. Tape devices are the most common backup or long term archive medium, though there are still several considerations:

- Device Technology

  This should be governed by the requirements below, but is more often just a question of cost per megabyte. The most important factors should be the reliability, longevity, performance and capacity.

Volume of information should be considered too, as this might suggest a tape library. Short term archive may suggest an optical device. These decisions are covered in 2.1, “Selecting the Hardware Components” on page 17.

- Performance

  It is important to consider the length of time that a backup will require, and this is a function of the volume of data and the speed with which the device can write it. If backups need to be taken every evening, then a device capable of completing the process in the time available should be chosen.

- Capacity

  This is a question of cost, storage space, and ease of use. The more information that can be packed onto the media, the better generally, as this means that less media will be required for backups. Storage space is therefore less, and if a single cartridge is sufficient, no operator intervention may be required. If multiple cartridges will be required, and operator intervention is not possible, then a tape library should be considered.

- Longevity

  As was mentioned earlier in this section, the length of time that the media can be safely stored is important. This governs not only the backup cycles, but for how long the media can be safely reused.

- Reliability

  This is a very important issue. Although checks on the success of a backup can and should be performed, unreliable devices that have a high percentage of errors, and produce occasional unreadable backups, are time consuming and dangerous. Some devices encounter read back problems too, even though the media copy may be good.

- Compatibility

  Device technology improves and changes with time. It is a good idea to ensure that next generation of devices support existing archive and backup media.

These considerations are discussed in relation to tape technology in 2.2.3, “Tape Storage” on page 34.

## 5.6 Summary

This chapter has looked in detail at the planning and design requirements for storage subsystems. Design of the subsystem involves considering the following points:

1. Disk Utilization

   How the physical subsystem will be organized from the perspective of:

   - Volume Groups
   - Physical Volumes
   - Logical Volumes
   - File Systems

2. Performance

For those applications that require high performance, designing the storage subsystem for maximum performance. This involves optimizing:

- Adapter performance and function
- Physical disk device performance and function
- Optimizing the Logical Volume Manager for performance
- Optimizing file systems for performance
- Optimizing operating system parameters for performance
- Optimizing application design for performance

3. Availability

   For those applications that require high availability, designing the storage subsystem for maximum availability. This involves optimizing:

   - Adapter and disk organization
   - Implementing redundancy
   - Possible use of RAID
   - Optimizing the Logical Volume Manager for availability
   - Using the JFS if possible
   - Optimizing application design for availability

4. Backup

   Designing a strategy that allows for as full a recovery as necessary in the event of failure, for the business to continue. This entails the following:

   - Considering all possible failure scenarios and designing a strategy to cope with them
   - Selecting the appropriate backup type
   - Selecting the relevant backup commands to use
   - Selecting the appropriate devices

# Chapter 6. General AIX Storage Management

This chapter will explore Storage Management from a more practical aspect. Much of the functionality available with Version 3 is still included in Version 4, so this chapter will provide useful information for Storage Management at either release.

## 6.1 Introduction

The purpose of this chapter is to provide the reader with information, which it is hoped will prove useful for applying the basic concepts of storage management into their business environment. The areas which will be covered will include the management of physical storage devices, volume groups and logical volumes using the Logical Volume Manager (LVM) functions provided in AIX. Consideration will also be given to issues relating to performance, availability and the capability of backing up and restoring.

## 6.2 Managing Physical Volumes

Management of physical volumes involves day-to-day activities that not only ensure that they are installed and configured correctly, but also that they are maintained in a correct operating environment and monitored regularly so that disasters from physical volume failures are prevented, by taking precautionary steps.

For a physical volume to be used for storage purposes, either by the LVM or directly via a low-level interface, it must first be recognized by the system and configured to be in an *available* state. This can be done fairly quickly and with ease, using the AIX Systems Management Interface Tool (SMIT). Once recognized by the system it can then be included in a volume group and a logical volume or a journaled file system can then be created on it, providing users the ability to store data in it.

When a RISC System/6000* computer system is powered on or rebooted, the AIX operating system will attempt to configure all devices physically connected to it. Some devices may be attached while the system is up, and these can normally be configured using the `cfgmgr` command, or by using SMIT. The fact that a physical volume is configured and known to the system does not mean that it is ready to be used for storage purposes.

This section will attempt to describe only those areas specifically relating to physical volumes. This will include:

- Configuring physical volumes
- Modifying physical volume characteristics
- Removing physical volumes
- Monitoring physical volumes

## 6.2.1 Configuration of Physical Volumes

It is possible to check the configured state of a physical volume which has been correctly installed. This can be done using SMIT or by issuing the following command:

```
# lsdev -Cc disk
```

The above command will produce output that will look something like the following:

```
hdisk0 Available 00-06-00-00 857 MB SCSI Disk Drive
hdisk1 Available 00-06-00-10 857 MB SCSI Disk Drive
hdisk2 Available 00-07-00-00 857 MB SCSI Disk Drive
hdisk3 Available 00-07-00-10 857 MB SCSI Disk Drive
hdisk4 Defined   00-08-00-00 857 MB SCSI Disk Drive
hdisk5 Defined   00-08-00-10 857 MB SCSI Disk Drive
```

The second column of this output indicates the configured state of each physical volume. Only those disks with an `Available` state have been successfully configured by the system. It is quite likely that disks in the `Defined` state were switched off during the configuration process. If this is the case they can be configured, as previously mentioned, by using the command `cfgmgr` or `smit cfgmgr` after powering on.

```
# cfgmgr
```

## 6.2.2 Modifying Physical Volume Characteristics

There is very little that can be done with respect to modifying the characteristics of a physical volume. The two characteristics which can be changed should be given important consideration, since they provide a way of controlling the usage of physical volumes.

It may sometimes be necessary to restrict further physical partitions from being allocated to any new or existing logical volumes. When a new logical volume is created or an existing one extended, *free* physical partitions are allocated to it.

The `chpv` command can be used to restrict further physical partition allocations from occurring. This can easily be achieved by issuing the following command:

```
# chpv -an PVname
```

After issuing the above command any allocations for physical partitions for the physical volume `PVname` will not be allowed. Note, however, that access to existing journaled file systems and logical volumes is still possible.

If the physical volume characteristics need to be reversed, this can be carried out by issuing the following command:

```
# chpv -ay PVname
```

An active physical volume is considered to be in an `Available` state since it will continue to allow logical I/O to it to occur. The state of a physical volume can be changed from active to not active to stop all logical I/O to it from occurring. There are instances when access to file system or logical volume data needs to be stopped, particularly if the physical volume is partially or wholly damaged, and needs to be repaired or replaced. In a high security environment, it may be necessary to physically remove a disk from the system and secure it in a secure place for overnight periods. This may be achieved by making the physical volume unavailable or `Removed`.

Whatever the reason, the physical volume can be made unavailable by setting the state to `Removed` using the command:

```
# chpv -vr PVname
```

In the above example, the state of physical volume, `PVname`, is changed from `Available` to `Removed`. To check the state use the `lsvg` command.

The above modification is only allowed if there are two or more physical volumes in a volume group and more importantly if this action can be performed without losing quorum. In a two-disk volume group, the chpv command will fail if the disk containing two copies of the VGDA/VGSA is being removed, since more than 50% of the VGDA and VGSA copies will be lost. Also, before a physical volume can be made unavailable, all file systems must be unmounted and all open logical volumes must be closed.

To bring the physical volume `PVname` back into an `Available` state, thereby allowing logical I/O to the device to occur, the following command needs to be executed:

```
# chpv -va PVname
```

### 6.2.3 Removing Physical Volumes

The configured state of physical volumes is `Available` when the system is powered on. However, to unconfigure a physical volume, and place it in the `Defined` state, the `rmdev` command can be used. Before a physical volume is disconnected from the system, it must be unconfigured. In the `Defined` state, access to the physical volume by the LVM will be prevented until it is again made available. The `rmdev` command as invoked below, will result in the change of state of the physical volume from `Available` to `Defined`:

```
# rmdev -l PVname
```

Although physical volume `PVname` will be unconfigured, its definition will still remain in the ODM. This information must remain, particularly if the physical volume will be reinstated with the same characteristics as before.

### 6.2.4 Monitoring Physical Volumes

Physical volume failures can and do occur for many reasons. More often than not they are caused by inadequate operating conditions, such as cables connected to physical volumes left loosely on the floor risking being pulled out, temperature and humidity not controlled properly, physical volumes exposed to direct sunlight and strong magnetic fields. These physical conditions need to be addressed for physical volumes to function properly. The tolerances of physical volume may differ, and these can be obtained from the hardware specifications supplied by the manufacturers.

Failures arising as a result of these conditions can always be avoided. However, sometimes physical volumes also suffer from other problems which cannot be identified so easily. An example of this might include a non-operational cooling fan in a physical volume, or a damaged sector on the disk. It is, therefore, imperative that physical volumes are monitored regularly, both in terms of their physical environment and their physical characteristics, while they remain in operation.

An important command available to a systems administrator is `errpt` which can allow physical volume failures, and those impending, from being detected early. Error reporting must be started on the system in order for this command to produce useful information. Different levels of detail can be extracted by using different command line options. Initially, it may only be necessary to extract summary information to see what errors have been reported, how frequently they are occurring, and whether or not they are of a permanent or temporary nature. This can then be followed by a more detailed report to find out their causes. A summary error report can be quickly produced by using the following command:

```
#errpt | pg
```

This will produce a one line summary for each error logged on the system with the most recent error first. The fields identifying the error will be:

| | |
|---|---|
| **IDENTIFIER:** | A numeric error identifier for the type of error that has occurred. |
| **TIMESTAMP:** | This will indicate the date and time the error occurred. The format of this field is `MMDDhhmmYY`, representing the month, day, hour, minute, and year respectively. |
| **T:** | The error type used to identify if the error is permanent (`P`) or temporary (`T`). |
| **C:** | The error class used to identify if the error is hardware (`H`), software (`S`) or operator (`O`) related. |
| **RESOURCE_NAME:** | The name of the resource for which the error is being reported. |
| **DESCRIPTION:** | A short description of the error. |

The following example shows how the errpt command can be used to produce a more detailed report for each logged error:

```
# errpt -a | pg
```

It is worth piping the output through either more or pg if there are many errors logged.

Of all the fields displayed, the most useful in identifying the nature and cause of the error are:

**ERROR LABEL:** This is a label used to identify the error. An example of a physical volume error is DISK_ERR4.

**Error Class:** This describes if the error is caused by a hardware or software problem denoted by (H) or (S) respectively.

**Error Type:** This describes if the error is permanent (PERM) or temporary (TEMP).

**Description:** This will be a short description of the error.

**Probable Causes:** If included, this field will identify the likely cause of the error which can be a software program or a physical device.

**Failure Causes:** This will identify the exact cause of the reported failure.

**Recommended Actions**
This will describe any recovery or reporting action that will need to be taken.

For more information about how to interpret the output of both the summary and detailed reports, please refer to the errpt command and its associated documentation in InfoExplorer.

## 6.2.5 Listing Information about Physical Volumes

A physical volume correctly installed on the system can be assigned to a volume group and can subsequently be used to hold file systems and logical volumes. Requirements of logical volumes can vary and sometimes their position within a physical volume can be quite important. So information about free physical partitions and their availability within different sectors on the disk can be very useful. There are several commands which can be used to identify such information pertinent to physical volumes. However, a single command which can provide this is lspv.

### 6.2.5.1 Listing Physical Volumes on the System

The lspv command when executed without any arguments will produce output which will identify the physical volume by the name that it is known to the system, the unique physical volume identifier that has been assigned to it and the volume group, if any, to which it belongs. It will appear as:

```
# lspv
hdisk0         00000310df1bbcef    rootvg
hdisk1         00000310df26b596    rootvg
hdisk2         000001856246d451    None
```

In the above example, `hdisk2` does not appear to be allocated to a volume group yet and so the third field reflects this by appearing as `None`. Physical volumes, `hdisk0` and `hdisk1`, on the other hand, are allocated to volume group `rootvg`.

#### 6.2.5.2 Listing Physical Volume Characteristics

The `lspv` command can also be used to retrieve more detailed information about physical volumes. The command must however be invoked with the name of the disk for which information is required as the argument.

For example:

```
# lspv hdisk0
```

If the physical volume being interrogated is currently not allocated to a volume group, no detailed information can be produced about it and an appropriate message will be output to indicate this.

You will note that the information on the left shows detail pertinent to the physical volume itself, whereas that on the right provides detail about the volume group that the physical volume is allocated to. Some of the detail extracted from this output will be discussed in more detail in sections 6.3, “Managing Volume Groups” on page 101 and 6.4, “Managing Logical Volumes” on page 112, since it is more relevant there.

In brief, the information produced is:

| | |
|---|---|
| **PHYSICAL VOLUME:** | The name of the physical volume. |
| **PV IDENTIFIER:** | Physical volume identifier unique to the system. |
| **PV STATE:** | Availability state of the physical volume for logical I/O. This state can be changed using the `chpv` command mentioned in section 6.2.2, “Modifying Physical Volume Characteristics” on page 94. |
| **STALE PARTITIONS:** | The number of physical partitions that are marked stale. Partitions can become stale when the physical volume is temporarily made unavailable while their mirrored copies on other physical volumes change. This will be reviewed in sections 6.3, “Managing Volume Groups” on page 101 and 6.4, “Managing Logical Volumes” on page 112. |
| **PP SIZE:** | The size of the physical partition, set when the volume group is added. This will be reviewed in sections 6.3, “Managing Volume Groups” on page 101 and 6.4, “Managing Logical Volumes” on page 112. |

| | |
|---|---|
| **TOTAL PPs:** | The total number of physical partitions that exist on the physical volume. |
| **FREE PPs:** | The number of physical partitions available on the physical volume that have not been allocated to file systems or logical volumes. |
| **USED PPs:** | The number of physical partitions on the physical volume that have already been allocated to file systems or logical volumes. |
| **FREE DISTRIBUTION:** | This lists the number of physical partitions that are available in each of the various regions of the physical volume. The use of this information will be discussed in section 6.3, “Managing Volume Groups” on page 101 and 6.4, “Managing Logical Volumes” on page 112. |
| **USED DISTRIBUTION:** | The same as FREE DISTRIBUTION, except that it lists the number of allocated partitions. |
| **VOLUME GROUP:** | The name of the volume group to which the physical volume belongs. This will be reviewed in sections 6.3, “Managing Volume Groups” on page 101 and 6.4, “Managing Logical Volumes” on page 112 |
| **VG IDENTIFIER:** | Volume group identifier unique to the system. |
| **VG STATE:** | The state of the volume group. This will be reviewed in section 6.4, “Managing Logical Volumes” on page 112. |
| **ALLOCATABLE:** | A yes/no setting to indicate whether or not *free* physical partitions on this physical volume can be allocated. For more information see the chpv command in section 6.2.2, “Modifying Physical Volume Characteristics” on page 94. |
| **LOGICAL VOLUMES:** | The number of logical volumes residing on this physical volume. |
| **VG DESCRIPTORS:** | The number of Volume Group Descriptor Areas (VGDAs) residing on this physical volume. |

#### 6.2.5.3 Listing Logical Volume Allocation within a Physical Volume

The `lspv` command can also be used to check how the physical volume is used. It can provide information relating to each logical volume on the physical volume, such as its name, number of logical and physical partitions allocated, distribution across the physical volume, and mount point if one exists.

An example `lspv` invocation providing this detail is:

```
# lspv -l hdisk3
hdisk3:
LV NAME              LPs   PPs   DISTRIBUTION          MOUNT POINT
lv00                 4     4     00..04..00..00..00    /expfs
loglv00              1     1     00..01..00..00..00    N/A
```

In this example, physical volume hdisk3 has two logical volumes on it, lv00 and loglv00. Logical volume lv00 is allocated 4 logical partitions and 4 physical partitions on this physical volume. All four physical partitions reside in outer-middle region of the disk. The logical volume is used in a file system whose mount point is /expfs. As logical volume loglv00 is not associated with a file system, its mount point is shown as N/A.

### 6.2.5.4 Listing Physical Partition Allocation by Physical Volume Region

We have already seen how to retrieve information about the distribution of physical partitions allocated to logical volumes on a particular physical volume. It may sometimes be necessary to check, in more detail, the range of physical partitions allocated to a logical volume and the region of the disk used for those partitions. A file can be repositioned to the center of the disk to ensure that it is accessed more quickly if performance is an issue.

The lspv command invocation providing this level of detail is:

```
# lspv -p hdisk3
hdisk3:
PP RANGE  STATE   REGION        LV ID             TYPE      MOUNT POINT
  1-15    free    outer edge
 16-20    free    outer middle
 21-23    used    outer middle  lv00              jfs       /expfs
 24-24    used    outer middle  loglv00           jfslog    N/A
 25-27    free    outer middle
 28-28    used    outer middle  lv00              jfs       /expfs
 29-30    free    outer middle
 31-45    free    center
 46-60    free    inner middle
 61-75    free    inner edge
```

From the above example, we note that physical partitions allocated to the file system /expfs (logical volume lv00) are 21 through 23, and 28, and are positioned at the outer-middle region of the disk.

### 6.2.5.5 Listing Physical Partition Allocation Table

Although we can determine the range of physical partitions allocated to a logical volume and its distribution, this information does not provide enough detail to determine if a logical volume is allocated a contiguous range of physical partitions. We may require this information if we are considering ways of improving the I/O performance for a logical volume.

The lspv command, with the parameters as shown below, will produce such information.

```
# lspv -M hdisk3
hdisk3:1-20
hdisk3:21       lv00:3:2
hdisk3:22       lv00:1:2
hdisk3:23       lv00:2:2
hdisk3:24       loglv00:1
hdisk3:25-27
hdisk3:28       lv00:4:2
hdisk3:29-75
```

The output above consists of the following space separated fields:

| | |
|---|---|
| **PVname:PP[-PP]** | PVname being the physical volume name and PP being the physical partition number. The PP number will only be specified as a range when there is more than one free contiguous physical partition on the disk. |
| **LVname:LP[:COPY]** | LVname being the logical volume name and LP the logical volume partition. The COPY value is also output, if the logical partition is mirrored. |

In the above example output, we note that logical volume `lv00` has been allocated physical partitions `21, 22, 23`, and `28`, However, the order in which they are allocated to logical partitions `1, 2, 3`, and `4` is `22, 23, 21`, and `28` respectively.

## 6.3 Managing Volume Groups

The section will describe the operations which can be performed on volume groups.

Like physical volumes, volume groups can be created and removed, and their characteristics can also be modified. Additional operations such as `varying on/varying off` and `importing/exporting` of volume groups can also be performed. This section will describe the operations pertinent to volume groups.

### 6.3.1 Adding a Volume Group

Before a new volume group can be added to the system, one or more physical volumes, not used in other volume groups, and in an `Available` state, must exist on the system. Please see section 6.2, “Managing Physical Volumes” on page 93 for more detail.

It is important to decide upon certain information such as the volume group name and the physical volumes to use prior to adding a volume group. Even though it is possible at a later time to change such detail, it may not always be easy nor convenient, and users may even have to be temporarily denied access to the data if the volume groups need to be varied off.

New volume groups can be added to the system by using the `mkvg` command or using SMIT. Of all the characteristics set at creation time, the following are essentially the most important:

- Volume group name, unique on the system
- Names of all physical volumes to be used in the volume group
- Maximum number of physical volumes that can exist in the volume group

- Physical partition size for the volume group
- Flag to activate the volume group automatically at each system restart

For example:

```
# mkvg -y myvg -d 10 -s 8 hdisk1 hdisk5
```

In this example, a volume group with the name `myvg` is created, using physical volumes `hdisk1` and `hdisk5`, and the physical partition size for this volume group is set to `8KB`. Since the volume group is limited to a maximum of 10 physical volumes, eight more can still be added at a later time. The maximum number of physical volumes, 10 in the above example, allowed in a volume group should be given careful consideration since the physical volume space overhead increases with larger numbers.

Volume groups can also be added through SMIT using the command `smit mkvg`. Limited functionality is provided by the SMIT command. The main differences are:

- `smit mkvg` does not provide the `-d` flag to set the maximum number of physical volumes, it uses a default value of 32.
- `smit mkvg` does not provide the `-m` flag to set the maximum size of the physical volume. This flag will determine how many physical partitions are used, it uses a default value of 1016 partitions.
- `smit mkvg` always uses the `-f` flag to force creation of the volume group.

For a new volume group to be successfully added to the system using the `mkvg` command, the root file system should have between 1 to 2MB of free space. Check this using the `df` command. This free space is required because a file is written in the directory `/etc/vg` each time a new volume group is added. It is also important to note that the `-f` flag will allow a physical volume which still has a VGDA on it to be allocated to a new volume group. However, the physical volume must not be part of another volume group that is varied on.

## 6.3.2 Modifying Volume Group Characteristics

Not many changes can be made to the characteristics of a volume group. The changes that are possible are:

- Activation characteristics, which will determine whether or not the volume group is automatically varied on at every system restart
- Unlocking a volume group
- Adding a physical volume
- Removing a physical volume

### 6.3.2.1 Modifying Volume Group Activation Characteristics

The command to allow a volume group to be varied on automatically each time a system is restarted is:

```
# chvg -ay VGname
```

In this example, volume group VGname will be varied on automatically each time the system is restarted.

To turn off automatic varying on of a volume group, the following command needs to be executed:

```
# chvg -an VGname
```

It may sometimes also be necessary to allow a volume group to remain varied on, even though quorum is lost. In a two-disk volume group, if the physical volume with the two VGDAs is damaged, then the volume group will be varied off since quorum is lost. In AIX Version 4, it is now possible to prevent a volume group from being varied off automatically when quorum is lost and access to data on the good physical volumes still continues.

In the example below, the volume group VGname will remain varied on irrespective of loss of quorum.

```
# chvg -Qn VGname
```

The following example command will ensure volume group VGname is varied off after quorum is lost.

```
# chvg -Qy VGname
```

The chvg command invoked with the -Q flag will only have effect when the system is restarted. It is important that the boot image is updated after executing the chvg -Qy or chvg -Qn command. This can be done using either the bosboot or savebase command. Failure to do so will not make the change to the volume group and will have no effect when the system is restarted.

#### 6.3.2.2 Unlocking a Volume Group

In AIX Version 4, it is now also possible to unlock a volume group. A volume group can become *locked* when an LVM command terminates abnormally. This is quite likely when the system crashes while an LVM operation is being performed on the system or if an LVM command core dumps.

The example command below will unlock volume group, VGname.

```
# chvg -u VGname
```

In order for the above command to succeed no other LVM command must be operating on the specific volume group.

### 6.3.2.3 Adding a Physical Volume

It may sometimes be necessary to increase the free space available in a volume group so that existing file systems and logical volumes within the volume group can be extended, or new ones can be added. To do this requires additional physical volumes to be made available within the volume group. It is possible to add physical volumes to a volume group, up to the maximum specified at creation time. When adding physical volumes in this way, all data on the physical volume will be destroyed.

A physical volume can be added using the `extendvg` command. In the following example, physical volume `hdisk3` is being added to volume group `myvg`.

```
# extendvg myvg hdisk3
```

The `extendvg` command will fail if the physical volume being added already belongs to a varied on volume group on the current system. Also, if the physical volume being added belongs to a volume group that is currently not varied on, the user will be asked to confirm whether or not to continue.

### 6.3.2.4 Removing a Physical Volume

It may sometimes be necessary to free up one or more physical volumes from a volume group. Suppose that three physical volumes have been allocated to a volume group and only two are actually used for data storage. In this instance, the unused physical volume could be removed from the volume group so that it can be made available for use in other volume groups. It may also be necessary to remove a physical volume if it becomes damaged so that maintenance work can be carried out on it. Whatever the reason, physical volumes can be removed using the `reducevg` command.

In the following example, physical volume `hdisk3` is removed from the volume group `myvg`:

```
# reducevg myvg hdisk3
```

The `reducevg` command will only succeed in removing a physical volume if:

- No logical volumes exist on the physical volume being removed.
- The volume group is varied on.

The `reducevg` command provides the `-d` and `-f` flags. The `-d` flag is useful since it deallocates all logical partitions and deletes all logical volumes from the specified physical volume upon user confirmation. The `-f` flag used in conjunction with the `-d` flag will force the deallocation of logical partitions and deletion of logical volumes without user confirmation.

If the logical volumes on the physical volume specified to be removed also span other physical volumes in the volume group, the removal operation may destroy the integrity of those logical volumes, regardless of the physical volume on which they reside.

## 6.3.3 Importing and Exporting a Volume Group

There may be times when a volume group may need to be moved from one RISC System/6000 system to another, so that logical volume and file system data in the volume group can be accessed directly on the target system. It may even be necessary to remove all knowledge of a volume group from the system, if file systems and logical volumes within it are no longer being accessed. By having such redundant volume groups on the system. the physical volumes within it remain tied up unnecessarily, when they could be used within other volume groups.

However, before the physical volumes in a volume group are actually disconnected, it would be good practice to remove the system definition of the volume group to which they are allocated. To remove all knowledge of a volume group from the ODM database, the volume group needs to be *exported* using the `exportvg` command. This command will not remove any user data in the volume group but only remove its definition from the ODM database. Similarly, when a volume group is moved, the target system needs to be made aware of the new volume group. This can be achieved by *importing* the volume group using the `importvg` command which will add an entry to the ODM database.

In the example below, volume group `myvg` will be exported:

```
# exportvg myvg
```

Once exported, a volume group can no longer be accessed.

There are some restrictions when using the `exportvg` command to export a volume group. These are:

- The volume groups must be varied off. See 6.3.4, "Varying On and Varying Off Volume Groups" on page 106 for more details.
- The *rootvg* volume group cannot be exported. This is because varying off the *rootvg* is not possible. See 6.3.4, "Varying On and Varying Off Volume Groups" on page 106 for more details.
- The volume group must not have any active paging space logical volumes on it. In order to export a volume group with an active paging space on it you must:
  - Change the state of the paging space so that it is not automatically activated on system restart
  - Reboot the system
  - Vary off the volume group
  - Export the volume group
- A subset of physical volumes cannot be exported individually.

In the following example use of `importvg`, volume group `myvg` is being imported onto the target system using `hdisk3`. The information about the volume group characteristics, such as the other physical volumes in the group and the logical volumes and file systems, will be read from the VGDA held on physical volume `hdisk3`.

```
# importvg -y myvg hdisk3
```

In this example, the name to be given to the imported volume group is specified using the `-y` flag. However, if the specified volume group name is already in use, the `importvg` will fail with an appropriate error message, since duplicate volume group names are not allowed. In this instance, the command can be rerun with a unique volume group name specified, or it can be rerun without both the `-y` flag and the volume group name, which gives the imported volume group a unique system default name. It is also possible that some logical volume names may also conflict with those already on the system. The `importvg` command will automatically reassign these with system default names.

In AIX Version 4, when a volume group is imported it is automatically varied on, whereas, in AIX Version 3, the volume group has to be varied on separately.

The important thing to remember when moving volume groups from system to system, is that the `exportvg` command is always run on the source system prior to importing the volume group to the target system. Consider that a volume group is imported on system `Y` without actually performing an `exportvg` on system `X`. If system `Y` makes a change to the volume group, such as removing a physical volume from the volume group, and the volume group is imported back onto system `X` the ODM database on system `X` will not be consistent with the changed information for this volume group.

It is however, worth noting that a volume group can be moved to another system without it first being exported on the source system.

### 6.3.4 Varying On and Varying Off Volume Groups

Before administrative activities such as opening of logical volumes and mounting of file systems can be performed, the relevant volume groups need to be made available. This can be achieved by varying on a volume group using the `varyonvg` command. Likewise, when access to a volume group needs to be stopped entirely, it can be varied off after unmounting all file systems and closing all open logical volumes within it. The `varyoffvg` command can be used to vary off a volume group.

During the varying on process, a number of different operations are performed in order to make a volume group available. They are:

- The VGDA and VGSA information is read from each of the physical volumes in the volume group.
- Each physical volume's VGDA and VGSA header and trailer timestamps are validated. If, for example, the VGDA header and trailer timestamps on a particular physical volume do not match, it is likely that the organizational information held within it will be inconsistent.
- If the number of valid VGDAs found represents a majority, that is more than 50%, the volume group will be varied on. If not, the varying on process will fail. The vary on process can be made to continue even when quorum is lost by using this `-f` flag to `varyonvg`.

- Since, the valid VGDA with the latest timestamp is likely to hold the most recent information about the organization of the volume group, it is used to overwrite all other VGDAs in the volume group.
- If any invalid VGSAs (where the timestamps do not match) are found, then `syncvg` is run to resynchronize any stale partitions within the volume group.

The following example shows how `varyonvg` can be used to varyon a volume group.

```
#varyonvg myvg
```

This command will vary on volume group `myvg` based on the varying on process mentioned above. If quorum was lost, the volume group `myvg` would not be varied on. With a number of optional flags specified with the `varyonvg` command, the default processing can be overridden.

The optional flags are:

| | |
|---|---|
| **-f** | Forces the volume group to be varied on even though a majority of VGDAs does not exist. Forcing a volume group to vary on could be quite dangerous, particularly if a damaged physical volume is holding logical partitions of a logical volume which is being updated. This would cause corruption of the data. |
| **-n** | Disables the synchronization of the stale physical partitions within the volume group. This allows flexibility to the systems administrator in providing control over how the volume group can be recovered. |
| **-p** | This permits a volume group to be varied on only when all the physical volumes in the volume group are available. |
| **-s** | Allows a volume group to be varied on in system maintenance mode. In this mode no logical volumes can be opened, thereby disallowing all logical I/O to logical volume and file system data. Since logical volume commands can still be run on the volume group, it provides a mechanism for looking at and resolving any problems that may occur on it. |

To vary off a volume group, the following command can be issued:

```
# varyoffvg myvg
```

Before a volume group can actually be varied off all open logical volumes must be closed and all mounted file systems must be unmounted. If a volume group exhibits some problems and needs to be repaired, this can be done by varying off the volume group directly into maintenance mode. This can be achieved by using the `-s` flag.

## 6.3.5 Monitoring Volume Groups

Volume groups rely on the underlying physical volumes to be operational the whole time that they are activated. If, however, physical volumes become damaged, they can affect the state of volume groups. Therefore, like physical volumes, it is important that volume groups are also monitored regularly so that extensive damage can be avoided. This section will review those AIX logical volume commands which will help in monitoring volume groups and their characteristics.

### 6.3.5.1 Listing Volume Groups on the System

Although there are several AIX commands available to find out about the volume groups on a system, the most preferred is `lsvg`. This command interrogates the ODM database for all volume groups currently known to the system.

**Note**

A volume group which has been exported using the `exportvg` command will not appear in the output.

An example use of the `lsvg` command and its output is:

```
# lsvg
rootvg
myvg
```

Since the above command lists all known volume groups it may sometimes be desired to list only those volume groups which are currently varied on.

Using the `-o` flag with `lsvg` will provide this detail.

For example:

```
lsvg -o
rootvg
```

### 6.3.5.2 Listing the Characteristics of a Volume Group

A volume group has many characteristics which can be observed, such as the physical partition size for it, the number of physical volumes it consists of, how much free and used space there is and more. It may be essential to observe how much free space there is within a volume group to help decide whether or not a logical volume or file system can be extended by a particular amount, or even if a new logical volume or file system can be created with the required size. Apart from the free space, it may also be helpful to find if the varied on volume group shows any problems with regards to the physical volumes and physical partitions. If a volume group needed to be varied on forcibly, this could be attributed to a physical volume not having valid VGDA information on it. There could also be stale physical partitions within a volume group, particularly if mirrored copies of logical volumes on damaged physical volumes are not updated. It is possible to see such information at a glance, about any varied on volume group, by issuing the `lsvg` command as follows:

```
# lsvg myvg
VOLUME GROUP:   myvg            VG IDENTIFIER:  00000446f5eac0e3
VG STATE:       active          PP SIZE:        4 megabyte(s)
VG PERMISSION:  read/write      TOTAL PPs:      574 (2296 megabytes)
MAX LVs:        256             FREE PPs:       571 (2284 megabytes)
LVs:            2               USED PPs:       3 (12 megabytes)
OPEN LVs:       0               QUORUM:         2
TOTAL PVs:      2               VG DESCRIPTORS: 2
STALE PVs:      1               STALE PPs       1
ACTIVE PVs:     1               AUTO ON:        yes
```

In this example, volume group `myvg` is being described.

The meaning of the fields in the above output and their values as found in the this example will be explained.

**VOLUME GROUP:** This is the name of the volume group. In this example it is `myvg`.

**VG STATE:** This describes if the volume group is varied on or varied off. In our example, the content of this field is `active` indicating that the volume group is varied on. This field can have any one of the following values:

- `active/complete - varied on and all physical volumes active`
- `active/partial  - varied on but one or more physical volumes are inactive`
- `inactive        - varied off`

**VG PERMISSION:** This describes if the volume group is accessible with read-only permission or both read and write permission. The volume group in this example has read and write access permission.

**MAX LVs:** This field represents that maximum number of logical volumes that can be created within a volume group which is 256.

**LVs:** This represents the number of logical volumes that have so far been created within the volume group. In our example, only two logical volumes exist within the volume group `myvg`.

**OPEN LVs:** This describes the number of logical volumes that are currently open for logical I/O. In the above example, there are no logical volumes currently open.

**TOTAL PVs:** The total number of physical volumes that exist within the volume group. In volume group `myvg` there are two physical volumes.

**STALE PVs:** The number of inactive physical volumes in the volume group. The example appears to have one physical volume which is inactive. This indicates there is a problem with one of the physical volumes in the volume group.

**ACTIVE PVs:** The number of active physical volumes within the volume group. Volume group `myvg` has one active (working) physical volume.

| | |
|---|---|
| **VG IDENTIFIER:** | This field shows the system wide unique alphanumeric identifier for the volume group. In the example, this value is `00000446f5eac0e3`. |
| **PP SIZE:** | A numeric value representing the size, in megabytes, of each physical partition within the volume group. This value is specified when the volume group is created. The example volume group uses the default physical partition size of `4MB`. |
| **TOTAL PPs:** | This field shows the total number of physical partitions which exist in the volume group. It also shows, in brackets, the size of the volume group which is calculated using the physical partition size. Volume group `myvg` has `574` physical partitions allocated. |
| **FREE PPs:** | This field shows the amount of unallocated space in the volume group in terms of physical partitions. The size in megabytes, is also shown in brackets. The number of free physical partitions in the above example is `571`. |
| **USED PPs:** | This field shows the number of used physical partitions. The format of the contents of this field is the same as for the two previous fields. In the above example, only `3` physical partitions (`12MB`) have been used. |
| **QUORUM:** | This field represents the number of physical volumes that would be needed to represent a majority. For a two disk volume group, this number represents the number of VGDAs, rather than physical volumes, which would be required to maintain quorum (a majority). |
| **VG DESCRIPTORS:** | This value represents the number of VGDAs currently available in the varied on volume group. In the example volume group `myvg`, there appears to be `2` VGDAs available. The example volume group consists of two physical volumes and so there should really be `3` VGDAs available. From the above output it can clearly be seen that there is a problem accessing the third VGDA. |
| **STALE PPs:** | This field represents the number of stale physical partitions. The example shows `1` stale physical partition. This is likely since one of the physical volumes is currently inactive. |
| **AUTO ON:** | This field describes if the volume group will be varied on automatically at system restart. This characteristic can be changed using the `chvg` command. Volume group `myvg`, in the above example, will be varied on automatically each time the system is rebooted. |

#### 6.3.5.3 Listing the Logical Volumes in a Volume Group

The `lsvg` command can be used to list all the logical volumes in a varied on volume group. To do so the `-l` flag needs to be specified together with the volume group name.

For example:

```
# lsvg -l myvg
myvg:
LV NAME          TYPE       LPs   PPs   PVs  LV STATE      MOUNT POINT
mylv             jfs        6     12    2    open/syncd    /myjfs
```

The above command provides details of each logical volume on a separate line. The information includes the following:

| | |
|---|---|
| **LV NAME:** | This is the name of the logical volume. |
| **TYPE:** | This field describes the type of logical volume it is. This can be any one of the following special types: • paging (used for the paging device) • boot (used for the boot device) • sysdump (used for the system dump device) • jfslog (used for the JFS log) • jfs (used for the journaled file system) If a user defined logical volume type has been specified, this field will reflect this. |
| **LPs:** | This will be the number of logical partitions allocated to the logical volume. |
| **PPs:** | This will be the number of physical partitions allocated to the logical volume. If a logical volume has mirrored copies, this number will be the LPs value multiplied by the number of mirrored copies. |
| **PVs:** | This represents the number of physical volumes across which the physical partitions are spread. |
| **LV STATE:** | The state of the logical volume specified as any one of the following: • open/syncd - This specifies the logical volume is open and synchronized • close/syncd - This specifies the logical volume is closed and synchronized |
| **MOUNT POINT:** | This is the mount point of a file system if one exists. If a file system has not been added to a logical volume the entry will appear as N/A. |

### 6.3.5.4 Listing Physical Volume Status within a Volume Group

So far we have seen how the `lsvg` command can be used to list the volume groups, their characteristics in detail and also information about the logical volumes which have been created on them. The `lsvg` command can also be used to extract information about the physical volumes that exist within a volume group. To view this information the `-p` flag needs to be used.

For example:

```
# lsvg -p myvg
myvg:
PV_NAME        PV STATE    TOTAL PPs   FREE PPs    FREE DISTRIBUTION
hdisk0         active      287         267         58..37..57..57..58
hdisk2         active      287         280         58..50..57..57..58
hdisk3         active      287         280         58..50..57..57..58
```

For each physical volume identified for the volume group, the following information is provided:

| | |
|---|---|
| **PV_NAME:** | The name of the physical volume. |
| **PV STATE:** | Indicates whether or not the physical volume is active. |
| **TOTAL PPs:** | The number of physical partitions that exist on the physical volume in question. |
| **FREE PPs:** | The number of physical partitions on the physical volume that have so far not been allocated to a logical volume or file system. |
| **FREE DISTRIBUTION:** | The distribution of unallocated physical partitions on the physical volume over specific regions of the disk. The regions being: Outer edge; Outer middle; Center; Inner middle; Inner edge |

- Outer edge
- Outer middle
- Center
- Inner middle
- Inner edge

It is useful to view the distribution of free (unallocated) physical partitions, according to regions of the disk. This would be very beneficial, particularly when deciding for the placement of logical volumes or file systems for fast access. It can provide useful information about the placement of existing logical volumes and file systems, and can help in determining if a reorganization of the logical volumes is required, so that free contiguous physical partitions can be made available for other allocation requests.

## 6.4 Managing Logical Volumes

Physical volumes and volume groups are normally not addressed directly by users and applications to access data, and they cannot be manipulated to provide disk space for use by users and applications. However, logical volumes provide the mechanism to make disk space available for use, giving users and applications the ability to access data stored on them.

Logical volumes need to be managed on a day-to-day basis, and this section will highlight those management issues relating to logical volumes, and why they should be given important consideration. The areas to be covered will be:

- Adding a logical volume
- Removing a logical volume
- Increasing the size of a logical volume

- Copying a logical volume
- Migrating and reorganizing logical volumes
- Listing a logical volume
- Listing a summary of a logical volume allocation
- Using `lslv` to read the VGDA on a physical volume

### 6.4.1 Adding a Logical Volume

In order to provide users the ability to store and retrieve data on the disk, logical volumes need to be added to a volume group on the system. However, before a logical volume is actually created, certain characteristics about it, such as its size, physical partition placement policy, and the volume group in which it should belong need to be specified. These characteristics can be better determined by understanding the needs of the users and applications that will utilize the logical volume.

The command which will add a logical volume to a volume group is `mklv`. An example of this command is:

```
# mklv -y mylv -c 2 myvg 10
```

The above example command will create a logical volume `mylv` in the volume group `myvg`. The logical volume will be allocated 10 logical partitions and each logical partition will consist of `2` physical partitions.

The two vital pieces of information that are mandatory when creating a logical volume are:

1. The number of logical partitions
2. The name of the volume group to which it will belong

Many different characteristics for the logical volume can be set at creation time using the `mklv` command. In AIX Version 4, since it is possible to create *striped logical volumes*, the `mklv` command has been updated accordingly. For more information about the use of `mklv` and its flags, please refer to the InfoExplorer hypertext documentation.

### 6.4.2 Removing a Logical Volume

Under different circumstances, logical volumes may need to be removed from a volume group. Consider that a logical volume is no longer used for storage purposes by users and applications. The data within the logical volume could be backed up and the space occupied by the logical volume could be freed by removing the logical volume from the volume group. There may even be times when a logical volume may need to be removed because it has more than the required number of logical partitions allocated. In this instance, the following steps could be performed to free up the excess logical partition allocation:

- Back up all data in the logical volume
- Remove the logical volume
- Recreate the logical volume with the reduced logical partition allocation

- Restore the data

The resulting free space could be put to better use by allocating it to other logical volumes requiring it. Whatever the reason, a logical volume can be removed by using the `rmlv` command. An example use of this command is:

```
# rmlv mylv
```

This command will remove the logical volume `mylv` from the system. The command will appropriately remove all knowledge of the logical volume from the:

- ODM database
- VGDAs on all physical volumes
- /dev directory

It is also possible to remove all logical partitions on a particular physical volume by using the `rmlv` command. For example:

```
# rmlv -p hdisk4 mylv
```

This command will remove copies of all logical partitions for the logical volume `mylv` residing on the physical volume `hdisk4`.

**Warning**

If the logical partitions being removed are the only ones remaining for the logical volume, this command will also remove the logical volume from the system.

Since by default, the `rmlv` command will perform its task requesting user confirmation, the `-f` flag is provided to override this.

## 6.4.3 Increasing the Size of a Logical Volume

Over time, users and application needs for available disk space will definitely grow, and for this reason, the size of logical volumes will also need to be increased. This can be achieved by using the `extendlv` command. However, there must be sufficient free (unallocated) physical partitions available within the volume group to satisfy the operation.

For example:

```
# extendlv mylv 10
```

This will extend the logical volume `mylv` by 10 logical partitions using the available free space in the volume group.

Certain rules need to be adhered to when using the `extendlv` command to extend *striped logical volumes*. For more information about the use of the `extendlv` command and its flags, please refer to the InfoExplorer hypertext documentation.

### 6.4.4 Copying a Logical Volume

Logical volumes may need to be copied for a number of reasons. If a disk is to be removed and replaced by a faster one, the logical volumes on that disk will need to be copied to the new disk. Logical volumes can be copied to new logical volumes or to existing logical volumes which are then over-written.

In order to copy a logical volume, use the `cplv` command, as in the following example:

```
# cplv -v myvg -y newlv oldlv
```

This copies the contents of `oldlv` to a new logical volume called `newlv` in the volume group `myvg`. If the volume group is not specified, the new logical volume will be created in the same volume group as the old logical volume. This command creates a new logical volume. The following example demonstrates how to copy a logical volume to an existing logical volume.

```
# cplv -e existinglv oldlv
```

This copies the contents of `oldlv` to the logical volume `existinglv`. Confirmation for the copy will be requested as all data in `existinglv` will be over-written.

**Warning**

If `existinglv` is smaller than `oldlv`, then data will be lost, probably resulting in corruption.

Copying a logical volume can also be done through smit using the `smit cplv` fastpath.

### 6.4.5 Migrating and Reorganizing Logical Volumes

As the uses of existing logical volumes change, sooner or later there will be a requirement to modify the placement some logical volumes to alter the performance characteristics. There are two commands that can assist in this process:

- `migratepv`

  This command will move the contents of one physical volume to another. The two physical volumes must be in the same volume group. It is also possible to stipulate which logical volumes on the physical volume will be migrated. The command can be used as follows:

  ```
  # migratepv -l lv oldpv newpv
  ```

This will move the physical partitions belonging to `lv` from physical volume `oldpv` to physical volume `newpv`. Omitting the `-l` flag will move all physical partitions.

- `reorgvg`

  This command will attempt to reallocate physical partitions for logical volumes in an attempt to adhere more closely to the policies defined in the logical volume manager for the logical volumes. The command can be used as follows:

  ```
  # reorgvg myvg mylv
  ```

  This will reorganize the physical partitions belonging to `mylv` in `myvg` in an attempt to more closely satisfy the policies defined for `mylv` at creation time.

## 6.4.6 Listing a Logical Volume

All of the attributes defined for a logical volume can be listed using the `lslv` command as follows:

```
# lslv mylv
LOGICAL VOLUME:     mylv                   VOLUME GROUP:   myvg
LV IDENTIFIER:      00013948b0189961.7     PERMISSION:     read/write
VG STATE:           inactive               LV STATE:       opened/syncd
TYPE:               jfs                    WRITE VERIFY:   off
MAX LPs:            500                    PP SIZE:        4 megabyte(s)
COPIES:             1                      SCHED POLICY:   parallel
LPs:                109                    PPs:            109
STALE PPs:          0                      BB POLICY:      relocatable
INTER-POLICY:       minimum                RELOCATABLE:    yes
INTRA-POLICY:       center                 UPPER BOUND     32
MOUNT POINT:        /myfs                  LABEL:          /myfs
MIRROR WRITE CONSISTENCY: on
EACH LP COPY ON A SEPARATE PV ?: yes
```

The fields displayed have the following meanings:

**LOGICAL VOLUME:** The name of the logical volume.

**VOLUME GROUP:** The name of the volume group that the logical volume is in.

**LV IDENTIFIER:** The system unique identifier for the logical volume.

**PERMISSION:** The access permission, which can be read-only, or read-write.

**VG STATE:** The current state of the volume group. This can be one of:

1. `active/complete` - all physical volumes are active.
2. `active/partial` - not all physical volumes are active.
3. `inactive` - the volume group is not active.

**LV STATE:** The current state of the logical volume. This can be one of:

1. `opened/stale` - logical volume is open, but some physical partitions do not contain current information.
2. `opened/syncd` - logical volume is open and synchronized.

3. `closed` - logical volume has not been opened.

| | |
|---|---|
| **TYPE:** | The type of the logical volume (JFS for example). |
| **WRITE VERIFY:** | Whether write verify is being used or not. |
| **MAX LPs:** | The maximum number of logical partitions that the logical volume can contain. |
| **PP SIZE:** | The size of the physical partitions in the logical volume. |
| **COPIES:** | The number of copies of the logical volume that exist. |
| **SCHED POLICY:** | Whether writes are to be scheduled serially, or in parallel to disk. |
| **LPs:** | The current number of logical partitions in the logical volume. |
| **PPs:** | The current number of physical partitions in the logical volume. |
| **STALE PPs:** | The number of physical partitions in the logical volume that do not contain current information. |
| **BB POLICY:** | Whether bad block allocation is to be used or not for this logical volume. |
| **INTER-POLICY:** | Whether the maximum or minimum range of disks should be used for logical partition allocation for this logical volume. |
| **RELOCATABLE:** | Whether partitions can be relocated if a reorganization occurs. |
| **INTRA-POLICY:** | Specifies the preferred location for physical partitions on the disk. This can be edge, middle, or center. |
| **UPPER BOUND:** | This indicates the maximum number of physical volumes within the volume group that can be used for physical partition allocation. |
| **MOUNT POINT:** | If this logical volume contains a file system, then this indicates the mount point for that file system. |
| **MIRROR WRITE CONSISTENCY:** | Whether writes are cached to help ensure consistency between mirrored copies. |
| **EACH LP COPY ON A SEPARATE PV ?:** | Whether the allocation policy is strict meaning that logical volume copies will be placed on separate physical volumes if possible. |

### 6.4.7 Listing a Summary of a Logical Volume Allocation

If a summary of the physical partition usage for a logical volume is required, rather than a complete listing of all attributes, the following command can be used:

```
# lslv -l mylv
mylv:/myfs
PV                COPIES        IN BAND       DISTRIBUTION
hdisk0            107:000:000   27%           019:004:029:032:023
hdisk1            002:000:000   100%          000:000:002:000:000
```

The fields shown in the output above have the following meaning:

**PV** The physical volume name.

**COPIES** This field has the following three sub-fields:

- Number of single copy logical partitions.
- Number of two copy logical partitions.
- Number of three copy logical partitions.

**IN BAND** This shows the percentage of physical partitions that could be allocated according to the intra-physical allocation policy.

**DISTRIBUTION** This shows for each disk region, the number of physical partitions allocated to logical volumes.

### 6.4.8 Reading the VGDA on a Physical Volume

If it is required to interrogate the VGDA on the physical disk in order to find the status of a logical volume, the following command can be used:

```
# lslv -n mypvid mylv
```

This will retrieve status information similar to that produced by the `lslv mylv`, but from the VGDA, rather than the ODM.

## 6.5 Managing the Storage Environment

Managing storage is about optimizing the environment for the requirements of the processes that will be using the subsystems within it. This will involve the following considerations:

- Performance of logical volumes
- Availability of logical volumes
- Logical volume space usage

Management of the environment also involves ensuring recovery is possible in the event of user errors or hardware and software failures.  The key to this is the development and implementation of a good backup strategy, and this will also be discussed. Mechanisms for backing up the system and their capabilities have changed somewhat from AIX Version 3 to AIX Version 4, and both environments will be examined.

**Note**

Please read this section in conjunction with Chapter 5, “Storage Subsystem Design” on page 77, as there are many other considerations involved in maximizing performance, availability and disk utilization.

## 6.5.1 Disk Space and Performance/Availability Management

This section will look at the management issues inherent in controlling performance, availability, and disk space utilization.

### 6.5.1.1 Managing Performance

In order to maximize the performance of a disk subsystem, certain options can be taken at logical volume and file system creation time. In addition, existing logical volumes can be modified to increase performance, and volume groups can be reorganized to improve performance.

***Creating Logical Volumes and File Systems for Performance:*** In order to maximize performance create logical volumes as follows; the smit menus for the creation will be shown in this section. For changing logical volume characteristics, the commands will be shown. Either approach is valid, and for a detailed discussion of the commands involved, see Chapter 7, "Storage Management Files and Commands Summary" on page 137, or the InfoExplorer documentation.

```
# smit mklv
```

This starts smit in the process for adding a new logical volume.

```
                               Add a Logical Volume

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

[TOP]                                             [Entry Fields]
[perflv]
* VOLUME GROUP name                                       datavg
  Number of LOGICAL PARTITIONS                           [25]               #
  PHYSICAL VOLUME names                                  [hdisk8 hdisk1]+
  Logical volume TYPE                                    [jfs]
  POSITION on physical volume                             center          +
  RANGE of physical volumes                               maximum         +
  MAXIMUM NUMBER of PHYSICAL VOLUMES                     [2]                #
    to use for allocation
  Number of COPIES of each logical                        1               +
    partition
  Mirror Write Consistency?                               no              +
  Allocate each logical partition copy                    no              +
    on a SEPARATE physical volume? Performance
  RELOCATE the logical volume during reorganization?  yes             +
  Logical volume LABEL                                   []
  MAXIMUM NUMBER of LOGICAL PARTITIONS                   [128]
  Enable BAD BLOCK relocation?                            yes             +
  SCHEDULING POLICY for writing logical                   parallel        +
    partition copies
  Enable WRITE VERIFY?                                    no              +
  File containing ALLOCATION MAP                         []
  Stripe Size?                                           [Not Striped]      +
[BOTTOM]

F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

This creates a logical volume with the following characteristics:

**PHYSICAL VOLUME names:** This field contains the names of the physical volumes that are to be used for the physical partitions of the logical volume being created.

**POSITION on physical volume:** This field specifies the desired location of the physical partitions on the disk. Center is chosen for optimum performance. The LVM will attempt to locate free center partitions on the disks specified previously; if not available, middle partitions, then edge partitions will be selected.

**RANGE of physical volumes:** This parameter governs the way in which the LVM will allocate partitions on the physical volumes specified above. Maximum constrains the LVM to allocating partitions across as many of the physical volumes as possible.

**Number of COPIES of each logical partition:** This field controls the level of mirroring. Set to 1 implies no mirroring.

**Mirror Write Consistency:** Only valid if mirroring.

**Allocate each logical partition copy on a SEPARATE physical volume?** Only valid if mirroring.

**RELOCATE the logical volume during reorganization?** This allows the physical partitions to be moved during reorganization if required. This can be useful if performance requirements change.

**SCHEDULING POLICY for writing logical partition copies:** Only valid for mirroring

**Enable WRITE VERIFY:** This parameter should be set to no to prevent the extra disk rotation required for verification.

**File containing ALLOCATION MAP:** It is possible to override the LVMs allocation policies and provide a file containing the physical partition locations required. An example of this can be found in 8.3.2, “Map Files Usage and Contents” on page 207.

**Stripe Size?** Striping is discussed later in this section.

Having created the logical volume, a file system must next be created within it:

```
# smit crfs
```

Select the option to **Add a Journaled File System on a Previously Defined Logical Volume**.

```
      Add a Journaled File System on a Previously Defined Logical Volume

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

                                                        [Entry Field]
* LOGICAL VOLUME name                                 perflv          +
* MOUNT POINT                                        [/tmp/nick]
  Mount AUTOMATICALLY at system restart?              yes             +
  PERMISSIONS                                         read/write      +
  Mount OPTIONS                                      []               +
  Start Disk Accounting?                              no              +
  Fragment Size (bytes)                               4096            +
  Number of bytes per inode                           4096            +
  Compression algorithm                               no              +






F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

This will create a file system with the following characteristics:

**Fragment Size (bytes):** This parameter controls the size of the basic unit of allocation at the file system level. Setting this to 4096 creates fragments of the largest size possible, thereby minimizing the overhead involved and maximizing performance.

**Number of bytes per inode:** This parameter governs the number of i-nodes actually created per number of bytes in the file system. This will have no specific effect on performance.

**Compression algorithm:** To maximize performance, do not use compression.

***Modifying Logical Volumes for Performance:*** In order to maximize the performance of an existing logical volume do the following:

```
# chlv -a c LVname
```

This command will change the intra-disk physical allocation policy to use the center of the disk if possible. In order for existing partitions to take advantage of the new policy, the volume group will need reorganizing. This is discussed in the next section. Partitions added if the logical volume is extended will be allocated using the new policy. `LVname` should be the name of the logical volume that is to be changed.

```
# chlv -e x LVname
```

This command will change the inter-disk physical allocation policy to use the maximum number of disks possible within the volume group, for allocating further physical partitions. Again, reorganization will be required if the existing partitions that comprise the logical volume are to take advantage of this. LVname should be the name of the logical volume that is to be changed.

***Reorganizing Volume Groups for Performance:*** In order to reorganize a volume group after policies have been changed for logical volumes within that group, the following command should be executed:

```
# reorgvg VGname LVname_1 LVname_2 LVname_3 ...
```

This command will instruct the LVM to attempt to reshuffle the physical partition allocations within the volume group VGname, in order to satisfy as far as possible the policy requirements of the logical volumes specified in the list (LVname_1, LVname_2, and LVname_3 in this example). The LVM will try and implement the policies for logical volumes in the order specified. In this example, LVname_1s allocation will take precedence over LVname_2.

Determining which logical volumes are in a volume group can be achieved using the lsvg command as follows:

```
# lsvg -l VGname
VGname:
LV NAME             TYPE       LPs    PPs   PVs  LV STATE      MOUNT POINT
datalog             jfslog     1      1     1    open/syncd    N/A
datapg              paging     5      10    2    closed/syncd  N/A
perflv              jfs        25     25    2    closed/syncd  /tmp/nick
datalv4             jfs        10     10    1    closed/syncd  /datajfs
#
```

***Using Striping:*** Further performance enhancement is possible by setting up a logical volume to use striping. An example of this procedure can be found in “How to Create a Striped Logical Volume” on page 273.

### 6.5.1.2 Managing Availability

In order to maximize availability, there are certain options that can be selected at logical volume creation time. Existing logical volumes can also be modified to increase availability, and both possibilities will be examined.

***Creating Logical Volumes for Availability:*** In order to maximize availability, create logical volumes as follows. Logical volume creation will be shown using smit, the commands are actually detailed in Chapter 7, “Storage Management Files and Commands Summary” on page 137, and documented in InfoExplorer. There are no particular availability related options during file system creation, though as has been mentioned previously, having a journaled file system itself provides enhanced availability through journaling.

```
# smit mklv
```

This starts smit in the process for adding a new logical volume.

```
                            Add a Logical Volume

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

[TOP]                                          [Entry Fields]
  Logical volume NAME                                 [availlv]
* VOLUME GROUP name                                    datavg
  Number of LOGICAL PARTITIONS                        [25]            #
  PHYSICAL VOLUME names                               [hdisk8 hdisk1 h]+
  Logical volume TYPE                                 [jfs]
  POSITION on physical volume                          center         +
  RANGE of physical volumes                            minimum        +
  MAXIMUM NUMBER of PHYSICAL VOLUMES                  [1]              #
    to use for allocation
  Number of COPIES of each logical                     3              +
    partition
  Mirror Write Consistency?                            yes            +
  Allocate each logical partition copy                 yes            +
    on a SEPARATE physical volume?
  RELOCATE the logical volume during reorganization?  yes            +
  Logical volume LABEL                                []
  MAXIMUM NUMBER of LOGICAL PARTITIONS                [128]
  Enable BAD BLOCK relocation?                         yes            +
  SCHEDULING POLICY for writing logical                sequential     +
    partition copies
  Enable WRITE VERIFY?                                 yes            +
  File containing ALLOCATION MAP                      []
  Stripe Size?                                        [Not Striped]    +
[BOTTOM]

F1=Help            F2=Refresh          F3=Cancel           F4=List
F5=Reset           F6=Command          F7=Edit             F8=Image
F9=Shell           F10=Exit            Enter=Do
```

This creates a logical volume with the following characteristics:

**PHYSICAL VOLUME names:** This parameter specifies the physical volumes within the volume group that should be used to hold the physical partitions that will be created. In this case, there are `3` physical volumes specified, as there will be `3` copies of the logical volume, and for maximum availability, each copy should be on a separate disk.

**POSITION on physical volume:** There are no particular availability advantages to be gained from whereabouts on the disk physical partitions are located. In this case, `center` has been chosen to improve performance.

**RANGE of physical volumes:** This parameter governs how many physical volumes the LVM will attempt to use when creating physical partitions for each copy. Setting the value to `minimum` instructs the LVM to use as few physical volumes as is possible.

**Number of COPIES of each logical partition:** This parameter specifies the degree of mirroring that will be implemented. Setting the value to `3` provides maximum availability with two redundant copies of the data existing.

**Mirror Write Consistency?** This parameter controls whether the LVM will cache logical partitions until all copies of the partition have been updated. Setting this to `yes` enhances availability by ensuring consistency between mirrored copies.

**Allocate each logical partition copy on a SEPARATE physical volume?** This parameter specifies whether copies should be allowed to share physical volumes. For maximum availability, it should be set to `yes`.

**RELOCATE the logical volume during reorganization?** This parameter governs whether the LVM will be allowed to move physical partitions belonging to this logical volume during a reorganization. Set this to `yes` if there may be a requirement to modify the policies controlling this logical volume.

**SCHEDULING POLICY for writing logical partition copies:** This parameter controls how copies will be written to disk. For maximum availability, this should be set to `sequential`, which ensures each write to a copy must complete before the next occurs, thereby maximizing the probability of a successful copy being made.

**Enable WRITE VERIFY?** This parameter toggles the write verification feature. For maximum availability, it should be set to `yes`.

**File containing ALLOCATION MAP:** As described in the previous example, this parameter allows the location of physical partitions on the physical volumes to be directly controlled by the user. As physical location of partitions on each disk is not an availability issue, this feature is not required.

**Stripe Size?** This should be set to `Not Striped`, as striping cannot be used with mirroring.

***Modifying Logical Volumes for Availability:*** In order to maximize availability for an existing logical volume, do the following. It will be necessary to check that enough physical partitions exist on the selected physical volumes to support the new number of mirror copies required. This can be achieved using the `lsvg` command as shown here:

```
# lsvg -p VGname
VGname:
PV_NAME          PV STATE    TOTAL PPs   FREE PPs    FREE DISTRIBUTION
hdisk8           active      75          18          15..00..00..00..03
hdisk1           active      287         206         58..09..24..57..58
#
```

This command shows the physical volumes in the volume group, and the free partitions available, both in total, and in actual location.

```
# mklvcopy -e m -u 1 -s y -k LVname 3 hdiskX hdiskY ...
```

This modifies logical volume `LVname` as follows:

**-e m** This flag sets the inter-disk physical policy, causing the LVM to use the minimum number of disks for future partition allocations to `LVname`

**-u 1** This flag sets the maximum number of physical volumes to be used in each new allocation of partitions. Setting this to `1` means use the minimum possible.

**-s y** This flag instructs the LVM to use a different physical volume for each new copy of the logical volume. This ensures maximum availability by placing each copy on a separate physical disk.

**-k** This flag instructs the LVM to synchronize the data in the newly created copies.

**LVname 3** `LVname` is the name of the logical volume to be modified, and the numeral following it, indicates the new number of copies of each logical partition required (the level of mirroring). For maximum availability, set this to `3`.

**hdiskX hdiskY ...** The last part of this command should be a list of the physical volumes that are to be used for the updated logical volume. The values put in here should be the names of the physical disks. Using the smit menus for this operation provides a prompt for the names of existing physical volumes in the volume group. Alternatively use the `lsvg` command, as detailed above, to list physical volumes in a volume group.

Next, the write verify and scheduling policies should be modified:

```
# chlv -d s -v y -w y LVname
```

This changes the policies for `LVname` as follows:

**-d s** This flag sets the scheduling policy for writing logical partitions to sequential. This is explained in the previous section on creating the logical volume for availability.

**-v y** This flag sets the write verification feature on. Again the purpose behind this is explained in the previous section.

**-w y** This flag enables mirror write consistency, which is also explained in the previous section.

***Mirroring the Root Volume Group:*** An example of the process of mirroring the root volume group is shown in 8.2, “rootvg Mirroring - Implementation and Recovery” on page 187.

***Reorganizing Volume Groups for Availability:*** This procedure is exactly the same as has already been described in the previous section on performance.

#### 6.5.1.3 Managing Disk Space Utilization

Maximizing disk space utilization is possible through configuration of the journaled file system at creation time. As has already been described in 5.2.4, “File Systems” on page 79, the primary configuration options are the fragment size, the number of bytes per i-node, and whether compression will be used or not. This section will show the smit and system commands used to create a file system, highlighting those parameters important in disk space management.

To create a file system do the following:

```
# smit crjfs
```

Select the volume group that will contain the file system and then:

```
                          Add a Journaled File System

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

                                                        [Entry Fields]
  Volume group name                                   datavg            #
* SIZE of file system (in 512-byte blocks)           [20000]
* MOUNT POINT                                        [/tmp/nick]       +
  Mount AUTOMATICALLY at system restart?              no               +
  PERMISSIONS                                         read/write       +
  Mount OPTIONS                                      []                +
  Start Disk Accounting?                              no               +
  Fragment Size (bytes)                               512              +
  Number of bytes per inode                           512              +
  Compression algorithm                               LZ               +






F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

This is the same as using the following system command:

```
# crfs -v jfs -g datavg  -a size=20000 -m /tmp/nick -A no  -p rw  -t no \
  -a frag=512 -a nbpi=512 -a compress=LZ
```

This will create the file system as follows:

**-a frag=512:** The same as Fragment Size (bytes), this parameter sets the size of the minimum allocation unit within the file system.

**-a nbpi=512:** The same as Number of bytes per inode, this parameter controls how many i-nodes will be created in the file system. As each i-node takes up 128 bytes of physical space, they can use up a great deal of disk.

**-a compress=LZ:** The same as compression algorithm, this option allows a compression type to be selected. By default, the system provides the `LZ` mechanism. Utilizing compression can improve disk space usage (depending upon the file data) by up to a factor of 2.

## 6.5.2 Backup and Restore Management

This section will show how to use the smit menus and system commands available to backup and restore both system and user information.

### 6.5.2.1 Backups

**Note**

Prior to any file system backup, run the `fsck` command to ensure file system consistency.

***Backing Up User Files or File Systems***

**Warning**

Do not attempt to back up mounted file systems, as this may result in inconsistencies in the backed up copy. This warning is not valid for the root file system which is discussed in the next section.

Using the smit menus to effect these backups will not present the full range of backup options, as this would become unnecessarily complicated, and negate the purpose of smit (ease of use). To backup user files or file systems using smit enter the following:

```
# smit backfile
```

This starts smit in the process for backing up files or directories by name:

```
                           Backup a File or Directory

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

                                                       [Entry Fields]
  This option will perform a backup by name.
* Backup DEVICE                                     [/dev/fd0]       +/
* FILE or DIRECTORY to backup                       [.]
  Current working DIRECTORY                         [/u/nickh]        /
  Backup LOCAL files only?                           yes             +
  VERBOSE output?                                    no              +
  PACK files?                                        no              +





F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

This will cause the `backup` command to be executed as follows:

```
# cd /u/nickh ; find . -fstype jfs -print | backup -iq -f /dev/fd0
```

Essentially, this changes directory to the required starting point, locates all specified files, and passes them to the backup command which is implemented using the following parameters:

| | |
|---|---|
| **-i** | This flag causes a backup by name |
| **-q** | This flag indicates that the backup medium (in this case the diskette drive) is ready to use, and a prompt is not required. |

**-f /dev/fd0** This flag indicates which device should be used for output, in this case the diskette drive. The smit menu option provides a prompt for device selection here.

After executing this command, the specified files will have been copied to the requested device, assuming the device was ready and capable of executing the request, and the files and/or directories specified could be found.

To back up user file systems, do the following, ensure that the file systems to be backed up are unmounted first:

```
# umount FSname
# smit backfilesys
```

This unmounts file system `FSname`, and starts smit in the process for backing up a file system. If a message is returned to the effect that the file system is busy, then someone is currently using the file system.

```
                                Backup a Filesystem

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

                                                         [Entry Fields]
  This option will perform a backup by inode.
* FILESYSTEM to backup                                [/u]           +/
* Backup DEVICE                                       [/dev/fd0]     +/
  Backup LEVEL (0 for a full backup)                  [0]             #
  RECORD backup in /etc/dumpdates?                     no            +





F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

This generates the system command shown below:

```
# backup -f /dev/fd0 -0 /u
```

By default, the `backup` command performs a backup by i-node.

**-f** This flag specifies the device to use for the backup. In this case the diskette device.

**-0** This flag specifies the backup level. Level 0 is a full backup, levels 1 to 9 are incremental backups. In an incremental backup, only those files that have changed since the last backup at or below that level are backed up.

**/u** The last part of the command indicates which file system to actually backup.

**Warning**

Any files with UID or GID greater than 65535 will not be backed up properly as the UID and GID will be truncated to two bytes. Therefore they will be restored with invalid UID and GID. This is only true for backup by i-node.

***Backing Up the System Image Including User Volume Groups:*** This section will show how to use smit menus and system commands to back up the operating system volume group and user volume groups.

To back up the root volume group, ensure that all root volume group file systems that require backing up are mounted, then do the following:

- Ensure no local directories are mounted over other local directories, as this will cause the mounted over directory to be backed up twice. To check where directories are mounted, use the `mount` command.
- Ensure at least 8.2MB of free space are available in the /tmp file system. Use the `df` command to verify this.
- For AIX Version 4, ensure that the `sysbr` fileset (BOS System Management Tools) is loaded. Use `lslpp -l bos.sysmgt.sysbr` to verify this.
- Ensure the backup device is fully operational.

```
# smit mksysb
```

This will start smit in the process for creating an installable backup of the operating system (rootvg).

```
                               Back Up the System

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

                                                        [Entry Fields]
    WARNING:  Execution of the mksysb command will
              result in the loss of all material
              previously stored on the selected
              output medium. This command backs
              up only rootvg volume group.

* Backup DEVICE or FILE                              [/dev/rmt0]       +/
  Make BOOTABLE backup?                               yes              +
     (Applies only to tape media)
  EXPAND /tmp if needed?   (Applies only to bootable  no               +
   media)
  Create MAP files?                                   no               +
  EXCLUDE files?                                      no               +
  Number of BLOCKS to write in a single output       []                 #
     (Leave blank to use a system default)

F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

This will cause the following system command to be executed:

```
# mksysb -i /dev/rmt0
```

The command executed is much more complex, as it attempts to check various prerequisites, and adjust space if required. The command shown will create a bootable image of the system on the tape device specified (/dev/rmt0), but may fail if there is insufficient space in /tmp.

**-i** This flag causes the generation of the /image.data file that contains important install information on all the volume groups, logical volumes, file systems, paging spaces, and physical volumes.

**/dev/rmt0** The last part of this command specifies the output device to use. In order for a bootable image to be created, this must be a tape device.

**MAP Files:** Using map files from the smit menu ensures that physical partitions are allocated exactly as they were in the original, when the backup is installed.

For a non-bootable backup of the operating system volume group, or for a backup of a user volume group, do the following:

- Ensure that the volume group is varied on. This can be confirmed using `lsvg VGname`.
- Ensure all file systems required in the volume group are mounted. This can be confirmed with the `mount` command.
- Ensure the backup device is fully operational.

```
# smit savevg
```

This starts smit in the process for backing up a volume group:

```
                              Back Up a Volume Group

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

                                                            [Entry Fields]
    WARNING:  Execution of the savevg command will
              result in the loss of all material
              previously stored on the selected
              output medium.

* Backup DEVICE or FILE                                  [/dev/rmt0]       +/
* VOLUME GROUP to back up                                [datavg]          +
  Create MAP files?                                       no               +
  EXCLUDE files?                                          no               +
  Number of BLOCKS to write in a single output           []                 #
     (Leave blank to use a system default)



F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

This generates the following system command:

```
# savevg -i -f /dev/rmt0 VGname
```

If it is required to change the sizes of file systems, so that at restore of the volume group, wasted space has been cut down, the following command should be run prior to the `savevg` command:

```
# mkvgdata -m VGname
```

This will cause map files to be created for the volume group. The file */tmp/vgdata/VGname/VGname.data* can then be edited to alter the size of any file systems in the volume group to that required. If this is done, the `savevg` command must be executed without the `-i` or `-m` flags as these will cause the changes to be overwritten. The `savevg` command should then be executed as follows:

```
# savevg -mf/dev/rmt0 VGname
```

| | |
|---|---|
| **-i** | This causes the generation of the image.data file mentioned in the section on backing up the system volume group. |
| **-m** | This flag causes map files to be written with the backup data to enable the exact replication of physical partition location upon restore. |
| **-f /dev/rmt0** | This flag specifies the device to be used for the backup, in this case the tape device at rmt0. |

***Implementing Scheduled Backups:*** Implementing scheduled backups at the operating system level involves using a combination of the backup commands discussed already, and the system scheduler *cron*, to provide a basic automatic backup. More sophisticated backup scheduling and control is possible using script files to execute more complex functions such as checking file systems prior to backup, checking for error conditions, and unmounting file systems prior to execution. The highest level of control available can be found in higher level tools as described in Appendix B, “Higher Level Storage Management Products” on page 341.

For examples of this simple level of scheduling automatic backups, see InfoExplorer documentation, in particular the article "Implementing Scheduled Backups".

#### 6.5.2.2 Restores

This final section will look at some of the smit menus and system commands available to restore backed up information.

***Restoring Individual User Files:*** Restoring individual files that have been accidentally erased requires locating the backup medium on which they were stored. This can be time consuming and involves using the following command to search the backup archives:

```
# restore -T -f /dev/rmt0
```

This will list the contents of the backup archive on device `rmt0`. Alternatively, the `-i` flag can be used which will interactively prompt for which files and directories to restore.

**Note**

It is a good idea to restore files initially to the */tmp* directory to avoid overwriting information accidentally.

In order to restore from a complete level 0 backup of files or directories, do the following:

```
# smit restfile
```

This will start smit in the process for restoring files or directories:

```
                          Restore a File or Directory

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

                                                     [Entry Fields]
* Restore DEVICE                                  [/dev/fd0]        +/
* Target DIRECTORY                                [.]                /
  FILE or DIRECTORY to restore                    []
  (Leave blank to restore entire archive.)
  VERBOSE output?                                  no               +
  Number of BLOCKS to read in a single input      []                 #
    operation




F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

This will execute the following system command:

```
# cd . ; restore -xdq -f /dev/fd0
```

This will change directory to the target directory, and then restore all files from the backup media specified by the `-f` flag into it.

**-x** This flag causes the restore command to restore files by name.

**-d** This flag indicates that the file parameter is a directory, and all files in the directory should be restored by name.

**-q** This flag specifies that the medium specified by the `-f` flag is ready for use and a prompt is not required.

***Restoring a User File System:*** This section shows the method for restoring a full level 0 backup of a file system or directory:

```
# smit restfilesys
```

This starts smit in the process for restoring a file system or directory:

```
                              Restore a Filesystem

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

                                                        [Entry Fields]
* Restore DEVICE                                     [/dev/fd0]       +/
* Target DIRECTORY                                   [.]               /
  VERBOSE output?                                     yes             +
  Number of BLOCKS to read in a single input         []                #
    operation






F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

This causes the following command to be executed:

```
# cd . ; restore -rq -f /dev/rmt0 -v
```

This changes directory to the target directory and restores a complete file system. The file parameter would be ignored in this case, even if included.

**-r** This flag specifies that a whole file system is to be restored.

**-q** This flag specifies that the media is ready for reading and a prompt is not required.

**-f** This flag indicates the media device to be read from (the tape device at `rmt0` in this case).

**-v** This flag shows more information about the restore process, such as file sizes.

***Restoring a User Volume Group:*** In order to restore an entire user volume group, do the following:

```
# smit restvg
```

This starts smit in the process for remaking a volume group:

```
                              Remake a Volume Group

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

                                                     [Entry Fields]
* Restore DEVICE or FILE                          [/dev/rmt0]       +/
  SHRINK the filesystems?                         no                +
  PHYSICAL VOLUME names                           []                +
     (Leave blank to use the PHYSICAL VOLUMES listed
      in the vgname.data file in the backup image)
  Number of BLOCKS to read in a single input      []                 #
     (Leave blank to use a system default)




F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

This causes the following system command to be executed:

```
# restvg -f /dev/rmt0
```

The `restvg` command will restore the complete volume group from the specified media. If the option to shrink the file system is chosen, this is equivalent to using the `-s` flag with the system command, and causes the logical volumes within the volume group to be recreated at the minimum size necessary to contain their file systems.

Physical volume names can also be appended to the command (or included in the smit menu), and if they are, the specified physical volumes will be used to restore the volume group to, rather than those found in the VGname.data file. The physical volumes must be empty, and not belong to any other volume groups.

## 6.6 Summary

This chapter has covered the actual physical management of the elements of storage subsystems that have so far been discussed in theory. The following tasks were detailed:

- Managing Physical Volumes
  - How to configure new physical volumes

    This section discusses how to make new physical volumes known to the system.
  - How to modify physical volume characteristics

    This section discusses how to make physical volumes available and unavailable for access by the logical volume manager.
  - How to remove physical volumes from the system

    This section discusses how to remove physical volumes from the system.

  – How to monitor the state of physical volumes

- Managing Volume Groups

  This section discusses how to monitor physical volumes for error conditions. It also looks at finding out what physical volumes are on the system, which volume groups they belong to, and what is stored on them.

  – How to add new volume groups

    This section discusses how to create new volume groups and define their initial characteristics.

  – How to modify volume group characteristics

    This section discusses how to modify the state of volume groups and their characteristics. It looks at how to unlock volume groups, how to add physical volumes to volume groups, and remove physical volumes from volume groups.

  – How to import and export volume groups

    This section discusses how to make volume groups available and unavailable to the system through import and export, for the purposes of maintenance or transfer from system to system.

  – How to vary on and off volume groups

    This section discusses how to make volume groups ready for access by the logical volume manager, and other processes that wish to access data within a volume group.

  – How to monitor volume groups

    This section discusses monitoring volume groups from the point of view of listing the volume groups on the system, listing their characteristics, looking at the logical volumes contained within them, and listing the status of physical volumes within the volume groups.

- Managing Logical Volumes

  – How to add new logical volumes

    This section discusses how to create new logical volumes within a volume group.

  – How to remove logical volumes

    This section discusses how to remove logical volumes from volume groups.

  – How to increase the size of logical volumes

    This section discusses how to modify logical volumes in terms of increasing their size.

- Managing the Storage Environment

  – Performance Management

    This section discusses how to maximize performance when creating logical volumes and file systems, when modifying them, and through the use of striping. Reorganizing volume groups to improve performance is also looked at.

  – Availability Management

    This section discusses how to maximize availability when creating and modifying logical volumes through mirroring. Reorganizing volume groups to improve availability is also looked at.

  – Disk Space Management

    This section discusses how to maximize disk space utilization through options available at file system creation.

- Managing Backup and Restore

  – Backup Management

    This section discusses how to backup information from the user and system perspectives. Backing up user files, directories, file systems, and volume groups are examined, as well as creating installable system backups and scheduling backups.

  – Restore Management

    This section discusses how to restore backed up information.  Restoring user files, directories, file systems and volume groups are examined.

# Chapter 7. Storage Management Files and Commands Summary

This chapter provides details of storage management commands and usage. Commands common to AIX Version 3 and AIX Version 4 are covered, as well as those specific to AIX Version 4. Although common commands are being reviewed first, they will be initially grouped according to the AIX Version 4 fileset that they belong to. This will help the reader become more familiar with the AIX Version 4 environment.

## 7.1 How to Understand and Use this Chapter

To learn more about a file in an AIX Version 4 environment, it is advisable to first determine the fileset it belongs to, which is discussed in 7.1.1, “Major AIX Version 4 Filesets Relevant to Storage Management” on page 138. To learn more about a file in an AIX Version 3 environment, it is helpful to know what logical function the file has that corresponds to the AIX Version 4 fileset description. Otherwise, refer to each of the four fileset groups in 7.2, “Common Storage Management Commands Using AIX Version 3 Syntax” on page 140 and use the criteria in this section to read about a specific file.

As discussed in 7.1.1, “Major AIX Version 4 Filesets Relevant to Storage Management” on page 138, 7.2, “Common Storage Management Commands Using AIX Version 3 Syntax” on page 140 refers to all files in the four major fileset logical groups. It then advises the reader to check 7.3, “AIX Version 4 Specific File Features” on page 158 if necessary.

The files listed in 7.2, “Common Storage Management Commands Using AIX Version 3 Syntax” on page 140 and 7.3, “AIX Version 4 Specific File Features” on page 158 are organized in a logical manner according to the fileset that they belong to. Files in the same fileset are then grouped in the following logical breakdown:

1. What part of the installation package they belong to (that is, the usr, root or share part).
2. Which AIX Version 4 directory path are they in (it is assumed that the product bos.compat that includes filesets such as *AIX 3.2 to 4.1 Compatibility Links* has not been installed; the missing links are noted in 7.3, “AIX Version 4 Specific File Features” on page 158).
3. Alphabetical order (this ensures that commands that do similar tasks, such as the `ch*` commands that *change* object attributes, are located near each other in this chapter).

Each file is initially described by a brief statement that includes:

- A comment about the purpose of the file.
- Which of the following categories it belongs to:
  - Object file commands
  - Shell script commands (Korn shell, Bourne shell or C shell)

  – ASCII data file (that can be editted by the systems administrator using a text editor such as the vi editor)
  – Other file types

There is then a reference to its documentation status which is one of:

- *Undocumented*

  **Warning - DANGER - Warning**

  An undocumented command is usually not required to be used during setup or regular operational systems management tasks. Hence, these commands should be used with caution. Preferably, the equivalent high level command should be used first. For example, to copy a logical volume, try to use the documented `cplv` command before trying to use `copyrawlv`.

- *Documented*

  Search in AIX Version 4.1 Hypertext Information Base Library. In particular, refer to the hardcopy or electronic versions of *AIX Version 4.1 Commands Reference* and *AIX Version 3.2 Files Reference* for more details and examples concerning this file.

Finally, the chapter concludes by mentioning some other useful commands that are not part of the AIX Version 3 or AIX Version 4 base operating system. It then shows you examples of how to look at logical volume manager and journaled file system information.

### 7.1.1 Major AIX Version 4 Filesets Relevant to Storage Management

The *AIX Version 4.1 Installation Guide* describes how software is packaged, and reminds us that that the systems administrator needs to consider what functions are required, and hence what filesets should be installed. The command:

```
# lslpp -l bos.*|pg
```

will provide a list of base operating system filesets that are installed. The major ones discussed in this chapter are:

| | |
|---|---|
| **bos.rte.lvm** | Logical Volume Manager |
| **bos.rte.filesystem** | Filesystem Administration |
| **bos.sysmgt.sysbr** | System Backup and BOS Installation Utilities |
| **bos.rte.archive** | Archive Commands |

All files in these four filesets are referred to in this chapter, and are listed in section 7.2, “Common Storage Management Commands Using AIX Version 3 Syntax” on page 140. If a file has significant changes from AIX Version 3, or if it is a new file that has been introduced by AIX Version 4, then a reference is given to look in section 7.3, “AIX Version 4 Specific File Features” on page 158.

Other filesets that contain commands that are relevant to AIX storage management include:

| | |
|---|---|
| **bos.rte.boot** | Boot Commands |
| **bos.rte.serv_aid** | Error Log Service Aids |
| **bos.diag.rte** | Hardware Diagnostics |
| **bos.rte.diag** | Diagnostics |
| **bos.sysmgt.serv_aid** | Software Error Logging and Dump Service Aids |
| **bos.rte.compare** | File Compare Commands |
| **bos.rte.methods** | Device Configuration Methods |
| **bos.sysmgt.quota** | File System Quota Commands |

Only some of the most important files from these filesets that are relevant to AIX storage management are discussed in this chapter.

The contents of a fileset can be seen from the command:

```
# lslpp -f fileset_name |pg
```

Note that it is easy to find what fileset a file belongs to in an AIX Version 4 system, if the filset in question is installed, by using the command:

```
# lslpp -f all|pg
```

and by then using the / search syntax at the colon prompt. For example, to find that the `cplv` command belongs to the bos.rte.lvm fileset, type:

```
:/cplv
```

and press the **Enter** key followed by entering:

```
:-
```

once or twice to move backwards through the output until the fileset name appears, such as:

```
  bos.rte.lvm 4.1.0.0   /usr/lib/liblvm.a
```

## 7.2 Common Storage Management Commands Using AIX Version 3 Syntax

This section looks at the AIX Version 3 commands.

### 7.2.1 Using Logical Volume Manager Files

The following commands are logical volume manager related.

#### 7.2.1.1 Usr Part Files which are in the /usr/sbin Directory.

**allocp** `allocp` is an object file command that is used to generate an allocation map that is required when a logical volume is created, extended, reduced or removed.

It is an undocumented command whose usage is:

```
allocp: [-i LVid] [-t Type] [-c Copies]
        [-s Size] [-k] [-u UpperBound>]
        [-e InterPolicy] [-a InterPolicy]
```

**cfgvg** `cfgvg` is a Bourne shell script command that is called by /etc/rc to varyon volume groups that have the auto-varyon flag set.

It is an undocumented command that requires no flags.

**chlv** `chlv` is a Bourne shell script command that changes only the characteristics of a logical volume.

It is a documented command whose usage is:

```
chlv -n NewLVname LVname
chlv [-a IntraPolicy] [-e InterPolicy] [-L Label] [-u UpperBound]
        [-s Strict] [-b BadBlocks] [-d Schedule] [-p Permission]
        [-r Relocate] [-t Type] [-w MirrorWriteConsistency]
        [-v Verify] [-x MaxLPs] LVname...
```

**chps** `chps` is an object file command that changes the attributes of a paging space.

It is a documented command whose usage is:

```
chps [-s NewLPs] [-a {y|n}] Psname
```

**chpv** `chpv` is a Bourne shell script command that changes the characteristics of a physical volume.

It is a documented command whose usage is:

```
chpv { -a Allocation | -v Availability } PVname
```

**chvg** `chvg` is a Bourne shell script command that changes the characteristics of a volume group.

It is a documented command whose usage is:

```
chvg [-a Auto on] [-Q quorum] VGname...
```

Note that there is a new flag available, `-u` in AIX Version 4. Please refer to the entry for `chvg` in 7.3, “AIX Version 4 Specific File Features” on page 158.

**copyrawlv** `copyrawlv` is an object file command that is used by `cplv` to do the actual copying on disk.

Extreme caution is required if this executable is used by the systems administrator The `strings` command suggests that `copyrawlv` does not contain any built in syntax advice and hence is not likely to be designed to used manually. However, as an example, after some necessary set up work, `cplv` uses this command as follows:

```
# Copy one lv to another.
copyrawlv /dev/sRawLVName /dev/dRawLVName Size
```

Where `sRawLVName` is the source logical volume, `dRawLVName` is the destination, and `Size` is the size.

**cplv** `cplv` is a Bourne shell script command that copies a logical volume.

It is a documented command whose usage is:

```
cplv [-v VGname] [-y NewName | -Y Prefix] SourceLV
cplv -e [-f] DestinationLV SourceLV.
```

**exportvg** `exportvg` is a Bourne shell script command that exports the definition of a volume group.

It is a documented command whose usage is:

```
exportvg VGname
```

Note that this command does *not* change any volume group configuration information on any of the disks that belong to it, but the command only removes all configuration information about the volume group (and any associated journalled file systems), from the system on which the `exportvg` is executed.

**extendlv** `extendlv` is a Bourne shell script command that extends the size of a logical volume.

It is a documented command whose usage is:

```
extendlv [-a IntraPolicy] [-e InterPolicy] [-m MapFile]
        [-s Strict] [-u UpperBound] LVname NumberOfLPs [PVname...]
```

**extendvg** `extendvg` is a Bourne shell script command that extends a volume group by adding a physical volume.

It is a documented command whose usage is:

```
extendvg [-f] VGname PVname...
```

**getlvcb** `getlvcb` is an object file command that gets information about a logical volume from the logical volume control block.

It is an undocumented command whose usage is: suggested by other high level shell scripts, such as `updatelv`, that call it. This script tells us that the syntax is like:

```
getlvcb -aceLrsSPtu LVName
getlvcb -f LVName
```

Please refer to the entry for `getlvcb` in 7.3, "AIX Version 4 Specific File Features" on page 158.

**getlvname** `cfgvg` is an object file command that generates or checks a logical volume name.

It is an undocumented command whose usage is:

```
getlvname [-Y Prefix] [-n LVname] [Type]
```

**getlvodm** `getlvodm` is an object file command that obtains volume group and logical volume information from the ODM.

It is an undocumented command whose usage is:

```
getlvodm [-a LVdescript] [-B LVdesrcript] [-b LVid]
         [-cVid] [-C] [-d VGdescript]
         [-e LVid] [-F] [-g PVid] [-h]
         [-j PVdescript] [-k] [-L VGdescript]
         [-l LVdescript] [-m LVid] [-p PVdescript]
         [-r LVid] [-s VGdescript] [-t VGid]
         [-u VGdescript] [-v VGdescript] [-w VGid]
         [-y LVid]
```

Please refer to the entry for `getlvodm` in 7.3, "AIX Version 4 Specific File Features" on page 158.

**getvgname** `getvgname` is an object file command that is used to return a new unused volume group name.

It is an undocumented command whose usage is:

```
getvgname [-n VGname]
```

**importvg** `importvg` is a Bourne shell script command that brings into the system all the configuration details of a volume group from a set of physical volumes.

It is a documented command whose usage is:

```
importvg [-V MajorNumber] [-y VGname] [-f] PVname
```

Please refer to the entry for `importvg` in 7.3, "AIX Version 4 Specific File Features" on page 158.

**ipl_varyon** `ipl_varyon` is an object file command that is used to vary on the root volume group during system boot processing.

It is an undocumented command whose usage is:

```
ipl_varyon [-d ipldevice] [-i ] [-v ]
```

**lchangelv** `lchangelv` is an object file command that changes logical volume attributes in the VGDA on disk.

It is an undocumented command whose usage is:

```
lchangelv -l LVid [-s MaxPartitions] [-n LVname] [-M SchedulePolicy]
     [-p Permissions] [-r BadBlocks] [-v WriteVerify][-w mirwrt_consist]
```

**lchangepv** `lchangepv` is an object file command that that changes physical volume attributes in the VGDA on disk.

It is an undocumented command whose usage is:

```
lchangepv -g VGid -p PVid [-r RemoveMode] [-a AllocateMode]
```

**lcreatelv** `lcreatelv` is an object file command that creates a logical volume on disk.

It is an undocumented command whose usage is:

```
lcreatelv -N LVname -g VGid -n MinorNumber [ -M MirrorPolicy]
            [-s MaxLPs] [-p Permissions] [ -r Badblocks] [-v WriteVerify]
            [-w mirwrt_consist]
```

**lcreatevg** `lcreatevg` is an object file command that creates the volume group on the disk and populates the VGDA.

It is an undocumented command whose usage is:

```
lcreatevg -a VGname -V MajorNumber -N PVname -n MaxLVs
          -D VGDescriptorSize -s PPSize [-f] [-t]
```

**ldeletelv** `ldeletelv` is an object file command that removes a logical volume from a volume group.

It is an undocumented command whose usage is:

```
ldeletelv -l LVid
```

**ldeletepv** `ldeletepv` is an object file command that removes a physical volume from a volume group.

It is an undocumented command whose usage is:

```
ldeletepv -g VGid -p PVid
```

**lextendlv** `lextendlv` is an object file command that extends a logical volume by `Size` partitions according to the map file `Filename` and updates the VGDA on disk.

It is an undocumented command whose usage is:

```
lextendlv -l LVid -s Size Filename
```

**linstallpv** `linstallpv` is an object file command that adds a physical volume to a volume group and updates the VGDA on disk.

It is an undocumented command whose usage is:

```
linstallpv -N PVname -g VGid [-f]
```

**lmigratepp** `lmigratepp` is an object file command that is used by higher level commands such as `migratepv` to copy a physical partition from one physical volume to another.

It is an undocumented command whose usage is:

```
lmigratepp -g VGid -p SourcePVid -n SourcePPnumber
       -P DestinationPVid -N DestinationPPnumber
```

**lmktemp** `lmktemp` is an object file command that is used to create temporary map files for use by `allocp` during the creation and removal of logical volumes (refer to the contents of the `mklv` and `rmlv` scripts).

It is an undocumented command whose usage is:

```
lmktemp TmpMapFile [size]
```

**lquerylv** `lquerylv` is an object file command that obtains logical volume information from the VGDA for many other commands.

It is an undocumented command whose usage is:

```
lquerylv -L LVid [-p PVname] [-NGnMScsPRvoadlArtw]
```

Please refer to the entry for `lquerylv` in 7.3, “AIX Version 4 Specific File Features” on page 158.

For examples on how to use `lquerylv`, please refer to 7.4, “Using Commands to View AIX Version 4 Logical Volume Manager Information” on page 164.

**lquerypv** `lquerypv` is an object file command that obtains physical volume information from structures in memory unless the PVname is specified.

It is an undocumented command whose usage is:

```
lquerypv -p PVid [-g VGid | -N PVname] [-scPnaDdAt]
```

For examples on how to use `lquerypv`, please refer to 7.4, “Using Commands to View AIX Version 4 Logical Volume Manager Information” on page 164.

**lqueryvg** `lqueryvg` is an object file command that obtains volume group information from structures in memory unless the PVname is specified.

It is an undocumented command whose usage is:

```
lqueryvg [-g VGid | -p PVname] [-NsFncDaLPAvt]
```

For examples on how to use `lqueryvg`, please refer to 7.4, “Using Commands to View AIX Version 4 Logical Volume Manager Information” on page 164.

**lqueryvgs** `lqueryvgs` is an object file command that provides a summary of the volume groups known to the system.

It is an undocumented command whose usage is:

```
lqueryvgs [-NGAt]
```

**lreducelv** `lreducelv` is an object file command that reduces the size of a logical volume, *not* a journaled file system, and updates only the VGDA on disk.

It is an undocumented command whose usage is:

```
lreducelv -l LVid -s Size Filename
```

**lresynclp** `lresynclp` is an object file command that synchronizes a stale logical partition in a logical volume.

It is an undocumented command whose usage is:

```
lresynclp -l LVid -n LPnumber
```

**lresynclv** `lresynclv` is an object file command that synchronizes all stale logical partitions in a logical volume.

It is an undocumented command whose usage is:

```
lresynclv -l LVid
```

**lresyncpv** `lresyncpv` is an object file command that will synchronize all physical partitions on a physical volume with the related copies of the logical partition to which they correspond.

It is an undocumented command whose usage is:

```
lresyncpv -g VGid -p PVid
```

**lslv** `lslv` is an object file command that shows you information about a logical volume.

It is a documented command whose usage is:

```
lslv [-l | -m] [-n DescriptorPV] LVname
lslv: [-n DescriptorPV] -p PVname [LVname]
```

For examples on how to use `lslv`, please refer to 7.4, “Using Commands to View AIX Version 4 Logical Volume Manager Information” on page 164.

Please refer to the entry for `lslv` in 7.3, “AIX Version 4 Specific File Features” on page 158.

**lsps** `lsps` is an object file command that shows you information about paging type logical volumes.

It is a documented command whose usage is:

```
lsps {-s | [-c | -l] {-a | Psname | -t {lv|nfs} } }
```

**lspv** `lspv` is an object file command that shows you information about a physical volume in a volume group.

It is a documented command whose usage is:

```
lspv [-M | -l | -p]  [-n DescriptorPV] [-v VGid] [PVname]
```

For examples on how to use `lspv`, please refer to 7.4, “Using Commands to View AIX Version 4 Logical Volume Manager Information” on page 164.

**lsvg** `lsvg` is an object file command that shows you information about the volume groups in your system.

It is a documented command whose usage is:

```
lsvg [-o] [-n PVname]
       lsvg [-i] [-M | -l | -p] VGname
```

For examples on how to use `lslv`, please refer to 7.4, “Using Commands to View AIX Version 4 Logical Volume Manager Information” on page 164.

**lsvgfs** `lsvgfs` is an object file command that lists the file systems that are in the specified volume group.

It is a documented command whose usage is:

```
lsvgfs VGname
```

**lvaryoffvg** `lvaryoffvg` is an object file command that is called by the varyoffvg command to vary off a volume group, and then update the VGDA on disk, but not the ODM.

It is an undocumented command whose usage is:

```
lvaryoffvg -g VGid [-f]
```

**lvaryonvg** `lvaryonvg` is an object file command that is called by the `mkvg` command to vary on a volume group.

It is an undocumented command whose usage is:

```
lvaryonvg -a VGname -V MajorNumber -g VGid
        [-ornpft] Filename
```

**lvchkmajor** `lvchkmajor` is an object file command that checks whether a major device number is being used.

It is a documented command whose usage is:

```
lvchkmajor Majornumber VGname
```

**lvgenmajor** `lvgenmajor` is an object file command that creates or gets the major number for the logical volumes that belong to the volume group specified as an argument to the `redefinevg` or `mkvg` commands.

It is an undocumented command whose usage is:

```
lvgenmajor VGname
```

**lvgenminor** `lvgenminor` is an object file command that returns a minor number that is used during the creation of a logical volume.

It is an undocumented command whose usage is:

```
lvgenminor [-p PreferredNumber] MajorNumber NewDeviceName
```

**lvlstmajor** `lvlstmajor` is an object file command that lists currently unused major numbers.

It is a documented command whose usage is:

```
lvlstmajor
```

**lvmmsg** `lvmmsg` is an object file command that is used by other logical volume manager commands to generate messages.

It is an undocumented command whose usage is:

```
lvmmsg MessageNumber
```

**lvrelmajor** `lvrelmajor` is an object file command that frees up the major number of a volume group when its removed from the system.

It is an undocumented command whose usage is:

```
lvrelmajor VGname
```

**lvrelminor** `lvrelminor` is an object file command that frees up a minor number for a logical volume or volume group that's removed from the system.

It is an undocumented command whose usage is:

```
lvrelminor Name
```

**migfix** `migfix` is an object file command that is used by the `reorgvg` command to help determine the proper order of physical partition moves.

It is an undocumented command whose usage is:

```
migfix map_file_names
```

This command is used by the `reorgvg` script command.

**migratepv** `migratepv` is a Bourne shell script command that is used to move physical partitions from one physical volume to another.

It is a documented command whose usage is:

```
migratepv [-i] [-l LVname] SourcePV DestinationPV...
```

For examples on how to use `migratepv`, please refer to 8.8.1, “How to Use the migratepv Command” on page 315.

**mklv** `mklv` is a Bourne shell script command that creates a logical volume.

It is a documented command whose usage is:

```
mklv [-a IntraPolicy] [-b BadBlocks] [-c Copies] [-d Schedule]
[-e InterPolicy] [-i] [-L Label] [-m MapFile] [-r Relocate]
[-s Strict] [-t Type] [-u UpperBound] [-v Verify] [-w MWC]
[-x MaxLPs] [-y LVname] [-Y Prefix] VGname NumberOfLPs [PVname...]
```

Please refer to the entry for `mklv` in 7.3, "AIX Version 4 Specific File Features" on page 158.

**mklvcopy** `mklvcopy` is a Bourne shell script command that makes copies of logical partitions for a logical volume

It is a documented command whose usage is:

```
mklvcopy [-a IntraPolicy] [-e InterPolicy]
        [-k] [-m MapFile] [-u UpperBound] [-s Strict]
        LVname LPcopies [PVname...]
```

**mkps** `mkps` is an object file command that creates a paging space using a logical volume or an NFS server.

It is a documented command whose usage is:

```
mkps [-a] [-n] [-t lv] -s NumLPs Vgname Pvname
mkps [-a] [-n] -t nfs hostname pathname
```

**mkvg** `mkvg` is a Bourne shell script command that creates a volume group.

It is a documented command whose usage is:

```
mkvg [-d MaxPVs] [-f] [-i] [-m MaxPVsize]
        [-n] [-s PPsize]
        [-V MajorNumber] [-y VGname] PVname...
```

**putlvcb** `putlvcb` is an object file command that is used by high-level shell scripts `updatelv`, `rmlvcopy`, `mklvcopy mklv`, `extendlv`, `cplv` and `chlv` to update the logical volume control block. Hence, be *very* careful when you change logical volume information.

It is an undocumented command whose usage is:

```
putlvcb [-a IntraPolicy] [-c Copies] [-e InterPolicy] [-i LVid]
        [-n Size] [-r Relocate] [-L Label] [-t Type]
        [-u UpperBound] [-s Strict] LVName
putlvcb [-f FileSystemName] LVName
```

Please refer to the entry for `putlvcb` in 7.3, "AIX Version 4 Specific File Features" on page 158.

**putlvodm** `putlvodm` is an object file command that places logical volume manager information *only* into the ODM, so it is called by many other logical volume manager commands to help ensure that ODM information is synchronized with data stored in other areas, such as the disk VGDA.

It is an undocumented command whose usage is:

```
putlvodm [-a IntraPolicy] [-B label] [-c Copies] [-e InterPolicy]
         [-L LVid] [-l LVname] [-n NewLVName] [-r Relocate]
         [-s Strict] [-t Type] [-u UpperBound] [-y Copyflag]
         [-z Size] LVid
putlvodm [-o Auto-on] [-k] [-K] [-q VGstate]
         [-v VGname -m majornum] [-V] VGid
putlvodm [-p VGid] [-P] PVid
```

Please refer to the entry for `putlvodm` in 7.3, “AIX Version 4 Specific File Features” on page 158.

**redefinevg** `redefinevg` is a Bourne shell script command that redefines the set of physical volumes of the specified volume group in the device configuration database.

It is a documented command whose usage is:

```
redefinevg {-d PVname | -i VGid} [-V MajorNumber] VGname
```

**reducevg** `reducevg` is a Bourne shell script command that deletes physical volumes from a specified volume group.

It is a documented command whose usage is:

```
reducevg [-d] [-f] VGname PVname...
```

**reorgvg** `reorgvg` is a Bourne shell script command that reorganizes the physical partition allocation map for a volume group.

It is a documented command whose usage is:

```
reorgvg [-i] VGname [LVname...]
```

**rmlv** `rmlv` is a Bourne shell script command that removes logical volumes from a volume group.

It is a documented command whose usage is:

```
rmlv [-f] LVname...
```

Please refer to the entry for `rmlv` in 7.3, “AIX Version 4 Specific File Features” on page 158.

**rmlvcopy** `rmlvcopy` is a Bourne shell script command that removes copies from a logical volume.

It is a documented command whose usage is:

```
rmlvcopy LVname LPcopies [PVname...]
```

**rmps** `rmps` is an object file command that removes a paging space.

It is a documented command whose usage is:

```
rmps Psname
```

**synclvodm** `synclvodm` is a Bourne shell script command that synchronizes logical volume and volume group information.

It is a documented command whose usage is:

```
synclvodm [-v] VGname [LVname...]
```

**syncvg** `syncvg` is a Bourne shell script command that synchronizes logical partition copies.

It is a documented command whose usage is:

```
syncvg [-i] [-f] {-l|-p|-v} Name
```

**tstresp** `tstresp` is an object file command that is used by the `cplv`, `extendvg`, `mkvg` and `rmlv` shell scripts to convert a user's response to a question into a return code, so that the calling command can act appropriately.

It is an undocumented command whose usage is:

```
# tstresp yes
#  echo $?
1
# tstresp no
# echo $?
0
```

**updatelv** `updatelv` is a Bourne shell script command that updates the logical volume control block and the ODM.

It is an undocumented command whose usage is:

```
updatelv LVname VGname
```

**updatevg** `updatevg` is a Bourne shell script command that is used to synchronize volume group information in the ODM if the ODM has at least a valid volume group identifier.

It is an undocumented command whose usage is:

```
updatevg VGname
```

**varyoffvg** `varyoffvg` is a Bourne shell script command that deactivates a volume group so that it can't be accessed.

It is a documented command whose usage is:

```
varyoffvg [-s] VGname
```

**varyonvg** `varyonvg` is an object file command that activates a volume group so that it can be accessed.

It is a documented command whose usage is:

```
varyonvg [-f] [-n] [-s] [-p] VGname
```

#### 7.2.1.2 Usr Part Files which are in the /usr/lib Directory

**liblvm.a** This is the Logical Volume Manager Library that is used by many logical volume manager subroutines. Please refer to programming information in AIX Version 4.1 Hypertext Information Base Library.

**libsm.a** This is another logical volume manager library. You can use the `what` command to see which functions are in this library. Please refer to programming information in AIX Version 4.1 Hypertext Information Base Library.

**./methods/deflvm**
This is a file that is used during device configurations. Again, it is only of interest to programmers.

There are no files in the root or share parts of the bos.rte.lvm fileset.

### 7.2.2 Using File System Administration Commands

#### 7.2.2.1 Usr Part Files which are in the /usr/sbin Directory.

**chfs** `chfs` is an object file command that changes file system attributes such as mount point, permissions, and size.

It is a documented command whose usage is:

```
chfs [-n Nodename] [-m NewMountpoint] [-u Group] [-A {yes|no}]
     [-t {yes|no}] [-p {ro|rw}] [-a Attribute=Value] [-d Attribute]
     FileSystem
```

**chvfs** chvfs is an object file command that changes entries in the /etc/vfs file.

It is a documented command whose usage is:

```
chvfs VfsEntry
```

**crfs** crfs is an object file command that creates a file system within a previously created logical volume.

It is a documented command whose usage is:

```
crfs -v Vfs {-g Volumegroup | -d Device} -m Mountpoint
   [-u Mountgroup] [-A {yes|no}] [-t {yes|no}] [-p {ro|rw}]
   [-l Logpartitions] [-n nodename] [-a Attribute=Value]
```

**crvfs** crvfs is an object file command that adds entries to the /etc/vfs file.

It is a documented command whose usage is:

```
crvfs VfsEntry
```

**dfsck** dfsck is an object file command that checks for file system consistency, and allows interactive repair of file systems.

It is a documented command whose usage is:

```
dfsck [-Options] Filesystem1 ... [-Options] Filesystem2 ...
```

**dumpfs** dumpfs is an object file command that prints out the superblock, i-node map, and disk map for a file system or special device.

It is a documented command whose usage is:

```
dumpfs {FileSystem | Device}
```

**fdformat** fdformat is an object file command that formats diskettes or read/write optical media disks.

It is a documented command whose usage is:

```
fdformat [-h] Device
```

**ff** ff is an object file command that reads i-node information for the specified filesystem, and then writes it to stdout.

It is a documented command whose usage is:

```
ff [-3MIldsu -V Vfs -i Ilist -p Path -n File
   -a # -m # -c #] /InputDevice
```

**format** format is an object file command that formats diskettes for use by the system.

It is a documented command whose usage is:

```
format [-fl] [-d Device]
```

**fsck** fsck is an object file command that checks for file system consistency, and allows interactive repair of file systems.

It is a documented command whose usage is:

```
fsck [-y|-n|-p] [-f] [-V Vfs] [-d #] [-i #]
     [-t File] [-o Options] Filesystem ...
```

**fsdb** fsdb is an object file command that allows the user to examine, alter, and debug the file system specified in the command.

It is a documented command whose usage is:

```
fsdb FileSystem [-]
```

**fuser**

`fuser` is an object file command that lists the process numbers of local processes that use the file(s) specified.

It is a documented command whose usage is:

```
fuser [-ku] File ... [-]
```

See 7.3, “AIX Version 4 Specific File Features” on page 158 for changes in the `fuser` command.

**imfs**

`imfs` is an object file command that is uses information from /etc/filesystems to export or import logical volumes.

It is an undocumented command whose usage is:

```
imfs [-xlf] vgname ...
```

See 7.3, “AIX Version 4 Specific File Features” on page 158 for changes in the `imfs` command.

**logform**

`logform` is an object file command that is used to initialize a logical volume for use a journaled file system log.

It is a documented command whose usage is:

```
logform LogName
```

**logredo**

`logredo` is an object file command that uses the journaled file system log to reestablish consistency in the specified file system.

It is an undocumented command whose usage is:

```
logredo [-n] filename
```

**lsfs**

`lsfs` is an object file command that displays characteristics of the specified file system such as mount points, permissions, and file system size.

It is a documented command whose usage is:

```
lsjfs [-q] {-a | -v Vfs| -u Group | Filesystem ...}
```

**lsjfs**

`lsjfs` is a Korn shell script file that processes the output of the `lsfs` command into a form acceptable by smit.

It is an undocumented command whose usage is:

```
lsjfs [-q] [-c|-l] {-a | -v vfstype | -u mtgroup | fsname [fsname ...]}
```

**lsvfs**

`lsvfs` is an object file command that lists entries in the /etc/vfs file.

It is a documented command whose usage is:

```
lsvfs {-a | Vfsname}
```

**mkfs**

`mkfs` is an object file command that makes a new file system on the specified device.

It is a documented command whose usage is:

```
mkfs [-b BootProgram] [-i Inodes] [-l Label]
     [-o Options] [-p Prototype]
     [-s Size] [-v VolumeLabel] [-V vfs] {Device|Filesystem}
```

**mklost+found**

`mklost+found` is a Bourne shell script that creates a lost and found directory in the current directory for the `fsck` command.

It is a documented command whose usage is:

```
mklost+found
```

**mknod** `mknod` is an object file command that makes a directory entry and creates an i-node for a special file when used by the root user. Otherwise it creates a named pipeline.

It is a documented command whose usage is:

```
mknod Name {p}
mknod Name {b | p} Major Minor
```

**mkproto** `mkproto` is a Bourne shell script that constructs a prototype for a new file system.

It is a documented command whose usage is:

```
mkproto Special Proto
```

**mount** `mount` is an object file command that instructs the operating system to make the specified file system available for use from the specified point.

It is a documented command whose usage is:

```
mount [-fipr] [-n Node] [-o Options] [-t Type] [-{v|V} Vfs]
          [-a | all | [[Node:]Device] [Directory]]
```

**ncheck** `ncheck` is an object file command that displays the path name for files specified by i-node in the specified file system.

It is a documented command whose usage is:

```
ncheck [ [-a] [-i InodeNumbers ...] | [-s] ] [FileSystem]
```

**proto** `proto` is an object file command that creates a prototype file for a file system or part of a file system.

It is a documented command whose usage is:

```
proto Directory [Prefix]
```

**rmfs** `rmfs` is an object file command that removes a file system.

It is a documented command whose usage is:

```
rmfs [-r] FileSystem
```

**rmvfs** `rmvfs` is an object file command that removes entries from the /etc/vfs file.

It is a documented command whose usage is:

```
rmvfs VfsName
```

**umount** `umount` is an object file command that unmounts a file system from its mount point.

It is a documented command whose usage is:

```
umount [-sf] {-a|-n Node|-t Type|all|allr|Device|File|Directory|Filesystem}
```

**unmount** `unmount` is an object file command that has exactly the same function as the `umount` command.

It is a documented command whose usage is:

```
unmount [-sf] {-a|-n Node|-t Type|all|allr|Device|File|Directory|Filesystem}
```

#### 7.2.2.2 Usr Part Files which are in the /usr/bin Directory

**istat** `istat` is an object file command that displays information about a particular i-node number.

It is a documented command whose usage is:

```
istat {FileName | I-NodeNumber Device}
```

#### 7.2.2.3 Root Part Files which are in the /etc Directory

**filesystem**
`filesystems` is a text file containing file system definitions for all file systems.

**vfs** `vfs` is a text file containing definitions for all file system types.

#### 7.2.2.4 Root Part Files which are in the /sbin/helpers Directory

**v3fshelper** `v3fshelper` is an object file command that is used by the `mount` and `umount` commands to implement file system mounts and unmounts.

There are no files in the share parts of the bos.rte.filesystem fileset.

### 7.2.3 Using System Backup and BOS Installation Utilities

This section contains backup and installation commands.

#### 7.2.3.1 Usr Part Files which are in the /usr/lpp/bosinst Directory

**bosmenus** `bosmenus` is an object file command that displays the BOS administration menus. This command has changed in AIX Version 4, please refer to 7.3, “AIX Version 4 Specific File Features” on page 158 for details.

#### 7.2.3.2 Usr Part Files which are in the /usr/bin Directory

**mksysb** `mksysb` is a Korn shell script that creates an installable image of the root volume group.

It is a documented command whose usage is:

```
mksysb Device
```

**mkszfile** `mkszfile` is a Korn shell script that creates the `/.fs.size` file for use by the `mksysb` command.

It is a documented command whose usage is:

```
mkszfile [-f]
```

#### 7.2.3.3 Usr Part Files which are in the /usr/sbin Directory

**mkinsttape** `mkinsttape` is a Bourne shell script that creates the BOS install/maintenance tape image.

It is an undocumented command whose usage is:

```
mkinsttape [/file]
```

There are no files in the root or share parts of the bos.sysmgt.sysbr fileset.

## 7.2.4 Using Archive Commands

This section contains the archive commmands.

### 7.2.4.1 Usr Part Files which are in the /usr/bin Directory

**compress** `compress` is an object file command that reduces the size of the specified file using the adaptive LZ algorithm.

It is a documented command whose usage is:

```
compress [-CcdFfnqVv] [-b Bits] [file ...]
```

**cpio** `cpio` is an object file command that copies files into and out of archive storage.

It is a documented command whose usage is:

```
cpio -o[acvBC<value> <name-list >collection
cpio -i[bcdmrstuvfBC<value>S6] [pattern ...] <collection>
cpio -p[adlmuv] directory <name-list>
```

**dd** `dd` is an object file command that reads a file in, converts the data (if required), and copies the file out.

It is a documented command whose usage is:

```
dd [cbs=BlockSize] [count=InputBlocks] [files= InputFiles]
   [fskip=SkipEOFs] [if=InFile] [of=OutFile] [seek=RecordNumber]
   [skip=SkipInputBlocks] [ibs=InputBlockSize] [obs=OutputBlockSize]
   [bs=BlockSize] [conv=[ascii|ebcdic|lcase|ucase|iblock|ibm|noerror
   |swab|sync|oblock|notrunc|block|unblock]]
```

**mt** `mt` is an object file command that sends commands to a streaming tape device.

It is a documented command whose usage is:

```
mt [ -f device ] subcommand [ count ]
valid subcommands are: weof eof fsf bsf fsr bsr rewind offline
                       rewoffl status
```

**pack** `pack` is an object file command that saves the specified file(s) in a compressed form.

It is a documented command whose usage is:

```
pack [-] [-f] File ...
```

**pax** `pax` is object file command that extracts, writes and lists members of archive files. It also copies file and directory hierarchies.

It is a documented command whose usage is:

```
pax -[cdnv] [-f archive] [-s replstr] [pattern...]
pax -r [-cdiknuvy] [-f archive] [-p string] [-s replstr] [pattern...]
pax -w [-dituvyX] [-b blocking] [[-a] -f archive] [-s replstr]
      [-x format] [pathname...]
pax -r -w [-diklntuvyX] [-p string] [-s replstr] [pathname...] directory
```

See 7.3, “AIX Version 4 Specific File Features” on page 158 for changes in AIX Version 4.

**pcat** `pcat` is an object file command that unpacks the specified files and writes them to standard output.

It is a documented command whose usage is:

```
pcat {File|File.Z} ...
```

**tar** `tar` is an object file command that writes files to, or retrieves files from, archive storage media.

It is a documented command whose usage is:

```
tar -{crtux} [-BFdhilmpsvw] [-num] [-ffile[-num]]
             [-bblocks] [-S feet] [-S feet@density] [-S blocksb]
             [-Linputlist] [-C directory] [-Nblocks] file ...
```

See 7.3, "AIX Version 4 Specific File Features" on page 158 for changes in AIX Version 4.

**tcopy** `tcopy` is an object file command that copies information from one tape device to another.

It is a documented command whose usage is:

```
tcopy Source [Destination]
```

**tctl** `tctl` is an object file command that sends commands to a streaming tape device.

It is a documented command whose usage is:

```
tctl [ -Benv ] [ -b num ] [ -p num ]
     [ -f device ] subcommand [ count ]
valid subcommands are: weof eof fsf bsf fsr bsr rewind offline rewoffl
                       erase retension read write status
```

See 7.3, "AIX Version 4 Specific File Features" on page 158 for changes in AIX Version 4.

**uncompress** `uncompress` is an object file command that restores files compressed by the `compress` command to their original size.

It is a documented command whose usage is:

```
uncompress [-cFfnqVv] [file ...]
```

**unpack** `unpack` is an object file command that expands files that were compressed using the `pack` command.

It is a documented command whose usage is:

```
unpack File ...
```

**zcat** `zcat` is an object file command that will uncompress data in tha same way as the `uncompress` though always to standard output.

It is a documented command whose usage is:

```
zcat [-FfnV] [file ...]
```

See 7.3, "AIX Version 4 Specific File Features" on page 158 for changes in AIX Version 4.

#### 7.2.4.2 Usr Part Files which are in the /usr/sbin Directory

**backbyinode**

`backbyinode` is an object file command that uses the `backup` command to backup files by i-node.

It is a documented command whose usage is:

```
backbyinode [-b Number1] [-f Device] [-l Number2]
            [-u] [-?] [-c] [w|W]] [-Level] [Filesystem]
```

**backbyname**

`backbyname` is an object file command that used the `backup` command to backup files by name.

It is a documented command whose usage is:

```
backbyname -i [-b Number] [-p [-e RegularExpression]] [-f Device]
              [-INumber] [-o] [-q] [-v]
```

**backup** `backup` is an object file command that backs up files or file systems by i-node or name.

It is a documented command whose usage is:

```
backup [-b Number1] [-f Device] [-l Number2]
       [-u] [-?] [-c] [w|W]] [-Level] [Filesystem]
backup -i [-b Number] [-p [-e RegularExpression]] [-f Device]
          [-INumber] [-o] [-q] [-v]
```

**flcopy** `flcopy` is an object file command that copies information to and from diskettes.

It is a documented command whose usage is:

```
flcopy [-f Device] [-h] [-r] [-t Number]
```

**rdump** `rdump` is an object file command that backups local files by i-node number to a remote machine.

It is a documented command whose usage is:

```
rdump [-b Number1] [-d Density] -f Machine: Device [-sSize]
      [-u] [-?] [-c] [w|W]] [-Level] [Filesystem]
```

**restbyinode** `restbyinode` is an object file command that uses the restore command to restore files that were backed up by i-node.

It is an undocumented command whose usage is:

```
restbyinode -[thvy] [-f device] [-s #] [-b #] [file file ...]
restbyinode -[xhmvy] [-f device] [-s #] [-b #] [file file ...]
restbyinode -[ihmvy] [-f device] [-s #] [-b #]
restbyinode -[rvy] [-f device] [-s #] [-b #]
restbyinode -[Rvy] [-f device] [-s #] [-b #]
```

See 7.3, “AIX Version 4 Specific File Features” on page 158 for changes in AIX Version 4.

**restbyname** `restbyname` is an object file command that uses the `restore` command to restore files that were backed up by name.

It is a documented command whose usage is:

```
restbyname -[thvy] [-f device] [-s #] [-b #] [file file ...]
restbyname -[xhmvy] [-f device] [-s #] [-b #] [file file ...]
restbyname -[ihmvy] [-f device] [-s #] [-b #]
restbyname -[rvy] [-f device] [-s #] [-b #]
restbyname -[Rvy] [-f device] [-s #] [-b #]
```

**restore** `restore` is an object file command that restores files or file systems that were backed up using the `backup` command.

It is a documented command whose usage is:

```
For by name backups:
restore -[AxvqMd] [-f device] [-s #] [-b #] [file file ...]
restore -[t | T]vq] [-f device] [-s #] [-b #]
restore [-X # [-d]] [-f device] [-s #] [-b #] [file file ...]
For version 2 inode backups:
restore [-d] -[r] [-f device] [file ...]
For version 3 inode backups:
restore -[t | T]hvyB] [-f device] [-s #] [-b #] [file file ...]
restore -[xhmvyB] [-f device] [-s #] [-b #] [file file ...]
restore -[ihmvy] [-f device] [-s #] [-b #]
restore -[rvyB] [-f device] [-s #] [-b #]
restore -[RvyB] [-f device] [-s #] [-b #]
```

See 7.3, “AIX Version 4 Specific File Features” on page 158 for changes in AIX Version 4.

**rmt** `rmt` is an object file command that allows control of remote tape devices via subcommands.

It is a documented command whose usage is:

```
rmt
valid subcommands: O DeviceMode, C Device, L WhenceOffset
                   W Count, R Count, I OperationCount
```

**rrestore** `rrestore` is an object file command that restores files from a remote machines device that were backed up by i-node.

It is a documented command whose usage is:

```
rrestore [-b Number] [-h] [-i] [-m] [-r] [-R] [-s Number]
[-t]
         [-v] [-y] [-x] -fMachine: Device [FileSystem ...] [File ...]
```

See 7.3, “AIX Version 4 Specific File Features” on page 158 for changes in AIX Version 4.

**tapechk** `tapechk` is Korn shell script that performs simple consistency checking for streaming tape drives.

It is a documented command whose usage is:

```
tapechk [-?] Number1 Number2
```

There are no files in the share or usr parts of the bos.rte.archive fileset.

### 7.2.5 Using Other Fileset Commands

Other documented commands that are relevant to AIX storage management that are in the filesets referred to in 7.1.1, “Major AIX Version 4 Filesets Relevant to Storage Management” on page 138 include:

| | |
|---|---|
| `bootlist boot logical volume` | Updates the list of boot devices. |
| `bosboot` | Builds a boot logical volume. |
| `bootinfo` | Gives information about the boot physical volume. |
| `savebase` | Saves ODM information to the boot logical volume. |
| `/sbin/rc.boot` | A shell script executed during the system boot. |
| `/etc/rc` | A shell script executed during the system boot. |

| | |
|---|---|
| `swapspaces` | Activates paging devices. |
| `snap` | A tool used to gather data for problem analysis. |
| `diag` | Used to execute the hardware diagnostics utilities. |
| `lscfg` | Gives detailed information about the RISC System/6000* hardware configuration. |
| `quotaon` | Starts the disk quota monitor. |
| `errpt` | Formats the error log information. |
| `diff` | Compares the contents of two text files. |
| `lsdev` | Lists the devices known to the system. |
| `lsattr` | Lists the attributes of the devices known to the system |
| `mkdev` | Configures a device. |
| `rmdev` | Removes a device. |
| `lvedit` | Used for interactive definition and placement of logical volumes within a volume group. Although this command was part of the optional program product "Extended Commands" (bosext1.extcmds.obj) in AIX V3.2, it is now part of the separate licensed program product known as "Performance Toolbox/6000", product number 5969-623, in AIX Version 4. |

## 7.3 AIX Version 4 Specific File Features

This section looks at those commands that are new or changed in AIX Version 4.

### 7.3.1 Using Logical Volume Manager Files in an AIX Version 4 Environment

This section looks at logical volume manager commands.

#### 7.3.1.1 Usr Part Files which are in the /usr/sbin Directory

As well as the specific AIX Version 4 noted for each individual file, the files listed in this section no longer have symbolic links to the /etc directory. The current workaround until you change all your pathnames is to install the *AIX 3.2 to 4.1 Compatibility Links* fileset.

**chvg** A new flag, `-u` allows the systems administrator to unlock a volume group if another logical volume manager operation has abnormally terminated. It is important to ensure that no other process is using this volume group when this process is run.

It is a documented command whose usage is:

```
chvg [-a Auto on] [-Q quorum] [-u] VGname...
```

**getlvcb** The high level shell script `updatelv` that calls this command does so with two new flags in AIX Version 4. These flags are

`-P` - stripe width

`-S` - the first physical partition number used on the 2nd disk when P is 2.

It is an undocumented command whose usage is:

```
getlvcb -aceLrsSPtu LVName
getlvcb -f LVName
```

**getlvodm** `getlvodm` obtains volume group and logical volume information from the ODM. In AIX Version 4, it has a new flag, `-G`.

It is an undocumented command whose usage is:

```
getlvodm [-a LVdescript] [-B LVdesrcript] [-b LVid]
         [-cVid] [-C] [-d VGdescript]
         [-e LVid] [-F] [-g PVid] [-h]
         [-j PVdescript] [-k] [-L VGdescript]
         [-l LVdescript] [-m LVid] [-p PVdescript]
         [-r LVid] [-s VGdescript] [-t VGid]
         [-u VGdescript] [-v VGdescript] [-w VGid]
         [-y LVid] [-G LVdescript]
```

**importvg** We found that on the level of AIX Version 4 that we used, an imported volume group was left in a varied on state when `importvg` completed its execution. This behaviour contradicts the information that we had access to, but we believe that is a reasonable and logical step to want to varyon and access a volume group after you have imported it.

**lquerylv** A new flag, `-b`, has been added that tells us the stripe exponent, stripe_exp, so that 2 raised to the power of stripe_exp gives the stripe size.

It is an undocumented command whose usage is:

```
lquerylv -L LVid [-p PVname] [-NGnMScsPRvoadlArtwb]
```

**lslv** Although this command does not have any new flags, it may have more output if it used to obtain information about a striped logical volume. In this case only, the following are two extra fields in the first column of the output of the command `lslv stripedlvname`

```
STRIPE WIDTH:       2
STRIPE SIZE:        32K
```

It is a documented command whose usage is:

```
lslv [-l | -m] [-n DescriptorPV] LVname
lslv [-n DescriptorPV] -p PVname [LVname]
```

**mklv** This has a new flag if you want to use striping, `-S StripeSize`

It is a documented command whose usage is:

```
mklv [-a IntraPolicy] [-b BadBlocks] [-c Copies] [-d Schedule]
[-e InterPolicy] [-i] [-L Label] [-m MapFile] [-r Relocate]
[-s Strict] [-t Type] [-u UpperBound] [-v Verify] [-w MWC]
[-x MaxLPs] [-y LVname] [-Y Prefix] [-Y StripeSize]
VGname NumberOfLPs [PVname...]
```

**putlvcb** Use this command with *extreme* caution, and refer to the `updatelv` command for some of its flags, including those that are for striping parameters.

It is an undocumented command whose usage is:

```
putlvcb [-a IntraPolicy] [-c Copies] [-e InterPolicy] [-i LVid]
        [-n Size] [-r BBReloc] [-L Label] [-s Strict]
        [-t Type] [-u Upper] [-S StripeExponent]
        [-O StripeWidth] LVName
putlvcb [-f FileSystemName] LVName
```

**putlvodm** `putlvodm` has a new flag in AIX Version 4, the `-S` flag which specifies the stripe size.

It is an undocumented command whose usage is:

```
putlvodm [-a IntraPolicy] [-B label] [-c Copies] [-e InterPolicy]
         [-L LVid] [-l LVname] [-n NewLVName] [-r Relocate]
         [-s Strict] [-t Type] [-u UpperBound] [-y Copyflag]
         [-z Size] [-S StripeSize] LVid
putlvodm [-o Auto-on] [-k] [-K] [-q VGstate]
         [-v VGname] [-V] VGid
putlvodm [-p VGid] [-P] PVid
```

In addition, the `-m majornum` flag that was used with a VGid is no longer available.

**rmlv** The `rmlv` command allows a physical volume name to be specified. Only logical partitions on this physical volume will be removed, and the logical volume itself will not be removed unless no other partitions exist on other physical volumes.

It is a documented command whose usage is:

```
rmlv [-f] [-p PVname] LVname...
```

#### 7.3.1.2 Usr Part Files which are in the /usr/lib Directory

There are no files that were not in AIX Version 3.

There are no files in the root or share parts of the bos.rte.lvm fileset.

### 7.3.2 Using File System Administration Commands in an AIX Version 4 Environment

This section contains file system administration commands.

#### 7.3.2.1 Usr Part Files which are in the /usr/sbin Directory

**defragfs** `defragfs` is an object file command that increases a file systems contiguous free space by reorganizing file fragment allocations.

It is a documented command whose usage is:

```
defragfs [-q | -r] {device | mount-path}
```

**fuser** The AIX Version 4 version of the `fuser` command no longer has the `-` flag. New flags automatically override the old settings.

It is a documented command whose usage is:

```
fuser [-ku] File ...
```

**imfs** The AIX Version 4 version of the `imfs` command no longer has the `-f` flag.

It is an undocumented command whose usage is:

```
imfs [-xl] vgname ...
```

**lsjfs** In AIX Version 4 the `lsjfs` Korn shell script has been rewritten slightly so that the `lsfs` command is now called with the `-q` command as well.

It is an undocumented command whose usage is:

```
lsfs {-a | -v Vfs| -u Group | Filesystem ...}
```

#### 7.3.2.2 Usr Part Files which are in the /usr/bin Directory

See the AIX Version 3 section for files in this fileset.

#### 7.3.2.3 Root Part Files which are in the /etc Directory

See the section on AIX Version 3 for files in this fileset.

#### 7.3.2.4 Root Part Files which are in the /sbin/helpers Directory

See the section on AIX Version 3 for files in this fileset.

There are no files in the share parts of the bos.rte.filesystem fileset.

### 7.3.3 Using System Backup and BOS Installation Utilities in an AIX Version 4 Environment

This section contains backup and installation commands.

#### 7.3.3.1 Usr Part Files which are in the /usr/lpp/bosinst Directory

**BosMenus** `BosMenus` performs the same function as the AIX Version 3 command `bosmenus`, though it operates slightly differently.

**CheckSize** `CheckSize` is used during the installation process to check that there is enough disk space for the operating system.

It is an undocumented command whose usage is:

```
CheckSize [-s] [-p]
```

**Get_RVG_Disks** `Get_RVG_Disks` is used during the installation process to create a database of available disks according to the volume groups they are in.

It is an undocumented command whose usage is:

```
Get_RVG_Disks
```

**bicfgsup** `bicfgsup` runs the startup script from the installation device before calling the `Get_RVG_Disks`.

It is an undocumented command whose usage is:

```
bicfgsup
```

**bi_main** `bi_main` performs the main operating system installation.

**bosinst.template** This file defines a template for the flow of the installation process.

**image.template** This file contains template definitions for the installation process.

**tape** This directory contains the following file:

**tape/tapefiles1** This file contains a list of key operating system files.

#### 7.3.3.2 Usr Part Files which are in the /usr/bin Directory

**mksysb** `mksysb` is a Korn shell script command that creates an installable image of the root volume group.

It is a documented command whose usage is:

```
mksysb [-i] [-m] [-e] [-b blocks] device
```

**mkszfile** `mkszfile` is a Korn shell script that saves the system state to a file for use during reinstallation.

It is a documented command whose usage is:

```
mkszfile [-m]
```

**mkvgdata** `mkvgdata` is a symbolic link to `mkszfile`.

**restvg** `restvg` is a Korn shell script that restores a user volume group from a backup image created by the `savevg` command.

It is a documented command whose usage is:

```
restvg [-b Blocks] [-f Device] [-q] [-s] [DiskName ...]
```

**savevg** `savevg` is a Korn shell script that finds and backs up all files for a specified volume group.

It is a documented command whose usage is:

```
savevg [-i] [-m] [-e] [-b blocks] [-f device] vgName
```

This is a symbolic link to the `mksysb` command.

#### 7.3.3.3 Usr Part Files which are in the /usr/sbin Directory

**mkinsttape** `mkinsttape` is a Korn shell script command that creates a BOS installation/maintenance tape file image.

It is an undocumented command whose usage is:

```
mkinsttape [/file]
```

#### 7.3.3.4 Root Part Files which are in the /etc Directory

**preserve.list** This file contains a list of files that will be copied during a preservation installation.

There are no files in the share parts of the bos.sysmgt.sysbr fileset.

### 7.3.4 Using Archive Commands in an AIX Version 4 Environment

This section contains archive commands.

#### 7.3.4.1 Usr Part Files which are in the /usr/bin Directory

**pax** `pax` has an options flag in AIX Version 4, which was not present in AIX Version 3.

It is a documented command whose usage is:

```
pax -[cdnv] [-f archive] [-s replstr] [pattern...]
pax -r [-cdiknuvy] [-f archive] [-o options] [-p string] [-s replstr]
       [pattern...]
pax -w [-dituvyX] [-b blocking] [[-a] -f archive] [-o options]
       [-s replstr] [-x format] [pathname...]
pax -r -w [-diklntuvyX] [-p string] [-s replstr] [pathname...] directory
```

**tar** `tar` is an object file command that enables writing data to, and reading data from, an archive storage medium. There is a new `-o` options flag that provides backwards compatibility with older (non-AIX) versions of `tar`. The `-S` flag has also been enhanced.

It is a documented command whose usage is:

```
tar -{c|r|t|u|x} [-BdFhilmopsvw]
                 [-Number] [-fFile]
                 [-bBlocks] [-S [Feet] [Feet @Density] [Blocksb]]
                 [-LInputList] [-NBlocks] [-C Directory] File ...
```

**tctl** `tctl` is an object file command that sends commands to a streaming tape device. In AIX Version 4 the `-e` flag is no longer used, and there is an extra command, the `reset` command.

It is a documented command whose usage is:

```
tctl [ -Bnv ] [ -b Blocks ] [ -p Num ] [-f Device] Subcommand [Count]
valid subcommands are: weof, eof, fsf, bsf, fsr, bsr, rewind, offline,
                       rewoffl, erase, retension, read, write, reset,
                       status
```

**zcat** `zcat` is an object file command that expands a file compressed using the `compress` command to standard out. The AIX Version 4 version of this command no longer uses the `-F` and `-f` flags.

It is a documented command whose usage is:

```
zcat [-nV] [File...]
```

#### 7.3.4.2 Usr Part Files which are in the /usr/sbin Directory

**restbyinode** `restbyinode` is an object file command that uses the `restore` command to restore files that were backed up by inode.

It is an undocumented command whose usage is:

```
restbyinode -t[Dhvy] [-f Device] [-s Number] [-b Number] [File ...]
restbyinode -x[Dhmvy] [-f Device] [-s Number] [-b Number] [File ...]
restbyinode -i[Dhmvy] [-f Device] [-s Number] [-b Number]
restbyinode -r[Dvy] [-f Device] [-s Number] [-b Number]
restbyinode -R[Dvy] [-f Device] [-s Number] [-b Number]
```

There is a new flag in AIX Version 4, `-D`.

**restore** `restore` is an object file command that copies files recently backed up on a local device, onto the system. There have been a number of flag changes in AIX Version 4.

It is a documented command whose usage is:

```
Usage for Backup by Name:ber] [-f Device] [-s Number] [File ...]
restore -x[Mdqv] [-b Number] [-f Device] [-s Number] [File ...]
        Extracts files by name.[-f Device] [-s Number] [File ...]
restore -T|-t [-qv] [-b Number] [-f Device] [-s Number]
        Lists a table of contents or information about the backup.
restore -X Number [-Mdqv] [-b Number] [-f Device] [-s Number] [File ...]
        Extracts beginning at a specified volume number.
Usage for Version 2 Backup by Inode:
restore -r[d] [-f Device] [File ...]ce] [-s Number]
Usage for Backup by Inode: systems.
restore -t[Bhqvy] [-b Number] [-f Device] [-s Number] [File ...]
        Lists a table of contents.
restore -x[Bhmqvy] [-b Number] [-f Device] [-s Number] [File ...]
        Extracts files by name.
restore -i[hmqvy] [-b Number] [-f Device] [-s Number]
        Restores files interactively
restore -r[Bqvy] [-b Number] [-f Device] [-s Number]
        Restores full file systems.
restore -R[Bvy] [-b Number] [-f Device] [-s Number]
```

```
        Restores full file systems.
```

**rrestore** `rrestore` is an object file command that copies previously backed up file systems from a remote machine's device to the local machine. The `-D` flag is new in AIX Version 4.

It is a documented command whose usage is:

```
rrestore -t[Dhvy] -f Host: Device [-s Number] [-b Number] [File ...]
rrestore -x[Dhmvy] -f Host: Device [-s Number] [-b Number] [File ...]
rrestore -i[Dhmvy] -f Host: Device [-s Number] [-b Number]
rrestore -r[Dvy] -f Host: Device [-s Number] [-b Number]
rrestore -R[Dvy] -f Host: Device [-s Number] [-b Number]
```

There are no files in the share or usr parts of the bos.rte.archive fileset.

## 7.4 Using Commands to View AIX Version 4 Logical Volume Manager Information

This section discusses sample output from the various options of the following commands:

1. `lsvg`
2. `lslv`
3. `lspv`
4. `lqueryvg`
5. `lquerylv`
6. `lquerypv`

Some of these commands are discussed further in Chapter 6, “General AIX Storage Management” on page 93. You may decide to use the `script` command to easily record the command syntax and output in one or more files. You can see from the script command timestamps included in the output that we executed these commands sequentially for the same logical volumes and all the physical volumes in the datavg volume group. By comparing the different command output formats, you can both understand the output and decide which commands you prefer. Note that we had to filter the output files to remove control M characters from the end of each line by executing commands like:

```
# tr -d '\015' < lsvg.scr > lsvg.txt
```

You can see the control M characters when you `vi` edit the output files.

First assume the volume group is normal, so run `lsvg` like:

```
Script started on Wed Jul 27 17:26:48 1994
# lsvg datavg
VOLUME GROUP:   datavg                  VG IDENTIFIER:  000004467b689da1
VG STATE:       active                  PP SIZE:        4 megabyte(s)
VG PERMISSION:  read/write              TOTAL PPs:      362 (1448 megabytes)
MAX LVs:        256                     FREE PPs:       289 (1156 megabytes)
LVs:            6                       USED PPs:       73 (292 megabytes)
OPEN LVs:       0                       QUORUM:         2
TOTAL PVs:      2                       VG DESCRIPTORS: 3
STALE PVs:      0                       STALE PPs       0
ACTIVE PVs:     2                       AUTO ON:        yes
# lsvg -l datavg
datavg:
LV NAME             TYPE       LPs   PPs   PVs  LV STATE      MOUNT POINT
datalv1             jfs        10    20    2    closed/syncd  /datajfs1
datalv2             jfs        10    20    2    closed/syncd  /datajfs2
datalv3             jfs        12    12    1    closed/syncd  /datajfs3
datalv4             jfs        10    10    1    closed/syncd  /datajfs4
datalog             jfslog     1     1     1    closed/syncd  N/A
datapg              paging     5     10    2    closed/syncd  N/A
# lsvg -p datavg
datavg:
PV_NAME           PV STATE    TOTAL PPs   FREE PPs    FREE DISTRIBUTION
hdisk8            active      75          50          15..00..05..15..15
hdisk1            active      287         239         58..09..57..57..58

script done on Wed Jul 27 17:28:28 1994
```

*Figure 31. Sample lsvg Output*

The first `lsvg` command quickly tells us how much of the volume group's disk space is used, and how much can be allocated to new or existing logical volumes. The -l flag provides us with a good volume group logical volume summary where we can:

- Check which logical volumes are mirrored by the ratio of physical partitions to logical partitions; in this case, there are two mirror copies of the logical volumes `datalv1`, `datalv2` and `datapg`.
- Check which logical volumes are open and therefore used by the operating system; in this case all are closed and so we can varyoff the volume group.

The -p flag provides a simple indication of how well organized the volume group is; in other words, if one physical volume is empty, and the other is almost full based on the `FREE PPs` column, then a I/O workload imbalance may result in a performance degradation.

For more detailed volume group output, execute:

```
Script started on Wed Jul 27 17:28:37 1994
# lsvg -M datavg

datavg
hdisk8:1-15
hdisk8:16       datalv1:1:1
hdisk8:17       datalv1:2:1
hdisk8:18       datalv1:3:1
hdisk8:19       datalv1:4:1
hdisk8:20       datalv1:5:1
hdisk8:21       datalv1:6:1
hdisk8:22       datalv1:7:1
hdisk8:23       datalv1:8:1
hdisk8:24       datalv1:9:1
hdisk8:25       datalv1:10:1
hdisk8:26       datalv2:1:2
hdisk8:27       datalv2:2:2
hdisk8:28       datalv2:3:2
hdisk8:29       datalv2:4:2
hdisk8:30       datalv2:5:2
hdisk8:31       datalv2:6:2
hdisk8:32       datalv2:7:2
hdisk8:33       datalv2:8:2
hdisk8:34       datalv2:9:2
hdisk8:35       datalv2:10:2
hdisk8:36       datapg:1:2
hdisk8:37       datapg:2:2
hdisk8:38       datapg:3:2
hdisk8:39       datapg:4:2
hdisk8:40       datapg:5:2
hdisk8:41-75
hdisk1:1-58
hdisk1:59       datalv1:1:2
hdisk1:60       datalv1:2:2
hdisk1:61       datalv1:3:2
hdisk1:62       datalv1:4:2
hdisk1:63       datalv1:5:2
hdisk1:64       datalv1:6:2
hdisk1:65       datalv1:7:2
hdisk1:66       datalv1:8:2
hdisk1:67       datalv1:9:2
hdisk1:68       datalv1:10:2
```

*Figure 32. Sample lsvg -M Output*

and continuing on the next screen:

```
hdisk1:69       datalv2:1:1
hdisk1:70       datalv2:2:1
hdisk1:71       datalv2:3:1
hdisk1:72       datalv2:4:1
hdisk1:73       datalv2:5:1
hdisk1:74       datalv2:6:1
hdisk1:75       datalv2:7:1
hdisk1:76       datalv2:8:1
hdisk1:77       datalv2:9:1
hdisk1:78       datalv2:10:1
hdisk1:79       datalv3:1
hdisk1:80       datalv3:2
hdisk1:81       datalv3:3
hdisk1:82       datalv3:4
hdisk1:83       datalv3:5
hdisk1:84       datalv3:6
hdisk1:85       datalv3:7
hdisk1:86       datalv3:8
hdisk1:87       datalv3:9
hdisk1:88       datalv3:10
hdisk1:89       datalv3:11
hdisk1:90       datalv3:12
hdisk1:91       datalv4:1
hdisk1:92       datalv4:2
hdisk1:93       datalv4:3
hdisk1:94       datalv4:4
hdisk1:95       datalv4:5
hdisk1:96       datalv4:6
hdisk1:97       datalv4:7
hdisk1:98       datalv4:8
hdisk1:99       datalv4:9
hdisk1:100      datalv4:10
hdisk1:101      datalog:1
hdisk1:102      datapg:1:1
hdisk1:103      datapg:2:1
hdisk1:104      datapg:3:1
hdisk1:105      datapg:4:1
hdisk1:106      datapg:5:1
hdisk1:107-287

script done on Wed Jul 27 17:28:53 1994
```

*Figure 33. Continued Sample lsvg -M Output*

This is the most comprehensive output available from the `lsvg` command. We can see how it documents the exact use of physical partitions on all physical volumes in the volume group, compared to the summary presented by using the -p flag as shown in Figure 31 on page 165. However, we can see from the `lslv -p hdisk1 datalv3` command output shown in Figure 38 on page 171. and the `lspv -p hdisk1` command shown in Figure 40 on page 173 that there are more suitable commands to use to check where the used physical partitions are. The `lsvg -M datavg` information can be used to create logical volume map files and is hence very useful if a corrupt VGDA needs to be fixed by recreating the datavg volume group.

Now lets look at the output from the `lslv` command by executing:

```
Script started on Wed Jul 27 17:57:00 1994
# lslv datapg
LOGICAL VOLUME:     datapg                 VOLUME GROUP:   datavg
LV IDENTIFIER:      000004467b689da1.6     PERMISSION:     read/write
VG STATE:           active/complete        LV STATE:       closed/syncd
TYPE:               paging                 WRITE VERIFY:   off
MAX LPs:            128                    PP SIZE:        4 megabyte(s)
COPIES:             2                      SCHED POLICY:   parallel
LPs:                5                      PPs:            10
STALE PPs:          0                      BB POLICY:      relocatable
INTER-POLICY:       minimum                RELOCATABLE:    yes
INTRA-POLICY:       middle                 UPPER BOUND:    32
MOUNT POINT:        N/A                    LABEL:          None
MIRROR WRITE CONSISTENCY: off
EACH LP COPY ON A SEPARATE PV ?: yes
# lslv datalv3
LOGICAL VOLUME:     datalv3                VOLUME GROUP:   datavg
LV IDENTIFIER:      000004467b689da1.3     PERMISSION:     read/write
VG STATE:           active/complete        LV STATE:       closed/syncd
TYPE:               jfs                    WRITE VERIFY:   off
MAX LPs:            128                    PP SIZE:        4 megabyte(s)
COPIES:             1                      SCHED POLICY:   parallel
LPs:                12                     PPs:            12
STALE PPs:          0                      BB POLICY:      relocatable
INTER-POLICY:       minimum                RELOCATABLE:    yes
INTRA-POLICY:       middle                 UPPER BOUND:    32
MOUNT POINT:        /datajfs3              LABEL:          /datajfs3
MIRROR WRITE CONSISTENCY: on
EACH LP COPY ON A SEPARATE PV ?: yes
# lslv -l datapg
datapg:N/A
PV                COPIES        IN BAND       DISTRIBUTION
hdisk1            005:000:000   100%          000:005:000:000:000
hdisk8            005:000:000   0%            000:000:005:000:000
# lslv -l datalv3
datalv3:/datajfs3
PV                COPIES        IN BAND       DISTRIBUTION
hdisk1            012:000:000   100%          000:012:000:000:000
```

*Figure 34. Sample lslv Output*

If no flags are used, the logical volume attributes are listed in a format similar to that used for the `lsvg` command. As expected, the command `lslv -l datapg` provides a better summary of where the datapg physical partitions are located on disk than does the output of the `lsvg` command shown in Figure 31 on page 165.

To check how logical partitions have been mapped to physical partitions, execute:

```
# lslv -m datapg
datapg:N/A
LP    PP1  PV1               PP2  PV2               PP3  PV3
0001  0102 hdisk1            0036 hdisk8
0002  0103 hdisk1            0037 hdisk8
0003  0104 hdisk1            0038 hdisk8
0004  0105 hdisk1            0039 hdisk8
0005  0106 hdisk1            0040 hdisk8
# lslv -m datalv3
datalv3:/datajfs3
LP    PP1  PV1               PP2  PV2               PP3  PV3
0001  0079 hdisk1
0002  0080 hdisk1
0003  0081 hdisk1
0004  0082 hdisk1
0005  0083 hdisk1
0006  0084 hdisk1
0007  0085 hdisk1
0008  0086 hdisk1
0009  0087 hdisk1
0010  0088 hdisk1
0011  0089 hdisk1
0012  0090 hdisk1

script done on Wed Jul 27 18:04:36 1994
```

*Figure 35. Sample lslv -m Output*

This is probably the best way to check your configuration of a highly available volume group. Since each mirror copy is listed in a separate column, you just have to ensure that each row contains two or three *different* physical volume names, depending on whether you have two or three copies of a logical volume. In other words, you can quickly confirm that the copies are on different disks.

For detailed disk layout from `lslv` to see exact physical partition placement, execute:

```
Script started on Wed Jul 27 18:04:58 1994
# lslv -p hdisk1 datapg
hdisk1:datapg:N/A
FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE       1-10
FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE      11-20
FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE      21-30
FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE      31-40
FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE      41-50
FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE                    51-58

USED   USED   USED   USED   USED   USED   USED   USED   USED   USED      59-68
USED   USED   USED   USED   USED   USED   USED   USED   USED   USED      69-78
USED   USED   USED   USED   USED   USED   USED   USED   USED   USED      79-88
USED   USED   USED   USED   USED   USED   USED   USED   USED   USED      89-98
USED   USED   USED   0001   0002   0003   0004   0005   FREE   FREE      99-108
FREE   FREE   FREE   FREE   FREE   FREE   FREE                          109-115

FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE     116-125
FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE     126-135
FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE     136-145
FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE     146-155
FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE     156-165
FREE   FREE   FREE   FREE   FREE   FREE   FREE                          166-172

FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE     173-182
FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE     183-192
FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE     193-202
FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE     203-212
FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE     213-222
FREE   FREE   FREE   FREE   FREE   FREE   FREE                          223-229

FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE     230-239
FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE     240-249
FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE     250-259
FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE     260-269
FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE     270-279
FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE                   280-287
```

*Figure 36. Sample lslv -p Output*

For the `datapg` logical volume on the `hdisk8` physical volume, execute:

```
# lslv -p hdisk8 datapg
hdisk8:datapg:N/A
FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE       1-10
FREE   FREE   FREE   FREE   FREE                                          11-15

USED   USED   USED   USED   USED   USED   USED   USED   USED   USED      16-25
USED   USED   USED   USED   USED                                          26-30

USED   USED   USED   USED   USED   0001   0002   0003   0004   0005      31-40
FREE   FREE   FREE   FREE   FREE                                          41-45

FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE      46-55
FREE   FREE   FREE   FREE   FREE                                          56-60

FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE      61-70
FREE   FREE   FREE   FREE   FREE                                          71-75
```

*Figure 37. Continued Sample lslv -p Output*

For the `datalv3` logical volume, execute:

```
# lslv -p hdisk1 datalv3
hdisk1:datalv3:/datajfs3
FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE      1-10
FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE     11-20
FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE     21-30
FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE     31-40
FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE     41-50
FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE                   51-58

USED   USED   USED   USED   USED   USED   USED   USED   USED   USED     59-68
USED   USED   USED   USED   USED   USED   USED   USED   USED   USED     69-78
0001   0002   0003   0004   0005   0006   0007   0008   0009   0010     79-88
0011   0012   USED   USED   USED   USED   USED   USED   USED   USED     89-98
USED   USED   USED   USED   USED   USED   USED   USED   FREE   FREE     99-108
FREE   FREE   FREE   FREE   FREE   FREE   FREE                         109-115

FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE    116-125
FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE    126-135
FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE    136-145
FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE    146-155
FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE    156-165
FREE   FREE   FREE   FREE   FREE   FREE   FREE                         166-172

FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE    173-182
FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE    183-192
FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE    193-202
FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE    203-212
FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE    213-222
FREE   FREE   FREE   FREE   FREE   FREE   FREE                         223-229

FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE    230-239
FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE    240-249
FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE    250-259
FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE    260-269
FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE    270-279
FREE   FREE   FREE   FREE   FREE   FREE   FREE   FREE                  280-287

script done on Wed Jul 27 18:08:22 1994
```

*Figure 38. Continued Sample lslv -p Output*

This is probably the best character based pictorial representation of the disk regions that shows the exact location of the used and free physical partitions. It will also show you exactly which physical partitions are stale if you have implemented mirroring by printing the word `STALE` or by printing a ? character next to the logical partition number. The number 0001 in Figure 38 indicates that the first logical partition of the datalv3 logical volume uses physical partition 79 on hdisk1, so the word `USED` on a physical partition refers to the fact that its used by a logical volume other than datalv3. The numbering helps us determine how badly a logical volume is fragmented within a physical volume, which may result in a performance degradation. This is *not* the case in this example because the physical partitions of each of the copies of the datapg and datalv3 logical volumes have been allocated in a contiguous manner. You may find it easier to notice this contiguity from the output of the `lslv -m lvname` commands shown in Figure 35 on page 169.

As can be seen from the outputs for hdisk1 in Figure 36 on page 170 or in Figure 38 and for hdisk8 in Figure 37 on page 170, it is easy to compare both the size and utilization of the disk regions of different disks. If you have many physical volumes, a summarized view of this information can be obtained from the output of the `lspv -l disk_name` command presented in Figure 39 on page 172. Finally, we can deduce the names of the different disk regions by comparing the numerical ranges presented in Figure 38 with those in Figure 40 on page 173 for hdisk1.

Now, take a look at the `lspv` command by executing:

```
Script started on Wed Jul 27 18:11:12 1994
# lspv hdisk1
PHYSICAL VOLUME:    hdisk1                   VOLUME GROUP:     datavg
PV IDENTIFIER:      00000201dc8b0b32         VG IDENTIFIER     000004467b689da1
PV STATE:           active
STALE PARTITIONS:   0                        ALLOCATABLE:      yes
PP SIZE:            4 megabyte(s)            LOGICAL VOLUMES:  6
TOTAL PPs:          287 (1148 megabytes)     VG DESCRIPTORS:   1
FREE PPs:           239 (956 megabytes)
USED PPs:           48 (192 megabytes)
FREE DISTRIBUTION:  58..09..57..57..58
USED DISTRIBUTION:  00..48..00..00..00
# lspv hdisk8
PHYSICAL VOLUME:    hdisk8                   VOLUME GROUP:     datavg
PV IDENTIFIER:      0002479088f5f347         VG IDENTIFIER     000004467b689da1
PV STATE:           active
STALE PARTITIONS:   0                        ALLOCATABLE:      yes
PP SIZE:            4 megabyte(s)            LOGICAL VOLUMES:  3
TOTAL PPs:          75 (300 megabytes)       VG DESCRIPTORS:   2
FREE PPs:           50 (200 megabytes)
USED PPs:           25 (100 megabytes)
FREE DISTRIBUTION:  15..00..05..15..15
USED DISTRIBUTION:  00..15..10..00..00
# lspv -l hdisk1
hdisk1:
LV NAME               LPs   PPs   DISTRIBUTION          MOUNT POINT
datalv1               10    10    00..10..00..00..00    /datajfs1
datalv2               10    10    00..10..00..00..00    /datajfs2
datalv3               12    12    00..12..00..00..00    /datajfs3
datalv4               10    10    00..10..00..00..00    /datajfs4
datalog               1     1     00..01..00..00..00    N/A
datapg                5     5     00..05..00..00..00    N/A
# lspv -l hdisk8
hdisk8:
LV NAME               LPs   PPs   DISTRIBUTION          MOUNT POINT
datalv1               10    10    00..10..00..00..00    /datajfs1
datalv2               10    10    00..05..05..00..00    /datajfs2
datapg                5     5     00..00..05..00..00    N/A
```

*Figure 39. Sample lspv Output*

Just like the `lsvg` and `lslv` commands, you can execute the `lspv` command with no flags to display the disk attributes. Note that the output from the `lspv -l hdisk1` command in Figure 39 is *not the same* as that from the `lsvg -l datavg` command shown in Figure 31 on page 165, although both indicate the number of physical partitions and logical partitions whose ratio indicates the extent of any mirroring configuration.

However, if your logical volumes are not mirrored, then you may prefer to summarize the logical volume information by executing `lspv` with a -p flag as follows:

```
# lspv -p hdisk1
hdisk1:
PP RANGE  STATE   REGION        LV ID             TYPE       MOUNT POINT
  1-58    free    outer edge
 59-68    used    outer middle  datalv1           jfs        /datajfs1
 69-78    used    outer middle  datalv2           jfs        /datajfs2
 79-90    used    outer middle  datalv3           jfs        /datajfs3
 91-100   used    outer middle  datalv4           jfs        /datajfs4
101-101   used    outer middle  datalog           jfslog     N/A
102-106   used    outer middle  datapg            paging     N/A
107-115   free    outer middle
116-172   free    center
173-229   free    inner middle
230-287   free    inner edge
# lspv -p hdisk8
hdisk8:
PP RANGE  STATE   REGION        LV ID             TYPE       MOUNT POINT
  1-15    free    outer edge
 16-25    used    outer middle  datalv1           jfs        /datajfs1
 26-30    used    outer middle  datalv2           jfs        /datajfs2
 31-35    used    center        datalv2           jfs        /datajfs2
 36-40    used    center        datapg            paging     N/A
 41-45    free    center
 46-60    free    inner middle
 61-75    free    inner edge

script done on Wed Jul 27 18:13:04 1994
```

*Figure 40. Sample lspv -p Output*

Like the `lspv -l` output shown in Figure 39 on page 172, we know:

- The names of the logical volumes on the specified physical volume
- The logical partition distribution
- The number of physical partitions used

  We get this from the sum of the differences of the `PP RANGE` for each row that refers to a particular logical volume Also, this number is the same as the number of logical partitions for a non-mirrored logical volume.

- The associated journaled file system mount point

However, the `lspv -p` output shown in Figure 40 also tells us:

- The type of logical volume
- The unambiguous state of every physical partition

  This is very useful because we can easily see if a logical volume on this disk will become fragmented if we extend it on this disk, as would occur for `datalv1`, `datalv2`, `datalv3`, `datalv4`, or `datalog` in this example.

If you need to create map files for logical volumes that exist only on one disk, then you can execute `lspv -M` as shown in:

```
Script started on Wed Jul 27 18:13:44 1994
# lspv -M hdisk1
hdisk1:1-58
hdisk1:59       datalv1:1:2
hdisk1:60       datalv1:2:2
hdisk1:61       datalv1:3:2
hdisk1:62       datalv1:4:2
hdisk1:63       datalv1:5:2
hdisk1:64       datalv1:6:2
hdisk1:65       datalv1:7:2
hdisk1:66       datalv1:8:2
hdisk1:67       datalv1:9:2
hdisk1:68       datalv1:10:2
hdisk1:69       datalv2:1:1
hdisk1:70       datalv2:2:1
hdisk1:71       datalv2:3:1
hdisk1:72       datalv2:4:1
hdisk1:73       datalv2:5:1
hdisk1:74       datalv2:6:1
hdisk1:75       datalv2:7:1
hdisk1:76       datalv2:8:1
hdisk1:77       datalv2:9:1
hdisk1:78       datalv2:10:1
```

*Figure 41. Sample lspv -M Output*

On the next screen:

```
hdisk1:79       datalv3:1
hdisk1:80       datalv3:2
hdisk1:81       datalv3:3
hdisk1:82       datalv3:4
hdisk1:83       datalv3:5
hdisk1:84       datalv3:6
hdisk1:85       datalv3:7
hdisk1:86       datalv3:8
hdisk1:87       datalv3:9
hdisk1:88       datalv3:10
hdisk1:89       datalv3:11
hdisk1:90       datalv3:12
hdisk1:91       datalv4:1
hdisk1:92       datalv4:2
hdisk1:93       datalv4:3
hdisk1:94       datalv4:4
hdisk1:95       datalv4:5
hdisk1:96       datalv4:6
hdisk1:97       datalv4:7
hdisk1:98       datalv4:8
hdisk1:99       datalv4:9
hdisk1:100      datalv4:10
hdisk1:101      datalog:1
hdisk1:102      datapg:1:1
hdisk1:103      datapg:2:1
hdisk1:104      datapg:3:1
hdisk1:105      datapg:4:1
hdisk1:106      datapg:5:1
hdisk1:107-287
```

*Figure 42. Continued Sample lspv -M Output*

For `hdisk8`, try:

```
# lspv -M hdisk8
hdisk8:1-15
hdisk8:16       datalv1:1:1
hdisk8:17       datalv1:2:1
hdisk8:18       datalv1:3:1
hdisk8:19       datalv1:4:1
hdisk8:20       datalv1:5:1
hdisk8:21       datalv1:6:1
hdisk8:22       datalv1:7:1
hdisk8:23       datalv1:8:1
hdisk8:24       datalv1:9:1
hdisk8:25       datalv1:10:1
hdisk8:26       datalv2:1:2
hdisk8:27       datalv2:2:2
hdisk8:28       datalv2:3:2
hdisk8:29       datalv2:4:2
hdisk8:30       datalv2:5:2
hdisk8:31       datalv2:6:2
hdisk8:32       datalv2:7:2
hdisk8:33       datalv2:8:2
hdisk8:34       datalv2:9:2
hdisk8:35       datalv2:10:2
hdisk8:36       datapg:1:2
hdisk8:37       datapg:2:2
hdisk8:38       datapg:3:2
hdisk8:39       datapg:4:2
hdisk8:40       datapg:5:2
hdisk8:41-75

script done on Wed Jul 27 18:14:09 1994
```

*Figure 43. Continued Sample lspv -M Output*

If you concatenate this `lspv -M` output from all the physical volumes in your volume group, then the combined file is the same as that obtained from the `lsvg -M` command, as shown in Figure 32 on page 166 and in Figure 33 on page 167.

If the volume group is varied off, it is still possible to get some volume group information from `lsvg -n hdiskx`, and also, all the previous `lslv` and `lspv` output, if, in each command, the `-N PVName` flag is used. Check in infoExplorer for the use of this flag, as the returned data may not be current.

If the ODM is badly corrupted or if a volume group has not been configured, then the previous commands may fail. However, the following commands will allow the disks in a volume group to be read directly. As well as helping you repair the ODM, you may also be able to determine what information is stored on a disk when the other physical volumes in the disk's volume group are not available. We can simulate these two scenario's by exporting the volume group so that the physical volume assignment by the operating system is:

```
# lspv
hdisk0        0000020158496d72    availvg
hdisk1        00000201dc8b0b32    None
hdisk2        000002007bb618f5    availvg
hdisk3        00000446431550c9    availvg
hdisk4        000137231982c0f2    stripevg
hdisk5        00014732b1bd7f57    rootvg
hdisk6        0001221800072440    stripevg
hdisk7        00012218da42ba76    rootvg
hdisk8        0002479088f5f347    None
```

*Figure 44. Sample lspv Output to See all Known Physical Volumes and Volume Groups*

First, use `lqueryvg` on the unassigned disks `hdisk1` and `hdisk8` to obtain general volume group information; always use the `-t` flag for field titles.

```
Script started on Wed Jul 27 19:13:24 1994
# lqueryvg -p hdisk1 -Avt
Max LVs:        256
PP Size:        22
Free PPs:       289
LV count:       6
PV count:       2
Total VGDAs:    3
Logical:        000004467b689da1.1   datalv1 1
                000004467b689da1.2   datalv2 1
                000004467b689da1.3   datalv3 1
                000004467b689da1.4   datalv4 1
                000004467b689da1.5   datalog 1
                000004467b689da1.6   datapg 1
Physical:       0002479088f5f347 2   0
                00000201dc8b0b32 1   0
VGid:           000004467b689da1
# lqueryvg -p hdisk8 -Avt
Max LVs:        256
PP Size:        22
Free PPs:       289
LV count:       6
PV count:       2
Total VGDAs:    3
Logical:        000004467b689da1.1   datalv1 1
                000004467b689da1.2   datalv2 1
                000004467b689da1.3   datalv3 1
                000004467b689da1.4   datalv4 1
                000004467b689da1.5   datalog 1
                000004467b689da1.6   datapg 1
Physical:       0002479088f5f347 2   0
                00000201dc8b0b32 1   0
VGid:           000004467b689da1

script done on Wed Jul 27 19:14:03 1994
```

*Figure 45. Sample lqueryvg Output*

The same `VGid` proves that they both belong to the same volume group, and we know that there are no other disks since the PV count is two. Since the names of the logical volumes are included in this `lqueryvg` command output, it is clearly beneficial to give them meaningful names to help you remember the contents of the logical volumes.

We can use a logical volume identifier and the physical volume name to execute the following two commands to extract more logical volume and physical volume information from the disk VGDA and VGSA:

```
Script started on Wed Jul 27 19:14:19 1994
# lquerylv -p hdisk1 -L000004467b689da1.6 -at
LVname:         datapg
VGid:           4467b689da1
MaxLP:          128
MPolicy:        2
MWrtConsist:    2
LVstate:        1
Csize:          5
PPsize:         22
Permissions:    1
Relocation:     1
WrVerify:       2
open_close:     2
stripe_exp:     0
striping_wid    0
# lquerylv -p hdisk1 -L000004467b689da1.6 -rt
LVMAP:  00000201dc8b0b32 102  1
LVMAP:  0002479088f5f347 36   1
LVMAP:  00000201dc8b0b32 103  2
LVMAP:  0002479088f5f347 37   2
LVMAP:  00000201dc8b0b32 104  3
LVMAP:  0002479088f5f347 38   3
LVMAP:  00000201dc8b0b32 105  4
LVMAP:  0002479088f5f347 39   4
LVMAP:  00000201dc8b0b32 106  5
LVMAP:  0002479088f5f347 40   5
```

*Figure 46. Sample lquerylv Output for the Mirrored datapg Logical Volume*

We now know that `datapg` has two mirror copies, and is configured for high availability since we can see from the physical volume identifiers that each logical partition copy is on a different physical volume. Of course, it was much easier to view this information from the output of the `lslv -m datapg` command shown in Figure 35 on page 169.

For the `datalv3` logical volume, execute:

```
# lquerylv -p hdisk1 -L000004467b689da1.3 -at
LVname:         datalv3
VGid:           4467b689da1
MaxLP:          128
MPolicy:        2
MWrtConsist:    1
LVstate:        1
Csize:          12
PPsize:         22
Permissions:    1
Relocation:     1
WrVerify:       2
open_close:     2
stripe_exp:     0
striping_wid    0
# lquerylv -p hdisk1 -L000004467b689da1.3 -rt
LVMAP:  00000201dc8b0b32 79   1
LVMAP:  00000201dc8b0b32 80   2
LVMAP:  00000201dc8b0b32 81   3
LVMAP:  00000201dc8b0b32 82   4
LVMAP:  00000201dc8b0b32 83   5
LVMAP:  00000201dc8b0b32 84   6
LVMAP:  00000201dc8b0b32 85   7
LVMAP:  00000201dc8b0b32 86   8
LVMAP:  00000201dc8b0b32 87   9
LVMAP:  00000201dc8b0b32 88   10
LVMAP:  00000201dc8b0b32 89   11
LVMAP:  00000201dc8b0b32 90   12

Script done on Wed Jul 27 19:21:31 1994
```

*Figure 47. Sample lquerylv Output for the Non-Mirrored datalv3 Logical Volume*

For more physical volume information, execute `lquerypv`. You'll need to use the physical volume identifier to specify which disk you want to know about, and then use the volume group identifier and a physical volume name to specify which disk you want to read to get the information.

Note that you will need a terminal that's about 115 columns wide to view output neatly as follows:

```
Script started on Wed Jul 27 19:24:33 1994
# lquerypv -p 0002479088f5f347 -g 4467b689da1 -N hdisk8 -dt\
|grep 000004467b689da1.6|pg
PVMAP:  0002479088f5f347:36   1 ODMtype  000004467b689da1.6   1
     00000201dc8b0b32:102  0000000000000000:0
PVMAP:  0002479088f5f347:37   1 ODMtype  000004467b689da1.6   2
     00000201dc8b0b32:103  0000000000000000:0
PVMAP:  0002479088f5f347:38   1 ODMtype  000004467b689da1.6   3
     00000201dc8b0b32:104  0000000000000000:0
PVMAP:  0002479088f5f347:39   1 ODMtype  000004467b689da1.6   4
     00000201dc8b0b32:105  0000000000000000:0
PVMAP:  0002479088f5f347:40   1 ODMtype  000004467b689da1.6   5
     00000201dc8b0b32:106  0000000000000000:0
(EOF):
# lquerypv -p 00000201dc8b0b32 -g 4467b689da1 -N hdisk1 -at
PP Size:        22
PV State:       0
Total PPs:      287
Alloc PPs:      48
Total VGDAs:    1
# lquerypv -p 0002479088f5f347 -g 4467b689da1 -N hdisk1 -at
PP Size:        22
PV State:       0
Total PPs:      75
Alloc PPs:      25
Total VGDAs:    2
#
# lspv
hdisk0         0000020158496d72    availvg
hdisk1         00000201dc8b0b32    None
hdisk2         000002007bb618f5    availvg
hdisk3         00000446431550c9    availvg
hdisk4         000137231982c0f2    stripevg
hdisk5         00014732b1bd7f57    rootvg
hdisk6         0001221800072440    stripevg
hdisk7         00012218da42ba76    rootvg
hdisk8         0002479088f5f347    None
```

*Figure 48. Sample lquerypv Output*

The first `lqueryvg` command output has been simplified by being piped into the `grep` command so that it only includes the lines that refer to the datapg logical volume. The information here agrees with the physical partition allocation map obtained from the `lspv -p` command that is displayed in Figure 40 on page 173. The next two `lqueryvg` command outputs match the information obtained from the `lsvg` commands as shown in Figure 31 on page 165. In particular, note that:

- The physical partition size is expressed as a power of 2, so 2 to the power of 22 is roughly 4MB
- We first obtained information about hdisk1, and then about hdisk8, but both commands used the one copy of the VGDA that's on hdisk1. However, we could have obtained exactly the same information by accessing either of the VGDA copies on hdisk8. Recall that the two executions of the `lqueryvg` command shown in Figure 45 on page 176 also provided identical output because they read copies of the same VGDA information that is placed on every physical volume in a volume group.

Now that we know exactly what these "mystery" physical volumes contain, we can import them and access the data by executing:

```
# importvg -y datavg hdisk1
datavg
#
# mount /datajfs1
# ls -la /datajfs1
total 16
drwxr-sr-x   2 sys      sys          512 Jul 25 14:33 .
drwxr-xr-x  35 bin      bin         1024 Jul 27 17:33 ..
script done on Wed Jul 27 19:29:40 1994
```

*Figure 49. Accessing a Disk after Reading its VGDA to Check its Contents*

Now we can complete the above steps by a comparison of the output. The main point is that the same data can be obtained from many sources in many different formats, so its up to the systems administrator to decide which format is preferred.

## 7.5 Using Commands to View AIX Version 4 Journaled File System Information

This section discusses sample output for some of the options of the following:

1. Commands included in filesets of AIX Version 4:

   The first two commands discussed, `du` and `df`, both produce similar output. Before looking at the commands themselves a brief overview of their differences in implementation will be given to account for the slight differences in output.

   On any given file system, execute:

   ```
   # du -sk /filesystem_path
   ```

   and then:

   ```
   # df /filesystem_path
   ```

   If you substract the number of free KB from the number of Total KB, you will get a number of used KB. This number will be higher than that which the `du` command will report as used on that same file system. The reason is the methodology used by each command.

   The `du` command basically walks down the directory tree taking the size of each file and rounding it up to the next multiple of the cluster size, which is 4KB under AIX Version 3. The results of the rounding operation is then added together to make a total, which is the number the `du` command returns. Thus, if you run `du -sk` in a directory with two files under 4KB each, the number output would be 12; 4KB for each of the two files and another 4KB for the directory entry. If you had a file that was 4097 bytes long (one byte over 4KB) and executed `du -sk file` then the number returned would be 8 because its size is rounded to the next increment of 4 KB, in this case, 8192 bytes or 8KB. The `du` command returns an approximation of the size of the file space used and does not include any file system overhead.

The `df` command looks at the super block of the file system to determine how many 4KB data blocks are unallocated. Of the allocated storage, some of the space will be allocated for I-nodes. I-nodes are part of the overhead necessary for accessing information in the file system. As a result of this, both files and I-nodes are added into the final total of allocated storage space and a more accurate determination of file system usage is made.

The amount of space which is used by inodes can be determined from the equation

```
kilobyte space = total i-nodes / 8
```

where the `total i-nodes` can be determined by running `df -v` and adding the `iused` and `ifree` columns.

If you were to increase the size of that file system but not add any new files, then the `du` command would return the same number as before. The `df` command, however, would show more file system space was allocated than before the file system was increased, because when the file system was increased, more I-nodes were allocated.

- `du`

```
# du -ksr /home
103325  /home
#
```

  This is a useful way of executing the disk usage command so that you get a brief output that you can easily convert to MBs used, and you can easily compare it to the following `df` output:

- `df`

```
# df -kI
Filesystem    1024-blocks      Used      Free %Used Mounted on
/dev/hd4             8192      4308      3884   52% /usr
/dev/hd2           319488    315980      3508   98% /usr
/dev/hd9var         12288       940     11348    7% /var
/dev/hd3            12288       748     11540    6% /tmpe
/dev/hd1           122880    110128     12752   89% /home
/dev/lv00          106496     24948     81548   23% /usr/local
```

  The previous display file systems command is beneficial because the block numbers can easily be converted to MBs and the output is similar to that for the `df` command in AIX V3.2. If you also want to display i-node information in a wider output format, then use the -v flag as well in the previous `df` command.

  As is discussed elsewhere, `du` shows us that /home has physically used 103325 x 1024 byte blocks, whereas `df` says that 110128 x 1024 byte blocks have been allocated. This means that we currently have an overhead of about 6% ((110128 - 103325) / 122880) of the total size of /home required to store the indices, or i-nodes, that are used by the operating system when we want to access our data.

- `fsdb`

```
# fsdb /home


File System:                             /home

File System Size:                        245760  (512 byte blocks)
Disk Map Size:                               18  (4K blocks)
Inode Map Size:                               4  (4K blocks)
Fragment Size:                              512  (bytes)
Allocation Group Size:                     8192  (fragments)
Inodes per Allocation Group:               1024
Total Inodes:                             30720
Total Fragments:                         245760
```

Exit the `fsdb` command by typing `q` and pressing the **Enter** key.

- `lsfs`

```
# lsfs -q /home
Name            Nodename   Mount Pt               VFS   Size    Options    Auto

Accounting
/dev/hd1        --         /home                  jfs   245760  --         yes

no
  (lv size: 245760, fs size: 245760, frag size: 512, nbpi: 4096, compress: no)
#
```

This command output complements the the journaled file system attributes obtained from the `fsdb` command. Of course, not all of these attributes are displayed if you execute these commands in AIX Version 3.

**Warning - debug journaled file system carefully**

The `fsdb` command, along with the `dumpfs` command that is not discussed here, should only be used by *very experienced* systems administrators as a last resort when they want to try to recover data from a damaged journaled file system. If you think that you are likely to need to use them, it would be wise to practice using these low-level commands before a disaster.

2. Commands included in filesets of other program products:

   As you become familiar with the information discussed in the AIX V3.2 Performance Monitoring and Tuning Guide article "Monitoring and Tuning Disk I/O" in the AIX Version 4.1 Hypertext Information Base Library, it is clear that the following commands provide you with much more journaled file system information. Although these commands were part of the optional program product "Extended Commands" (bosext1.extcmds.obj) in AIX V3.2, they are now part of the separate licensed program product known as "Performance Toolbox/6000 , product number 5696-623" in AIX Version 4. Hence, this product is a wise investment if you really want to fine tune and monitor your journaled file system configuration and performance.

   - `fileplace`

     This command tells us what physical and logical blocks are used by a file. Consider the following example discussed in the AIX V3.2 Performance Monitoring and Tuning Guide article "Monitoring and Tuning Disk I/O".

```
# fileplace -pv big1

The resulting report is:

File: big1  Size: 3554273 bytes  Vol: /dev/hd10 (4096 byte blks)
Inode: 19  Mode: -rwxr-xr-x  Owner: frankw  Group: system

Physical blocks (mirror copy 1)                    Logical blocks
-------------------------------                   --------------
01584-01591  hdisk0       8 blks,    32 KB,   0.9%    01040-01047
01624-01671  hdisk0      48 blks,   192 KB,   5.5%    01080-01127
01728-02539  hdisk0     812 blks,  3248 KB,  93.5%    01184-01995

  868 blocks over space of 956:  space efficiency = 90.8%
  3 fragments out of 868 possible:  sequentiality = 99.8%
```

The above numbers do accurately reflect the extent of file fragmentation; the lower the percentages the greater the fragmentation. Each row above represents a contiguous area of disk space, so this file occupies three disk chunks, or fragments. The first physical block used is block 01584, and the last is block 02539, so that the total number of contiguous physical disk blocks that are available in this range is (02539 - 01584 + 1) = 956.

space efficiency = blocks_used / blocks_available

In this example, this is 868 / 956 = 90.8%. As expected, 100% efficiency can be achieved if all available blocks are used for one contiguous file.

sequentiality = (blocks_used - (number_fragments - 1)) / blocks_used

Hence, in this case (868 - (3 - 1)) / 868 = 99.8%. This means that in the ideal case where a single fragment file uses x contiguous blocks, its sequentiality is (x - 0) / x = 100%.

- `filemon`

  The `filemon` command monitors a trace of file system and I/O system events and reports on the file and I/O access performance during that period. It can produce an extensive output, an example of which is presented in the AIX V3.2 Performance Monitoring and Tuning Guide article "Monitoring and Tuning Disk I/O". Note this article's recommendation to experiment with this command. This will help you become familiar with its output, and also estimate the performance degradation that you will experience when you use this tool in a production environment.

# Chapter 8. Practical Examples

This chapter contains a series of practical examples covering a variety of storage management and problem solving situations.

Each example has three major sections:

- An introduction and general description.
- A summary of the commands that can be used by an experienced systems administrator.
- A detailed description that may include:
  – What the output is and what it means.
  – Why a particular command is used.
  – How to use the commands, usually with ASCII smit screens, note that on your screen, the output may vary due to:
    - A different level of AIX Version 4.
    - Different terminal attributes such as the number of lines displayed in an output screen.

**Warning - read smit documentation**

Before using smit:

- Become familiar with relevant smit documentation, such as that provided in *AIX Version 4.1 System Management Guide: Operating System and Devices*.
- Be aware that some of the storage management menus have been changed.

## 8.1 Planning

Before a key is pressed to configure the available equipment, careful planning is a wise investment. Hence, we begin by considering what volume group(s) our disks should belong to, and how should they be connected to the RISC System/6000.

We have nine SCSI-1 disks available that range in capacity from 355MB to 1.2GB. To show a number of different logical volume manager features coexisting in AIX Version 4, these disks can be initially arranged in four volume groups. The implementation of this volume group setup is shown and discussed in 8.3, “Storage Subsystem Design” on page 204.

Since there are two SCSI-1 adapters available for the nine available SCSI-1 disks, then four disks can be connected to one adapter, and five disks can be connected to the second adapter. The CD-ROM and 8mm tape drive are not likely to be involved in as much I/O as the disks, so their location is not as critical.

A typical setup of this hardware can be seen from the output of the following `lsdev` command:

```
# lsdev -Cc disk
hdisk0 Available 00-08-00-0,0 670 MB SCSI Disk Drive
hdisk1 Available 00-08-00-1,0 670 MB SCSI Disk Drive
hdisk2 Available 00-08-00-2,0 355 MB SCSI Disk Drive
hdisk4 Available 00-07-00-0,0 1.2 GB SCSI Disk Drive (in 2.4 GB Disk Unit)
hdisk5 Available 00-07-00-1,0 1.2 GB SCSI Disk Drive (in 2.4 GB Disk Unit)
hdisk6 Available 00-07-00-2,0 1.2 GB SCSI Disk Drive (in 2.4 GB Disk Unit)
hdisk7 Available 00-07-00-3,0 1.2 GB SCSI Disk Drive (in 2.4 GB Disk Unit)
hdisk3 Available 00-08-00-3,0 320 MB SCSI Disk Drive
hdisk8 Available 00-07-00-4,0 857 MB SCSI Disk Drive
# lsdev -Cc cdrom
cd1 Available 00-08-00-4,0 CD-ROM Drive
#
# lsdev -Cc tape
rmt0 Available 00-08-00-6,0 2.3 GB 8mm Tape Drive
```

Note that the allocation of hdisk names resulted from the following:

- Lower SCSI addresses are configured first
- The SCSI adapter in slot seven was added after that in slot eight, so its devices were also configured later

**Warning - For hdiskx, x may change**

We expect when this system is reinstalled, the disk devices will be reconfigured. Depending on what is powered on at installation time, the disk name assigned to a particular device at a particular SCSI address may change.

The devices connected to the SCSI adapter in slot seven are inside a model 9334-500, which is designed to provide extra storage capacity for the RISC System/6000. The power supply in the 9334, and the second SCSI adapter in the RISC System/6000, combine to help to reduce the number of single points of failure that exists with the standard components in the RISC System/6000. All this equipment is located in close proximity in an appropriate office environment.

Once the hardware is correctly connected and working, the operating system needs to be installed, by default in the rootvg, before detailed configuration can be completed. To enable the rootvg to be mirrored, AIX Version 4 is initially installed only on hdisk0, before a copy is created on hdisk2. Please refer to the *AIX Version 4.1 Installation Guide* both before and during the initial installation of AIX Version 4 on hdisk0.

More detail regarding the level of AIX Version 4 in use can be obtained from the commands `lslpp` or `uname` (please refer to the *AIX Version 4.1 Commands Reference* for usage details). For these practical examples, we used:

```
# uname -a
AIX 9421A-UP bilbo 1 4 000004461000
#
```

The mirrored operating system implementation is described in the next section.

**Warning - Always have good backups in place**

It is very important that you are familiar with the backup concepts discussed elsewhere in this book (see 5.5, “Planning Backup Strategies” on page 87), and also in the book *AIX Version 4.1 System Management Guide: Operating System and Devices*, (you may have *AIX Version 4.1 System Management Guide: Operating System and Devices* available in your *AIX Version 4.1 Hypertext Information Base Library*).

If any example in this document does not work in your particular circumstances, then reinstallation from a backup may be your only viable recovery method.

## 8.2 rootvg Mirroring - Implementation and Recovery

Once AIX Version 4 has been installed, this section describes how to create a mirror of rootvg and then how to test it. In the following example, a second copy of each logical volume on hdisk0 is made on hdisk2 which is an externally powered 355MB disk unit. This device is then powered off at various times to test the continued availability of the operating system. The availability test is discussed for two scenarios:

- Disk power failure before AIX Version 4 is loaded when the RISC System/6000 is turned on.
- Disk power failure during normal operations.

This section is based on the suggestions provided by the *AIX Version 4.1 Hypertext Information Base Library* articles *Mirroring rootvg for Maximum Operating System Availability* and *Recovering a Disk Drive without Reformatting*. As suggested by the title of this article, the availability test assumes that the disk media has not been damaged and thus has a valid, unique PVID. This means that the recovery steps can be as simple as a system reboot once the non-media related disk problem is fixed.

However, if the media fails:

1. Remove all physical partitions from the failed disk.
2. Remove the failed disk from the volume group.
3. Add the new disk to the volume group.
4. Rebuild the logical volume copies and synchronize them.
5. Rebuild any single copy logical volumes and restore backups.

For more details, refer to the *AIX Version 4.1 Hypertext Information Base Library* article *Recovering from Disk Drive Problems*.

The performance implications of rootvg mirroring is not investigated in this example.

#### 8.2.1.1 Command Line Summary

1. Document your initial rootvg configuration; the following commands produce the necessary output:

```
# lspv
# lsvg -l rootvg
# lsvg rootvg
# lsvg -p rootvg
# lslv -m hd9var
# lsvg -M rootvg
```

2. Create logical volume copies:

   - Turn off quorum checking:

   ```
   # chvg -a y -Q n rootvg
   ```

   - Add a physical volume to mirror to (if necessary), in these examples we are mirroring to a new physical volume called `hdisk2`:

   ```
   # extendvg -f rootvg hdisk2
   ```

   This command assumes that you wish to add a new physical volume called `hdisk2` to the root volume group.

   - Create the mirrored copies for all logical volumes:

   ```
   # mklvcopy hd4 2 hdisk2
   ```

   Repeat this for every logical volume in rootvg:

     – hd1 (/home).
     – hd2 (/usr).
     – hd3 (/tmp).
     – hd8 (jfslog).
     – hd9var (/var).
     – hd6 (default paging space).
     – Any other logical volumes that you may have created, except the boot logical volume (see detailed guidance for the reasoning behind this).

3. Create second boot logical volume, and build a boot image on it:

```
# mklv -y hd5x  -t boot -a e rootvg 1 hdisk2
# bosboot -a -l /dev/hd5x -d /dev/hdisk2
```

4. Update bootlist:

```
# bootlist -m normal hdisk0 hdisk2
```

5. Synchronize rootvg copies:

```
# varyonvg rootvg
```

This completes the command line overview of the process. A detailed description of how to achieve mirroring for the root volume group now follows.

#### 8.2.1.2 Detailed Guidance

***How to Document the Initial rootvg Configuration:*** The initial layout of rootvg can be seen from the output of the following commands. More examples describing the use of these commands, and similar variations to them, are provided in Chapter 7, "Storage Management Files and Commands Summary" on page 137.

In order to see how to use smit to execute most of these commands so that the output can be viewed in the smit.log file, then please refer to "How to Document the Volume Group Design" on page 236.

```
# lspv
hdisk0         00014732b1bd7f57    rootvg
hdisk1         0001221800072440    newvg
hdisk2         00012218da42ba76    None
hdisk6         000002007bb618f5    myvg
hdisk7         000002007bb623c1    None
hdisk3         0002479088f5f347    None
#
# lsvg -l rootvg
rootvg:
LV NAME             TYPE       LPs   PPs   PVs  LV STATE      MOUNT POINT
hd6                 paging     8     8     1    open/syncd    N/A
hd5                 boot       1     1     1    closed/syncd  N/A
hd8                 jfslog     1     1     1    open/syncd    N/A
hd4                 jfs        1     1     1    open/syncd    /
hd2                 jfs        50    50    1    open/syncd    /usr
hd9var              jfs        3     3     1    open/syncd    /var
hd3                 jfs        2     2     1    open/syncd    /tmp
hd1                 jfs        1     1     1    open/syncd    /home
paging00            paging     16    16    1    open/syncd    N/A
# lsvg rootvg
VOLUME GROUP:   rootvg                   VG IDENTIFIER:  00000446899fd108
VG STATE:       active                   PP SIZE:        4 megabyte(s)
VG PERMISSION:  read/write               TOTAL PPs:      159 (636 megabyte)
MAX LVs:        256                      FREE PPs:       76 (304 megabyte)
LVs:            9                        USED PPs:       83 (332 megabyte)
OPEN LVs:       8                        QUORUM:         2
TOTAL PVs:      1                        VG DESCRIPTORS: 2
STALE PVs:      0                        STALE PPs       0
ACTIVE PVs:     1                        AUTO ON:        yes
#
# lsvg -p rootvg
rootvg:
PV_NAME           PV STATE    TOTAL PPs   FREE PPs    FREE DISTRIBUTION
hdisk0            active      159         76          28..24..00..00..24
#
# lslv -m hd9var |pg
hd9var:/var
hd9var:/var
LP    PP1  PV1               PP2  PV2               PP3  PV3
0001  0074 hdisk0
0002  0003 hdisk0
0003  0004 hdisk0
#
```

It is also useful to document the complete current partition map of the rootvg volume group by using the command `lsvg -M rootvg|pg`. This command may produce a long output for a large volume group so its output is not included here. However, the outputs of `lsvg -l rootvg` and `lslv -m hd9var` clearly show, from the one to one ratio of logical to physical partitions, that no logical volume in the rootvg is currently mirrored.

***How to Create the rootvg Logical Volume Mirror Copies:*** In this example, the mirrored rootvg consists of only two disks. This means that by default, one disk contains two copies of the VGDA. This disk is thus required to be operational to maintain quorum. To ensure that the rootvg volume group stays online when this disk fails, using the mirror logical volume copies, quorum needs to be turned off.

Turn the rootvg quorum function off by entering:

1. `smitty vg`.

2. From the Volume Groups menu select **Set Characteristics of a Volume Group**.
3. From the Set Characteristics of a Volume Group menu, select **Change a Volume Group**.
4. On the menu Change a Volume Group, type in `rootvg` for the option labelled `VOLUME GROUP name` and press the **Enter** key (this could also be selected from the option **F4=List**).
5. Change the `QUORUM` field so the screen looks like:

```
                              Change a Volume Group

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

                                                        [Entry Fields]
* VOLUME GROUP name                                   rootvg
* Activate volume group AUTOMATICALLY                 yes               +
    at system restart?
* A QUORUM of disks required to keep the volume       no                +
   group on-line ?







F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

6. As suggested by **Enter=Do**, press the **Enter** key.

When smit returns `OK`, a second disk is added to rootvg so that mirror copies of all rootvg logical volumes can be created on it.

To add hdisk2 to the rootvg:

1. Use **F3=Cancel** to return the menu named Set Characteristics of a Volume Group.
2. From this menu, select **Add a Physical Volume to a Volume Group**.
3. Type `rootvg` and `hdisk2` so that the screen looks like:

```
                    Add a Physical Volume to a Volume Group

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

                                                      [Entry Fields]
* VOLUME GROUP name                                 [rootvg]
* PHYSICAL VOLUME names                             [hdisk2]











F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

4. As suggested by **Enter=Do**, press the **Enter** key.
5. Use **F10=Exit** to return to the command prompt.

Now create a mirrored copy of all file systems, the file systems log, and the paging spaces on hdisk2.

For the root file system:

1. Type `smitty lv`.
2. Select **Set Characteristic of a Logical Volume**.
3. Select **Add a Copy to a Logical Volume**.
4. To select the root file system, either type `hd4` and press the **Enter=Do** key, *or* press **F4=List** to display a screen that looks like:

```
                         Add Copies to a Logical Volume

Type or select a value for the entry field.
Press Enter AFTER making all desired changes.

  ___________________________________________________________________________
  |                          LOGICAL VOLUME name                            |
* |                                                                         |
  |                                                                         |
  | Move cursor to desired item and press Enter.                            |
  |                                                                         |
  |   loglv00            jfslog     1     1     1    closed/syncd  N/A      |
  |   lv00               jfs        1     2     2    closed/stale  /myfs    |
  |   hd6                paging     8     8     1    open/syncd    N/A      |
  |   hd5                boot       1     1     1    closed/syncd  N/A      |
  |   hd8                jfslog     1     1     1    open/syncd    N/A      |
  |   hd4                jfs        1     1     1    open/syncd    /        |
  |   hd2                jfs        50    50    1    open/syncd    /usr     |
  |   hd9var             jfs        3     3     1    open/syncd    /var     |
  |   hd3                jfs        2     2     1    open/syncd    /tmp     |
  |   hd1                jfs        1     1     1    open/syncd    /home    |
  |   paging00           paging     16    16    1    open/syncd    N/A      |
  |                                                                         |
  | F1=Help                F2=Refresh              F3=Cancel                |
F1| F8=Image               F10=Exit                Enter=Do                 |
F5| /=Find                 n=Find Next                                      |
  |_________________________________________________________________________|
```

5. Press the **down** key until the line that contains `hd4` is highlighted, and then press the **Enter=Do** key.
6. Move the cursor again to the field named `NEW TOTAL number of logical partition copies` and then use the **Tab** key to select the value `2`.
7. Leave the field `SYNCHRONIZE the data in the new logical partition copies?` with its default of no since we'll synchronize it later in "How to Synchronize rootvg" on page 196.
8. Move the cursor to the field named `PHYSICAL VOLUME names` and then either type in `hdisk2` or use the **F4=List** function key to select it so the screen looks like:

```
                        Add Copies to a Logical Volume

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

                                                      [Entry Fields]
* LOGICAL VOLUME name                                 hd4
* NEW TOTAL number of logical partition               2                +
    copies
  PHYSICAL VOLUME names                              [hdisk2]          +
  POSITION on physical volume                         center           +
  RANGE of physical volumes                           minimum          +
  MAXIMUM NUMBER of PHYSICAL VOLUMES                 [32]               #
    to use for allocation
  Allocate each logical partition copy                yes              +
    on a SEPARATE physical volume?
  File containing ALLOCATION MAP                     []
  SYNCHRONIZE the data in the new                     no               +
    logical partition copies?



F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

9. When smit returns `OK` to indicate that the command is complete, use the **F3=Cancel** key a few times to return to the menu with the title Logical Volumes.
10. Repeat the above copy creation for each of the following logical volumes:
    a. Copy hd1 that contains /home.
    b. Copy hd2 that contains /usr.
    c. Copy hd3 that contains /tmp.
    d. Copy hd8 that contains the file system log.
    e. Copy hd9var that contains /var.
    f. Copy hd6 that contains the default paging device.
    g. Copy paging00 that contains a second paging device.

**Warning - Check your dump device**

If you have a new AIX Version 4 system, then the hd6 logical volume is also likely to be the system dump device. This can be checked by the command `sysdumpdev`.

If hd6 is the dump device and you want to be able to capture a valid dump, then *you must change the primary dump device* by using the command `sysdumpdev -p /dev/dump_device_name -P`.

Alternatively, you can follow the smit menus obtained from the command `smitty sysdumpdev` to check and, if necessary, change the primary dump device.

*Do not mirror the dump device*. Please refer to the article *Developing a Logical Volume Strategy* in *AIX Version 4.1 Hypertext Information Base Library*. Any dumps to a mirrored dump device will fail.

h. We can easily check that the copies have been created by using the following `lsvg` command:

```
# lsvg -l rootvg
rootvg:
LV NAME          TYPE      LPs   PPs   PVs  LV STATE      MOUNT POINT
hd6              paging    8     16    2    open/stale    N/A
hd5              boot      1     1     1    closed/syncd  N/A
hd8              jfslog    1     2     2    open/stale    N/A
hd4              jfs       1     2     2    open/stale    /
hd2              jfs       50    100   2    open/stale    /usr
hd9var           jfs       3     6     2    open/stale    /var
hd3              jfs       2     4     2    open/stale    /tmp
hd1              jfs       1     2     2    open/stale    /home
paging00         paging    16    32    2    open/stale    N/A
#
```

Note that the logical volumes are currently in a `stale` state. This reflects the fact that the data in the most recently created copies is older than that in the original copies; the data is synchronized in a subsequent step.

i. As stated in the *AIX Version 4.1 Hypertext Information Base Library* article *Mirroring rootvg for Maximum Operating System Availability*, the creation of a mirror copy of hd5, the boot logical volume, is not recommended. Instead, create a new boot logical volume called hd5x.

1) Select, in the Logical Volumes menu, the option **Add a Logical Volume**.

2) When prompted for the `VOLUME GROUP name`, type in `rootvg` and press **Enter=Do**, or use **F4=List** to select it.

3) In the Add a Logical Volume menu, leave all entries as default, except for `Logical volume NAME`, `Number of LOGICAL PARTITIONS`, `PHYSICAL VOLUME names`, and `Logical volume TYPE`, so that the screen looks like:

```
                              Add a Logical Volume

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

[TOP]                                                     [Entry Fields]
  Logical volume NAME                                  [hd5x]
* VOLUME GROUP name                                     rootvg
* Number of LOGICAL PARTITIONS                         [2]              #
  PHYSICAL VOLUME names                                [hdisk2]        +
  Logical volume TYPE                                  [boot]
  POSITION on physical volume                           outer_edge      +
  RANGE of physical volumes                             minimum         +
  MAXIMUM NUMBER of PHYSICAL VOLUMES                   []               #
    to use for allocation
  Number of COPIES of each logical                      1               +
    partition
  Mirror Write Consistency?                             yes             +
  Allocate each logical partition copy                  yes             +
    on a SEPARATE physical volume?
[MORE...9]

F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

Note that you can use any `Logical volume NAME`, and you can use more than one physical partition, although this does waste space since hd5 only occupies 4MB. For the `Logical volume TYPE`, you *must type in the word boot* to ensure that you do not get the default type of jfs, which is for an ordinary jfs file system like /home. Finally, do not forget to type `hdisk2` for the `PHYSICAL VOLUME name` so that *hd5x is not created on hdisk0*, which is where hd5, the original boot logical volume, exists.

4) Use **F10=Exit** to exit smit when the command completion is indicated by:

```
                                 COMMAND STATUS

Command: OK            stdout: yes           stderr: no

Before command completion, additional instructions may appear below.

hd5x











F1=Help             F2=Refresh          F3=Cancel           F6=Command
F8=Image            F9=Shell            F10=Exit            /=Find
n=Find Next
```

5) Now that hd5x exists, build a boot image on it by entering the following command after using the **F10=Exit** key to leave smit.

```
# bosboot -a -l /dev/hd5x -d /dev/hdisk2

bosboot: Boot image is 4259 512 byte blocks.
```

The output will appear after approximately 30 seconds.

**Warning - Be careful with bosboot**

It is *very important* to be aware of the following advice given in the *AIX Version 4.1 Hypertext Information Base Library* article *Mirroring rootvg for Maximum Operating System Availability*.

*If you put on a ptf that performs a* `bosboot` *or personally do* `bosboot` *and you are mirroring the rootvg, you must remember to do a* `bosboot` *to the secondary /blv.*

Furthermore, we suggest that you execute the command `bootlist -m normal hdisk0 hdisk2`, and then reboot using hd5 which is on hdisk0, *before* you execute any command that calls the `bosboot` command.

If you do not do this, you may get errors such as:

```
installp:  bosboot verification starting...

0301-168 bosboot: The current boot logical volume, /dev/hd5,
        does not exist on /dev/hdisk2.
The installation or updating script is unable to continue
installp:  An error occurred during bosboot processing.
        Please correct the problem and rerun installp.
```

11. Now that all logical volumes in the rootvg exist with their primary copy on hdisk0 and their mirror copy on hdisk2, the list of devices to attempt to boot from in normal mode needs to be updated so the RISC System/6000 can boot from hdisk2 if hdisk0 is not available.

    Use the command:

```
#
# bootlist -m normal hdisk0 hdisk2
#
```

***How to Synchronize rootvg:*** The newly created mirror copies need to be synchronized with the originals to complete the creation of a mirrored rootvg. This can be done with the command `syncvg -v rootvg`, or, to use smit:

1. Type `smitty vg`.
2. From the `Volume Groups` menu, select **Activate a Volume Group**.
3. For the field `VOLUME GROUP name`, type `rootvg` or use the **F4=List** to select it so that the screen looks like:

```
                              Activate a Volume Group

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

                                                      [Entry Fields]
* VOLUME GROUP name                                 [rootvg]          +
  RESYNCHRONIZE stale physical partitions?           yes              +
  Activate volume group in SYSTEM                    no               +
    MANAGEMENT mode?
  FORCE activation of the volume group?              no               +
    Warning--this may cause loss of data
   integrity.









F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

4. Press **Enter=Do** to execute the synchronization process.

   This smit menu actually starts the command `varyonvg rootvg` which can be seen from the **F6=Command** function key. The `varyonvg` command actually starts the `syncvg` command before `varyonvg` exits. This can be seen by pressing **F10=Exit** when smit returns an `OK` prompt, and then searching through the output of the `ps -ef` command to find:

```
    root 7066    1   0 13:33:36  pts/0  0:00 bsh /usr/sbin/syncvg -v root
    root 7264 6494   0 13:17:41  pts/1  0:00 -ksh
    root 7604 7066   1 13:34:50  pts/0  0:00 lresynclv -l 00000446899fd108
    root 7858 7264   5 13:34:46  pts/1  0:00 lsvg -l rootvg
    root 8118 6056  34 13:35:05  pts/0  0:00 ps -ef
```

**Warning - syncvg continues**

Although smit quickly returns an `OK` prompt, `syncvg` continues to run, and, depending on the size of your rootvg, may run for a long time.

As well as the previous `ps -ef` command, you can regularly repeat the following command until the field `STALE PPs` has a value of 0, which indicates synchronization is complete.

```
# lsvg rootvg
VOLUME GROUP:   rootvg                  VG IDENTIFIER:  00000446899fd108
VG STATE:       active                  PP SIZE:        4 megabyte(s)
VG PERMISSION:  read/write              TOTAL PPs:      243 (972 megabytes)
MAX LVs:        256                     FREE PPs:       76 (304 megabytes)
LVs:            10                      USED PPs:       167 (668 megabytes)
OPEN LVs:       8                       QUORUM:         1
TOTAL PVs:      2                       VG DESCRIPTORS: 3
STALE PVs:      1                       STALE PPs       76
ACTIVE PVs:     2                       AUTO ON:        yes
```

In this example, `syncvg` required approximately one hour and 15 minutes on a quiesced system.

Note that the value of the `QUORUM:` field is `1` because the quorum function has been turned off.

***How to Check the Implementation of a Mirrored rootvg:*** When `syncvg` finally completes, execute the following command:

```
# lsvg -l rootvg
rootvg:
LV NAME             TYPE       LPs   PPs   PVs  LV STATE      MOUNT POINT
hd6                 paging     8     16    2    open/syncd    N/A
hd5                 boot       1     1     1    closed/syncd  N/A
hd8                 jfslog     1     2     2    open/syncd    N/A
hd4                 jfs        1     2     2    open/syncd    /
hd2                 jfs        50    100   2    open/syncd    /usr
hd9var              jfs        3     6     2    open/syncd    /var
hd3                 jfs        2     4     2    open/syncd    /tmp
hd1                 jfs        1     2     2    open/syncd    /home
paging00            paging     16    32    2    open/syncd    N/A
hd5x                boot       2     2     1    closed/syncd  N/A
#
```

This shows there now exists two boot type logical volumes, two copies of all other logical volumes, (indicated by the 2:1 ratio of PPs to LPs), and all the rootvg logical volumes are now in a `syncd` state.

Other commands you can use to check the new rootvg configuration include:

```
# lslv -m hd9var |pg
hd9var:/var
LP    PP1  PV1               PP2  PV2               PP3  PV3
0001  0074 hdisk0            0003 hdisk2
0002  0003 hdisk0            0004 hdisk2
0003  0004 hdisk0            0005 hdisk2
# lsvg -p rootvg
rootvg:
PV_NAME           PV STATE    TOTAL PPs   FREE PPs    FREE DISTRIBUTION
hdisk0            active      159         76          28..24..00..00..24
hdisk2            active      84          0           00..00..00..00..00
# lsvg -M rootvg|pg
rootvg
more output.....
hdisk0:134      hd2:48:1
hdisk0:135      hd2:49:1
hdisk0:136-159
hdisk2:1        hd2:49:2
hdisk2:2        hd2:50:2
hdisk2:3        hd9var:1:2
more output.....
```

Notice that hdisk2 is full. This means that we can not currently extend the rootvg logical volumes that have mirror copies on hdisk2. However, we can create new non-mirrored logical volumes on hdisk0 in the rootvg volume group, but their data would be unavailable if hdisk0 fails.

The implementation of a mirrored rootvg is now complete.

***How to Test the rootvg Logical Volume Mirror Copies:*** Recall that the `bootlist` command used earlier forces the RISC System/6000 to try to boot from hdisk0 before hdisk2. Hence, the first test requires AIX Version 4 to be shut down, and then the internal disks must be disconnected from their power cables before the RISC System/6000 is powered back on.

**Warning - Handle hardware with care**

Ensure that a qualified individual is available to follow the correct procedures required when a RISC System/6000 unit is serviced.

There are error messages displayed during the boot sequence that are associated with the powered off internal disks. You can easily confirm there is a disk problem from the following commands:

```
# lsvg -l rootvg
rootvg:
LV NAME            TYPE       LPs   PPs   PVs  LV STATE      MOUNT POINT
hd6                paging     8     16    2    open/syncd    N/A
hd5                boot       1     1     1    closed/syncd  N/A
hd8                jfslog     1     2     2    open/stale    N/A
hd4                jfs        1     2     2    open/stale    /
hd2                jfs        50    100   2    open/stale    /usr
hd9var             jfs        3     6     2    open/stale    /var
hd3                jfs        2     4     2    open/stale    /tmp
hd1                jfs        1     2     2    open/stale    /home
paging00           paging     16    32    2    open/syncd    N/A
hd5x               boot       2     2     1    closed/syncd  N/A
#
# lsdev -Cc disk
hdisk0 Defined   00-08-00-0,0 670 MB SCSI Disk Drive
hdisk1 Defined   00-08-00-1,0 670 MB SCSI Disk Drive
hdisk2 Available 00-08-00-2,0 355 MB SCSI Disk Drive
hdisk4 Available 00-07-00-0,0 1.2 GB SCSI Disk Drive (in 2.4 GB Disk Unit
hdisk5 Available 00-07-00-1,0 1.2 GB SCSI Disk Drive (in 2.4 GB Disk Unit
hdisk6 Available 00-07-00-2,0 1.2 GB SCSI Disk Drive (in 2.4 GB Disk Unit
hdisk7 Available 00-07-00-3,0 1.2 GB SCSI Disk Drive (in 2.4 GB Disk Unit
hdisk3 Available 00-08-00-3,0 320 MB SCSI Disk Drive
```

The `lsvg` command shows how the rootvg logical volumes are now in a `stale` state, and the `lsdev` shows that the internal hdisk0 is not available for normal operations.

The command:

```
# bootinfo -b
hdisk2
#
```

shows that the mirrored rootvg configuration has worked, since AIX Version 4 has now booted from hdisk2 instead of hdisk0.

**Warning - do not change rootvg configuration**

Do *not make any changes to rootvg configuration* at this point since this information would only be recorded on the copies on hdisk2. Since *this test sequence* involves a reboot next from hdisk0 while hdisk2 remains powered off, then the VGSA on hdisk0 will be flagged as having the most recent copies of the rootvg logical volumes.

Hence the hdisk0 copies are used to overwrite the hdisk2 copies during the subsequent synchronization step after the external 355MB hdisk2 device is powered back on.

Shut down the RISC System/6000 by executing the `shutdown -f` command, so that power can then be restored to hdisk0. Since hdisk2 is an external 355MB disk unit, leave it powered off when the RISC System/6000 is turned on so that the RISC System/6000 will now boot from hdisk0 again instead of hdisk2.

Among the boot messages, you will see:

```
varyonvg: Volume group rootvg is varied on.
PV Status:      hdisk0  00014732b1bd7f57        PVACTIVE
                hdisk2  00012218da42ba76        PVMISSING
0516-068 lresynclv: Unable to completely resynchronize volume. Run
        diagnostics if necessary.
0516-932 /usr/sbin/syncvg: Unable to synchronize volume group rootvg.
0516-068 lresynclv: Unable to completely resynchronize volume. Run
        diagnostics if necessary.
0516-932 /usr/sbin/syncvg: Unable to synchronize volume group rootvg.
```

This is normal since hdisk2 really is unavailable. The `varyonvg rootvg` command is run automatically during the boot sequence and thus the above errors are recorded.

We can again confirm that hdisk0 was used to boot by the command:

```
# bootinfo -b
hdisk0
```

You can also repeat the command `lsvg -l rootvg` to verify that the logical volumes are still in a `stale` state.

In this example, we were surprised that the paging devices hd6 and paging00 were not in a `stale` state. This may change in a later level of AIX Version 4 than the one that we tested.

However, you can force the paging devices to become `stale` by starting many memory intensive processes in a loop. For example, you can use the graphical version of the *AIX Version 4.1 Hypertext Information Base Library* from the command `info &`.

We can see that the paging devices are now `stale` from:

```
# lsvg -l rootvg
rootvg:
LV NAME             TYPE       LPs   PPs   PVs  LV STATE      MOUNT POINT
hd6                 paging     8     16    2    open/stale    N/A
hd5                 boot       1     1     1    closed/syncd  N/A
hd8                 jfslog     1     2     2    open/stale    N/A
hd4                 jfs        1     2     2    open/stale    /
hd2                 jfs        50    100   2    open/stale    /usr
hd9var              jfs        3     6     2    open/stale    /var
hd3                 jfs        2     4     2    open/stale    /tmp
hd1                 jfs        1     2     2    open/stale    /home
paging00            paging     16    32    2    open/stale    N/A
hd5x                boot       2     2     1    closed/syncd  N/A
#
```

**Warning - Don't be misled by lsps**

Note that the output of `lsps`:

```
# lsps -a
Page Space  Physical Volume   Volume Group    Size   %Used  Active  Auto
paging00    hdisk0            rootvg          64MB      43     yes   yes
paging00    hdisk2            rootvg          64MB      43     yes   yes
hd6         hdisk0            rootvg          32MB     100     yes   yes
hd6         hdisk2            rootvg          32MB     100     yes   yes
#
```

may indicate that all copies of paging devices are accessible, when in fact those on hdisk2 are not.

More detailed information about the status of each logical partition and physical partition can be obtained from the commands discussed in Chapter 7, “Storage Management Files and Commands Summary” on page 137. For example, use:

```
# lslv -p hdisk2 hd6
hdisk2:hd6:N/A
STALE  USED   STALE  USED   STALE  STALE  USED   USED   STALE  STALE
STALE  STALE  STALE  STALE  STALE  STALE  STALE

0001?  0002?  0003?  0004?  0005?  0006?  0007?  0008?  STALE  STALE
USED   USED   USED   USED   USED   USED   USED
more output.....
```

to see that all copies of hd6 logical partitions on hdisk2 happen to be in a `STALE` state, as indicated by the question mark.

Also note that *not all physical partitions on hdisk2 are* `STALE`; those physical partitions that have not been accessed for any I/O operation are still in a `USED` state. However, as seen from the `lsvg -l rootvg` command, the logical volumes that these physical partitions belong to have been marked stale.

***How to return to a synchronized state:*** The most simple method is to reboot the RISC System/6000. However in this example, assuming there are other users currently on the system, configure the defined hdisk2 using the following steps:

1. Execute the command `smitty devices`.
2. Select **Fixed Disk**.
3. Select **Configure a Defined Disk**.
4. From the Disk sub-menu that appears, select **hdisk2 Defined 00-08-00-2,0 355 MB SCSI Disk Drive**.
5. Press **F10=Exit** when smit returns an `OK` prompt.

After you've confirmed that the disk is `Available` from the `lsdev -Cc disk` command, repeat the synchronization step used in the creation of the mirrored rootvg. Hence:

1. Execute the command `smitty vg`.

2. Select **Activate a Volume Group**.
3. Type `rootvg` or use **F4=List** to select it.
4. Press the **Enter=Do** key.
5. Press **F10=Exit** when smit returns an `OK` prompt.

**Note**

We suggest that you use the `varyonvg` command rather than both the `chpv` and `syncvg` commands to synchronize the rootvg volume group.

From the output of the following command:

```
# iostat

tty:      tin         tout   avg-cpu:  % user    % sys     % idle    % iowait
          0.3         12.9               6.1      5.1       78.9      10.0

Disks:        % tm_act     Kbps      tps    Kb_read   Kb_wrtn
hdisk0          14.9      55.5       5.3    231182     65737
hdisk3           0.0       0.2       0.0      1052         0
hdisk1           0.2       1.2       0.0      1070      5191
hdisk4           0.2       2.8       0.0     14777        69
hdisk5           0.1       1.6       0.0      8694        46
hdisk6           0.0       0.6       0.0      3172       154
hdisk7           0.0       0.2       0.0      1052         0
hdisk2           1.2      10.9       0.1        43     58171
#
```

we can see that, as discussed earlier, the copies on hdisk0 are most recent and are being read so that a write operation can update the copies on hdisk2 now that it is available again.

***Simulation of disk failure during normal operations:*** This test uses hdisk2, a 355MB external disk device. Since this is an external disk, we can power it off while the system is being used to verify that normal processing is not halted (we are not concerned about any performance implications in this scenario).

First execute the `lsvg -l rootvg` command to confirm that all rootvg logical volumes are now in a `syncd` state.

Power off hdisk2 and repeat the command to obtain output such as:

```
# lsvg -l rootvg
rootvg:
LV NAME             TYPE       LPs   PPs   PVs  LV STATE      MOUNT POINT
hd6                 paging     8     16    2    open/syncd    N/A
hd5                 boot       1     1     1    closed/syncd  N/A
hd8                 jfslog     1     2     2    open/stale    N/A
hd4                 jfs        1     2     2    open/stale    /
hd2                 jfs        50    100   2    open/stale    /usr
hd9var              jfs        3     6     2    open/stale    /var
hd3                 jfs        2     4     2    open/syncd    /tmp
hd1                 jfs        1     2     2    open/syncd    /home
paging00            paging     16    32    2    open/syncd    N/A
hd5x                boot       2     2     1    closed/syncd  N/A
#
```

Note that *not all rootvg logical volumes are now* `stale`.

- hd8 is `stale` because a write occurred to a jfs.
- hd4 is `stale` because / contains the ODM files that are read to help produce the command output.
- hd2 is `stale` because /usr contains the `lsvg` command that is read so that it can be loaded into RAM and then executed.
- hd9var is `stale` because there have been some temporary files created since hdisk2 was powered off.

The other logical volumes are not currently involved in an I/O operation and so they remain in a `syncd` state.

Once power is restored to hdisk2, it can again be again synchronized with hdisk0 by using the `varyonvg rootvg` or the corresponding `smitty vg` selection.

## 8.3 Storage Subsystem Design

For this section, it is very beneficial for the reader to become familiar with the concepts discussed in:

- Chapter 5, “Storage Subsystem Design” on page 77.
- Chapter 6, “General AIX Storage Management” on page 93.
- *AIX Version 4.1 System Management Guide: Operating System and Devices*, which may be in :cit,AIX Version 4.1 Hypertext Information Base Library on your system.
- *AIX V3.2 Performance Monitoring and Tuning Guide*, which may be in *AIX Version 4.1 Hypertext Information Base Library* on your system.
- The following *AIX Version 4.1 Hypertext Information Base Library* articles:
  - Developing a Logical Volume Strategy
  - Configuring a Storage System for Maximum Performance
  - Developing a Volume Group Strategy
  - Configuring a Storage System for Maximum Availability
  - Create a File System Log on a Dedicated Disk for a User-Defined Volume Group

– Backing Up Your System

– Installing BOS from a System Backup

– Logical Volume Storage Overview

– File Systems Overview

Once the available hardware has been reviewed (please refer to 8.1, “Planning” on page 185), the next step in storage subsystem design is to plan and design your volume group configuration.

### 8.3.1 A Volume Group Design Example

Two major aims in storage subsystem design are to achieve the optimum performance for disk access requests (in other words, the fastest disk access possible), and also to achieve the highest possible availability (in other words, provide the system with as good a chance as is practically possible that disk access requests will not fail). These aims are discussed in more detail elsewhere, but it is important to note at this point that these aims can often interfere with each other. In other words, a high availability configuration will often result in slower access times to the data that is now stored in a highly available state.

Sometimes, a particular configuration option will be beneficial for both performance and availability, but then there is likely to be an associated extra cost for that choice. In this example, the price paid for a second SCSI adapter has bought us the option of placing some disk devices on this second adapter. This can improve performance because the I/O requests workload can now be shared between both adapters. This also improves availability if disk mirroring is implemented using disks on different adapters, because we would then still have access to one disk if one of the adapters failed.

However, our particular configuration and storage needs does not allow us to fully utilize this benefit. Recall from 8.1, “Planning” on page 185 that for this example, we have a total of nine disks to allocate. We have already allocated one internal 670MB disk and the external 355MB disk to the rootvg volume group. We are not interested in the performance of disk I/O for the logical volumes in the rootvg, so we've allocated the slowest disks for the rootvg. We did not use both internal 670MB disks for rootvg because we wanted to be able to power off a rootvg disk while the system is being used; please refer to 8.2, “rootvg Mirroring - Implementation and Recovery” on page 187.

This leaves us with seven more disks to allocate, two on the SCSI adapter in slot eight, and five on the adapter in slot seven. Ideally, a system with multiple disks should consist of multiple volume groups; usually such a system should have at least one non-rootvg volume group.

The guidelines for volume group design are discussed elsewhere, see Chapter 5, “Storage Subsystem Design” on page 77, and also refer to the article Developing a Volume Group Strategy, but for this example, we want to create three volume groups, primarily for safe and easy maintenance. This allows us to do different storage management related tasks in different volume groups, and hence we can isolate the effects of theses tasks. In other words, a volume group synchronization operation will potentially only result in extensive I/O in two or three disks, instead of say seven disks if they are all grouped together as one volume group. Multiple volume groups allow journaled file systems to be created in one volume group, and raw logical volumes can be used by databases in another volume group. Also, we can destroy the configuration of one volume group and its associated components (disks, logical volumes, data) during one example without affecting the integrity of data, file systems, and logical volumes used in other examples in other volume groups. Finally, we have the options of implementing different quorum characteristics in the different volume groups, and we can use a different physical partition size for each volume group.

**Design Change - Now or later?**

If you do not fully understand all the implications of a proposed design, but need to implement a design *today*, then do so provided that you at least understand that any future disk reallocation work may be a large job that may require significant system maintenance time, and possible end-user interruptions.

In our example, the seven disks left after the rootvg set up can be allocated to one volume group, or up to seven different volume groups. There are arguments for and against creating three volume groups. However, for expediency and the reasons outlined above, we shall create three volume groups, each with a physical partition size of 4MB, and we're ready to change this in the future if required.

The choice of three volume groups also illustrates that *any design has to work with the available resources.* We only have two disks available on the SCSI adapter in slot eight and hence the benefits of using a second adapter will only be available to at most two volume groups. Hence we need to prioritize the creation of our volume groups. In this example design, assume that the created logical volumes will require all available volume group physical partitions. Also assume that for some logical volumes, their content is such that performance is more critical than availability (for example, assume they store large archived databases). For other logical volumes, assume that availability is more critical (for example, a small customer database with names and phone numbers). Since this example has three volume groups, then one of these volume groups will have to sacrifice either performance or availability because it will use only one SCSI adapter. We place priority on the logical volumes that require optimal performance, so, in this example, create the following volume groups using the specified disks for the reasons stated:

- stripevg

  This volume group is primarily intended to contain examples associated with the new AIX Version 4 logical volume manager and file system features. Striping is most beneficial for large sequential I/O operations, so we want to use two large disks of similar size. Striping is meant to improve performance, so use disks on different adapters.

  Since the adapter in slot eight only has a 670MB disk and a 320MB disk, use the 670 disk for stripevg. There are four 1.2GB disks and one 857MB disk configured using the adapter in slot seven, so use the 857MB disk as the second disk in stripevg.

```
hdisk1 Available 00-08-00-1,0 670 MB SCSI Disk Drive
hdisk8 Available 00-07-00-4,0 857 MB SCSI Disk Drive
```

Use hdisk1 and hdisk8 for stripevg.

- availvg

  This volume group is primarily intended to contain examples that show how to implement a high availability strategy using two disks. Since availability is not as important as performance, then we will use two 1.2GB disks. This is also a realistic availability configuration because it allows the entire contents of one disk to be duplicated on the other (conversely, if we used a 857MB and a 1.2GB disk here, then we could only protect the contents of the 857MB disk from failure).

  We must ensure that the disks can be independently powered on, so choose hdisk4 and hdisk6 because these 1.2GB disks are physically located in different parts of the 9334-500 machine used in these examples. To ensure that we can continue to operate with only one of the two disks, then we also need to turn off the *quorum* attribute of availvg.

```
hdisk4 Available 00-07-00-0,0 1.2 GB SCSI Disk Drive (in 2.4 GB Disk Unit)
hdisk6 Available 00-07-00-2,0 1.2 GB SCSI Disk Drive (in 2.4 GB Disk Unit)
```

  Use hisk4 and hdisk6 for availvg.

- perfvg

  This volume group is primarily intended to contain examples that show how to implement a good performance strategy. Use the 320MB disk connected to the adapter in slot eight. There are two disks left, so this volume group can have either two or three disks in it. However, we want to allow for future growth so leave one 1.2GB disk unallocated. The two disks are sufficient for the design examples in this volume group.

```
hdisk5 Available 00-07-00-1,0 1.2 GB SCSI Disk Drive (in 2.4 GB Disk Unit)
hdisk3 Available 00-08-00-3,0 320 MB SCSI Disk Drive
```

  Use hdisk3 and hdisk5 in perfvg.

### 8.3.2 Map Files Usage and Contents

A map file is used to specify exactly which physical partitions on which disks will contain the logical partitions for the primary, secondary, or tertiary copy of a logical volume. The physical partitions are allocated to logical partitions for a logical volume copy according to the order in which they appear in the map file. Each logical volume copy should have its own map file, and the map files of each logical volume copy should each allocate the same number of physical partitions. Hence it offers very precise control when a logical volume is first created (the primary copy), or when the secondary or tertiary copies of a logical volume are subsequently created in a mirrored environment.

Before map files are created, we need to check the following:

- What is the numerical range of physical partitions for the different disk regions?
- Which physical partitions. are free on our target disks, hdisk5 and hdisk3?

You can easily check this with the following commands:

```
# lspv -p hdisk5
hdisk5:
PP RANGE  STATE   REGION        LV ID               TYPE       MOUNT POINT
  1-58    free    outer edge
 59-115   free    outer middle
116-172   free    center
173-229   free    inner middle
230-287   free    inner edge
# lspv -p hdisk3
hdisk3:
PP RANGE  STATE   REGION        LV ID               TYPE       MOUNT POINT
  1-15    free    outer edge
 16-30    free    outer middle
 31-45    free    center
 46-60    free    inner middle
 61-75    free    inner edge
```

An example of the use of map files is given in the *AIX Version 4.1 Hypertext Information Base Library* article *Developing a Logical Volume Strategy*. However, the examples that follow here in 8.3, "Storage Subsystem Design" on page 204 use the following map files to create logical volumes in perfvg:

- badmir.map for perflv1:

```
hdisk5:101-110
```

- goodmir.map for perflv2:

```
hdisk5:201-210
```

- centre.map for perflv3:

```
hdisk5:111-112
hdisk3:44-45
hdisk5:113-114
hdisk3:42-43
hdisk5:115-116
hdisk3:40-41
```

- inedge.map for perflv4:

```
hdisk5:233-237
hdisk3:66-70
```

- badmir.map2 for perflv1:

```
hdisk5:91-100
```

- goodmir.map2 for perflv2:

```
hdisk3:51-60
```

When you use map files to specify exactly which physical partitions on a disk to use, you can ignore the *inter-disk* allocation policies specified by the smit options:

- `RANGE of physical volumes.`
- `Allocate each logical partition copy on a SEPARATE physical volume?`

You can also ignore the *intra-disk* smit option:

- `POSITION on physical volume.`

When you use smit, these fields have default values which can be ignored because the map file physical partition allocation will have the higher precedence.

For example, the use of the two map files badmir.map and badmir.map2 to create the two copies of the perflv1 logical volume later will result in both copies being placed on hdisk5. Hence, this gives you the same result as you would obtain if you set `RANGE of physical volumes` to `minimum`. This is why this field must be ignored. If you try to change this field, you'll get an error like

```
0516-690 mklv: The -a, -e, -u, -s, and -c options cannot be
        used with the -m option.
Usage: mklv [-a IntraPolicy] [-b BadBlocks] [-c Copies] [-d Schedule]
        [-e InterPolicy] [-i] [-L Label] [-m MapFile] [-r Relocate]
        [-s Strict] [-t Type] [ -u UpperBound] [-v Verify&rbr. [-w MWC]
        [-x MaxLPs] [-y LVname] [-Y Prefix] [-S StripeSize] VGname NumberOfLPs
        [PVname...]
Makes a logical volume.
```

### 8.3.3 A Design Example for Improved Availability

This section will show you how to implement a mirrored environment that will help you minimize the disruption caused by a hardware failure. The example in this section assumes that you accept the cost of the extra disk capacity required to implement mirroring.

If you do not have enough physical volumes to do this, then you can still improve your availability by specifying minimum as the target range of physical volumes during the creation of your logical volumes. This may be helpful if you know two physical volumes in a volume group are much more reliable than another, because if the less reliable physical volume fails, you may be able to access the logical volumes that exist on one of the good disks.

We have already discussed a mirrored rootvg volume group, so this example shows you how a non-rootvg volume group can be mirrored to provide higher availability than in a non-mirrored environment.

Since mirroring requires a minimum of two physical volumes we will also show how to identify these resources. We will use the name, availvg for our volume group and and for our logical volume and journaled file system we expect to use the names, availlv and availjfs respectively.

### 8.3.3.1 Command Line Summary

1. First check to see what disks are available and that they are not assigned to an existing volume group:

```
# lspv
hdisk4  0000020158496d72        none
hdisk6  000002007bb618f5        none
#lsdev -Cc disk
hdisk4 Available 00-07-00-0,0 1.2 GB SCSI Disk Drive (in 2.4 GB Disk Unit)
hdisk6 Available 00-07-00-2,0 1.2 GB SCSI Disk Drive (in 2.4 GB Disk Unit)
```

2. Create original non-rootvg using both physical volumes:

```
# mkvg -f -y'availvg' 'hdisk4 hdisk6'
```

3. Add a logical volume to the the volume group availvg creating two copies, each on a different physical volume. The logical volume will consist of six logical partitions:

```
# mklv -y'availlv' -e'x' -c'2' -v'y' 'availvg' '6'
```

4. Create a journaled file system, `/availjfs`, using the logical volume created above:

```
# crfs -v jfs -d'availlv' -m'/availjfs' -A'yes' -p'rw' -t'no' \
-a frag='4096' -a nbpi='4096' -a compress='no'
```

5. Mount the journaled file system:

```
# mount /availjfs
```

6. Create a copy of the journaled log logical volume:

```
mklvcopy -e'x' '-k' 'loglv00' '2'
```

7. Turn off quorum checking:

```
# chvg -a'y' -Q'n' 'availvg'
```

You now have a volume group with mirrored logical volumes and a file system mounted and ready to be used.

### 8.3.3.2 Detailed Description

The above summary steps have shown us how to create a mirrored volume group. In this section we will look at each command separately, showing its output and also verify that we have successfully created a mirrored volume group.

***How to Create a Mirrored non-rootvg Volume Group:*** In order to create a mirrored volume group we need two or more free physical volumes. In our example we have chosen *hdisk4* and *hdisk6*, each capable of being powered on and off separately. This will be useful in simulating a physical volume failure by switching off one of the active physical volumes. A mirrored logical volume, availlv, will be created with a size of six logical partitions (24MB), with each copy on a separate physical volume.

In order to achieve high availability we need to make sure that for each of the physical volumes selected for the volume group:

- They are on different SCSI adapters.
- They have their own power supply.

1. First let us look at the availability of the physical volumes for the volume group. Execute the `lspv` command to check which physical volumes are currently not assigned to a volume group:

```
# lspv
hdisk0         00014732b1bd7f57    rootvg
hdisk1         000137231982c0f2    stripevg
hdisk2         00012218da42ba76    rootvg
hdisk3         00000201dc8b0b32    perfvg
hdisk4         0000020158496d72    none
hdisk5         0002479088f5f347    perfvg
hdisk6         000002007bb618f5    none
hdisk7         00000446431550c9    none
hdisk8         0001221800072440    stripevg
```

   Since the physical volumes `hdisk4`, `hdisk6`, and `hdisk7` are attached to the same SCSI adapter and do not have their own power supply, we do not have the optimal availability scenario. However, each of the physical volumes have their own power switch, and so `hdisk4` and `hdisk6` will be chosen, since we will be able to simulate a hard disk failure by switching off the power to either one of these two disks.

2. Create a volume group that contains these two physical volumes by executing the `smitty mkvg` command. On the following screen enter the name of the volume group and the names of the physical volumes we have identified. After filling out the fields press **Enter**.

```
                               Add a Volume Group

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

                                                        [Entry Fields]
  VOLUME GROUP name                                  [availvg]
  Physical partition SIZE in megabytes                4                +
* PHYSICAL VOLUME names                              [hdisk4 hdisk6]   +
  Activate volume group AUTOMATICALLY                 yes              +
    at system restart?
* ACTIVATE volume group after it is                   yes              +
    created?
  Volume Group MAJOR NUMBER                          []                +#

F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

Press the **F10** key after smit returns with `OK`.

We have now created the volume group, availvg and are ready to add a logical volume. Note that the volume group is automatically varied on.

3. To create the availlv logical volume:

   a. Execute the `smitty mklv` command:

```
                              Add a Logical Volume

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

[TOP]                                                   [Entry Fields]
  Logical volume NAME                                [availlv]
* VOLUME GROUP name                                   availvg
* Number of LOGICAL PARTITIONS                       [6]               #
  PHYSICAL VOLUME names                              []                +
  Logical volume TYPE                                []
  POSITION on physical volume                         outer_middle     +
  RANGE of physical volumes                           maximum          +
  MAXIMUM NUMBER of PHYSICAL VOLUMES                 []                #
    to use for allocation
  Number of COPIES of each logical                    2                +
    partition
  Mirror Write Consistency?                           yes              +
  Allocate each logical partition copy                yes              +
    on a SEPARATE physical volume?
[MORE...9]

F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

   b. This is the first screen of this smit menu. On this screen enter information for the following fields as shown above:

      - `Logical volume NAME`
      - `Number of LOGICAL PARTITIONS`
      - `RANGE of physical volumes`
      - `Number of COPIES of each logical partition`

      For the range and copies fields use **F4=List** function key and select the appropriate value. The `RANGE` field must be `maximum` so that each logical partition copy is placed on a separate physical volume. The `COPIES` field must be set to `2` so that two copies of each logical partition are created.

c. To access information on the second screen use the PageDown key on the keyboard. The second screen of the smit menu looks like:

```
                              Add a Logical Volume

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

[MORE...9]                                            [Entry Fields]
  Number of COPIES of each logical                  2                      +
    partition
  Mirror Write Consistency?                         yes                    +
  Allocate each logical partition copy              yes                    +
    on a SEPARATE physical volume?
  RELOCATE the logical volume during reorganization? yes                   +
  Logical volume LABEL                             []
  MAXIMUM NUMBER of LOGICAL PARTITIONS             [128]
  Enable BAD BLOCK relocation?                      yes                    +
  SCHEDULING POLICY for writing logical             parallel               +
    partition copies
  Enable WRITE VERIFY?                              yes                    +
  File containing ALLOCATION MAP                   []
  Stripe Size?                                     [Not Striped]           +
[BOTTOM]

F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

On this screen use the **F4** key and select **yes** for the field `Enable WRITE VERIFY?`. The effect of this to read the data after it has been written to make sure that the write was successful.

d. Press **Enter** after making the above changes. When smit returns with `OK`, press the **F10** key to exit smit.

e. Execute the command `lslv -m availlv` to get information about the physical partition map for the logical volume availlv:

```
# lslv -m availlv
availlv:N/A
LP    PP1  PV1               PP2  PV2               PP3  PV3
0001  0082 hdisk4            0085 hdisk6
0002  0082 hdisk6            0085 hdisk4
0003  0083 hdisk4            0086 hdisk6
0004  0083 hdisk6            0086 hdisk4
0005  0084 hdisk4            0087 hdisk6
0006  0084 hdisk6            0087 hdisk4
```

**Note copy location**

Each logical partition copy is placed on a different physical volume.

f. Let us now check to see which region of each physical volume has been used for logical volume availlv. Execute the following commands:

```
# lspv -p hdisk4
hdisk4:
PP RANGE  STATE   REGION        LV ID         TYPE   MOUNT POINT
  1-58    free    outer edge
 59-81    free    outer middle
 82-87    used    outer middle  availlv       jfs    N/A
 88-115   free    outer middle
116-172   free    center
173-229   free    inner middle
230-287   free    inner edge
# lspv -p hdisk6
hdisk6:
PP RANGE  STATE   REGION        LV ID         TYPE   MOUNT POINT
  1-58    free    outer edge
 59-81    free    outer middle
 82-87    used    outer middle  availlv       jfs    N/A
 88-115   free    outer middle
116-172   free    center
173-229   free    inner middle
230-287   free    inner edge
```

The above output shows that on both `hdisk4` and `hdisk6` the outer-middle region of the disk is used, as expected.

4. Now type `smitty jfs` and select the menu option **Add a Journaled File System on a Previously Defined Logical Volume** . On the smit screen, first press **F4** then choose the logical volume `availlv` from the list and press **Enter**. Then enter `/availjfs` for the field `MOUNT POINT`, and change the default setting for `Mount AUTOMATICALLY at system restart?` to `yes` by pressing the **F4** key and choosing `yes` from the list. The screen should look like the following when all the fields have been entered:

```
      Add a Journaled File System on a Previously Defined Logical Volume


Type or select values in entry fields.
Press Enter AFTER making all desired changes.

                                                    [Entry Fields]
* LOGICAL VOLUME name                              availlv           +
* MOUNT POINT                                     [/availjfs]
  Mount AUTOMATICALLY at system restart?           yes               +
  PERMISSIONS                                      read/write        +
  Mount OPTIONS                                   []                 +
  Start Disk Accounting?                           no                +
  Fragment Size (bytes)                            4096              +
  Number of bytes per inode                        4096              +
  Compression algorithm                            no                +

F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

Press **Enter** when all the fields have been filled out. The file system is created when smit returns with `OK` as shown below:

```
                            COMMAND STATUS

Command: OK            stdout: yes           stderr: no

Before command completion, additional instructions may appear below.

Based on the parameters chosen, the new /availjfs JFS file system
is limited to a maximum size of 134217728 (512 byte blocks)

New File System size is 49152













F1=Help              F2=Refresh           F3=Cancel          F6=Command
F8=Image             F9=Shell             F10=Exit           /=Find
n=Find Next
```

Press **F10** to exit smit.

5. Since this is the first journaled file system created in the volume group availvg, a log logical volume (journal log) is automatically created. This log logical volume also needs to be mirrored through the following procedure:

   a. To identify the name of the journal log within the volume group availvg, execute the command:

   ```
   # lsvg -l availvg
   availvg:
   LV NAME         TYPE       LPs   PPs   PVs  LV STATE      MOUNT POINT
   availlv         jfs        6     12    2    closed/syncd  /availjfs
   loglv00         jfslog     1     1     1    closed/syncd  N/A
   ```

   From the above output we can see that the journal log is called `loglv00` since it is of type `jfslog`.

   b. Execute the following command to find out which physical volume is used to hold the journal log:

   ```
   # lslv -m loglv00
   loglv00:N/A
   LP    PP1  PV1               PP2  PV2               PP3  PV3
   0001  0088 hdisk4
   ```

   From the output of the above two commands, also note that only one physical partition has been allocated to `loglv00` and it is not mirrored.

   c. Now we need to create a copy of the log logical volume (journal log). Type `smitty mklvcopy` and enter `loglv00` for the `LOGICAL VOLUME name` field and press **Enter**. On the next smit screen change the content of:

   - `NEW TOTAL number of logical partition copies` to `2`.
   - `RANGE of physical volumes` to `maximum`.

- SYNCHRONIZE the data in the new logical partition copies? to yes.

so that the screen looks like:

```
                 Add Copies to a Logical Volume



Type or select values in entry fields.
Press Enter AFTER making all desired changes.

                                                      [Entry Fields]
* LOGICAL VOLUME name                               loglv00
* NEW TOTAL number of logical partition             2              +
    copies
  PHYSICAL VOLUME names                            []              +
  POSITION on physical volume                       outer_middle   +
  RANGE of physical volumes                         maximum        +
  MAXIMUM NUMBER of PHYSICAL VOLUMES               [32]             #
    to use for allocation
  Allocate each logical partition copy              yes            +
    on a SEPARATE physical volume?
  File containing ALLOCATION MAP                   []
  SYNCHRONIZE the data in the new                   yes            +
    logical partition copies?



F1=Help             F2=Refresh          F3=Cancel         F4=List
F5=Reset            F6=Command          F7=Edit           F8=Image
F9=Shell            F10=Exit            Enter=Do
```

Press **Enter** after making the changes. When smit returns with OK press **F10** to exit smit.

6. Check that we have successfully mirrored the two logical volumes in the volume group by typing:

```
# lsvg -l availvg
availvg:
LV NAME           TYPE       LPs   PPs   PVs  LV STATE      MOUNT POINT
availlv           jfs        6     12    2    closed/syncd  /availjfs
loglv00           jfslog     1     2     2    closed/syncd  N/A
```

The output indicates that the jfslog loglv00 consists of one logical partition with each physical partition copy on a different physical volume. Likewise, for availlv, the 6 logical partitions consist of 12 physical partitions with each copy residing on a different physical volume.

7. Now mount the file system */availjfs* using the command:

```
# mount /availjfs
```

8. We must now turn off quorum checking so that in the event of losing 51% or more of the physical volumes (VGDAs), the volume group *availvg* is not varied off automatically. Execute the command smitty chvg and enter availvg for the field VOLUME GROUP name and press **Enter**. On the second smit screen, as shown below, change the field A QUORUM of disks required to keep the volume group on-line? to no by pressing **F4** and selecting no from the list. Then press **Enter**.

```
                       Change a Volume Group


Type or select values in entry fields.
Press Enter AFTER making all desired changes.

                                                     [Entry Fields]
* VOLUME GROUP name                                 availvg
* Activate volume group AUTOMATICALLY               yes             +
    at system restart?
* A QUORUM of disks required to keep the volume     no              +
   group on-line ?



F1=Help          F2=Refresh       F3=Cancel        F4=List
F5=Reset         F6=Command       F7=Edit          F8=Image
F9=Shell         F10=Exit         Enter=Do
```

When smit returns with `OK` press **F10** to exit smit.

***Verify a Mirrored Volume Group for Availability:*** We are now ready to test the mirrored volume group availvg. As explained before, the two physical volumes `hdisk4` and `hdisk6` are connected to the same SCSI adapter so we will not be able to test for SCSI failures. However, we can simulate a disk failure by powering off one of these physical volumes since each physical volume has its own power switch.

You can use a Korn shell script to simulate a disk failure and recovery. The script automatically generates some logical I/O to the volume group availvg using the `dd` command and then requests the user to switch off one of the physical volumes. Stale physical partitions are automatically detected and the user is once again prompted to power on the physical volume. Following this, the resynchronization of the stale partitions is then performed using the `varyonvg` command. The `dd` operations expects the InfoExplorer file, `/usr/lpp/info/lib/en_US/aix41/cmds/cmds.rom`, to be installed on the system.

You can use the script in the following example test sequence that checks the availability of the *availvg* volume group.

1. Save the following script as *availvg.ksh*.

```
# /var/tmp/availvg.ksh.out
integer syncrun=0;
integer cnt=1;
while true
do
   PS=`ps -ef | grep -v grep | grep "dd if=/usr/lpp/" | \
       awk '{print $8}'`
   if [ "$PS" != "timex" ]
   then
      echo dd number: $cnt started >> /var/tmp/availvg.ksh.out 2>&1
      timex dd if=/usr/lpp/info/lib/en_US/aix41/cmds/cmds.rom \
               of=/availjfs/cmds.rom.dd bs=100k >> \
               /var/tmp/availvg.ksh.out 2>&1 &
      cnt=cnt+1
      if [ $syncrun > 0 ]
      then
         ps -ef >> /var/tmp/availvg.ksh.out
      fi
   fi
   while true
   do
         echo "Checking for stale partitions." | \
              tee -a /var/tmp/availvg.ksh.out
         echo "Please wait..." | tee -a /var/tmp/availvg.ksh.out
         PPS=`lsvg availvg | grep "STALE PPs" | awk '{print $6}'`
         if [ "$PPS" = "0" ]
         then
            echo "Stale partitions not found." | \
                 tee -a /var/tmp/availvg.ksh.out
            echo
        "To recreate stale partitions power off one disk unit" | \
                 tee -a /var/tmp/availvg.ksh.out
            echo "and press enter. To quit press CTRL-C." | \
                 tee -a /var/tmp/availvg.ksh.out
            syncrun=0
            read a
            break
         else
            echo "$PPS stale partitions currently found." |a\
                 tee -a /var/tmp/availvg.ksh.out
            SYNC=`ps -ef | grep -v grep | grep "/usr/sbin/syncvg" | \
                 awk '{print $9}'`
            if [ "$SYNC" = "/usr/sbin/syncvg" ]
            then
               break
            else
               echo "Press enter when power, cables etc checked." | \
                    tee -a /var/tmp/availvg.ksh.out
               read ans
               echo "Varyonvg started..." >> \
                    /var/tmp/availvg.ksh.out 2>&1
               (time /usr/sbin/varyonvg availvg >> \
                    /var/tmp/availvg.ksh.out 2>&1) 2>> \
                    /var/tmp/availvg.ksh.out &
               syncrun=1
               break
            fi
         fi
   done
done
```

2. Before we execute the script let us look at the status of the logical volumes using the `lsvg -l availvg` command:

```
# lsvg -l availvg
availvg:
LV NAME          TYPE       LPs   PPs   PVs  LV STATE      MOUNT POINT
availlv          jfs        6     12    2    open/syncd    /availjfs
loglv00          jfslog     1     2     2    open/syncd    N/A
```

The output shows that the logical volumes `availlv` and `loglv00` are open and synchronized, (`open/syncd`).

3. Now execute the script `availvg.ksh`, as follows:

```
# ksh availvg.ksh
Checking for stale partitions.
Please wait...
Stale partitions not found.
To recreate stale partitions power off one disk unit
and press enter. To quit press CTRL-C.
```

4. At this point power off physical volume `hdisk6` and then press **Enter**.

   Since the file copy operation is started again after switching off the disk, we now have `stale` partitions. This is shown by the following output:

```
Checking for stale partitions.
Please wait...
7 stale partitions currently found.
Press enter when power, cables etc checked.
```

5. From another terminal let us look at the state of the logical volumes in availvg before we power on `hdisk6`.

```
# lsvg -l availvg
availvg:
LV NAME          TYPE       LPs   PPs   PVs  LV STATE      MOUNT POINT
availlv          jfs        6     12    2    open/stale    /availjfs
loglv00          jfslog     1     2     2    open/stale    N/A
```

   We now note that both `availlv` and `loglv00` are marked `stale`. To get more detailed information about the particular partitions that have become stale execute the command `lslv -p hdisk6 availlv`. This command is described in Chapter 7, “Storage Management Files and Commands Summary” on page 137.

6. Now power on `hdisk6` and press **Enter**. The following output is produced:

```
Varyonvg started...
Checking for stale partitions.
Please wait...
6 stale partitions currently found.
Checking for stale partitions.
Please wait...
5 stale partitions currently found.
Checking for stale partitions.
Please wait...
4 stale partitions currently found.
Checking for stale partitions.
Please wait...
3 stale partitions currently found.
Checking for stale partitions.
Please wait...
2 stale partitions currently found.
Checking for stale partitions.
Please wait...
1 stale partitions currently found.
Checking for stale partitions.
Please wait...
Stale partitions not found.
To recreate stale partitions power off one disk unit
and press enter. To quit press Ctrl-C.
```

7. At this point press **Ctrl-C** to exit the shell script.

   During the availability verification test the file copy command continues to run, even while the `varyonvg` command is executing, to synchronize stale partitions. This is deliberately done to simulate continuous I/O activity which would occur in a production system.

8. Since the test is now complete, let us look at the state of the logical volumes using the `lsvg -l availvg` command.

```
# lsvg -l availvg
availvg:
LV NAME          TYPE       LPs   PPs   PVs  LV STATE      MOUNT POINT
availlv          jfs        6     12    2    open/syncd    /availjfs
loglv00          jfslog     1     2     2    open/syncd    N/A
```

   As expected, the logical volume partitions have all been synchronized. From the results of our test we can conclude that mirroring of a non-rootvg volume group can be carried out with ease, and provides much *higher* availability than a non-mirrored volume group. As we saw in our test, I/O to the *good* physical volume continues during the disk failure.

### 8.3.4 A Design Example for Improved Performance

First, create perfvg that contains hdisk3 and hdisk5 using the same procedure as for the creation of availvg.

1. Execute `smitty vg`
2. Select **Add a Volume Group**
3. Type `perfvg` for `VOLUME GROUP name`
4. Type `hdisk3 hdisk5` for `PHYSICAL VOLUME names`
5. Press **Enter=Do** and then **F10=Exit** when smit returns an `OK` prompt
6. Remember to ensure that perfvg is synchronized when you have finished creating all the logical volumes in it, if some of them are mirrored. This

procedure is discussed just before “How to Document the Volume Group Design” on page 236.

#### 8.3.4.1 Command Line Summary

In this section we will be creating two mapped mirrored logical volumes with different performance characteristics, and then two mapped non-mirrored logical volumes, also with differing performance characteristics. We will then create a jfs log logical volume and a paging logical volume, before documenting our design. This summary will take you through the steps you would need to follow at the command line:

1. Create two mapped mirrored logical volumes:

   - Create a logical volume with poor performance characteristics using the following command:

     ```
     # mklv -y'perflv1' -d's' -m'/home/maps/badmir.map' 'perfvg' '10'
     ```

     This creates a logical volume of size 10 logical partitions in the perfvg volume group. Scheduling will be done sequentially, and mirror write consistency is on. The physical partitions will be allocated according to the map file badmir.map.

   - Add the mirrored copy:

     ```
     # mklvcopy -m'/home/maps/badmir.map2' 'perflv1' '2'
     ```

     This creates a copy of the physical partitions using the map file badmir.map2 to allocate partitions.

   - Create a logical volume with good performance characteristics using the following command:

     ```
     # mklv -y'perflv2' -w'n' -m'/home/maps/goodmir.map' 'perfvg' '10
     ```

     This creates a logical volume of size 10 logical partitions in the perfvg volume group. Scheduling will be done in parallel, and mirror write consistency is off. The physical partitions will be allocated according to the map file goodmir.map.

   - Add the mirrored copy:

     ```
     # mklvcopy -m'/home/maps/goodmir.map2' 'perflv2' '2'
     ```

     This creates a copy of the physical partitions using the map file goodmir.map2 to allocate partitions.

2. Create two mapped non-mirrored logical volumes:

   - Create a logical volume with poor performance characteristics using the following command:

```
# mklv -y'perflv4' -m'/home/maps/inedge.map' 'perfvg' '10'
```

This creates a logical volume of size 10 logical partitions, the physical partitions being allocated according to the map in inedge.map.

- Create a logical volume with good performance characteristics using the following command:

```
# mklv -y'perflv3' -m'/home/maps/center.map' 'perfvg' '10'
```

This creates a logical volume of size 10 logical partitions, the physical partitions being allocated according to the map in center.map.

3. Create a jfslog logical volume:

- Create the logical volume using the following command:

```
# mklv -y'perflog' -t'jfslog' -a'c' 'perfvg' '1' 'hdisk5'
```

This will create a jfslog logical volume of size 4MB, located in the center partitions of the disk hdisk5 in the perfvg volume group.

- Format the jfslog using the following command:

```
# /usr/sbin/logform /dev/perflog
  logform: destroy /dev/perflog (y)?
#
```

This initializes the jfslog logical volume for use.

4. Create a paging logical volume:

- Create the logical volume using the following command:

```
# mklv -y'perfpg' -t'paging' -a'c' -e'x' -c'2' -w'n' 'perfvg' '5
```

This will create a paging space logical volume of size 5 logical partitions, using physical partitions located in the center of the disk for maximum performance. A mirrored copy will be created, and mirror write consistency will be set to off. The maximum number of disks possible will also be used to maximize performance.

- Ensure the paging space will be activated at each system reboot using the following command:

```
# chps -a'y' 'perfps'
```

- Activate the new paging space using the following command:

```
# swapon /dev/'perfps'
```

This causes the system to begin using the new page space.

5. Synchronize the volume group:

   When the following command exits, check that any commands that it calls, such as `syncvg`, have also exited.

   ```
   varyonvg perfvg
   ```

6. Document the volume group design:

   Create two files:

   a. `/home/vginfo/vg.detail` to contain a complete detailed partition map from the `lsvg` command:

      ```
      lsvg -M perfvg > /home/vginfo/vg.detail
      ```

   b. `/home/vginfo/vg.summary` to contain a summary partition map from the `lspv` command:

      - Save logical volume description for `hdisk3`:

        ```
        lspv -l hdisk3 > /home/vginfo/vg.summary
        ```

      - Save physical partitions description for `hdisk3`:

        ```
        lspv -p hdisk3 >> /home/vginfo/vg.summary
        ```

      - Save logical volume description for `hdisk5`:

        ```
        lspv -l hdisk5 >> /home/vginfo/vg.summary
        ```

      - Save physical partitions description for `hdisk5`:

        ```
        lspv -p hdisk5 >> /home/vginfo/vg.summary
        ```

   c. Refer to “An Example Description of a Volume Group Design” on page 240 for the output files we obtained.

The performance characteristics of this volume group will be investigated in the detailed guidance section that follows.

### 8.3.4.2 Detailed Guidance

This section will now look at these processes in detail:

***How to Create Two Mirrored Logical Volumes:*** This section shows how to create two logical volumes which have different attribute settings for those attributes that significantly affect performance in a mirrored environment. The different attributes, described by their smit field name, are:

- `Mirror Write Consistency?`
- `SCHEDULING POLICY for writing logical partition copies`
- `Enable WRITE VERIFY?`
- `File containing ALLOCATION MAP`

  The main difference in the maps is that the good mirrored logical volume uses a second disk for its copy, but the bad mirrored logical volume uses the same disk for its primary and secondary copy.

The two logical volumes are:

- perflv1 - the bad mirrored logical volume
- perflv2 - the good mirrored logical volume

**Warning - Choose attributes carefully**

It is very important to note that when the above attributes are set to give optimal performance, the availability of the good mirror perflv2 suffers. Hence, this choice between performance and availability is a good example of the design decisions that you will have to make.

Let's create two mirrored logical volumes; one whose attributes should give good performance, and one whose attributes should give bad performance. Start by creating only the primary copy so that allocation maps can be used.

**If you want to avoid map files**

Please refer to “How to Create a Paging Type Logical Volume” on page 233 for an example of how to create a mirrored logical volume (two copies) with optimal performance attributes, that does *not* use a physical partition allocation map file.

The *good logical volume*, perflv2, will use goodmir.map, and the *bad logical volume*, perflv1, will use badmir.map. These map files were displayed earlier in 8.3, “Storage Subsystem Design” on page 204.

For the bad mirror:

1. Type `smitty lv`.
2. Select **Add a Logical Volume**.
3. Type `perfvg` and press **Enter=Do**, or select `perfvg` using **F4=List**.
4. Type the logical volume name, such as `perflv1`.
5. Type the number of logical partitions to allocate for this logical volume; in this case type `10`.
6. Leave the `Number of COPIES of each logical partition` set to the default of `1` since we'll add the second copy later.
7. Leave the `Mirror Write Consistency?` set as `yes`. This will only have meaning once we create copies. It will then result in an extra disk I/O operation to the edge of the disk where the Mirror Write Consistency data is stored. This extra I/O will thus decrease performance.

The smit screen at this stage looks like:

```
                              Add a Logical Volume

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

[TOP]                                                   [Entry Fields]
  Logical volume NAME                                [perflv1]
* VOLUME GROUP name                                   perfvg
* Number of LOGICAL PARTITIONS                       [10]                    #
  PHYSICAL VOLUME names                              []                     +
  Logical volume TYPE                                []
  POSITION on physical volume                         outer_middle          +
  RANGE of physical volumes                           minimum               +
  MAXIMUM NUMBER of PHYSICAL VOLUMES                 []                      #
    to use for allocation
  Number of COPIES of each logical                    1                     +
    partition
  Mirror Write Consistency?                           yes                   +
  Allocate each logical partition copy                yes                   +
    on a SEPARATE physical volume?
[MORE...9]
F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

8. Press the **Page Down** or **Down Arrow** key to get to the bottom of the next page.

9. Type in the path name of the allocation map file /home/maps/badmir.map. This file specifies 10 contiguous inner middle physical partitions to be used.

10. Change the SCHEDULING POLICY for writing logical partition copies from the default of parallel to sequential by using the **Tab** key to toggle the value. This will ensure that all updates to mirror copies will occur in sequence, which will obviously be slower than parallel writes.

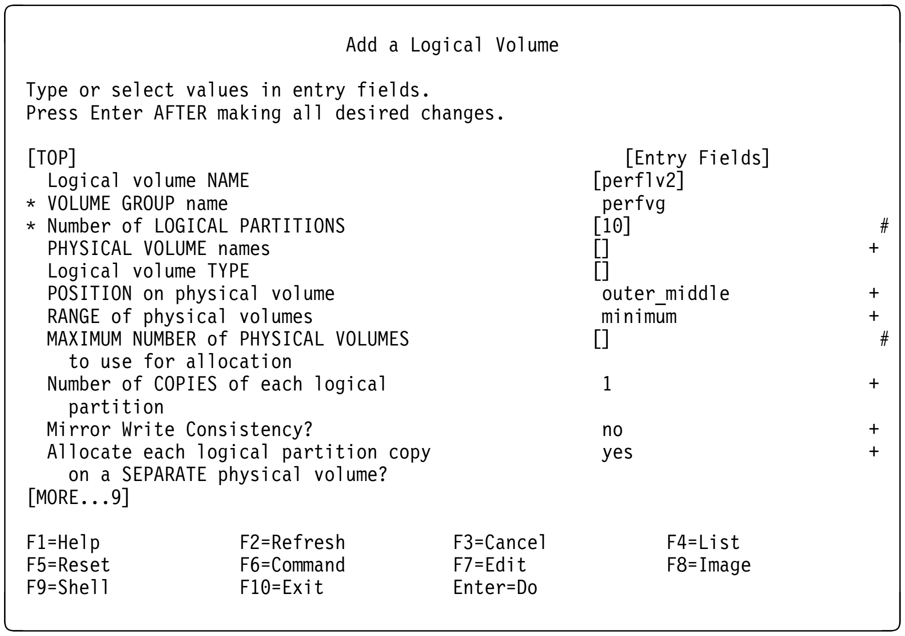
11. Leave Enable WRITE VERIFY? as the default, yes (again, this is the slower option), so that the screen looks like:

```
                              Add a Logical Volume

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

[MORE...9]                                              [Entry Fields]
  Number of COPIES of each logical                    1                     +
    partition
  Mirror Write Consistency?                           yes                   +
  Allocate each logical partition copy                yes                   +
    on a SEPARATE physical volume?
  RELOCATE the logical volume during reorganization?  yes                   +
  Logical volume LABEL                               []
  MAXIMUM NUMBER of LOGICAL PARTITIONS               [128]
  Enable BAD BLOCK relocation?                        yes                   +
  SCHEDULING POLICY for writing logical               sequential            +
    partition copies
  Enable WRITE VERIFY?                                yes                   +
  File containing ALLOCATION MAP                     [/home/maps/badmir.map]
  Stripe Size?                                       [Not Striped]          +

[BOTTOM]

F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

12. Press the **Enter=Do** key to create the logical volume.
13. When smit returns OK, press **F3=Cancel** to return to the Logical Volumes menu.

Now create the primary copy of the mirrored logical volume with good mirroring performance attributes.

1. Follow the same process as for the bad performance mirror example. Start by again selecting **Add a Logical Volume**:



```
                              Add a Logical Volume

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

[TOP]                                                   [Entry Fields]
  Logical volume NAME                                [perflv2]
* VOLUME GROUP name                                   perfvg
* Number of LOGICAL PARTITIONS                       [10]                 #
  PHYSICAL VOLUME names                              []                  +
  Logical volume TYPE                                []
  POSITION on physical volume                         outer_middle       +
  RANGE of physical volumes                           minimum            +
  MAXIMUM NUMBER of PHYSICAL VOLUMES                 []                   #
    to use for allocation
  Number of COPIES of each logical                    1                  +
    partition
  Mirror Write Consistency?                           no                 +
  Allocate each logical partition copy                yes                +
    on a SEPARATE physical volume?
[MORE...9]

F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

2. This time type perflv2 as the name of the logical volume.
3. Use the **Tab** key to toggle Mirror Write Consistency? to no.This will reduce disk movement for each I/O request and so it should result in better performance.
4. Leave the other fields with their defaults and press the **Page Down** key.
5. Leave the Number of COPIES of each logical partition set to the default of 1 since we'll add the second copy later.
6. The only field that now requires alteration is the File containing ALLOCATION MAP field, where you should type /home/maps/goodmir.map.
7. Press the **Enter=Do** key on the screen that now looks like:

```
                              Add a Logical Volume

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

[MORE...9]                                              [Entry Fields]
  Number of COPIES of each logical                    1                      +
    partition
  Mirror Write Consistency?                           no                     +
  Allocate each logical partition copy                yes                    +
    on a SEPARATE physical volume?
  RELOCATE the logical volume during reorganization?  yes                    +
  Logical volume LABEL                               []
  MAXIMUM NUMBER of LOGICAL PARTITIONS               [128]
  Enable BAD BLOCK relocation?                        yes                    +
  SCHEDULING POLICY for writing logical               parallel               +
    partition copies
  Enable WRITE VERIFY?                                no                     +
  File containing ALLOCATION MAP                     [/home/maps/goodmir.map]
  Stripe Size?                                       [Not Striped]           +
[BOTTOM]

F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

8. When smit returns `OK`, press **F3=Cancel** to return to the `Logical Volumes` menu.

We now have two single copy logical volumes whose attributes, when mirroring is implemented, will either give bad or optimal performance. Map files will also be used to create the copies.

For the good mirror:

1. Select **Set Characteristic of a Logical Volume** from the following screen:

```
                                Logical Volumes

Move cursor to desired item and press Enter.

  List All Logical Volumes by Volume Group
  Add a Logical Volume
  Set Characteristic of a Logical Volume
  Show Characteristics of a Logical Volume
  Remove a Logical Volume
  Copy a Logical Volume















F1=Help             F2=Refresh          F3=Cancel           F8=Image
F9=Shell            F10=Exit            Enter=Do
```

2. Select **Add a Copy to a Logical Volume**.
3. Type `perflv2` and press **Enter=Do**.

4. Use the **Tab** key to change `NEW TOTAL number of logical partition copies` to `2`.
5. Leave the field `SYNCHRONIZE the data in the new logical partition copies?` with its default of `no` since we'll synchronize it later, just before section “How to Document the Volume Group Design” on page 236.
6. Change `NEW TOTAL number of logical partition copies` to `2`.
7. Type `/home/maps/goodmir.map2` in the `File containing ALLOCATION MAP` field. This map uses physical partitions on the second disk so that parallel disk I/O should give better performance. The screen should look like:

```
                         Add Copies to a Logical Volume

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

                                                       [Entry Fields]
* LOGICAL VOLUME name                                 perflv2
* NEW TOTAL number of logical partition               2                     +
    copies
  PHYSICAL VOLUME names                              []                     +
  POSITION on physical volume                         outer_middle          +
  RANGE of physical volumes                           minimum               +
  MAXIMUM NUMBER of PHYSICAL VOLUMES                 [32]                    #
    to use for allocation
  Allocate each logical partition copy                yes                   +
    on a SEPARATE physical volume?
  File containing ALLOCATION MAP                     <home/maps/goodmir.m
  SYNCHRONIZE the data in the new                     no                    +
    logical partition copies?



F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

8. Press the **Enter=Do** key to create the logical volume copy.
9. When smit returns `OK`, press **F3=Cancel** to return to the `Set Characteristic of a Logical Volume` menu.

Now create the bad mirror copy:

1. Select **Add a Copy to a Logical Volume**.
2. Type `perflv1` and press **Enter=Do**.
3. Use the **Tab** key to change `NEW TOTAL number of logical partition copies` to `2`.
4. Leave the field `SYNCHRONIZE the data in the new logical partition copies?` with its default of no since we'll synchronize it later, just before section “How to Document the Volume Group Design” on page 236.
5. Type `/home/maps/badmir.map2` in the `File containing ALLOCATION MAP` field. This map uses physical partitions on the same disk as the primary copy so that, along with the sequential disk I/O, we should get the worst performance.
6. Press the **Enter=Do** key to create the logical volume copy.
7. When smit returns `OK`, press **F10=Exit** to return to the command prompt.

***How to Create Two Mapped Non-mirrored Logical Volumes:*** This section shows how to create two logical volumes which have different logical partition locations on hdisk3 and hdisk5. This enables us to investigate:

- How the Intra-Physical Volume Allocation Policy, described by smit as `POSITION on physical volume`, affects performance in a non-mirrored environment.
- How to use a physical partition map; in smit, use `File containing ALLOCATION MAP`, to get precise control of logical partition location.

The two logical volumes are:

- perflv3 - uses good disk regions according to centre.map.
- perflv4 - uses bad regions according to inedge.map.

**Warning - Choose carefully**

It is very important to note that when the above attributes are set to give optimal performance, the availability of a logical volume, even when it is not mirrored, and thus exists as only a single copy, may suffer. For example, if your map file uses all disks in a volume group, or if the Inter-Physical Volume Allocation Policy is set to maximum, then although the extra disk heads may reduce data access time, access to a logical volume may become difficult or impossible if *any* disk fails.

We could have also degraded performance but improved the *reliability* of a disk write operation by changing `Enable WRITE VERIFY?` from its `no` default value to `yes` This attribute is not investigated in this example.

Let's create both perflv3 and perflv4 using the map files that you can create using your favorite editor, such as the `vi` text editor.

**If you want to avoid map files**

Please refer to "How to Create a Journal Log Type Logical Volume" on page 231, for an example of how to create a non-mirrored logical volume (one copy) with optimal performance attributes, that does *not* use a physical partition allocation map file.

Since we're using map files, create these logical volumes using the smit defaults, and once you've specified a map file, you only need to specify the `Number of LOGICAL PARTITIONS` and the `Logical volume NAME` (note that `Mirror Write Consistency` does *not* apply when only a single copy of a logical volume exists; that is, there is no mirroring, and hence we can ignore this field).

To create perflv4:

1. Type `smitty mklv` to get to the menu whose title is `Add a Logical Volume`.
2. Type `perfvg` in the field `VOLUME GROUP name` and press the **Enter=Do** key, or use **F4=List** to select it.
3. Type `10` in the field `Number of LOGICAL PARTITIONS`.
4. Type `perflv4` in the field `Logical volume NAME` so that the screen looks like:

```
                              Add a Logical Volume

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

[TOP]                                                    [Entry Fields]
  Logical volume NAME                                 [perflv4]
* VOLUME GROUP name                                    perfvg
* Number of LOGICAL PARTITIONS                        [10]                #
  PHYSICAL VOLUME names                               []                 +
  Logical volume TYPE                                 []
  POSITION on physical volume                          outer_middle      +
  RANGE of physical volumes                            minimum           +
  MAXIMUM NUMBER of PHYSICAL VOLUMES                  []                  #
    to use for allocation
  Number of COPIES of each logical                     1                 +
    partition
  Mirror Write Consistency?                            yes               +
  Allocate each logical partition copy                 yes               +
    on a SEPARATE physical volume?
[MORE...9]

F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

5. Press the **Page Down** or **Down Arrow Key** to get to the bottom of the next page.

6. Type the map file path name, such as /home/maps/inedge.map, in the field `File containing ALLOCATION MAP` so that the screen looks like:

```
                              Add a Logical Volume

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

[MORE...9]                                               [Entry Fields]
  Number of COPIES of each logical                     1                 +
    partition
  Mirror Write Consistency?                            yes               +
  Allocate each logical partition copy                 yes               +
    on a SEPARATE physical volume?
  RELOCATE the logical volume during reorganization?  yes               +
  Logical volume LABEL                                []
  MAXIMUM NUMBER of LOGICAL PARTITIONS                [128]
  Enable BAD BLOCK relocation?                         yes               +
  SCHEDULING POLICY for writing logical                parallel          +
    partition copies
  Enable WRITE VERIFY?                                 no                +
  File containing ALLOCATION MAP                      [/home/maps/inedge.map]
  Stripe Size?                                        [Not Striped]      +
[BOTTOM]

F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
```

7. Press the **Enter=Do** key to create the logical volume.

8. When smit returns `OK`, press **F3=Cancel** to return to the command prompt.

To create perflv3:

1. Type `smitty mklv` to get to the menu whose title is `Add a Logical Volume`.

2. Type `perfvg` in the field `VOLUME GROUP name` and press the **Enter=Do** key, or use **F4=List** to select it.

3. Type `12` in the field `Number of LOGICAL PARTITIONS`; 12 physical partitions allows us to place three partition pairs on each disk.
4. Type `perflv3` in the field `Logical volume NAME` so that the screen looks like:

```
                              Add a Logical Volume

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

[TOP]                                                [Entry Fields]
  Logical volume NAME                             [perflv3]
* VOLUME GROUP name                                perfvg
* Number of LOGICAL PARTITIONS                    [12]                #
  PHYSICAL VOLUME names                           []                 +
  Logical volume TYPE                             []
  POSITION on physical volume                      outer_middle      +
  RANGE of physical volumes                        minimum           +
  MAXIMUM NUMBER of PHYSICAL VOLUMES              []                  #
    to use for allocation
  Number of COPIES of each logical                 1                 +
    partition
  Mirror Write Consistency?                        yes               +
  Allocate each logical partition copy             yes               +
    on a SEPARATE physical volume?
[MORE...9]

F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

5. Press the **Page Down** or **Down Arrow** key to get to the bottom of the next page.
6. Type the map file path name, such as /home/maps/centre.map, in the field `File containing ALLOCATION MAP`, so that the screen looks like:

```
                              Add a Logical Volume

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

[MORE...9]                                           [Entry Fields]
  Number of COPIES of each logical                 1                 +
    partition
  Mirror Write Consistency?                        yes               +
  Allocate each logical partition copy             yes               +
    on a SEPARATE physical volume?
  RELOCATE the logical volume during reorganization?  yes            +
  Logical volume LABEL                            []
  MAXIMUM NUMBER of LOGICAL PARTITIONS            [128]
  Enable BAD BLOCK relocation?                     yes               +
  SCHEDULING POLICY for writing logical            parallel          +
    partition copies
  Enable WRITE VERIFY?                             no                +
  File containing ALLOCATION MAP                  [/home/maps/centre.map]
  Stripe Size?                                    [Not Striped]      +
[BOTTOM]

F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
```

7. Press the **Enter=Do** key to create the logical volume.
8. When smit returns `OK`, press **F3=Cancel** to return to the command prompt.

***How to Create a Journal Log Type Logical Volume:*** This section shows how to create a jfslog logical volume that can be used by one or more AIX Version 4 journaled file systems. You may want to do this to improve your system's performance, since the log can be placed on the center region of the fastest disk in your volume group.

Create the journaled file system log device *before* any journaled file system is created in the volume group. Otherwise a default device, such as loglv01, will be created automatically. In this example, we'll create perflog before we create any journaled file systems in the perfvg volume group.

For more information, refer to the *AIX Version 4.1 Hypertext Information Base Library* article *Create a File System Log on a Dedicated Disk for a User-Defined volume group*.

To create perflog:

1. Type `smitty mklv` to get to the menu whose title is Add a Logical Volume.
2. Type `perfvg` in the field `VOLUME GROUP name` and press the **Enter=Do** key, or use **F4=List** to select it.
3. Type `perflog` in the field `Logical volume NAME`.
4. Type `1` in the field `Number of LOGICAL PARTITIONS`.
5. Type `hdisk5` in the field `PHYSICAL VOLUME names`, or use **F4=List** to select it.
6. Type `jfslog` in the field `Logical volume TYPE`. Note that there is *no* select option available here.
7. Use the **Tab** key to toggle `POSITION on physical volume` to the `center` setting so that the screen looks like:

```
                              Add a Logical Volume

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

[TOP]                                                   [Entry Fields]
  Logical volume NAME                                [perflog]
* VOLUME GROUP name                                   perfvg
* Number of LOGICAL PARTITIONS                       [1]                     #
  PHYSICAL VOLUME names                              [hdisk5]               +
  Logical volume TYPE                                [jfslog]
  POSITION on physical volume                         center                +
  RANGE of physical volumes                           minimum               +
  MAXIMUM NUMBER of PHYSICAL VOLUMES                 []                      #
    to use for allocation
  Number of COPIES of each logical                    1                     +
    partition
  Mirror Write Consistency?                           yes                   +
  Allocate each logical partition copy                yes                   +
    on a SEPARATE physical volume?
[MORE...9]

F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

8. We can execute this command with the rest of the fields left with their default values, since most fields do not affect a logical volume that consists of one physical partition. This logical volume can only exist as one copy on one disk. Hence, instead of pressing the **Page Down** key to go to the next screen, press the **Enter=Do** key to create the logical volume.
9. When smit returns `OK`, press **F3=Cancel** to return to the command prompt.

10. We now need to format the newly created journaled file system log device perflog with the following command:

```
# /usr/sbin/logform /dev/perflog
logform: destroy /dev/perflog (y)?
#
```

The following example illustrates that this command *should not* damage the data in a clean (in other words, `fsck` has been used), *unmounted* journaled file system. It just initializes the journaled file system log device, so that it can record the changes to the pointers that reference the data stored in a journaled file system.

**Warning - Use logform carefully**

For more information, refer to the *AIX Version 4.1 Hypertext Information Base Library* article *Create a File System Log on a Dedicated Disk for a User-Defined volume group*, and also refer to the `logform` command in the *AIX Version 4.1 Commands Reference*.

```
# lsvg -l vgname
LV NAME             TYPE       LPs   PPs   PVs  LV STATE      MOUNT POINT
perflog             jfslog     1     1     1    closed/syncd  N/A
lv04                jfs        1     1     1    closed/syncd  /ritest2
# /usr/sbin/logform /dev/perflog
logform: destroy /dev/perflog (y)?
# mount /ritest2
# cp /etc/motd /ritest2
# ls -la /ritest2
total 24
drwxr-sr-x   2 sys      sys         512 Jul 20 16:51 .
drwxr-xr-x  29 bin      bin        1024 Jul 20 15:29 ..
-r-xr--r--   1 root     sys         880 Jul 20 16:51 motd
# umount /ritest2
# /usr/sbin/logform /dev/perflog
logform: destroy /dev/perflog (y)?
# mount /ritest2
# ls -la /ritest2
total 24
drwxr-sr-x   2 sys      sys         512 Jul 20 16:51 .
drwxr-xr-x  29 bin      bin        1024 Jul 20 15:29 ..
-r-xr--r--   1 root     sys         880 Jul 20 16:51 motd
# lsvg -l vgname
LV NAME             TYPE       LPs   PPs   PVs  LV STATE      MOUNT POINT
perflog             jfslog     1     1     1    open/syncd    N/A
lv04                jfs        1     1     1    open/syncd    /ritest2
```

The logical volume *perflog* is now ready to be used.

***How to Create a Paging Type Logical Volume:*** This section shows how to create a mirrored paging device in a non-rootvg volume group with attributes that give optimal performance. You may wish to do this for memory intensive applications that will potentially result in a lot of I/O to the paging logical volumes.

Execute `smitty pgsp` so your screen looks like:

```
                                  Paging Space

Move cursor to desired item and press Enter.

  List All Paging Spaces
  Add Another Paging Space
  Change / Show Characteristics of a Paging Space
  Remove a Paging Space
  Activate a Paging Space















F1=Help             F2=Refresh          F3=Cancel           F8=Image
F9=Shell            F10=Exit            Enter=Do
```

and then select **Add Another Paging Space** to display:

```
                            Add Another Paging Space

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

                                                       [Entry Fields]
  Volume group name                                  perfvg
  SIZE of paging space (in logical partitions)      [5]                       #
  PHYSICAL VOLUME name                                                       +
  Start using this paging space NOW?                 yes                     +
  Use this paging space each time the system is      yes                     +
          RESTARTED?











F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

You can easily see these menu choices provide no control over the placement of the paging space logical partition, nor do they allow us to create multiple copies of the paging logical volume.

We want to use all the disks in the volume group to provide more heads to respond to access requests, so we'll use a `maximum` range. We'll leave the scheduling policy as `parallel` so that all disks can handle I/O requests for this logical volume simultaneously. We'll also specify the `center` disk region and turn off `Mirror Write Consistency?` to minimize disk activity, since now the disk heads will have a better chance of being able to stay near the center of the disk platters during an I/O request. Hence, use the familiar logical volume creation method as follows:

1. Type `smitty mklv` to get to the menu whose title is `Add a Logical Volume`.
2. Type `perfvg` in the field `VOLUME GROUP name` and press the **Enter=Do** key, or use **F4=List** to select it.
3. Type `perfpg` in the field `Logical volume NAME`.
4. Type `5` in the field `Number of LOGICAL PARTITIONS`.
5. Type `paging` in the field `Logical volume TYPE`. Note that there is *no* select option available here.
6. Use the **Tab** key to toggle `POSITION on physical volume` to the `center` setting.
7. Use the **Tab** key to toggle `RANGE of physical volumes` to the `maximum` setting.
8. Use the **Tab** key to toggle `Number of COPIES of each logical partition` to a value of `2`. This will result in the creation of both a primary and secondary copy of the perfpg logical volume.
9. Use the **Tab** key to toggle `Mirror Write Consistency?` to the `no` setting so that your screen looks like:

```
                           Add a Logical Volume

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

[TOP]                                                 [Entry Fields]
  Logical volume NAME                                [perfpg]
* VOLUME GROUP name                                   perfvg
* Number of LOGICAL PARTITIONS                       [5]                #
  PHYSICAL VOLUME names                              []                +
  Logical volume TYPE                                [paging]
  POSITION on physical volume                         center           +
  RANGE of physical volumes                           maximum          +
  MAXIMUM NUMBER of PHYSICAL VOLUMES                 []                 #
    to use for allocation
  Number of COPIES of each logical                    2                +
    partition
  Mirror Write Consistency?                           no               +
  Allocate each logical partition copy                yes              +
    on a SEPARATE physical volume?
[MORE...9]

F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

10. We can execute this command with the rest of the fields left with their default values. Hence, instead of pressing Page Down to go to the next screen, press the **Enter=Do** key to create the logical volume.
11. When smit returns `OK`, press **F3=Cancel** to return to the command prompt.
12. Now execute `smitty pgsp`, but this time select **Change / Show Characteristics of a Paging Space**.
13. Move your cursor to highlight **perfpg** and then press the **Enter=Do**.
14. Use the **Tab** key to toggle `Use this paging space each time the system is RESTARTED?` from `no` to `yes` so that your screen looks like:

```
                Change / Show Characteristics of a Paging Space

Type or select values in entry fields.
Press Enter AFTER making all desired changes.
                                                        [Entry Fields]
  Paging space name                                   perfpg
  Volume group name                                   perfvg
  Physical volume name                                hdisk5
  NUMBER of additional logical partitions            []                   #
  Use this paging space each time the system is       yes                 +
          RESTARTED?













F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

15. Press the **Enter=Do** key to change the paging space.
16. When smit returns `OK`, press **F3=Cancel** to return to the **Paging Space** menu.
17. To immediately start to use the new paging device, you can now:
    - Reboot AIX Version 4 using the `shutdown -Fr` command, or:
        a. Select **Activate a Paging Space**.
        b. Use the **F4=List** key to select **perfpg**.
        c. Press the **Enter=Do** key to activate the perfpg logical volume.
        d. When smit returns `OK`, press **F10=Exit** to return to the command prompt.

***Synchronize the Volume Group:*** The final step that we need to do is to synchronize perfvg. The parts of this step, similar to that described in "How to Synchronize rootvg" on page 196, are:

1. Execute the command `smitty vg`.
2. Select **Activate a Volume Group**.
3. Type `perfvg` or use **F4=List** to select it.
4. Press the **Enter=Do** key.
5. Press **F10=Exit** when smit returns an `OK` prompt.

If we have to create copies of many small logical volumes, it is more efficient for the systems administrator to use one command after hours to synchronize them. This means that the configuration work can be done during normal business hours without any significant I/O burdens to normal operations.

***How to Document the Volume Group Design:*** Now that we've created perfvg, we can choose some of the commands discussed in Chapter 7, "Storage Management Files and Commands Summary" on page 137 to enable us to:

- Check that all logical volumes have been created correctly.

- Record the configuration in our system logbook for reference should we have to manually recreate perfvg (of course, you should have multiple, tested volume group backup images stored safely. This is discussed in 8.4, “Managing Backup and Restore” on page 247).

If you refer to the Chapter 7, “Storage Management Files and Commands Summary” on page 137 chapter, you can see that the commands:

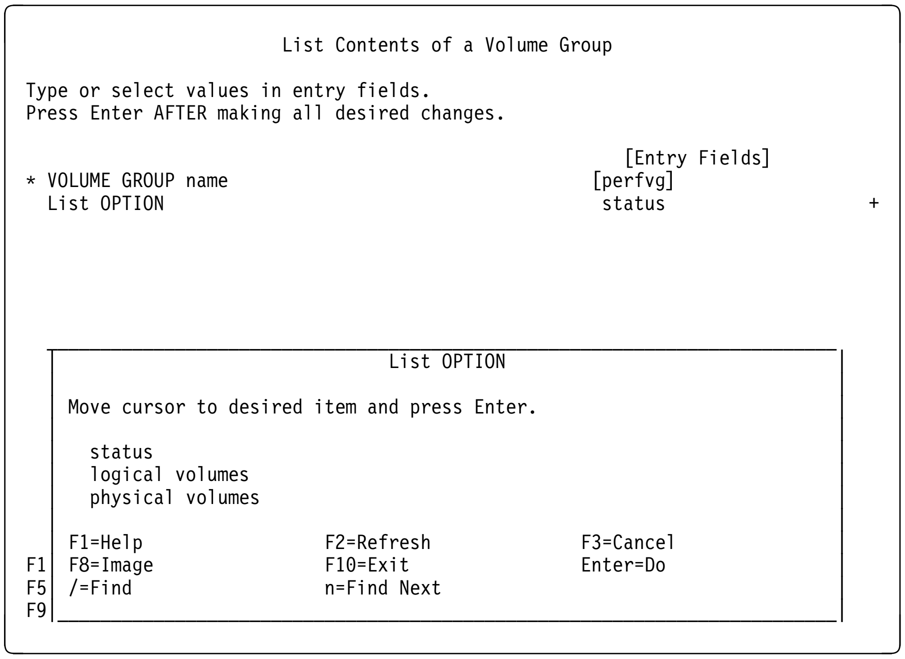
- `lsvg`
- `lspv`
- `lslv`

are quite simple since they only have a few flags. Hence we prefer to execute these commands directly from the command line rather than through the smit interface. Therefore, although the following is a brief summary of how to use the correct smit options, you may prefer to follow the simple method outlined in the previous command summary to enable you to document your volume group configuration.

You should also note that the most comprehensive volume group command, `lsvg -M vgname`, does not have a smit interface and hence must be executed from the command line. It can also produce a long output for a large volume group with many physical volumes in it. A smaller summarized version of its output can be obtained by using the `lspv` command for each disk in the volume group, which you can do using the method below. Note that you could also use `lslv`, but in this case, we shall use `lspv` because we only have two disks compared to six logical volumes, so we only have to execute `lspv` twice to get a complete description of perfvg.

Execute `lspv` from smit using the following procedure (we will also show you how you can execute `lsvg` and `lslv` from `smit`):

1. To get to the menu with the title Logical Volume Manager, execute the command `smitty lvm`, or, if you do not like to use a fastpath:
   a. Execute the command `smitty`.
   b. Select **System Storage Management (Physical & Logical Storage)**.
   c. Select **Logical Volume Manager**.
2. If you want to use the `lsvg` command:
   a. Select **Volume Groups**.
   b. Select **List Contents of a Volume Group**.
   c. Type `perfvg` and press the **Enter=Do** key, or use **F4=List** to select it.
   d. For the field `List OPTION`, press the **F4=List** key to display a screen like:



```
                        List Contents of a Volume Group

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

                                                        [Entry Fields]
* VOLUME GROUP name                                  [perfvg]
  List OPTION                                         status              +





   ___________________________________________________________________________
  |                              List OPTION                                  |
  |                                                                           |
  | Move cursor to desired item and press Enter.                              |
  |                                                                           |
  |   status                                                                  |
  |   logical volumes                                                         |
  |   physical volumes                                                        |
  |                                                                           |
  | F1=Help                 F2=Refresh              F3=Cancel                 |
F1| F8=Image                F10=Exit                Enter=Do                  |
F5| /=Find                  n=Find Next                                       |
F9|___________________________________________________________________________|
```

- If you move the cursor to highlight `status` and press **Enter=Do** twice, the **F6=Command** shows you that the displayed output is for the command `lsvg perfvg`.
- If you move the cursor to highlight `logical volumes` and press **Enter=Do** twice, the **F6=Command** shows you that the displayed output is for the command `lsvg -l perfvg`.
- If you move the cursor to highlight `physical volumes` and press **Enter=Do** twice, the **F6=Command** shows you that the displayed output is for the command `lsvg -p perfvg`.

e. Press **F10=Exit** to return to the command prompt when you've finished reading the output.

f. For an example of the output of `lsvg`, please refer to Chapter 7, “Storage Management Files and Commands Summary” on page 137.

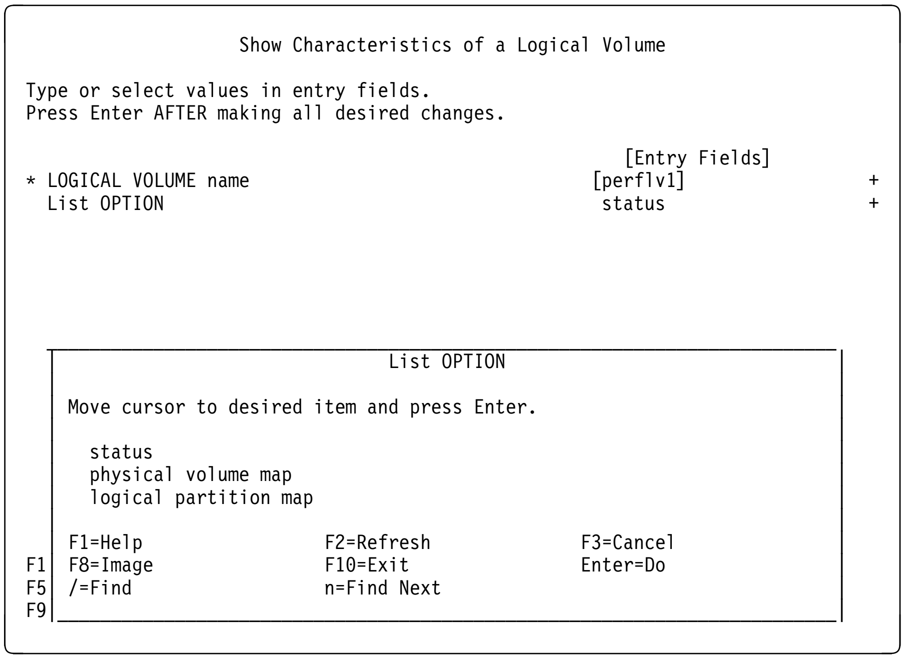
3. If you want to use the `lslv` command:

   a. Select **Logical Volumes**.

   b. Select **Show Characteristics of a Logical Volume**.

   c. Type `perlv1` and press the **Enter=Do** key, or use **F4=List** to select it.

   d. For the field `List OPTION`, press the **F4=List** key to display a screen like:



```
                    Show Characteristics of a Logical Volume

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

                                                       [Entry Fields]
* LOGICAL VOLUME name                               [perflv1]             +
  List OPTION                                        status               +




    ______________________________________________________________________
   |                             List OPTION                              |
   |                                                                      |
   | Move cursor to desired item and press Enter.                         |
   |                                                                      |
   |   status                                                             |
   |   physical volume map                                                |
   |   logical partition map                                              |
   |                                                                      |
   | F1=Help                F2=Refresh              F3=Cancel             |
F1 | F8=Image               F10=Exit                Enter=Do              |
F5 | /=Find                 n=Find Next                                   |
F9 |______________________________________________________________________|
```

- If you move the cursor to highlight `status` and press **Enter=Do** twice, the **F6=Command** shows you that the displayed output is for the command `lslv perflv1`.
- If you move the cursor to highlight `physical volume map` and press **Enter=Do** twice, the **F6=Command** shows you that the displayed output is for the command `lslv -l perflv1`.
- If you move the cursor to highlight `logical partition map` and press **Enter=Do** twice, the **F6=Command** shows you that the displayed output is for the command `lslv -m perflv1`.

e. For an example of the output of `lslv`, please refer to Chapter 7, “Storage Management Files and Commands Summary” on page 137.

f. Press **F10=Exit** to return to the command prompt when you've finished reading the output.

4. For this volume group design, we can execute the following two smit commands to get the sample output that follows:

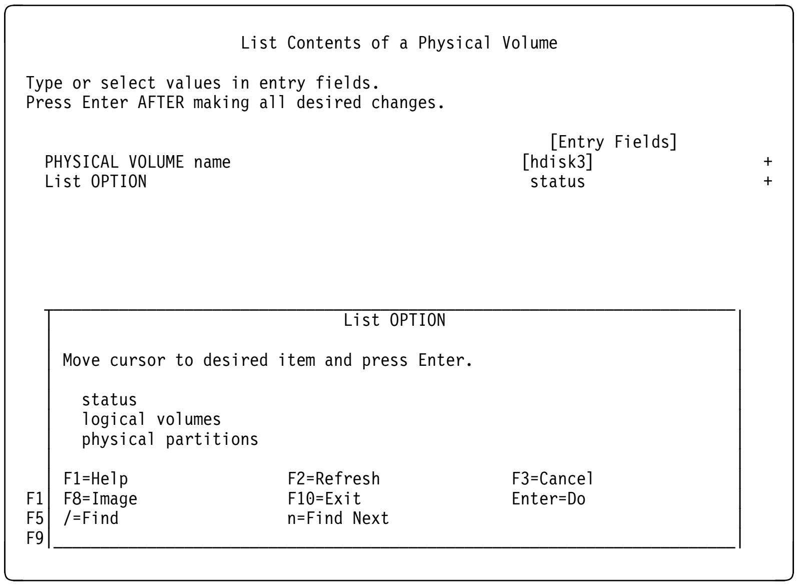
   a. Select **Physical Volumes**.

   b. Select **List Contents of a Physical Volume**.

   c. For hdisk3:

      1) Type `hdisk3` and press the **Enter=Do** key, or use **F4=List** to select it.

      2) For the field `List OPTION`, press the **F4=List** key to display a screen like:



```
                     List Contents of a Physical Volume

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

                                                      [Entry Fields]
  PHYSICAL VOLUME name                              [hdisk3]            +
  List OPTION                                        status             +




  ______________________________________________________________________
 |                              List OPTION                             |
 |                                                                      |
 | Move cursor to desired item and press Enter.                         |
 |                                                                      |
 |   status                                                             |
 |   logical volumes                                                    |
 |   physical partitions                                                |
 |                                                                      |
 | F1=Help                F2=Refresh             F3=Cancel              |
F1| F8=Image               F10=Exit               Enter=Do               |
F5| /=Find                 n=Find Next                                   |
F9|______________________________________________________________________|
```

3) Move the cursor to highlight `logical volumes` and press **enter=Do** twice. The **F6=Command** shows you that the displayed output is for the command `lspv -l hdisk3`.

4) Press **F3=Cancel** to return to the screen with the title `List Contents of a Physical Volume` when you've finished reading the output.

5) For the field `List OPTION`, press the **F4=List** key again to bring up the same menu as shown above.

6) Move the cursor to highlight `physical partitions` and press **enter=Do** twice. The **F6=Command** shows you that the displayed output is for the command `lspv -p hdisk3`.

7) Press **F3=Cancel** to return to the screen with the title `List Contents of a Physical Volume` when you've finished reading the output.

d. For hdisk5, repeat the steps described for hdisk3.

5. Press **F10=Exit** to return to the command prompt when you've finished reading the output.

6. Save the file /smit.log since it will contain the output of these `lspv` commands, which will be similar to those given in the next section.

***An Example Description of a Volume Group Design:*** The `lspv` commands output in the `/smit.log` or `/home/vginfo/vg.summary` files for the physical volumes in perfvg should look like:

```
# lspv -l hdisk3
hdisk3:
LV NAME              LPs   PPs   DISTRIBUTION          MOUNT POINT
perfpg               5     5     00..00..05..00..00    N/A
perflv3              6     6     00..00..06..00..00    N/A
perflv2              10    10    00..00..00..10..00    N/A
perflv4              5     5     00..00..00..00..05    N/A
# lspv -p hdisk3
hdisk3:
PP RANGE  STATE   REGION        LV ID              TYPE       MOUNT POINT
  1-15    free    outer edge
 16-30    free    outer middle
 31-34    free    center
 35-39    used    center        perfpg             paging     N/A
 40-45    used    center        perflv3            jfs        N/A
 46-50    free    inner middle
 51-60    stale   inner middle  perflv2            jfs        N/A
 61-65    free    inner edge
 66-70    used    inner edge    perflv4            jfs        N/A
 71-75    free    inner edge
#
# lspv -l hdisk5
hdisk5:
LV NAME              LPs   PPs   DISTRIBUTION          MOUNT POINT
perflv1              10    20    00..20..00..00..00    N/A
perflv3              6     6     00..05..01..00..00    N/A
perflog              1     1     00..00..01..00..00    N/A
perfpg               5     5     00..00..05..00..00    N/A
perflv2              10    10    00..00..00..10..00    N/A
perflv4              5     5     00..00..00..00..05    N/A
# lspv -p hdisk5
hdisk5:
PP RANGE  STATE   REGION        LV ID              TYPE       MOUNT POINT
  1-58    free    outer edge
 59-90    free    outer middle
 91-100   stale   outer middle  perflv1            jfs        N/A
101-110   used    outer middle  perflv1            jfs        N/A
111-115   used    outer middle  perflv3            jfs        N/A
116-116   used    center        perflv3            jfs        N/A
117-117   used    center        perflog            jfslog     N/A
118-139   free    center
140-144   used    center        perfpg             paging     N/A
145-172   free    center
173-200   free    inner middle
201-210   used    inner middle  perflv2            jfs        N/A
211-229   free    inner middle
230-232   free    inner edge
233-237   used    inner edge    perflv4            jfs        N/A
238-287   free    inner edge
#
```

The `lsvg -M perfvg` command output in the /home/vginfo/vg.detail file should look like:

```
perfvg
hdisk3:1-34
hdisk3:35       perfpg:2:1
hdisk3:36       perfpg:4:1
hdisk3:37       perfpg:1:2
hdisk3:38       perfpg:3:2
hdisk3:39       perfpg:5:2
hdisk3:40       perflv3:11
hdisk3:41       perflv3:12
hdisk3:42       perflv3:7
hdisk3:43       perflv3:8
hdisk3:44       perflv3:3
hdisk3:45       perflv3:4
hdisk3:46-50
hdisk3:51       perflv2:1:2
hdisk3:52       perflv2:2:2
hdisk3:53       perflv2:3:2
hdisk3:54       perflv2:4:2
hdisk3:55       perflv2:5:2
hdisk3:56       perflv2:6:2
hdisk3:57       perflv2:7:2
hdisk3:58       perflv2:8:2
hdisk3:59       perflv2:9:2
hdisk3:60       perflv2:10:2
hdisk3:61-65
hdisk3:66       perflv4:6
hdisk3:67       perflv4:7
hdisk3:68       perflv4:8
hdisk3:69       perflv4:9
hdisk3:70       perflv4:10
hdisk3:71-75
hdisk5:1-90
hdisk5:91       perflv1:1:2
hdisk5:92       perflv1:2:2
hdisk5:93       perflv1:3:2
hdisk5:94       perflv1:4:2
hdisk5:95       perflv1:5:2
hdisk5:96       perflv1:6:2
hdisk5:97       perflv1:7:2
hdisk5:98       perflv1:8:2
hdisk5:99       perflv1:9:2
hdisk5:100      perflv1:10:2
```

the long output continues like this:

```
hdisk5:101      perflv1:1:1
hdisk5:102      perflv1:2:1
hdisk5:103      perflv1:3:1
hdisk5:104      perflv1:4:1
hdisk5:105      perflv1:5:1
hdisk5:106      perflv1:6:1
hdisk5:107      perflv1:7:1
hdisk5:108      perflv1:8:1
hdisk5:109      perflv1:9:1
hdisk5:110      perflv1:10:1
hdisk5:111      perflv3:1
hdisk5:112      perflv3:2
hdisk5:113      perflv3:5
hdisk5:114      perflv3:6
hdisk5:115      perflv3:9
hdisk5:116      perflv3:10
hdisk5:117      perflog:1
hdisk5:118-139
hdisk5:140      perfpg:1:1
hdisk5:141      perfpg:3:1
hdisk5:142      perfpg:5:1
hdisk5:143      perfpg:2:2
hdisk5:144      perfpg:4:2
hdisk5:145-200
hdisk5:201      perflv2:1:1
hdisk5:202      perflv2:2:1
hdisk5:203      perflv2:3:1
hdisk5:204      perflv2:4:1
hdisk5:205      perflv2:5:1
hdisk5:206      perflv2:6:1
hdisk5:207      perflv2:7:1
hdisk5:208      perflv2:8:1
hdisk5:209      perflv2:9:1
hdisk5:210      perflv2:10:1
hdisk5:211-232
hdisk5:233      perflv4:1
hdisk5:234      perflv4:2
hdisk5:235      perflv4:3
hdisk5:236      perflv4:4
hdisk5:237      perflv4:5
hdisk5:238-287
```

***How to Test the Performance of the Design:*** This section gives an example of how you can obtain an indication of what effect the different attributes can have when you create a logical volume.

**Warning - Your results will be different**

Of course, every site may have its unique features, such as different hardware, different I/O requests, and different system loads, which may result in different results for you if you try the following commands.

You can do a simple test by just copying a very large file from the same fixed location on another volume group to each of:

- perflv1
- perflv2
- perflv3
- perflv4

To do this, we first need to create a journaled file system on each of these logical volumes:

1. To create /perfjfs1 on perflv1:
   a. Execute `smitty jfs` to get the Journaled File Systems menu.
   b. Select **Add a Journaled File System on a Previously Defined Logical Volume**.
   c. For the field `LOGICAL VOLUME name`, use the **F4=List** key to select `perflv1`.
   d. Type `/perfjfs1` in the field `MOUNT POINT`.
   e. Change the field `Mount AUTOMATICALLY at system restart?` to `yes` by using the **Tab** key.
   f. Leave the other fields with their default values so that the screen looks like:

```
      Add a Journaled File System on a Previously Defined Logical Volume


Type or select values in entry fields.
Press Enter AFTER making all desired changes.

                                                        [Entry Fields]
* LOGICAL VOLUME name                                 perflv1           +

* MOUNT POINT                                        [/perfjfs1]
  Mount AUTOMATICALLY at system restart?              yes               +
  PERMISSIONS                                         read/write        +
  Mount OPTIONS                                      []                 +
  Start Disk Accounting?                              no                +
  Fragment Size (bytes)                               4096              +
  Number of bytes per inode                           4096              +
  Compression algorithm                               no                +







F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

   g. Press the **Enter=Do** key.
   h. Press the **F3=Cancel** key when smit returns an `OK` message to return to the menu with the title `Add a Journaled File System on a Previously Defined Logical Volume`.
2. For perflv2, repeat the above to create the /perflv2 journaled file system.
3. For perflv3, repeat the above to create the /perflv3 journaled file system.
4. For perflv4, repeat the above to create the /perflv4 journaled file system.

Now we need to check that we have a suitable source file, and copy it four times to each of the newly created journaled file systems. Use the `timex` command to record the time required by the `cp` copy command. If you have access to *AIX Version 4.1 Hypertext Information Base Library*, then you may be able to do the following (note that our test used files from a copy of InfoExplorer that was loaded on a physical volume).

```
# cd /usr/lpp/info/lib/en_US/aix41
# ls -l cmds/cmds.romm
-rw-r--r--   1 root     system   21805056 May 12 09:33 cmds/cmds.rom
# timex cp cmds/cmds.rom manage/manage.rom /perfjfs1

real 59.53
user 0.35
sys  9.14
# timex cp cmds/cmds.rom manage/manage.rom /perfjfs2

real 34.15
user 0.40
sys  10.64
# timex cp cmds/cmds.rom manage/manage.rom /perfjfs3

real 28.62
user 0.37
sys  10.36
# timex cp cmds/cmds.rom manage/manage.rom /perfjfs4

real 28.66
user 0.42
sys  9.99
```

You may wish to use a command such as `iostat 5 | tee iostat.perfjfsx` to monitor disk activity during each of these commands, which is what we did.

Let's now look at these results for the mirrored and non-mirrored tests:

1. Two copy logical volume tests - perflv1 and perflv2.

   The 25 second difference clearly indicates the cost required to create a highly available logical volume. As discussed in Chapter 5, “Storage Subsystem Design” on page 77, and in the AIX V3.2 Performance Monitoring and Tuning Guide, the following options will degrade performance during a write operation:

   - Scheduling policy
   - Write verify
   - Mirror write consistency
   - Placing both copies on the same physical volume

   You can see the effect of the copy location data in the following output from the `iostat` command:

   - For the copy to perflv1 (one disk):

     ```
     tty:      tin        tout   avg-cpu:  % user    % sys     % idle    % io
               0.2       158.9              4.0     42.5       20.2      33.

     Disks:        % tm_act     Kbps      tps    Kb_read   Kb_wrtn
     hdisk0          35.1     157.3      23.8       756        32
     hdisk1           0.0       0.0       0.0         0         0
     hdisk2          31.7     229.9      13.0      1120        32
     hdisk3           0.0       0.0       0.0         0         0
     hdisk4           0.0       0.0       0.0         0         0
     hdisk5          73.1     494.0      11.2         4      2471
     hdisk6           0.0       0.0       0.0         0         0
     hdisk7           0.0       0.0       0.0         0         0
     hdisk8           0.0       0.0       0.0         0         0
     ```

     You can see that a write is only occurring on one disk here.

- For the copy to perflv2 (two disks):

```
tty:      tin        tout   avg-cpu:  % user    % sys     % idle    % io
          0.2       158.9             10.0      21.2        5.8      63.

Disks:        % tm_act     Kbps      tps    Kb_read   Kb_wrtn
hdisk0          50.3      78.2      14.6        200       192
hdisk1           0.0       0.0       0.0          0         0
hdisk2          77.8     411.2      17.8       1868       192
hdisk3          45.9     408.8      15.2          0      2048
hdisk4           0.0       0.0       0.0          0         0
hdisk5          53.3     414.4      26.1         24      2052
hdisk6           0.0       0.0       0.0          0         0
hdisk7           0.0       0.0       0.0          0         0
hdisk8           0.0       0.0       0.0          0         0
```

  You can see that write operations occur on both disks here.

2. Single copy logical volume tests - perflv3 and perflv4.

   The main difference in the maps is that the good non-mirrored logical volume uses a second disk for some of its logical partitions, arranged in a partially contiguous manner using the center and outer middle regions of the disks. This method of creating perflv3 shows the fine control available from the use of map files. For example, the file centre.map:

```
#cat centre.map
hdisk5:111-112
hdisk3:44-45
hdisk5:113-114
hdisk3:42-43
hdisk5:115-116
hdisk3:40-41
```

   shows that a logical volume built with it will occupy the center region of hdisk3 and the center and outer middle regions of hdisk5. It also shows that we have decided to use two physical partitions from hdisk5, then two physical partitions from hdisk3, and so on. The allocation precision obtained from the use of a map file can be seen in the output of the following command:

```
# lslv -m perflv3
perflv3:/perfjfs3
LP    PP1  PV1               PP2  PV2               PP3  PV3
0001  0111 hdisk5
0002  0112 hdisk5
0003  0044 hdisk3
0004  0045 hdisk3
0005  0113 hdisk5
0006  0114 hdisk5
0007  0042 hdisk3
0008  0043 hdisk3
0009  0115 hdisk5
0010  0116 hdisk5
0011  0040 hdisk3
0012  0041 hdisk3
```

   If the same logical volume had been built on hdisk3 and hdisk5 using a maximum range for its Inter-Physical Volume Allocation Policy, then the pattern would be one physical partition on hdisk5, one on hdisk3, and so on. This would give better performance, so it's not surprising that for both single copy physical volumes, the copy time was about 28.6 seconds.

The fact that the time is approximately the same also suggests that the center/middle disk region is not much faster than the edge region. However, this write had no competition from other disk requests so the disk heads will have minimal movement across the disk platter regions.

One final performance result of interest is that in our scenario, mirroring *always* degraded performance, even when it was tuned for optimal performance. This is not surprising since every logical write request is translated into two physical write operations. However, you may obtain different results in another environment, particularly if your test is based on a read rather than a write operation, which we did not investigate here.

## 8.4 Managing Backup and Restore

It is critically important that a systems administrator both implements and understands a reliable backup and recovery policy. This section shows you an example of how to use the volume group backup utilities to save and recover your system, if your data or configuration information is damaged beyond a practical repair timeframe.

In particular, the examples in this section will describe:

- How to save the contents and configuration of the perfvg volume group.
- How to restore the contents and configuration of the perfvg volume group.
- How to use the `mksysb` command to save an image of the volume group.
- How to choose some of the storage management related installation options to reinstall this rootvg image.

**Suggestion - One image**

You should usually place one volume group image on one tape when you use the smit defaults. This is what you may want to use as a simple backup rule. Usually, volume groups will be several gigabytes large if they contain two to three physical volumes, so each volume group will thus usually require at least one tape cartridge. Also note that the smit fields that you see when you execute `smitty savevg`:

- Only allow you to enter the name of *one* volume group in the `VOLUME GROUP to back up` field.
- Do not allow you to specify a particular image on the backup device.

However, you may be able to get around this by using the `tctl` command and the no-rewind tape device name as in the following sequence from the command line:

```
# savevg -i -f'/dev/rmt0.1' 'availvg'
# savevg -i -f'/dev/rmt0.1' 'perfvg'
# tctl -f/dev/rmt0 rewind
# restore -Tvf/dev/rmt0.1
# restore -Tvf/dev/rmt0.1
```

This seemed to work fine, but is not fully investigated in this example.

If you have a number of small machines attached to a server that has a large capacity tape drive, then you may decide to use disk space on the server as a temporary storage area for all your volume group images from the smaller machines until you back them up.

You must become familiar with the backup and recovery issues and procedures discussed in:

- 3.2.1, “Backup/Restore” on page 63.
- 5.5, “Planning Backup Strategies” on page 87.
- *AIX Version 4.1 System Management Guide: Operating System and Devices* and *AIX Version 4.1 Installation Guide*.

  These books may be in *AIX Version 4.1 Hypertext Information Base Library* on your system. For these examples in particular, you should refer to the following articles within them.

  – *Backing Up Your System*.

    This article appears in both documents at the level of AIX Version 4 that we used for these examples. Although the articles are very similar, we found that:

    - The version in *AIX Version 4.1 Installation Guide* was easier to follow to create a rootvg image.
    - The version in *AIX Version 4.1 System Management Guide: Operating System and Devices* had more information regarding how to backup other volume groups that are part of your system configuration.

- *AIX Version 4.1 System Management Guide: Operating System and Devices*.

  The articles of interest for these examples in this document include:

  – *Restoring a User Volume Group*.

  – *Backing Up the System Image Including User Volume Groups*.

  – *Developing a Backup Strategy*.

- *AIX Version 4.1 Installation Guide*.

  The articles of interest for these examples in this document include:

  – *Installing BOS from a System Backup*.

- *AIX Version 4.1 System User*.

  This document may also be on *AIX Version 4.1 Hypertext Information Base Library* on your system and so you may be able to refer to the articles in the section called *Backup Files and Storage Media*.

## 8.4.1 How to Use the savevg and restvg Commands

This example follows the steps in *Backing Up Your System* and *Restoring a User Volume Group*, in *AIX Version 4.1 System Management Guide: Operating System and Devices*, to create and then restore a backup tape image of perfvg. Since we can `SHRINK the filesystems?` when we restore the volume group with `restvg`, we'll create one backup with map files to try to preserve our design efforts in 8.3.4, "A Design Example for Improved Performance" on page 220.

We can then use the same backup to rebuild perfvg a second time, but this time we'll try to shrink the journaled file systems. Note that if we shrink the journaled file systems, then the resulting extra free physical partitions in the volume group means that we can *not* maintain the physical partition map.

### 8.4.1.1 Command Line Summary

There is a simple sequence of commands that can be used by an experienced systems administrator to manage the backup and recovery of user volume groups. These simple commands come from a few smit menus which are described in the next section.

If you want to discover what smit is doing under the covers, press the **F6=Command** command key to see that:

- For `savevg` to build an image of perfvg that includes map files smit executes:

```
savevg -i -f'/dev/rmt0' -m'' 'perfvg'
```

  To check the backup, execute `restore -Tqvf/dev/rmt0.1`.

- For `restvg` to recreate perfvg with the same physical partition map, smit executes:

```
restvg -f'/dev/rmt0'
```

- For `restvg` to recreate perfvg with shrunken journaled file systems, smit executes:

```
restvg -f'/dev/rmt0' -s''
```

You should note that:

- We found that for this example on our level of AIX Version 4, the mirror secondary copies of the perfvg logical volumes were not restored unless we used an image that had been built without map files, such as from:

  ```
  savevg -i -f'/dev/rmt0' 'perfvg'
  ```

  Of course, you'll then have to check the new physical partition map to ensure that it is satisfactory.

- If you want to rebuild a volume group, you must ensure that all target disks are considered free for allocation by the operating system, so execute the `lspv` command. Assume that you are recreating a volume group on the same disks that were used by the volume group when `savevg` was executed. If these disks are still being used by the volume group, then you can:

  1. Unmount all journaled file systems (you may have to change paging devices and reboot before this step if necessary).
  2. Use the `varyoffvg` command on the volume group.
  3. Use the `exportvg` command for the volume group.
  4. Check with `lspv`.
  5. If you still have trouble recreating the volume group using the backup image, then you can try to format the target physical volumes.

#### 8.4.1.2 Detailed Guidance

To create the backup image of the perfvg volume group:

1. Execute `smitty vg` to get to the menu with the title Volume Groups.
2. Select **Back Up a Volume Group**, or, from the smit menu:
   a. Execute `smitty`.
   b. Select **System Storage Management (Physical & Logical Storage)**.
   c. Select **Logical Volume Manager**.
   d. Select **Volume Groups**.
   e. Select **Back Up a Volume Group**.
3. If your tape device is different to the default `/dev/rmt0`, then type the correct target tape device (or file name) in the `Backup DEVICE or FILE` field, or use the **F4=List** key to select it.
4. Type `perfvg` in the `VOLUME GROUP to back up` field, or use the **F4=List** key to select it.
5. Use the **Tab** key to toggle the `Create MAP files?` field value from no to `yes`.

   This should ensure that we maintain the precise physical partition allocation documented in 8.3.2, "Map Files Usage and Contents" on page 207, that we used to create perfvg. Your screen should look like:

```
                             Back Up a Volume Group

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

                                                        [Entry Fields]
    WARNING:  Execution of the savevg command will
              result in the loss of all material
              previously stored on the selected
              output medium.
* Backup DEVICE or FILE                              [/dev/rmt0]            +/
* VOLUME GROUP to back up                            [perfvg]               +
  Create MAP files?                                   yes                   +
  EXCLUDE files?                                      no                    +
  Number of BLOCKS to write in a single output       []                      #
     (Leave blank to use a system default)





F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

6. Press the **Enter=Do** key to backup perfvg.
7. Although your backup may require multiple tape volumes, our example fits on one tape and the output screen should resemble:

```
                                 COMMAND STATUS

Command: OK            stdout: yes           stderr: no

Before command completion, additional instructions may appear below.

a ./tmp/vgdata/vgdata.files
a ./tmp/vgdata/perfvg/filesystems
a ./tmp/vgdata/perfvg/perfvg.data
a ./tmp/vgdata/perfvg/perflog.map
a ./tmp/vgdata/perfvg/perflv1.map
a ./tmp/vgdata/perfvg/perflv2.map
a ./tmp/vgdata/perfvg/perflv3.map
a ./tmp/vgdata/perfvg/perflv4.map
a ./tmp/vgdata/perfvg/perfpg.map
a ./perfjfs4
a ./perfjfs3
a ./perfjfs2
a ./perfjfs1
0512-038 savevg: Backup Completed Successfully.


F1=Help             F2=Refresh          F3=Cancel           F6=Command
F8=Image            F9=Shell            F10=Exit            /=Find
n=Find Next
```

   You must check the end of the output by using any appropriate key such as **End**, or **Page Down**, or **Ctrl-V** to look for the string `0512-038 mksysb: Backup Completed Successfully`. This will ensure that there is no hidden error message, although such a message may be only a warning. In this case, our backup seems to be alright.

8. Press the **F3=Cancel** key to return to the Volume Groups menu.
9. You should check your backup by:
   a. Selecting **List Files in a Volume Group Backup** from the `Volume Groups` menu.

   b. If your tape device is different to the default `/dev/rmt0`, then type the correct target tape device (or file name) in the `Backup DEVICE or FILE` field, or use the **F4=List** key to select it.

   c. Press the **Enter=Do** key to check the backup of your volume group. If your backup is on multiple tape volumes, insert them as required.

10. Press the **F10=Exit** key to return to the command prompt when your backup (and backup check) is complete.

Now that our backup is complete, we can try to rebuild the perfvg volume group with the same physical partition layout as at the time of the backup.

Before we restored the backup, we ran the following commands:

```
# lspv -M hdisk3 > /tmp/perfvg/hdisk3.map.before
# lspv -M hdisk5 > /tmp/perfvg/hdisk5.map.before
```

We can easily repeat similar commands after we've recreated perfvg so that we can check if there are any changes to the physical partition layout by using the `diff` command on the output files.

To recreate perfvg:

1. You must ensure that all target disks are considered free for allocation by the operating system. In other words, you must see the word `None` next to the disk name when you execute the `lspv` command. Assume that you are recreating a volume group on the same disks that were used by the volume group when `savevg` was executed. If these disks are still being used by the volume group when you want to rebuild it, then you can:

   a. Unmount all journaled file systems. (You will have to change paging devices and reboot before this step if necessary.)

   b. Use the `varyoffvg` command on the volume group.

   c. Use the `exportvg` command for the volume group.

   d. Check via `lspv`.

      For this example, the procedure is:

      1) Execute `chps -a'n' 'perfpg'` and reboot.

         A smit menu for this deactivation of a paging logical volume, from the command `smitty chps`, is discussed in 8.7, “Manipulating Page Space” on page 303.

      2) Execute `umount /perfjfs1`.

      3) Execute `umount /perfjfs2`.

      4) Execute `umount /perfjfs3`.

      5) Execute `umount /perfjfs4`.

      6) Vary off the perfvg volume group using `varyoffvg perfvg`.

      7) Export the perfvg volume group using `exportvg perfvg`.

      8) Check that the `lspv` output looks like:

```
# lspv
hdisk0         00014732b1bd7f57    rootvg
hdisk1         0001221800072440    stripevg
hdisk2         00012218da42ba76    rootvg
hdisk4         0000020158496d72    availvg
hdisk5         00000201dc8b0b32    None
hdisk6         000002007bb618f5    availvg
hdisk3         0002479088f5f347    None
hdisk8         000137231982c0f2    stripevg
hdisk7         none                None
```

`hdisk5` and `hdisk3` are not associated with any volume group by the operating system, and hence they can be used as the target physical volumes for the recreation of perfvg.

2. Execute `smitty restvg`.

   Or, if you have come down from the main smit menu to the Volume Groups menu, then select **Remake a Volume Group**. *Don't* select Restore Files in a Volume Group Backup.

3. If your tape device is different from the default `/dev/rmt0`, then type the correct source tape device (or file name) in the `Restore DEVICE or FILE` field, or use the **F4=List** key to select it so that your screen looks like:

```
                             Remake a Volume Group

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

                                                         [Entry Fields]
* Restore DEVICE or FILE                              [/dev/rmt0]           +/
  SHRINK the filesystems?                              no                   +
  PHYSICAL VOLUME names                               []                    +
     (Leave blank to use the PHYSICAL VOLUMES listed
      in the vgname.data file in the backup image)
  Number of BLOCKS to read in a single input          []                     #
     (Leave blank to use a system default)








F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

4. Press the **Enter=Do** key to get to the following menu prompt:

```
                                 COMMAND STATUS

Command: running       stdout: yes           stderr: yes

Before command completion, additional instructions may appear below.


  Will create the Volume Group: perfvg
  Target Disks: hdisk3
hdisk5
  Allocation Policy:
        Shrink Filesystems:     no
        Preserve Physical Partitions for each Logical Volume:   yes


Enter "y" to continue:
```

5. Type the character `y` and press **Enter=Do**

   Note that you are asked to confirm the target disks since they may contain data that you want to keep. Remember that we only exported perfvg to free up these disks, so hdisk3 and hdisk5 still contain valid data because `exportvg` does not write to the physical volumes that are in the exported volume group.

   If you did *not* check that your target disks are free, you may see an error such as:

```
                                 COMMAND STATUS

Command: failed        stdout: yes           stderr: yes

Before command completion, additional instructions may appear below.


  Will create the Volume Group: perfvg
  Target Disks: hdisk3
hdisk5
  Allocation Policy:
        Shrink Filesystems:     no
        Preserve Physical Partitions for each Logical Volume:   yes


Enter "y" to continue:
0512-037 restvg: Target Disk hdisk3 Already belongs to a Volume Group.  Restore
of Volume Group canceled.




F1=Help             F2=Refresh          F3=Cancel           F6=Command
F8=Image            F9=Shell            F10=Exit            /=Find
n=Find Next
```

   If you get this error even after you have exported the old volume group, you may have to first double check using the `lsdev -Cc disk` command that the physical volume names have not changed since you made the backup. You may also have to format the target disks.

However, you should usually have no problem getting to a screen like

```
                                   COMMAND STATUS

Command: OK            stdout: yes           stderr: yes

Before command completion, additional instructions may appear below.

[TOP]

  Will create the Volume Group: perfvg
  Target Disks: hdisk3
hdisk5
  Allocation Policy:
        Shrink Filesystems:     no
        Preserve Physical Partitions for each Logical Volume:   yes


Enter "y" to continue: New volume on /dev/rmt0:
 Cluster 51200 bytes (100 blocks).
    Volume number 1
    Date of backup: Tue Jul 12 19:14:13 1994
[MORE...18]

F1=Help             F2=Refresh          F3=Cancel           F6=Command
F8=Image            F9=Shell            F10=Exit            /=Find
n=Find Next
```

You should go to the bottom of the smit output by using any appropriate key such as **End**, or **Page Down**, or **Ctrl-V** to confirm there is no hidden error message, although such a message may be only a warning.

6. In our example, the command seems to have completed successfully so press the **F10=Exit** key to return to the command prompt so that we can confirm that:
   - The physical partition layout has been restored.
   - The data files have been restored.

***Check the Restored Volume Group:*** The `restvg` command has automatically mounted our file systems and there are no data access problems. Although we expect our mirror setup to be maintained, the level of AIX Version 4 used in this example has resulted in only one physical partition being allocated to each logical partition in every logical volume in the perfvg volume group. This can be seen from the output of:

```
# lsvg -l perfvg
perfvg:
LV NAME             TYPE       LPs   PPs   PVs  LV STATE      MOUNT POINT
perflv1             jfs        10    10    1    open/syncd    /perfjfs1
perflv2             jfs        10    10    1    open/syncd    /perfjfs2
perflv3             jfs        12    12    2    open/syncd    /perfjfs3
perflv4             jfs        10    10    2    open/syncd    /perfjfs4
perflog             jfslog     1     1     1    open/syncd    N/A
perfpg              paging     5     5     2    closed/syncd  N/A
```

However, it is only the secondary copies that have been lost. The primary copies have been restored to an identical physical partition layout. If you look at the contents of the file badmir.map in 8.3.2, “Map Files Usage and Contents” on page 207, you can see that the layout specified by this map file is consistent with the output of the following command:

```
# lspv -M hdisk5 |grep perflv1
hdisk5:101      perflv1:1
hdisk5:102      perflv1:2
hdisk5:103      perflv1:3
hdisk5:104      perflv1:4
hdisk5:105      perflv1:5
hdisk5:106      perflv1:6
hdisk5:107      perflv1:7
hdisk5:108      perflv1:8
hdisk5:109      perflv1:9
hdisk5:110      perflv1:10
#
```

If you have many large logical volumes in the volume group that you've recreated, then it may not be easy to visually compare them. As an alternative, you can execute the following commands:

```
# lspv -M hdisk3 > hdisk3.map.after
# lspv -M hdisk5 > hdisk5.map.after
# diff hdisk5.map.after hdisk5.map.before|grep perflv3
# diff hdisk3.map.after hdisk3.map.before|grep perflv3
#
```

The `diff` command compares the ASCII text files that contain the physical volume physical partition allocation map both before and after perfvg was rebuilt. The `grep` command confirms that `diff` has found no difference for the perflv3 logical volume, so we know that its layout has been maintained.

***How to Recover Space in a User Volume Group:*** Unlike the rootvg volume group journaled file systems, you may be able to recover space in a logical volume in another volume group without affecting other users. For example, you may be able to:

1. Make a current backup of logical volume data.
2. Close the logical volume (for example, by unmounting the associated &jfs).
3. Remove the logical volume.
4. Recreate the logical volume (and its associated journaled file system) with a smaller size.
5. Restore the data.

However, if you have multiple logical volumes that you wish to recover data from in one volume group, then the above process may be lengthy. It's probably easier to backup the volume group using `savevg`, export it to deallocate its physical volumes, and then recreate it with `restvg`, as in the following procedure that is almost identical to the previous example.

1. Execute `smitty restvg.` to get to the menu with the title **Remake a Volume Group**
2. If your tape device is different to the default `/dev/rmt0`, then type the correct source tape device (or file name) in the `Restore DEVICE or FILE` field, or use the **F4=List** key to select it.

3. Press the **Tab** key to toggle the field `SHRINK the filesystems?` from `no` to `yes` so that your screen should look like:

```
                             Remake a Volume Group

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

                                                     [Entry Fields]
* Restore DEVICE or FILE                          [/dev/rmt0]              +/
  SHRINK the filesystems?                          yes                     +
  PHYSICAL VOLUME names                           []                       +
     (Leave blank to use the PHYSICAL VOLUMES listed
      in the vgname.data file in the backup image)
  Number of BLOCKS to read in a single input      []                        #
     (Leave blank to use a system default)









F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

4. Press the **Enter=Do** key to get to the following menu prompt:

```
                                 COMMAND STATUS

Command: running       stdout: yes           stderr: yes

Before command completion, additional instructions may appear below.


  Will create the Volume Group: perfvg
  Target Disks: hdisk3
hdisk5
  Allocation Policy:
        Shrink Filesystems:     yes
        Preserve Physical Partitions for each Logical Volume:   no


Enter "y" to continue:
```

5. Type the character `y` and press **Enter=Do**.

   Note that you are asked to confirm the target disks since they may contain data that you want to keep. Remember that we only exported perfvg to free up these disks, so hdisk3 and hdisk5 still contain valid data because exportvg does not write to the physical volumes that are in the exported volume group.

   You should get to a screen like:

```
                                    COMMAND STATUS

Command: OK            stdout: yes           stderr: yes

Before command completion, additional instructions may appear below.

[TOP]


  Will create the Volume Group: perfvg
  Target Disks: hdisk3
hdisk5
  Allocation Policy:
        Shrink Filesystems:     yes
        Preserve Physical Partitions for each Logical Volume:   no


Enter "y" to continue: New volume on /dev/rmt0:
 Cluster 51200 bytes (100 blocks).
    Volume number 1
[MORE...18]

F1=Help             F2=Refresh          F3=Cancel           F6=Command
F8=Image            F9=Shell            F10=Exit            /=Find
n=Find Next
```

You should go to the bottom of the smit output by using any appropriate key such as **End**, or **Page Down**, or **Ctrl-V** to confirm there is no hidden error message, although such a message may be only a warning.

6. In our example, the command seems to have completed successfully so press the **F10=Exit** key to return to the command prompt so that we can confirm that:
   - The journaled file systems and their logical volumes have been made as small as is necessary to physically have enough room for the restored data files.
   - The data files have been restored.

The output of the following commands shows us that the space saving operation has worked. The mirrored logical volumes have been correctly created, and the journaled file systems have been mounted so that we can confirm that our data files have been restored:

```
# lsvg -l perfvg
perfvg:
LV NAME             TYPE       LPs   PPs   PVs  LV STATE      MOUNT POINT
perflv1             jfs        1     2     2    open/syncd    /perfjfs1
perflv2             jfs        1     2     2    open/syncd    /perfjfs2
perflv3             jfs        1     1     1    open/syncd    /perfjfs3
perflv4             jfs        1     1     1    open/syncd    /perfjfs4
perflog             jfslog     1     1     1    open/syncd    N/A
perfpg              paging     5     10    2    closed/syncd  N/A
#
# df -I /perf*
Filesystem    512-blocks      Used      Free %Used Mounted on
/dev/perflv1        2640       208      2432    7% /perfjfs1
/dev/perflv2        2640       208      2432    7% /perfjfs2
/dev/perflv3        3152       208      2944    6% /perfjfs3
/dev/perflv4        2640       208      2432    7% /perfjfs4
#
```

Note that although each journaled file system requires one 4MB logical partition, the journaled file system is actually much smaller than this, and can be expanded to over 8000 512 byte blocks before a second logical partition will be allocated to it.

## 8.4.2 How to Use the mksysb Command

This example follows the steps in "Backing Up Your System", in the AIX Version 4.1 Installation Guide, to create a backup bootable tape image of rootvg. We can do this twice:

- One backup with map files.
- One backup without map files.

Since we are concerned about the location of our logical volume copies in our mirrored rootvg example, we only need to do a backup that will create map files. In fact, creating map files provides more installation choices; we can *change the field* in the installation menu from its default of yes so that we do not have to use the map files on the tape to rebuild the rootvg.

Once the backup is complete, we can try to reinstall AIX Version 4 from our backup tape and confirm that the mirror copies are on separate physical volumes:

- With the default installation options (no maps and no shrink).
- With the map file installation option.
- With the shrink option set to yes.

Note that the entry for the image.data file in the *AIX Version 3.2 Files Reference* reminds us that this file in the / directory should not be modified.

### 8.4.2.1 Command Line Summary

Unlike AIX Version 3, the command called by smit is actually a script that for a bootable tape effectively runs the following command:

```
# /usr/bin/mksysb -i $BFLAG $EFLAG $MFLAG $DEVICE
```

The script that is actually run is a great deal more complicated, and can be viewed by using the **F6=Command** key from the smit Back Up the System menu.

### 8.4.2.2 Detailed Guidance

Our first example shows how to create a backup that includes map files for the rootvg. This should enable us to use this backup tape to rebuild a system that has the same disk configuration, with the physical partitions of each logical volume located in exactly the same place. This will ensure that your system performance does not suffer because, for example, a paging logical volume could otherwise be rebuilt on a slow physical volume instead of the fast physical volume that it was on when the AIX Version 4 rootvg image was built.

***Always Document the Current System:*** Before we start any backup, it is wise to collect the output of a few commands to document the current system configuration. This information may be very valuable if you encounter a problem when you use this backup image to install AIX Version 4.

You can record information such as:

```
# lspv
hdisk0         00014732b1bd7f57    rootvg
hdisk1         0001221800072440    stripevg
hdisk2         00012218da42ba76    rootvg
hdisk4         0000020158496d72    availvg
hdisk5         00000201dc8b0b32    perfvg
hdisk6         000002007bb618f5    availvg
hdisk3         0002479088f5f347    perfvg
hdisk8         000137231982c0f2    stripevg
hdisk7         none                None
# lsdev -Cc disk
hdisk0 Available 00-08-00-0,0 670 MB SCSI Disk Drive
hdisk1 Available 00-08-00-1,0 670 MB SCSI Disk Drive
hdisk2 Available 00-08-00-2,0 355 MB SCSI Disk Drive
hdisk4 Available 00-07-00-0,0 1.2 GB SCSI Disk Drive (in 2.4 GB Disk Unit)
hdisk5 Available 00-07-00-1,0 1.2 GB SCSI Disk Drive (in 2.4 GB Disk Unit)
hdisk6 Available 00-07-00-2,0 1.2 GB SCSI Disk Drive (in 2.4 GB Disk Unit)
hdisk3 Available 00-08-00-3,0 320 MB SCSI Disk Drive
hdisk8 Available 00-07-00-4,0 857 MB SCSI Disk Drive
hdisk7 Available 00-07-00-3,0 1.2 GB SCSI Disk Drive (in 2.4 GB Disk Unit)
# df
Filesystem    512-blocks      Free %Used    Iused %Iused Mounted on
/dev/hd4            8192      4480   45%      714    34% /
/dev/hd2          409592     32688   92%     5044     9% /usr
/dev/hd9var        24576      3952   83%       95     3% /var
/dev/hd3           24576     23008    6%       70     1% /tmp
/dev/hd1            8192      7680    6%       70     6% /home
/dev/availlv       49152      4888   90%       17     0% /availjfs
/dev/strlv16k      98304      9856   89%       18     0% /strjfs16k
/dev/strlv32k      65536      2640   95%       42     0% /strjfs32k
/dev/lv01          57344       616   98%     5726     8% /frag512
/dev/lv00          57344         0  100%     5100     7% /frag4096
/dev/lv02          16384       288   98%     1748    85% /frag512-1
/dev/perflv1       81920     79280    3%       16     0% /perfjfs1
/dev/perflv2       81920     79280    3%       16     0% /perfjfs2
/dev/perflv3       98304     95152    3%       16     0% /perfjfs3
/dev/perflv4       81920     79280    3%       16     0% /perfjfs4
#
# lsps -a
Page Space  Physical Volume   Volume Group    Size   %Used  Active  Auto  Type
perfpg      hdisk5            perfvg          20MB       0      no    no    lv
perfpg      hdisk3            perfvg          20MB       0      no    no    lv
hd6         hdisk0            rootvg          32MB      24     yes   yes    lv
hd6         hdisk2            rootvg          32MB      24     yes   yes    lv
#
```

Note that since the creation of the mirror copies of the rootvg logical volumes, we deleted the `paging00` device and increased the /tmp journaled file system by 4MB. An example of the output of `lsvg -M rootvg` before this change is shown in "How to Check the Implementation of a Mirrored rootvg" on page 198. This is very useful command output to keep when you want to create a rootvg image that includes map files.

***Create the rootvg Image on a Bootable Tape:*** As well as the prerequisites listed in *Backing Up Your System*, in *AIX Version 4.1 Installation Guide*, you need to ensure that you have:

- The fileset containing the required tape device software installed, *if* your tape drive has been attached to your RISC System/6000 temporarily for the purpose of backing it up (in other words, the tape device was not powered on and attached to this RISC System/6000 when it was previously installed).

- Given thought to the consequences of using this rootvg image to install a different RISC System/6000. In other words, do you need to:
  - Change the root password before the backup.
  - Install additional filesets containing device driver software for the target machine if its hardware configuration is *not identical* to the source RISC System/6000 where the image was created.
  - Change communication parameters to avoid a network conflict.

We can see from the above output of the `df` command that we have 23008 512 byte blocks free in the /tmp journaled file system. This is more than 8.2MB, so we should have enough working space for the backup process. However, even if `df` said that /tmp was almost full or on the borderline of being likely to run out of space, then since we know that rootvg has some free physical partitions in it, we can just change the smit field `EXPAND /tmp if needed?` as described below. We also know that all the rootvg journaled file systems that we want to backup are currently mounted. To create the rootvg image:

1. Execute the command `smitty mksysb`.

   If you want to find this in the AIX Version 4 smit menu hierarchy:

   a. Execute the command `smitty`.
   b. Select **System Storage Management (Physical & Logical Storage)**.
   c. Select **System Backup Manager**.
   d. Select **Back Up the System**.

   Your screen should now have a menu with the title Back Up the System.

2. Type the name of our backup device, such as `/dev/rmt0`, in the `Backup DEVICE or FILE` field if its different to the default value that appears in the field.
3. Ensure that we'll have enough working space by using the **Tab** key to toggle `EXPAND /tmp if needed?` to no.
4. Use the **Tab** key to toggle `Create MAP files?` from no to `yes` so that your screen looks like:

```
                                 Back Up the System

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

                                                        [Entry Fields]
    WARNING:  Execution of the mksysb command will
              result in the loss of all material
              previously stored on the selected
              output medium. This command backs
              up only rootvg volume group.

* Backup DEVICE or FILE                              [/dev/rmt0]            +/
  Make BOOTABLE backup?                               yes                   +
     (Applies only to tape media)
  EXPAND /tmp if needed?   (Applies only to bootable  yes                   +
   media)
  Create MAP files?                                   yes                   +
  EXCLUDE files?                                      no                    +
  Number of BLOCKS to write in a single output       []                     #
#
     (Leave blank to use a system default)

F1=Help            F2=Refresh          F3=Cancel           F4=List
F5=Reset           F6=Command          F7=Edit             F8=Image
F9=Shell           F10=Exit            Enter=Do
```

5. Press the **Enter=Do** key to create the backup using the write enabled tape that we placed in the tape drive (we want to backup *all* files and we'll let the operating system determine the appropriate number of blocks to use for the /dev/rmt0 tape device).

6. Insert a second tape if required.

   Our example backup image fits on one 2.3GB 8mm tape cartridge. If your rootvg image requires multiple large capacity tapes, then you may need to reconsider your volume group design.

7. Wait for the backup to complete, which will be indicated by a screen that looks like:

```
                                   COMMAND STATUS

Command: OK            stdout: yes           stderr: yes

Before command completion, additional instructions may appear below.

[TOP]
File System size changed to 24576

bosboot: Boot image is 5173 512 byte blocks.
Backing up to /dev/rmt0.1
Cluster 51200 bytes (100 blocks).
Volume 1 on /dev/rmt0.1
a           10 ./tapeblksz
a           24 ./tmp/vgdata/rootvg/hd1.map
a         1300 ./tmp/vgdata/rootvg/hd2.map
a           72 ./tmp/vgdata/rootvg/hd3.map
a           24 ./tmp/vgdata/rootvg/hd4.map
a           12 ./tmp/vgdata/rootvg/hd5.map
a           24 ./tmp/vgdata/rootvg/hd5x.map
[MORE...6679]

F1=Help            F2=Refresh          F3=Cancel           F6=Command
F8=Image           F9=Shell            F10=Exit            /=Find
n=Find Next
```

   As can be seen from this output, the map files that contain the physical partition allocation data are the first files that are backed up.

You should go to the bottom of the smit output by using any appropriate key such as **End**, or **Page Down**, or **Ctrl-V** to confirm that the end of the output looks like:

```
a ./perfjfs3
a ./perfjfs4
a ./availjfs
a ./strjfs16k
a ./strjfs32k
a ./frag4096
a ./bosinst.data
0512-038 mksysb: Backup Completed Successfully.
```

It is important to check that there is no hidden error message, although such a message may be only a warning. In this case, our backup seems to be alright.

8. You may find that it is easier to read the first and last pages of this long output by checking your smit.log file when you exit smit by pressing the **F10=Exit** key.

**Warning - label all tapes**

You will eventually become very frustrated if you do not correctly label your backup tape(s) to include:

- The date of backup.
- The size of the rootvg image backed up (you may wish to keep a printed copy of the /image.data file so that you can estimate how much disk space is required on a target system installed with the SHRINK option set to yes in the installation menu).
- The root password information.
- A communications configuration summary.
- The AIX version and release level.
- The tape name to identify it accurately in your backup tape pool.

9. Write protect and safely store your tape(s).

***Check the rootvg Image:*** Briefly, it is important to note that you should check your backups regularly. A bootable tape should be checked by actually trying to boot the system in service mode using the tape. The actual files backed up should be checked by the smit option **List Files in a System Image** found in the System Backup Manager smit menu.

***How to Do a Thorough Backup Tape Test:*** *Use the tape to reinstall the source system!!!*

To do this, you should refer to *Installing BOS from a System Backup* in the *AIX Version 4.1 Installation Guide*. This article describes in detail the steps required to recover your mksysb image, which is what we did for this example. You will improve your understanding of the installation process if you continue with the *prompted installation*.

In this example, you will encounter a problem if you try to use map files. As we discussed at the start of this chapter, the names of the physical volumes may be reconfigured if some of the disks were added into the system at different times. This resulted in the installation process thinking that hdisk5 and hdisk7 were the target disks for the rootvg. You can check the actual SCSI addresses of these disks to confirm that this is correct. However, because the map files only contain the names of the disks, then the installation process only recognized hdisk0 and hdisk3 (the original names of the rootvg disks) as having map files.

Hence, we are forced to install AIX Version 4 with the defaults of:

- `Use Maps` set to `No`.
- `Shrink File System` set to `No`.
- `hdisk5` and `hdisk7` as the `Disk(s) Where You Want to Install`.

This problem with the physical volume names shows us something useful; a backup volume group image created with map files does *not* have to be installed with the `Use Maps` set to `yes`.

When the installation is complete, we can see the following disk configuration:

```
# lspv
hdisk0        0000020158496d72    None
hdisk1        00000201dc8b0b32    None
hdisk2        000002007bb618f5    None
hdisk3        none                None
hdisk4        000137231982c0f2    None
hdisk5        00014732b1bd7f57    rootvg
hdisk6        0001221800072440    None
hdisk7        00012218da42ba76    rootvg
hdisk8        0002479088f5f347    None
# lsdev -Cc disk
hdisk0 Available 00-07-00-0,0 1.2 GB SCSI Disk Drive (in 2.4 GB Disk Unit)
hdisk1 Available 00-07-00-1,0 1.2 GB SCSI Disk Drive (in 2.4 GB Disk Unit)
hdisk2 Available 00-07-00-2,0 1.2 GB SCSI Disk Drive (in 2.4 GB Disk Unit)
hdisk3 Available 00-07-00-3,0 1.2 GB SCSI Disk Drive (in 2.4 GB Disk Unit)
hdisk4 Available 00-07-00-4,0 857 MB SCSI Disk Drive
hdisk5 Available 00-08-00-0,0 670 MB SCSI Disk Drive
hdisk6 Available 00-08-00-1,0 670 MB SCSI Disk Drive
hdisk7 Available 00-08-00-2,0 355 MB SCSI Disk Drive
hdisk8 Available 00-08-00-3,0 320 MB SCSI Disk Drive
#
```

The new assignment of disk names reflects the following two precedents:

1. SCSI physical volumes connected to adapters that are in lower slot numbers are configured first.
2. SCSI physical volumes with smaller addresses are configured first.

This means that the disk at address 00-08-00-0,0 which was hdisk0 is now called hdisk5. Likewise, hdisk2 became hdisk7. However, note that the disk physical volume identifiers have not changed. In other words, the number 00014732b1bd7f57 that was associated with the rootvg disk hdisk0 is still associated with the same physical volume, which is now called hdisk5. This is expected because when an identifier is given to a disk, it is actually recorded on the VGDA of the disk.

Some of a physical volume Volume Group Descriptor Area can be seen by the following low level command:

```
# lqueryvg -p hdisk0 -At
Max LVs:        256
PP Size:        22
Free PPs:       560
LV count:       2
PV count:       2
Total VGDAs:    3
Logical:        000004461ed9e52e.1   availlv 1
                000004461ed9e52e.2   loglv00 1
Physical:       0000020158496d72 2   0
                000002007bb618f5 1   0
#
```

This tells us that the disk that is currently called `hdisk0` belongs to a volume group that contains one other physical volume. Notice that the volume group physical volumes are identified by their unique hexadecimal number rather than by a name such as hdisk0.

The above command will also help us fix another problem that exists since our installation of the backup tape. We can see from the earlier output of the `lspv` command that the other non-rootvg physical volumes have the word `None` next to them which reflects the fact that the current operating system does not know about our user volume groups. This means that we will have to reimport these volume groups. This is not difficult since we can use the output of the `lspv` command and the `lqueryvg` command for some of the disks to determine how many user volume groups we have.

Alternatively, we could use the following command for every disk to determine the volume group configuration. When you can see the logical volume names on your screen, you can press the **Ctrl** and **C** keys simultaneously to exit this command.

```
# /usr/bin/strings /dev/rhdisk0| more
XImr
_LVM
DEFECT
_LVM
DEFECT
XImr
availlv
loglv00
```

Of course, since we had saved the output of the commands:

- `lspv`
- `lsdev -Cc disk`

in our original system, then we do not have to use `lqueryvg` or `strings`.

**Warning - Name your logical volumes**

This example clearly illustrates the value of using meaningful names for your logical volumes and volume groups. We recommended that you always use the option `Add a Journaled File System on a Previously Defined Logical Volume` in the menu found from `smitty jfs`, rather than `Add a Journaled File System` for long term data files.

It is easier for us to recognize something called availlv rather than lv00.

***How to Import a Volume Group:*** To import the user volume groups:

1. Execute `smitty importvg` to get to the menu with the title Import a Volume Group, or, more generally:
   a. Execute `smitty`.
   b. Select **System Storage Management (Physical & Logical Storage)**.
   c. Select **Logical Volume Manager**.
   d. Select **Volume Groups**.
   e. Select **Import a Volume Group**.
2. Type the name of the volume group, such as `availvg`, in the `VOLUME GROUP name` field.
3. Type the name of one physical volume that you know belongs to this volume group, such as `hdisk0` for availvg, in the `PHYSICAL VOLUME name` field, or use the **F4=List** key to select it.

   Note that only one physical volume is required to import a volume group. As we saw from the earlier output of the `lqueryvg` command, each disk in a volume group knows what physical volumes belong to the volume group, and what logical volumes exist on the volume group.
4. Press the **Enter=Do** key when your screen looks like:

```
                             Import a Volume Group

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

                                                      [Entry Fields]
  VOLUME GROUP name                                [availvg]
* PHYSICAL VOLUME name                             [hdisk0]                 +
* ACTIVATE volume group after it is                 yes                     +
    imported?
  Volume group MAJOR NUMBER                        []                       +#











F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

5. Press the **F10=Exit** key to return to the command prompt when smit returns an `OK` message.

   **Warning - Import user volume groups**

   With the level of AIX Version 4 that we used for these examples, we found that it is *always* necessary to re-import your user volume groups when a rootvg backup image is installed.

6. Repeat this sequence for all volume groups whose data you want to access. In this example, repeat the command for the perfvg and stripevg volume groups.

   We executed `importvg` directly from the command line as follows:

```
# importvg -y availvg hdisk0
availvg
# importvg -y perfvg hdisk1
perfvg
# importvg -y stripevg hdisk4
stripevg
```

We can easily confirm that the volume group configuration has been restored by the following command:

```
# lspv
hdisk0         0000020158496d72    availvg
hdisk1         00000201dc8b0b32    perfvg
hdisk2         000002007bb618f5    availvg
hdisk3         none                None
hdisk4         000137231982c0f2    stripevg
hdisk5         00014732b1bd7f57    rootvg
hdisk6         0001221800072440    stripevg
hdisk7         00012218da42ba76    rootvg
hdisk8         0002479088f5f347    perfvg
#
```

Note that all volume groups were automatically varied on when they were imported, as can be from the output of:

```
# lsvg -o
stripevg
perfvg
availvg
rootvg
```

Now that the volume group configuration has been restored, we can mount the journaled file systems in these volume groups. to check that we can still access our data by executing the command:

```
# mount all
mount: /dev/hd1 on /home: Device busy
mount: /dev/newlv on /newfs: No such file or directory
Replaying log for /dev/perflv1.
Replaying log for /dev/availlv.
```

We can quickly check the restoration of the files in our journaled file systems from the command:

```
# df
Filesystem    512-blocks      Free %Used    Iused %Iused Mounted on
/dev/hd4            8192      4520   44%      713    34% /
/dev/hd2          409592     32712   92%     5044     9% /usr
/dev/hd9var        24576     21712   11%       76     1% /var
/dev/hd3           24576     22640    7%       59     1% /tmp
/dev/hd1            8192      7712    5%       51     4% /home
/dev/perflv1       81920     79280    3%       16     0% /perfjfs1
/dev/perflv2       81920     79280    3%       16     0% /perfjfs2
/dev/perflv3       98304     95152    3%       16     0% /perfjfs3
/dev/perflv4       81920     79280    3%       16     0% /perfjfs4
/dev/availlv       49152      4888   90%       17     0% /availjfs
/dev/strlv16k      98304      9856   89%       18     0% /strjfs16k
/dev/strlv32k      65536      2640   95%       42     0% /strjfs32k
/dev/lv01          57344       616   98%     5726     8% /frag512
/dev/lv00          57344         0  100%     5100     7% /frag4096
/dev/lv02          16384       288   98%     1748    85% /frag512-1
```

From a comparison with this command's output some time before the rootvg was built, we can see that all journaled file systems are identical except for the fact that the rootvg journaled file systems have more free space. This occurred because we deleted some files before we built the image.

Finally, we need to check whether our rootvg mirrored configuration will protect us from disk failure. The output of the following command suggests that we may be safe:

```
# lsvg -l rootvg
rootvg:
LV NAME             TYPE       LPs   PPs   PVs  LV STATE      MOUNT POINT
hd6                 paging     8     16    2    open/syncd    N/A
hd5                 boot       1     1     1    closed/syncd  N/A
hd8                 jfslog     1     2     2    open/syncd    N/A
hd4                 jfs        1     2     2    open/syncd    /
hd2                 jfs        50    100   2    open/syncd    /usr
hd9var              jfs        3     6     2    open/syncd    /var
hd3                 jfs        3     6     2    open/syncd    /tmp
hd1                 jfs        1     2     2    open/syncd    /home
hd5x                boot       2     2     1    closed/syncd  N/A
#
```

Now the last time our example system booted, it used the hd5 logical volume on hdisk5, the 670MB disk at SCSI address 08-00. This can be seen from:

```
# bootinfo -b
hdisk5
#
```

We used the `strings` command on both the hd5 and hd5x raw devices and thought that we may be able to reboot from the hd5x logical volume after executing:

```
# bootlist -m normal hdisk7 hdisk5
```

However, our reboot hung at some point after the message `PERFORM auto-varyon of Volume Groups` was displayed. This suggests that it is either a problem with what we thought was a valid boot image on hd5x, and/or, that there is a problem with the new physical partition map that was creation by the AIX Version 4 installation program.

When we checked the new rootvg physical partition map, we found that the hd5x logical volume had been created on hdisk5 instead of hdisk7. Hence we used the following commands:

```
# migratepv -l hd5x hdisk5 hdisk7
# bosboot -a -l /dev/hd5x -d /dev/hdisk7

bosboot: Boot image is 4275 512 byte blocks.
# bosboot -a -l /dev/hd5 -d /dev/hdisk5

bosboot: Boot image is 4275 512 byte blocks.
```

For more examples of how to use the `migratepv` command, please refer to 8.8.1, “How to Use the migratepv Command” on page 315.

We are now able to successfully boot using either hdisk5 or hdisk7, so our first example installation of a rootvg image is complete.

**Warning - Always document rootvg**

This boot problem reminds us that it is very important to use some commands, such as those discussed in “How to Document the Volume Group Design” on page 236, to record the physical partition map of a mirrored rootvg configuration.

So far, we've tried to install a rootvg backup image that uses map files (and hence does not change a journaled file systems' size). However, in our example, we were forced to abandon the use of map files because the disk names changed. If you do use map files, you should execute the command `lsvg -M rootvg > filename` on both the source and target machines, and then use the `diff` command on the output files to confirm that the physical partition maps are identical.

***How to Save Space in the rootvg:*** Now we can try to use the new *SHRINK* option in the installation menus of AIX Version 4 to save space in the rootvg volume group, if some of its logical volumes have unused space. For example, if you de-install a large program product, you may end up with a lot of free space in /usr that you would rather allocate to another logical volume in the rootvg volume group.

Briefly, recall that our rootvg from the end of 8.4.2, "How to Use the mksysb Command" on page 259 looks like:

```
# lsvg -l rootvg
rootvg:
LV NAME             TYPE       LPs   PPs   PVs  LV STATE      MOUNT POINT
hd6                 paging     8     16    2    open/syncd    N/A
hd5                 boot       1     1     1    closed/syncd  N/A
hd8                 jfslog     1     2     2    open/syncd    N/A
hd4                 jfs        1     2     2    open/syncd    /
hd2                 jfs        50    100   2    open/syncd    /usr
hd9var              jfs        3     6     2    open/syncd    /var
hd3                 jfs        3     6     2    open/syncd    /tmp
hd1                 jfs        1     2     2    open/syncd    /home
hd5x                boot       2     2     1    closed/syncd  N/A
#
```

The disk space recovery installation procedure is almost identical to that documented in the previous example in 8.4.2, "How to Use the mksysb Command" on page 259. The only difference is that you must install AIX Version 4 with the defaults of:

- `Use Maps` set to `No`.
- `Shrink File System` set to `Yes`.

  This is the *critical* field.
- `hdisk5` and `hdisk7` as the `Disk(s) Where You Want to Install`.

**Warning - Do not edit /image.data**

Although the article *Backing Up the System Image Including User Volume Groups* in AIX Version 4.1 System Management Guide: Operating System and Devices, suggests that we can change the SHRINK variable in the image.data file, the entry for this file in the *AIX Version 3.2 Files Reference* reminds us that it is not wise to edit this file. Although it says that it is alright to edit the SHRINK field, we suggest that you do *not* do this, since you can get the same effect by changing the SHRINK field in the AIX Version 4 installation menu.

When the installation is complete, run the commands:

```
#  df -kI
Filesystem    1024-blocks      Used      Free %Used Mounted on
/dev/hd4            4096      1928      2168   47% /
/dev/hd2          192512    188184      4328   97% /usr
/dev/hd9var         4096      1084      3012   26% /var
/dev/hd3           12288      1736     10552   14% /tmp
/dev/hd1            4096       240      3856    5% /home
and so on...
# lsvg -l rootvg
rootvg:
LV NAME             TYPE       LPs   PPs   PVs  LV STATE      MOUNT POINT
hd6                 paging     8     16    2    open/syncd    N/A
hd5                 boot       1     1     1    closed/syncd  N/A
hd8                 jfslog     1     2     2    open/syncd    N/A
hd4                 jfs        1     2     2    open/syncd    /
hd2                 jfs        47    94    2    open/syncd    /usr
hd9var              jfs        1     2     2    open/syncd    /var
hd3                 jfs        3     6     2    open/syncd    /tmp
hd1                 jfs        1     2     2    open/syncd    /home
hd5x                boot       2     2     1    closed/syncd  N/A
#
```

The `df` command also shows that we now have a minimal amount of free space in each journaled file system. You can see that we've recovered three logical partitions from hd2 (/usr) and two from hd9var (/var), so we have 10 more free physical partitions in rootvg that can be used to increase or create other logical volumes. This occurs because we recover two physical partitions for every logical partition since we have implemented a double copy mirrored rootvg volume group.

Finally, do not forget to check the location of the hd5x logical volume. You may have to move it using `migratepv` as was shown at the end of the last `mksysb` example. Also, you will need to repeat the `bosboot` commands for both hd5 and hd5x before you can simulate a rootvg physical volume failure.

## 8.5 Utilizing the New AIX Version 4 Features

This section contains some practical examples in the usage of the new storage related features in AIX Version 4. This includes:

1. Striped logical volumes
2. Fragments
3. JFS compression
4. File systems greater than 2GB in size

First, create stripevg that contains hdisk1 and hdisk8 using the same procedure as for the creation of availvg:

1. Execute `smitty vg`..
2. Select **Add a Volume Group**.
3. Type `stripevg` for `VOLUME GROUP name`.
4. Type `hdisk1 hdisk8` for `PHYSICAL VOLUME names`.
5. Press **Enter=Do** and then **F10=Exit** when smit returns an `OK` prompt.

## 8.5.1 Striped Logical Volumes

There are performance benefits in using striped logical volumes, particularly when sequential read/write access to large files is of importance. Although it is beyond the scope of this book to provide a practical example which would demonstrate this, results taken from a benchmark using striping are provided later in this section.

The purpose of the example to follow is to show how a striped logical volume can be created in AIX Version 4.

### 8.5.1.1 Command Line Summary

1. Create a striped logical volume, consisting of `60` logical partitions, called `stripelv32k`, in the volume group `stripevg` using disks `hdisk1` and `hdisk8`. Specify a stripe size of `32k`:

```
# mklv -y'stripelv32k' -S'32K' 'stripevg' '60' 'hdisk1 hdisk8'
```

2. Create a file system called `strjfs32k` using logical volume `strlv32k`:

```
# crfs -v jfs -d'strlv32k' -m'/strjfs32k' -A'yes' -p'rw' -t'no' \
-a frag='4096' -a nbpi='4096' -a compress='no'
```

3. Mount the file system:

```
# mount /strjfs32k
```

### 8.5.1.2 Detailed Description

The above summary steps show how a striped logical volume can be created and subsequently used to create a journaled file system. In the following section we will use smit to create the same striped logical volume and file system, and will review the steps necessary to identify the resources required.

In the example we will *not* discuss how to tune a striped logical volume for optimal performance. There are many different factors which need to be considered when tuning a striped logical volume for optimal performance. Some of these include system-wide operating system parameters, real memory requirements of applications, and the availability of hardware resources.

Changing a system-wide operating system parameter such as `maxpgahead` (maximum number of pages to read ahead), to provide a high performance striped logical volume for one application can sometimes cause degradation in performance for another application running on the same system. Also, if striping is done across two disks attached to a single SCSI adapter this would not provide a performance increase over non-striped disks.

Therefore, a lot of research and preparation work needs to be carried out in order to provide an *optimal* performance environment suitable to all applications. Since the needs for each site will differ, a particular system configuration providing high performance sequential access to files stored in a striped logical volume will not necessarily provide the same performance benefits at another site.

However, some basic principles should be followed when creating striped logical volumes for high-performance. These are:

- Spread the logical volume across as many physical volumes as possible.
- Use as many disk drive adapters, as possible, for the physical volumes.
- Create striped logical volumes using a volume group which is dedicated to striping alone. Do not mix non-striped logical volumes with striped logical volumes.

***How to Create a Striped Logical Volume:*** For this example we have chosen to use an existing volume group, stripevg which consists of two physical volumes, hdisk1 and hdisk8. The logical volume and filesystem we will create will be called /strlv32k and /strjfs32k, respectively. The logical volume will consist of 60 logical partitions.

1. Use the `lsdev` command to make sure that the physical volumes hdisk1 and hdisk8 in the volume group stripevg are attached to different SCSI adapters:

   ```
   # lsdev -Cc disk
   hdisk1 Available 00-08-00-1,0 670 MB SCSI Disk Drive
   hdisk8 Available 00-07-00-4,0 857 MB SCSI Disk Drive
   ```

   We can see from the above output that `hdisk1` is attached to the SCSI adapter located in slot `08` and `hdisk8` is attached to the SCSI adapter in slot `07`.

2. Check that the physical volumes used in the volume group `stripevg` have no physical partitions allocated:

   ```
   #lsvg -M stripevg

   stripevg
   hdisk1:1-159
   hdisk8:1-203
   ```

   The above output shows that no logical volumes currently exist and all partitions on each physical volume are free.

3. Create a striped logical volume over these physical volumes using the command `smitty mklv`:

   a. On the first screen enter `stripevg` for the volume group name and press **Enter**.

   b. On the second screen, shown below, enter:

      - `strlv32k` for the field `Logical volume NAME`.
      - `60` for the field `Number of LOGICAL PARTITIONS`.
      - `hdisk1 hdisk8` for the field `PHYSICAL VOLUME names`.

```
                         Add a Logical Volume

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

[TOP]                                                [Entry Fields]
  Logical volume NAME                           [strlv32k]
* VOLUME GROUP name                              stripevg
* Number of LOGICAL PARTITIONS                  [60]                #
  PHYSICAL VOLUME names                         [hdisk1 hdisk8]    +
  Logical volume TYPE                           []
  POSITION on physical volume                    outer_middle      +
  RANGE of physical volumes                      minimum           +
  MAXIMUM NUMBER of PHYSICAL VOLUMES            []                  #
    to use for allocation
  Number of COPIES of each logical               1                 +
    partition
  Mirror Write Consistency?                      yes               +
  Allocate each logical partition copy           yes               +
    on a SEPARATE physical volume?
[MORE...9]

F1=Help          F2=Refresh       F3=Cancel        F4=List
F5=Reset         F6=Command       F7=Edit          F8=Image
```

c. Press the **PageDown** key to move to the next page of this smit screen, shown below:

```
                          Add a Logical Volume

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

[MORE...9]                                            [Entry Fields]

  Number of COPIES of each logical                    1               +
    partition
  Mirror Write Consistency?                           yes             +
  Allocate each logical partition copy                yes             +
    on a SEPARATE physical volume?
  RELOCATE the logical volume during reorganization?  yes             +
  Logical volume LABEL                               []
  MAXIMUM NUMBER of LOGICAL PARTITIONS               [128]
  Enable BAD BLOCK relocation?                        yes             +
  SCHEDULING POLICY for writing logical               parallel        +
    partition copies
  Enable WRITE VERIFY?                                no              +
  File containing ALLOCATION MAP                     []
  Stripe Size?                                       [32K]            +
[BOTTOM]

F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

d. Using the **Tab** key toggle to the value **32K** for the field `Stripe Size?`

e. Press **Enter**.

f. Press **F10** to exit when smit returns with `OK`.

4. Create a journaled files system using the logical volume strlv32k with the command `smitty crjfslv`.

   The following smit screen will appear:

```
  Add a Journaled File System on a Previously Defined Logical Volume


Type or select values in entry fields.
Press Enter AFTER making all desired changes.

                                                    [Entry Fields]
* LOGICAL VOLUME name                             stripelv         +

* MOUNT POINT                                    [/stripefs]
  Mount AUTOMATICALLY at system restart?          yes              +
  PERMISSIONS                                     read/write       +
  Mount OPTIONS                                  []                +
  Start Disk Accounting?                          no               +
  Fragment Size (bytes)                           4096             +
  Number of bytes per inode                       4096             +
  Compression algorithm                           no               +



F1=Help          F2=Refresh       F3=Cancel        F4=List
F5=Reset         F6=Command       F7=Edit          F8=Image
F9=Shell         F10=Exit         Enter=Do
```

On this smit screen:

a. Press **F4** and select **strlv32k** from the list.

b. Enter `/strjfs32k` for the field `MOUNT POINT`.

c. Using the **Tab** toggle to the value `yes` for the field `Mount AUTOMATICALLY at system restart?`

d. Press **Enter**.

e. Press **F10** to exit when smit returns with `OK`.

We have now successfully created a striped logical volume and journaled file system.

#### 8.5.1.3 Benchmark Results for an I/O Bound Test Using Striping

Based on a particular Motorola benchmark, an intensive I/O bound application was developed in FORTRAN. The application test included performing continuous sequential access to about 2.4GB of data held within a journaled file system. The I/O activity performed by the application included reading forward, reading backward, and reading then writing forward. For comparison, the test was conducted, on separate occasions, using a striped logical volume and a non-striped logical volume.

The striped logical volume was created with a stripe size of 32K and the block size used for the disk I/O was 98304 bytes (96K). Certain operating system parameters were tuned to achieve better performance using the `vmtume` command. For example **maxpgahead** was set to **256** to allow up to this many 4K pages to be read ahead sequentially.

The hardware environment used for the test consisted of an RISC System/6000 model 590 with 512MB of memory. Three corvette adapters and six 2GB disks were configured for the striping test.

The results of this test was as follows:

**Results**

```
      Non-striped Run                          Striped Run
User     System     Elapsed           User     System     Elapsed
(hrs)    (hrs)      (hrs)             (hrs)    (hrs)      (hrs)

10.01    2.05       25.18             10.05    2.21       14.50
```

From the above timing results we can see that the test conducted using a striped logical volume was completed in 14.50 hours, whereas the same test within a non-striped logical volume took 25.18 hours. With the user and system times similar for both tests we can conclude that striping provides much better performance.

### 8.5.2 How to Use Fragments for Disk Usage Efficiency

The purpose of this example is to show how file systems created with a small fragment size can provide better disk space utilization than file systems created with a large fragment size when used to store a large number of small files. The example will demonstrate how to set up file systems with different fragment sizes and number-of-bytes-per-inode (NBPI) values.

For this exercise we will create two file systems, one with a fragment size of 512 bytes and the other with the default fragment size of 4096 bytes. For both file systems we will use a value of 512 for NBPI so that more than the default number of inodes are created. Each file system will be allocated 50000 512 byte blocks.

The test for efficient use of disk space will be determined by the disk space used when a number of equal sized files are stored within each file system. In each of these file systems we will store several small files, each 512 bytes in size.

#### 8.5.2.1 Command Line Summary

1. First create a journaled file system called `/frag512` with a `512` byte fragment size and a `512` NBPI value in the existing volume group `stripevg`:

```
crfs -v jfs -g'stripevg' -a size='50000' -m'/frag512' -A'yes' -p'rw' \
-t'no' -a frag='512' -a nbpi='512' -a compress='no'
```

2. Next create a journaled file system with a `4096` byte fragment size and a `512` NBPI value in the existing volume group `stripevg`:

```
crfs -v jfs -g'stripevg' -a size='50000' -m'/frag4096' -A'yes' \
-p'rw' -t'no' -a frag='4096' -a nbpi='512' -a compress='no'
```

3. Mount each of the above file systems:

```
# mount /frag512
# mount /frag4096
```

### 8.5.2.2 Detailed Description

The above two summary steps show how a file system can be created from the command line. In the following section we will look at each command separately, and also conduct example tests to verify the efficiency of using file systems with a small fragment size.

***How to Create a File System with a Different Fragment Size:*** In our example we have chosen to use an existing volume group, stripevg which consists of physical volumes hdisk1 and hdisk8. The file system created with the 512 byte fragment size will be called /frag512 and that created with a fragment size of 4096 bytes will be called /frag4096.

1. Create the 512 byte fragment size file system using the command `smitty crjfs`.

   Select the volume group **stripevg** from the list by moving to it using the **down** cursor key and pressing **Enter**.

   On the second smit screen, shown below, enter or change details for the following fields:

   - `SIZE of file system (in 512 byte blocks)`
   - `MOUNT POINT`
   - `Mount AUTOMATICALLY at system restart?`
   - `Fragment Size (bytes)`
   - `Number of bytes per inode`

```
                           Add a Journaled File System

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

                                                         [Entry Fields]
  Volume group name                                    stripevg
* SIZE of file system (in 512-byte blocks)            [50000]
* MOUNT POINT                                         [/frag512]
  Mount AUTOMATICALLY at system restart?               yes            +
  PERMISSIONS                                          read/write     +
  Mount OPTIONS                                       []              +
  Start Disk Accounting?                               no             +
  Fragment Size (bytes)                                512            +
  Number of bytes per inode                            512            +
  Compression algorithm                                no             +



F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

   a. Enter `50000` for the file system size.
   b. Enter `/frag512` for the mount point.
   c. Using the **Tab** key rotate to `yes` for the field `Mount AUTOMATICALLY at system restart?`
   d. Enter `512` for the fragment size.
   e. Enter `512` for number of bytes per inode.
   f. Press **Enter** when all fields have been filled out.

g. When processing finishes smit returns with OK, as shown below:

```
                       COMMAND STATUS

Command: OK            stdout: yes          stderr: no

Before command completion, additional instructions may appear below.

Based on the parameters chosen, the new /frag512 JFS file system
is limited to a maximum size of 16777216 (512 byte blocks)

New File System size is 57344




F1=Help             F2=Refresh          F3=Cancel           F6=Command
F8=Image            F9=Shell            F10=Exit            /=Find
n=Find Next
```

Press **F10** to exit smit.

**Note**

The output on this screen shows that the new file system size is 57344 512 bytes instead of 50000. This is because the file system is rounded up to the nearest allocation group size. See 3.1.4.1, "Journaled File System" on page 58 for a description of file system structure.

2. Now repeat the above steps to create the file system called /frag4096. However, this time use 4096 bytes for the file system fragment size instead of 512 bytes.
3. With both file systems now created we need to mount each in turn using the commands:

```
# mount /frag512
# mount /frag4096
```

Look at the output for the two mounted file systems produced by the `df` command:

```
# df -I /frag512 /frag4096
Filesystem    512-blocks      Used      Free %Used Mounted on
/dev/lv01          57344     16528     40816   28% /frag512
/dev/lv00          57344     16504     40840   28% /frag4096
```

The above output shows us that we have `40816` 512 byte blocks available in the file system `/frag512` and `40840` 512 byte blocks available in the file system `/frag4096`.

***How to Test the Efficiency of Disk Space Utilization:*** Now that we have created two file systems which have almost identical characteristics apart from their fragment sizes, we can look at testing their efficiency for storing a large number of very small files. For the test we will use a file whose size is 512 bytes which will occupy only one 512 byte fragment.

Use the following shell script, `mkfile` to create the file `512bytefile` with a size of 512 bytes.

```
#!/bin/ksh
# mkfile filesize
usage()
{
   clear
   echo " "
   echo " "
   echo " "
   echo " "
   echo "Usage: mkfile filesize"
   echo "       filesize should be in multiples of 512 bytes"
   echo " "
   echo " "
   echo " "
   echo " "
   exit
}
# Main...
if [ $# != 1 ]
then
   usage
fi
filesize=$1
filename="$1"bytefile
integer mod=`expr $filesize % 512`
integer div=`expr $filesize / 512`
if [ $mod != 0 ]
then
   usage
fi
integer i=0;
integer j=`expr $div \* 128`
> $filename
echo " "
echo "Creating file \"$filename\". Please wait..."
while true
do
      echo "yes" >> $filename
      i=i+1
      if [ $i = $j ]
      then
         break
      fi
done
```

Create the file using the command:

```
# cd /var/tmp
# mkfile 512
```

To test the number of 512 byte files that can be stored in each file system we will use the following sample Korn shell script called `fragcopy`. This shell script will continue to make copies in the target file system until either the file system become full or the target file count is reached. During processing a count will be displayed showing the number of files that have been copied successfully. Note that the first file has a count suffix of `0`.

```
#!/bin/ksh
# fragcopy
usage()
{
   clear
   echo " "
   echo " "
   echo " "
   echo " "
   echo "Usage: fragcopy numfiles dir/sourcefilename dir/targetfilename"
   echo " "
   echo " "
   echo " "
   echo " "
   exit
}
# Main...
integer i=0
integer cnt=$1
source=$2
target=$3
if [ $# != 3 ]
then
   usage
fi
while true
do
      cp $source $target.$i
      if [ $? != 0 ]
      then
         echo " "
         exit
      fi
      i=i+1
      echo "   Files copied: \c"
      echo "$i\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\b\c"
      if [ $i = $cnt ]
      then
         echo " "
         break
      fi
done
```

Create copies of the file `512bytefile` in the file system `/frag512` using the command:

```
# fragcopy 8 /var/tmp/512bytefile /frag512/frag8
```

Now let us look at the contents of the directory `/frag512`:

```
# ls -lt /frag512
total 8
-rw-r--r--   1 root     sys          512 Jul 11 18:02 frag8.0
-rw-r--r--   1 root     sys          512 Jul 11 18:02 frag8.1
-rw-r--r--   1 root     sys          512 Jul 11 18:02 frag8.2
-rw-r--r--   1 root     sys          512 Jul 11 18:02 frag8.3
-rw-r--r--   1 root     sys          512 Jul 11 18:02 frag8.4
-rw-r--r--   1 root     sys          512 Jul 11 18:02 frag8.5
-rw-r--r--   1 root     sys          512 Jul 11 18:02 frag8.6
-rw-r--r--   1 root     sys          512 Jul 11 18:02 frag8.7
```

Before we look at the df output for /frag512 let us create eight occurrences of the file 512bytefile in the filesystem /frag4096.

Create copies of the file `512bytefile` in `/frag4096` using the command:

```
# fragcopy 8 /var/tmp/512bytefile /frag4096/frag8
```

Look at the directory contents for `/frag4096`:

```
# ls -lt /frag4096
total 8
-rw-r--r--   1 root     sys          512 Jul 11 18:02 frag8.0
-rw-r--r--   1 root     sys          512 Jul 11 18:02 frag8.1
-rw-r--r--   1 root     sys          512 Jul 11 18:02 frag8.2
-rw-r--r--   1 root     sys          512 Jul 11 18:02 frag8.3
-rw-r--r--   1 root     sys          512 Jul 11 18:02 frag8.4
-rw-r--r--   1 root     sys          512 Jul 11 18:02 frag8.5
-rw-r--r--   1 root     sys          512 Jul 11 18:02 frag8.6
-rw-r--r--   1 root     sys          512 Jul 11 18:02 frag8.7
```

Now that we have the two file systems with the same number of files let us see how much disk space has been utilized in each using the `df` command:

```
# df -I /frag512 /frag4096
Filesystem    512-blocks      Used      Free %Used Mounted on
/dev/lv01          57344     16536     40808   28% /frag512
/dev/lv00          57344     16568     40776   28% /frag4096
```

We expected the file system /frag512 to use one 4K block and /frag4096 to use eight 4K blocks. We can verify this by comparing the results of `df` before and after the file copy operation.

Looking at the change in the `Used` column of the `df` output the following calculation shows how many 512 byte blocks have been used by each file system:

```
blks used by file copy = blks used before - blks used after
```

Based on this calculation the number of 512 byte blocks used by `/frag512` is:

```
blks used by /frag512 = 16536 - 16528 = 8
```

This is correct since we created eight 512 byte files in this file system.

The following calculation shows how many blocks were used by the file system `/frag4096`.

```
blks used by /frag4096 = 16568 - 16504 = 64
```

This is also exactly as we expected since each file copied to /frag4096 is allocated a 4K block. With eight files this has resulted in 32K bytes used, which expressed in 512 byte blocks is 64.

We can therefore conclude, based on the results of the test, that the use of smaller fragment sizes leads to more efficient use of disk space when a large number of small files need to be stored. We have also observed that file systems using a large fragment size can cause much wasted space particularly when the files being stored are smaller than 4096 bytes.

### 8.5.3 How to Use JFS Compression and Check its Consequences

This example shows you how to create a compressed journaled file system, and then how to use some simple commands to investigate the effects of compression on both AIX Version 4 performance and disk space usage.

To investigate compression, let's use the availvg volume group. The example was done *after* the `migratepv` example discussed in 8.8.1, "How to Use the migratepv Command" on page 315. This means that we have three physical volumes available, each with 287 4MB physical partitions, of which only 14 physical partitions are currently used.

Finally, remember that compression *can only be specified when a journaled file system is created*, and that compression *must* use a journaled file system with fragments that are less than 4096 bytes; in other words either 512 or 1024 or 2048 bytes. This example also investigates the differences between choosing 512 or 2048 as a fragment size when you create a journaled file system.

#### 8.5.3.1 Command Summary

The following commands show you how to create and mount two compressed journaled file system, one with a fragment size of 512, the other with a fragment size of 2048. The other `crfs` command shows you how to create, for comparison, a third journaled file system that also has a fragment size of 2048, but does *not* use compression.

```
# crfs -v jfs -g'availvg' -a size='80000' -m'/compress' -A'yes' \
# -p'rw' -t'no' -a frag='2048' -a nbpi='4096' -a compress='LZ'
# ... output follows... then execute
# crfs -v jfs -g'availvg' -a size='80000' -m'/compress512' -A'yes' \
# -p'rw' -t'no' -a frag='512' -a nbpi='4096' -a compress='LZ'
# ... output follows... then execute
# crfs -v jfs -g'availvg' -a size='80000' -m'/uncompress' -A'yes' \
# -p'rw' -t'no' -a frag='2048' -a nbpi='4096' -a compress='no'
```

To check that the journaled file systems have been correctly created, use:

```
lsfs -q
```

To mount the journaled file systems, execute:

```
# mount /compress
# mount /compress512
# mount /uncompress
```

Next we can check the performance of the compressed file system by copying a 20MB file (bigfile) to each file system, and measuring the performance. First check that the logical volume configuration is similar:

```
# lspv -p hdisk0
```

Now record copy times:

```
# timex cp /strjfs16k/bigfile /compress
# timex cp /strjfs16k/bigfile /uncompress
# timex cp /strjfs16k/bigfile /compress512
```

Finally, check that all files are the same size:

```
# ls -lt /compress /uncompress /strjfs16k
```

Lastly, we can check the disk utilization in order to investigate the efficiency of the compression. Copy the following 2560 byte files:

```
# cp /strjfs32k/fragdata/2560bytefile /compress512/2560bytefile
# cp /strjfs32k/fragdata/2560bytefile /compress/2560bytefile
# cp /strjfs32k/fragdata/2560bytefile /uncompress/2560bytefile
# cp /strjfs32k/fragdata/2560bytefile /frag512/2560bytefile
```

Use `du` to check much space is really used:

```
# du /strjfs32k/fragdata/2560bytefile
# du /compress512/2560bytefile
# du /compress/2560bytefile
# du /uncompress/2560bytefile
# du /frag512/2560bytefile
```

Use `ls` to verify the normal size of each file:

```
# ls -l /strjfs32k/fragdata/2560bytefile /frag512/2560bytefile
# ls -l /compress512/2560bytefile /compress/2560bytefile
# ls -l /uncompress/2560bytefile
```

### 8.5.3.2 Detailed Guidance

***How to Create a Compressed JFS:*** Since the availvg volume group has plenty of free space and one totally empty disk after the migration in 8.8.1, "How to Use the migratepv Command" on page 315, then in this case we can create the journaled file system straight away, *without* first creating a target logical volume for the journaled file system. As you can see later in this section, the logical volume manager in this case uses a physical partition map for the journaled file systems in this example that does not have a significant effect on our performance results, which are discussed in "How to Check the Performance of a Compressed File System" on page 288.

Although we want to create three journaled file systems for this example, the method is almost identical with only a few fields that are different. Hence smit menus are only provided once.

To create a 40MB compressed journaled file system with a fragment size of 2048 bytes mounted at /compress:

1. Execute the fastpath `smitty crjfs` to get to the following volume group menu selection:

```
                          Volume Group Name

Move cursor to desired item and press Enter.

  availvg
  rootvg
  perfvg
  stripevg

F1=Help                F2=Refresh             F3=Cancel
F8=Image               F10=Exit               Enter=Do
/=Find                 n=Find Next
```

   While `availvg` is highlighted, press the **Enter=Do** key to get to the menu with the title `Add a Journaled File System`.

   Alternatively, you can go through the smit hierarchy by:

   a. Executing `smitty`.

   b. Selecting **System Storage Management (Physical & Logical Storage)**.

   c. Selecting **File Systems**.

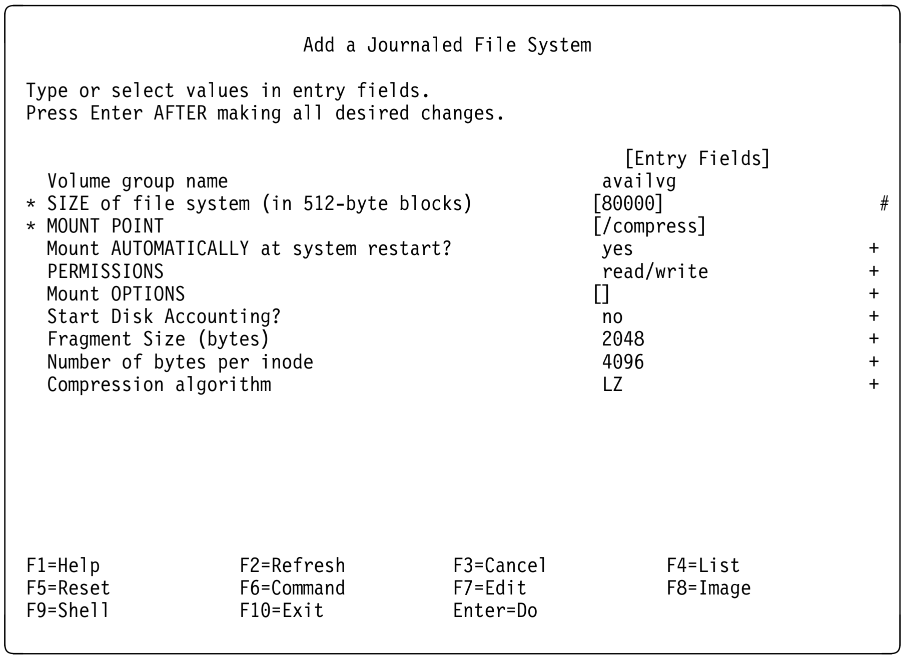
d. Selecting **Add / Change / Show / Delete File Systems**.

e. Selecting **Journaled File Systems**.

f. Selecting **Add a Journaled File System**.

g. Selecting the **availvg** volume group. to get to the menu with the title Add a Journaled File System.

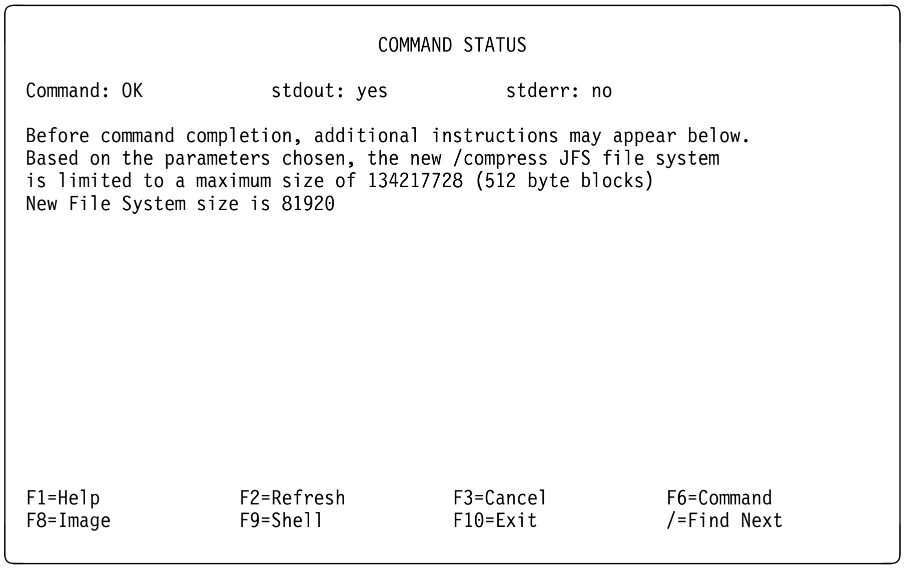
2. Type `80000` for the field `SIZE of file system (in 512-byte blocks)`. 80 000 times 512 bytes is roughly 40MB.
3. Type `/compress` for the field `MOUNT POINT`.
4. Use the **Tab** key to toggle the field `Mount AUTOMATICALLY at system restart?` from `no` to `yes`.
5. Use the **Tab** key to toggle the field `Fragment Size (bytes)` from `4096` to `2048`, or use the **F4=List** key to select it.
6. Use the **Tab** key to toggle the field `Compression algorithm` from `no` to `LZ` so that your screen looks like:



```
                          Add a Journaled File System

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

                                                        [Entry Fields]
  Volume group name                                   availvg
* SIZE of file system (in 512-byte blocks)           [80000]                #
* MOUNT POINT                                        [/compress]
  Mount AUTOMATICALLY at system restart?              yes                  +
  PERMISSIONS                                         read/write           +
  Mount OPTIONS                                      []                    +
  Start Disk Accounting?                              no                   +
  Fragment Size (bytes)                               2048                 +
  Number of bytes per inode                           4096                 +
  Compression algorithm                               LZ                   +








F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

7. Leave the other fields with their default values and press the **Enter=Do** key to create the /compress journaled file system.

   When the journaled file system has been created, your screen should look like:



```
                                    COMMAND STATUS

Command: OK            stdout: yes           stderr: no

Before command completion, additional instructions may appear below.
Based on the parameters chosen, the new /compress JFS file system
is limited to a maximum size of 134217728 (512 byte blocks)
New File System size is 81920













F1=Help             F2=Refresh          F3=Cancel           F6=Command
F8=Image            F9=Shell            F10=Exit            /=Find Next
```

8. Press the key **F10=Exit** to return to the command prompt.

Now repeat the above procedure to:

1. Create a 40MB compressed journaled file system with a frag size of 512 bytes mounted at /compress512:
    a. Execute the fastpath `smitty crjfs`.
    b. With `availvg` highlighted, press the **Enter=Do** key to get to the menu with the title Add a Journaled File System.
    c. Type `80000` for the field `SIZE of file system (in 512-byte blocks)`.
    d. Type `/compress512` for the field `MOUNT POINT`.
    e. Use the **Tab** key to toggle the field `Mount AUTOMATICALLY at system restart?` from `no` to `yes`.
    f. Use the **Tab** key to toggle the field `Fragment Size (bytes)` from `4096` to `512`, or use the **F4=List** key to select it.
    g. Use the **Tab** key to toggle the field `Compression algorithm` from `no` to `LZ`.
    h. Leave the other fields with their default values and press the **Enter=Do** key to create the /compress512 journaled file system.
    i. Press the key **F10=Exit** to return to the command prompt.
2. Create a 40MB *non-compressed* journaled file system with a fragment size of 2048 bytes mounted at /uncompress:
    a. Execute the fastpath `smitty crjfs`.
    b. With `availvg` highlighted, press the **Enter=Do** key to get to the menu with the title Add a Journaled File System.
    c. Type `80000` for the field `SIZE of file system (in 512-byte blocks)`.
    d. Type `/uncompress` for the field `MOUNT POINT`.
    e. Use the **Tab** key to toggle the field `Mount AUTOMATICALLY at system restart?` from `no` to `yes`.

f. Use the **Tab** key to toggle the field `Fragment Size (bytes)` from `4096` to `2048`, or use the **F4=List** key to select it.

g. Do *not* change the field `Compression algorithm`; leave it with the default setting of `no`.

h. Leave the other fields with their default values and press the **Enter=Do** key to create the /uncompress journaled file system.

i. Press the key **F10=Exit** to return to the command prompt.

***How to Check the Characteristics of the New JFS:*** We could use smit to check the characteristics of *each individual* journaled file system by using the fastpath `smitty chjfs` and selecting, for example, **/compress**. To view a summary for all the journaled file systems, we could also:

1. Execute `smitty fs` to get to the `File Systems` menu.
2. Select **List All File Systems** to execute the command `lsfs`.

However, the flag `-q` now also tells us about the new AIX Version 4 journaled file system attributes, so the best way to check our new journaled file systems is to execute:

```
# lsfs -q /compress* /uncomp* /frag512
Name            Nodename   Mount Pt               VFS   Size    Options    Auto Ac

/dev/lv05       --         /compress              jfs   81920   rw         yes  no
  (lv size: 81920, fs size: 81920, frag size: 2048, nbpi: 4096, compress: LZ)
/dev/lv07       --         /compress512           jfs   81920   rw         yes  no
  (lv size: 81920, fs size: 81920, frag size: 512, nbpi: 4096, compress: LZ)
/dev/lv06       --         /uncompress            jfs   81920   rw         yes  no
  (lv size: 81920, fs size: 81920, frag size: 2048, nbpi: 4096, compress: no)
/dev/lv01       --         /frag512               jfs   57344   rw         yes  no
  (lv size: 57344, fs size: 57344, frag size: 512, nbpi: 512, compress: no)
/dev/strlv32k   --         /strjfs32k             jfs   65536   rw         yes  no
  (lv size: 65536, fs size: 65536, frag size: 4096, nbpi: 4096, compress: no)
```

Note that the output may appear distorted if your screen is not 90 columns wide. We also included data for /frag512 and /strjfs32k since they will be used later in "How to Check the Disk Usage of a Compressed File System" on page 289.

***How to Mount the New JFS:*** To mount the newly created journaled file systems so that we can use them, rather than use smit, we suggest that it is easier to execute:

```
# mount /compress
# mount /uncompress
# mount /compress512
```

However, if you want to use smit, for example to access /compress:

1. Execute `smitty fs`.
2. Select **Mount a File System**.
3. Based on the previous output of the `lsfs -q` command, type `/dev/lv05` in the `FILE SYSTEM name` field, or use the **F4=List** key to select it.

4. Again based on the previous output of the `lsfs -q` command, type `/compress` in the `DIRECTORY over which to mount` field, or use the **F4=List** key to select it so that your screen looks like:

```
                              Mount a File System

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

                                                       [Entry Fields]
  FILE SYSTEM name                                  [/dev/lv05]            +
  DIRECTORY over which to mount                     [/compress]            +
  TYPE of file system                                                      +
  FORCE the mount?                                   no                    +
  REMOTE NODE containing the file system            []
    to mount
  Mount as a REMOVABLE file system?                  no                    +
  Mount as a READ-ONLY system?                       no                    +
  Disallow DEVICE access via this mount?             no                    +
  Disallow execution of SUID and sgid programs       no                    +
    in this file system?





F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

5. Press the **Enter=Do** to execute the `mount` command:

6. When smit returns an `OK` message, press the **F10=Exit** key to return to the command line.

***How to Check the Performance of a Compressed File System:*** We can obtain a simple indication of the performance degradation that we get when we use a compressed journaled file system by recording how long it takes to copy a 20MB file to each of the /compress, /compress512 and the /uncompress journaled file systems. Of course, the exact nature of your data files, their access rate, and other environmental conditions will give you quite different results from the sample values that this example provides. Note we do not use smit to execute these simple commands, so first let's summarize our test, and then discuss it afterwards.

Before we commence our test, we need to check that the underlying logical volume configuration will not result in any bias in the results. We can check the logical volumes by executing:

```
# lspv -p hdisk0
hdisk0:
PP RANGE  STATE   REGION        LV ID             TYPE       MOUNT POINT
  1-58    free    outer edge
 59-68    used    outer middle  lv05              jfs        /compress
 69-78    used    outer middle  lv06              jfs        /uncompress
 79-88    used    outer middle  lv07              jfs        /compress512
 89-115   free    outer middle
116-172   free    center
173-229   free    inner middle
230-287   free    inner edge
```

You can see that all 10 physical partitions of each logical volume are on the same disk region (note that the logical volume manager automatically used the empty hdisk0, after the migratepv in 8.8.1, “How to Use the migratepv Command” on page 315, to create the new logical volumes). Each copy operation will be done sequentially from the same source file, so that the main reason for the copy time differences is the attributes of each target journaled file system.

To test the copy times, execute:

```
# timex cp /strjfs16k/bigfile /compress

real 42.70
user 0.27
sys  5.77
# timex cp /strjfs16k/bigfile /uncompress

real 8.71
user 0.20
sys  5.94
# df -kI /compress /uncompress
Filesystem    1024-blocks      Used      Free %Used Mounted on
/dev/lv05           40960     11188     29772   27% /compress
/dev/lv06           40960     21020     19940   51% /uncompress
# timex cp /strjfs16k/bigfile /compress512

real 39.66
user 0.25
sys  4.31
# ls -lt /compress /uncompress /strjfs16k
/strjfs16k:
total 39328
-rw-r--r--   1 root     sys      20131943 Jul 21 14:51 bigfile
/uncompress:
total 39328
-rw-r--r--   1 root     sys      20131943 Jul 21 14:57 bigfile
/compress:
total 19664
-rw-r--r--   1 root     sys      20131943 Jul 21 14:53 bigfile
```

First, notice that although the `ls` output shows that each file is about 20MB big, the `df -kI` output gives you an idea of how compression can save disk space. This is looked into in more detail in the next section, “How to Check the Disk Usage of a Compressed File System.”

However, the `timex` results indicate the performance costs of the disk saving benefits when we used a compressed file system.  We can see that it took about 40 seconds to copy bigfile to our compressed file system that uses 512 byte fragments, then about 43 seconds to copy the same file to our compressed file system that uses 2048 byte fragments, but only nine seconds to a *non-compressed* file system that also uses 2048 byte fragments. Our copy time has increased by about 370% (100 x 34/9), because bigfile was being compressed in /compress by the journaled file system code while the `cp` command was actually writing the bigfile file. Finally, notice that there was not much difference in our example between our copy to a fragment size of 2048, 43 seconds, compared to when the fragment size was decreased to 512 bytes, which only saved three seconds.

***How to Check the Disk Usage of a Compressed File System:*** To check how much disk space is available initially in the empty journaled file systems, execute:

```
# df -kI /compress /uncompress /compress512
Filesystem    1024-blocks      Used      Free %Used Mounted on
/dev/lv05           40960      1332     39628    3% /compress
/dev/lv06           40960      1332     39628    3% /uncompress
/dev/lv07           40960      1344     39616    3% /compress512
```

Note that the journaled file system with the smaller fragment (512 versus 2048), has more space initially allocated for the journaled file system organizational data (in other words, areas like the journaled file system maps).

If you refer to 8.5.2, “How to Use Fragments for Disk Usage Efficiency” on page 276, you will see that we can use the ksh shell scripts `mkfile` and `fragcopy` to create files with a size that is a multiple of 512 byte blocks. In this example, we use the file 2560bytefile that consists of five 512 byte blocks. We can then use the `du` command to see many disk blocks are really used.

If we copy the files using the `cp` commands given in the command summary, then the following `ls` command confirms that we have five files that appear to occupy the same amount of disk space.

```
# ls -l /strjfs32k/fragdata/2560bytefile /frag512/2560bytefile
-rw-r--r--   1 root     sys    2560 Jul 21 16:53 /strjfs32k/fragdata/2560bytefile
-rw-r--r--   1 root     sys    2560 Jul 21 17:09 /frag512/2560bytefile
# ls -l /compress512/2560bytefile /compress/2560bytefile
-rw-r--r--   1 root     sys    2560 Jul 21 16:56 /compress512/2560bytefile
-rw-r--r--   1 root     sys    2560 Jul 21 16:57 /compress/2560bytefile
# ls -l /uncompress/2560bytefile
-rw-r--r--   1 root     sys    2560 Jul 21 16:57 /uncompress/2560bytefile
```

However, the following `du` command output reports the true number of 512 byte disk blocks that are actually used by each file:

```
# du /strjfs32k/fragdata/2560bytefile
8       /strjfs32k/fragdata/2560bytefile
# du /frag512/2560bytefile
5       /frag512/2560bytefile
# du /compress512/2560bytefile
1       /compress512/2560bytefile
# du /compress/2560bytefile
4       /compress/2560bytefile
# du /uncompress/2560bytefile
8       /uncompress/2560bytefile
```

To correctly interpret this data, we need to recall the journaled file system attributes documented in “How to Check the Characteristics of the New JFS” on page 287.

As expected the source file /strjfs32k/fragdata/2560bytefile requires 8 x 512 = 4096 bytes because /strjfs32k was created with default journaled file system attributes, so it has to use at least one complete 4K fragment to store 2560 bytes. Now the file /uncompress/2560bytefile also uses 4096 bytes, but in this case, it used two 2048 byte fragments. The first fragment is completely full, but the second fragment contains 3 x 512 = 1536 of wasted space that can't be used by any other file.

If we now use compression, our disk space requirements are halved, since we now only require 4 x 512 = 2048 bytes to store the /compress/2560bytefile file. However, this is still using a full fragment or less in /compress which has a fragment size of 2048 bytes. So when we check the space used by /compress512/2560bytefile, we can see that the LZ compression algorithm has actually shrunk the file to 20% (512 / 2560) or less of its original size. This is not too surprising since we know that the shell script `mkfile` (as given in 8.5.2, “How to Use Fragments for Disk Usage Efficiency” on page 276) just creates a file that has the word yes repeated on each line many times. Such a repetitive file is likely to be much easier to compress than your real data files.

Finally, we can see that if performance is not critical, it is wise to combine compression with a low fragment size when you create a journaled file system. The `du` output for the file /frag512/2560bytefile shows us that for journaled file systems with a 512 byte fragment size, we require, as expected, five fragments to store 2560 bytes. However this is reduced to only one fragment when the journaled file system is also configured at creation to use compression as well as a 512 byte fragment size.

### 8.5.4 How to Create and Use a JFS Greater than 2GB

This section shows you how to expand an existing journaled file system to a size greater than 2GB, which is the maximum journaled file system size in AIX Version 3. Again, as in the section 8.5.3, “How to Use JFS Compression and Check its Consequences” on page 282, we will use the availvg volume group, because it has the most available disk space. We will be increasing the availlv to a new total size of 3GB after removing its mirror copy so that we have enough disk space.

#### 8.5.4.1 Command Summary

First of all we reduce the number of copies of `availlv` to `1`:

```
# rmlvcopy 'availlv' '1'
```

Next we increase the size of the logical volume to `900` logical partitions which equates to 3600MB:

```
# chlv -x'900' 'availlv'
```

Finally, we increase the size of the JFS `availjfs` to `6000000` 512 byte blocks which equates to 3GB:

```
# chfs -a size='6000000' '/availjfs'
```

### 8.5.4.2 Detailed Guidance

***How to Remove a Logical Volume Copy:*** As can be seen from the following:

```
# lsvg availvg
VOLUME GROUP:   availvg                  VG IDENTIFIER:  000004461ed9e52e
VG STATE:       active                   PP SIZE:        4 megabyte(s)
VG PERMISSION:  read/write               TOTAL PPs:      861 (3444 megabytes)
MAX LVs:        256                      FREE PPs:       817 (3268 megabytes)
LVs:            5                        USED PPs:       44 (176 megabytes)
OPEN LVs:       5                        QUORUM:         1
TOTAL PVs:      3                        VG DESCRIPTORS: 3
STALE PVs:      0                        STALE PPs       0
ACTIVE PVs:     3                        AUTO ON:        yes
# lsvg -l availvg
availvg:
LV NAME             TYPE       LPs   PPs   PVs  LV STATE      MOUNT POINT
availlv             jfs        6     12    2    open/syncd    /availjfs
loglv00             jfslog     1     2     2    open/syncd    N/A
lv05                jfs        10    10    1    open/syncd    /compress
lv06                jfs        10    10    1    open/syncd    /uncompress
lv07                jfs        10    10    1    open/syncd    /compress512
#
```

`availlv` currently has two mirror copies. However, the `availvg` volume group is not big enough to hold two mirror copies of the `availlv` logical volume when it is expanded to 3MB. This would require 6MB in `availvg`. We currently only have 3268MB available, as indicated by the `FREE PPs:` field in the second column of the output of the `lsvg availvg` command.

Hence we can remove one of the mirror copies if we:

1. Execute the fastpath `smitty rmlvcopy` to get to the screen with the title Remove Copies from a Logical Volume, or, to go through the smit hierarchy:
   a. Execute `smitty`.
   b. Select **System Storage Management (Physical & Logical Storage)**.
   c. Select **Logical Volume Manager**.
   d. Select **Logical Volumes**.
   e. Select **Set Characteristic of a Logical Volume**.
   f. Select **Remove Copies from a Logical Volume**.
2. Type `availlv` in the `LOGICAL VOLUME name` field and press the **Enter=Do** key, or use the **F4=List** key to select it.
3. Use the **Tab** key to toggle the contents of the field `NEW maximum number of logical partition copies` from `2` to `1` so that the screen looks like:

```
                    Remove Copies from a Logical Volume

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

                                                      [Entry Fields]
* LOGICAL VOLUME name                                availlv
* NEW maximum number of logical partition            1                    +
    copies
  PHYSICAL VOLUME name(s) to remove copies from     []                    +











F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

Since one copy of availlv currently exists on each of two identical disks (so that we are protected from disk failure), then we can ignore the third field. However, if one disk is not as fast or reliable as the other, then we may decide to remove the copy of availlv that it contains.

4. Press the **Enter=Do** key to remove a copy of availlv.
5. When smit returns an `OK` prompt, press the **F10=Exit** key to return to the command prompt.

***How to Change a Logical Volume Copy:*** Now availlv only exists as a single copy logical volume, and there is sufficient space available in availvg to expand it to 3GB. However, by default, when a logical volume is created, it is limited to a maximum of 128 physical partitions. Since the availvg volume group uses a physical partition size of 4MB, availlv can only grow to 4 x 128 = 512MB. This also means that the /availjfs that uses this logical volume also can not get bigger than 512MB.

Fortunately, you can change the maximum number of logical partitions in a logical volume if you:

1. Execute the fast path `smitty chlv1` to get to the menu with the title Change a Logical Volume, or, to go through the smit hierarchy:
   a. Execute `smitty`.
   b. Select **System Storage Management (Physical & Logical Storage)**.
   c. Select **Logical Volume Manager**.
   d. Select **Logical Volumes**.
   e. Select **Set Characteristic of a Logical Volume**.
   f. Select **Change a Logical Volume**.
2. Type `availlv` in the `LOGICAL VOLUME name` field and press the **Enter=Do** key, or use the **F4=List** key to select it.

3. Type `900` in the `MAXIMUM NUMBER of LOGICAL PARTITIONS` field.

   This enables us to increase the size of /availjfs journaled file system that uses the availlv logical volume, up to 4 x 900 = 3600MB. Hence we still allow for a growth of 600MB beyond our initial 3GB objective so that we can increase /availjfs without having to first change the `MAXIMUM NUMBER of LOGICAL PARTITIONS` (unless, of course we wanted to increase /availjfs by another 1GB).

4. We are not currently concerned about the other fields so we'll leave them with default values so that the screen should look like:

```
                            Change a Logical Volume

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

[TOP]                                                   [Entry Fields]
* Logical volume NAME                                 availlv
  Logical volume TYPE                                [jfs]
  POSITION on physical volume                         outer_middle          +
  RANGE of physical volumes                           maximum               +
  MAXIMUM NUMBER of PHYSICAL VOLUMES                 [32]                    #
    to use for allocation
  Allocate each logical partition copy                yes                   +
    on a SEPARATE physical volume?
  RELOCATE the logical volume during reorganization?  yes                   +
  Logical volume LABEL                               [/availjfs]
  MAXIMUM NUMBER of LOGICAL PARTITIONS               [900]
  SCHEDULING POLICY for writing logical               parallel              +
    partition copies
  PERMISSIONS                                         read/write            +

[MORE...3]

F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

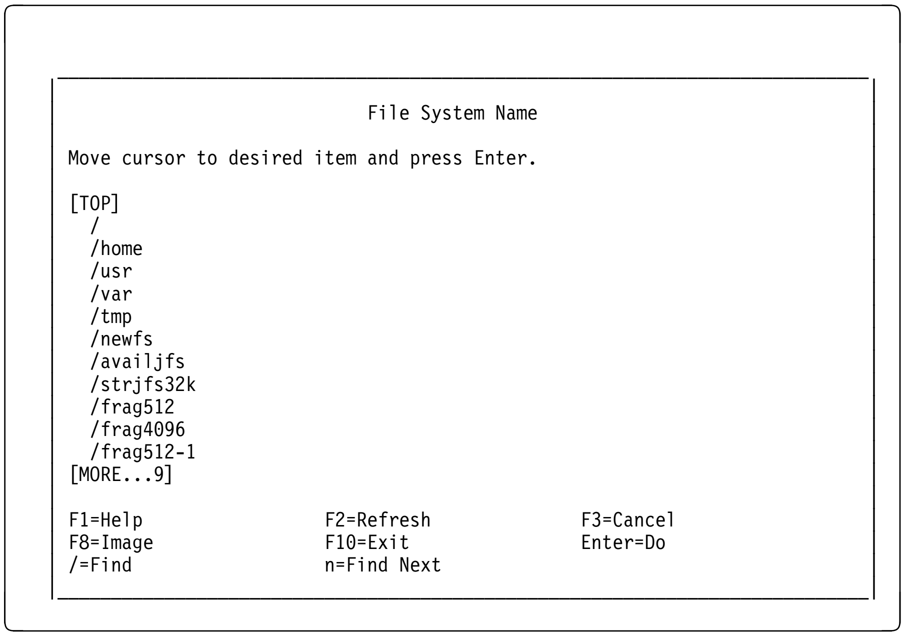
5. Press the **Enter=Do** to change this logical volume.

6. When smit returns with an `OK` prompt, press the **F10=Exit** to return to the command line.

***How to Increase the Size of a JFS:*** Now that we have ensured that the availlv logical volume can accommodate a 3GB journaled file system, we can increase the /availjfs journaled file system.

To increase /availjfs so that it is a total of 3GB:

1. Execute the fast path `smitty chjfs` to get to a screen like:



```
                            File System Name

Move cursor to desired item and press Enter.

[TOP]
  /
  /home
  /usr
  /var
  /tmp
  /newfs
  /availjfs
  /strjfs32k
  /frag512
  /frag4096
  /frag512-1
[MORE...9]

F1=Help                 F2=Refresh              F3=Cancel
F8=Image                F10=Exit                Enter=Do
/=Find                  n=Find Next
```

Or, to go through the smit hierarchy to get to the above selection screen:

a. Execute `smitty`.

b. Select **System Storage Management (Physical & Logical Storage)**.

c. Select **File Systems**.

d. Select **Add / Change / Show / Delete File Systems**.

e. Select **Journaled File Systems**.

f. Select **Change / Show Characteristics of a Journaled File System**.

2. Use the **Down Arrow** to move the cursor so that the journaled file system `/availjfs` is highlighted.

3. Press the **Enter=Do** key.

4. Type `6000000` in the `SIZE of file system (in 512-byte blocks)` field, since 6000000 x 512 = 3000000000, or more simply, 3GB.

   Since this is the only field we need to change, the screen should like:

```
            Change/Show Characteristics of a Journaled File System


Type or select values in entry fields.
Press Enter AFTER making all desired changes.

                                                         [Entry Fields]
  File system name                                      /availjfs
  NEW mount point                                      [/availjfs]
  SIZE of file system (in 512-byte blocks)             [6000000]
  Mount GROUP                                          []
  Mount AUTOMATICALLY at system restart?                yes                  +
  PERMISSIONS                                           read/write           +
  Mount OPTIONS                                        []                    +
  Start Disk Accounting?                                no                   +
  Fragment Size (bytes)                                 4096
  Number of bytes per inode                             4096
  Compression algorithm                                 no




F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

5. Press the **Enter=Do** key to change the journaled file system.
6. When the command is complete, your screen should look like:

```
                                COMMAND STATUS

Command: OK            stdout: yes           stderr: no

Before command completion, additional instructions may appear below.

File System size changed to 6004736














F1=Help             F2=Refresh          F3=Cancel           F6=Command
F8=Image            F9=Shell            F10=Exit            /=Find
n=Find Next
```

7. Press the **F10=Exit** key to return to the command prompt.

***How to Check the Attributes of a JFS greater than 2GB:*** Now that we have increased /availjfs to a total size of 3GB, we have also forced the availlv logical volume that the /availjfs journaled file system uses to increase to 3GB. We can check how availvg and availlv have changed by executing the following commands:

```
# lsvg availvg
VOLUME GROUP:   availvg                 VG IDENTIFIER:  000004461ed9e52e
VG STATE:       active                  PP SIZE:        4 megabyte(s)
VG PERMISSION:  read/write              TOTAL PPs:      861 (3444 megabytes)
MAX LVs:        256                     FREE PPs:       96 (384 megabytes)
LVs:            5                       USED PPs:       765 (3060 megabytes)
OPEN LVs:       5                       QUORUM:         1
TOTAL PVs:      3                       VG DESCRIPTORS: 3
STALE PVs:      0                       STALE PPs       0
ACTIVE PVs:     3                       AUTO ON:        yes
# lsvg -l availvg
availvg:
LV NAME             TYPE       LPs   PPs   PVs  LV STATE      MOUNT POINT
availlv             jfs        733   733   3    open/syncd    /availjfs
loglv00             jfslog     1     2     2    open/syncd    N/A
lv05                jfs        10    10    1    open/syncd    /compress
lv06                jfs        10    10    1    open/syncd    /uncompress
lv07                jfs        10    10    1    open/syncd    /compress51
#
```

We can clearly see that the `availvg` volume group now uses 3060MB, with only 384MB that can currently be allocated, from the existing physical volumes in this volume group, to new or existing logical volumes in this volume group. Also, we note that the `availlv` logical volume now uses 733 4MB physical partitions, which is approximately 4 x 733 = 2932MB (remember that 1MB may be 1048576 bytes or 1000000 bytes, depending upon the context in which it is used, so rounding errors can become significant).

To verify that we can actually use all of this space, we again used the `fragcopy` script from 8.5.2, "How to Use Fragments for Disk Usage Efficiency" on page 276, to copy a 21MB file many times.

```
# ls -l /availjfs/cmds.rom.dd
-rw-r--r--   1 root     sys      21805056 Jul  8 12:23 /availjfs/cmds.rom
# ksh fragcopy 140 /availjfs/cmds.rom.dd /availjfs/cmds.rom.dd &
# ls -l /availjfs
total 72608
-rw-r--r--   1 root     sys      21805056 Jul  8 12:23 cmds.rom.dd
-rw-r--r--   1 root     sys      15368192 Jul 21 18:50 cmds.rom.dd.0
cp: /availjfs/cmds.rom.dd.135: No space left on device
# df -kI /availjfs
Filesystem    1024-blocks      Used      Free %Used Mounted on
/dev/availlv      3002368   3002368         0  100% /availjfs
#
# ls /availjfs |wc -l
     137
# ls -lt /availjfs|more
total 5808264
-rw-r--r--   1 root     sys      8065024 Jul 21 19:40 cmds.rom.dd.135
-rw-r--r--   1 root     sys      21805056 Jul 21 19:40 cmds.rom.dd.134
-rw-r--r--   1 root     sys      21805056 Jul 21 19:39 cmds.rom.dd.133
```

From the results of the `ls` commands, we can see that there was enough room for 134 + 1 = 135 complete new copies of the original 21MB file before we filled the /availjfs journaled file system. The full journaled file system is indicated by both the `cp` command error, and the output of the `df -kI` command.

This example shows that AIX Version 4 allows us to successfully use journaled file systems that have a capacity greater than the AIX Version 3 limit of 2GB. Although we will not go into the details here, you can also specify a size greater than 2GB when you initially create the logical volume and its associated journaled file system.

## 8.6 Migrating to AIX Version 4

This section discusses and shows how the logical volume manager and journaled file system configuration of an existing AIX Version 3 system can be maintained when it is upgraded to AIX Version 4 by a migration installation.

The actual migration installation is discussed in depth in the AIX Version 4.1 Installation Guide, which is the essential companion to this section.

#### 8.6.1.1 Command Line Summary

Ensure that you have documented your storage organization prior to migration so that you can confirm the process occurs successfully. Remember to take adequate backups (as described in 8.4, “Managing Backup and Restore” on page 247), before *any* reorganization.

Use the following command for each physical volume to establish partition allocation:

```
# lspv -M hdiskx > map.hdiskx
```

This will store the output for `hdiskx` in the file `map.hdiskx`. Use the following commands for volume groups to record the configuration:

```
# lsvg volume_group > lsvg-volume_group
# lsvg -l volume_group > lsvg-l-volume_group
```

This will store information regarding volume group organization and the logical volumes contained within them. Lastly record information about the file systems:

```
# df > df.fs
# cat /etc/filesystems > fs
```

This will save information regarding the file systems and their configuration.

Given that all other planning and organizational tasks have been performed (see *AIX Version 4.1 Installation Guide*), we can now restart our system with the AIX Version 4 installation media loaded and the key in the `service` position. Selecting the migration option from the `Installation and Settings` menu will cause a migration to AIX Version 4 to occur. See the detailed guidance section in this chapter for more information.

Lastly, once the migration has successfully taken place, we can confirm that our storage organization is as we expected it to be. Essentially, we can perform the same documentation tasks that we instituted at the start of this process, and then compare the results.

### 8.6.1.2 Detailed Guidance

Our migration test uses a graphical console display and CD-ROM AIX Version 4 installation media. As well as the important prerequisite of having a good backup of whatever operating system and data is on the target disks, it is also highly advisable to have the current configuration documented. For this example, documenting the AIX V3.2.5 logical volume manager and journaled file system configuration also shows how this is preserved during the migration to AIX Version 4.

***How to Document AIX Version 3.2.5 before a Migration***

1. Logical volume manager configuration

   Our example system has three physical volumes organized in two volume groups that are rootvg and 325vg. The exact disk partition map can be saved to a separate map file for each disk by executing the following familiar sequence of commands:

```
# lspv -M hdisk0 > map.hdisk0
# lspv -M hdisk1 > map.hdisk1
# lspv -M hdisk2 > map.hdisk2
```

   Your file format should be similar to the following example for hdisk2:

```
hdisk2:1-17
hdisk2:18       loglv00:1
hdisk2:19       lv00:1
hdisk2:20       lv00:2
hdisk2:21       lv00:3
hdisk2:22       lv00:4
hdisk2:23       lv00:5
hdisk2:24       lv00:6
hdisk2:25       lv00:7
hdisk2:26       lv00:8
hdisk2:27       lv00:9
hdisk2:28       lv00:10
hdisk2:29-84
```

   To summarize the logical volume manager information, we can use many of the commands discussed in Chapter 7, “Storage Management Files and Commands Summary” on page 137. In our example, we use the following sequence of `lsvg` commands:

```
# lsvg rootvg > lsvg-rootvg
# lsvg -l rootvg > lsvg-l-rootvg
# lsvg 325vg > lsvg-325vg
# lsvg -l 325vg > lsvg-l-325vg
```

   We can check the contents of these configuration files by executing the following sequence of `cat` commands:

```
# cat lsvg-rootvg
VOLUME GROUP:   rootvg                  VG IDENTIFIER:  000005083df45081
VG STATE:       active                  PP SIZE:        4 megabyte(s)
VG PERMISSION:  read/write              TOTAL PPs:      243 (972 megabytes)
MAX LVs:        256                     FREE PPs:       8 (32 megabytes)
LVs:            16                      USED PPs:       235 (940 megabytes)
OPEN LVs:       12                      QUORUM:         2
TOTAL PVs:      2                       VG DESCRIPTORS: 3
STALE PVs:      0                       STALE PPs       0
ACTIVE PVs:     2                       AUTO ON:        yes
#
# cat lsvg-l-rootvg
rootvg:
LV NAME             TYPE       LPs   PPs   PVs  LV STATE      MOUNT POINT
hd6                 paging     10    10    1    open/syncd    N/A
hd61                paging     10    10    1    open/syncd    N/A
hd5                 boot       2     2     1    closed/syncd  /blv
hd7                 sysdump    2     2     1    open/syncd    /mnt
hd8                 jfslog     1     1     1    open/syncd    N/A
hd4                 jfs        2     2     1    open/syncd    /
hd2                 jfs        76    76    2    open/syncd    /usr
hd1                 jfs        1     1     1    open/syncd    /home
hd3                 jfs        82    82    2    open/syncd    /tmp
hd9var              jfs        31    31    1    open/syncd    /var
hdag1               lfs        2     2     1    closed/syncd  N/A
dumpfiles           jfs        5     5     1    open/syncd    /var/adm/ras
agroot              lfs        1     1     1    closed/syncd  N/A
tmpvar              jfs        1     1     1    closed/syncd  N/A
varrpc              jfs        5     5     1    open/syncd    /var/dce/rpc/socket
xmconsole           jfs        4     4     1    open/syncd    /tmp/xm
#
# cat lsvg-325vg
VOLUME GROUP:   325vg                   VG IDENTIFIER:  00011605f67f40e9
VG STATE:       active                  PP SIZE:        4 megabyte(s)
VG PERMISSION:  read/write              TOTAL PPs:      84 (336 megabytes)
MAX LVs:        256                     FREE PPs:       73 (292 megabytes)
LVs:            2                       USED PPs:       11 (44 megabytes)
OPEN LVs:       2                       QUORUM:         2
TOTAL PVs:      1                       VG DESCRIPTORS: 2
STALE PVs:      0                       STALE PPs       0
ACTIVE PVs:     1                       AUTO ON:        yes
#
# cat lsvg-l-325vg
325vg:
LV NAME             TYPE       LPs   PPs   PVs  LV STATE      MOUNT POINT
loglv00             jfslog     1     1     1    open/syncd    N/A
lv00                jfs        10    10    1    open/syncd    /325jfs
```

The above information shows us that rootvg has two physical volumes in it and that it contains some logical volumes for an application (DCE). We can also see that there is one data logical volume in the 325vg that contains one physical volume.

2. JFS configuration

   This is easier to record; in this example, we saved a copy of the file /etc/filesystems, and we then saved the output of the `df` command to a file named `df.I`. We can check its output by executing:

```
# cat df.I
Filesystem     Total KB    used    free %used Mounted on
/dev/hd4           8192    6520    1672   79% /
/dev/hd9var      126976   13144  113832   10% /var
/dev/hd2         311296  299168   12128   96% /usr
/dev/hd3         335872   76472  259400   22% /tmp
/dev/hd1           4096     496    3600   12% /home
/dev/dumpfiles    20480   11120    9360   54% /var/adm/ras
/dev/varrpc       20480     928   19552    4% /var/dce/rpc/socket
/dev/xmconsole    16384     544   15840    3% /tmp/xm
/dev/lv00         40960    1380   39580    3% /325jfs
```

***Installing AIX Version 4:*** Now that we have completed the documentation *and* all the prerequisites documented in *AIX Version 4.1 Installation Guide* in the chapter called *Installing BOS from CD-ROM or Tape*, we can continue the process described in the *Start the System* section in the same chapter.

After we select English as an Installation language, and press the **Enter** key, we arrive at the Welcome to Base Operating System Installation and Maintenance menu. The simplest choice is to now select **>>> 1 Installation and Settings** so that we can *check and change* the installation options. In our example, the defaults in the following screen were suitable.

```
                                Installation and Settings

Either type 0 and press Enter to install with current settings, or type the
number of the setting you want to change and press Enter.

    1  System Settings:
         Method of Installation.............Migration
         Disk Where You Want to Install.....hdisk0...

    2  Primary Language Environment Settings (AFTER Install):
         Cultural Convention................English (United States)
         Language ..........................English (United States)
         Keyboard ..........................English (United States)


    3  Install Trusted Computing Base.......No

>>> 0  Install AIX with the current settings listed above.

                       +-----------------------------------------------------
    88  Help ?         |    WARNING: Base Operating System Installation will
    99  Previous Menu  |    destroy or impair recovery of SOME data on the
                       |    destination disk hdisk0.
>>> Choice [0]:
```

However, if you need to change any of the above values, please refer to the references given in *Verify the Default Installation and System Settings* in the chapter *Installing BOS from CD-ROM or Tape* in *AIX Version 4.1 Installation Guide*. In particular, we found in *AIX Version 4.1 Installation Guide*. In particular, we found that as we checked the physical volume allocation by following the procedure in *Change the Destination Disk* in the same chapter, the AIX Version 4 installation process correctly recognized which physical volumes belong to the rootvg, and which belong to other volume groups, based on their unique SCSI addresses. We can now complete the migration installation of AIX Version 4 by following the procedure in the section *Install from CD-ROM or Tape* in the same chapter.

***How to Check the Configuration after Migration:*** When the system reboots after AIX Version 4 is installed, there may be many systems management tasks for the systems administrator to complete. In our example, we want to quickly check our storage configuration details. We can again generate a set of configuration files as we did before the migration by executing the following set of similar commands:

```
# lspv -M hdisk0 > map.hdisk0.41
# lspv -M hdisk1 > map.hdisk1.41
# lspv -M hdisk2 > map.hdisk2.41
# lsvg rootvg > lsvg-rootvg.41
# lsvg -l rootvg > lsvg-l-rootvg.41
# lsvg 325vg > lsvg-325vg.41
# lsvg -l 325vg > lsvg-l-325vg.41
# df -Ik > df.Ik.41
```

We can quickly use the `diff` command on the map files to verify that our partition map has been maintained. Although `diff` for the hdisk0 and hdisk2 files gives no output , as expected `diff` for hdisk1 results in the following:

```
# diff map.hdisk1 map.hdisk1.41
11c11,14
< hdisk1:11-17
---
> hdisk1:11     hd2:77
> hdisk1:12     hd2:78
> hdisk1:13     hd2:79
> hdisk1:14-17
```

This shows that /usr journaled file system on the hd2 logical volume has grown by three physical partitions during the migration installation. The increase in the rootvg volume group is also verified by the change in the `lsvg rootvg` output as follows:

```
# diff lsvg-rootvg lsvg-rootvg.41
4,6c4,6
< MAX LVs:       256                       FREE PPs:      8 (32 megabytes)
< LVs:           16                        USED PPs:      235 (940 megabytes)
< OPEN LVs:      12                        QUORUM:        2
---
> MAX LVs:       256                       FREE PPs:      5 (20 megabytes)
> LVs:           16                        USED PPs:      238 (952 megabytes)
> OPEN LVs:      11                        QUORUM:        2
```

You can see how the `diff` command used on configuration files can quickly help us isolate any configuration changes, especially when the output files are large. However, you need to carefully check its output because the differences may be irrelevant. For example, the command `diff lsvg-l-325vg lsvg-l-325vg.41` suggests that the entire 325vg logical volume configuration has changed. Close inspection reveals that in our example, the only change is that the position of the output columns, starting with PVs, has been moved.

Finally, we need to check the configuration of the journaled file system in AIX Version 4. Although the command `diff filesystems filesystems.41` has no output and so none of the journaled file system attributes recorded in it have changed, we should check the space utilization of the journaled file systems by executing the command

```
# df -kI
Filesystem    1024-blocks      Used      Free %Used Mounted on
/dev/hd4             8192      6904      1288   84% /
/dev/hd2           323584    315948      7636   97% /usr
/dev/hd9var        126976     12404    114572    9% /var
/dev/hd3           335872     15656    320216    4% /tmp
/dev/hd1             4096       496      3600   12% /home
/dev/dumpfiles      20480     11128      9352   54% /var/adm/ras
/dev/varrpc         20480       928     19552    4% /var/dce/rpc/socket
/dev/lv00           40960      1384     39576    3% /325jfs
```

This verifies that only the /usr journaled file system has had more space allocated to it and used, but the output also shows that other journaled file systems have changes in the number of `1024-blocks` used due to a variety of factors that may include:

- A change in the number of LPPs installed, and/or their individual disk space requirements.
- The size of the log files in / and /var. Note in particular the new AIX Version 4 logs in /var/adm/ras which include:
  - devinst.log
  - bosinstlog
  - BosMenus.log
  - bootlog
- The storage of some configuration information for the original AIX V3.2.5 in /tmp/bos (this required about 5MB in our example).
- Any user changes; we deleted a large file from /tmp to create enough free space for the AIX V3.2.5 configuration data.

Note that just like the `lsvg -l` command, the output format has changed so we do not benefit from the `diff` command. In AIX Version 4, the default block size used by `df` is 512 bytes, so we need to use the `-k` flag to report the output using 1024 bytes which is the default value for AIX Version 3.

***Overall Effects of Migration:*** Our example shows that there are no major storage management compatibility issues involved during a migration from AIX V3.2.5 to AIX Version 4. However, of course we cannot use any new AIX Version 4 features, such as journaled file system compression, on an existing journaled file system that was migrated from AIX Version 3 *unless* we recreate it and restore its data. As well as this, we *must* also be aware of any other migration issues, such as those discussed in *AIX Version 4.1 Installation Guide*, in particular in the section *Compatibility Between AIX Version 3.2 and AIX Version 4.1*.

## 8.7 Manipulating Page Space

This section shows you how to implement the most common maintenance tasks for your paging logical volumes. The examples manipulate the `hd6` logical volume in AIX Version 4 that contains two mirror copies. However, you can easily apply the procedures described here for other paging devices, where, depending on their attributes, you may *not* need to:

- Modify any boot files.
- Repeat commands such as `bosboot`, which is only necessary in this example because we deal with a mirrored rootvg.

For this section, it is very beneficial for the reader to become familiar with the concepts discussed in:

- 3.1.1, "Page Space" on page 45.
- Chapter 5, "Storage Subsystem Design" on page 77.
- Chapter 6, "General AIX Storage Management" on page 93.
- *AIX Version 4.1 System Management Guide: Operating System and Devices*, which may be in *AIX Version 4.1 Hypertext Information Base Library* on your system.

  In particular, refer to the chapter that discusses paging space and virtual memory. Note that the following articles in this chapter are used as a reference for the examples in this section:

  – *Adding and Activating a Paging Space*.
  – *Resizing or Moving the hd6 Paging Space*.
  – *Changing or Removing a Paging Space*.

**Warning - Reboots required**

It is important to note that paging devices can *not* be deactivated, so any maintenance task that requires this, such as the removal of a paging logical volume, will have to be done at an appropriate time to minimize user disruption. This is probably a helpful limitation, since it reminds us that any system maintenance task must be carefully scheduled to help you cope in case there are any disasters, foreseen or unforeseen, during your maintenance work.

## 8.7.1 How to Decrease the Default hd6 Paging Logical Volume

This next section looks at reducing the size of the hd6 default paging space logical volume.

### 8.7.1.1 Command Line Summary

This example demonstrates the tasks required to reduce the size of a paging space. In particular, it provides the extra steps required in the more complex scenario where we want to decrease the default rootvg paging logical volume, hd6, when it is part of a mirrored rootvg. First, let's look at the paging spaces that we have:

```
# lsps -a
Page Space  Physical Volume   Volume Group    Size   %Used  Active  Auto  Type
perfpg      hdisk1            perfvg          20MB       0      no   yes    lv
perfpg      hdisk8            perfvg          20MB       0      no   yes    lv
hd6         hdisk5            rootvg          32MB      22     yes   yes    lv
hd6         hdisk7            rootvg          32MB      22     yes   yes    lv
```

This shows us the size of the paging space that we are interested in, as well as the current paging space usage. Next let's see how much memory we have:

```
# lsattr -E -l sys0 -a realmem
realmem 49152 Amount of usable physical memory in Kbytes False
```

This gives us a basis for calculating how big page space needs to be, more information being presented in the detailed guidance section. Before we alter this though, we must create another temporary page space as it would be a bad idea to be without it:

```
# mkps -a -n -s 20 rootvg
paging00
```

This makes a new paging space of size 80MB. Next we make `hd6` inactive, and cause `paging00` to be used at the next reboot:

```
# chps -a n hd6
#
edit the one entry in /sbin/rc.boot... search via /swapon to find line near
  # Start paging if no dump
  [ ! -f /needcopydump ] && swapon /dev/paging00
# bosboot -l /dev/hd5x -d /dev/hdisk7 -a
# bosboot: Boot image is 4275 512 byte blocks.
# bosboot -l /dev/hd5 -d /dev/hdisk5 -a
# bosboot: Boot image is 4275 512 byte blocks.
```

We also recreate the boot images to reflect the change and then reboot. Now we can remove and recreate the hd6 page space to be the size that we wish. First ensure that the dump device is not hd6:

```
# sysdumpdev -pP /dev/sysdumpnull
# sysdumpdev -l
primary             /dev/sysdumpnull
secondary           /dev/sysdumpnull
copy directory      /tmp
forced copy flag    TRUE
```

Then remove `hd6`, recreate the two mirror copies with the new required size, then activate it:

```
# rmps hd6
# mklv -y'hd6' -e'x' -c'2' -v'y' 'rootvg' '7'
# swapon /dev/hd6
```

The rc.boot file must now be edited again to reflect the new page space, and the boot images again updated:

```
edit the one entry in /sbin/rc.boot... search via /swapon to find line near
  # Start paging if no dump
  [ ! -f /needcopydump ] && swapon /dev/hd6
# bosboot -l /dev/hd5x -d /dev/hdisk7 -a
# bosboot: Boot image is 4275 512 byte blocks.
# bosboot -l /dev/hd5 -d /dev/hdisk5 -a
# bosboot: Boot image is 4275 512 byte blocks.
```

Now reboot the system and then update the bootlist:

```
# shutdown -Fr
# bootlist -m normal hdisk5 hdisk7
```

Finally, remove the temporary page space:

```
# chps -a n paging00
# rmps paging00
```

Don't forget to change the system dump device back if required.

#### 8.7.1.2 Detailed Guidance

This task has a number of component steps that also serve to illustrate general paging space management tasks. Thus, although this entire section is based on the one procedure given in the *AIX Version 4.1 System Management Guide: Operating System and Devices* article *Resizing or Moving the hd6 Paging Space*, we do this procedure in the following subsections.

***How to Check Prerequisites before Changing hd6:*** The first task is that you need to properly understand your system's performance so that you not remove too much capacity from your paging logical volumes. In this example, we can execute the following commands to give us a current snapshot:

```
# lsps -a
Page Space  Physical Volume   Volume Group    Size   %Used  Active  Auto  Type
perfpg      hdisk1            perfvg          20MB       0      no   yes    lv
perfpg      hdisk8            perfvg          20MB       0      no   yes    lv
hd6         hdisk5            rootvg          32MB      22     yes   yes    lv
hd6         hdisk7            rootvg          32MB      22     yes   yes    lv
#
# lsattr -E -l sys0 -a realmem
realmem 49152 Amount of usable physical memory in Kbytes False
#
```

You can see that we are currently using only about 7MB of our paging space, even though we have 49MB of RAM.

**Warning - Understand performance**

It is very important to be familiar with the issues discussed in the *AIX V3.2 Performance Monitoring and Tuning Guide* (which may be available in the *AIX Version 4.1 Hypertext Information Base Library* on your system) before you decide exactly how much paging space you need.

This decision depends on many factors, such as application needs and the number of users.

In this example, we want to maintain the amount of paging space suggested by the following rule of thumb:

> Use a 1:1 ratio of total paging space to system RAM.

This means that we only want to decrease hd6 by 4MB so that we will still have a total of 48MB of paging space.

As is described in 6.2, "Managing Physical Volumes" on page 93, there are many ways to check the physical partition layout and usage in a volume group. To check rootvg, we can execute:

```
# lspv -l hdisk5
hdisk5:
LV NAME               LPs   PPs   DISTRIBUTION          MOUNT POINT
hd5                   1     1     01..00..00..00..00    N/A
hd6                   8     8     00..08..00..00..00    N/A
hd8                   1     1     00..00..01..00..00    N/A
hd4                   1     1     00..00..01..00..00    /
hd2                   50    50    00..00..29..21..00    /usr
hd9var                3     3     00..00..00..03..00    /var
hd3                   3     3     00..00..00..03..00    /tmp
hd1                   1     1     00..00..00..01..00    /home
# lspv -l hdisk7
hdisk7:
LV NAME               LPs   PPs   DISTRIBUTION          MOUNT POINT
hd2                   50    50    02..00..14..17..17    /usr
hd9var                3     3     03..00..00..00..00    /var
hd3                   3     3     03..00..00..00..00    /tmp
hd1                   1     1     01..00..00..00..00    /home
hd5x                  2     2     02..00..00..00..00    N/A
hd6                   8     8     00..08..00..00..00    N/A
hd8                   1     1     00..00..01..00..00    N/A
hd4                   1     1     00..00..01..00..00    /
#
```

We can clearly see that rootvg is mirrored in a high availability configuration to help protect us from disk failure. So we know that we will gain a free, unallocated physical partition, on each physical volume when we decrease hd6 by one logical partition.

We also know from the `lsdev -Cc disk` command that hdisk7 is only a 355MB disk, and so is almost full, whereas hdisk5 is a 670MB disk, and so has many more free physical partitions, particularly near its edges (note the first and last columns are mainly `00` under the heading `DISTRIBUTION` above).

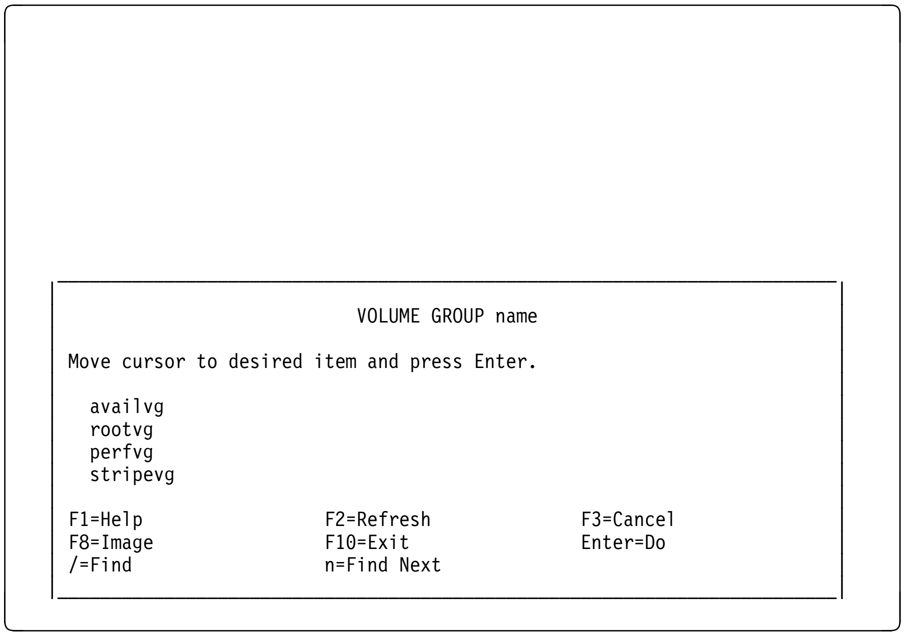
Based on this information, we have decided to create a non-mirrored temporary paging space. We could make it small, but we'll follow the suggestion in the *Resizing or Moving the hd6 Paging Space* article, and make it 80MB in size, since we know that we have enough space.

Finally, note that it is *not* good enough to simply activate the perfpg paging logical volume to use it while we work with hd6, because perfpg is in the perfvg volume group. The AIX Version 3 and AIX Version 4 boot processes expect the hd6 logical volume to be in the root volume group if hd6 is used, since this volume group is the first one that is accessed during the boot process.

***How to Add a New Paging Logical Volume to a Volume Group:*** Now that we've checked the rootvg volume group, we need to create another paging device to temporarily use as the main system paging device while we work with hd6. The process described here is very similar to that documented in the article *Adding and Activating a Paging Space*. Note that we could create a paging type logical volume. However, this process has already been described in "How to Create a Paging Type Logical Volume" on page 233, and we are not concerned about the physical partition location here so we can use the `mkps` command.

To create a new paging logical volume:

1. Execute the fast path `smitty mkps` to get to the screen that looks like:



```
                         VOLUME GROUP name

Move cursor to desired item and press Enter.

  availvg
  rootvg
  perfvg
  stripevg

F1=Help                  F2=Refresh               F3=Cancel
F8=Image                 F10=Exit                 Enter=Do
/=Find                   n=Find Next
```

   Alternatively, you can go through the smit hierarchy by:

   a. Executing `smitty`.
   b. Selecting **System Storage Management (Physical & Logical Storage)**.
   c. Selecting **Logical Volume Manager**.
   d. Selecting **Paging Space**.
   e. Selecting **Add Another Paging Space** to get to a screen that prompts you to select a volume group from a menu similar to that shown above.

2. Use the **Arrow** keys to highlight the `rootvg` volume group name, and then press the **Enter=Do** key.

3. Type `20` for the field `SIZE of paging space (in logical partitions)`, 20 times 4MB gives us an 80MB temporary paging logical volume.
4. Use the **Tab** key to toggle the field `Start using this paging space NOW?` from `no` to to `yes`, or use the **F4=List** key to select it.
5. Use the **Tab** key to toggle the field `Use this paging space each time the system is RESTARTED?` from `no` to `yes` so that your screen looks like:

```
                              Add Another Paging Space

 Type or select values in entry fields.
 Press Enter AFTER making all desired changes.

                                                          [Entry Fields]
   Volume group name                                    rootvg
   SIZE of paging space (in logical partitions)        [20]                      #
   PHYSICAL VOLUME name                                                          +
   Start using this paging space NOW?                   yes                      +
   Use this paging space each time the system is        yes                      +
           RESTARTED?










 F1=Help              F2=Refresh           F3=Cancel            F4=List
 F5=Reset             F6=Command           F7=Edit              F8=Image
 F9=Shell             F10=Exit             Enter=Do
```

6. Press the **Enter=Do** to create the temporary paging logical volume.
7. When smit returns the device name, such as `paging00` in this example, with smit's `OK` prompt, you can press the **F10=Exit** key to return to the command line.

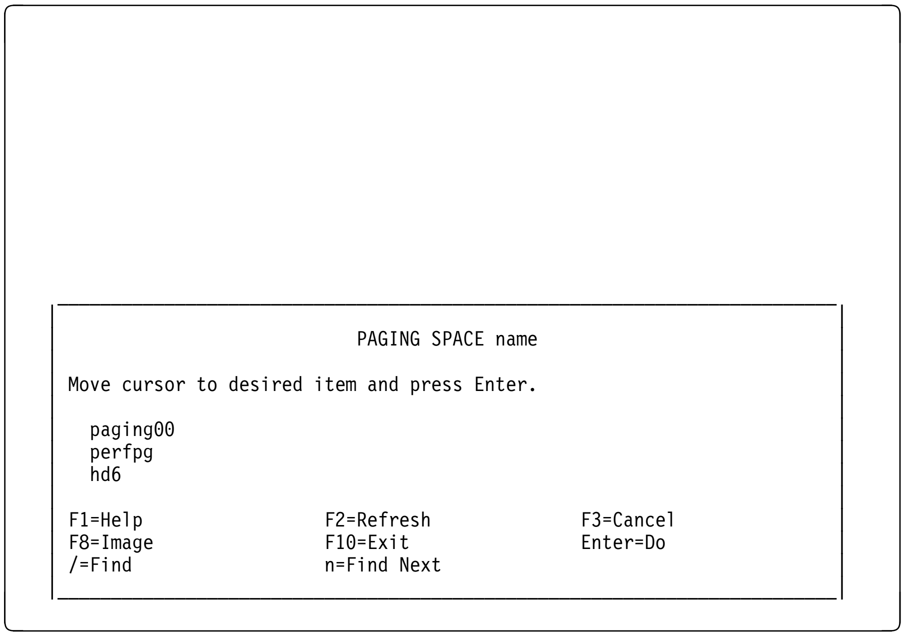
You can now use the command `lsps -a` to check that this new device is active. To use smit:

1. Execute `smitty`.
2. Select **System Storage Management (Physical & Logical Storage)**.
3. Select **Logical Volume Manager**.
4. Select **Paging Space**.
5. Select **List All Paging Spaces**.
6. When smit returns the `lsps -a` output, with smit's `OK` prompt, you can press the **F10=Exit** key to return to the command line.

***How to Change the Attributes of a Paging Logical Volume:*** We now need to change the hd6 logical volume's boot attributes so that we can remove it. This change example is based on that described in the *AIX Version 4.1 Hypertext Information Base Library* article *Changing or Removing a Paging Space*.

To change the hd6 paging logical volume:

1. Execute the fast path `smitty chps` to get to a `PAGING SPACE name` prompt in a screen like:



```
                             PAGING SPACE name

Move cursor to desired item and press Enter.

  paging00
  perfpg
  hd6

F1=Help                 F2=Refresh              F3=Cancel
F8=Image                F10=Exit                Enter=Do
/=Find                  n=Find Next
```

Alternatively, you can go through the smit hierarchy by:

a. Executing `smitty`.
b. Selecting **System Storage Management (Physical & Logical Storage)**.
c. Selecting **Logical Volume Manager**.
d. Selecting **Paging Space**.
e. Selecting **Change / Show Characteristics of a Paging Space** to get to a screen that prompts you to select a paging logical volume from a menu similar to that shown above.

2. Use the **Arrow** keys to highlight the `hd6` paging space name, and then press the **Enter=Do** key.
3. Use the **Tab** key to toggle the field `Use this paging space each time the system is RESTARTED?` from `yes` to `no` so that your screen looks like:

```
                Change / Show Characteristics of a Paging Space

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

                                                      [Entry Fields]
  Paging space name                                 hd6
  Volume group name                                 rootvg
  Physical volume name                              hdisk5
  NUMBER of additional logical partitions          []                        #
  Use this paging space each time the system is     no                       +
          RESTARTED?









F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

4. Press the **Enter=Do** to change the hd6 paging logical volume.
5. When smit returns an `OK` prompt, you can press the **F10=Exit** key to return to the command line.

***How to Complete the Steps to Rebuild a Smaller hd6:*** Although we have changed hd6, it is still an active logical volume (you can see that its `LV STATE` is `open/syncd` if you execute the `lsvg -l rootvg` command). Hence we must use the command `shutdown -Fr` to reboot the RISC System/6000, *but we must first modify the boot file* that explicitly references a paging logical volume that is called hd6. We also need to save our changes so far, to the boot logical volumes.

We need to edit the file `/sbin/rc.boot`. In this example we used the `vi` editor, so to use `vi`:

1. Execute `vi /sbin/rc.boot`.
2. Type the characters `/swapon` and press the **Enter** key to find the relevant line.
3. Press the character `w` four times while in command mode to move the cursor to a position under the character `h` in the word `hd6`.
4. Press the characters `cw` to change the word hd6.
5. Type the word `paging00` so that the lines look like:

```
                          # Start paging if no dump
                          [ ! -f /needcopydump ] && swapon /dev/paging00
```

6. Press the **Esc** key to return to command mode.
7. Use the capital zz sequence, in other words type the characters `ZZ`, to save our updated rc.boot file.

Now if we try to update the boot disk as suggested in the article *Resizing or Moving the hd6 Paging Space* in InfoExplorer, we will get the following error:

```
# bootinfo -b
hdisk7
# bosboot -d /dev/hdisk7 -a
0301-168 bosboot: The current boot logical volume, /dev/hd5,
        does not exist on /dev/hdisk7.
```

Since we have a mirrored rootvg with two boot logical volumes on different disks, then each boot image needs to be updated with the following commands:

```
# bosboot -l /dev/hd5x -d /dev/hdisk7 -a
bosboot: Boot image is 4275 512 byte blocks.
# bosboot -l /dev/hd5 -d /dev/hdisk5 -a
bosboot: Boot image is 4275 512 byte blocks.
```

Now we can reboot the RISC System/6000 by executing the command `shutdown -Fr`.

When the system is up, you can login to check that hd6 can now be removed by executing the command:

```
# lsvg -l rootvg |head
rootvg:
LV NAME            TYPE       LPs   PPs   PVs  LV STATE      MOUNT POINT
hd6                paging     8     16    2    closed/syncd  N/A
hd5                boot       1     1     1    closed/syncd  N/A
```

We can now remove the hd6 logical volume.

**Warning - Check dump device**

*If you are using AIX Version 4, then you need to check what your dump device* is by executing the command `sysdumpdev -l`. If your command ouput looks like:

```
# sysdumpdev -l
primary              /dev/hd6
secondary            /dev/sysdumpnull
copy directory       /tmp
forced copy flag     TRUE
```

then your hd6 logical volume will still be in an open state and hence cannot be removed. If your primary dump device is hd6, then you can change it by executing the following command (note that you can get to the equivalent smit menus for these commands by executing `smitty sysdumpdev`):

```
# sysdumpdev -Pp /dev/sysdumpnull
primary              /dev/sysdumpnull
secondary            /dev/sysdumpnull
copy directory       /tmp
forced copy flag     TRUE
```

Now follow the procedure described in "How to Remove a Paging Logical Volume" on page 314 to delete the hd6 logical volume.

We can now recreate hd6 to make it only 28MB in size, instead of its original 32MB, to save 4MB of disk space.

The procedure is almost identical to that described in 8.3.3, "A Design Example for Improved Availability" on page 209, where we created availlv. The only differences are:

- The name of the volume group is *rootvg*.
- The name of the 2 mirror copy logical volume that we are creating is *hd6*.
- Type `paging` for the field `Logical volume TYPE`.

Note that this command is *different* to the `mklv` command in the procedure suggested by the *Resizing or Moving the hd6 Paging Space* article, since that example only shows you how to work with a single copy hd6. Also note that we are not following a procedure similar to that described in "How to Add a New Paging Logical Volume to a Volume Group" on page 308, because it would require an extra step to change the name of the new paging logical volume from a name like paging01, to hd6.

Now that hd6 exists again, we need to activate it, so:

1. Execute the fast path `smitty swapon` to get to a menu with the title Activate a Paging Space. Alternatively, you can go through the smit hierarchy by:
   a. Executing `smitty`.
   b. Selecting **System Storage Management (Physical & Logical Storage)**.

   c. Selecting **Logical Volume Manager**.
   d. Selecting **Paging Space**.
   e. Selecting **Activate a Paging Space** to get to the same menu.
2. Press the **F4=List** to generate a list of paging logical volumes.
3. Use the **Arrow** keys to highlight the `hd6` logical volume name, and then press the **Enter=Do** key twice.
4. When smit returns an `OK` prompt, press the **F10=Exit** to return to the command line.

Now that hd6 is active, we need to:

1. Reverse the previous change to the /sbin/rc.boot file.
2. Repeat the command `bosboot -l /dev/hd5x -d /dev/hdisk7 -a`.
3. Repeat the command `bosboot -l /dev/hd5 -d /dev/hdisk5 -a`.
4. Execute `shutdown -Fr` to reboot the RISC System/6000.
5. When the system comes up, execute the `bootlist -m normal hdisk5 hdisk7` command to check that we can still boot from either rootvg mirror copy.

At this stage, your system is almost back to normal and your paging information should look like:

```
# lsps -a
Page Space  Physical Volume   Volume Group    Size   %Used  Active  Auto  Type
paging00    hdisk5            rootvg          80MB       0     yes   yes    lv
perfpg      hdisk1            perfvg          20MB       8     yes   yes    lv
perfpg      hdisk8            perfvg          20MB       8     yes   yes    lv
hd6         hdisk5            rootvg          28MB      22     yes    no    lv
hd6         hdisk7            rootvg          28MB      21     yes    no    lv
```

This verifies that we have recovered one logical partition, which is two physical partitions (8MB) from the hd6 logical volume, so we can now remove the temporary paging00 logical volume.

### *How to Remove a Paging Logical Volume*

Now that the smaller hd6 logical volume has been returned to its original operating conditions, we can follow the process described in the article *Changing or Removing a Paging Space* to remove our temporary logical volume.

To remove the paging device paging00:

1. Follow the procedure given in “How to Change the Attributes of a Paging Logical Volume” on page 309 to change paging00 so that it will not be active after a reboot.
2. Reboot the RISC System/6000 by executing the `shutdown -Fr` command.
3. When the system is up, login in as root and execute the fast path `smitty rmps` to get to the menu with the title Remove a Paging Space. Alternatively, you can go through the smit hierarchy by:

   a. Executing `smitty`.
   b. Selecting **System Storage Management (Physical & Logical Storage)**.
   c. Selecting **Logical Volume Manager**.
   d. Selecting **Paging Space**.
   e. Selecting **Remove a Paging Space** to get to the same menu.
4. Press the **F4=List** to generate a list of paging logical volumes.
5. Use the **Arrow** keys to highlight the `paging00` logical volume name, and then press the **Enter=Do** key three times (once to enter the name in the field, once to get the warning, and the third time to execute the command).
6. When smit returns an `OK` prompt, press the **F10=Exit** to return to the command line.

## 8.8 Common Disk Management and Error Recovery Procedures

This section will show examples of the use of the `migratepv` and the `rgrecover` command and shell script respectively. We also include the contents of the `dsksyn` script that many people have used in AIX Version 3, although we did *not* test this script in AIX Version 4.

For further examples of recovery procedures, see Appendix C, "General Volume Group Recovery" on page 349.

### 8.8.1 How to Use the migratepv Command

In this section we will look at how to migrate the contents of one physical volume to another physical volume within the same volume group.

The example will use the volume group availvg which consists of two physical volumes hdisk0 and hdisk2, and the contents of the physical volume hdisk0. will be migrated to physical volume hdisk3.

You will note that the physical volume names have changed for this volume group and do not match those listed in 8.3.3, "A Design Example for Improved Availability" on page 209. The change has occurred as a result of running the `mksysb` restore example. See 8.4, "Managing Backup and Restore" on page 247 for more details.

Also note that in our tests we could not successfully migrate all logical volumes in one step using the `migratepv` command, although this should have been possible. To work around this problem we used a variant of the `migratepv` command which allows migration of individual logical volumes. However, in the command line summary we have used another variant of the `migratepv` command which performs an entire physical volume migration.

#### 8.8.1.1 Command Line Summary

1. Using the `lspv` command, check to see if there is a physical volume which is currently not assigned to a volume group:

```
# lspv
hdisk0        0000020158496d72    availvg
hdisk1        00000201dc8b0b32    perfvg
hdisk2        000002007bb618f5    availvg
hdisk3        none                None
hdisk4        000137231982c0f2    stripevg
hdisk5        00014732b1bd7f57    rootvg
hdisk6        0001221800072440    stripevg
hdisk7        00012218da42ba76    rootvg
hdisk8        0002479088f5f347    perfvg
```

2. Add physical volume `hdisk3` to volume group `availvg`:

```
extendvg -f 'availvg' 'hdisk3'
```

3. Identify the logical volumes in volume group `availvg`:

```
# lsvg -l availvg
availvg:
LV NAME            TYPE       LPs   PPs   PVs  LV STATE      MOUNT POINT
availlv            jfs        6     12    2    open/syncd    /availjfs
loglv00            jfslog     1     2     2    open/syncd    N/A
```

4. Migrate the contents of `hdisk0` to `hdisk3`:

```
# migratepv 'hdisk0' 'hdisk3'
```

5. To confirm that all physical partitions have been migrated, execute the `lspv` command on `hdisk0` and `hdisk3`:

```
# lspv -M hdisk0
hdisk0:1-287
#
# lspv -M hdisk3
hdisk3:1-81
hdisk3:82       availlv:1:2
hdisk3:83       availlv:2:2
hdisk3:84       availlv:3:2
hdisk3:85       availlv:4:2
hdisk3:86       availlv:5:2
hdisk3:87       availlv:6:2
hdisk3:88       loglv00:1:2
hdisk3:89-287
```

The above results show that the `migratepv` command has moved the contents of hdisk0 to hdisk3.

#### 8.8.1.2 Detailed Guidance

Let us now look at these steps in more detail, and see how a physical volume migration can be done using smit. We will also look at the commands which help us identify whether or not all physical partitions have been migrated.

***How to Migrate Physical Volume contents to another disk:*** Before we start a physical volume migration to another disk, we need to confirm that the target physical volume has sufficient storage capability to hold all physical partitions which will be migrated. In this section we will look at the commands that provide this vital information.

To reiterate, we will migrate physical volume hdisk0 to physical volume hdisk3.

1. Identify all physical volumes which are currently *not* assigned to a volume group using the command:

   ```
   # lspv
   hdisk0         0000020158496d72    availvg
   hdisk1         00000201dc8b0b32    perfvg
   hdisk2         000002007bb618f5    availvg
   hdisk3         none                None
   hdisk4         000137231982c0f2    stripevg
   hdisk5         00014732b1bd7f57    rootvg
   hdisk6         0001221800072440    stripevg
   hdisk7         00012218da42ba76    rootvg
   hdisk8         0002479088f5f347    perfvg
   ```

   Each line of the above output shows the name of a configured physical volume. If this physical volume belongs to an existing volume group, the line also shows its system-wide unique physical volume identifier and the name of the volume group to which it belongs.

   However, from the above information we note that physical volume `hdisk3` does not currently belong any volume group, making it a candidate for the target disk for this example.

2. Check the partition map for our source physical volume hdisk0:

   ```
   # lspv -M hdisk0
   hdisk0:1-81
   hdisk0:82       availlv:1:2
   hdisk0:83       availlv:2:2
   hdisk0:84       availlv:3:2
   hdisk0:85       availlv:4:2
   hdisk0:86       availlv:5:2
   hdisk0:87       availlv:6:2
   hdisk0:88       loglv00:1:2
   hdisk0:89-287
   ```

   Note that logical volumes `availlv` and `loglv00` have their second logical partition copies allocated on this physical volume. The logical volume `availlv` has `6` physical partitions allocated on this physical volume, and logical volume `loglv00` has `1` physical partition.

3. Using the `lsdev` command, let us look at the size of physical volumes `hdisk0` and `hdisk3`:

   ```
   # lsdev -Cc disk
   hdisk0 Available 00-07-00-0,0 1.2 GB SCSI Disk Drive (in 2.4 GB Disk Unit
   hdisk1 Available 00-07-00-1,0 1.2 GB SCSI Disk Drive (in 2.4 GB Disk Unit
   hdisk2 Available 00-07-00-2,0 1.2 GB SCSI Disk Drive (in 2.4 GB Disk Unit
   hdisk3 Available 00-07-00-3,0 1.2 GB SCSI Disk Drive (in 2.4 GB Disk Unit
   hdisk4 Available 00-07-00-4,0 857 MB SCSI Disk Drive
   hdisk5 Available 00-08-00-0,0 670 MB SCSI Disk Drive
   hdisk6 Available 00-08-00-1,0 670 MB SCSI Disk Drive
   hdisk7 Available 00-08-00-2,0 355 MB SCSI Disk Drive
   hdisk8 Available 00-08-00-3,0 320 MB SCSI Disk Drive
   ```

   Since `hdisk0` and `hdisk3` are of identical size, there should be no problems in performing the physical volume migration.

4. Add physical volume hdisk3 to the volume group availvg using the command `smitty extendvg`.

   The following screen will appear:

```
                    Add a Physical Volume to a Volume Group

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

                                                     [Entry Fields]
* VOLUME GROUP name                                 [availvg]         +
* PHYSICAL VOLUME names                             [hdisk3]          +





F1=Help          F2=Refresh       F3=Cancel        F4=List
F5=Reset         F6=Command       F7=Edit          F8=Image
```

   On this smit screen:

   a. Enter `availvg` for the field `VOLUME GROUP name`.
   b. Enter `hdisk3` for the field `PHYSICAL VOLUME names`.
   c. Press **Enter**.
   d. Press **F10** after smit returns with `OK`.
   e. Confirm that we now have three physical volumes in volume group `availvg` using the command:

```
# lsvg -p availvg
availvg:
PV_NAME            PV STATE    TOTAL PPs   FREE PPs    FREE DISTRIBUTION
hdisk0             active      287         280         58..50..57..57..58
hdisk2             active      287         280         58..50..57..57..58
hdisk3             active      287         287         58..57..57..57..58
```

   From the above output we can see that three physical volumes now exist in availvg, and as expected all physical partitions on `hdisk3` are free.

   **Note**

   It is *not* a requirement that a new target physical volume is added to the volume group. For a `migratepv` to succeed it is only necessary that the target physical volume has a sufficient number of free physical partitions equal to or greater than the number of partitions being moved from the source physical volume.

We are now ready to perform the migration test. However, since the `migratepv` command will still allow access to the data being migrated, we will simulate this by executing the following shell script, called `migpvtst` during the migration process.

```
#!/bin/ksh
# migpvtst
cd /availjfs
while true
do
      ls
      sleep 1
done
```

5. Execute `migpvtst` from another terminal:

```
# ksh migpvtst
cmds.rom.dd
cmds.rom.dd
cmds.rom.dd
```

The above sample output shows that the file `cmds.rom.dd` was displayed once every second.

6. Migrate the contents of physical volume `hdisk0` to `hdisk3` using the command `smitty migratepv`:

```
                   Move Contents of a Physical Volume

Type or select a value for the entry field.
Press Enter AFTER making all desired changes.

                                                       [Entry Fields]
* SOURCE physical volume name                       [hdisk0]           +









F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

   a. On this smit screen enter `hdisk0` for the field `SOURCE physical volume name`.
   b. Press **Enter**.

      On the next smit screen, shown below:
   c. Enter `hdisk3` for the field `DESTINATION physical volumes`.
   d. Press **Enter**.
   e. Press **F10** when smit return with `OK`.

```
                 Move Contents of a Physical Volume

Type or select values in entry fields.
Press Enter AFTER making all desired changes.

                                                     [Entry Fields]
* SOURCE physical volume name                      hdisk0
* DESTINATION physical volumes                    [hdisk3]          +
  Move only data belonging to this                []                +
    LOGICAL VOLUME?








F1=Help             F2=Refresh          F3=Cancel           F4=List
F5=Reset            F6=Command          F7=Edit             F8=Image
F9=Shell            F10=Exit            Enter=Do
```

**Warning**

If smit returns with `OK` *and* also displays error messages like:

```
0516-158 lmigratepp: Destination physical partition number not
        entered.
Usage: lmigratepp -g VGid -p SourcePVid -n SourcePPnumber
        -P DestinationPVid -N DestinationPPnumber
0516-812 migratepv: Warning, migratepv did not completely
        succeed; all physical partitions have not been
        moved off the PV.
```

this indicates that the migration has *failed*. When this happens, rerun the command for each logical volume that exists on the source physical volume. The command `lspv -l diskname` will identify all logical volumes contained on the physical volume specified by the `diskname` parameter. Alternatively, press **F4** on the field `Move only data belonging to this LOGICAL VOLUME?` and select a logical volume from the displayed list.

7. Confirm that there are no physical partitions allocated on `hdisk0` by excuting the command:

```
# lspv -M hdisk0
hdisk0:1-287
```

   As expected all `287` physical partitions are now free on `hdisk0`.

8. Confirm that seven physical partitions now exist on `hdisk3` using the command:

```
# lspv -M hdisk3
hdisk3:1-81
hdisk3:82       availlv:1:2
hdisk3:83       availlv:2:2
hdisk3:84       availlv:3:2
hdisk3:85       availlv:4:2
hdisk3:86       availlv:5:2
hdisk3:87       availlv:6:2
hdisk3:88       loglv00:1:2
hdisk3:89-287
```

9. Press **Ctrl-C** to stop the shell script `migpvtst` from running.

Note that the shell script `migpvtst` still continued to list the files in the directory `/availjfs` both during and after the migration of physical volume `hdisk0`. The above steps show us that a migration of the contents of one physical volume to another can be easily performed, and furthermore, without denying users access to data residing on the source physical volume.

### 8.8.2 How to Use the rvgrecover Shell Script

There are many references that you need to need to help you resolve problems quickly. These include the article *Recovering from Disk Drive Problems* in *AIX Version 4.1 System Management Guide: Operating System and Devices*, and also the article *Recovering Volume Groups* in the *AIX Version 4.1 Problem Solving Guide and Reference*. This latter article includes the following script called `rvgrecover`:

```
PV=/dev/ipldevice
VG=rootvg
    cp /etc/objrepos/CuAt /etc/objrepos/CuAt.$$
    cp /etc/objrepos/CuDep /etc/objrepos/CuDep.$$
    cp /etc/objrepos/CuDv /etc/objrepos/CuDv.$$
    cp /etc/objrepos/CuDvDr /etc/objrepos/CuDvDr.$$
    lqueryvg -Lp $PV | awk '{ print $2 }' | while read LVname; do
        odmdelete -q "name = $LVname" -o CuAt
        odmdelete -q "name = $LVname" -o CuDv
        odmdelete -q "value3 = $LVname" -o CuDvDr
    done
    odmdelete -q "name = $VG" -o CuAt
    odmdelete -q "parent = $VG" -o CuDv
    odmdelete -q "name = $VG" -o CuDv
    odmdelete -q "name = $VG" -o CuDep
    odmdelete -q "dependency = $VG" -o CuDep
    odmdelete -q "value1 = 10" -o CuDvDr
    odmdelete -q "value3 = $VG" -o CuDvDr
    importvg -y $VG $PV      # ignore lvaryoffvg errors
    varyonvg $VG
```

To test this script, note that we start with a system whose ODM is fine as indicated by:

```
# lsdev -Cc disk
hdisk0 Available 00-08-00-0,0 670 MB SCSI Disk Drive
hdisk1 Available 00-08-00-1,0 355 MB SCSI Disk Drive
hdisk2 Available 00-08-00-2,0 355 MB SCSI Disk Drive
# lsvg rootvg
VOLUME GROUP:   rootvg                   VG IDENTIFIER:  000005083df45081
VG STATE:       active                   PP SIZE:        4 megabyte(s)
VG PERMISSION:  read/write               TOTAL PPs:      243 (972 megabytes)
MAX LVs:        256                      FREE PPs:       5 (20 megabytes)
LVs:            16                       USED PPs:       238 (952 megabytes)
OPEN LVs:       11                       QUORUM:         2
TOTAL PVs:      2                        VG DESCRIPTORS: 3
STALE PVs:      0                        STALE PPs       0
ACTIVE PVs:     2                        AUTO ON:        yes
```

To simulate a corrupt ODM, we can execute the following commands:

**Warning - DO NOT DO THIS**

You must use a test machine to do this process, since if you have any problems, you may have to reinstall.

```
# odmdelete -o CuAt -q'name=rootvg'
0518-307 odmdelete: 3 objects deleted.
# lsvg rootvg
0516-310 lsvg: Unable to find attribute rootvg in the Device
        Configuration Database. Execute synclvodm to attempt to
        correct the database.
#
# odmdelete -o CuAt -q'name=hd3'
0518-307 odmdelete: 4 objects deleted.
# odmdelete -o CuAt -q'name=hd5'
0518-307 odmdelete: 5 objects deleted.
# lslv hd3
LOGICAL VOLUME:     hd3                    VOLUME GROUP:   rootvg
LV IDENTIFIER:                             PERMISSION:     ?
VG STATE:           inactive               LV STATE:       ?
TYPE:               jfs                    WRITE VERIFY:   ?
MAX LPs:            ?                      PP SIZE:        ?
COPIES:             1                      SCHED POLICY:   ?
LPs:                ?                      PPs:            ?
STALE PPs:          ?                      BB POLICY:      ?
INTER-POLICY:       minimum                RELOCATABLE:    yes
INTRA-POLICY:       middle                 UPPER BOUND:    32
MOUNT POINT:        /tmp                   LABEL:          None
MIRROR WRITE CONSISTENCY: ?
EACH LP COPY ON A SEPARATE PV ?: yes
```

Now we can execute the `rvgrecover` shell script. During the execution, you may see messages on your screen like:

```
0518-307 odmdelete: 1 objects deleted.
0518-307 odmdelete: 0 objects deleted.
0516-510 updatevg: Physical volume not found for physical volume
        identifier 00000997c020352d.
0516-548 synclvodm: Partially successful with updating volume
        group rootvg.
0516-782 importvg: Partially successful importing of /dev/ipldevice.
```

We can then check that whether the rootvg has been recovered by executing:

```
# lsvg rootvg
VOLUME GROUP:   rootvg                  VG IDENTIFIER:  000005083df45081
VG STATE:       active                  PP SIZE:        4 megabyte(s)
VG PERMISSION:  read/write              TOTAL PPs:      243 (972 megabytes)
MAX LVs:        256                     FREE PPs:       5 (20 megabytes)
LVs:            16                      USED PPs:       238 (952 megabytes)
OPEN LVs:       11                      QUORUM:         2
TOTAL PVs:      2                       VG DESCRIPTORS: 3
STALE PVs:      0                       STALE PPs       0
ACTIVE PVs:     2                       AUTO ON:        yes
# lslv hd3
0516-304 lslv: Unable to find device id 00000997c020352d in the Device
        Configuration Database.
LOGICAL VOLUME:     hd3                   VOLUME GROUP:   rootvg
LV IDENTIFIER:      000005083df45081.9    PERMISSION:     read/write
VG STATE:           active/complete       LV STATE:       opened/syncd
TYPE:               jfs                   WRITE VERIFY:   off
MAX LPs:            128                   PP SIZE:        4 megabyte(s)
COPIES:             1                     SCHED POLICY:   parallel
LPs:                82                    PPs:            82
STALE PPs:          0                     BB POLICY:      relocatable
INTER-POLICY:       minimum               RELOCATABLE:    yes
INTRA-POLICY:       center                UPPER BOUND:    32
MOUNT POINT:        /tmp                  LABEL:          /tmp
MIRROR WRITE CONSISTENCY: on
EACH LP COPY ON A SEPARATE PV ?: yes
```

It seems that there is still an ODM problem as indicated by the `0516-304` error message. After the initial invocation of the `rvgrecover` script, only some objects in the ODM database (CuAt) were recovered. The physical volume information for hdisk0 has not immediately been recovered by this script. When we reboot the RISC System/6000, we find that the PVid for hdisk0 is recovered from the VGDA on one of the rootvg disks. However, as can be seen in the following, hdisk0 is still not included as part of the rootvg volume group, since its status is none:

```
# lspv
hdisk0         00000997c020352d    none
hdisk1         00000997c01fd413    rootvg
hdisk2         000010732623885a    325vg
```

However, we can repeat the execution of the `rvgrecover` script after this reboot, and then we find that the ODM information for physical volume hdisk0 is updated correctly. This can be seen from:

```
# lspv
hdisk0         00000997c020352d    rootvg
hdisk1         00000997c01fd413    rootvg
hdisk2         000010732623885a    325vg
```

## 8.8.3 How to Use the dsksync Shell Script

This shell script will synchronize your disks on a AIX Version 3 system so they will be named in the correct order. The order may differ from that expected from the configuration rules as physical volumes and adapters are added and removed over a period of time to your system. For example: hdisk0, hdisk2, hdisk3 instead of hdisk0, hdisk1, hdisk2. The order of the disk names generally does not cause errors, but it may cause confusion for the user. Run the following `dsksync` script to alleviate such confusion. The script will rename the hard disks.

You may need to use a shell script similar to that given in in 8.8.2, “How to Use the rvgrecover Shell Script” on page 321 after you run this script. Make sure the key is in the *Normal* position before running this script.

```
lsdev -Cc disk | awk '{ print $1 }' | while read HDname; do
          odmdelete -q "name = $HDname" -o CuAt
          odmdelete -q "value = $HDname" -o CuAt
          odmdelete -q "name = $HDname" -o CuDep
          odmdelete -q "name = $HDname" -o CuDv
          odmdelete -q "value3 = $HDname" -o CuDvDr
          odmdelete -q "name = $HDname" -o CuVPD
done
rm -f /dev/hdisk*
rm -f /dev/rhdisk*

savebase
```

When the shell script completes successfully, run the `shutdown -Fr` command to shutdown and reboot AIX Version 3.

# Appendix A. Overview of Hardware Components

This appendix contains highlights of hardware storage components available on the RS/6000.

## A.1 Storage Product Interface Adapters

This section looks at the hardware adapters available to connect various hardware storage components to the RS/6000 system units.

### A.1.1 SCSI Adapters

The following are examples of SCSI adapters that are available to connect SCSI devices to the RS/6000.

#### A.1.1.1 IBM SCSI High Performance I/O Controller

This Micro Channel adapter occupies one slot in the RS/6000 and provides:

- One SCSI internal and/or external bus interface
- 4MB/sec maximum synchronous data transfer
- 2MB/sec maximum asynchronous data transfer
- One byte wide single-ended implementation
- Maximum bus length of six meters

This adapter is supported in the following systems:

- #2828
  - RS/6000 Models 320, 32H, 32E
- #2829
  - RS/6000 500 series, all models
- #2835
  - RS/6000 200 series, all models except 250, 25S, 25W, 25T
  - RS/6000 300 series, all models
  - RS/6000 500 series, all models
  - RS/6000 900 and R series, all models

#### A.1.1.2 IBM SCSI-2 High Performance I/O Controller

This Micro Channel adapter occupies one slot in the RS/6000 and provides:

- One SCSI-2 internal and/or external interface
- 10MB/sec maximum synchronous data transfer
- 2.5MB/sec maximum asynchronous data transfer
- One byte wide single-ended implementation
- Maximum bus length of three to six meters, depending upon configuration
- Command Tag Queueing

This adapter is supported in the following systems:

- #2410
  - RS/6000 200 series, all models
  - RS/6000 Models 41T, 41W
  - RS/6000 Model C10
  - RS/6000 300 series, all models
  - RS/6000 500 series, all models except 520, 530, 540
  - RS/6000 900 and R series, all models except 930
- #2831
  - RS/6000 500 series, all models except 520, 530, 540

#### A.1.1.3 IBM SCSI-2 Differential High Performance External I/O Controller

This Micro Channel adapter occupies one slot in the RS/6000 and provides:

- One SCSI-2 internal and/or external bus interface
- 10MB/sec maximum synchronous data transfer
- 2.5MB/sec maximum asynchronous data transfer
- One byte wide differential interface
- Maximum bus length of 19 meters
- Command Tag Queueing

This adapter is supported in the following systems:

- #2420
  - RS/6000 200 series, all models except 250, 25S, 25W, 25T
  - RS/6000 models 41T, 41W
  - RS/6000 model C10
  - RS/6000 model 3AT, 3BT
  - RS/6000 300 series, all models except 320, 32H, 32E
  - RS/6000 500 series, all models except 520, 530, 540
  - RS/6000 900 and R series, all models except 930

#### A.1.1.4 IBM SCSI-2 Fast/Wide Adapter/A

This Micro Channel adapter occupies one slot in the RS/6000 and provides:

- Two independent SCSI-2 bus interfaces, one internal, one external
- 20MB/sec maximum synchronous transfer rate
- 3.6MB/sec maximum asynchronous transfer rate
- Two byte wide single-ended implementation
- Maximum bus length of three to six meters, depending upon bus configuration
- Command Tag Queueing

- Up to 30 total SCSI device addresses, 15 internal, and 15 external. This capability is currently limited by AIX to 14 total addresses, 7 internal, and 7 external

This adapter is supported in the following systems:

- #2415
  - RS/6000 models 250, 25S, 25W, 25T
  - RS/6000 models 41T, 41W
  - RS/6000 model C10
  - RS/6000 300 series, all models except 320
  - RS/6000 500 series, all models except 520, 530, 540
  - RS/6000 900 and R series, all models except 930

### A.1.1.5 IBM SCSI-2 Differential Fast/Wide Adapter/A

This Micro Channel adapter occupies one slot in the RS/6000 and provides:

- Two independent SCSI-2 bus interfaces, one internal, one external
- 20MB/sec maximum synchronous data transfer
- 3.6MB/sec maximum asynchronous data transfer
- Maximum bus length of three to six meters, depending on internal bus configuration
- Maximum bus length of 25 meters, depending on external bus configuration
- Command Tag Queueing
- Two byte wide single-ended implementation, internal bus
- Two byte wide differential implementation, external bus
- Up to 30 total SCSI device addresses, 15 internal, and 15 external. This capability is currently limited by AIX to a total of 14 addresses, 7 internal, and 7 external

This adapter is supported in the following systems:

- #2416
  - RS/6000 models 250, 25S, 25W, 25T
  - RS/6000 models 41T, 41W
  - RS.6000 model C10
  - RS/6000 300 series, all models except 320
  - RS/6000 500 series, all models except 520, 530, 540
  - RS/6000 900 and R series, all models except 930

### A.1.1.6 Integrated IBM SCSI High-Performance I/O Controller

This integrated controller provides the following capabilities:

- One SCSI internal and/or external bus interface
- 4MB/sec maximum synchronous data transfer
- 2MB/sec maximum asynchronous data transfer

- One byte wide single-ended implementation
- Maximum bus length of six meters

The controller is integrated into the following models:

- RS/6000 models 340, 34H, 350, 355, 360, 365, 370, 37T, 375
- RS/6000 500 series, 570 and above
- RS/6000 900 and R series 970 and above, R10, R20

### A.1.1.7 Integrated SCSI Controller

This integrated controller provides:

- One SCSI internal and/or external bus interface
- 5MB/sec maximum synchronous data transfer
- 5MB/sec maximum asynchronous data transfer
- One byte wide single-ended implementation
- Maximum bus length of six meters

The controller is integrated into the following models:

- RS/6000 model M20
- RS/6000 200 series, all models except 250, 25S, 25T, 25W

### A.1.1.8 Integrated SCSI-2 Controller

This integrated controller provides:

- One SCSI-2 internal and/or external bus interface
- 10MB/sec maximum synchronous data transfer
- 5MB/sec maximum asynchronous data transfer
- One byte wide single-ended implementation
- Maximum bus length for models 250, 25S, 25T, 25W:
  - Three meters at SCSI-2 data rates (5 - 10MB/sec)
  - Six meters at SCSI data rates (<5MB/sec)
- Maximum bus length for models 41T, 41W, C10
  - Bus length limited to 2.3 meters external to the system

### A.1.1.9 Integrated IBM SCSI-2 Fast/Wide Adapter/A

This adapter provides the following capabilities:

- Two independent SCSI-2 bus interfaces, one internal, one external
- 20MB/sec maximum synchronous data transfer rate
- 3.6MB/sec maximum asynchronous data transfer rate
- Maximum bus length of three to six meters, depending upon bus configuration
- Command Tag Queueing
- Two byte wide single-ended implementation. Up to 30 total SCSI device addresses, 15 internal, and 15 external. This capability is currently limited by AIX to a total of 14 addresses, 7 internal, and 7 external

This adapter is integrated into the following models:

- RS/6000 300 series, models 380, 390, 3AT, 3BT

## A.1.2 Serial Adapters

The following are examples of serial adapters that can be used to attach serial devices to the RS/6000.

### A.1.2.1 High Performance Disk Drive Subsystem Adapter

This Micro Channel adapter occupies one slot on the RS/6000 and provides:

- Support for up to four 9333 subsystems
- Support for up to 16 serial disk drives per adapter
- 8MB/sec full duplex operation with packet multiplexing allowing concurrent communication with all attached devices
- Maximum cable length of 10 meters

The adapter is supported in the following systems:

- #6212
  - RS/6000 200 series, all models
  - RS/6000 model C10
  - RS/6000 300 series, all models
  - RS/6000 500 series, all models
  - RS/6000 900 and R series, all models

## A.1.3 HiPPI Adapters

The following adapter can be used to attache HiPPI compatible devices to the RS/6000.

### A.1.3.1 HiPPI Adapter

This Micro Channel adapter occupies 3 adjacent slots in the RS/6000, though due to power constraints, must be considered to occupy 5 slots. It provides:

- Peak rate simplex/duplex data transfer up to 800Mb/sec in each direction
- Maximum cable length of 25 meters (extendable via vendor switches and fibre optic extenders)
- Connection to the 9570 Disk Array Subsystem

The adapter is supported in the following systems:

- #2735
  - RS/6000 500 series, models 570, 580, 58H, 590, 59H
  - RS/6000 900 and R series, models 970, 97B, 980, 98B, 990, R24

## A.1.4 ESCON Adapters

The following adapter can be used to attach ESCON* compatible devices to the RS/6000.

### A.1.4.1 System/390 ESCON Channel Emulator

This Micro Channel adapter requires 2 slots on the RS/6000 and provides:

- 17MB/sec data transfer rate
- Support for attachment to all models of the 3490 and 3490E tape subsystems
- Support for attachment to the 3494 and 3495 tape library dataservers

This adapter is supported by the following systems:

- #2754
  - RS/6000 models 340, 34H, 350, 360, 36T, 370, 37T
  - RS/6000 models 3AT, 3BT
  - RS/6000 500 series, all models
  - RS/6000 900 and R series, all models

## A.1.5 Channel Emulation Adapters

The following adapter can be used to attach channel compatible devices to the RS/6000.

### A.1.5.1 System/370 Channel Emulator/A

This Micro Channel adapter requires one slot in an RS/6000 and provides:

- 4.5MB/sec data transfer rate
- Support for up to 4 control units per block multiplexer channel
- Maximum cable length of 61 meters
- Support for all models of the 3480, 3490 and 3490E tape subsystems
- Support for the 3495 tape library dataserver

The adapter is supported in the following systems:

- #2759
  - RS/6000 300 series, all models
  - RS/6000 models 3AT, 3BT
  - RS/6000 500 series, all models
  - RS/6000 900 and R series, all models

## A.2 Disk Storage Products

This section looks at the disk storage products that are available for attachment to the RS/6000.

## A.2.1 Disk Drives

The following drive units can be installed.

### A.2.1.1 SCSI Drives

***3.5" Drives:*** The following drives are available. They are SCSI-2 single-ended unless otherwise specified.

- #2490 - 200MB, supported on 200, 300 series
- #2560 - 400MB (SCSI), supported on 200, 300 series
- #2390 - 540MB, supported on 200, 300 series
- #2555 - 1.0GB, supported on 200, 300, 500, 900 series
- #2565 - 1.0GB (differential), supported on 9334
- #2580 - 2.0GB, supported on 200, 300, 500, 900 series
- #2585 - 2.0GB (differential), supported on 9334

***5.25" Drives:*** The following drives are available:

- #2570 - 1.37GB (SCSI), supported on 500 series and 9334
- #2590 - 2.4GB (SCSI-2), supported on 500 series and 9334

### A.2.1.2 Serial Drives

The following drives are available:

- #3100 - 857MB (5.25"), supported on 9333
- #3110 - 1.07GB (5.25"), supported on 9333
- #3120 - 2.0GB (3.5"), supported on 9333

## A.2.2 Disk Subsystems

The following disk subsystems can be attached to the RS/6000.

### A.2.2.1 IBM 7203 and 7204 External Disk Drives

The 7203 provides an external disk drive supporting a removable disk pack of either 355MB or 1.0GB. This is useful for environments where security is an issue, as the disk pack can be removed and stored in a secure place. Disk packs can also be moved between machines, allowing easy sharing of information. The 7203 supports a standard SCSI interface, and is attachable to all systems.

The 7204 is an external disk unit supporting the following capacities:

- Model 320 - 320MB, SCSI-2 interface, supported on 200, 300, 500, 900 series
- Model 001 - 1.0GB, SCSI-2 interface, supported on 200, 300, 500, 900 series
- Model 010 - 1.0GB, SCSI-2 interface, supported on 200, 300, 500, 900 series, this unit has faster access times
- Model 215 - 2.0GB, SCSI-2 differential interface, supported on 300, 500, 900 series

### A.2.2.2 IBM 9334 SCSI Expansion Unit

The 9334 SCSI Expansion Unit provides support for up to four SCSI disk drives per unit. There are four models:

- Model 010 (SCSI-2), rack mounted, supported by the 900 series
- Model 011 (SCSI-2 differential), rack mounted, supported by the 900 series
- Model 500 (SCSI-2), desk side, supported by the 200, 300, 500 series
- Model 501 (SCSI-2 differential), desk side, supported by the 300, 500 series

### A.2.2.3 IBM 9333 High Performance Disk Drive Subsystem

The 9333 High Performance Disk Drive Subsystem attaches to a port on the High Performance Disk Drive Subsystem adapter, and supports up to four serial disks. The 9333 is designed to provide the fastest response time when an application makes large numbers of requests for short blocks of data.

The 9333 also supports multiple paths from its controller to the processor, allowing a 9333 to attach simultaneously to up to eight hosts processors. This is useful for high availability environments or data sharing. Independent electrical paths are provided to each host, so bandwidth is not shared, nor will electrical failure in one path affect the others.

There are four models of the 9333:

- Model 010 - rack mounted, supported by the 900 series (4.3GB max)
- Model 011 - rack mounted, supported by the 900 series (8.0GB max)
- Model 500 - desk side, supported by 34H, 360, 370, and 500 series (4.3 GB max)
- Model 501 - desk side, supported by 34H, 360, 370, and 500 series (8.0 GB max)

### A.2.2.4 IBM 7134 High Density SCSI Disk Subsystem

The 7134 High Density SCSI Disk Subsystem can hold 16 3.5" 2.0GB SCSI disk drives. These drives are split into two banks of eight drives, each on a separate internal (to the 7134) SCSI adapter. The 7134 itself requires a SCSI-2 differential fast/wide adapter to attach to the system. The subsystem can be connected to two hosts for availability reasons, and in this case, only six drives are supported in each bank.

There is one model of the 7134:

- Model 010 - rack mounted, supported by the 300, 500, 900, and R series

### A.2.2.5 IBM 7135 RAIDiant Array

The 7135 RAIDiant Array provides high data availability and/or performance using RAID technology (RAID is explained in 2.2.2.2, “Selecting the Correct Disk Storage Devices” on page 27); RAID levels 0, 1, 3, and 5 are supported. Essentially any combination of RAID levels are concurrently supported on the 7135, with the *Logical Unit*, or LUN of disks supporting each defined RAID level appearing as a single SCSI disk drive to the operating system.

The 7135 is connected to the host system via either a SCSI-2 differential adapter, or a SCSI-2 fast/wide differential adapter. The disks are connected internally to five

SCSI-2 buses, giving a maximum number of 30 disks; either 2.0GB, or 1.3GB 3.5" disks are supported.

The 7135 has an internal controller that manages the RAID functions, and a second controller may be added operating in either standby mode (taking over in the event of failure of the first), or in active mode (providing enhanced performance as well as availability). In addition, redundant power supplies and cooling are standard, and maintenance is supported concurrently on any failing hardware.

There are two models of the 7135:

- Model 010 (system rack), up to 12 disks, supported by 300, 500, 900, and R series
- Model 110 (desk side), up to 30 disks, supported by 300, 500, 900, and R series.

#### A.2.2.6 IBM 3514 High Availability Disk Array

The 3514 Disk Array provides a lower cost solution for those environments not requiring the full range of RAID support. The 3514 allows a maximum of eight disk drives, which can be either 1.0GB or 2.0GB (not mixed within the same unit). RAID levels 0 and 5 are supported, configurable from the front panel of the unit. All drives within the 3514 are used in the configured RAID level, and appear to the operating system as a single SCSI disk drive (one drive can be designated at a hot spare, to be used automatically in the event of failure of one of the other drives).

The 3514 is connected to the host system via a SCSI-2 fast/wide differential adapter, or a SCSI-2 differential adapter; internally, the disks are connected to the array controller via four SCSI-2 buses.

A redundant power supply is provided, but not cooling fans, or controller.

There are four models of the 3514:

- Model 212 (desk side), 1.0GB disks, supported by 250, 300 series, and 500 series
- Model 213 (desk side), 2.0GB disks, supported by 250, 300 series, and 500 series
- Model 312 (rack mount), 1.0GB disks, supported by 250, 300 series, and 500 series
- Model 313 (rack mount), 2.0GB disks, supported by 250, 300 series, and 500 series

#### A.2.2.7 IBM 9570 Disk Array Subsystem

The 9570 Disk Array is designed to support applications requiring very high performance access to information, and/or enhanced availability. The 9570 R5 supports RAID levels 1 and 5 concurrently within a system in separately defined partitions. The internal disks are 2.0GB SCSI disks supporting IPI-2 protocols, and are supported in configurations ranging from 12.9GB to 232.4GB of data.

The 9570 is connected to the host system via the HiPPI adapter, and can support a maximum sustained data transfer rate of over 60MB/sec.

Fault tolerance is provided in the form of redundant power supplies and cooling. The subsystem also provides its own console for error detection, collection and monitoring. Automatic log analysis and real time fault isolation can be performed.

The 9570 is rack based and there are many models depending upon the exact configuration required. The first rack in a subsystem will always contain the array controller, one or two HiPPI ports, and up to 10 drawers of disks (each drawer can have up to four disks). Three additional racks may be daisy chained to the first rack, also containing a maximum of 10 drawers. The model numbers are constructed as follows. The first digit may be a 0, 1 or 2; 0 indicates an expansion rack, 1 or 2 indicates a controller rack, the number determining how many HiPPI ports the rack contains. The last two digits will be either 20 (five drawers in the rack), or 40 (10 drawers in the rack). So, for example, a model 140 would be a controller rack with one HiPPI port and 10 drawers of disk.

## A.3 Tape Storage Products

The following section looks at the tape storage products that are available for attachment to the RS/6000.

### A.3.1 Tape Devices

The following tape devices are available.

#### A.3.1.1 IBM 7206

The 7206 is a standalone 4mm helical scan technology tape device (helical scan is explained in 2.2.3, “Tape Storage” on page 34). The 7206 attaches to the system via a SCSI, or SCSI-2 interface, depending upon the model. A media recognition feature is included that ensures that only data grade tape cartridges can be used. The 7206 support data compression, attach to all model of the RS/6000, and can be mounted inside the 500 and 900 series.

There are two models:

- Model 001

  The model 001 offers 2.0GB native cartridge capacity (up to 4GB when using compression). The data transfer rate is 183 KB/sec (up to 366 KB/sec when using compression). This model attaches via a SCSI adapter.

- Model 005

  The model 005 offers 4.0GB native cartridge capacity (up to 8GB when using compression). The data transfer rate is 400 KB/sec (up to 800 KB/sec when using compression). This model attaches via a SCSI-2 adapter.

#### A.3.1.2 IBM 7207

The 7207 is a standalone 0.25" longitudinal technology tape device (longitudinal technology is explained in 2.2.3, “Tape Storage” on page 34). All models attach to the system via a SCSI adapter, and none support compression. The 7207 attaches to all models of the RS/6000 and can be mounted inside.

There are three models:

- Model 001

The model 001 provides a maximum data transfer rate of 90KB/sec, and a maximum storage capacity of 150MB.

- Model 011

  The model 011 provides a maximum data transfer rate of 200KB/sec, and a maximum storage capacity of 525MB.

- Model 012

  The model 012 provides a maximum data transfer rate of 300KB/sec, and a maximum storage capacity of 1.2GB.

#### A.3.1.3 IBM 7208

The 7208 is a standalone 8mm helical scan tape device (helical scan technology is explained in 2.2.3, "Tape Storage" on page 34). The 7208 attaches to the system via a single-ended SCSI-2 adapter. Data compression is provided using the IBM IDRC (Improved Data Recording Capability) algorithm.

There is one model currently available for attachment to the RS/6000. The model 011 supports a sustained data transfer rate of 500KB/sec, and cartridge capacity of 5.0GB. With compression, data rates and capacities of up to 1MB/sec and 10GB respectively are achievable. The model 011 is supported on all models and may be mounted internally in the 500 and 900 series.

#### A.3.1.4 IBM 9348

The 9348 is a standalone 0.5" reel, longitudinal technology tape device (longitudinal technology is discussed in 2.2.3, "Tape Storage" on page 34). Tape recording densities of 1600 and 6250 bits per inch are supported with a data rate of 200KB/sec at 1600bpi, and a maximum data rate of 781 KB/sec at 6250bpi. The unit autoloads and autothreads tape reels, and attaches via a single-ended SCSI interface to the system unit. Reel data capacities are 40MB at 1600bpi, and 160MB at 6250bpi. There is only one model attachable to the RS/6000, the model 012, though the unit can be mounted in a rack.

#### A.3.1.5 IBM 3490

The 3490 includes a family of 0.5" longitudinal technology tape devices (longitudinal technology is explained in 2.2.3, "Tape Storage" on page 34). There are two basic components, the tape string controller and the tape devices themselves. The tape devices can be either 18 track or 36 track, and contain either two or four physical drives, each with a cartridge loader. The control units attach via SCSI-2 differential fast/wide, S/370* channel, or ESCON, depending upon the model. All models use the Improved Data Recording Capability (IDRC) algorithm to provide data compression.

As has been mentioned, there are various models, summarized below:

- Controllers
  - A0X Models

    The A01 supports 1 x 18 track tape device (B02 or B04). The A02 supports 2 x 18 track tape devices (B02 or B04).

  - AX0 Models

    The A10 supports 1 x 36 track tape device (B20 or B40). The A20 supports 2 x 36 track tape devices (B20 or B40).

All of these controllers attach to the host via ESCON or System/370 channel.

- Devices
  - B0X Models

    The B02 and B04 are both 18 track tape devices. Both support a data rate of 3MB/sec and a tape capacity of 200MB. The B02 has two physical drives, whil the B04 has four. All drives have cartridge loaders containing up to six cartridges.
  - BX0 Models

    The B20 and B40 are both 36 track tape devices. Both support a data rate of 3MB/sec and a tape capacity of 400MB. The B20 has two physical drives, whilst the B40 has four. All drives have cartridge loaders containing up to six cartridges.
- Combined Controller/Devices
  - CXX Models

    The C11 and C22 both support a single 36 track tape device, though the C11 supports a single physical drive, whilst the C22 supports two physical drives. Both models support a data rate of 3MB/sec, and a cartridge capacity of 400MB. Each physical device has a standard six cartridge ACL (Automatic Cartridge Loader). Attachment to the host is via ESCON, S/370 Channel, or SCSI-2 differential fast/wide.
  - EXX Models

    The E01 and E11 models both support maximum throughput of 3MB/sec, and a maximum uncompressed capacity of 5.6GB (these units support a 7 cartridge ACL). With compression, this capacity increases to 16.8GB, and the throughput to 6.5MB/sec. Both units attach to the host via a SCSI-2 differential or SCSI-2 differential fast/wide adapter. The E01 is the table top version of the E11 rack mounted model.

## A.3.2 Tape Libraries

The following tape libraries are available.

### A.3.2.1 Exabyte EXB-10e

The Exabyte tape library (IBM model number 0840-001) combines an 8mm helical scan technology device with a 10 cartridge autoloader. The cartridges fit into a removable magazine that offers up to 50GB of storage without compression (up to 100GB can be achieved using the compression feature); the sustained data rate is 500MB/sec, and can reach 1.0MB/sec with compression. Attachment to the system is via a SCSI-2 adapter.

The library has the following performance figures:

- Cartridge access time 24 seconds average
- Cartridge load/unload 25 seconds nominal
- Cartridge read/write 167 minutes
- File search time 136 seconds maximum

This product is supported by ADSM, Legato, and Unitree storage management products. These products are discussed briefly in Appendix B, “Higher Level Storage Management Products” on page 341.

#### A.3.2.2 Lago LS/380L DataWheel

The Lago Systems LS/380L DataWheel** tape library (IBM model number 0562-001) combines two 8mm helical scan technology tape devices with a 54 cartridge removable carousel and loader. The unit offers up to 270GB of data storage in uncompressed form (up to 540GB compressed). The DataWheel attaches to the system unit via a SCSI-2 adapter for both tape drives and the autoloader. An RS232 interface for control of the autoloader is also provided, if required by the software using the device. Peak data transfer rate is 4MB/sec, sustained transfer is 500KB/sec (uncompressed).

The Lago DataWheel has the following characteristics:

- Maximum cartridge search time 136 seconds
- Average file access time 0.75 seconds
- Interchangeable carousels
- Two independent tape drives and loader mechanisms

This product is supported by ADSM, UniTree, and Legato storage management products. These products are described briefly in Appendix B, “Higher Level Storage Management Products” on page 341.

#### A.3.2.3 IBM 3494-L10

The 3494 L10 is a single unit that combines a control unit with the automated cartridge loaders, a library manager, the tape devices, and the storage cells for the 0.5" tapes. The cartridge capacity for the unit depends upon whether the optional convenient I/O station for the library is installed or not. Without the I/O station, 240 cartridges can be stored, with it, 210. The I/O station allows cartridges to be easily added and removed from the subsystem. Storage units can be added to the subsystem, each of which provides capacity for 400 further cartridges. Up to seven units can be added to the first, of which up to three may be further drive units, and up to seven may be storage units. The drive units contain either C1A or C2A tape devices, and 300 cartridges. The C1A has a single tape drive, and the C2A has two. The maximum number of drives possible is therefore eight, with 2740 cartridges (one control unit, three drive units, and three storage units). The maximum number of cartridges is 3040, with two tape drives (one control unit, and seven storage units). This gives a maximum storage capacity of 2.4TB uncompressed, 7.2TB compressed. The CXX tape devices support 36 track bi-directional recording.

The C1A and C2A are analogous to the C11 and C22 devices mentioned in A.3.1, “Tape Devices” on page 334. Attachment to the system is via ESCON, System/370 channel, or SCSI-2 differential fast/wide.

The 3494 is supported by the ADSM storage management product which is briefly discussed in Appendix B, “Higher Level Storage Management Products” on page 341.

#### A.3.2.4 IBM 3495

The 3495 tape library dataserver utilizes the 3490 tape subsystem technology inside an enhanced automated library, along with a library manager. The subsystems attach to the host in the same way as discussed in the section on 3490 tape devices (see A.3.1, "Tape Devices" on page 334).

There are several models, each providing different levels of tape storage capacity:

- Model L20

  This model has an actual cartridge capacity of from 5660 to 6440. This gives theoretical storage capacity of 13,584 to 15,456GB.

- Model L30

  This model has an actual cartridge capacity of from 8,480 to 10,590. This gives theoretical storage capacity of 20,352 to 25,416GB.

- Model L40

  This model has an actual cartridge capacity of from 11,300 to 14,750. This gives theoretical storage capacity of 27,120 to 35,400GB.

- Model L50

  This model has an actual cartridge capacity of from 14,120 to 18,910. This gives theoretical storage capacity of 33,888 to 45,474GB.

- Model M10

  This model has an actual cartridge capacity of 100,000. This gives theoretical storage capacity of 240,000GB (Wow).

## A.4 Optical Storage Products

The following optical storage components are available for attachment to the RS/6000.

### A.4.1 Optical Devices

The following optical devices are available.

#### A.4.1.1 IBM 7209

The 7209 is a standalone external read/write optical disk drive. Optical technology is discussed in 2.2.4, "Optical Storage" on page 39. The 7209 drive has a single read/write head which means that only one side of the single optical cartridge supported by the drive can be accessed at a time. In order to access the other side, the cartridge must be physically removed and turned over by an operator. The 7209 uses a 5.25" double sided optical cartridge with a capacity of 595MB of data per side at a sector size of 512 bytes. Attachment to the host is via a single-ended SCSI adapter and the data transfer rate is 1424KB/sec.

#### A.4.1.2 IBM 7210

The 7210 is a self powered external CD-ROM device supporting a single 600MB optical read only disk. Optical technology is discussed in 2.2.4, "Optical Storage" on page 39. Average access times to files on the CD-ROM range from 200ms to 380ms, with data transfer rates of from 150KB/sec to 330KB/sec depending upon the model. Attachment to the system is via a single-ended SCSI adapter.

There are two models:

- Model 001

  The model 001 has an average access time of 380ms, and supports a data rate of 150KB/sec.

- Model 002

  The model 005 has an average access time of 200ms, and supports a data rate of 330KB/sec.

Both models are available for mounting inside the system.

## A.4.2 Optical Libraries

The following optical libraries are available.

### A.4.2.1 IBM 3995 Optical Library Dataserver

The 3995 combines multifunction optical drives (the number of drives depends upon the model) with an automated picker and optical cartridge storage to provide access to up to 376GB (unformatted) of optical storage. The 3995 models all support both read/writeable as well as WORM optical technology on both single sided and double sided 5.5" cartridges. Optical technology is discussed in 2.2.4, “Optical Storage” on page 39. There are 4 types of cartridge:

- 1.3GB at 1024 bytes per sector (double sided)
- 650MB at 1024 bytes per sector (single sided)
- 1.19GB at 512 bytes per sector (double sided)
- 595MB at 512 bytes per sector (single sided)

There are three models directly attachable to the RS/6000:

- Model A63

  The 3995-A63 supports up to 16 optical cartridges giving a maximum total unformatted capacity of 20GB of data. The unit contains a single multifunction optical drive and attaches to the host system via either a SCSI-2 or SCSI-2 differential adapter.

- Model 063

  The 3995-063 supports up to 32 optical cartridges giving a maximum total unformatted capacity of 40GB of data. The unit contains two multifunction optical drives, and attaches to the host system via either a SCSI-2 or SCSI-2 differential adapter.

- Model 163

  The 3999 163 supports up to 144 optical cartridges giving a maximum total unformatted capacity of 188GB of data. The unit contains four multifunction optical drives and attaches to the host system via a SCSI-2 differential adapter.

Maximum data rates for the 3995 model optical drives are the same as for the IBM 7209 optical drive described in A.4.1.1, “IBM 7209” on page 338.

# Appendix B. Higher Level Storage Management Products

This appendix is intended to provide an overview of some of the higher level storage management products available. The products will be compared in terms of function and positioning.

The main areas in which higher level tools provide enhanced function are:

1. Automation

   The provision of mechanisms to define when information should be backed up, archived or migrated, and what information should be selected. This allows the defined operations to be scheduled as required without the need for operator intervention.

2. Backup/restore

   The ability to create copies of a client system's vital data, so that in the event of a failure, the client can be restored to the same state that it was at the time of the last backup.

3. Archive/retrieve

   The ability to free up space at the client system by moving or archiving infrequently accessed information from the client to the archive storage space (usually at a server machine). If the information is required again, it can be retrieved from the archive.

4. Migration

   The ability to structure the storage subsystems in such a way that elements of the subsystem are used in the most efficient fashion. For example, frequently accessed information, or information requiring high performance access should be stored in fast storage (usually disk). Information that is less frequently accessed should be moved to less expensive, lower performance, higher capacity media such as optical; this should happen automatically if possible, thereby freeing up space in the much in demand fast storage. If the second level of storage (that used by the first movement, or migration) of information becomes full, or for information that is accessed even more rarely, a third level could be defined of even higher capacity, cheaper, slower media, such as tape.

   Levels in the hierarchy should also be accessible for specific purposes; for example, backups, or long term archives would be best stored in the tape level.

5. Disk space utilization

   A mechanism by which disk space on a client can be utilized more efficiently. This is usually implemented by using the client disk as a cache, and maintaining the full information space at a server. When data is requested by an application on the client, it can be transparently copied to the client cache - clients see the cache to be as large as the information space at the server.

   This can be used in conjunction with the capabilities mentioned in the previous points. The server information space can be treated as a level in a storage hierarchy, thereby increasing efficiency further. The space can also be backed up more easily.

6. Central management

The facility to manage the above capabilities from a central point, thereby minimizing the effort, and maximizing the efficiency.

7. Ease of use

   Provision of ergonomic interfaces to both the server and client functions. For example, the ability to define backup and restore policies for every client system in a network centrally, through a graphical user interface; from the client point of view, being able to simply specify the required files for backup/restore or archive/retrieve, again through a graphical user interface, and have the requests automatically processed.

8. Platform support

   The range of operating systems and hardware platforms across which the higher level application can operate.

The tools discussed below will be compared against the above points to enable a reasonable comparison to be drawn.

Other points for consideration include:

- Security

  Consideration of access security from clients to the server, and from any administrative components.

- Performance

  Consideration of the amount of time taken for backups or archive; usually related to the performance of the physical devices supported, the network protocols used, and whether concurrency is supported (multiple simultaneous client access).

- Device support

  Relating to the range of devices supported by the product, and their capabilities.

- Scalability

  What range of client support is available. Does the product support environments ranging from small workgroups of common machines through to large, complex networks of multiple system types?

- API provision

  Provision of an Application Programming Interface to allow other products to make use of the services provided by the storage management tool. Allowing applications such as databases for example to utilize storage managers to automatically backup information.

## B.1 ADSTAR Distributed Storage Manager

ADSM is a client/server based hierarchical storage manager that allows for centrally managed and scheduled, automated, network based backup and archive function. Both server and client components are supported across a wide range of platforms. An administrator component provides for local or remote configuration and management of the operation of ADSM via a command line or graphical user interface.

1. Automation

ADSM provides a scheduling function that allows backups/restores and archive/retrieves to be executed automatically by the server at the requested times. This means that the client systems can be backed up overnight for example, or at times when impact on user productivity is minimal.

2. Backup/restore

   Clients can have all of their vital data backed up across a network to the server storage automatically on a regular basis. Users can also issue manual backup requests for directory trees, directories, or even individual files if required. In the event of loss of data, the backed up information can be restored (in the event of complete loss for example) or requested directories or files can be individually restored at user request.

   ADSM also supports a large range of backup methods including full, incremental and selective, as well as policy based.

3. Archive/retrieve

   In the same way as backups and restores are implemented, archival and retrieval operations can be arranged. In the case of both backup and archive (if authorized), users can select the storage pool to which their backup/archive is directed.

4. Migration

   Storage at the server is organized into storage pools of similar device types (disk, tape, and optical). These pools can be linked into a hierarchy if required, and criteria set for movement (migration) of information down the hierarchy. For example the top level of a hierarchy may be comprised of a disk pool, the second layer optical, and the third tape. If the first pool approaches a preset capacity limit, ADSM will automatically migrate information to the next pool down to free up space. If a migrated file is requested, it is automatically copied from its location in the hierarchy to the requesting client.

5. Disk space utilization

   Client disk space utilization is not managed by ADSM at the current release, although a future release will provide this function.

6. Central management

   All of the functions provided by the server and all of the data storage is maintained centrally, and thus easily managed. An administrative component provides the capability to monitor and configure ADSM, either locally at the server, or remotely from any supported administration client machine in the network.

7. Ease of use

   ADSM provides command line and graphical user interfaces for both the administrative and client components. This maximizes ease of use, as menus present the available options, and icons depict the current configurations. The learning curve is consequently shorter, and productivity higher. Availability of the graphical user interface is dependant upon the platform; some platforms only support the command line interface for example.

8. Platform support

   The server component is supported under AIX, OS/2*, OS/400*, MVS and VM. ADSM for VSE is announced, and there is a statement of direction for ADSM/HP and ADSM/SUN.

The client component is supported under DOS, Microsoft Windows, OS/2, AIX, HP/UX**, SunOS**, DEC ULTRIX**, SCO 386 UNIX**, MAC, and Novell Netware**.

The administrative component is supported on DOS, Microsoft Windows, OS/2, AIX, HP/UX, SunOS, DEC ULTRIX, SCO 386 UNIX, TSO, and CMS.

## B.2 AIX File Storage Facility/6000

FSF/6000 is a client/server based storage manager that provides automated disk space management services to clients. Client disk space is managed by utilizing administrator defined policies to remove files from the client disk to maintain free space. The removed files are actually copied to the server and are transparently returned when required.

1. Automation

   FSF maintains a designated area of the clients disk as cache. Information created within this cache can be automatically maintained by FSF/6000. Data can be migrated on the basis of size, time since last access, or it can be pinned into the cache if it is regularly accessed. Information requested that has been removed from the cache to free up space is automatically and transparently copied back to the cache.

2. Backup/restore

   FSF does not provide this function.

3. Archive/retrieve

   FSF does not provide this function.

4. Migration

   FSF does not provide this function, although it can be configured to work with ADSM, with the FSF server using an ADSM storage pool as its client file space (location to maintain copies of client information). In this case, ADSM could automatically migrate information from the filespace when it approached a capacity threshold.

5. Disk space utilization

   As outlined in the section on automation, FSF manages disk space on behalf of clients. It does this by maintaining remote copies of any information created in the managed area of the clients storage at the server, either using NFS, or ADSM to do so (see 3.1.4.2, “Network File System” on page 61 for a brief explanation of NFS). When space becomes critical in the cache, local copies of the information are deleted using size or last access as selection criteria, thereby maintaining free space. For performance reasons, very frequently accessed files can be pinned locally (this prevents the file from being deleted, although a copy is always kept at the server).

6. Central management

   Client data is usually maintained at the FSF server location, but could be located on an NFS mounted directory from another machine. In the sense that all configuration must be done at the server though, FSF is centrally maintained, but only from the server.

7. Ease of use

Configuration and management of FSF is performed via SMIT menus. Actual usage should be transparent.

8. Platform support

   FSF/6000 is only supported under AIX.

## B.3 Legato NetWorker for RISC System/6000

Legato Networker** is a client/server based product that provides automated backup services in a networked environment. Networker client and server components are supported across a range of platforms.

1. Automation

   Backup operations can be scheduled at the server to take place when required.

2. Backup/restore

   Legato Networker provides backup/restore services to clients in a networked environment. Up to 12 different backup types may be scheduled:

   a. Full backup

      All files at the client are backed up

   b. Levels 1 through 9

      All files that have changed since a previous full (level 0) backup or since a previous lower level backup. For example, if a level 4 backup is scheduled for Monday night, then only files that have changed since the last level 0, 1, 2, or 3 backup will be backed up.

   c. Incremental backup

      All files that have changed since last backup, regardless of level, are backed up.

   d. Backup from client

      This level allows a backup to be skipped at a given time; for example, if a backup from client is scheduled for Saturday night, using this option will prevent that backup from occurring.

3. Archive/retrieve

   Legato Networker does not provide this function.

4. Migration

   Legato Networker performs backups directly to tape or optical devices. The concept of a hierarchy is not defined.

5. Disk space utilization

   Legato Networker does not provide this function.

6. Central management

   A command line and graphical user interface based administrative component is provided that allows Networker to be configured, managed, and monitored from any client in the network.

7. Ease of use

Initial setup and configuration of Legato is manual, however once setup, the graphical administrative component can be used to manage the product. There is no requirement for client interaction, so no interface is provided to the client components; the code for clients is accessed via NFS, or locally on disk, setup is manual.

8. Platform support

   The server component is supported under AIX.

   Client support is provided for AIX, Novell Netware, DOS, SunOS, Sony** NEW-OS, HP/UX, DEC ULTRIX, RISC/os, and SGI IRIX.

## B.4 UniTree for RISC System/6000

UniTree** is a client/server based hierarchical storage manager that provides centrally managed, automated hierarchical storage management in a networked environment.

1. Automation

   Similarly to FSF/6000, UniTree will automatically perform migration of client data within the UniTree file system down the defined hierarchy of storage devices, based on configurable criteria. When data is requested by a client, UniTree can transparently retrieve the information from the lower level in the hierarchy, and make it available to the requesting client.

2. Backup/restore

   UniTree does not provide backup/restore services for clients.

3. Archive/retrieve

   As with FSF/6000, UniTree provides remote access to a managed file system for clients. The file system space is maintained through automatic archival of files based upon configurable criteria (such as access frequency and size). When data is required by a client, it is transparently recovered from its place in the hierarchy.

4. Migration

   UniTree defines a hierarchy of storage devices, similar to ADSM, with faster, more expensive media such as disk at the top, moving down to slower, larger capacity, cheaper media at the bottom. Information is migrated down the hierarchy as described in the previous two sections thus ensuring that the most frequently accessed information is available on the fastest devices.

5. Disk space utilization

   Disk space utilization is maximized at the server, as automatic archival through migration ensures that there is always free space available. This does of course depend upon there being enough free space lower down the hierarchy for migration to succeed.

6. Central management

   The storage hierarchy is administered at the server, though all configuration and management is via SMIT. Each client utilizes the services provided via NFS (see 3.1.4.2, "Network File System" on page 61 for a brief description of NFS), or FTP.

7. Ease of use

Server management and administration is achieved via SMIT, and is therefore performed on the server machine. Client access to the UniTree file systems is via NFS or FTP, and should be transparent to the user. Likewise, migration and archival/retrieval of information is performed automatically and should be transparent.

8. Platform support

   The server is supported under AIX.

   Client platforms supported with the AIX server include SUN, DEC, SGI, HP and AT&T**.

# Appendix C. General Volume Group Recovery

This appendix contains examples of possible recovery techniques for various potential failures. The examples are presented *as is*, with no guarantee, and should be used only if the problem is fully understood.

Unlike the examples in Chapter 8, “Practical Examples” on page 185 that were executed in an AIX Version 4 environment, the examples here are presented in an AIX V3.2 environment. Hence, although the recovery principles are similar for AIX Version 4 and AIX V3.2, some modifications of the following procedures may be required.

## C.1 Disk Power Supply Failure

Scenario: System has two volume groups, rootvg and vg00. Volume group vg00 has an external disk drive, hdisk4. The power supply fails on hdisk4, the disk media itself is not harmed.

- Make hdisk4 unavailable

  1. Remove PV from the VG:

     ```
     # chpv -vr hdisk4
     ```

  2. Remove the disk from the system configuration:

     ```
     # rmdev -l hdisk4
     ```

  3. Repair the power supply.
  4. Add the disk back into the system configuration:

     ```
     # mkdev -l hdisk4
     ```

  5. Activate the PV in the VG:

     ```
     # chpv -v a hdisk4
     ```

  6. PV is still not active?

     ```
     # lsvg -p vg00
     vg00:
     PV_NAME       PV STATE          TOTAL PPs  FREE PPs ...
     hdisk2        active            75         60
     hdisk3        active            75         55
     hdisk4        missing           75         50
     ```

  7. Activate missing PV:

```
# varyonvg vg00
```

8. Synchronize stale partitions on disk:

```
# syncvg -p hdisk4
```

## C.2 General Disk Failure

Scenario: System has two volume groups, rootvg and vg00. A disk in vg00 fails and must be replaced. The disk name is hdisk5. The LVs on hdisk5 are: /dev/lvpat, /home/pat, /dev/lvcad, and /cad (mirror copy).

- Removing a failed PV

  1. Remove the PV from the VG:

  ```
  # chpv -v r hdisk5
  ```

  2. Unmount all single-copy file systems on the disk:

  ```
  # umount /home/pat
  ```

  3. Remove all single-copy file systems on the disk:

  ```
  # rmfs /home/pat
  ```

  4. Remove physical partition copies from the disk:

  ```
  # rmlvcopy lvcad 1 hdisk5
  ```

  5. Remove the disk from the VG:

  ```
  # reducevg -df vg00 hdisk5
  ```

  6. Delete the disk from the system configuration:

  ```
  # rmdev -d -l hdisk5
  ```

- Remove and replace hdisk5

  1. Configure the new disk into the system:

  ```
  # cfgmgr          (or an IPL)
  ```

2. Add the disk to the VG:

```
# extendvg vg00 hdisk5
```

3. Remake LVs and file systems:

```
# mklv -t jfs -y lvpat vg00 5 hdisk5
# crfs -v jfs -d lvpat -m /home/pat
```

4. Extend multiple-copy LVs onto disk:

```
# mklvcopy lvcad 2 hdisk5
```

5. Resynchronize copied physical partitions:

```
# syncvg -p hdisk5
```

- Restore data from backup for single-copy file systems

## C.3 Recovery After a Disk Is Replaced -- 1

Scenario: System has two volume groups, rootvg and vg00. Volume group vg00 contains three drives, hdisk1, hdisk2 and hdisk3. hdisk3 failed and has been replaced prior to any clean up. The LVs on hdisk3 are:

```
/dev/lvpat    /home/pat
/dev/lvca     /cad (mirror copy)
```

- VG information is in error

1. Run `lsvg` command to get VG status:

```
# lsvg -p vg00
PV_NAME          PV STATE      TOTAL PPs     FREE PPs  FREE DISTRIB.
hdisk1           active        75            59        15..01..13..15..15
hdisk2           active        84            65        17..06..08..17..17
0516-304 lsvg:  Unable to find device id 000045af344545ef in the
        Device Configuration Database
000045af344545ef missing       95            4         03..01..00..00..00
```

2. `reducevg` command produces errors:

```
# reducevg vg00 hdisk3

0516-022 ldeletepv: Illegal parameter or structure value.

0516-884 reducevg: Unable to remove physical volume hdisk3.
```

3. `lspv` does not show removed `hdisk3`:

```
# lspv
hdisk0      0000457a839d9efe    rootvg
hdisk1      00004224dce3930a    vg00
hdisk2      0000175005450a7f    vg00
hdisk3      00000601c3a717a4    none
```

4. `lqueryvg` still lists `hdisk3` as being part of `vg00`:

```
# lqueryvg -p hdisk1 -At

Max LVs:                256
PP Size:                22
Free PPs:               192
LV count:               6
PV count:               3
Total VGDAs:            3
Logical:        00001750ed06a88b.1     paging00    1
                00001750ed06a88b.2     lvpat       1
                00001750ed06a88b.3     loglv00     1
                00001750ed06a88b.4     lvcad       1
Physical:       0000175005450a7f       1           0
                00004224dce3930a       1           0
                000045af244545ef       1           0
```

- To recover

1. Remove all single-copy file systems on the disk:

```
# rmfs /home/pat
```

2. Remove LV mirror copies from the disk:

```
# rmlvcopy lvcad 1
```

3. Delete the PV from the VG in the VGDA:

```
# ldeletepv -g 00001750ed06a88b -p 000045af244545ef
```

4. Delete the PV from the VG in the ODM:

```
# odmdelete -q "value like '000045af244545ef*'" -o CuAt
```

5. Save new ODM information to boot logical volume:

```
# savebase
```

## C.4 Recovery After a Disk Replaced -- 2

Scenario: System has two volume groups, rootvg and vg00. Volume group vg00 has three disk drives in it, hdisk1, hdisk2 and hdisk3. hdisk3 failed and has been replaced prior to any clean up. Don't know what LVs were on hdisk3.

- VG information is erroneous
  1. System has been rebooted.
  2. `lsvg` command produces errors.

```
# lsvg -p vg00
PV_NAME       PV STATE      TOTAL PPs     FREE PPs  FREE DISTRIB.
hdisk1      active  75      59      15..01..13..15..15
hdisk2      active  84      65      17..06..08..17..17
0516-304 lsvg:  Unable to find device id 000045af344545ef in the
        Device Configuration Database
000045af344545ef        missing       95        4 03..03..00..00
```

  3. `reducevg` command produces errors:

```
# reducevg vg00 hdisk3

0516-022 ldeletepv: Illegal parameter or structure value.

0516-884 reducevg: Unable to remove physical volume hdisk3.
```

  4. `lspv` does not show the removed hdisk3:

```
# lspv
        hdisk0      0000457a839d9efe    rootvg
        hdisk1      00004224dce3930a    vg00
        hdisk2      0000175005450a7f    vg00
        hdisk3      00000601c3a717a4    none
```

  5. `lqueryvg` still lists `hdisk3` as being part of vg00:

```
# lqueryvg -p hdisk1 -At
Max LVs:                256
PP Size:                22
Free PPs:               192
LV count:               6
PV count:               3
Total VGDAs:            3
Logical:        00001750ed06a88b.1     paging00    1
                00001750ed06a88b.2     lvpat       1
                00001750ed06a88b.3     loglv00     1
                00001750ed06a88b.4     lvcad       1
Physical:       0000175005450a7f       1           0
                00004224dce3930a       1           0
                000045af244545ef       1           0
```

- Various LVM commands produce the following:

```
# lsps -a
Page Space  Physical Vol   Vol Group   Size   %Used   Active  Auto
0516-304  : Unable to find device id 000045af244545ef in the Device
  Configuration Database.
hd6         hdisk0         rootvg      64B     2      yes     yes         yes


# lspv -l hdisk3
0516-320  : Physical volume 000045ab34dd34ab is not assigned to a
        volume group.
```

- Try to remove via `ldeletepv`:

```
# ldeletepv -g 00001750ed06a88b -p 000045af244545ef
0516-016 ldeletepv: Cannot delete physical volume with allocated
        partitions.  Use either migratepv to move the partitions or
        reducevg with the -d option to delete the partitions.
```

- Which LVs are on hdisk3?

  1. The `lspv` command fails:

```
# lspv -l hdisk3
0516-320 :  Physical volume 00000601c3a717a4 is not assigned to a
        volume group.
```

  2. Use `lquerypv` command:

```
# lquerypv -p 000045af244545ef -g 00001750ed06a88b -dt | pg
  :
  :
PVMAP: 000045af244545ef:1   0  ODMTYPE 000000000000000.0  0
0000000000000000:0    000000000000000:0
  :
  :
PVMAP: 000045af244545ef :21  0  ODMTYPE 00001750ed06a88b.1 0
000000000000000:0  000000000000000:0
PVMAP: 000045af244545ef :22  0  ODMTYPE 00001750ed06a88b.4 0
000000000000000:0   000000000000000:0
PVMAP: 000045af244545ef :23  0  ODMTYPE 00001750ed06a88b.4 0
000000000000000:0   000000000000000:0
PVMAP: 000045af244545ef :24  0  ODMTYPE 00001750ed06a88b.2 0
000000000000000:0   000000000000000:0
  :
  :
```

- From `lqueryvg` and `lquerypv` determine which LVs were on `hdisk4`
  - lvpat (part on hdisk4 part on hdisk3)
  - lvcad (mirrored LV, only a copy on hdisk4)
  - paging00 (paging space all on hdisk4)
- Remove the LVs from hdisk4:

```
# rmlvcopy lvcad 1
# rmfs /home/pat

# rmps paging00
0517-062 rmps: Paging space paging00 is active
0517-061 rmps: Cannot remove paging space paging00
```

- How to remove the paging space:

  Edit /etc/swapspaces and remove the paging00 stanza:

```
paging00:
        dev = /dev/paging00
```

  Reboot.

```
# rmps paging00
rmlv: Logical volume paging00 is removed
```

- Remove the disk from the volume group:

```
# ldeletepv -g 00001750ed06a88b -p 000045af244545ef
0516-010 ldeletepv: Volume group must be varied on: use varyon
        command
```

  The volume group is varied on????

```
# lchangepv -g  00001750ed06a88b -p 000045af244545ef -r2
# ldeletepv -g 00001750ed06a88b -p 000045af244545ef
```

- Remove information from ODM:

```
# odmdelete -q "value like '000045af244545ef*'" -o CuAt
```

- Rebuild LVM configuration:

```
# extendvg vg00 hdisk3
# mklvcopy lvcad 2 hdisk3
# mklv -t jfs -y lvpat vg00 5 hdisk3
# crfs -v jfs -d lvpat -m /home/pat
# mkps -s 10 -n -a vg00 hdisk3
```

- Re-sync mirrored copies:

```
# syncvg -p hdisk3
```

## C.5 Disk Failure Recovery -- rootvg

Scenario: System has two disks in rootvg, hdisk0 and hdisk1. Most of the operating system is on hdisk0. hdisk0 fails and there is data on hdisk1 that needs be recovered. The logical volumes on hdisk1 are:

```
/dev/lv0      /home/cad1
/dev/lv01     /home/wordper
/dev/loglv00  log logical volume
```

- Accessing data in rootvg

  A jfslog logical volume must be on hdisk1:

  1. Boot from maintenance diskettes or tape. *NEVER import disks from the rootvg except in maintenance mode!*
  2. Select **Start a limited function maintenance shell**
  3. Import the rootvg from an available disk:

     ```
     # importvg -y rootvg hdisk1
     ```

  4. Vary on the VG without a quorum:

     ```
     # varyonvg -f -n rootvg
     ```

  5. Check and clean all available file systems:

     ```
     # fsck -y -V jfs /dev/lv00
     # fsck -y -V jfs /dev/lv00
     ```

  6. Mount first file systems:

     ```
     # mount -o log=/dev/loglv00 /dev/lv00 /mnt
     ```

  7. Backup user data:

     ```
     # cd /mnt
     # for i in ./* ./*/* ./*/*/*
     > do
     > echo $i
     > done | pax -wvf/dev/rmt0
     ```

     **Note:** This requires that you know the number of levels of subdirectories

  8. Unmount first file system, then mount second:

     ```
     # umount /mnt
     # mount -o log=/dev/loglv00 /dev/lv01 /mnt
     ```

  9. Backup user data:

```
# cd /mnt
# for i in ./* ./*/* ./*/*/*
> do
> echo $i
> done | pax -wvf/dev/rmt0
```

**Note:** This requires that you know the number of levels of subdirectories.

## C.6 Disk Failure -- rootvg

Scenario: System has four disks in the rootvg. LVs hd1, hd2, hd3, hd4 hd6 and hd6 are on hdisk0. The LV hd9var is on hdisk1. Other user LVs are 1, on hdisk1, hdisk2 and hdisk3. hdisk1 and hdisk2 fail, system now boots ot to 552 (cannot varyon the rootvg due to lack of quorum).

- Boot from diskette, choose option 4, **Start a limited function maintenance shell**:

```
# getrootfs hdisk0
0516-052 varyonvg: Volume group cannot be varied on without a
        quorum.  More physical volumes in the group must be active
        Run diagnostics on inactive PVs.
0516-780  importvg: Unable to import volume group from hdisk0.
```

- `getrootfs` does not do an `importvg -f`
- Change `getrootfs` -- From maintenance shell:

```
# importvg -fy rootvg hdisk0

PV Status:      hdisk0      000005960941e8c2            PVACTIVE
                hdisk1      0000175005450a7f            NONAME
                hdisk2      00000330ecb0948f            NONAME
                hdisk4      0000188edb0944dd            PVACTIVE
varyonvg: Volume group rootvg is varied on
0516-510 updatevg: Physical volume not found for physical volume
        identifier 0000175005450a7f.
0516-510 updatevg: Physical volume not found for physical volume
        identifier 00000330ecb0948f.
0516-548 synclvodm: Partially successful with updating volume
        group rootvg.
0516-782 importvg Partially successful importing of hdisk0 and hdisk4.

# varyonvg -fn rootvg
PV Status:  hdisk0  000005960941e8c2            PVACTIVE
                hdisk1      0000175005450a7f            NONAME
                hdisk2      00000330ecb0948f            NONAME
                hdisk4      0000188edb0944dd            PVACTIVE
varyonvg: Volume group rootvg is varied on.
```

- Now to change the `getrootfs` script from `importvg -y rootvg $disk` to `importvg -fy rootvg $disk`.

  1. Copy the required commands to the root file system:

```
# fsck /dev/hd2
# fsck /dev/hd4
# mount /dev/hd4 /mnt
# mount /dev/hd2 /mnt/usr
# cd /mnt/usr/bin
# cp sed /mnt/mysed
# cp chmod /mnt/mychmod   (Don't copy to /mnt/sed & /mnt/chmod)
# sync; sync
```

2. Reboot to maintenance mode:

```
# fsck /dev/hd4
# mount /dev/hd4 /mnt
# cp /mnt/mysed /usr/sbin/sed
# cp /mnt/mychmod /usr/sbin/chmod
```

3. Change the `getrootfs` script:

```
# cd /usr/sbin
# cat getrootfs | sed "s/importvg -y rootvg/importvg -fy rootvg/" >myfs
# chmod 777 myfs
# umount /mnt
```

4. Run new `myfs` script:

```
# myfs hdisk0    (whole bunch of messages)
# mount

node    mounted       mounted over   vfs    date     options
----    -------       ------------   ---    ----     -------
        /dev/ram0     /              jfs    Oct 14   rw
        /dev/hd4      /              jfs    Oct 14   rw...
        /dev/hd2      /usr           jfs    Oct 14   rw...
        /dev/hd3      /tmp           jfs    Oct 14   rw...
```

- Make changes to allow normal boot:

1. In /etc/filesystems comment out the lines in the /var stanza `type=bootfs` and `mount = automatic`. Comment character is `*`.

```
# mkdir /var/tmp
# TERM="whatever type terminal you are using"
# export TERM
# vi /etc/filesystems
```

2. In /sbin/rc.boot change the following:
   - Add a `sleep 1` before line `fsck -fp /var`
   - Comment out line `fsck -fp /var`

   On 3.2.4 or later also comment out lines:
   - `/../etc/mount -f /var`
   - `[ "$?" -ne 0 ] && loopled 0x518`

3. Run `bosboot` command:

```
# bosboot -a -d/dev/hdisk0
# shutdown -F
```

- Boot in normal mode

## C.7 Recovering after Losing VGDA

Scenario: System had a volume group vg00. Volume group vg00 included hdisk2 and hdisk3. hdisk2 failed and VGDA is broken on hdisk3.

- Create new volume group on hdisk3:

```
# mkvg -y newvg hdisk3
```

- Create LVs on hdisk3 over previous LVs:

```
# mklv -m /home/mapfile3.a -t jfs -y lv00
# mklv -m /home/mapfile3.b -t jfs -y lv01
# mklv -m /home/mapfile3.c -t jfs -y lv02
# mklv -t jfslog -y loglv00 newvg 1 hdisk3
# logform /dev/loglv00
```

- But wait, where do I get the /home/mapfile3.* files?
  - Save physical volume map information prior to daily backups:

```
# for i in  lspv | cut -f1 -d" "
> do
>    lspv -M $i > /home/map.$i
> done
```

  - Map file is created from PV map information.

    Format: PVname:PPnum1[2]

```
# cat map.file
        hdisk1:1-10
        hdisk1:23
        hdisk1:33
```

- Without map files, there is *no* way to recover
- Create entries in /etc/filesystems for new LVs:

```
# cat /etc/filesystems
  :
/home/newfs1:
                dev   =  /dev/lv00
                vfs   = jfs
                log   = /dev/loglv00
                mount     = true
                options         = rw
  :
```

- Mount all new file systems:

```
# mount /home/newfs1
# mount /home/newfs2
# mount /home/newfs3
```

# Glossary

**Ablative**. Ablative technology utilizes heat to remove a layer of some material. In this context, it relates to writing information with a laser by using the lasers heat to burn away a layer of the recording medium, thereby representing a binary value.

**Access pattern skew**. This refers to the tendency for reference to information to follow a pattern whereby, information is referenced from a certain area for some time, then another area, then a further one, rather than completely random jumps. Thus, if information in a file was written sequentially across a number of disks, utilization would tend towards one disk at a time. If however, the file data is split into blocks, and each block written to a separate disk, the skew is eliminated.

**Access time**. This refers to the total length of time from the initiation of a request for data, to the start of the receipt of that data from a device.

**Actuators**. An actuator is the mechanical assembly that is responsible for moving the disk head back and forth across the disk surface.

**Allocation group**. An allocation group consists of a set of i-node pointers to data blocks, and the data blocks themselves. This is a file system entity used to improve access to files within a file system based on locality of reference.

**Areal density**. This defines the density at which individual bits can resolved by the read head. This equates to the maximum bit density supported by the media.

**Archive**. Archiving involves moving data from the location that it is usually accessed from (normally fast, expensive storage), to lower cost storage such as tape. Information is normally archived if access to it will be very infrequent. Contrast with retrieval.

**Asynchronous**. This refers to an operation that can occur independently of other operations. An asynchronous communication for example, can be sent and then other work initiated without waiting for a response. Contrast with synchronous.

**Autochanger**. An autochanger is a mechanical device designed to load an remove media from a drive automatically. Tape and optical libraries have autochangers.

**Backup**. Backup involves taking a copy of data, usually on some form of removable media, so that in the event that information is lost, it can be easily recovered. Contrast with restore.

**Bad block relocation**. When a write of a block of data to a disk occurs, some software (and in some cases the hardware), is capable of detecting that the write failed (usually with a read following the write to test). In this case, transparently to the process that requested the write, the hardware or software can mark the block as bad so that it will not be used again, and redirect the write to a fresh block.

**Banding**. Traditionally, writing of bits to a disk surface occurs in a regular fashion; thus the further in toward the center of the disk, the less information can be stored. Banding refers to a process of dividing the disk surface into a number of concentric regions. As the disk write head moves into regions closer to the center of the disk, the bit write frequency increases proportionally, thereby maintaining the bit density.

**Block**. A block is a unit of data to be written or read. There are various block sizes, depending upon the media and software. Disk device drivers currently use a block size of 512 bytes to write to the disk.

**Bus**. A bus is a data and control path between devices. It consists of power lines, a number of data lines, and a number of control lines. There are various standards including Micro Channel and PCI.

**Cache**. A cache is a area of extremely fast (usually expensive) memory that is used to maintain frequently accessed information, or store information temporarily. Caches are used in various parts of a computer system. In disk subsystem controllers for example, writes to disk will actually occur to the cache so that a completion return code can be quickly returned to the writing process. The actual write will occur from the cache when the subsystem has time to satisfy it. The CPU also maintains several caches where instructions and data can be pre-loaded while the current instruction is executing.

**Caddy**. A caddy is a removable casing that a CD-ROM is placed in before being loaded into the optical drive.

**CCW**. Continuous composite write describes the magneto-optical implementation of WORM. Erasure and rewriting are prevented by simply not allowing the functions to take place. Contrast with WORM.

**CD-ROM**. A CD-ROM is an optical disk that has information stored on it before it is distributed. The information is permanently stored and cannot be erased or rewritten.

**Command tag queueing**. Command tag queuing refers to the SCSI-2 implementation of *piggy-backing* commands together to a device on the SCSI bus. This effectively allows commands to be overlapped, thereby improving performance.

**Compression**. Compression techniques utilize hardware or software implemented algorithms that are able to reduce the amount of storage needed by data. The reduction in space is dependent upon the data used, as well as the compression algorithm. Contrast with decompression.

**Data transfer rate**. This is the rate at which data can be moved from the host system to a device. It is normally measured in KB/sec or MB/sec.

**Decompression**. This is the process of restoring compressed data to its original state, so that it can be used again. Contrast with compression.

**Device driver**. A device driver is a piece of software written to assist in the management of a specific device. Other software will use the device driver as the interface to the device for reading, writing and control functions.

**Differential**. This refers to the communications technique of transmitting information as the difference voltage between two signals. Normally, information is transmitted as a single signal and can be corrupted by noise from external sources. Differential transmission means that both signal lines will be equally affected by any noise, the difference between them, the actual information, remaining constant.

**Directory**. A directory is a file system entity that is used to organize related information within file systems. The space allocated to a file system for file storage can be subdivided into directories so that files can be more sensibly organized. Directories can have sub-directories, thereby forming an organizational hierarchy. Files themselves can be thought of as being located within a specific directory, and access to them is defined by a path that is the directory hierarchy leading to them.

**Diskette**. A diskette contains a circular piece of magnetic material that is read and written in the same way as fixed magnetic disk. Diskettes are designed to be removed and easily transported and to enable this function, have lower tolerances and hence less storage capacity than fixed disks.

**Disk pack**. A disk pack contains a traditional fixed disk but can be removed in its entirety from the support structure (power, cooling, and connection bus). It is far less portable than a diskette, but can contain as much information as a normal fixed disk.

**Dispatch**. This refers to the action of taking a process that is waiting to use the processor from its wait queue and loading it into the processor for execution.

**Dump**. Should an unrecoverable error occur within the computer system, a dump usually occurs before the system halts completely, if possible. The dump consists of the contents of main memory and processor registers immediately prior to the error.

**Elevator seeking**. In order to maximize the efficiency of disk head seeks, a simple sort of the request queue can be implemented in software or hardware. This will allow the disk head to satisfy requests using the smallest possible head movements moving into the center of the disk and then out again, thereby minimizing seek times.

**Fast and wide**. The SCSI-2 standard defines a data bus up to 32 bits wide, and with a 10MHz cycle time. This is currently utilized at 2 bytes giving a data rate of 20MB/sec. Fast refers to the clock speed, and wide to the data bus.

**Fault tolerance**. Systems that have total redundancy are called fault tolerant. This means that all operation critical systems have a hot standby that can take over in the event of failure of the primary component.

**File system**. A file system is a high level entity that manages the storage of data. Through the file system, information can be organized within directories and files created, read, written, and erased.

**Floppy disk**. This is an earlier term for a diskette. It originates from the fact that older diskette designs utilized soft covers that were pliable.

**Fragment**. A fragment is a subdivision of a file system block. Blocks can be divided into a number of fragments (up to eight, dependent upon file system creation parameters). The purpose of fragments is to minimize the disk space wastage that occurs as a result of partially allocated blocks.

**Frame**. Real memory in a computer system is divided into sections for ease of manipulation. These sections vary in size depending upon the system implementation, and are known as page frames. Under AIX, a page frame is 4KB in size.

**HDA**. The mechanical component composed of the disk head, actuator, motor and platters, is known as the head disk assembly.

**Helical scan**. This technology was introduced from the consumer video marketplace. Tape is partially wrapped around a spinning recording head that is mounted at an angle to the tapes direction of travel. This results in data tracks being recorded at an angle across the tapes surface, thereby using the tape recording area most efficiently, and maximizing capacity.

**Hierarchical**. This refers to an organizational method that involves levels that are accessed by moving from one to another starting at the top of the hierarchy. An example is a directory tree in a file system, where files are found by navigating from the top of the tree through a series of subdirectories, until the file is found.

**Hierarchical storage management**. At a higher level, treating the various storage technologies available as levels, with disk being the level for interactive access, through optical for intermediate, to tape for backup/archive, defines a storage hierarchy through which data can be migrated according to space and usage requirements. The process of managing this mechanism is known as hierarchical storage management.

**IDRC**. This is a compression technique implemented on some IBM tape drives that allows data being written to the tape to be compressed as the writing is being done, thereby increasing the capacity of the tape medium. When data is read back, it is decompressed as the read occurs.

**I-node**. An i-node is a file system entity that is used to locate a files data on the actual disk. It contains pointers to the physical disk blocks containing the data.

**JFS log**. Every action that occurs within a file system is recorded into a log known as the journaled file system log. These actions include events such as opening files, writes to files, and closing files. If the system should fail during operation, upon reboot, the file systems can be brought back to consistent states by replaying the information contained in the log.

**Journaled file system**. The Journaled File System is the main AIX file system implementation. It defines a file system with a JFS log.

**Library**. A tape or optical drive coupled with an autochanger and racks of media comprises a library. Media can be unloaded and loaded from the racks automatically, on request from the host system.

**Licensed program products**. All software products purchased for use on the RS/6000 are known as licensed program products.

**Linear**. Linear with regard to tape technology implies recording information in a straight horizontal direction along the length of the tape.

**Locality of reference**. If when a process is executing, most of the time it runs is spent in several small sections of the code, with occasional jumps to other parts, then the process is said to display good locality of reference. This is beneficial, as it means that the operating system can maintain the small number of most utilized sections of the process in memory, and thereby achieve good performance.

**Logical partition**. A logical volume is composed of a number of logical partitions. Each logical partition maps directly to from one to three physical partitions where data is actually stored.

**Logical volume**. A logical volume is an area of physical disk storage comprising a number of logical partitions. Logical volume can be written to directly, or a file system can be created within them.

**Logical volume device driver**. The logical volume manager device driver is one of the components of the logical volume manager. It implements the logical volume manager policies for logical volumes.

**Logical volume manager**. The logical volume manager is a collection of device drivers, disk data areas, daemons, and management subroutines that collectively form a high level interface to disk storage. It provides functions for the creation, manipulation, access, and deletion of logical volumes.

**Longitudinal**. In terms of tape technology, longitudinal recording defines a mechanism for data recording that involves writing linear tracks on the tape surface.

**Magneto-resistive**. This technology is used to implement rewritable optical disk storage. Magnetic material in the optical media surface is heated with a laser and then its polarity altered with an electromagnet. The material used is such that a low powered laser shined on the material is polarized in different directions depending upon the magnetic polarity, thereby representing binary states.

**Mirroring**. This refers to the practice of maintaining two or more concurrent copies of information. All copies are updated for each write of the information. In the event of loss of a copy, the data can still be accessed from another copy.

**Mirror write consistency**. When mirroring is implemented and data is being written, there is a danger that if the system should fail during the writing of the data, all copies may end up in an inconsistent state. Mirror write consistency utilizes cache storage to maintain the data to be written until all copies have been updated, thereby ensuring consistency between copies.

**MTBF**. Mean time between failure is a measurement of the reliability of hardware components. It is calculated as total operating time of a group of components making up a device divided by the number of components in the device that fail over that period.

**Multitasking**. This is the capability of a computer system to divide its time between multiple processes or tasks, such that the processes all appear to be executing concurrently.

**NFS**. The network file system is an implementation of a remote file system. Files stored on a remote machine are made to appear as if they were being accessed from the local machine.

**NIC**. Numerically intensive computing generally refers to applications that require much intensive calculation, such as modelling or statistical analysis.

**Non-volatile**. This typically refers to memory storage that is capable of retaining information during periods without power.

**OEMI**. This is a standard third party interface used to attach peripheral devices.

**OLTP**. This describes a category of application that performs repetitive processing of records, such as bank account processing.

**Optical disk**. A storage medium that is read using optical technology, usually a laser. There are a number of different writing mechanisms including ablative, magneto-optical, and phase change.

**Page**. Generally, a page describes a block of information. In AIX a page is 4KB.

**Page fault**. When a page of an application that was waiting on some event, and has been paged out, is required, the CPU will try and access it, and in so doing generate a page fault as the page will not be in memory. The fault causes the missing page to be located in page space and copied back into memory, probably causing some other currently inactive page to be swapped out.

**Page frame**. Main memory is divided into a number of pages frames, in AIX, these are 4KB in size. Pages of information are then loaded into page frames.

**Page space**. Main memory is finite,and soon becomes filled with the pages of many executing applications. If at this point, more applications wish to run, there would be no room and they would have to wait. Page space defines a pool of storage on disk where pages of applications that are waiting on some event can be temporarily stored to make room for other application pages.

**Paging**. Paging describes the process of temporarily copying pages from main memory to page space in order to free up memory page frames for other applications to use.

**Parallel write**. When mirroring is being used, parallel write means that data to be written will be simultaneously scheduled to all copies. This is the quickest way to implement mirroring, though a failure during write will result in no valid copies. Contrast with sequential write.

**Physical partition**. A physical volume is divided up into a number of physical partitions whose size is defined when the volume group containing the disk is created. These partitions are then mapped to logical partitions when a logical volume is created.

**Physical volume**. Before a physical disk can be added to a volume group, it must be defined as a physical volume. This process assigns the disk a unique number by which it will be identified, and creates some on-disk data areas which are used to store information regarding the disks usage.

**Physical volume identifier**. The unique number assigned to a physical volume is known as the physical volume identifier.

**Pipeline**. Pipelining refers to the process of pre-fetching instructions into an instruction cache in order to speed up process execution.

**Platter**. Inside a disk drive is a spindle that connects a number of disks coated with a magnetic material. Read/write heads on arms are moved back and forth radially over the disks, which are spun to allow a series of concentric tracks to be written on each disk surface. Each such disk is known as a platter.

**PPM**. This refers to the process of determining a signal value by its presence or absence. Thus if the signal is there, it represents logic one, if not, logic zero. With optical disk, a low powered laser utilizes the same mechanism to read data, a returned signal being logic one, no returned signal logic zero.

**PWM**. This refers to the process of establishing a signal value using the change in state from present to absent. Thus a transition from absent to present is logic one, a transition from present to absent is logic zero. Using this technique means that data can be more densely packed as discrete signals are no longer required. Optical technology uses this technique where dots on the disk can actually be overlapped as it is only the change in state from a sequence of returned signals to no signal (or vice versa) that indicates a binary value.

**Quorum**. The logical volume manager implements a process known as quorum checking. This is used to ensure that before a volume group can be made available for use, over 50% of the disks in the group have valid VGDAs, indicating that they contain uncorrupted data. The quorum is the number of disks required to constitute more than 50% of the total disks in the group.

**RAID**. RAID arrays are designed to increase performance or availability through the implementation of one of the following modes of operation. RAID 0 stripes data across the disks for maximum performance.

RAID 1 pairs off the disks and mirrors data on each disk. RAID 3 stripes data across the disks and uses one further disk to record parity information to allow data to be reconstructed in the event of loss of one disk. RAID 5 splits the data into blocks and writes blocks sequentially across the disks, intermixing parity blocks with data blocks.

**Read ahead**. When an application wishes to access a data file, just the first few pages of data are actually read into memory. As the file is used, more pages are read in according to two system parameters, minpgahead, and maxpgahead. If the operating system detects that the file is being accessed sequentially, then it will read in minpgahead more pages when further pages are required. If access is still sequential, the next time pages are required, minpgahead + 2 will be read in. This value is incremented by two as long as the access remains sequential up to maxpgahead thereby enhancing performance for sequential reads.

**Redundancy**. Providing a duplicate component within a subsystem that can be switched in and used in the event of failure of the primary component means that the component has redundancy.

**Restore**. Restoring is the process of copying information back from its safe location (usually some form of removable media) to replace the original copy that has somehow been lost. Contrast with backup.

**Retrieve**. Retrieval is the process of moving data back from archive storage to its original location where it can be accessed. Contrast with archive.

**Rotational Latency**. When a block of data is to be read/written from a disk, the actuator moves the read/write head to the track where the block is located and then waits for the platter to rotate the start of the block underneath so reading/writing can begin. This delay before the start of the block arrives is called rotational latency.

**Scheduler**. The operating system maintains several priority queues of processes waiting for their turn to execute on the processor. The scheduler is the operating system component that decides which process is eligible to run next, and selects it for dispatch.

**SCSI**. The SCSI standards define a communications protocol and physical interfaces to support the attachment of SCSI compatible devices to a host system, and thence the devices controlled, and information read and written.

**Seek time**. The seek time is the sum of the time taken for the disk head to be moved to the required track plus the rotational latency.

**Segment**. The total AIX address space of 4 petabytes is divided into segments of 256MB. There are several different types of segment including working, persistent, client, and log segments.

**Sequential write**. When mirroring is being used, sequential write means that data to be written is scheduled to each mirror copy in turn, with the next not occurring until the previous has completed. This method gives the highest chances of at least one copy surviving in the event of failure during the write, but at the cost of performance. Contrast with parallel write.

**Serial**. When data is sent a single bit at a time (usually over two wires), the communications is said to be serial.

**Serpentine track interleaving**. This technology is an enhancement to longitudinal recording where the data is written to tape in a series of blocks. The tape head is capable of writing/reading several tracks simultaneously which it does during one pass down the length of the tape. The head is then stepped laterally and the pass restarted in the opposite direction. The stepping continues until the tape width is full.

**Single ended**. Single ended technology refers to non-differential communications where information is transmitted serially using four wires, two to send and two to receive.

**SSA**. This defines a new communications protocol and physical interfaces for connecting peripherals to the host system and communicating with them.

**Stale**. When mirroring is being used, should one of the copies of the data fail, then the copy is marked as stale, which reflects the fact that it can no longer be considered accurate until it has been resynchronized with the other copies after repairs have been effected.

**Streaming**. When data is written continuously to a device in one long run, the data is said to be streamed to the device, and the device itself capable of streaming.

**Striping**. Splitting data to be written into equal sized blocks and writing blocks simultaneously to separate disk drives is called striping the data and maximizes performance to the disks. Reading the data back is also scheduled in parallel, with a block being read concurrently from each disk then reassembled at the host.

**Stripe width**. The size of the block that data is split into for striping is known as the stripe width.

**Subsystem**. A subsystem is a collection of components that together perform some function on behalf of the host system. An example is a RAID array subsystem.

**Superblock**. A file system is split into a number of blocks whose size is 4KB in AIX. The second and thirty first (a backup copy) are designated as the superblock and contain administrative information regarding the file system such as fragment size and overall file system size.

**Swapping**. This is an alternative name for paging.

**Swap space**. This is an alternative name for page space.

**Synchronous**. This defines an operation that must occur with a fixed time relationship to another operation. An example of this is synchronous communications where each end maintains a clock, and data is sent at regular intervals, each clock tick for example. Contrast with asynchronous.

**TCP/IP**. This is a set of communications protocols that support the transmission of information between computers.

**Thin film**. This technology is used in the construction of read heads for tape and disk devices. It allows a very high degree of sensitivity and a correspondingly high bit density on the recording medium.

**Throughput**. This defines the rate at which information can be transferred across an interface and is a measure of performance. It is usually measured in KB/sec or MB/sec.

**Track**. This defines a single one bit wide stream of physical data written on a storage medium. Tracks are concentric circles on disk and most optical media, horizontal lines on longitudinal technology tape, and inclined lines on helical scan technology tape.

**Volatile**. Memory that does not maintain its contents during periods of no power is known as volatile storage. Contrast with non-volatile.

**Volume group**. This is a logical volume manager entity that contains a number of physical volumes.

**Volume group descriptor area**. Each physical volume has at least one VGDA stored on it. The VGDA contains information regarding the organization and location of all logical volumes and physical volumes within the volume group.

**Volume group identifier**. Each volume group has a unique number identifying it known as the volume group identifier.

**Volume group status area**. Each physical volume has at least one VGSA stored on it. The VGSA contains information regarding the status of all logical volumes and physical volumes within the volume group.

**Virtual memory manager**. This operating system component is responsible for managing memory allocation and usage. The VMM manages the mappings between real memory, page space and the file systems, and all addressing requests go through it.

**WORM**. Optical media that utilizes a destructive writing process meaning that once written, information cannot be erased. Contrast with CCW.

# List of Abbreviations

| | |
|---|---|
| ***AFS*** | Andrew File System |
| ***AG*** | Allocation Group |
| ***CCW*** | Continuous Composite Write |
| ***CD*** | Compact Disc |
| ***CD-ROM*** | Compact Disc Read Only Memory |
| ***DASD*** | Direct Access Storage Device |
| ***GB*** | Gigabytes |
| ***IBM*** | International Business Machines Corporation |
| ***IDRC*** | Improved Data Recording Capability |
| ***I/O*** | Input/Output |
| ***ITSO*** | International Technical Support Organization |
| ***JFS*** | Journaled File System |
| ***KB*** | Kilobytes |
| ***LP*** | Logical Partition |
| ***LV*** | Logical Volume |
| ***LVDD*** | Logical Volume Device Driver |
| ***LVID*** | Logical Volume Identifier |
| ***LVM*** | Logical Volume Manager |
| ***LPP*** | Licensed Program Product |
| ***LZ*** | Lempel Zev |
| ***MWC*** | Mirror Write Consistency |
| ***MTBF*** | Mean Time Between Failure |
| ***NBPI*** | Number of Bytes per I-node |
| ***NIC*** | Numerically Intensive Computing |
| ***NFS*** | Network File System |
| ***OEMI*** | Other Equipment Manufacturer Interface |
| ***OLTP*** | On Line Transaction Program |
| ***PP*** | Physical Partition |
| ***PPM*** | Pulse Position Modulation |
| ***PWM*** | Pulse Width Modulation |
| ***PV*** | Physical Volume |
| ***PVID*** | Physical Volume Identifier |
| ***RAID*** | Redundant Array of Independent Disks |
| ***RAM*** | Random Access Memory |
| ***ROM*** | Read Only Memory |
| ***SCSI*** | Small Computer System Interface |
| ***SSA*** | Serial Storage Architecture |
| ***TCP/IP*** | Transmission Control Protocol/Internet Protocol |
| ***VG*** | Volume Group |
| ***VGDA*** | Volume Group Descriptor Area |
| ***VGID*** | Volume Group Identifier |
| ***VGSA*** | Volume Group Status Area |
| ***VMM*** | Virtual Memory Manager |
| ***WORM*** | Write Once Read Many |

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**AIX Storage Management**

**Publication No. GG24-4484-00**

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