Chapter 6

Introduction to Hard Drives

You Will Learn…

- How data is stored on a hard drive
- How to use DOS and Windows commands to manage data on a hard drive
- How to identify various types of hard drives and understand advantages of each
- How to manage a hard drive to optimize its performance
- How to compare different removable drives

Hard Drive Technology

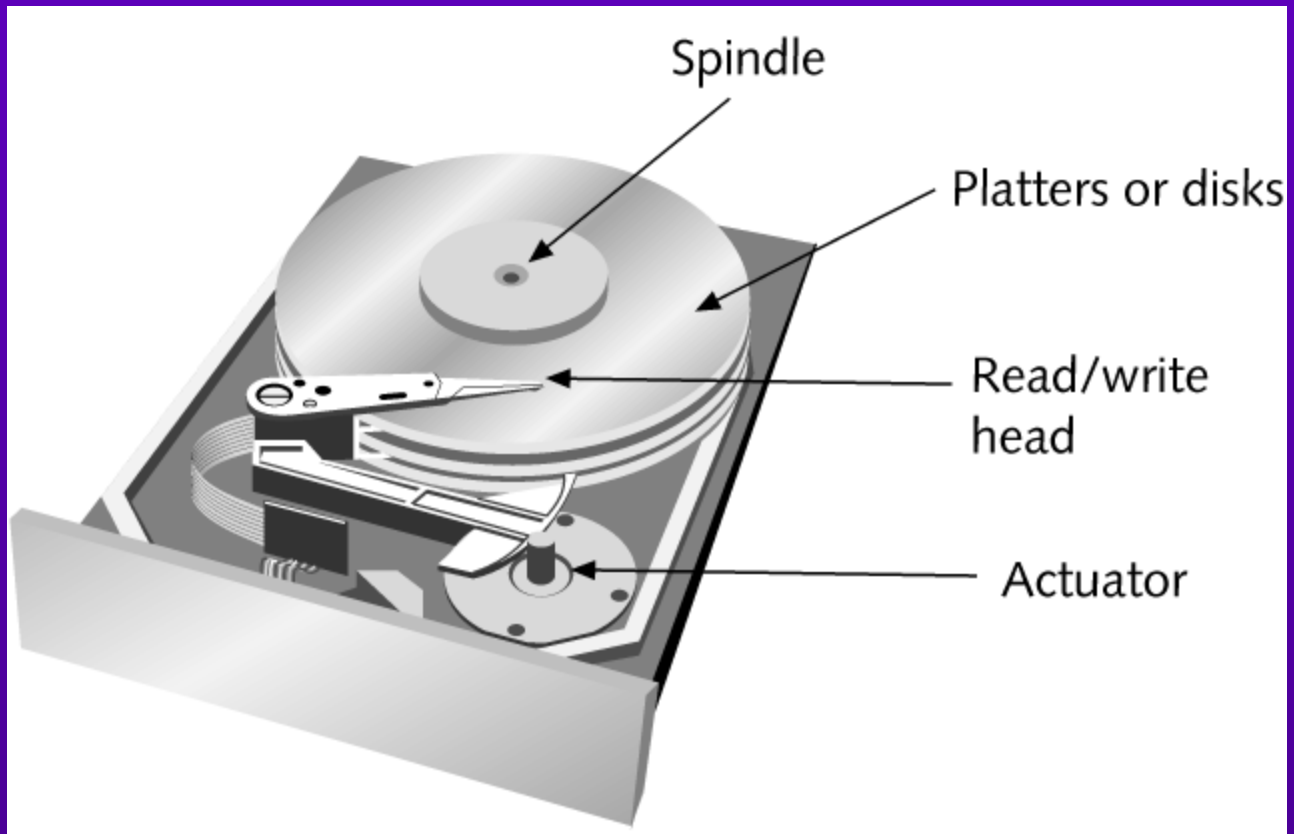

Figure 6-1 Inside a hard drive case

Hard Drive Technology

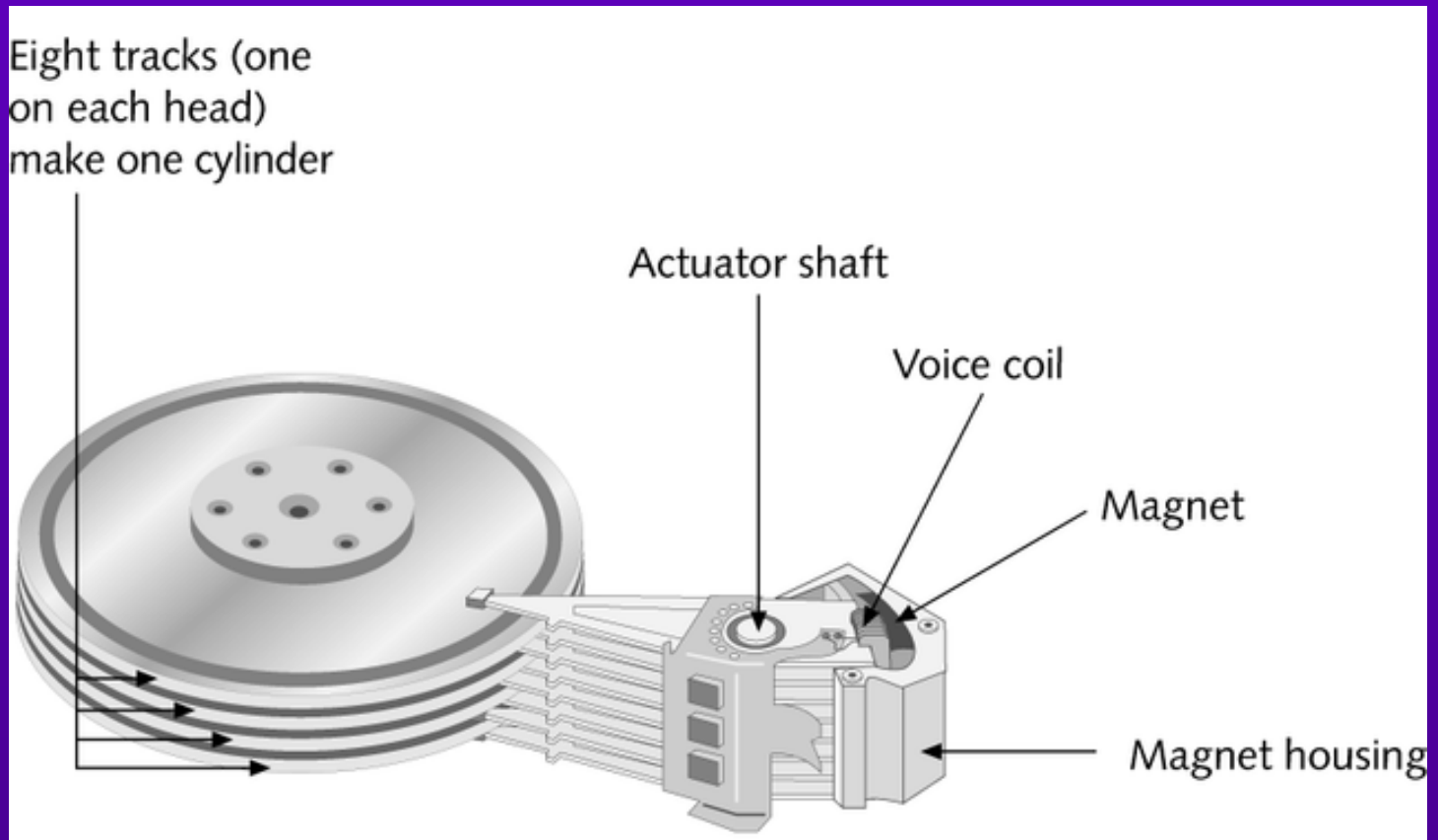

Figure 6-2 A hard drive with four platters

Hard Drive Technology

- Methods used to adjust for smaller tracks closer to center of platter
  - Write precompensation
  - Reduced write current

Integrated Device Electronics (IDE) Technology

- A hard drive whose disk controller is integrated into the drive
  - Eliminates need for controller cable
  - Increases speed
  - Reduces price
- Most system boards provide one or two IDE connections directly on system board

Hardware Subsystem with an IDE Hard Drive

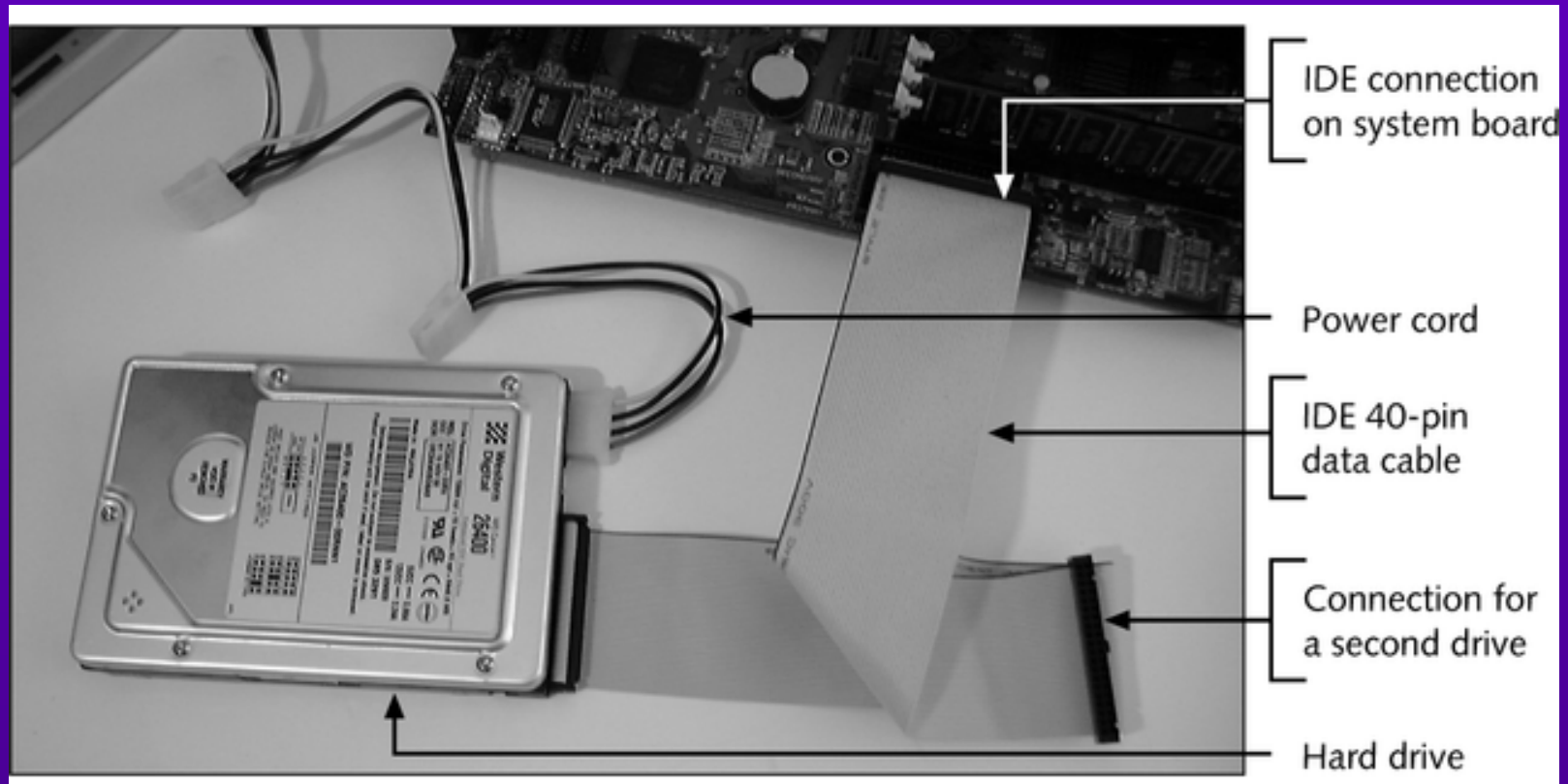

Figure 6-3 A PC's hard drive subsystem

Tracks and Sectors on MFM and RLL technologies

- Use either 17 or 26 sectors per track
  - Wastes drive space
  - Number of bytes a track can hold is determined by centermost track

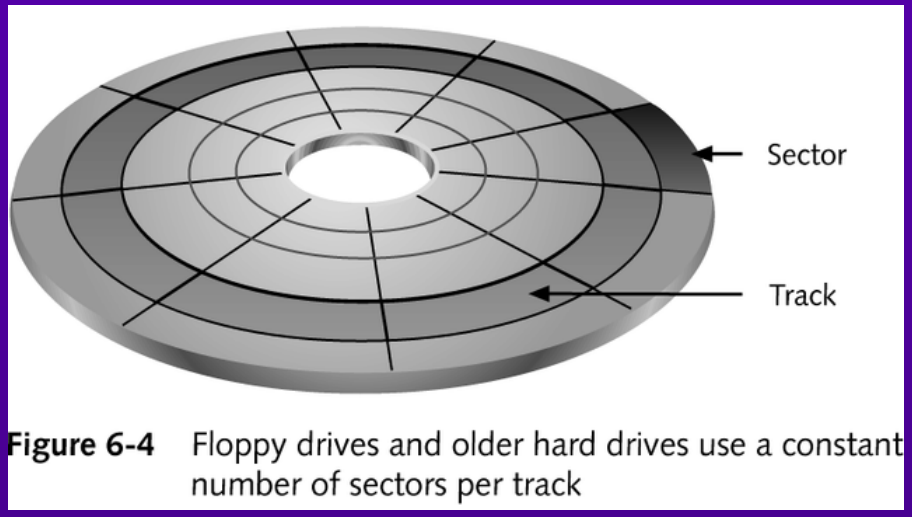

Figure 6-4 Floppy drives and older hard drives use a constant number of sectors per track

Tracks and Sectors on an IDE Drive

- Use zone bit recording
  - Tracks near center have smallest number of sectors per track
  - Number of sectors increases as tracks get larger
  - Have 512 bytes per sector for every sector on the drive

Zone Bit Recording

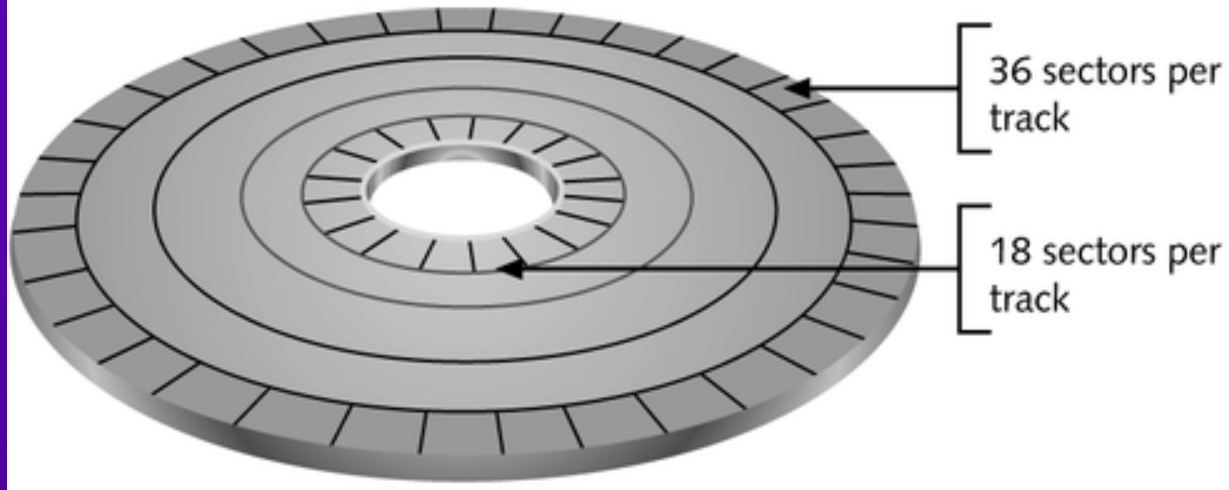

Figure 6-5 Zone bit recording can have more sectors per track as the tracks get larger

Enhanced IDE (EIDE) Drives

- Support newer, faster drive standard that allows systems to recognize drives larger than 504 MB and to handle up to four devices on the same controller

ANSI Standards for Hard Drives

Table 6-1 Summary of ANSI interface standards for hard drives

Standard (May Have More Than One Name)	Speed	Description
IDE/ATA ATA	Speeds range from 2.1 MB/sec to 8.3 MB/sec	The first ANSI hard drive standard for IDE hard drives. Limited to no more than 528 MB. Supports PIO and DMA transfer modes.
ATA-2 Fast ATA	Speeds up to 16.6 MB/sec	Breaks the 528-MB barrier. Allows up to 4 IDE devices. Supports PIO and DMA transfer modes discussed later in the chapter.
ATA-3	Little speed increase	Improved version of ATA-2
Ultra ATA Fast ATA-2 Ultra DMA DMA/33	Speeds up to 33.3 MB/sec	Defined a new DMA mode, but only supports slower PIO modes
Ultra ATA/66 Ultra DMA/66	Speeds up to 66.6 MB/sec	Uses a special 40-pin cable that provides additional ground lines on the cable to improve signal integrity

SCSI (Small Computer Systems Interface) Technology

- Provides a standard for communication between a subsystem of peripheral devices and the system bus
- Most SCSI drives are IDE drives

SCSI Technology

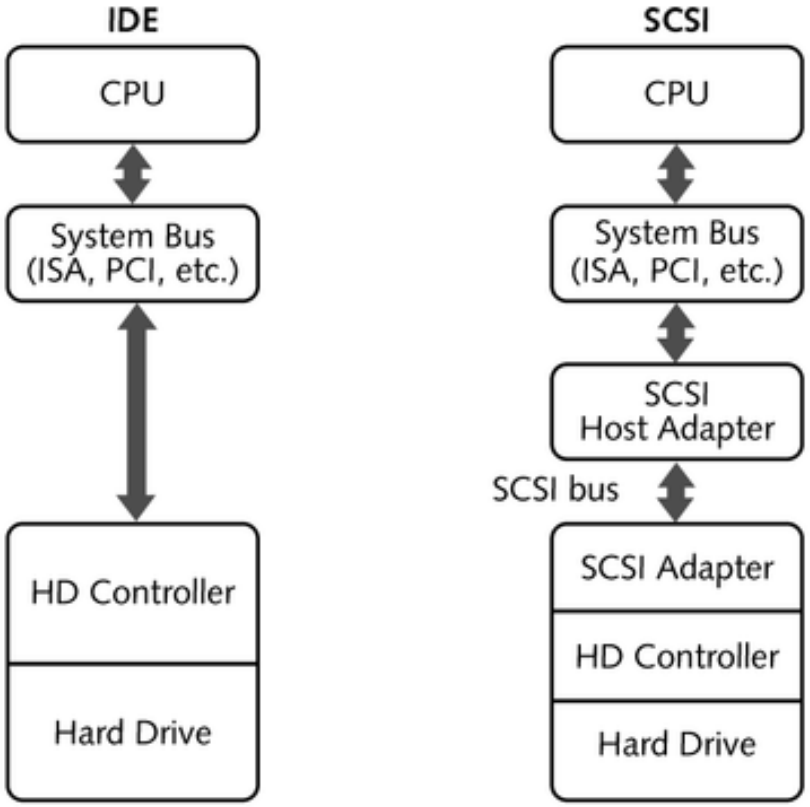

Figure 6-6 SCSI hard drives communicate with the CPU through the SCSI host adapter, but IDE drives communicate directly on the system bus

Differing SCSI Standards

- General categories
  - Narrow (8 bits)
  - Wide (16 bits)
- Ways a SCSI cable can be built
  - Single-ended
  - Differential
- Three major standards
  - SCSI-1 (Regular SCSI)
  - SCSI-2 (Fast SCSI)
  - SCSI-3 (Ultra SCSI)

Summary of Different SCSI Standards

Table 6-2 Summary of SCSI standards

Names for the SCSI Interface Standard	Bus width Narrow = 8 bits Wide = 16 bits	Transfer ZRate (MB/sec)	Maximum Length of Single-ended Cable (meters)	Maximum Length of Differential Cable (meters)	Maximum Number of Devices
SCSI-1 (Regular SCSI)[1]	Narrow	5	6	25	8
SCSI-2 (**Fast SCSI** or Fast Narrow)	Narrow	10	3	25	8
Fast Wide SCSI (Wide SCSI)	Wide	20	3	25	16
SCSI-3 (**Ultra SCSI** or Ultra Narrow or Fast-20 SCSI)	Narrow	20	1.5	25	8
Wide Ultra SCSI (Fast Wide 20)	Wide	40	1.5	25	16
Ultra2 SCSI	Narrow	40		12 LVD[2]	8
Wide Ultra2 SCSI	Wide	80			16
Ultra3 SCSI	Narrow	80		12 LVD[2]	8
Wide Ultra3 SCSI	Wide	160		12 LVD[2]	16

Sample Configuration of a SCSI Subsystem

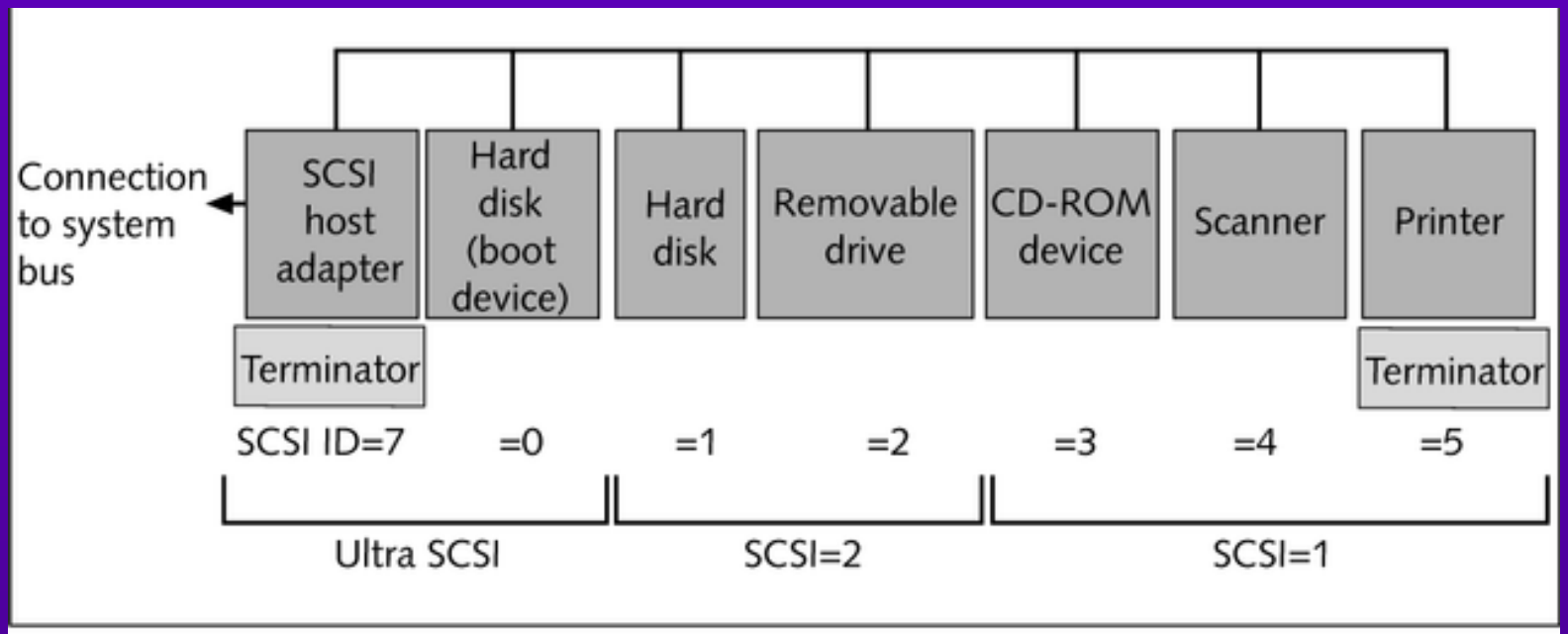

Figure 6-7 Sample SCSI subsystem configuration

Other Variations of SCSI Hardware and Software

- Termination
  - Several ways to terminate power
  - Types of terminators: passive, active, forced perfect
- Device drivers
  - Advanced SCSI Programming Interface (ASPI)
  - Common Access Method (CAM)
- Host adapter issues
  - Compare installation procedures and options

SCSI Subsystem

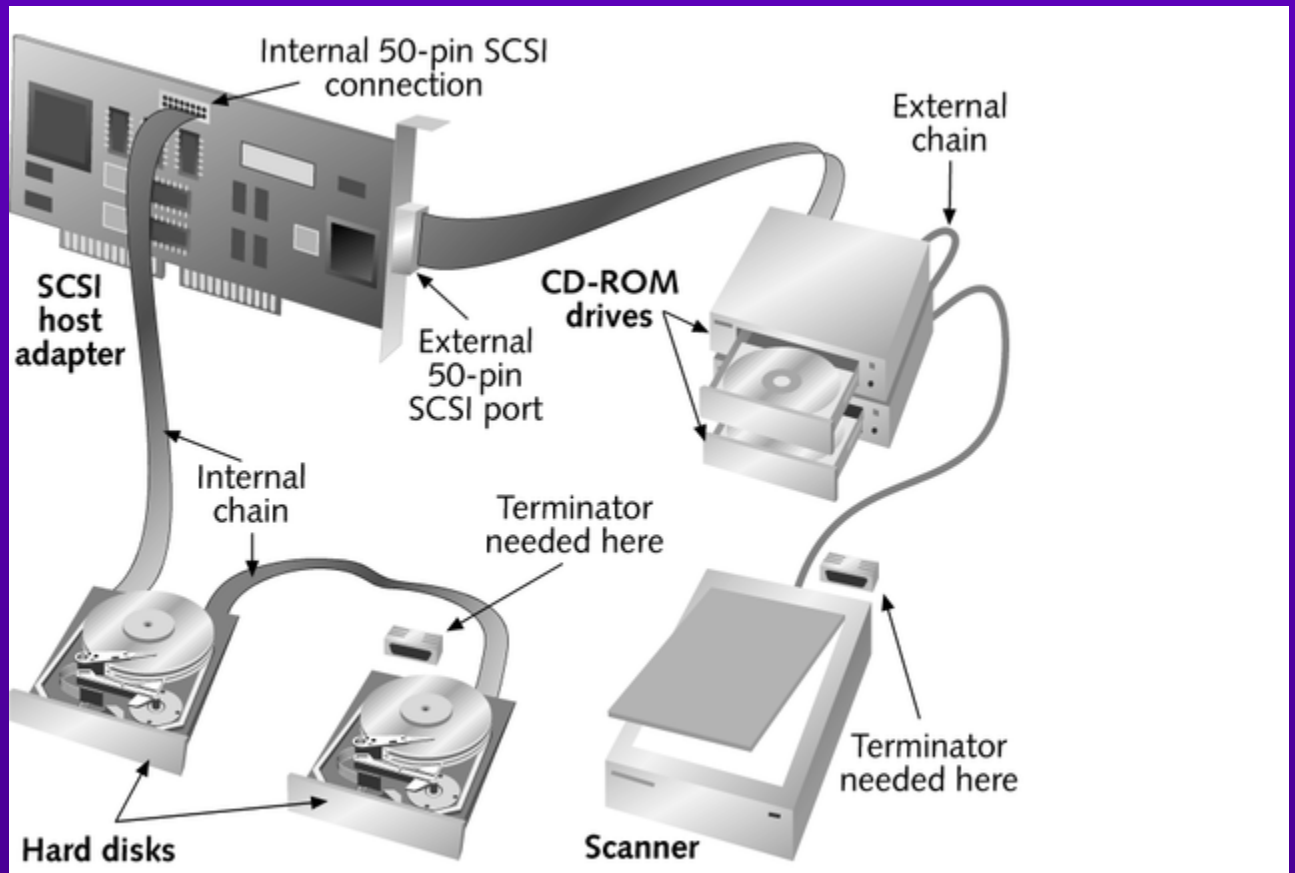

Figure 6-8 SCSI subsystem showing terminators at each end of the SCSI chain

SCSI Cables and Terminators

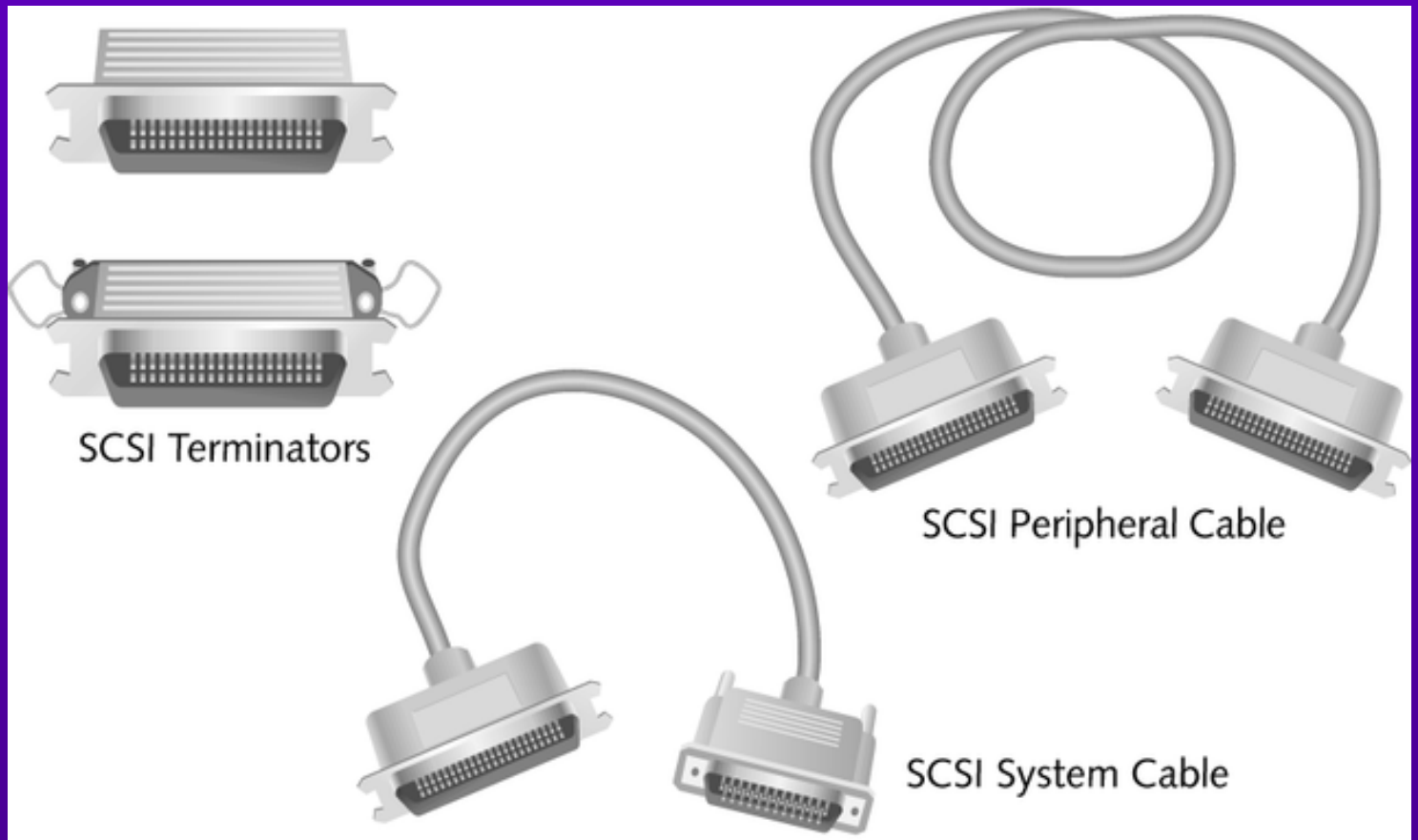

Figure 6-9 SCSI cables and terminators

Comparing SCSI Hard Drives and EIDE Hard Drives

- SCSI costs more than EIDE
- SCSI provides faster data transfer
- SCSI bus supports multitasking; EIDE processes data from one I/O device at a time
- SCSI host adapter allows connection to non-SCSI devices
- Without SCSI, if two IDE drives are on the same adapter, only one can be busy at a time

How a Hard Drive Is Logically Organized to Hold Data

- Steps in preparing a hard drive to hold data
  - Low-level format
  - Partitioning the hard drive
  - High-level format

Hard Drive Partitions

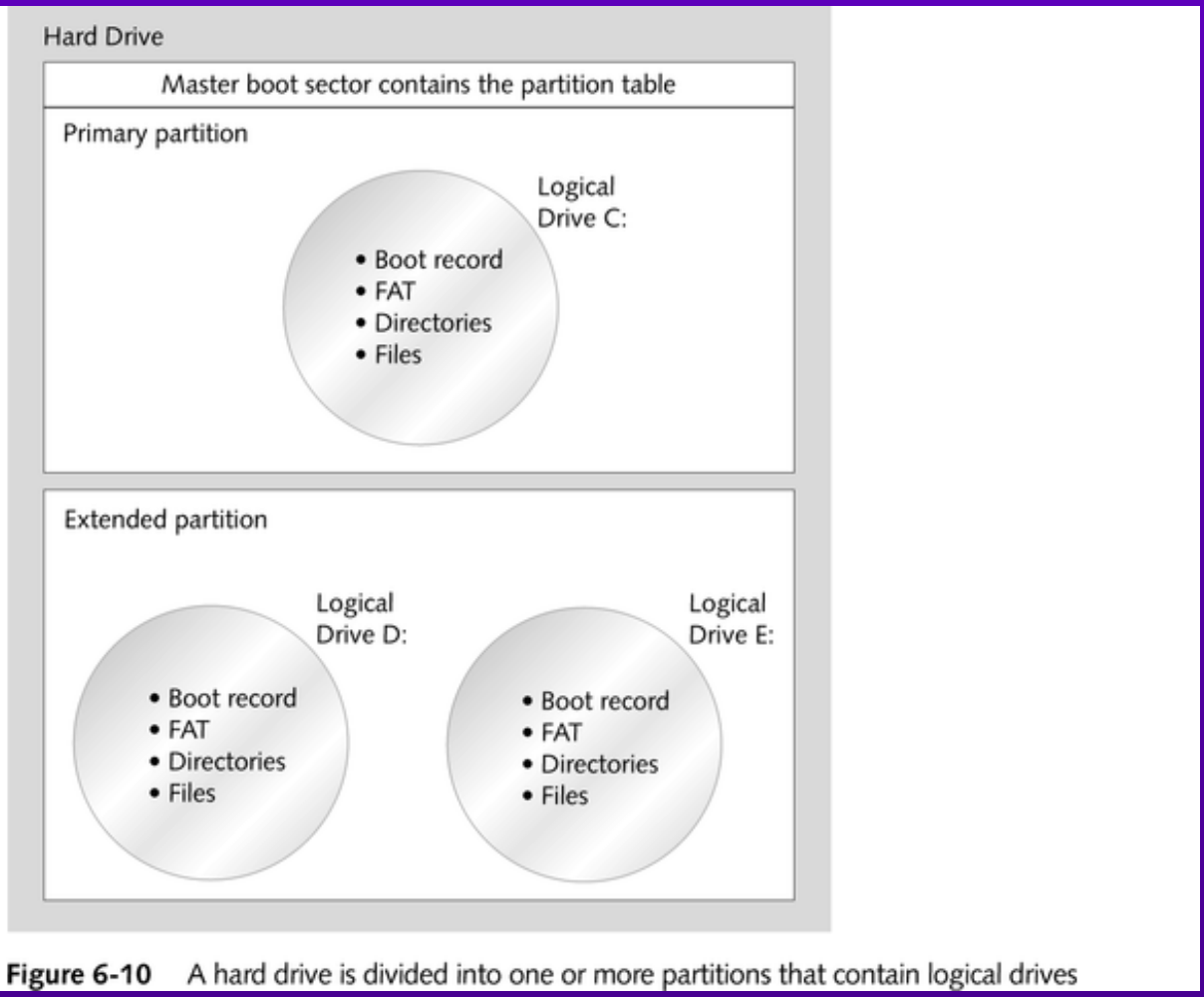

Figure 6-10 A hard drive is divided into one or more partitions that contain logical drives

Hard Drive Partition Table

Table 6-3 Hard drive partition table

Item	Bytes Used	Description
1	446 bytes	Program that calls the boot program on the OS boot record
2	16-byte total	Description of first partition
	1 byte	Is this the bootable partition? (Yes = 90h, No = 00h)
	3 bytes	Beginning location of the partition
	1 byte	System indicator; possible values are: 0 = Not a DOS partition 1 = DOS with a 12-bit FAT 4 = DOS with a 16-bit FAT 5 = Not the first partition 6 = Partition larger than 32 MB
	3 bytes	Ending location of partition
	4 bytes	First sector of the partition table relative to the beginning of the disk
	4 bytes	Number of sectors in the partition
3	16 bytes	Describes second partition, using same format as first partition
4	16 bytes	Describes third partition, using same format as first partition
5	16 bytes	Describes fourth partition, using same format as first partition
6	2 bytes	Signature of the partition table, always AA55

Logical Drives

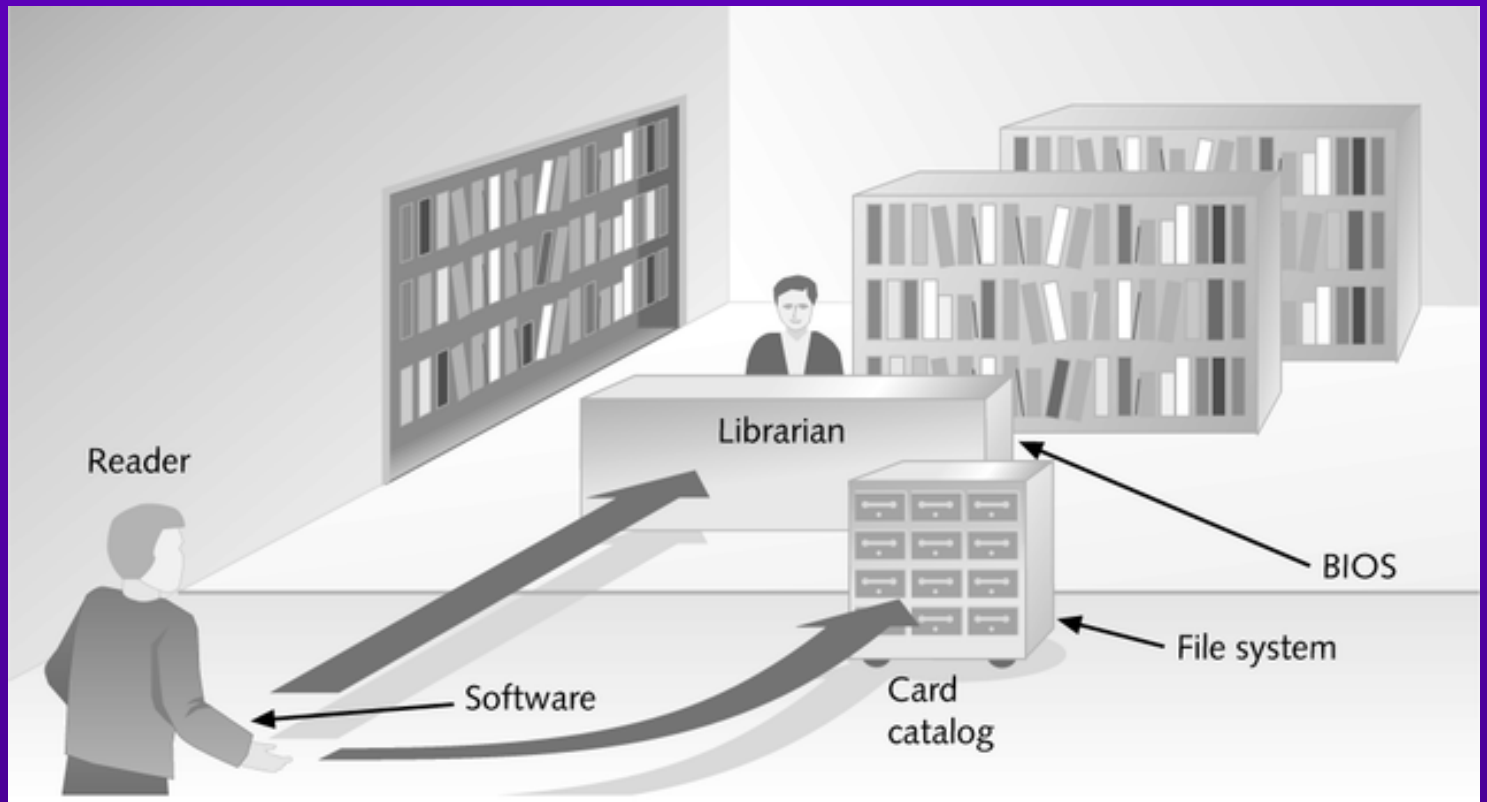

Figure 6-11 In some libraries, the reader (software) is not allowed in the stacks and depends on the librarian (BIOS) to know where to locate a book

Logical Drive

- A portion or all of a hard drive partition that is treated by the operating system as though it were a physical drive containing:
  - Boot record
  - FAT
  - Root directory

Boot Record

Table 6-4 Layout of the boot record

Description	Number of Bytes
Machine code	11
Bytes per sector	2
Sectors per cluster	1
Reserved	2
Number of FATs	1
Number of root directory entries	2
Number of logical sectors	2
Medium descriptor byte	1
Sectors per FAT	2
Sectors per track	2
Heads	2
Number of hidden sectors	2
Total sectors in logical volume	4
Physical drive number	1
Reserved	1
Extended boot signature record	1
32-bit binary volume ID	4
Volume label	11
Type of file system (FAT12, FAT16, or FAT32)	8
Program to load operating system (boot strap loader)	Remainder of the sector

Boot Record

Table 6-5 Disk type and descriptor byte

Disk Type	Descriptor Byte
3½-inch double-density floppy disk, 720K	F9
3½-inch high-density floppy disk, 1.44 MB	F0
Hard disk	F8

The FAT and the Root Directory

- The OS uses the FAT and a directory to keep track of which clusters are being used for a particular file, together with other information about the file (Figure 6-12)
- To the OS, each logical drive is treated like a single floppy disk: a physical drive divided into three logical drives is equivalent to three separate physical drives (Figure 6-13)

The FAT and the Root Directory

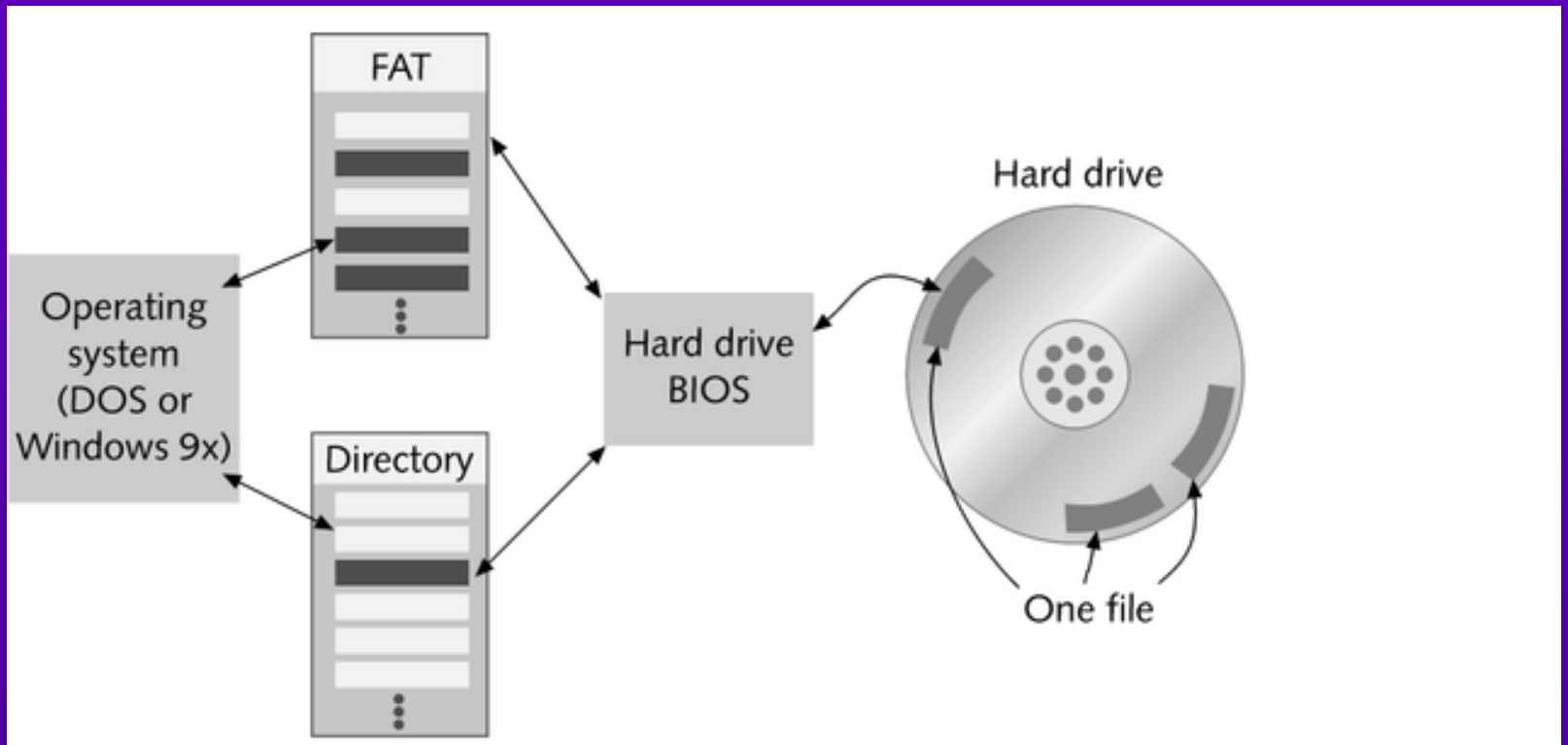

Figure 6-12 How the operating system views the hard drive when managing a file

The FAT and the Root Directory

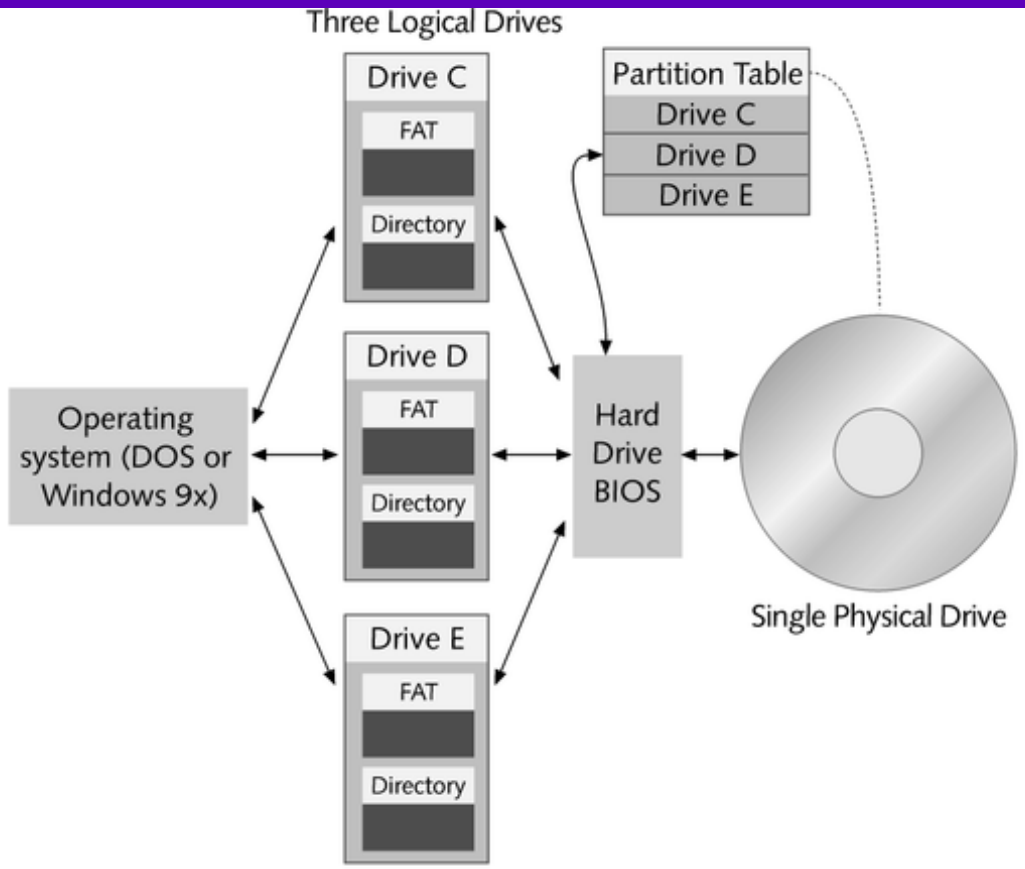

Figure 6-13 A single physical drive can be viewed by the operating system as one or more logical drives

The FAT and the Root Directory

- Virtual file allocation (VFAT)
  - An improved method of hard drive access that allows for long filenames and 32-bit access
- FAT32
  - Allows better management of very large hard drives
- The root directory
  - Layout is the same as for floppy disks

Communicating with the Hard Drive BIOS

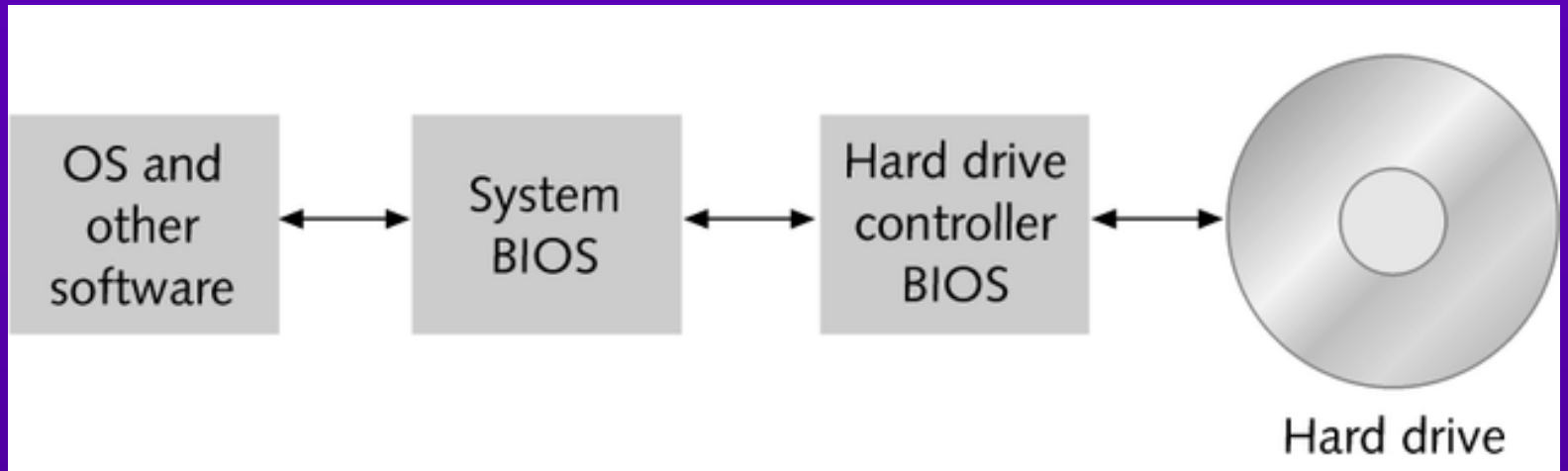

Figure 6-14 With older hard drives, cylinder, track, and sector information was communicated at each level

Communicating with the Hard Drive BIOS

- Calculating drive capacity
- Adjusting for more complex hard drive organization
- Physical geometry and logical geometry
- CHS or normal mode
- Translation methods
- System BIOS helps manage data transfer

CHS or Normal Mode

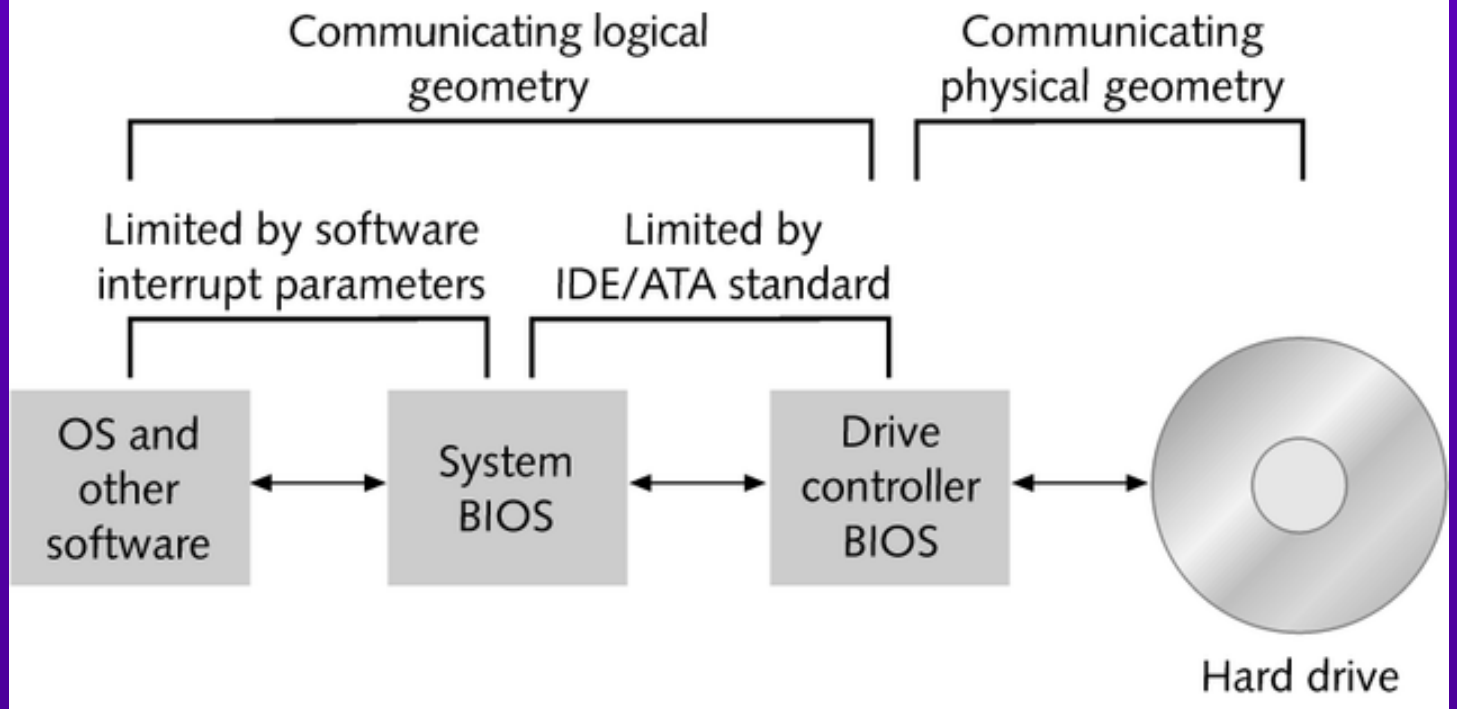

Figure 6-15 In using CHS mode to access a hard drive, limitations exist at two stages of communication, resulting in a combined limitation of 504 MB

CHS or Normal Mode

Table 6-6 CHS parameters used by a software interrupt for system BIOS to access a hard drive

Description	Cylinders	Heads	Sectors	Totals
Number of bits used to store the value	10 bits	8 bits	6 bits	24 bits
Value range	0 to 1023	0 to 255	1 to 63	NA
Maximum number of values	1024 cylinders	256 heads	63 sectors	7.88 GB

Table 6-7 Limitation of the IDE/ATA standard for hard drives

Description	Cylinders	Heads	Sectors	Total
Number of bits used to store the value	16 bits	4 bits	8 bits	28 bits
Maximum number of values	65,536 cylinders	16 heads	256 sectors	128 GB

CHS or Normal Mode

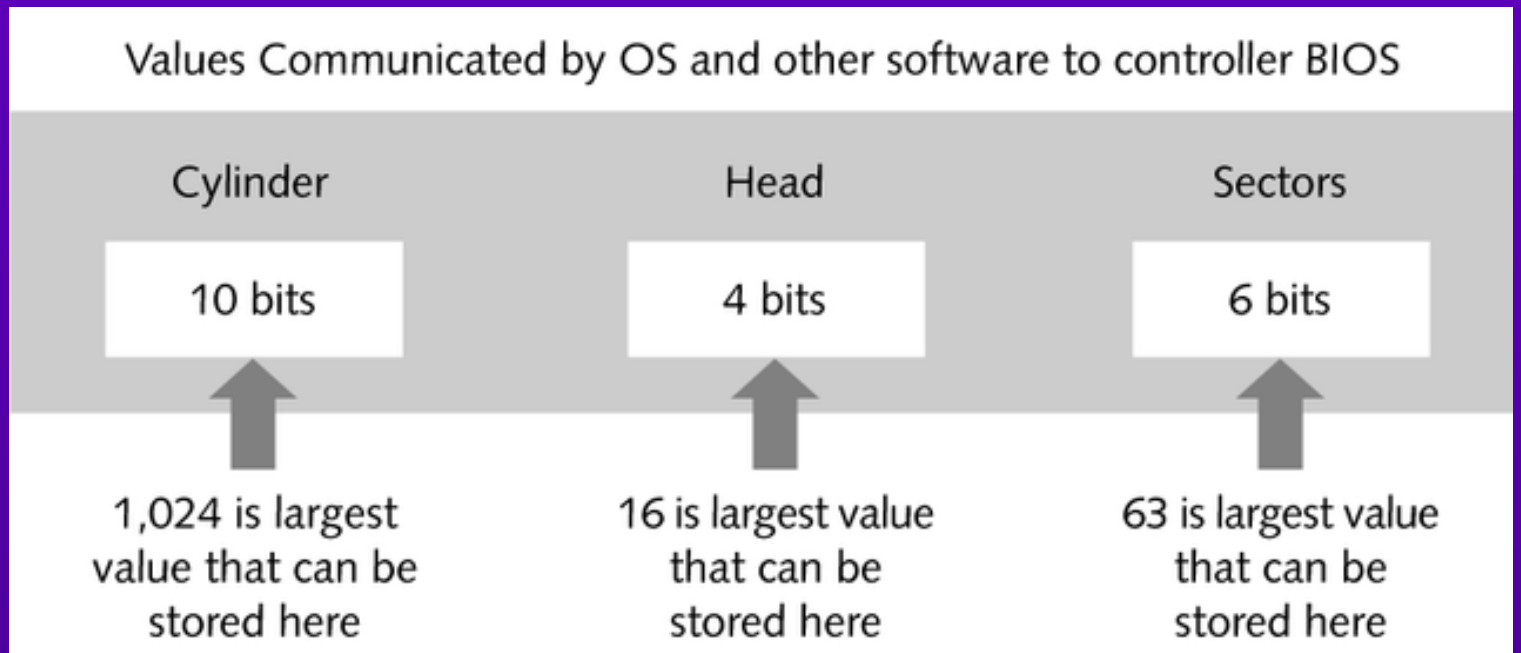

Figure 6-16 In using CHS mode, the three limitations on the number of bits to transfer cylinder, head, and sector information are caused by software interrupt parameters and IDE interface limitations

Translation Methods

- System BIOS supports a hard drive in one of three ways:
  - CHS (normal) mode
    - For drives less than 504 MB
  - ECHS mode, or large mode
    - Uses translation to access large-capacity drives
  - LBA mode
    - Uses translation to access large-capacity drives

Translation Methods

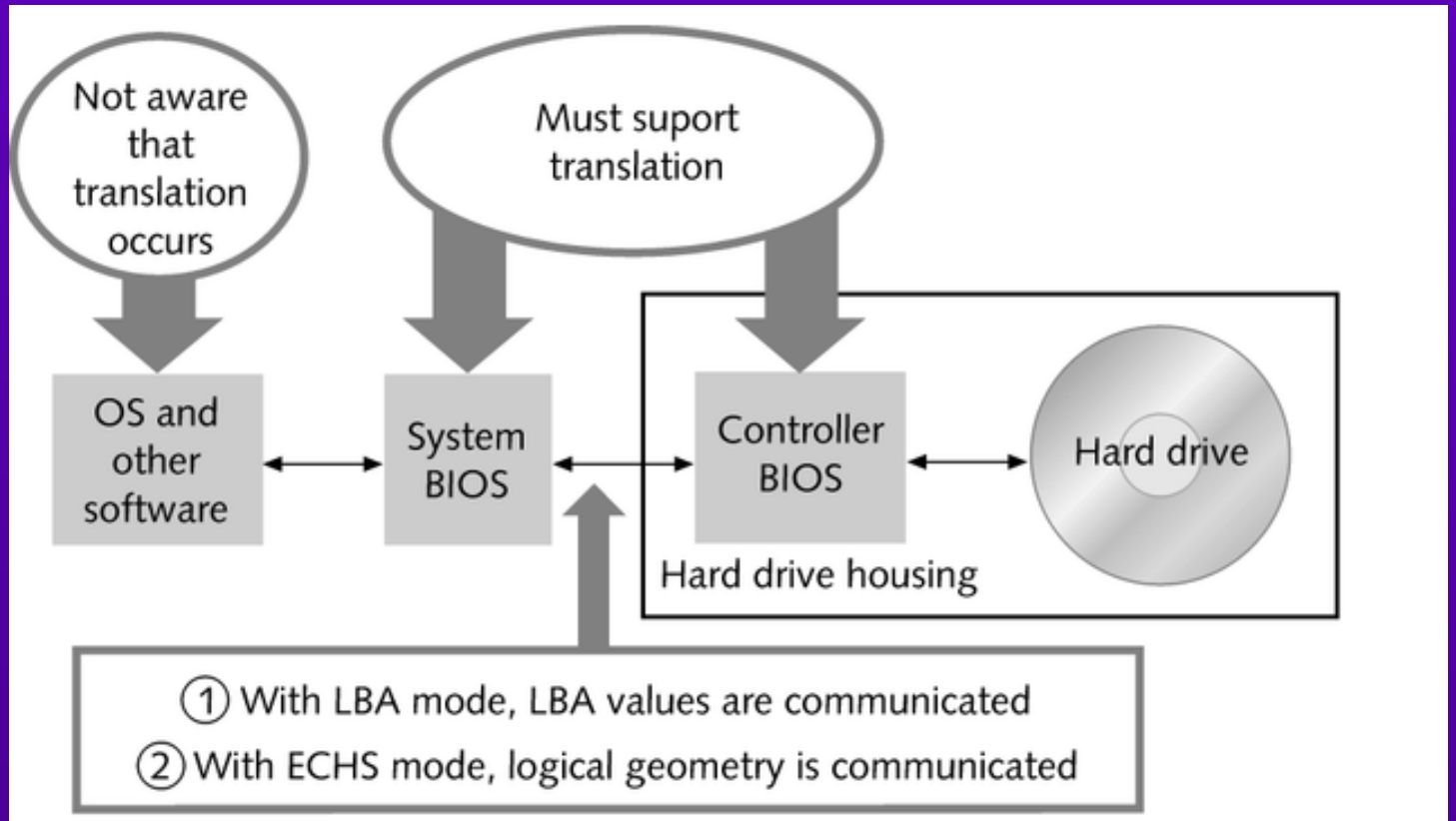

Figure 6-17 Translation methods must be supported by system BIOS and the hard drive controller BIOS within the hard drive housing

System BIOS Helps Manage Data Transfer

- System BIOS is used in three different ways to support a hard drive
  - Provides the interrupt handler for software interrupts
  - Can automatically detect and configure a hard drive
  - Helps manage data transfer over the I/O bus between the hard drive and memory

Operating System Commands to Manage a Hard Drive

- DOS commands
- Windows 3.x
- Windows 9x

DOS Commands to Manage a Hard Drive

- MKDIR or MD
  - Creates a subdirectory entry in a directory
- CHDIR or CD or CD
  - Changes the current default directory
- RMDIR RD
  - Removes a directory
- TREE
  - Displays directory structure of a hard drive or disk

continued

DOS Commands to Manage a Hard Drive

- ATTRIB
  - Displays or changes the read-only, archive, system, and hidden attributes assigned to a file
- MIRROR
  - Saves partition table information to disk when used with the /PARTN parameter

continued

DOS Commands to Manage a Hard Drive

- UNFORMAT
  - Reverses effect of an accidental format
  - Repairs a damaged partition table
- PATH
  - Lists where DOS and Windows 3.x should look to find executable program files
- Batch files
  - Series of DOS commands that will execute

MKDIR or MD Command

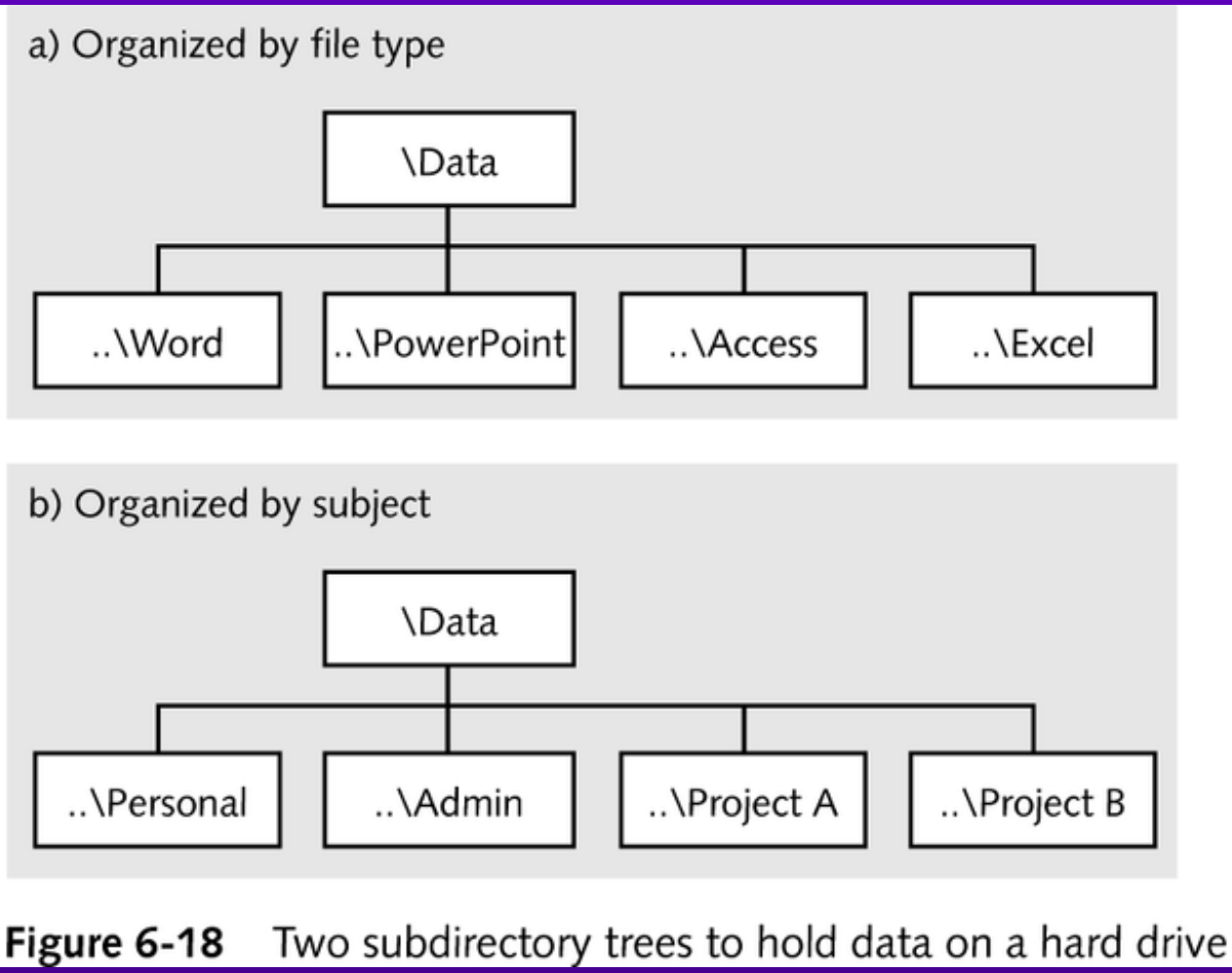

Figure 6-18 Two subdirectory trees to hold data on a hard drive

DIR Command


```
C:\>DIR \GAME /P

 Volume in drive C has no label
 Volume Serial Number is 0F52-09FC
 Directory of C:\GAME

.             <DIR>      02-18-93   4:50a
..            <DIR>      02-18-93   4:50a
CHESS         <DIR>      02-18-93   4:50a
NUKE          <DIR>      02-18-93   4:51a
PENTE         <DIR>      02-18-93   4:52a
NETRIS        <DIR>      02-18-93   4:54a
BEYOND        <DIR>      02-18-93   4:54a
        7 file(s)              0 bytes
                         9273344 bytes free

C:\>
```

Figure 6-19 DIR of the \GAME directory

Using Windows 3.x to Manage a Hard Drive

- Primary tool: File Manager
  - Create directory
  - Delete a directory
  - File properties
- The PATH command and batch files

File Menu in File Manager

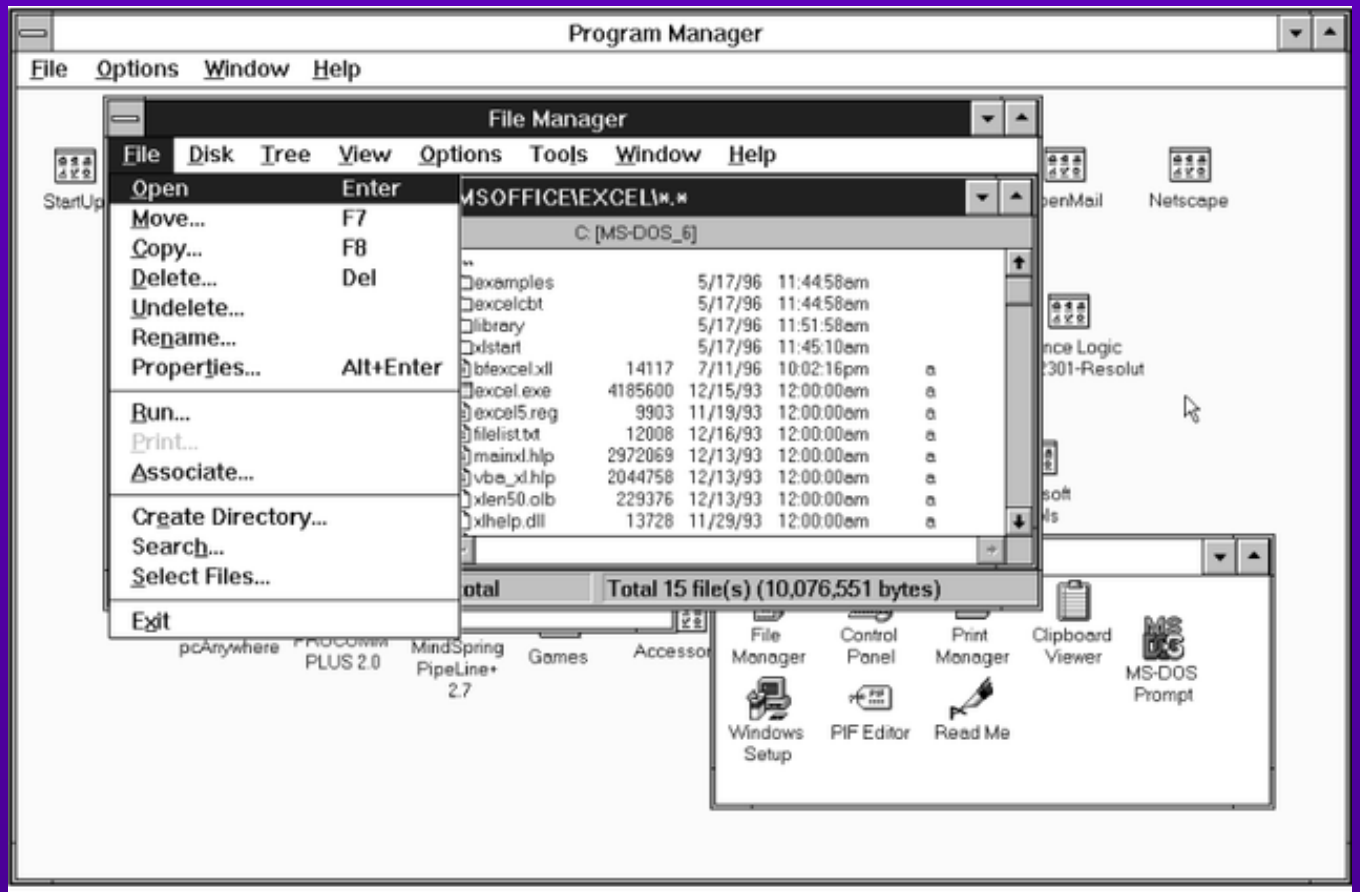

Figure 6-20 File menu in File Manager of Windows 3.1

Creating a Directory in Windows 3x

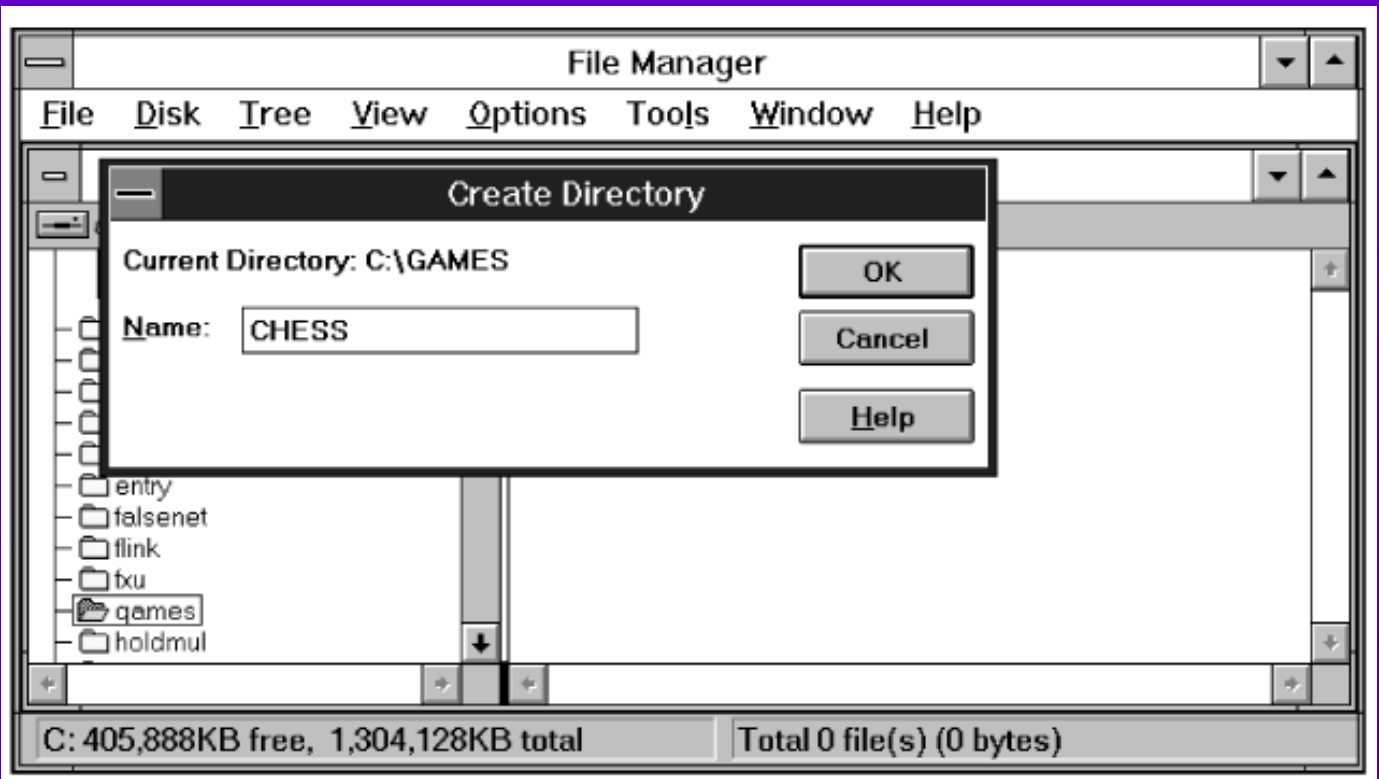

Figure 6-21 Creating a directory in Windows 3.1

Creating a Directory in Windows 3x

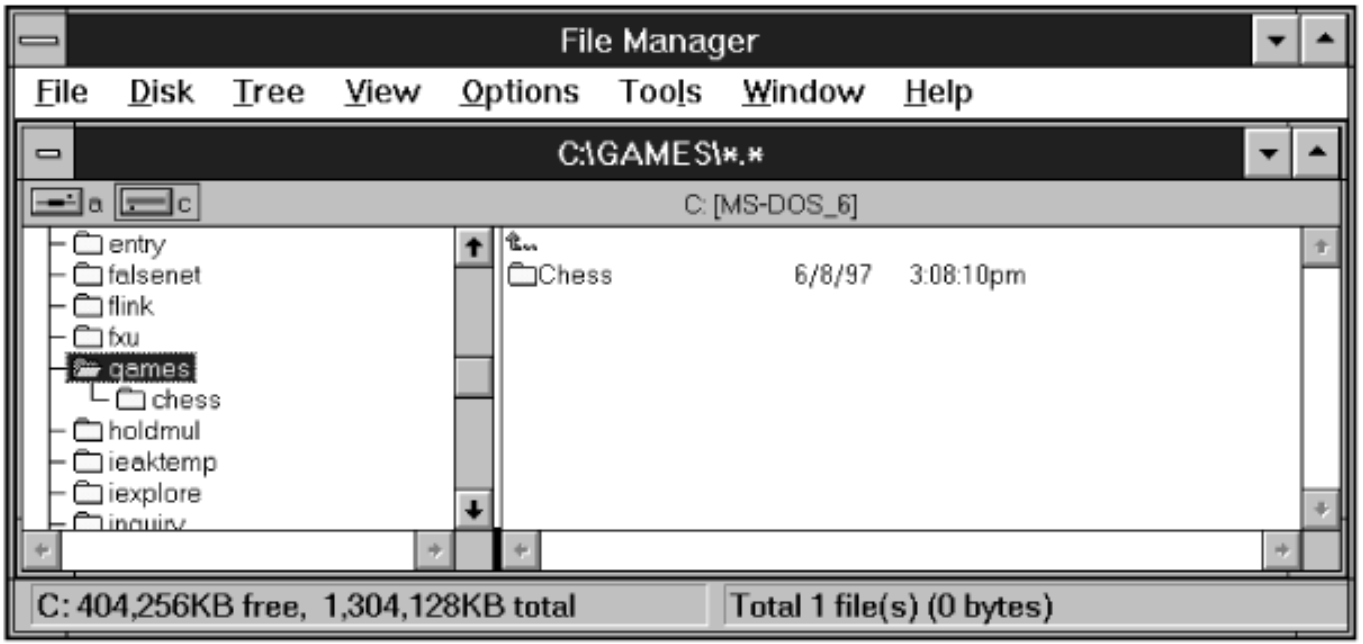

Figure 6-22 A new directory called Chess is created under \GAMES

Deleting a Directory in Windows 3x

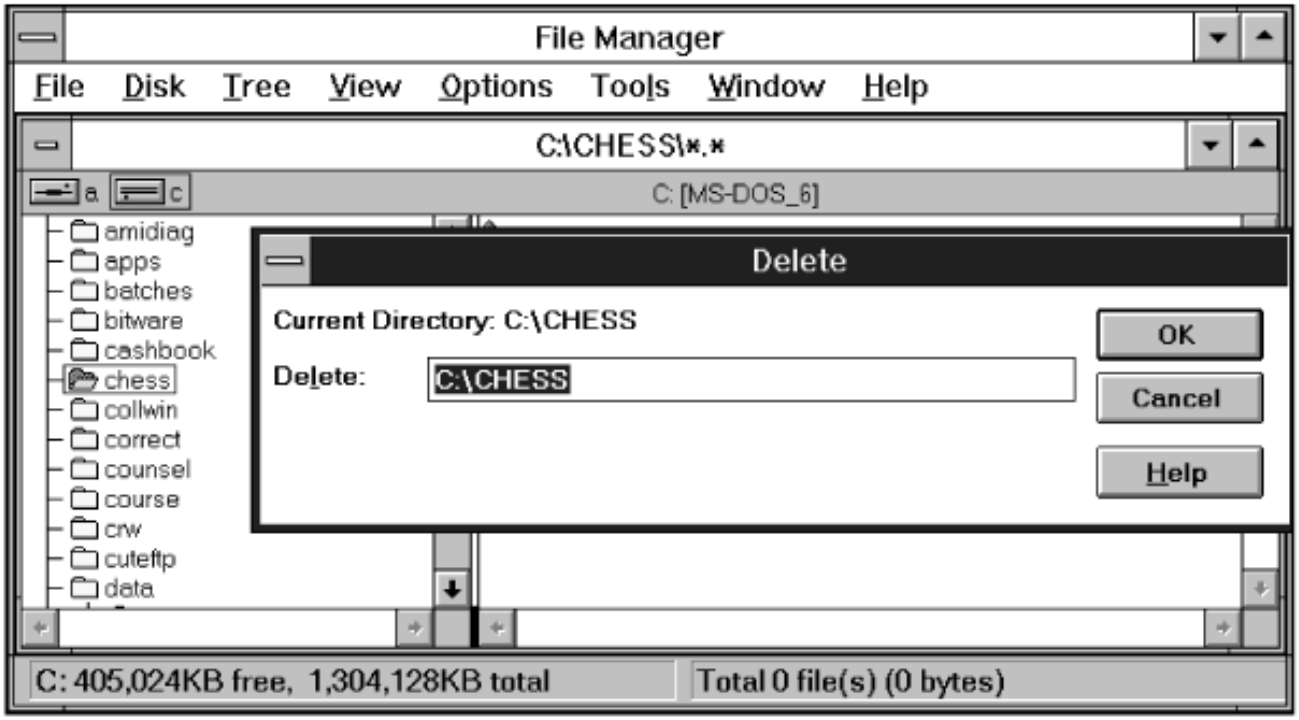

Figure 6-23 Deleting a directory

Windows 3x File Properties

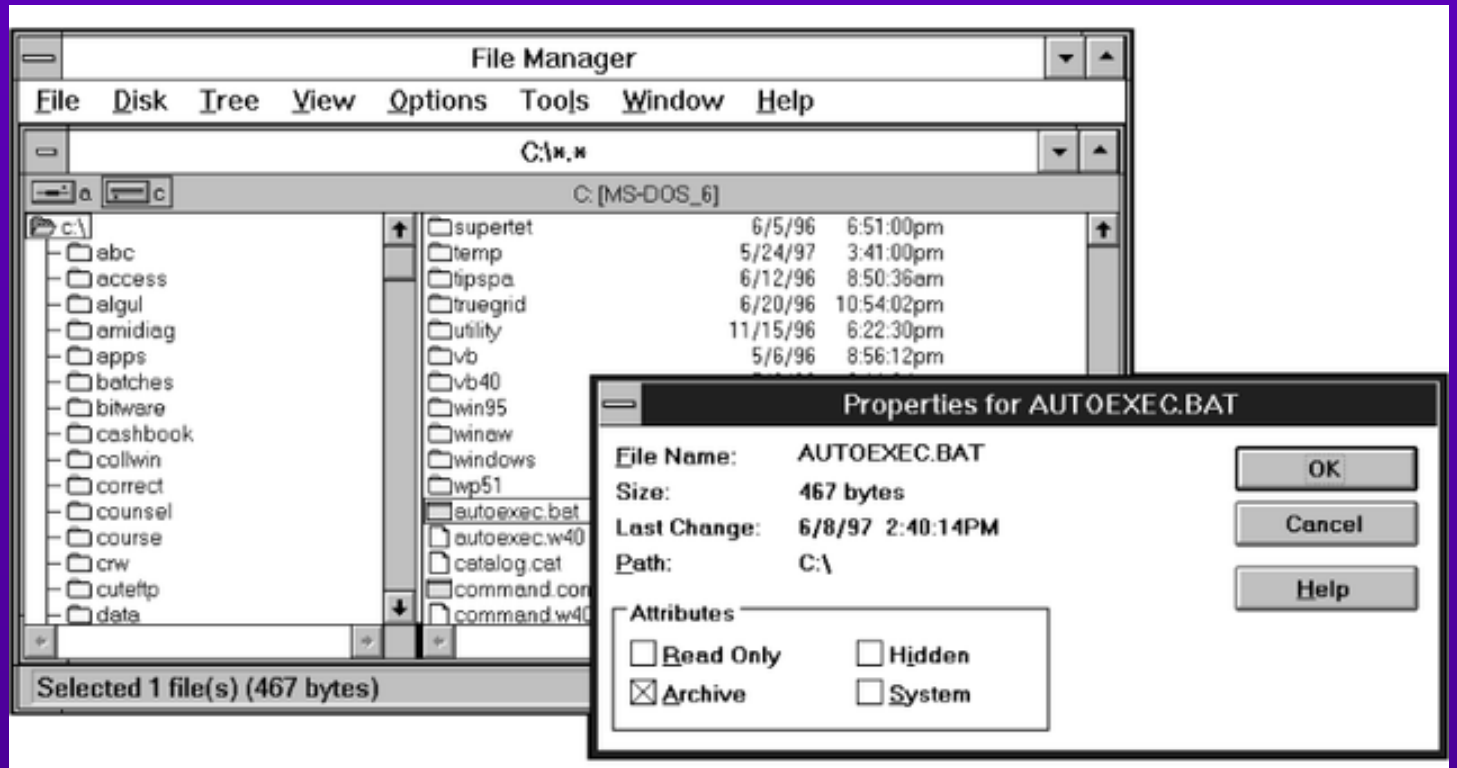

Figure 6-24 The properties of a file

Using Windows 9x to Manage a Hard Drive

- Primary tool: Windows 9x Explorer
  - Create a new folder
  - Delete a folder
  - File properties
- The PATH command and batch files

Creating a New Folder in Windows 9x

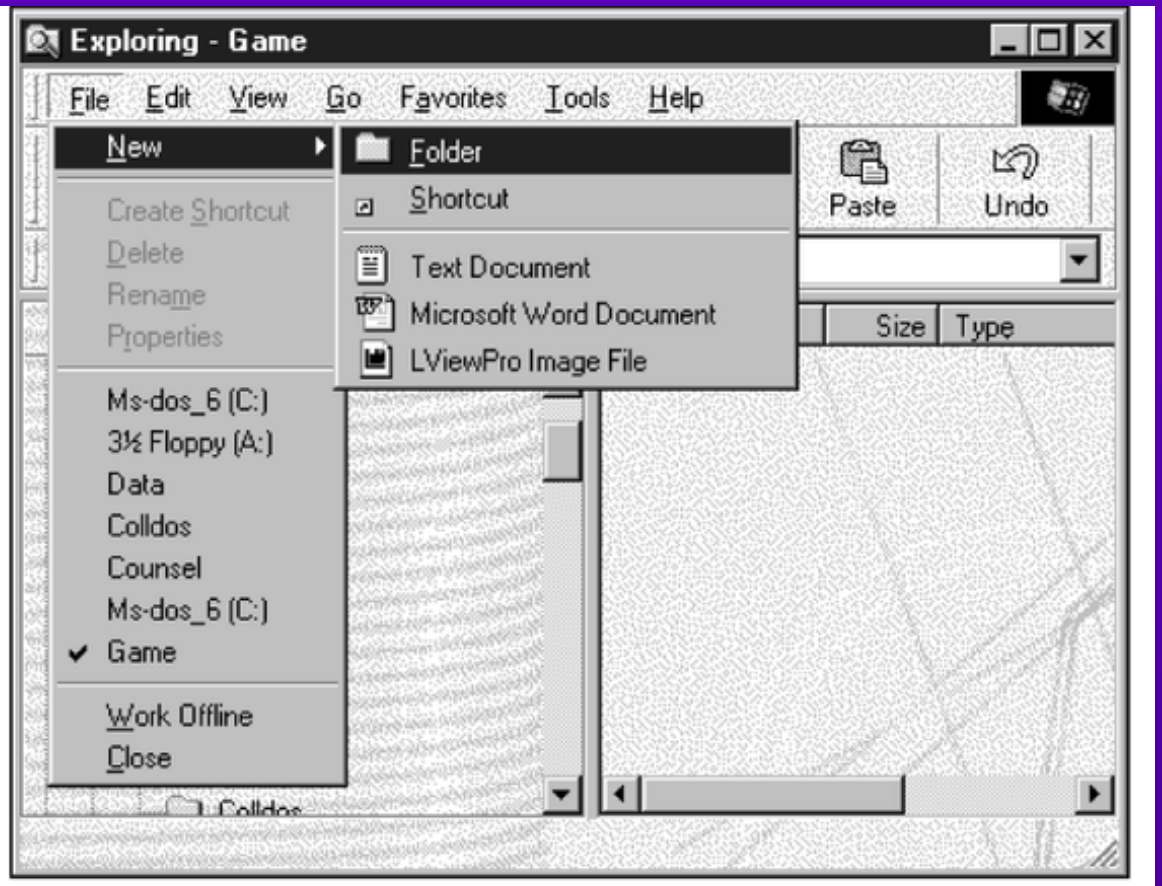

Figure 6-25 Create a new folder

Creating a New Folder in Windows 9x

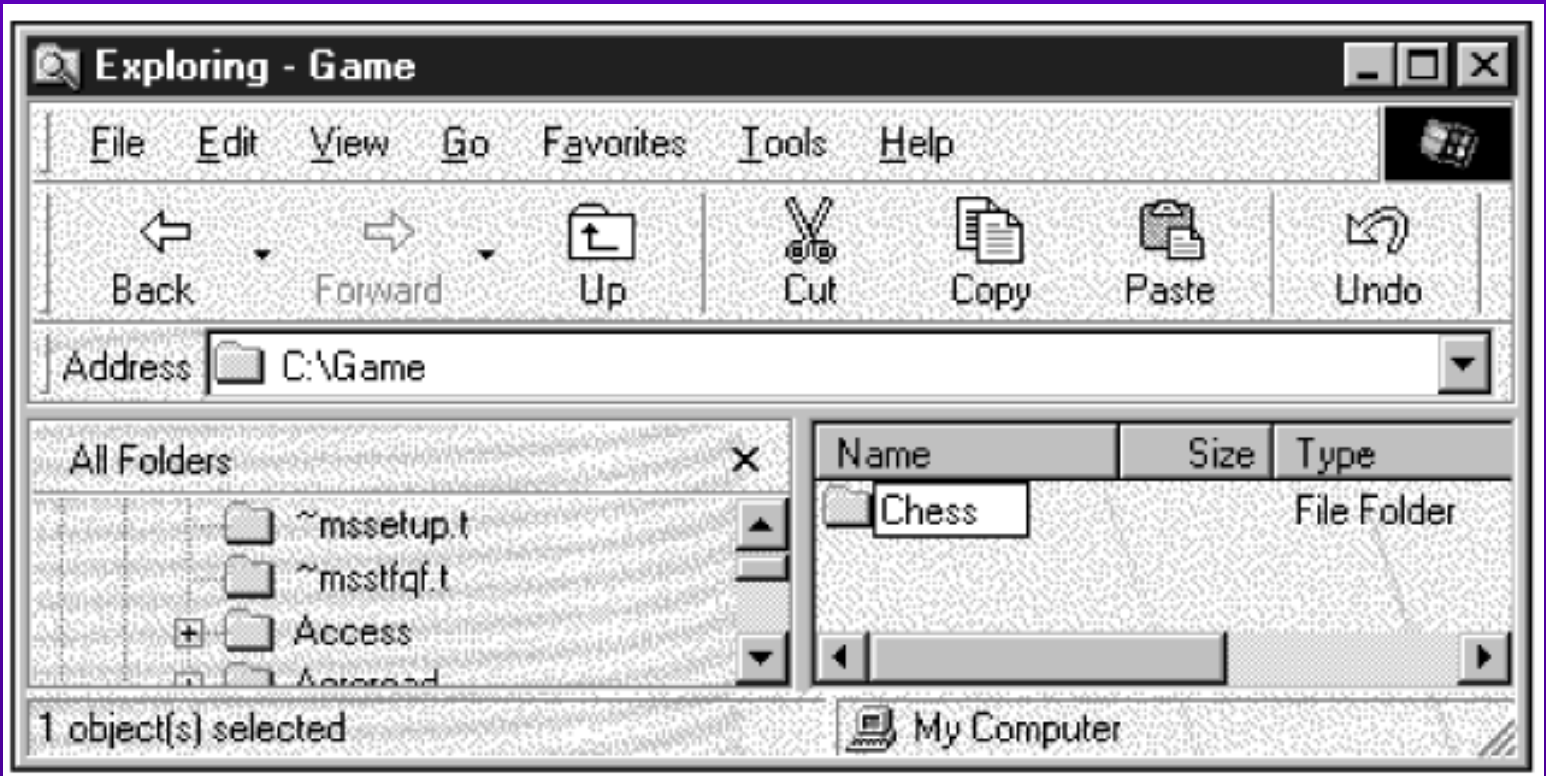

Figure 6-26 Edit the new folder's name

Deleting a Folder in Windows 9x

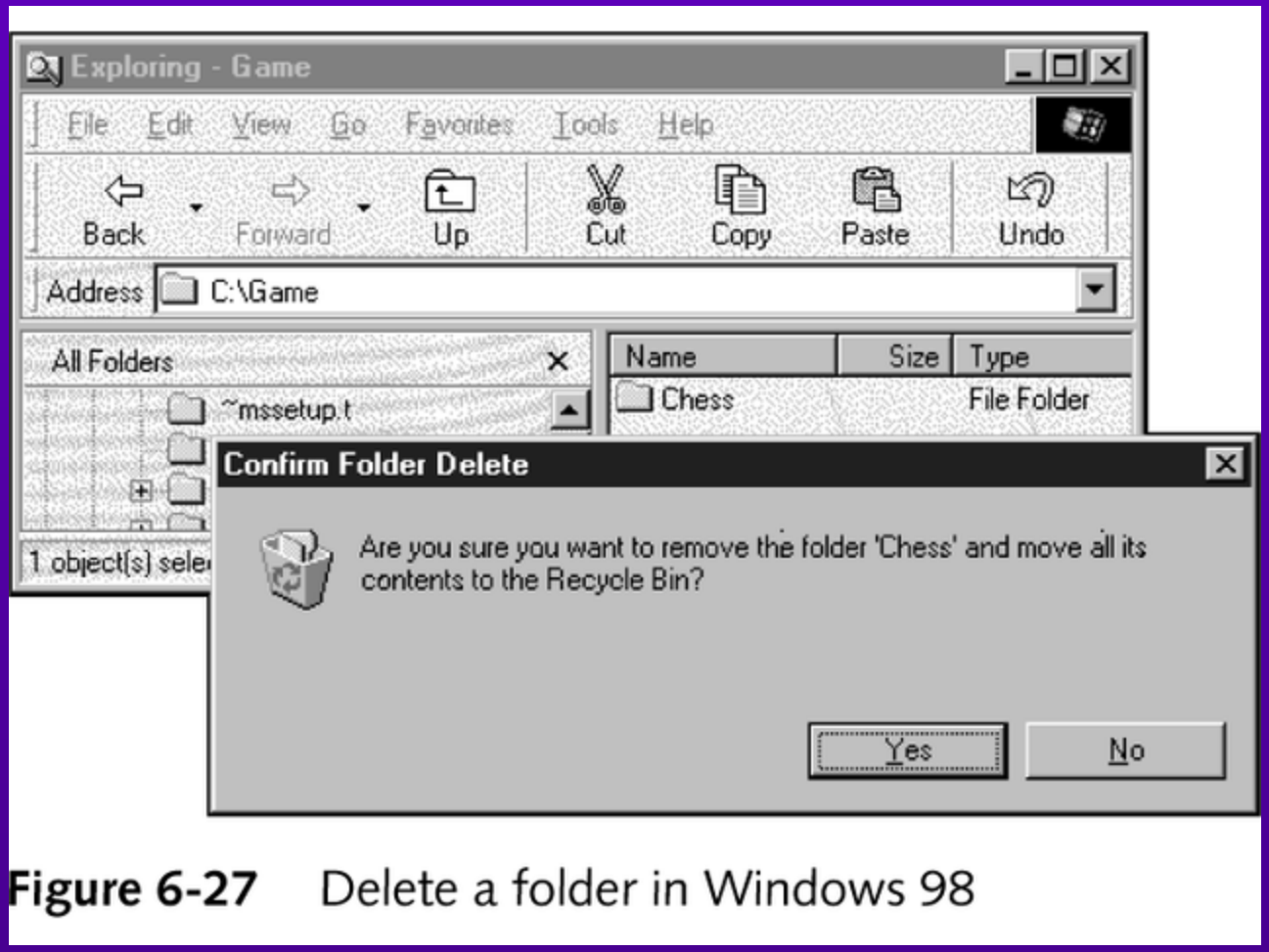

Figure 6-27 Delete a folder in Windows 98

Windows 9x File Properties

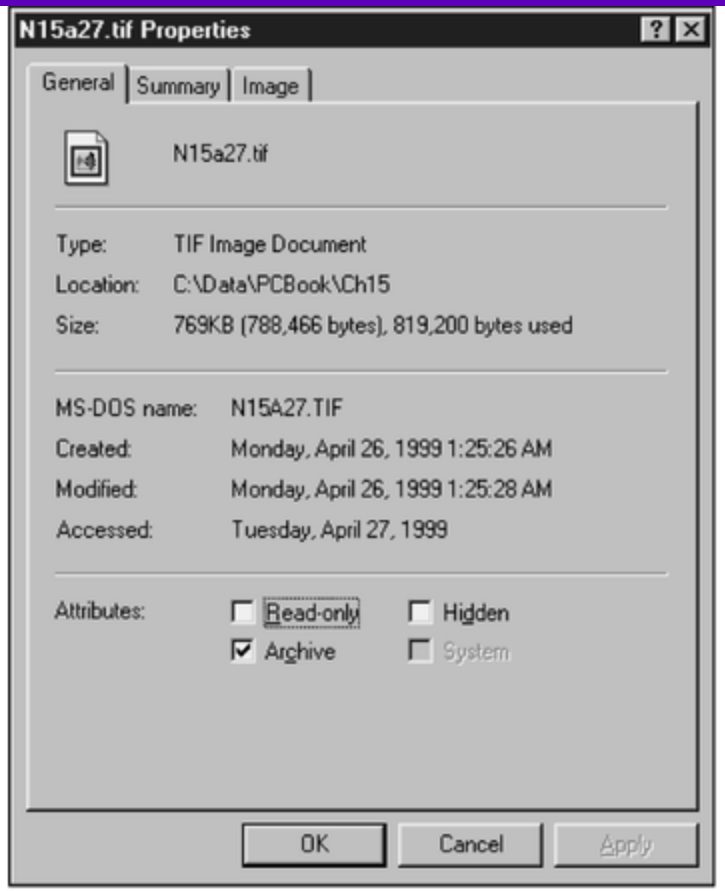

Figure 6-28 Properties of a file in Windows 98

Optimizing a Hard Drive

- Fragmentation
- Cross-linked and lost clusters
- Disk compression
- Disk caching

Fragmentation

- Distribution of data files in noncontiguous clusters; increases data access time
- Routine maintenance: defragment the hard drive
  - DOS
    - DOS 6+ DEFRAG or a utility software package
  - Windows 98
    - Defragmenter utility

Windows 98 Defragmenter Utility

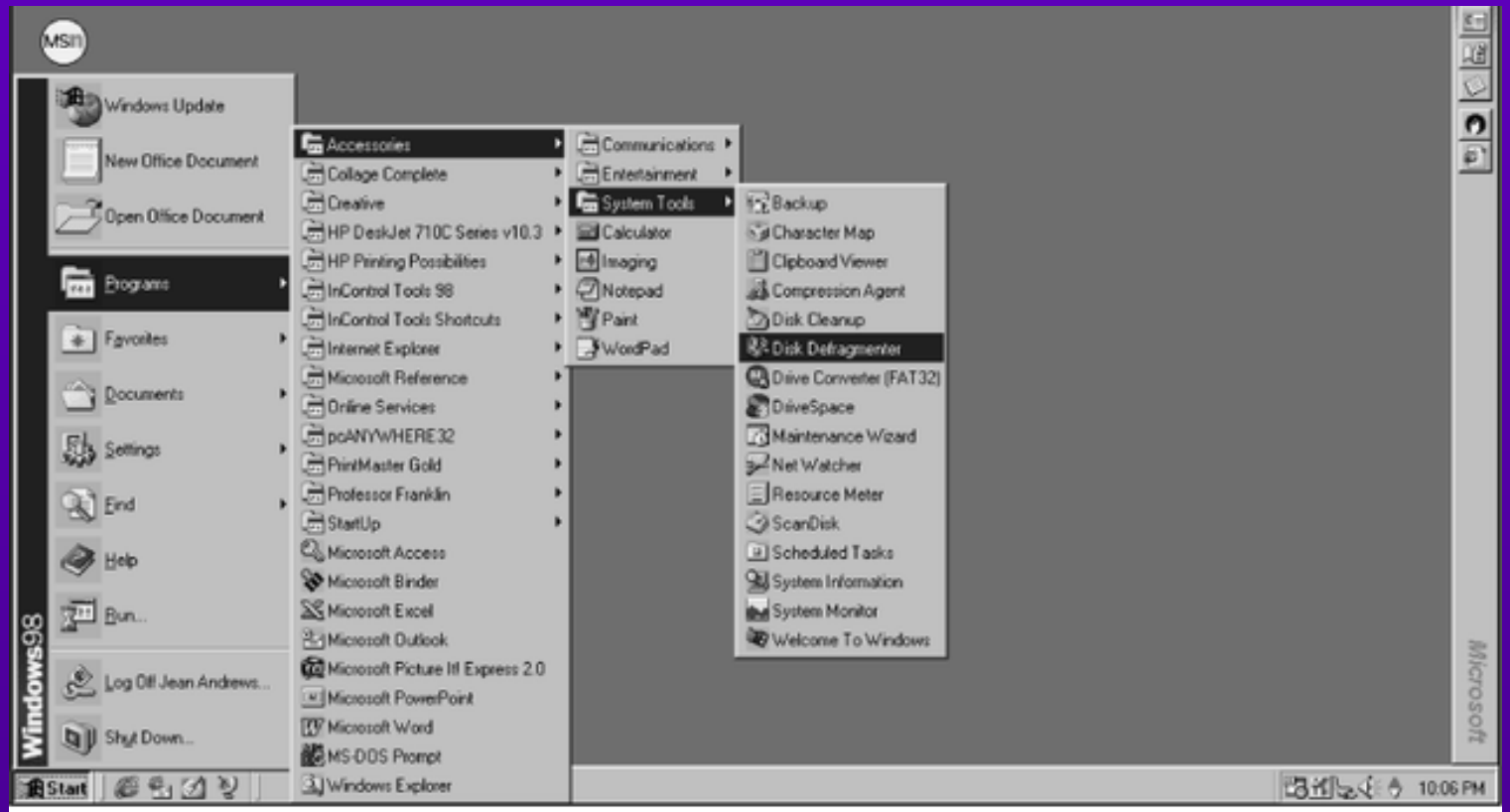

Figure 6-29 Windows 98 utilities

Disk Defragmenter Results

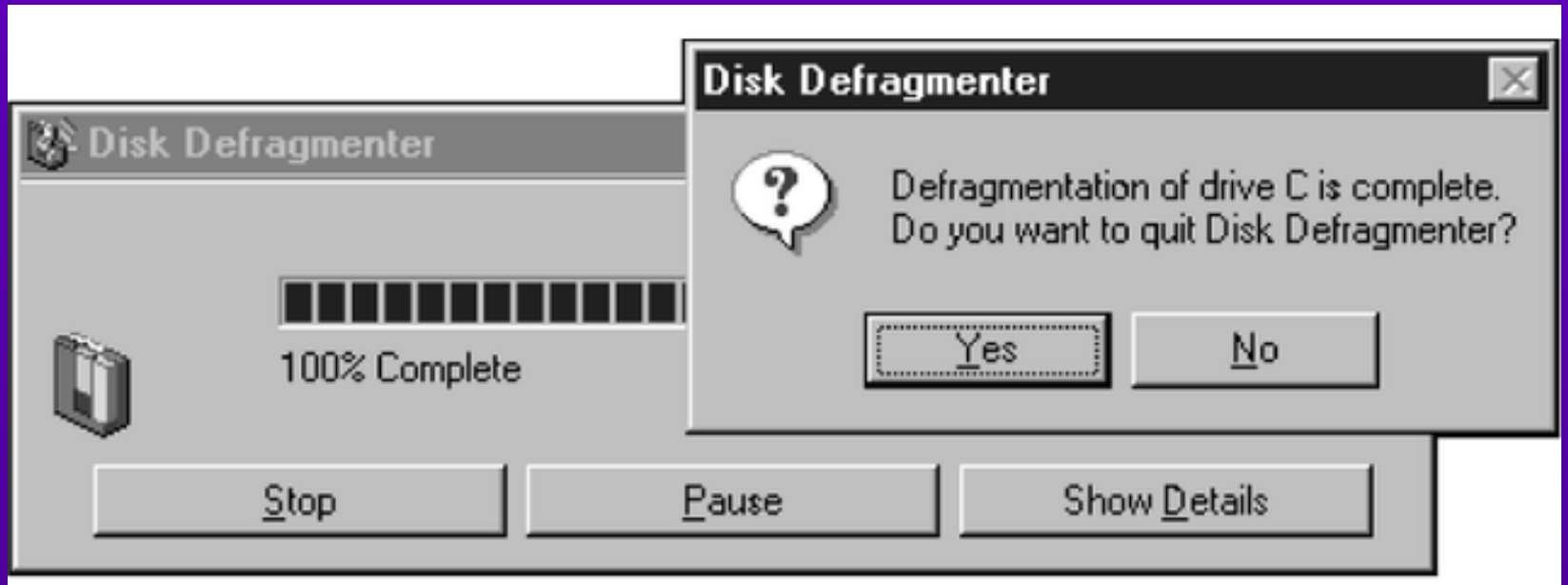

Figure 6-30 Disk Defragmenter results

Cross-linked and Lost Clusters

- Cross-linked
  - More than one file points to them
- Lost
  - No file in the FAT points to them
- To repair: use ScanDisk utility in either DOS or Windows 9x

Cross-linked and Lost Clusters

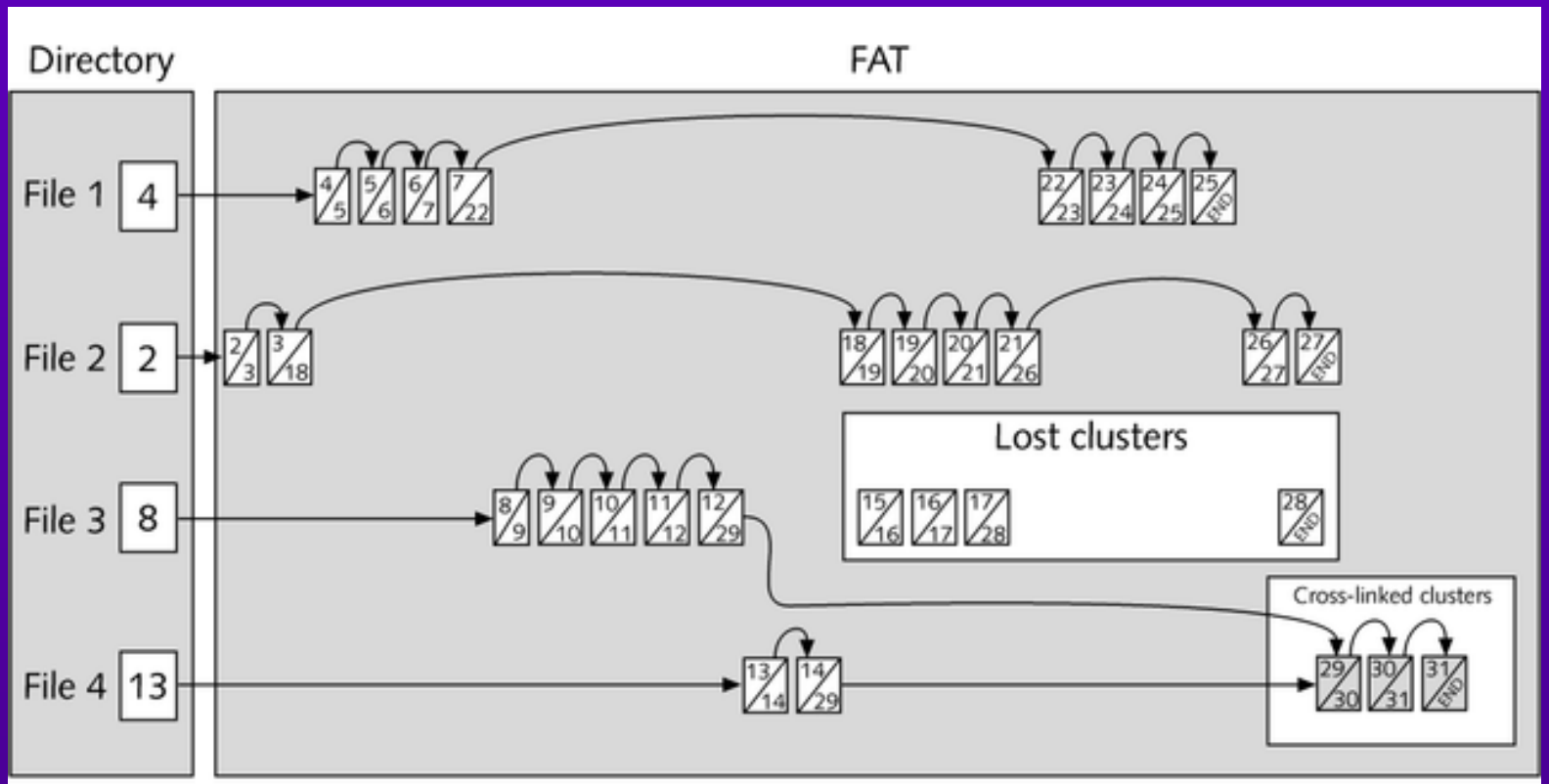

Figure 6-31 Lost and cross-linked clusters

SCANDISK Command for DOS

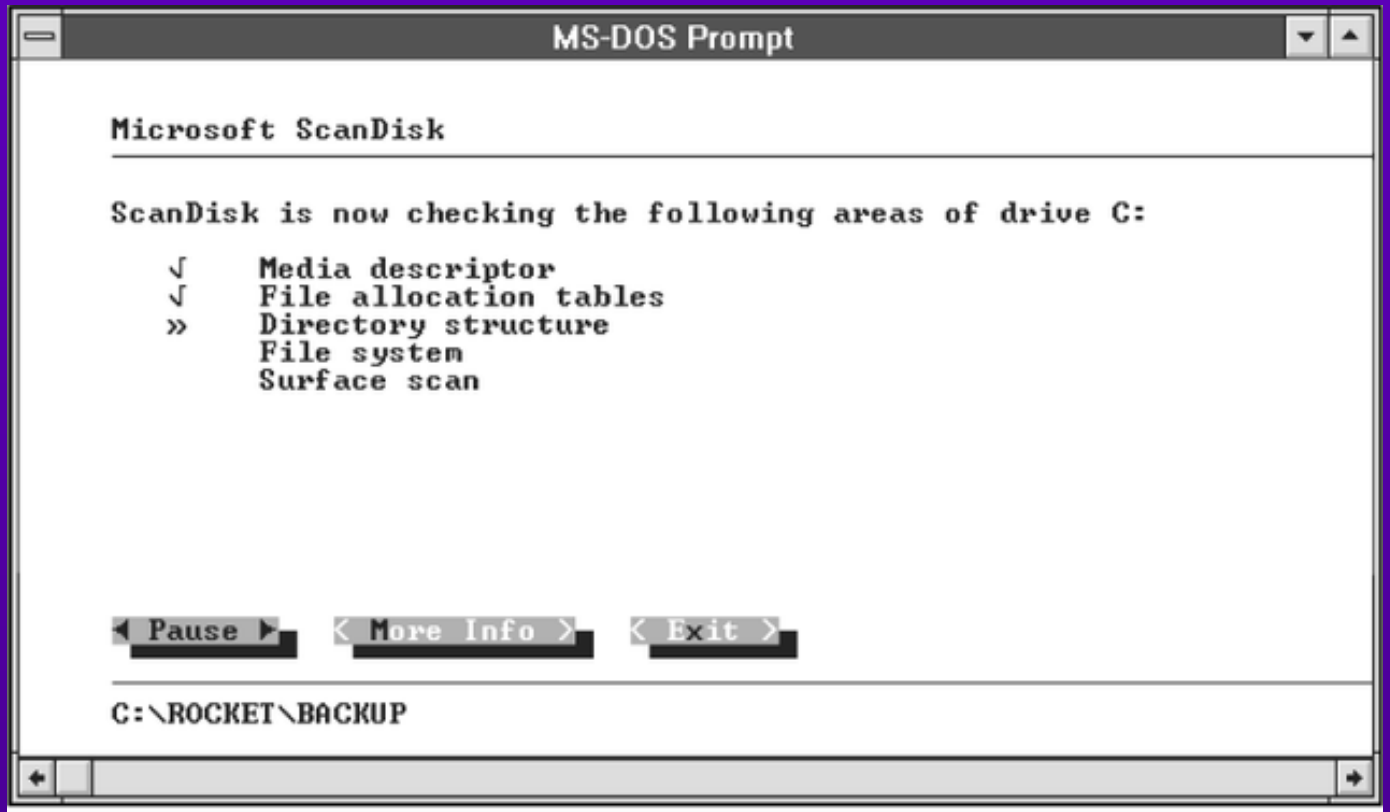

Figure 6-32 SCANDISK for DOS

ScanDisk

Figure 6-33 ScanDisk reports errors

ScanDisk

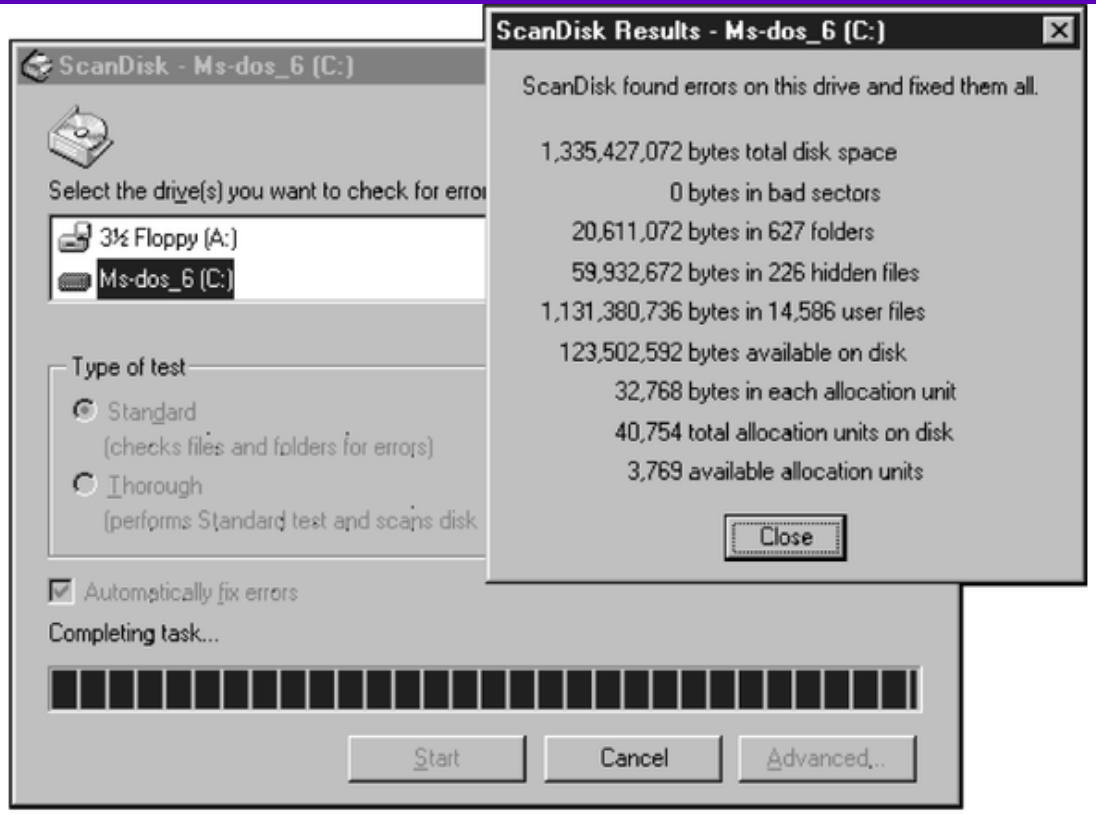

Figure 6-34 ScanDisk results

Disk Compression

- Compresses data on a hard drive to allow more data to be written to the drive
- Works by
  - Storing data on the hard drive in one big file and managing the writing of data and programs to that file
  - Rewriting data in files in a mathematically coded format that uses less space

Disk Compression in DOS and Windows 3.x

- Uses a device driver loaded in the CONFIG.SYS file
- PKZIP

Parts of a Compressed Drive

- Host drive
- Compressed volume file (CVF)

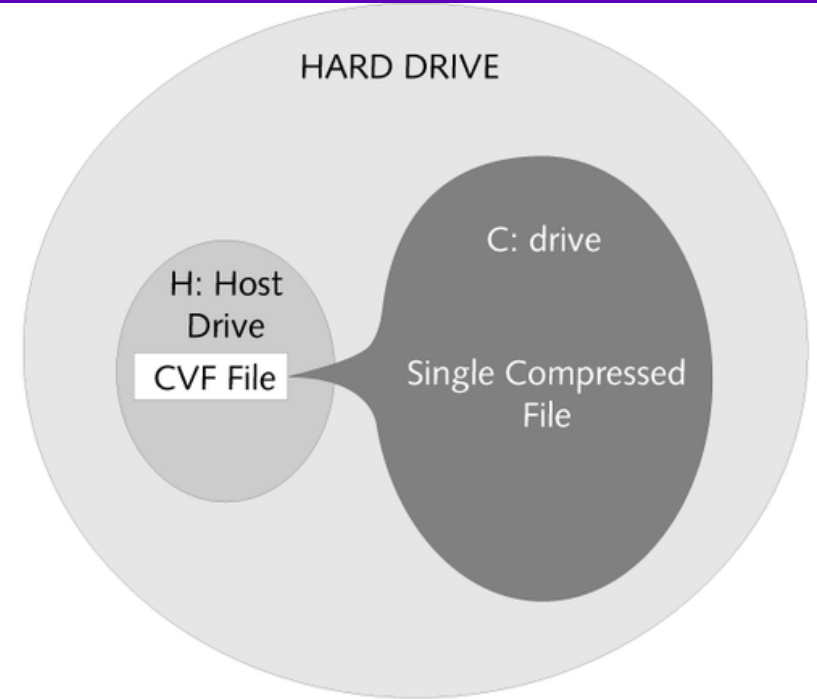

Figure 6-35 A compressed drive

Disk Compression in Windows 9x

- Uses DriveSpace to:
  - Assign different drive letter to hard drive, (e.g., H)
  - Compress entire contents of hard drive into a single file on drive H
  - Set up the drive so that Windows 9x and other applications view this compressed file as drive C
  - Configure Windows 9x so that each time it boots, DriveSpace driver will load and manage the compressed drive

Disk Compression in Windows 9x

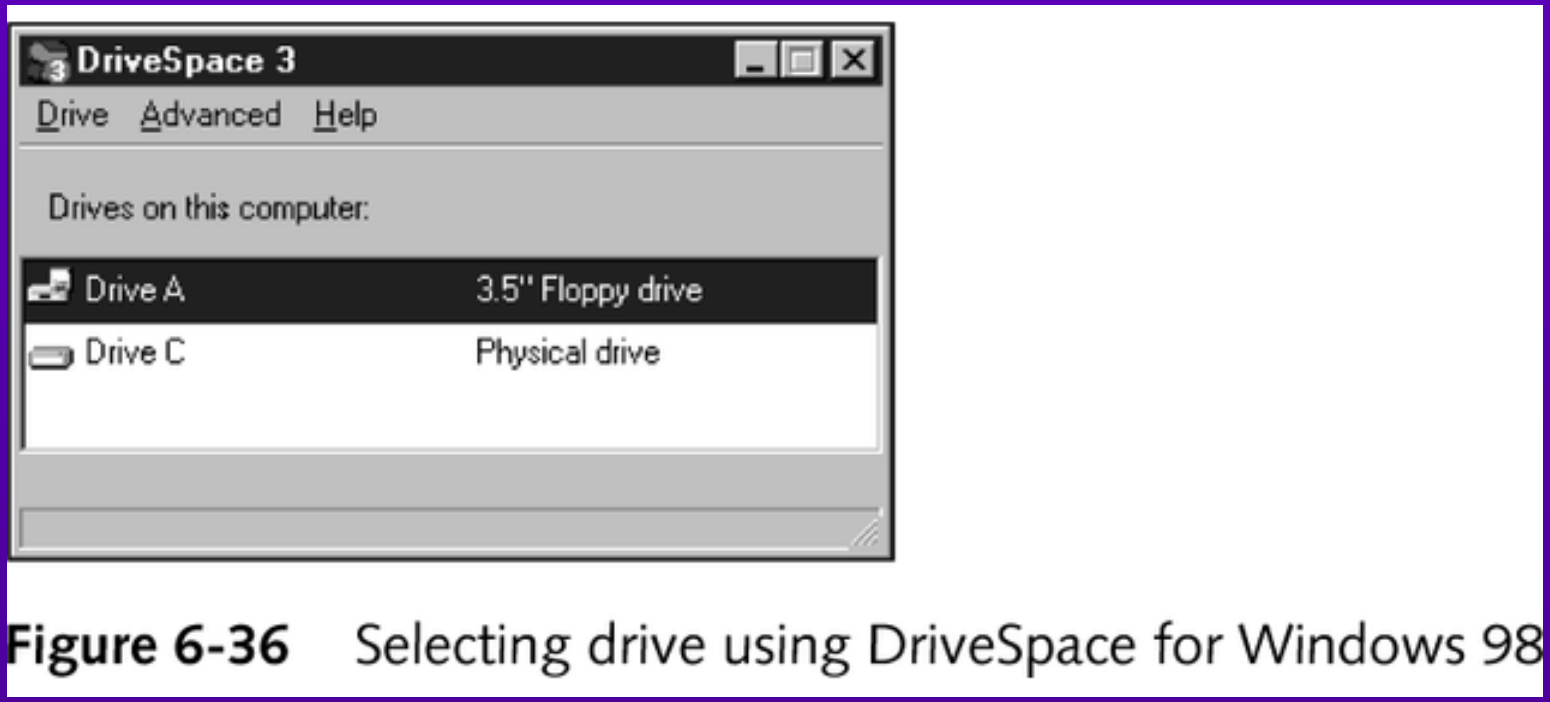

Figure 6-36 Selecting drive using DriveSpace for Windows 98

Disk Compression in Windows 9x

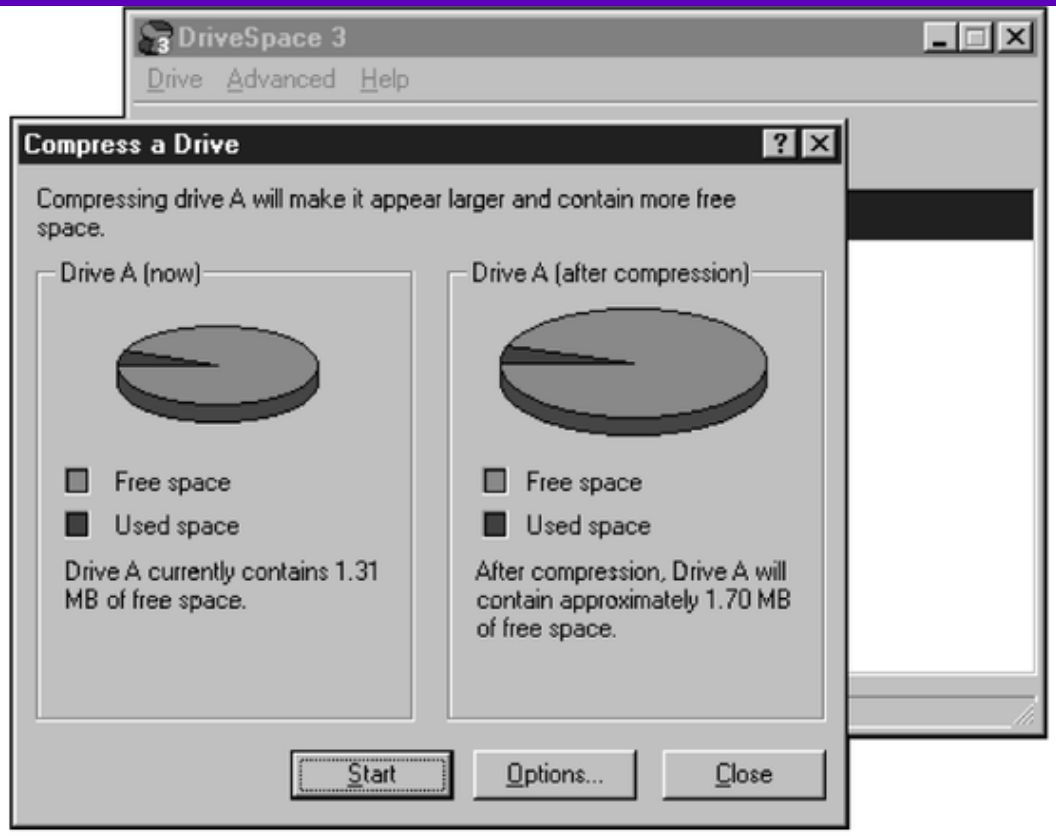

Figure 6-37 Drive compression predictions

Disk Compression in Windows 9x

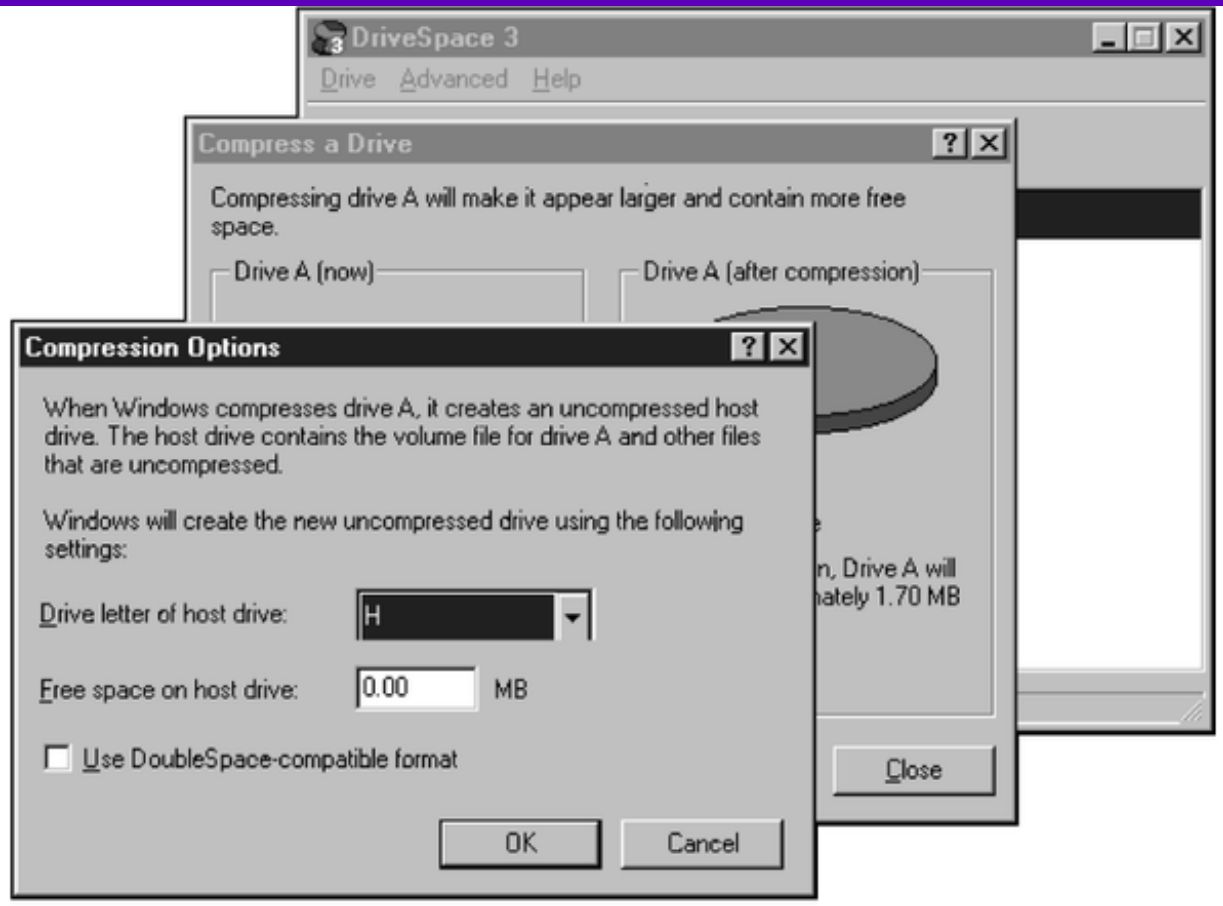

Figure 6-38 Drive compression options

Disk Compression in Windows 9x

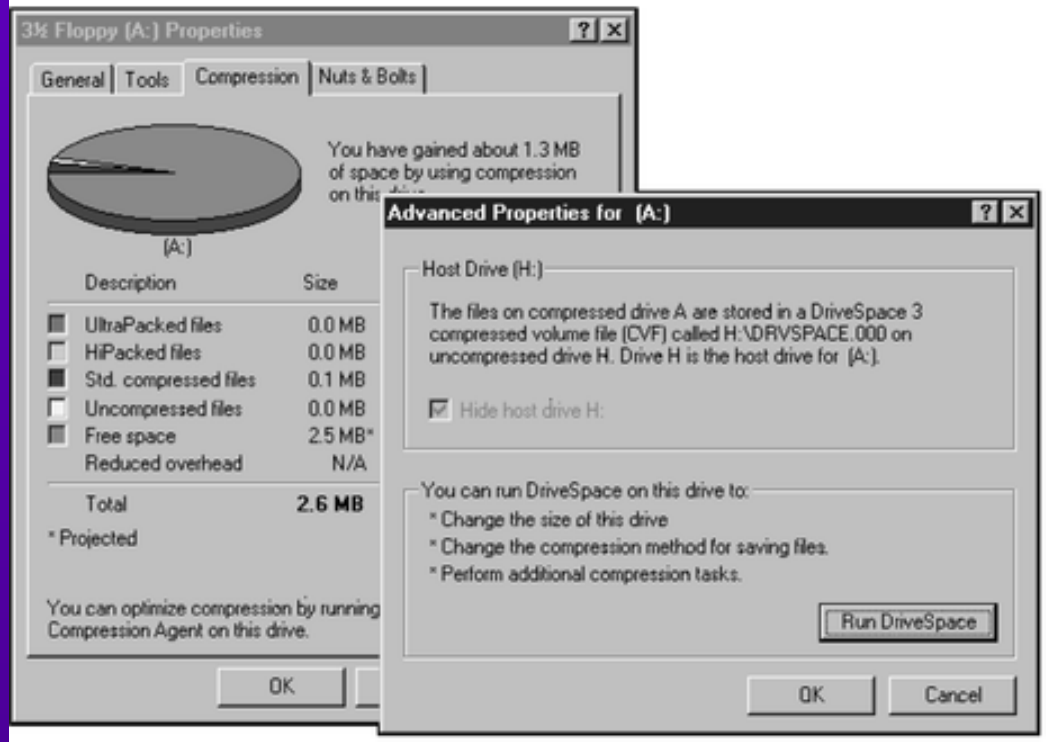

Figure 6-39 The Advanced Properties box gives information about the host drive for a compressed drive

Disk Compression in Windows 9x

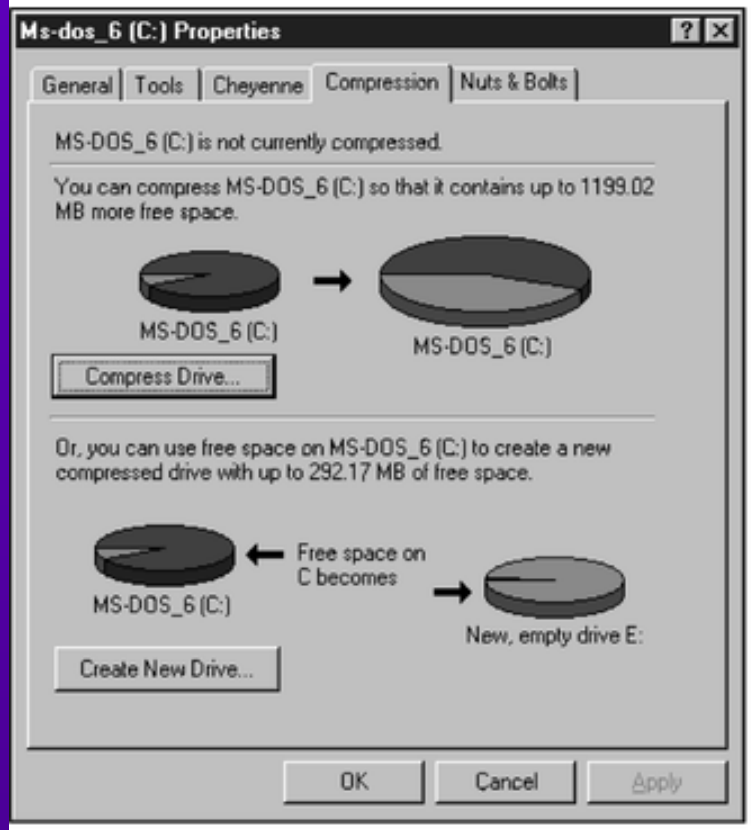

Figure 6-40 The Compression tab on the Properties box gives predictions about compressing a drive

Disk Compression in Windows 9x

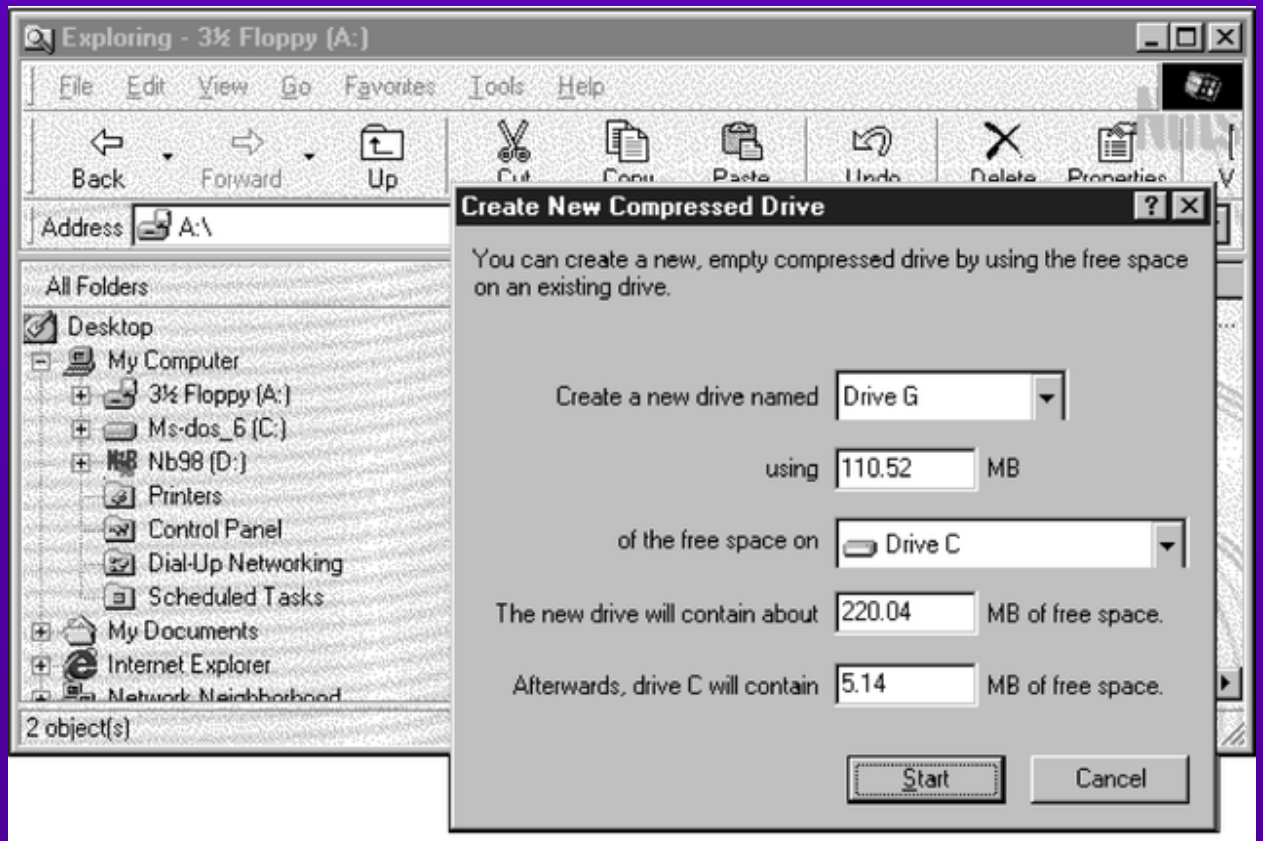

Figure 6-41 A new, empty compressed drive can be created by using free space on an existing drive

Disk Caching

- A method whereby recently retrieved data and adjacent data are read into memory in advance, anticipating the next CPU request
- Two kinds of hard drive caches
  - Hardware cache
  - Software cache

Disk Caching

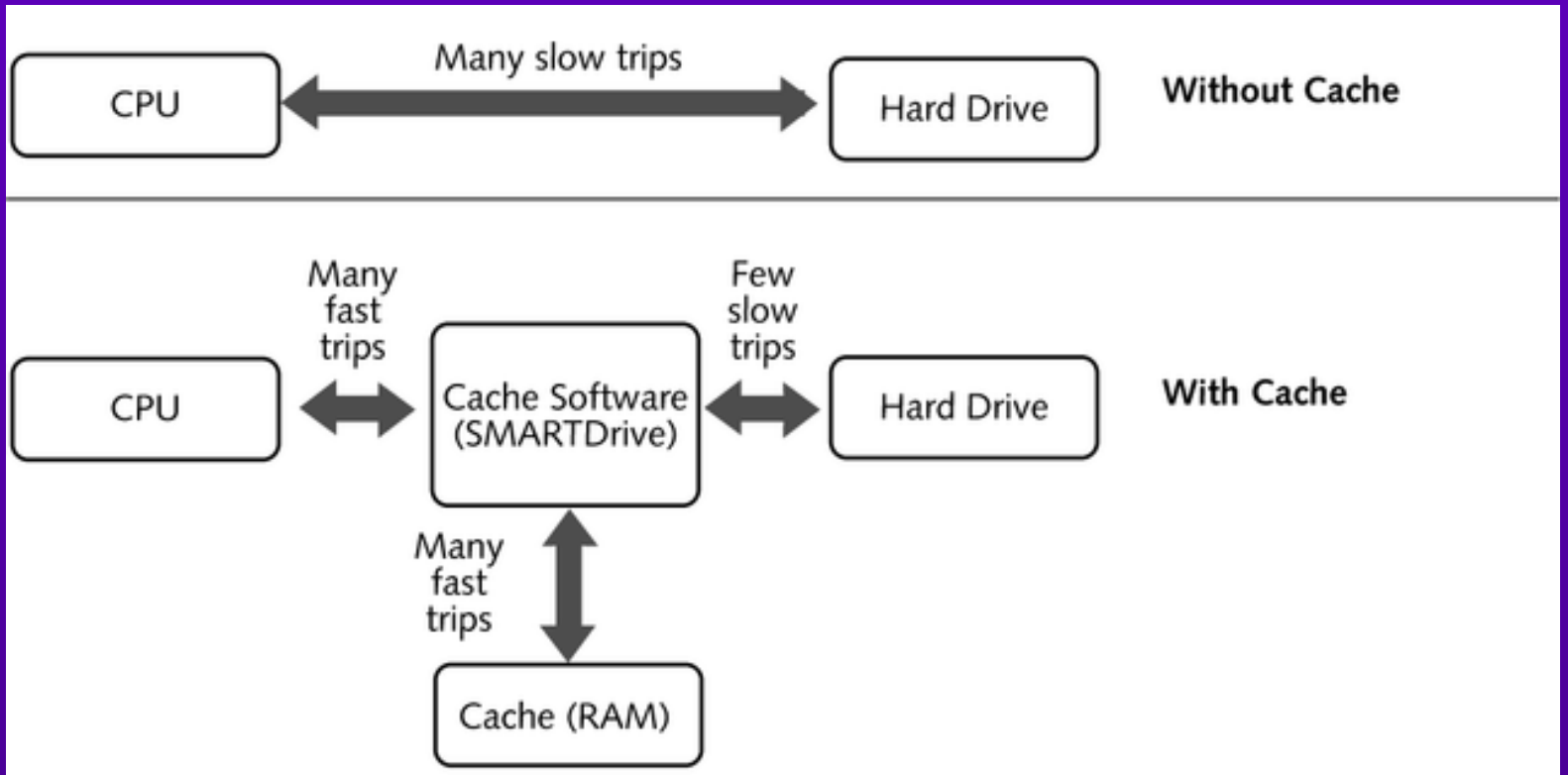

Figure 6-42 A CPU asking a hard drive for data without cache (upper part) and with cache (lower part)

Disk Caching

- Disk cache in DOS and Windows 3.x
  - SMARTDrive
  - Other packages (e.g., Norton Cache, Mace Cache, Super PC-Kwik Cache)
- VCACHE in Windows 9x
- DOS buffers
  - An area in memory where data waiting to be read or written is temporarily stored

Using DOS under Windows 9x to Manage a Hard Drive

- CAUTION: Using some DOS commands on a hard drive that uses Windows 9x as the OS may cause damage to a hard drive's file structure

DOS Commands to Avoid with Windows 9x

- Don’t use disk utility software that does not know about VFAT, long filenames or FAT32
- Don’t use FDISK, FORMAT C:, SYS C:, or CHKDSK while in a DOS session
- Don’t optimize or defragment the hard drive using software that does not know about long filenames

continued

DOS Commands to Avoid with Windows 9x

- Don’t run hard drive cache programs unless written especially for Windows 95 or Windows 98
- Don’t use older DOS backup programs (BACKYUP, MSBACKUP)

Removable Drives

- High-capacity drives, such as Zip or Jaz drives, that have disks that can be removed like floppy disks

Why Use a Removable Drive?

- Unlimited capacity
- Multiuser applications
- Transportability
- Data security
- Virus protection
- Organization
- Backup
- Fault tolerance
- Internet servers

Table 6-8 Reasons to add removable drives to your system

Advantage of Removable Drive	Description
Unlimited capacity	Because you can remove one disk and place a new one in the drive, there are no data storage limits.
Multiuser applications	In a business office, several users often share the same computer. If you require your own database or large files, as in desktop publishing or CAD/CAM applications, the removable drive can allow you to have your own hard drive capacity.
Transportability	Databases, software, and files can follow you from computer to computer. This is especially useful when you work on systems with weak WAN or LAN support.
Data security	Removable drives support data privacy. Simply remove the drive and place it under lock and key.
Virus protection	When downloading software or data to a removable drive, a possible virus will be contained to this drive. You can then scan this one drive prior to transporting data to other drives.
Organization	Removable drives permit data to be organized easily by volumes (just separate volumes onto different drives). This is especially useful for organizing several large projects.
Backup	When using a removable drive to back up data from the internal fixed hard drive, you can use fast random access to locate data or files; tape drives use sequential access, which is much slower.
Fault tolerance	If the computer stops working, it's easy to simply remove the drive and take it to another computer.
Internet servers	If removable drives are used for Internet services, each category can be stored on one removable drive. When you want to update that category, you can do the updating on another computer and then do an easy swap with the removable drive on the Internet server.

Available Products

- High-capacity disk drives
  - Iomega 3 ½-inch Zip drive: 100 MB or 250 MB
  - SuperDisk
    - Called LS-120 (laser servo 120 MB)
    - 120 MB of data
    - Backward compatibility with regular floppy disks
- Hard disk removable drives
  - Iomega Jaz drive: 1 GB or 2 GB capacity

Internal Zip Drive Kit

Figure 6-43 An internal Zip drive kit includes the IDE Zip drive, documentation, drivers on floppy disk, and one Zip disk

Chapter Summary

- Hard drive similarities to floppy drives
  - Has a file allocation table (FAT) and a root directory
  - Stores data on tracks that are divided into sectors, each of which contains 512 bytes
- Methods of organizing and formatting data
- Managing a healthy, previously installed hard drive
- Hard drive technologies
- Removable drives