

Understanding Disks and File Systems

When working with any operating system, it's important to understand how disks and file systems are used. Disks must be formatted using a specific file system, and the file system you choose can impact its performance and security. Windows operating systems include several different tools used to manage disks, and if you know how to use these tools, you can overcome most problems with any disk.

Exam 220-802 objectives in this chapter:

- 1.2 Given a scenario, install, and configure the operating system using the most appropriate method.
 - Partitioning
 - Dynamic
 - Basic
 - Primary
 - Extended
 - Logical
 - File system types/formatting
 - FAT
 - FAT32
 - NTFS
 - CDFS
 - Quick format vs. full format
 - Factory recovery partition
- 1.3 Given a scenario, use appropriate command line tools.
 - OS
 - FDISK
 - FORMAT

- DISKPART
 - CHKDSK
- 1.4 Given a scenario, use appropriate operating system features and tools.
 - Disk management
 - Drive status
 - Mounting
 - Extending partitions
 - Splitting partitions
 - Assigning drive letters
 - Adding drives
 - Adding arrays
- 1.7 Perform preventive maintenance procedures using appropriate tools.
 - Best practices
 - Scheduled check disks
 - Scheduled defragmentation
 - Tools
 - Check disk
 - Defrag
- 1.8 Explain the differences among basic OS security settings.
 - Shared files and folders
 - Administrative shares vs. local shares
- 4.3 Given a scenario, troubleshoot hard drives and RAID arrays with appropriate tools.
 - Tools
 - CHKDSK
 - FORMAT
 - FDISK
- 4.6 Given a scenario, troubleshoot operating system problems with appropriate tools.
 - Tools
 - DEFRAG

Understanding Disks, Partitions and Volumes

You probably remember from Chapter 4 that a hard disk drive is a physical piece of hardware with spinning platters and read/write heads. It's something you can touch. However, operating systems work with *partitions* or *volumes*, which are logical rather than physical.



You can divide, or partition, a physical disk into multiple volumes. Each volume is identified by a letter such as C, D, and so on. The operating system uses these letters as identifiers when accessing data on the different volumes.

NOTE PARTITIONS AND VOLUMES ARE THE SAME

Years ago, the terms *partitions* and *volumes* were used for different types of disks. However, these terms have merged and are interchangeable today. When you divide a disk, it's usually referred to as partitioning a disk, but when you use these partitions within the operating system, they are often called volumes. Don't be surprised if you see these terms mixed in different documentation, but the important thing to remember is that they are the same.

Figure 16-1 shows two ways you can partition a single hard drive, but there are more. In the first example, the disk is divided into four volumes. In the second example, a single disk is used to create a single volume.

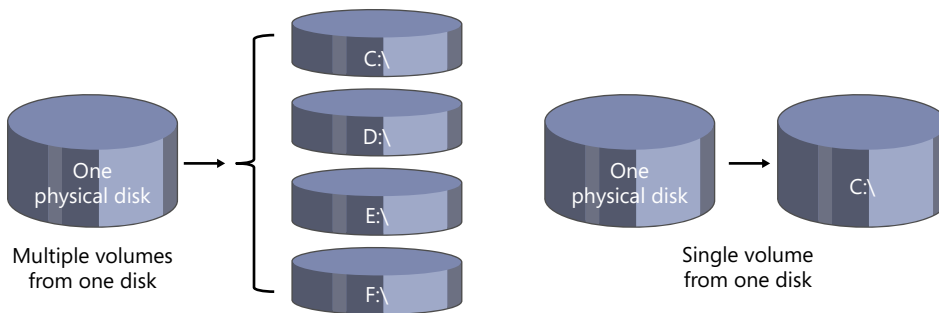


FIGURE 16-1 Partitioning a hard drive.

A logical question to ask is, “Why would you want multiple partitions?” It’s not necessary, but some people like to have different partitions to organize their data. For example, the operating system is on the C drive, and they create a second partition to store their data. Then again, they could leave it as a single partition and create a folder named Data for their files. It’s just a matter of preference.

MBR Partitions

The most common type of disk partitioning system in use is the *Master Boot Record (MBR)* partitioning scheme. You can divide an MBR disk into two types of partitions:

- **Primary partition.** A primary partition is used for a single volume, such as the C volume or D volume. One of the primary partitions is marked as active, indicating that it is bootable. During the startup process, the computer locates the active partition and attempts to boot from it. You can have as many as four primary partitions on a disk.

- **Extended partition.** An extended partition allows you to add multiple logical drives. For example, you can have one extended partition with three logical drives identified as G, H, and I. You can have only one extended partition on a disk. It isn't common to use extended partitions. The only reason you'd use one is to have more than four drive letters for a hard disk drive.

MBR disks have two limitations worth noting:

- The maximum size of a partition is 2 TB.
- You are limited to a total of four partitions for any disk. You can have four primary partitions, or you can have three primary partitions and one extended partition.

While these haven't been significant limitations in the past, larger hard drives are available, and a maximum disk size of 2 TB does pose problems for some users today.

GPT Partitions



The *Globally Unique Identifier (GUID) Partition Table (GPT)* overcomes the limitations of MBR disks and is specifically recommended for disks larger than 2 TB. The GPT partitioning scheme is supported in many current operating systems, such as Windows 7 and Linux. Key points to know about GPT disks include the following:

- **Larger volumes.** GPT has a theoretical limit of 9.4 zettabytes (ZB), and Windows-based systems support GPT disks as large as 256 TB. For context, a ZB is about a billion TB, but there aren't any disks of that size available—at least not yet.
- **More partitions.** Windows-based systems support as many as 128 primary GPT partitions on a single disk. Extended partitions are not needed or used with GPT disks.

Only fixed disks can be configured as GPT disks. Removable disks, such as flash drives, all use the MBR partitioning scheme.

Linux-based systems can use and boot from a GPT disk. Windows-based systems from Windows XP to Windows 7 can use a GPT disk. However, only 64-bit versions of Windows 7 can boot to a GPT disk and only if the computer is an Extensible Firmware Interface (EFI)-based system.

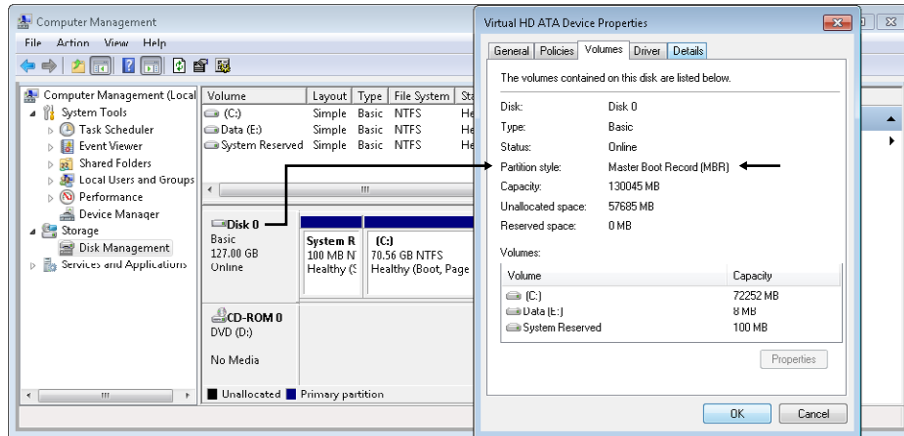
MORE INFO CHAPTER 2

Chapter 2 mentioned the UEFI, and as a reminder, UEFI is replacing or enhancing BIOS in many computers. Windows 7 can boot to GPT disks on UEFI-based systems but not on systems that only have a traditional BIOS.

Another benefit of GPT disks is that they are backward-compatible for applications that are expecting an MBR disk. A GPT disk includes a table called a *protective MBR* that simulates the MBR. Without this, older applications and disk utilities wouldn't be able to read the disk and might prompt the user to reformat it.

You can tell whether your system is using an MBR or GPT disk through the Disk Management tool by using the following steps on Windows 7:

1. Click Start, right-click Computer, and select Manage.
2. Select Disk Management.
3. Right-click a disk and select Properties. Select the Volumes tab and look at the Partition style as shown in the following graphic. The disk in the figure is an MBR disk.



You can convert an unpartitioned hard disk from MBR to GPT or from GPT to MBR from within the Disk Management console. For example, if it is an MBR disk, you can right-click the disk and select Convert To GPT. If it is a GPT disk, the option changes to Convert To MBR. These options are dimmed if the disk has any partitions on it.

Recovery Partition

Many computer manufacturers and resellers include a *recovery partition* with systems they sell. This is another partition on the hard drive that a user can access, often by pressing a specific key when the system starts.

If the primary partition develops a problem, the recovery partition can be used to restore the system to the exact state it was in when it was shipped. Users won't have access to any data or applications they added to their primary partition, but they will have a working system again.

EXAM TIP

A recovery partition is often invisible to the system. It isn't assigned a drive letter and usually isn't accessible with any applications other than the vendor's recovery application. If the primary partition is corrupted, such as from a virus, you can often use the recovery partition to restore the system to its original condition. Many vendors don't include media to restore a system, so if the recovery partition is modified or deleted, users won't be able to recover it.



Basic Disks vs. Dynamic Disks

Windows-based systems since Windows 2000 have supported two types of disks: *basic disks* and *dynamic disks*. Basic disks are used most often and are the simplest to use, but dynamic disks provide some additional capabilities. Both basic and dynamic disks can use either the MBR or the GPT partitioning scheme.

IMPORTANT BEST PRACTICE IS TO LEAVE DISKS AS BASIC

If you convert one disk to dynamic in a computer, you will not be able to use the system as a dual-boot system.

Unless you have a specific reason to do so, you should leave disks as basic instead of dynamic. Of course, that prompts the question, “What’s a reason to upgrade a disk to dynamic?”

Dynamic disks provide several benefits, such as the ability to create as many as 2,000 volumes on a single disk. This is useful for users who want to get beyond the four-partition limit of a basic MBR disk. You can also create striped, mirrored, and spanned volumes on dynamic disks, which are discussed in the following sections.

Dynamic Disks and RAID



One of the benefits of using dynamic disks is the ability to use a *redundant array of inexpensive disks (RAID)*. Different RAID configurations provide different benefits. A primary benefit of RAID is fault tolerance. A drive can develop a fault and fail, but the system can tolerate it and continue to operate.

However, you’ll find that dynamic disks do not support all the different RAID configurations on all operating systems. Common RAID configurations are presented in Chapter 4, and as a reminder, they are listed in Table 16-1.

TABLE 16-1 RAID Configurations

RAID	Number of Disks	Fault Tolerance	Dynamic Disk Support
RAID-0 Striped	At least two	No	Yes
RAID-1 Mirrored	Only two	Yes	Windows 7 (not Windows XP and Vista)
RAID-5	At least three	Yes	Only servers
RAID-10	At least four	Yes	No

If you convert the disk on any Windows-based system to dynamic disks, you can use RAID-0, but that is the only configuration that is universally supported. Only Windows 7

supports mirrored disks, and you can use RAID-5 (also called *striping with parity*) only on servers. Dynamic disks do not support RAID-10.



EXAM TIP

These limitations apply only to dynamic disks. Any system can support an external array of disks. For example, you can buy external disk enclosures configured as RAID-0, RAID-1, RAID-5, or RAID-10 and connect them with a USB, FireWire, or eSATA interface as described in Chapter 4. Windows views the external array as a single physical disk that can be partitioned as desired.

Striped Volumes (RAID-0)

You can create a striped volume (RAID-0) on any Windows-based system that supports dynamic disks. It includes space on more than one physical disk, but it appears to the operating system as a single physical volume. Dynamic disk striped volumes include at least two and up to 32 disks in the volume.

Each disk in the volume must be the same size, and data is stored in stripes on the different disks. For example, a two-disk striped volume would hold half of a file in one disk and the other half of the file in the other disk. The system can read both halves from the two disks at the same time, improving read performance. Additionally, the system can write both halves of a file to the two drives at the same time, improving write performance.

Mirrored Volumes (RAID-1)

Windows 7 supports mirrored volumes on dynamic disks. A mirrored volume includes two disks, and data written to one disk is also written to the other disk. If one of the disks fails, the system can continue to operate. Both disks must include partitions of exactly the same size.



EXAM TIP

You can create mirrored volumes (RAID-1) on Windows 7–based systems, but this configuration is not supported on Windows XP or Windows Vista. Windows XP and Windows Vista do support dynamic disks using RAID-0 and spanned volumes, but not RAID-1.

Spanned Volumes



A *spanned volume* includes space on more than one physical disk, but it appears to the operating system as a single physical volume. For example, if you have a D volume used for data but it's running out of space, you can add another physical disk and span the D volume to the new disk. The D volume will now have the additional space available.

You cannot span a boot or system volume, but you can span other volumes, such as one used for data. Chapter 11 describes the system and boot partitions in more depth. As a reminder, the system partition is where the system boot files are located (typically C:\), and

the boot partition is the location where the Windows-based system files are located (typically C:\Windows).

Spanned volumes don't provide any performance gains or fault tolerance benefits. Worse, if any physical drive in the spanned volume fails, the entire volume fails and all the data is lost. A better option is to use a mounted volume (described later in this chapter), which can be created on a basic disk.



EXAM TIP

Spanned volumes can be created only on dynamic disks. You can create a spanned volume with the Disk Management graphical user interface (GUI) tool covered later in this chapter.

**Quick Check**

1. What type of disk is limited to only four partitions?
2. What type of disk provides fault tolerance on Windows 7?

Quick Check Answers

1. Basic disk using MBR.
2. Dynamic disk using RAID-1.

File Systems

A file system is used to organize files and folders so that the operating system can access the files. Files are commonly organized in folders (sometimes called directories), and the file system allows users to browse through them to locate their files.



When you partition a hard drive, you are often prompted to choose a file system and format it. The *format* process organizes the partition based on which file system you choose. It also deletes existing data, so you don't want to reformat a disk unless you're willing to lose the data.

Several different file systems are available to format the hard drive with different characteristics. It's important to understand the differences between these file systems so that you can choose the best one.

NTFS is the recommended file system for most situations. However, there are other choices. The following sections describe the common file systems with a short discussion on disk clusters.

Understanding Clusters

You might recall that a hard drive has multiple platters and that each platter is divided using tracks, sectors, and clusters. These concepts are presented in Chapter 4, but as a reminder, the following bullets describe them and they're also shown in Figure 16-2.

- **Track.** A track is a complete circle around the hard drive. A drive will have many more tracks than the figure shows.
- **Sector.** The hard drive is logically divided into separate areas, similarly to how you'd cut a pie into separate slices, and a single portion of a track within a slice is a sector.
- **Cluster.** Multiple sectors are grouped together to form clusters. Clusters are also known as *allocation units*, and each cluster is identified with a unique number.

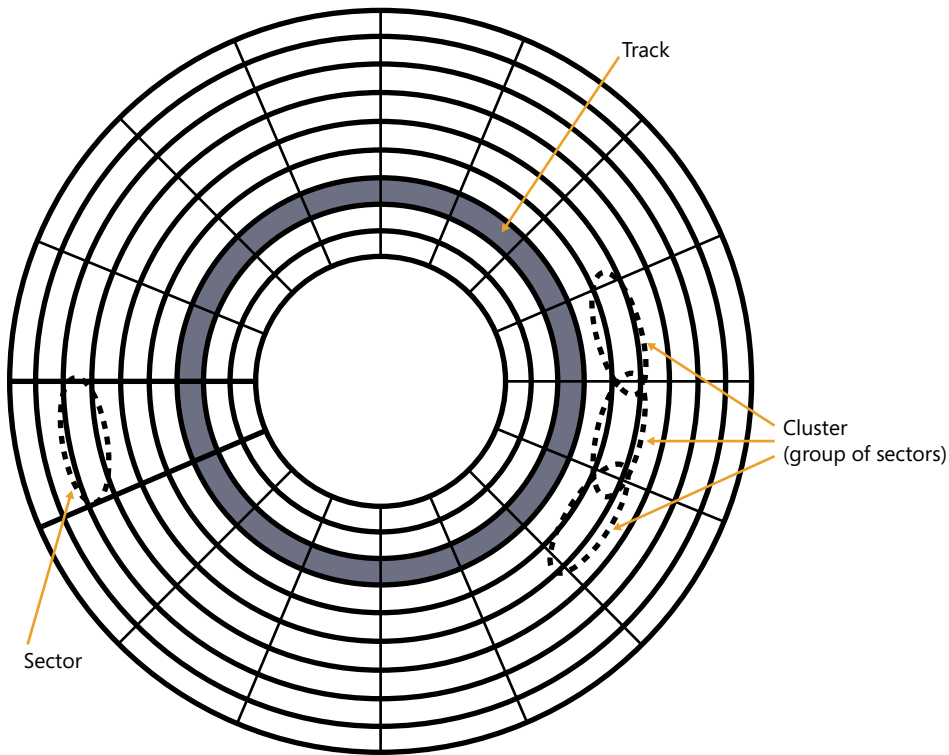


FIGURE 16-2 Tracks, sectors, and clusters.

File systems use a table to identify the location of files on a disk drive based on the clusters. For example, a file named A+Notes.docx stored on a hard drive might start in a cluster identified as 0x1357 and end at cluster 0x53A9. The operating system uses this information to locate and retrieve the file from the disk.

MORE INFO CHAPTER 1, “INTRODUCTION TO COMPUTERS”

Hexadecimal is covered in Chapter 1. As a reminder, the 0x prefix indicates that a number is hexadecimal, and each hexadecimal character represents four bits.

Cluster sizes vary between file systems, but the size of a cluster is commonly 4,096 bytes (or 4 KB). There aren't many files that are only 4 KB in size, so files are stored in multiple clusters.

Fragmentation

It's best if the files are stored in contiguous clusters so that the hard drive can start reading in one cluster and then continue reading until the entire file has been retrieved. For example, a 10-MB file would ideally start in one cluster on the hard drive and use each of the clusters after it until the entire file is stored on the drive. However, as a hard drive fills up, there isn't always enough space to store a file in contiguous clusters.

Instead, the file system divides or fragments a file and stores these fragments in different locations on a hard drive. A 10-MB file might have 5 MB written in one area, 3 MB in another area, and the last 2 MB in another area. When the file is read, the operating system retrieves each of these fragments and puts the file back together.

Some fragmentation is common on a disk. However, when a disk is used more and more often, fragmentation can become excessive. Instead of a file being divided into three fragments, it could be divided into dozens of fragments. The system has to work harder and harder to retrieve these fragments and put them back together.

Symptoms of a fragmented hard drive are as follows:

- **Disk thrashing.** The LED for the disk drive is constantly blinking, indicating heavy activity. Additionally, you can hear the drive working as the read/write head is constantly moving around the disk retrieving the different file fragments.
- **Slow performance.** The overall performance of the system slows down.

If you suspect a drive is highly fragmented, the best solution is to check it and defragment it. You can do so with the Disk Defragmenter GUI or the defrag command-line tool, both described later in this chapter.



EXAM TIP

If a system is slow and the hard drive LED shows constant activity, check for fragmentation. You can often optimize the overall performance of a computer and increase its efficiency by ensuring that disk drives are defragmented. You can use the defrag command or the Disk Defragmenter GUI to defrag a volume. If you have these symptoms but the drive is not defragmented, the system might need more physical memory.

Bad Sectors

Disk drives often have small areas that are faulty. As long as these areas are marked, they won't be used and they won't cause any problems. If you do a full format of a disk (described later in this chapter), it will check all the sectors on the disk and mark faulty areas as bad. You can also use the `chkdsk` command (also covered later in this chapter) to look for and mark bad sectors.

FAT16 and FAT32



The *File Allocation Table (FAT)* file system is native to Microsoft operating systems and widely supported by other operating systems, such as Linux. The two common versions of FAT are FAT16 and FAT32.

Each of the FAT versions uses a table to identify the location of files on a disk drive based on the clusters. FAT16 (commonly called just FAT) uses 16 bits, and FAT32 uses 32 bits to address these clusters. With more bits, the file system can address more clusters and support larger disks. Table 16-2 shows the different sizes of partitions and files supported by these FAT versions.

TABLE 16-2 FAT Versions

	FAT16	FAT32
Maximum partition size you can create	4 GB	32 GB
Maximum file size	2 GB	4 GB

If you ever try to copy or download a file larger than 4 GB to a FAT32 disk, you'll get an error that indicates you don't have enough space. You could have a brand new, empty 16-GB USB flash drive, but you'll still get this error. The reason isn't because you don't have enough space but because FAT32 can't handle files greater than 4 GB. Convert the drive to NTFS, and you won't have this problem.



EXAM TIP

When creating FAT32 partitions from within Windows, you are limited to a maximum size of 32 GB. It is possible to create larger FAT32 partitions by using other utilities or on other operating systems, and Windows-based systems can recognize and use them.

You can format disks as FAT, FAT32, or NTFS from Windows-based systems such as Windows 7. However, you can format disks as FAT only if they are smaller than 4 GB. If the disk size is larger than 4 GB, you can select only FAT32 or NTFS.

Windows-based systems support exFAT (or FAT64), but this format isn't widely supported on non-Windows-based systems. If you're formatting a disk larger than 32 GB, you'll also see exFAT as an option.

REAL WORLD FAT32 FILE SIZES LIMITED TO 4 GB

A friend of mine was trying to copy a large file (about 5 GB) from a computer to his USB flash drive a while ago. He had just purchased a brand new 8-GB flash drive, and it was apparently working fine. However, when he tried to copy the file, he received an error indicating there was no room on the drive. A well-meaning coworker told him that the USB flash drive was faulty and that he should return it. He almost did.

However, we got together to watch a game, and he mentioned the problem he was having. Luckily, I remembered that most USB flash drives are formatted as FAT32 and that the maximum file size you can copy to a FAT32 drive is 4 GB. If you try to copy larger files, it gives the same error he was seeing. The drive wasn't faulty. He was just trying to exceed the capacity of the file system. He converted the drive to NTFS and was saved the hassle of returning it. A little bit of knowledge can save a lot of wasted time.

NTFS



New Technology File System (NTFS) is a secure file system, and when using Windows-based systems, it is by far the best choice compared to any of the FAT versions. Microsoft recommends the use of NTFS with Windows operating systems, and newer operating systems such as Windows 7 must be installed on NTFS. The install program won't allow you to install Windows 7 on a FAT volume.

NTFS provides better security, improved performance, and more features than any of the FAT versions. Some of the features and capabilities include the following:

- **File and folder permissions.** You can assign permissions to control access to any files and folders. Permissions are covered in more depth in Chapter 25.
- **Encryption.** Files and folders can be encrypted with the Encrypting File System (EFS) to prevent unauthorized users from viewing the file contents.
- **Compression.** Files can be compressed so that they take up less space on a disk drive.
- **Larger volumes.** NTFS volumes can be as large as 2 TB on MBR disks or as large as 256 TB on GPT disks.
- **Efficient.** NTFS uses clusters within a hard drive more efficiently than any of the FAT file systems.
- **Built-in fault tolerance.** NTFS can detect and recover from some disk-related errors without any user intervention.

NOTE ENCRYPTION OR COMPRESSION

You can encrypt data on an NTFS drive or compress it. However, you cannot do both.

CDFS



The *compact disc file system (CDFS)* is the standard used to access files on optical discs. It is formally defined in ISO 9660 and widely supported by different operating systems, including Windows, Linux and Unix systems, and the Mac OS.



Quick Check

1. What's the maximum size of a FAT32 partition you can create on Windows?
2. What file system provides the best security?

Quick Check Answers

1. 32 GB.
2. NTFS.

Disk Management Tools

Windows provides several different tools that you can use to manage disks. Some of these tools, such as *Disk Management* and *Disk Defragmenter*, are available as GUI tools. Other tools, such as *chkdsk* and *diskpart*, are available from the command prompt.

Disk Management



Disk Management is a GUI available in all current Windows operating systems. It is included as a snap-in in the Computer Management console, but you can also access it directly. You can start Disk Management by taking any of the following actions:

- Click Start, right-click Computer, and select Manage. Select Disk Management in the Computer Management console.
- On Windows Vista and Windows 7: Click Start, type **diskmgmt.msc** in the Search text box and press Enter.
- On Windows XP: Click Start and select Run. Type **diskmgmt.msc** in the text box and press Enter.

Figure 16-3 shows the Disk Management console within Windows 7. Following are descriptions of the three numbered areas in the figure:

1. This section lists the volumes and provides information about them, such as the type of disk, the file system, the volumes' health, how big they are, and how much free space they have.
2. Disk 0 is a basic disk, and this shows that it has a system-reserved partition, a C volume, and unallocated space. New partitions can be created from unallocated space.
3. Disk 1 is a dynamic disk, and it has one volume labeled as E and unallocated space that can be used to create new volumes.

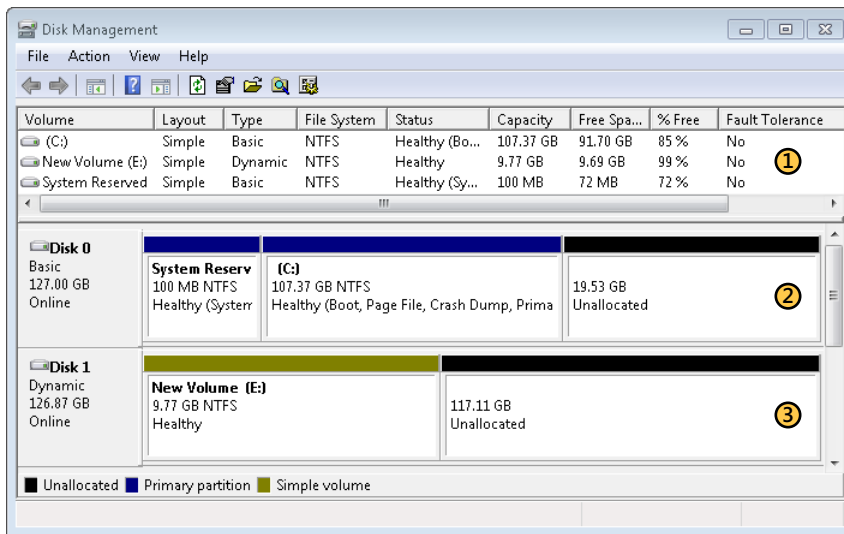


FIGURE 16-3 Disk Management.

NOTE IDENTIFY SYSTEM AND BOOT PARTITIONS

Notice that you can identify the system and boot partitions in the Disk Management console. This Windows 7–based system is using a special 100-MB System Reserved system partition on Disk 0. This is common on Windows Vista and Windows 7–based systems and is reserved so that users can enable BitLocker Drive Encryption if desired. It also holds some key boot files, so it should not be deleted.

Identifying Disk Status

The status column of the Disk Management console provides important information about the drive. Ideally, it will display *Healthy*, indicating that everything is fine. However, you also might see one of the following indicators:

- **Unreadable.** This often indicates a hardware failure.
- **Foreign.** When you move a dynamic disk from one system to another, the target system identifies it as a foreign disk. You can right-click the disk and select Import Foreign Disk so that the target system recognizes it.
- **Online.** Online disks are available for read/write access.
- **Online (Errors).** If input/output errors are detected on a dynamic volume, the status column will display this. You can right-click the disk and select Reactivate to return it to Online status. This error is a hint that the disk might be failing, so ensure that you have a good backup and then run some disk checks.
- **Offline.** The operating system might take a volume offline if it has detected a problem. The disk needs to be brought online to use it, and you can do so by right-clicking the disk and selecting Reactivate. If this doesn't work, there could be a hardware problem.
- **Missing.** This is displayed if one of the disks for a volume is not accessible. For example, this would appear if one of the disks in a mirrored or striped volume was not accessible. You might be able to reactivate the disk to get it to recognize the missing disk, but a missing disk often indicates a hardware problem.
- **Failed.** This indicates a hardware problem or that the file system is corrupted. You might be able to reformat it to still use the disk, or you can use chkdsk to repair the disk.

You have a variety of different commands from the context menus in these three areas. You can right-click a volume in the top pane or a volume within one of the disks to accomplish different tasks or view the volume's properties. The choices vary between different operating systems.

Disk Management on All Windows-Based Systems

Different operating systems provide different capabilities. The following list identifies what you can do on Windows XP, Windows Vista, and Windows 7.

- **Create partition/volume.** If the drive has unallocated space, you can right-click it and select New Partition (Windows XP) or New Simple Volume (Windows Vista and Windows 7).
- **Format.** You can right-click any volume and select Format. You'll be prompted to select the file system, such as NTFS or one of the FAT versions.
- **Delete.** Deleting a partition or volume changes the space to unallocated. If you delete an existing partition/volume, all data is lost.
- **Mount a volume.** You can mount a volume to an empty folder on a drive. Instead of the drive appearing as a separate letter, the space will be available in the mounted folder.

Disk Management on Windows Vista and Windows 7

You have some additional capabilities on Windows Vista-based and Windows 7-based computers from within the Disk Management console. These capabilities include:

- **Shrink a volume.** Shrinking a volume effectively allows you to repartition a hard disk without reformatting the entire disk. For example, if you have a single disk created as a single volume, you can shrink the volume to a smaller size, leaving unallocated space available. You can then create a new volume from the unallocated space.
- **Create a volume.** Use this to create and format a new volume from unallocated space.
- **Change drive letters.** If you want a drive, such as an optical drive, to use a specific drive letter, you can right-click the drive and select Change drive letters and paths. This causes the system to recognize the drive with the new letter.
- **Extend a volume.** This allows you to add space to a volume from unallocated space. For example, if you have a 10-GB volume and 5 GB of unallocated space, you can extend the volume to include the additional 5 GB of space, making it 15 GB in size.

NOTE EXTENDING A VOLUME VERSUS EXTENDED PARTITION

Extending a volume is not the same as creating an extended partition. Extending a volume is the opposite of shrinking a volume and essentially grows it from unallocated space. An extended partition is used with a primary partition and allows you to create multiple logical disks.

Initializing a Disk

When you add a new hard disk to a Windows-based system, it won't be recognized by the system until it is initialized. For example, if you start Windows Explorer, the disk won't appear. The solution is to open the Disk Management console and initialize the disk. This writes a signature onto the disk so that Windows recognizes it.

Initializing a disk doesn't affect any data on the drive. It also doesn't change any partitions or file systems.

If you start Disk Management, you'll be prompted to initialize new disks automatically. If you cancel this prompt, the status of the disk will be listed as Not Initialized.

Formatting a Volume or Array

Before an operating system can read and write data to a volume or disk array, it must be formatted. Windows-based systems will typically prompt you to format it as an NTFS volume, but you can also choose one of the FAT versions, as explained earlier.

If you format an existing volume, it removes access to any data on the volume. If the volume has data on it, back it up before formatting it.

NOTE DATA REMNANTS

You lose access to all data after formatting a volume. However, data remnants remain on the disk, so formatting isn't a reliable way to ensure that data is removed. If the drive has sensitive data, other tools should be used to remove the data.

When formatting a volume, you are often given two choices:

- **Full format.** In addition to preparing the drive, a full format scans a disk for bad sectors and marks them. A system will not write data to bad sectors.
- **Quick format.** A quick format does not scan a disk for bad sectors. It is quicker but not recommended for a regularly used system because the system might attempt to write data to bad sectors, resulting in corrupted files.



EXAM TIP

A full format checks for bad sectors and marks them. If you perform a quick format originally but later want to check the sectors on a disk, you can use the `chkdsk /r` command to check for and mark bad sectors.

You can format a disk from the command prompt with the `format` command or with the Disk Management GUI. The basic command from the command prompt is:

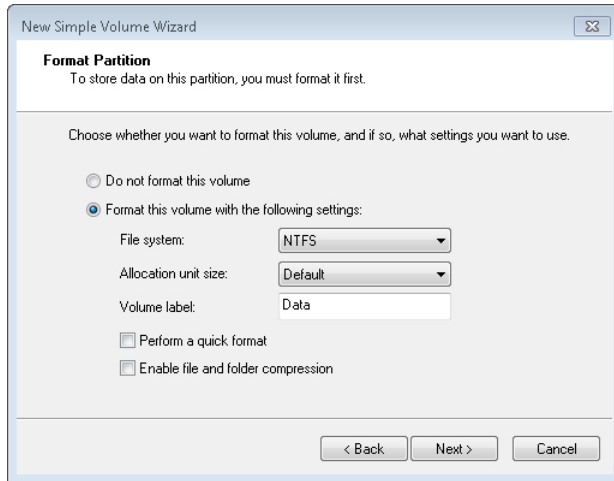
```
format volume /fs:file-system
```

For example, to format the P drive with NTFS, use the following command:

```
format p: /fs:ntfs
```

The following steps show how to create and format a volume in Disk Management on a Windows 7-based system:

1. Right-click the unallocated space and select **New Simple Volume**. Click **Next**.
2. The maximum size of the volume is automatically entered as the size of the new simple volume. You can change this size or accept the default. Click **Next**.
3. On the **Assign Drive Letter or Path** page, you can assign a specific drive letter or accept the default drive letter. Click **Next**.
4. On the **Format Partition** page, you can accept the default file system of NTFS or change it to one of the FAT versions based on the size of the volume. If you want to check the disk for bad sectors, **deselect Perform A Quick Format**. Your display will look similar to the following graphic. Click **Next**.



5. Click Finish. The operating system will format the drive.

Shrink a Volume

You can use these steps to shrink a volume in Windows Vista and Windows 7 by using Disk Management:

1. Right-click the C drive (or another drive if desired) and select Shrink Volume.
2. The system will identify the maximum amount of space in MB that you can shrink the drive to. You can accept the default or shrink it to a different size.
3. Click Shrink. When this is done, the amount of space you shrunk the drive by is identified as Unallocated space.

Extend a Volume

If you want to grow a disk by reclaiming unallocated space, you can do so by extending the volume. The following steps show how to extend a volume on Windows 7 by using Disk Management:

1. Right-click a volume and select Extend Volume. Click Next.
2. This will automatically select all of the unallocated space on the disk. You can change this to a smaller size and leave some unallocated space if desired. Click Next.
3. Click Finished. The volume you created in the previous step will be extended to take the additional space you specified.

Mount a Volume

An alternative to a spanned volume is a mounted volume. A mounted volume creates a mount-point folder path to a new disk rather than assigning a letter to the new disk. That is, it provides a logical pointer to the new disk.

Mounted volumes can be created on basic disks, eliminating the drawbacks of dynamic disks. The only requirements are that the existing disk must use NTFS and the mount-point folder must be empty.



EXAM TIP

Mounted volumes can be mounted only on empty NTFS folders.

You can use the following steps on a Windows 7 computer to create a mount point by using Disk Management:

1. Right-click the unallocated space of a disk and select New Simple Volume. Click Next.
2. This will automatically select all of the unallocated space on the disk. You can change this to a smaller size and leave some unallocated space if desired. Click Next.
3. Select Mount in the Following Empty NTFS Folder.
4. Click Browse. Browse to the location of an empty folder. You can also select an existing drive such as C and click New Folder and name your new folder. Click OK, and then click Next.
5. Select the formatting options you want and click Next. Click Finish.

Disk Management doesn't show that the new volume is a mount point. However, you can see it if you launch Windows Explorer. Click Start, select Computer, and select the C drive. Your display will look similar to Figure 16-4. In the figure, I named the mounted folder MountPoint. You can also see that instead of a folder icon it has a shortcut icon with an arrow.

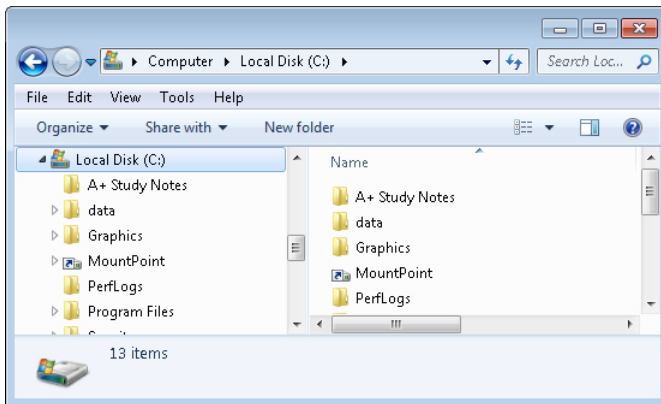


FIGURE 16-4 A mount point on a disk.

You can also identify mount points from the command prompt. If you enter the *dir* command, you'll see that the mounted folder appears as <JUNCTION> instead of as <DIR>.

Converting to Dynamic

You can use the following steps to convert a basic disk to a dynamic disk on a Windows 7–based system by using Disk Management. However, consider the following two important points before you do this:

- If any disk is dynamic, the system cannot be used as a dual-boot system.
- This is a one-way action. You shouldn't lose data converting to dynamic, but if you want to convert it back, you'll have to reformat the drive. All data will be lost if you convert a dynamic disk back to basic.

IMPORTANT CONVERTING A DISK TO A DYNAMIC DISK CAN BE RISKY

Ensure that you have backed up all data on the disk before continuing. Also, you cannot convert a dynamic disk back to a basic disk without first deleting all the volumes on the disk. When you delete the volumes, it deletes all the data on the volumes.

1. Right-click the disk in Disk Management, and select Convert to Dynamic Disk.
2. A dialog box will appear with the disk selected. Ensure that this is the disk you want to convert and click OK.
3. Click Convert on the Disks To Convert dialog box.
4. Review the warning from Disk Management indicating that you will no longer be able to use this system as a dual-boot system. Click Yes. After a moment, the disk will be listed as a dynamic disk.

Dynamic Disk Actions

If you created a dynamic disk, you have extra capabilities as described earlier. You can create a spanned volume, a mirrored volume, or a striped volume.

You can use the following steps to create a mirrored volume on Windows 7 by using Disk Management:

1. Right-click the unallocated space on a disk and select New Mirrored Volume. Click Next.
2. The disk you clicked will be selected. Select a second disk from the list of available disks and click Add.
3. The size will default to the maximum amount of space from either disk. You can change the size if desired. Click Next.
4. Click Next to accept the default drive letter.

5. Select the desired format options and click Next. Click Finish.
6. If the disks are basic disks, you will be prompted to convert them to dynamic. Click Yes. The system will create the mirrored volume.

You can use the following steps to create a striped volume on Windows 7 by using Disk Management:

1. Right-click the unallocated space on a disk and select New Striped Volume. Click Next.
2. The disk you clicked will be selected. Select a second disk from the list of available disks and click Add.
3. The size will default to the maximum amount of space from either disk. You can change the size if desired. Click Next.
4. Click Next to accept the default drive letter.
5. Select the desired format options and click Next. Click Finish.

Figure 16-5 shows Disk Management with three physical disks. Parts of disks 1 and 2 have been created as a mirrored volume, and other parts have been made into a striped volume. You would normally create either a single mirrored volume or a single striped volume using two physical disks. However, the figure shows what each looks like when they are created.

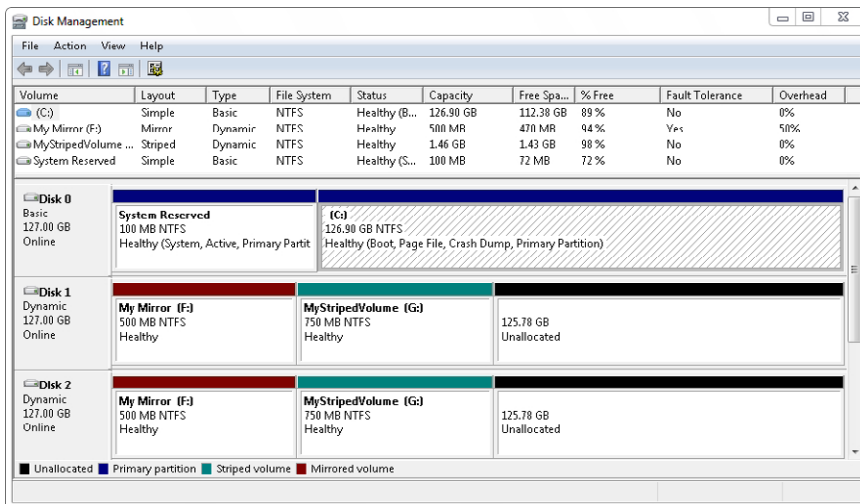


FIGURE 16-5 Mirrored and striped volumes in disk management.

You can see that only the mirrored volume (named My Mirror) provides fault tolerance. It shows 50% overhead because only half of the drive space is available. In contrast, the striped volume (named MyStripedVolume) includes two 750-MB disks and has about 1.43 GB of disk space available.



Diskpart

Diskpart is an advanced tool that you can use to manipulate a disk drive from the command prompt. You can do anything in diskpart that you can do in Disk Management. The benefit is that diskpart is available from the command prompt even when Disk Management is not available.

For example, when first installing Windows 7, you can press Shift+F10 to access the command prompt. You can then use diskpart to manipulate the disk before installing Windows 7.

You can start it from the command prompt by typing **diskpart** and pressing Enter. If you then type help and press Enter, you'll see a list of commands you can enter. Some of the common actions you can take are format, convert (between basic and dynamic, or between MBR and GPT disks), shrink, and expand.

When using diskpart, you must first select the object you want to work on. You can use the list command to list available objects, such as *list disk*, *list partition*, or *list volume*. You then select the object by using *select disk x*, *select partition x*, or *select volume x*, substituting *x* with the number shown from the list command. After the object is selected, you can run the desired command.

MORE INFO CHAPTER 14

Chapter 14 covers the command prompt in more depth, including how to open it and how to get help. As a reminder, you can get help by using the help switch (/?) or by entering help followed by the command. This also works within the diskpart command prompt.

As a short exercise, you can use the following steps to start diskpart, list the disks, and list the partitions:

1. Start the command prompt.
2. Type in **diskpart**, and press Enter. If you are prompted by User Account Control to continue, click Yes. A new window will appear with DISKPART> as the prompt.
3. Type in **list disk**, and press Enter. This lists all the disks in your system and will resemble the following graphic. Notice that Disk 1 and Disk 2 have an asterisk in the Dyn column. This indicates that they are dynamic disks. All of these disks are of the MBR type. If they were GPT disks, they would have an asterisk in the Gpt column.

```
C:\Windows\system32\diskpart.exe
Microsoft DiskPart version 6.1.7600
Copyright (C) 1999-2008 Microsoft Corporation.
On computer: WIN7-PC

DISKPART> list disk

   Disk ###  Status         Size      Free      Dyn  Gpt
   -----  -
   Disk 0    Online         126 GB    0 B
   Disk 1    Online         126 GB   125 GB  *
   Disk 2    Online         126 GB   125 GB  *
```

4. Type in **select disk 0**, and press Enter.
5. Type in **list partition**, and press Enter. This shows a listing of the partitions on disk 0.
6. Type in **exit**, and press Enter to exit diskpart.

Chkdsk and Check Disk



The *chkdsk* command is a valuable command that you can use to identify and resolve problems with disks and RAID arrays. If you run it without using any switches, it will run a check on the current disk and report the results back. However, it does not attempt any repairs unless one of the switches is used.

Two of the common switches used with the *chkdsk* command are listed in Table 16-3, along with the sample command.

TABLE 16-3 Common *chkdsk* Switches

Switch	Comments
/f chkdsk /f	Fixes errors on the disk.
/r chkdsk /r	Locates and recovers readable information. This implies /f, so it also fixes errors on the disk.



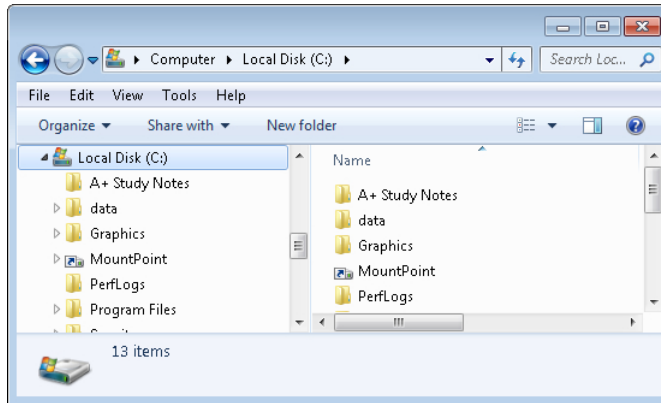
EXAM TIP

If Windows Vista or Windows 7 detects a problem with a volume, it will often schedule *chkdsk* to run the next time the system reboots.

If you attempt to run *chkdsk* or Check Disk to check a volume that is in use (such as the C drive), Windows will indicate that it can't check it while it is in use. You'll be prompted to schedule the disk check the next time the computer is booted. If you select Schedule disk, the system will run the check when it reboots.

You can also check a disk from Windows Explorer with the following steps:

1. With Windows Explorer open, browse to the hard drive you want to check.
2. Right-click the drive, and select Properties.
3. Click the Tools tab, and click Check Now. You'll see a display similar to the following graphic.



4. The two options in the Check Disk Data dialog box work the same as the `/f` and `/r` switches do with `chkdsk`. The first option works like the `/f` switch to fix errors, and the second option recovers information like the `/r` switch.



EXAM TIP

Both the `chkdsk` command-line tool and the Check Disk GUI will verify the integrity of the physical disk and file system integrity. The `chkdsk` tool is also available from the command prompt in safe mode and via the System Recovery tool in Windows Vista and Windows 7.

Convert



Whenever possible, it's best to use NTFS instead of one of the versions of FAT. However, you're sure to come across some FAT volumes. If you want to convert a volume from FAT to NTFS, you can do so with the `convert` command. Converting a volume does not reformat it, so it doesn't result in the loss of data.

The basic syntax of the command is as follows:

```
convert volume /fs:ntfs
```

You specify the volume letter followed by a colon. For example, if you want to convert the E drive from FAT32 to NTFS, you could use the following command:

```
convert e: /fs:ntfs
```



EXAM TIP

The `convert` utility allows you to convert a FAT file system to NTFS without losing any data. However, if you want to revert an NTFS volume to FAT, you must reformat the volume, and you'll lose all the data on the drive.

Disk Defragmenter and Defrag

The *Disk Defragmenter* is a tool that allows you to easily determine whether a disk is fragmented. It is available within Computer Management in Windows XP and as a separate GUI in Windows Vista and Windows 7. Figure 16-6 shows the disk defragmenter tool within Windows XP. In the figure, the drive has been analyzed, but there is very little fragmentation on this drive.

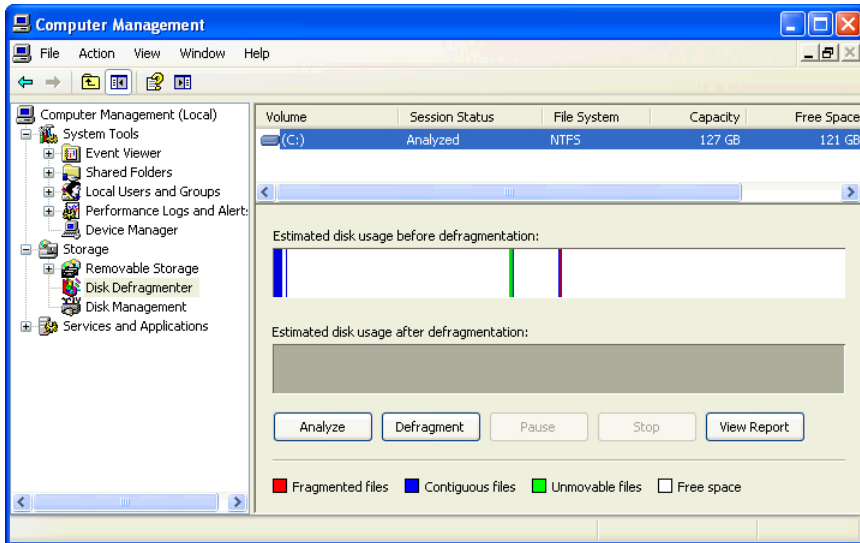


FIGURE 16-6 Using the Disk Defragmenter.

Windows Vista and Windows 7 both include schedules to automatically check a drive for fragmentation once a week. The schedule is included in the Windows Defrag menu within the Task Scheduler's Library of scheduled tasks. Unless these schedules have been disabled through Task Scheduler, you don't need to worry about defragmenting volumes on these systems.

Another way to defragment a hard drive is with the *defrag* command from the command prompt. The basic syntax is as follows:

```
defrag volume
```

For example, if you want to defrag the E drive, use the following command:

```
defrag e:
```

Table 16-4 shows two common switches you could use with the *defrag* command, along with sample usage.

TABLE 16-4 Common defrag Switches

Switch	Comments
/a defrag e: /a	Perform analysis of the drive. This provides a report but does not defrag the volume.
/c Defrag /c	Defragment all drives on the system.

Disk Cleanup



If you are running low on disk space on your system, you can use the *Disk Cleanup* utility to remove files that aren't needed. This includes temporary files such as those cached from browsing the Internet, files you've deleted but that remain in the Recycle Bin, and some system files that are no longer needed.

You can access the Disk Cleanup utility from within Windows Explorer by right-clicking any drive and selecting Properties. Ensure the General tab is selected, and click on the Disk Cleanup button. Figure 16-7 shows the Disk Cleanup utility within Windows 7.

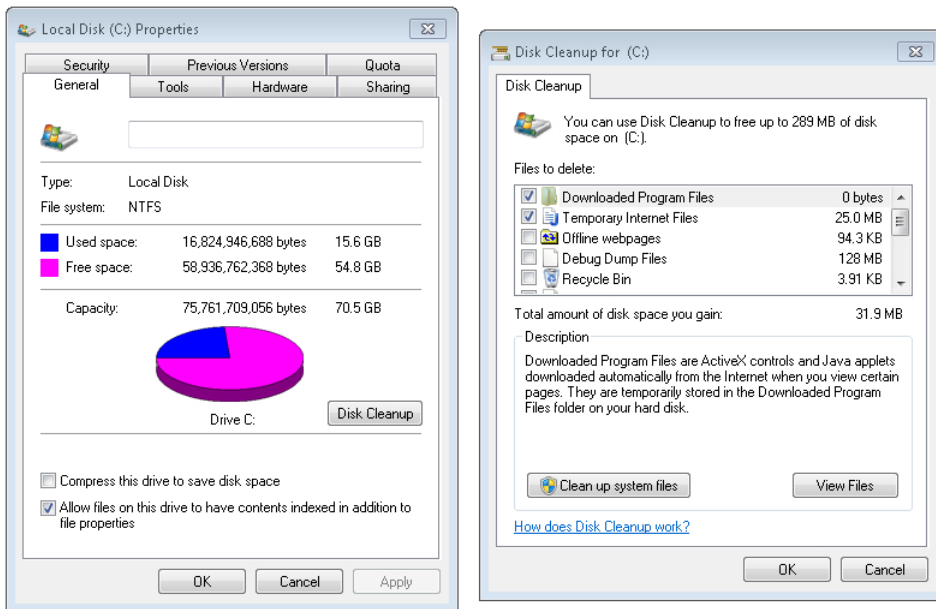


FIGURE 16-7 Using Disk Cleanup utility.

The system will calculate how much space can be saved by cleaning up the disk and allow you to choose which files to delete. If you click OK, it will delete the selected files. If you want to remove unneeded system files, you can click the Clean Up System Files button, and the system will calculate how much space you can save, including unneeded system files.

Fdisk



A very old command that you can use to partition a disk is called *fdisk*. It was required to partition a disk prior to installing an operating system. Technicians used bootable floppies with *fdisk*, and after booting, they used *fdisk* to partition the hard drive. However, most install programs now include built-in tools to partition a disk, so it is rarely needed.



Quick Check

1. Name two common tools that you can use to partition a hard drive.
2. What tool can you use to discover and repair errors on a disk?

Quick Check Answers

1. Disk Management and *diskpart*. *Fdisk* is not common but can also be used.
2. *Chkdsk* or Check Disk.

Shares



One way that you can share data with other users is to create a share on a computer. A *share* is simply a folder that has been shared and is available to other users on a network. Organizations often have file servers with multiple shares available on each server.

Shares are accessed over a network by using the Universal Naming Convention (UNC). A UNC path is in the format of `\\ServerName\ShareName`. For example, if a folder named *StudyNotes* has been shared on a server named *Server1*, the UNC path is `\\Server1\StudyNotes`. UNC path names are not case-sensitive. You can use all uppercase, all lowercase, or a combination.

You can view a listing of all the shares available on a system by using the following command at the command prompt:

```
Net share
```

MORE INFO CHAPTERS 18–24 AND CHAPTER 25

Chapters 18 through 24 cover networking in more depth, and Chapter 25 covers security in more depth, including both NTFS and share permissions. If a computer is connected with a network, the UNC paths provide connectivity, and a user with appropriate permissions can access the data.

Administrative Shares

Operating systems automatically create several shares, known as *administrative shares*. These are available to administrators but often aren't known by other users.

Administrative shares end in a dollar sign (\$), and any share that ends in a dollar sign is hidden. Anyone knowing the name of the share can access it. However, these shares are not visible to users browsing the network.

Table 16-5 lists some common administrative shares available on Windows-based systems.

TABLE 16-5 Administrative Shares

Share name	Resource
C\$, D\$, E\$, and so on	This is created for each hard drive (C, D, E, and so on) on a system.
Print\$	Location of printer drivers.
Admin\$	Location of Windows folder.

The UNC path for administrative shares is the same as other systems. For example, if a computer is named after a user named Sally, the administrator can connect to Sally's C drive with the following UNC path: \\Sally\C\$.



EXAM TIP

By default, administrative shares include a \$ symbol to hide them. It's also possible to add a \$ symbol to any share to hide it.

Local Shares

You can also share any folder on a disk by creating a share for it. The easiest way to do so is from within the Computer Management console.

Figure 16-8 shows the Computer Management console opened to the Shared Folders, Shares display on a Windows 7-based computer. It shows all the shares on this computer, including one named APlusStudy, which is sharing the C:\data\A+Study folder.

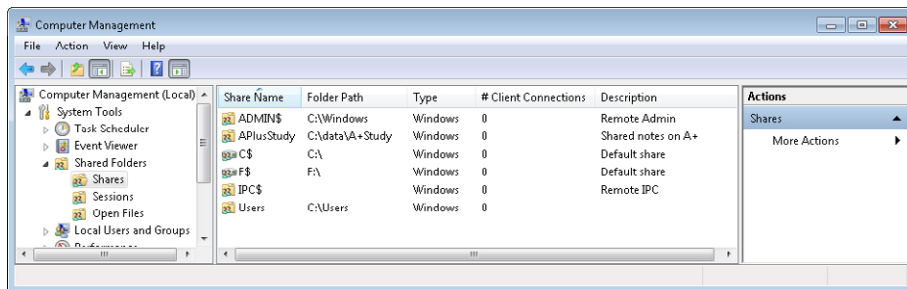


FIGURE 16-8 Viewing shares in Computer Management console.

You can create a share for any folder by right-clicking Shares and following the wizard to share it.

MORE INFO CHAPTER 24

Chapter 24 covers Windows 7 Homegroups used in small networks. Homegroups allow users to share files in their libraries. For example, users can share their Documents, Music, and Picture libraries. Shares can be used with Homegroups or without them.

Offline Files



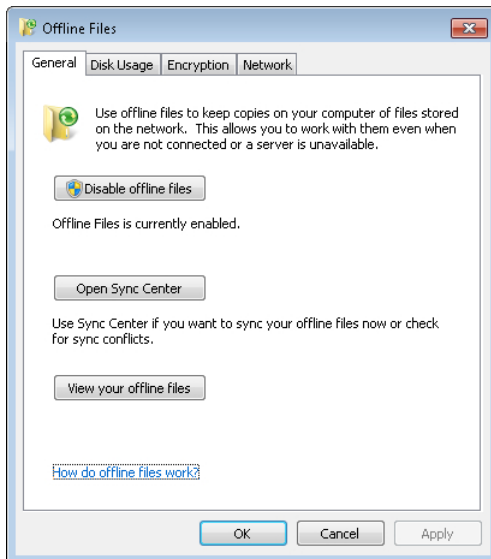
Users can access shared files as long as they are connected to the network. However, if they aren't connected to the network, they can't access the computer sharing the files. Sometimes users want to have access to these files even when they are disconnected, and the *offline files* feature gives them this ability.

When the offline files feature is enabled, users can right-click a file on a share and select Make Available Online. Windows then stores a copy of the file on the user's system.

Users can access this copy of the file while they're disconnected from the network. When they reconnect, Windows will automatically sync the files to ensure that each location has the most up-to-date version.

On Windows Vista and Windows 7, you can access the offline files settings with the following steps:

1. Click Start, and type **offline files** in the text box.
2. Select Offline Files in Windows Vista or Manage Offline Files in Windows 7. The display resembles the following graphic.



Users can disable offline files, force an immediate synchronization of the files, and view the offline files from here.

On Windows XP, you can access the Offline Files settings with the following steps:

1. Open Windows Explorer.
2. Select Tools | Folder Options.
3. Click the Offline Folders tab.



EXAM TIP

You can't use Offline Files and Fast User Switching on Windows XP. However, they will work together on Windows Vista and Windows 7.

**Quick Check**

1. What is used to allow access to folders on another system?
2. What allows users to access network-based files when users are disconnected from a network?

Quick Check Answers

1. Shares.
2. Offline files.

Chapter Summary

- MBR disks support disks up to 2 TB and with as many as four partitions on a disk.
- Windows-based systems support GPT disks as large as 256 TB and with as many as 128 partitions per disk.
- Most disks are basic disks. Windows supports dynamic disks, which provide additional capabilities such as striped, mirrored, and spanned volumes.
- Windows 7 supports mirrored volumes (RAID-1) on dynamic disks, but RAID-1 is not supported on Windows XP or Windows Vista.
- FAT16 and FAT32 are the most common types of FAT file systems. Maximum partition sizes on Windows-based systems are 4 GB for FAT16 and 32 GB for FAT32. The maximum file sizes are 2 GB for FAT16 and 4 GB for FAT32.
- NTFS is the preferred file system for Windows. It provides better performance and security.

- Disk Management is the primary GUI used to manage disks. It can create, format, manipulate, and delete disks. Diskpart is the command-line equivalent of Disk Management.
- Dynamic disks are listed as foreign if moved from one system to another. A foreign disk can be imported by using Disk Management.
- Chkdsk is a command-line tool used to check the integrity of disks. The /f switch will fix errors, and the /r disk will identify bad sectors and recover readable information.
- Disks can be converted from FAT to NTFS by using the convert command. The file system is converted without losing data.
- Fragmented hard drives are slower, and their LEDs will show constant activity. They can be defragmented with the Disk Defragmenter GUI or the defrag command-line tool.
- The Disk Cleanup tool can identify and remove unneeded files.
- Shares provide access to folders over a network. Offline files store copies of shared files on the local system so that users can access the files, even when disconnected from the network.

Chapter Review

Use the following questions to test your knowledge of the information in this chapter. The answers to these questions, and the explanations of why each answer choice is correct or incorrect, are located in the “Answers” section at the end of this chapter.

1. You are adding a 1-TB hard drive to a Windows 7–based system. Which file system should you use for the best performance?
 - A. FAT16
 - B. FAT32
 - C. FAT64
 - D. NTFS
2. A user asks what tool he can use to create a mirrored volume on a Windows 7–based system. What would you tell him?
 - A. You cannot create a mirrored volume on Windows 7.
 - B. Use Disk Management.
 - C. Use Windows Explorer.
 - D. Use Convert.

3. You have added a new disk drive to a Windows 7–based system, but it is not recognized. What needs to be done?
 - A. The disk needs to be converted to NTFS.
 - B. The disk needs to be converted to dynamic.
 - C. The disk needs to be imported.
 - D. The disk needs to be initialized.
4. You want your DVD player to be assigned the letter M within the operating system. What tool would you use?
 - A. Disk Defragmenter
 - B. Device Manager
 - C. Windows Explorer
 - D. Disk Management
5. You suspect the D partition on a disk drive has a problem, and you want to check it for bad sectors, recover readable information, and fix errors. What command would you use?
 - A. `chkdsk d:`
 - B. `chkdsk d: /f`
 - C. `chkdsk d: /r`
 - D. Check Disk d:
6. A computer is slow, and the disk drive LED is constantly blinking. What can be done to improve the performance?
 - A. Run `chkdsk`.
 - B. Format the drive as NTFS.
 - C. Shrink the volume.
 - D. Run `defrag`.

Answers

- 1. Correct Answer: D**
 - A. Incorrect:** FAT16 can't handle drives over 4 GB.
 - B. Incorrect:** You can create FAT32 volumes only as large as 32 GB.
 - C. Incorrect:** While FAT64 can handle a 1-TB drive, it isn't as efficient at handling clusters as NTFS.
 - D. Correct:** NTFS provides the best performance for large hard drives and also provides security.

- 2. Correct Answer: B**
 - A. Incorrect:** You can create a mirrored volume on Windows 7 but not on Windows Vista or Windows XP.
 - B. Correct:** You can use Disk Management to create a mirrored volume on a Windows 7–based system.
 - C. Incorrect:** You can browse a mirrored volume with Windows Explorer, but you cannot create one.
 - D. Incorrect:** The convert command will convert a FAT-based system to NTFS.

- 3. Correct Answer: D**
 - A. Incorrect:** Windows 7 can recognize FAT-based drives, so it isn't required to convert it to NTFS.
 - B. Incorrect:** Windows 7 can recognize basic disks, so it doesn't need to be converted to dynamic.
 - C. Incorrect:** If the disk is a dynamic disk, it will be recognized as foreign and must be imported.
 - D. Correct:** New disks need to be initialized within Disk Management if they aren't recognized.

- 4. Correct Answer: D**
 - A. Incorrect:** The Disk Defragmenter can optimize a drive but cannot change the drive letter.
 - B. Incorrect:** The Device Manager is used to manage devices and drives but can't reassign drive letters.
 - C. Incorrect:** Windows Explorer accesses the drive but can't reassign drive letters.
 - D. Correct:** The Disk Management tool can change the drive letter of any disk drive.

5. Correct Answer: C

- A. Incorrect:** Running `chkdsk` without a switch will check a drive, but it won't repair any errors.
- B. Incorrect:** The `/f` switch will fix errors, but it does not recover readable information.
- C. Correct:** The `/r` switch will locate bad sectors, recover readable information, and fix errors.
- D. Incorrect:** Check Disk can be accessed from Windows Explorer, but it is not a command.

6. Correct Answer: D

- A. Incorrect:** `Chkdsk` can detect and repair errors, but these symptoms indicate a fragmented hard drive.
- B. Incorrect:** Formatting the drive will delete all the data.
- C. Incorrect:** Shrinking a volume won't remove fragmentation.
- D. Correct:** These symptoms indicate that the hard drive is fragmented, and `defrag` will defragment the hard drive.