

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 the bullets describe them below and they're also shown in Figure 4-2.

- **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.

File systems use a table to identify the location of files on a disk drive based on the clusters. For example, a file named 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.

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.

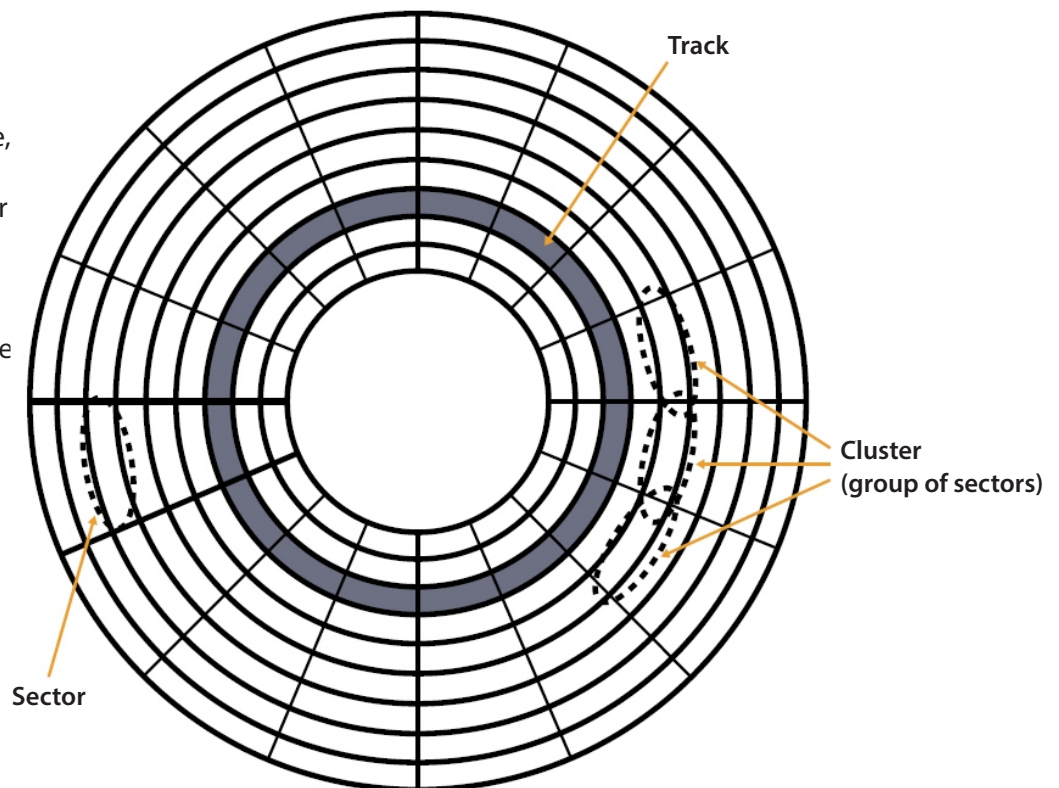


Figure 4-2. Tracks, sectors, and clusters.

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.



Programs and applications

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 4-2 shows the different sizes of partitions and files supported by these FAT versions.

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.

Table 4-2 FAT Version

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



FAT32 Partitions

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.

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.

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.

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.

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 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 textbox and press Enter.
- On Windows XP: Click Start and select Run. Type **diskmgmt.msc** in the text box and press Enter.

Figure 4-3 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.



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.

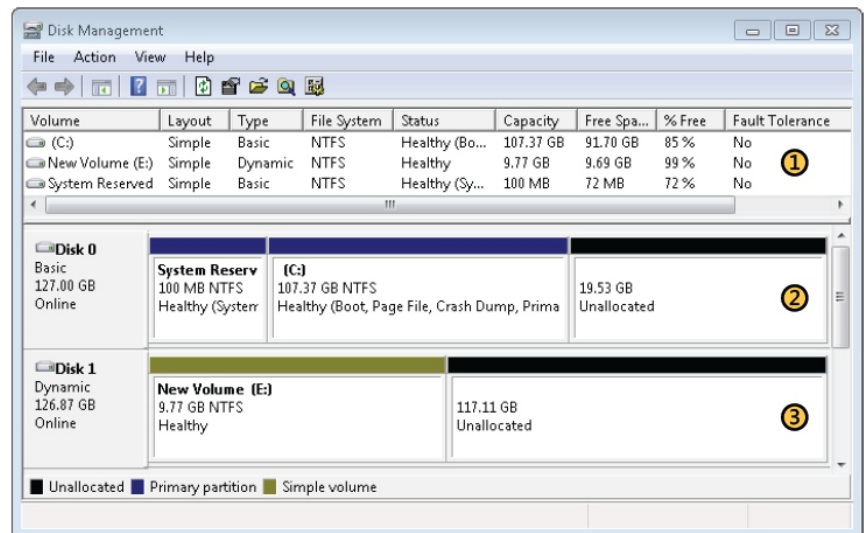


Figure 4-3. Disk Management

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 All Windows-Based Systems

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.



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.



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.



Full Formatting

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:

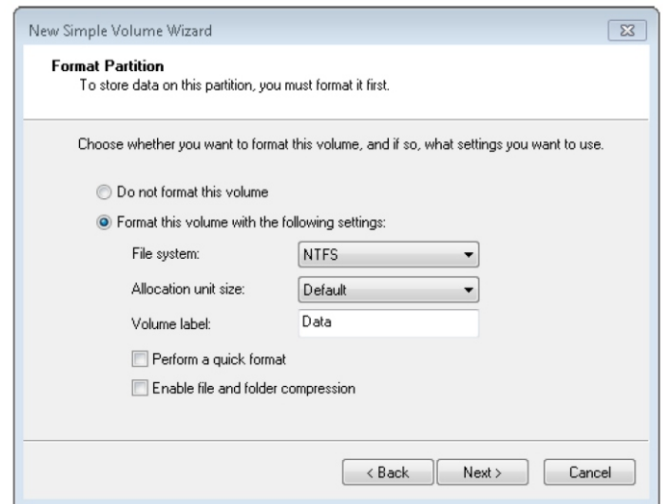
`format volume /fs:file-system`

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 picture(right). 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.

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 4-4. In the figure, a mounted folder named **MountPoint**. You can also see that instead of a folder icon it has a shortcut icon with an arrow.

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>`.

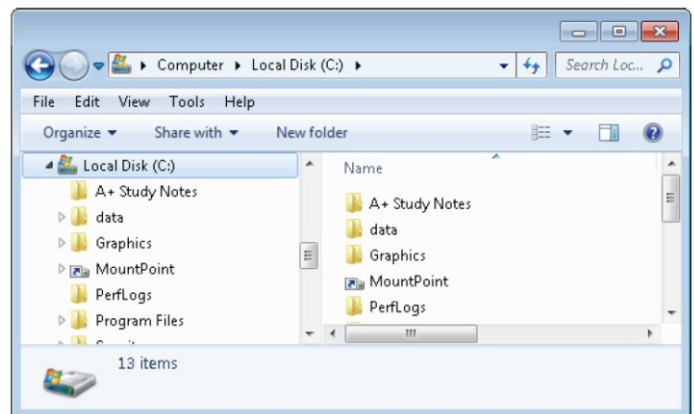


Figure 4-4. A mount point on a disk

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.

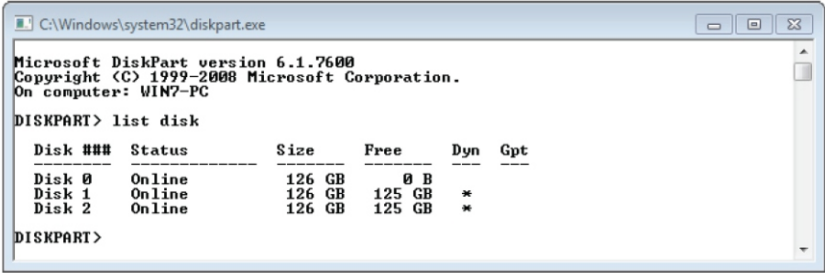
For example, when first installing Windows 7, you can press **Shift+F10** to access the command prompt. You can then use diskpart to manipulate the disk before installing Windows 7.

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.

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.



- 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 4-3, along with the sample command.

Table 4-3 Common chkdsk Switches

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

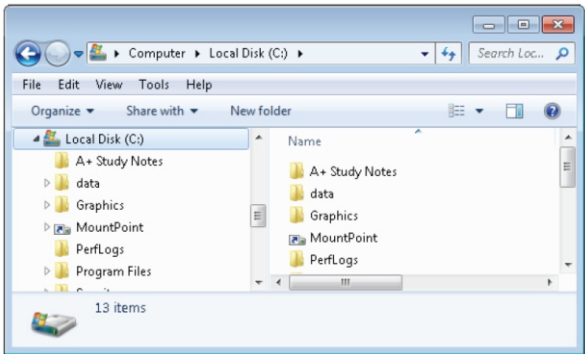


Volume problem with Windows 7 or Windows Vista
If Windows Vista or Windows 7 detects a problem with a volume, it will often schedule chkdsk to run the next time the system reboots.

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:

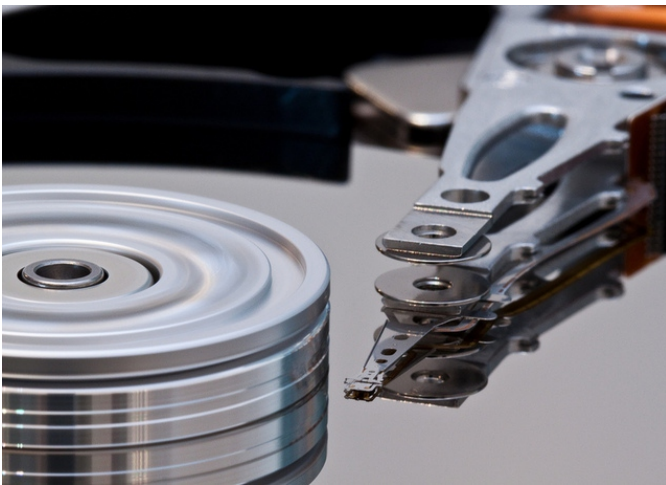
- 1. With Windows Explorer open, browse to the hard drive you want to check.
- 2. Right-click the drive, and select Properties.
- 3. Click the Tools tab, and click Check Now. You'll see a display similar to the following graphic.
- 4. The two options in the Check Disk Data dialog box work the same as 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.



Chapter 4

Laboratory Manual

DISK AND FILE SYSTEM



Laboratory Activities

- 4.01 Creating and Formatting Partitions with the Windows XP and Vista/7 Installation Media
- 4.02 Using Windows Tools to Create and Format Partitions

Chapter Analysis and Written Test

Lab Activity 4.02 Using Windows Tools to Create and Format Partitions

Once you have all of the machines' drives configured, partitioned, and formatted, and you've installed Windows, working with hard drive storage becomes much more intuitive. Windows includes tools that let you create, modify, and format partitions "on the fly" from within Windows. One of these utilities is called Disk Management.

This lab exercise assumes that you want to create a partition on the second or third hard drive installed on the Windows lab system and then format that partition with a file system. Disk Management will enable you to format the partition right away; however, you can also use another Windows utility that you should be intimately familiar with by now: My Computer/Computer. Follow the steps in this lab exercise to create and format a new partition.



Each version of Windows can read from and write to the FAT16, FAT32, and NTFS file systems. However, only Windows XP can be installed to a FAT16 or FAT32 partition —Windows Vista/7 must be installed on an NTFS partition.

Learning Objectives

In this exercise, you'll use the Disk Management program to partition a hard drive and format the partition with a file system.

At the end of this lab, you'll be able to

- set up a primary, active partition on a hard drive
- set up an extended partition and logical drives in that partition
- format partitions with various file systems

Lab Materials and Setup

The material you need for this lab is

- a PC with a primary hard drive that holds your Windows installation and the two blank hard drives that you can partition and format



Partitioning a hard drive destroys any data on it! Practice this lab only on drives that don't contain any data you need.

Let's Get the Lab Started

The steps for partitioning drives and formatting partitions in each version of Windows are very similar.

Step 1 Right-click the My Computer/Computer icon and select Manage to open a Computer Management window. Under the Storage node, click Disk Management.

Step 2 As in prior lab exercises, if there are any existing partitions on the second or third drive, highlight the partitions and either right-click and delete the partitions or simply press DELETE.

Step 3 Start the process of creating a partition by right-clicking an unpartitioned section of drive space and, in Windows XP, selecting New Partition (see Figure 4-5). In Vista/7, select New Simple Volume. This will start the New Partition Wizard or the New Simple Volume Wizard, depending on the OS.

Step 4 Click Next, and, in Windows XP, select Primary Partition (in Windows Vista/7, you will not have to select Primary Partition). At the next screen, enter the size of your new partition in megabytes.

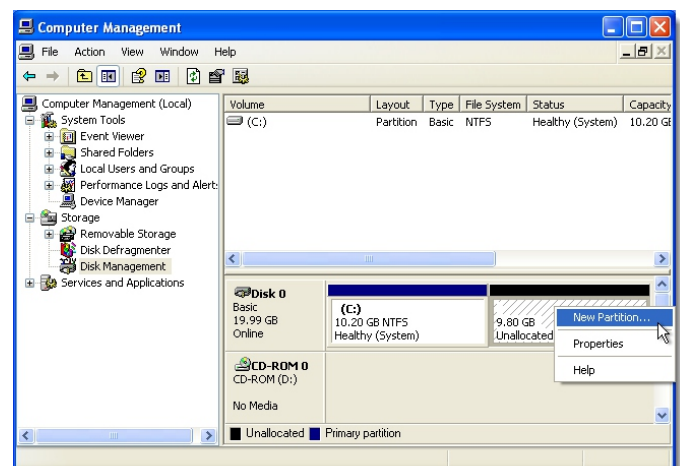


FIGURE 4-5 Creating a new partition in Disk Management

- Step 5** You can now assign a drive letter or mount the partition to an empty folder. For now, go with the default drive letter assignment and click Next again.
- Step 6** The next screen offers you the option to format the new partition with a file system. Select a file system: FAT, FAT32, or NTFS. (Note that Windows will not allow Disk Management to create a FAT16 partition larger than 4 GB or a FAT32 partition larger than 32GB.) Then enter a volume label if you want and click OK. Figure 4-6 shows this selection screen in the Disk Management utility.

Step 7 The utility warns you that formatting will erase all data on the drive. Click OK to begin formatting.

Step 8 You can also format partitions in My Computer/Computer, but generally speaking you'll use this method only to format removable media, such as USB thumb drives.

Right-click a drive icon in My Computer/Computer and select Format to open the Format dialog box (see Figure 4-7). Now proceed as in Step 6.

Step 9 Practice deleting, creating, and formatting different combinations of partitions and file systems to become comfortable with the Disk Management utility.

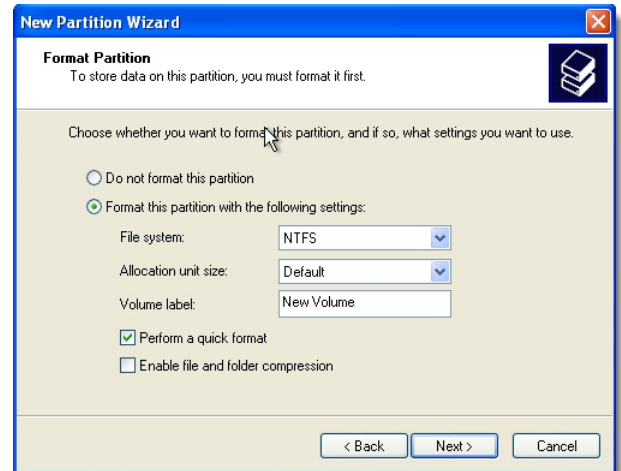


FIGURE 4-6 Formatting a partition in Disk Management

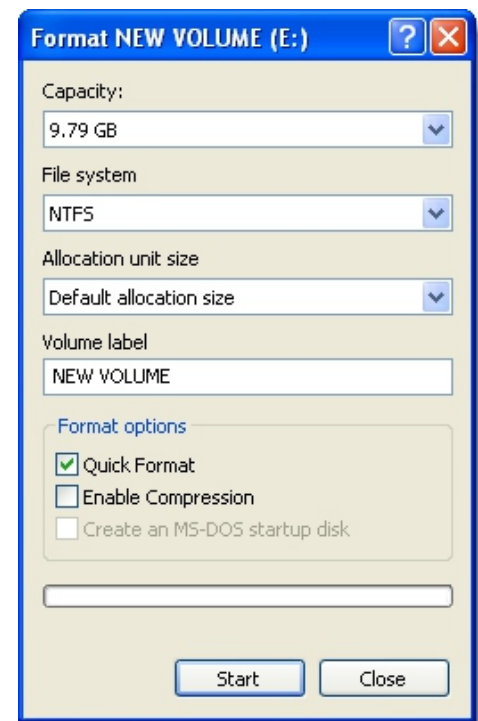


FIGURE 4-7 Formatting a partition in My Computer