chapter six

understanding and assessing hardware:

evaluating your system

objectives

After reading this chapter, you should be able to answer the following questions:

1. How can I determine whether I should upgrade my existing computer or buy a new one? ***(pp. 268–272)***
2. What does the CPU do, and how can I evaluate its performance? ***(pp. 272–276)***
3. How does memory work in my computer, and how can I evaluate how much memory I need? ***(pp. 276–279)***
4. What are the computer's main storage devices, and how can I evaluate whether they match my needs? ***(pp. 279–286)***
5. What components affect the output of video on my computer, and how can I evaluate whether they match my needs? ***(pp. 286–290)***
6. What components affect my computer's sound quality, and how can I evaluate whether they match my needs? ***(pp. 290–291)***
7. How can I improve the reliability of my system? ***(pp. 291–294)***

multimedia resources

Active Helpdesk

- Evaluating Your CPU and RAM **(p. 278)**
- Evaluating Computer System Components **(p. 287)**

Sound Bytes

- Using Windows 7 to Evaluate CPU Performance **(p. 276)**
- Memory Hierarchy Interactive **(p. 278)**
- Installing RAM **(p. 279)**
- CD, DVD, and Blu-ray Reading and Writing Interactive **(p. 283)**
- Installing a Blu-ray Drive **(p. 285)**

Companion Website

The Companion Website includes a variety of additional materials to help you review and learn more about the topics in this chapter. Go to: ***pearsonhighered.com/techinaction***

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how cool is this?

how cool is *this?*

It used to be that the case for a desktop computer was just a boring rectangular box—but no longer! Consider some of the new designs on the market. On the **Phobos** computer system by BFG Technologies, the front of the case features a **touch-panel LCD** that reports system performance parameters, controls music content, and presents a summary of storage and memory usage. There is also an integrated iPod/iPhone **docking station** on the top of the case. Or consider Falcon NorthWest, which delivers **custom paint** jobs on its system cases—images from its library, your own image, or even a screen from your favorite game.

The Thermaltake Level 10 wins for pure **artistry**. It isolates all the major subsections—motherboard, power supply, hard drives, optical drives—in a separate physical space. Each section is hinged and can swing open for easy access. Made of aluminum, the entire case helps disperse heat . . . and looks cool doing it!

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Is It the Computer or Me?

After saving up for a computer, Natalie took the leap a couple of years ago and bought a new desktop PC. Now she is wondering what to do. Her friends with newer computers are burning high-def Blu-ray movies they've made, and they're able to wirelessly connect their phones and synch up music files. They seem to be able to do a hundred things at once without their computers slowing down at all.

Natalie's computer can't do any of these things—or at least she doesn't think it can. Lately it seems to take longer to open files and scroll through Web pages. Making matters worse, her computer freezes often and takes a long time to reboot. Now she's wondering whether she should buy a new computer, but the thought of spending all that money again makes her think twice. As she looks at ads for new computers, she realizes she doesn't know what such things as "CPU" and "RAM" really are, or how they affect her system. Meanwhile, she's heard it's possible to upgrade her computer, but the task seems daunting. How will she know what she needs to do to upgrade, or whether it's even worth it?

Are you in the same situation? How well is your computer meeting your needs? Do you ever wonder whether your computer is fine and you just need more training to get it to work smoothly? Is that true, or do you really need a more sophisticated computer system? In this chapter, you'll learn how to evaluate your computer system to determine whether it is meeting your needs. You'll start by figuring out what you want your ideal computer to be able to do. You'll then learn more about important components of your computer—its CPU, memory, storage devices, audio and video devices, and ports—and how these components affect your system. Along the way, you'll find worksheets to help you conduct a system evaluation, and multimedia Sound Bytes that will show you how to install various components in your system and increase its reliability. You'll also learn about the various utilities available to help speed up and clean up your system. If you don't have a computer, this chapter will provide you with important information you will need about computer hardware to make an informed purchasing decision.

Is now a good time to buy a new computer? There never seems to be a perfect time to buy. It seems that if you can just wait a year, computers will inevitably be faster and cost less. Is this actually true?

As it turns out, it is true. In fact, a rule of thumb often cited in the computer industry, called **Moore's Law**, describes the pace at which CPUs (central processing units)—the small chips that can be thought of as the "brains" of the computer—improve. Named for Gordon Moore, the cofounder of the CPU chip manufacturer Intel, this rule predicts that the number of transistors inside a CPU will increase so fast that CPU capacity will double every 18 months. (The number of transistors on a CPU chip helps determine how fast it can process data.)

As you can see in Figure 6.1, this rule of thumb has held true since 1970, when Moore first published his theory. Imagine finding a bank that would agree to treat your money in this way. If you put 10 cents in that kind of savings account in 1965, you would have a balance of more than $100 million today! Moore himself, however, has predicted that around the year 2020 CPU chips will be manufactured in a different way, thus changing or eliminating the effects of Moore's Law altogether.

In addition to the CPU becoming faster, other system components also continue to improve dramatically. For example, the capacity of memory chips such as dynamic random access memory (DRAM)—the most common form of memory found in personal computers—increases about 60 percent every year. Meanwhile, hard drives have been growing in storage capacity by some 50 percent each year.

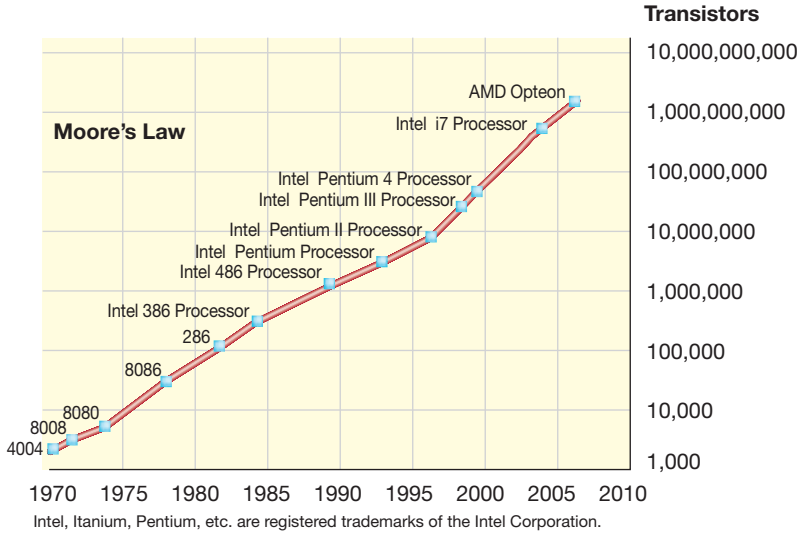

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Figure 6.1

Moore's Law predicts that CPUs will continue to get faster.

Source: Adapted from the Moore's Law animated demo at Intel.com.

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So, with technology advancing so quickly, how do you make sure you have a computer that matches your needs? No one wants to buy a new computer every year just to keep up with technology. Even if money weren't a consideration, the time it would take to transfer all of your files and reinstall and reconfigure your software would make buying a new computer every year terribly inefficient. Extending the life of a computer also reduces or postpones the environmental and security concerns involved in the disposal of computers.

No one wants to keep doing costly upgrades that won't significantly extend the life of a system, either. How can you determine if your system is suitable or if it just needs to be upgraded? Moreover, how can you know which is the better option—upgrading or buying a new computer? The first step is figuring out what you want your computer to do for you.

> "To determine your ideal system, consider what you want to be able to do with your computer."

What Is Your Ideal Computer?

As you decide whether your computer suits you, it's important to know exactly what you would want your ideal computer system to be able to do. Later, as you perform a system evaluation, you can compare your existing system to your ideal system. This will help you determine whether you should purchase hardware components to add to your system or buy a new system.

But what if I don't have a computer? Even if you're a new computer user and are looking to buy your first system, you will still need to evaluate what you want your system to do for you before you purchase a computer. Being able to understand and evaluate computer systems will make you a more informed buyer. You should be comfortable answering questions such as "What kinds of CPUs are there, and how does the CPU affect system performance?" and "How much RAM do I need, and what role will it play in my system?" It's important for you to be able to answer such questions before you buy a computer.

How do I know what my ideal system is? To determine your ideal system, consider what you want to be able to do with your computer. For example, do you need to bring your computer to school or work with you? Do you want to be able to edit digital photos and video? Do you want to watch and record Blu-ray discs? Or do you mainly use your computer for word processing and Internet access? The worksheet in Figure 6.2 lists a number of ways in which you may want to use your computer. In the second column, place a check next to those computer uses that apply to you. Also, set a priority of high, medium, or low in the rightmost column so that you can determine which features are most important to you.

Next, look at the list of desired uses for your computer and determine whether your current system can perform these activities. If there are things it can't do, you may need to purchase additional hardware or a new computer. For example, if you want to play and burn CDs and DVDs, all you need is a DVD–RW drive. However, you need a Blu-ray burner if you want to burn (record) the higher capacity Blu-ray discs. Likewise, if you plan to edit digital video files or play games that require high video frame rates for smooth in-game motion and have amazing soundtracks, you may want to add more memory, upgrade your video card, and buy a better set of speakers. Depending on the costs of the individual upgrade components, you may be better off buying a new system.

BITS AND BYTES

Moving to a New Computer Doesn't Have to Be Painful

Are you ready to buy a new computer but dread the prospect of transferring all your files and redoing all of your Windows settings? You could transfer all those files and settings manually, but Windows stores much information in the registry files, which can be tricky to update. So what do you do? Windows 7 incorporates Windows Easy Transfer, which lets you migrate files and settings from a Windows Vista system to a Windows 7 system via a network connection by using a flash drive or external hard drive or using optical media such as a CD or DVD.

Alternatively, other PC migration software is available, such as LapLink's PCmover, which is designed to make the transition to a new computer easier. For the latest information on such utilities, search on migration software at PCmag (**pcmag.com**). You'll be ready to upgrade painlessly in no time. If you prefer to avoid the do-it-yourself option, support technicians at retail stores (such as the Geek Squad at Best Buy) will often perform the migration for a small charge.

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Figure 6.2 | WHAT SHOULD YOUR IDEAL COMPUTER SYSTEM BE ABLE TO DO?

Computer Uses	Do You Want Your System to Do This?	Can Your System Do This Now?	Priority (High, Medium, Low)
Portability Uses			
Be light enough to carry easily			
Access the Internet wirelessly			
Entertainment Uses			
Access the Internet			
Play and record CDs and DVDs			
Play and record Blu-ray discs			
Record and edit digital videos			
Record and edit digital music			
Edit digital photos			
Play graphics-intensive games			
Transfer files wirelessly to mobile devices and other computers			
Transfer files using flash memory cards			
Upload media to social networking sites			
Have your peripheral devices work easily and speedily with your computer			
Purchase/rent music and videos from the Internet			
Talk with friends and family with live video and audio			
Use the computer to stream television and movies			
Other			
Educational Uses			
Perform word processing tasks			
Use educational software			
Access library and newspaper archives			
Create multimedia presentations			
Create backups of all your files			
Record notes with synchronized audio recordings			
Other			
Business Uses			
Create spreadsheets and databases			
Work on multiple software applications quickly and simultaneously			
Conduct online banking, pay bills online, or prepare your taxes			
Conduct online job searches or post résumés			
Synchronize your mobile device (smartphone or portable media player) with your computer			
Conduct online meetings with video and audio			
Organize business contacts and manage scheduling			
Other			

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Note that you also may need new software and training to use new system components. Many computer users forget to consider the training they'll need when they upgrade their computer. Missing any one of these pieces might make the difference between your computer enriching your life and its becoming another source of stress.

Where do I get the training I need? Of course, colleges offer a number of training options from full semester classes, to online modules, to weekend courses. In addition many online tutorials are available for most software products. For specific questions or skills, be sure to check YouTube and podcast directories. Many valuable series exist that answer your questions in step-by-step video demonstrations, such as MrExcel or Photoshop Quicktips. Some manufacturers, like Apple, offer classes at their stores for a yearly fee. Training shouldn't be an afterthought. Consider the time and effort involved in learning about what you want your computer to do before you buy hardware or software. If you don't, you may have a wonderful computer system but lack the skills necessary to take full advantage of it.

Choosing Either a Desktop or Notebook System

The first step in evaluating your system needs is determining whether you want a desktop or a notebook. In this discussion, we'll only be considering full-size desktops and notebooks. If your main need is Internet connectivity, not processing power, and a small screen and small keyboard are acceptable, a netbook may be a workable option. Netbooks are discussed in detail in Chapter 8.

To make the best decision, it's important to evaluate how and where you will use the computer. The main distinction between desktops and notebooks is portability. If you indicated in the chart in Figure 6.2 that you need to take your computer with you to work or school, or even want the flexibility to move from room to room in your house, a notebook is the best choice. If portability is not an absolute requirement, you should consider a desktop.

How does a notebook compare to a desktop for value? Desktop systems are invariably a better value than notebooks in terms of computing power gained for your dollar. Because of the notebook's small footprint (the amount of space it takes up on the desk), you pay more for each component. Each piece has had extra engineering time invested to make sure it fits in the smallest space. In addition, a desktop system offers more expandability options. It's easier to add new ports and devices because of the amount of room available in the desktop computer's design.

If a large monitor is important, desktops have an edge. Although 18-inch screens are now available on some notebooks, the weight of these systems (often more than 10 pounds) makes them really more of a "desktop replacement" than a portable computing solution. Light notebooks typically have 17-inch screens or smaller, while inexpensive 23-inch monitors are readily available for desktop solutions. If you need a large screen and portability, you may end up buying a notebook and a fixed desk monitor to connect to when you are at home, an extra cost.

Desktop systems also are more reliable. Because of the amount of vibration that a notebook experiences and the added exposure to dust, water, and temperature fluctuations that portability brings, notebooks often have a shorter lifespan than desktop computers. Manufacturers offer extended warranty plans that cover accidental damage and unexpected drops; however, such plans may be costly.

BITS AND BYTES

Taking Your System Out of the Box

You just brought your brand-new machine home, and it's loaded up with all kinds of bloat! Here are two steps you can take right away to have that truly fresh beginning you were hoping for.

1. Remove the preinstalled trial programs and advertisements installed by most vendors. A quick way to do this is with the free program PC DeCrapifier. Its wizard walks you through uninstalling the most common annoyances that came preloaded on your new system.
2. Grab the really valuable free software you *will* want to use. Consider loading OpenOffice.org, Firefox, iTunes, Picasa, and Gimp. (These packages are discussed in more detail in the Technology in Focus section titled "Computing Alternatives.")

Now go enjoy your new machine!

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Figure 6.3
ExpressCards add functionality to your notebook.

How long will a notebook be useful to me? The answer to that question depends on how easy it is to upgrade your system. Take note of the maximum amount of memory you can install in your notebook because that cannot be changed a few years down the road. Internal hard drives are not easy for novices to install in a notebook, but if you have a fast transfer port like an **external SATA (eSATA)** or USB 3.0 on your notebook, you can easily add an external hard drive for more storage space.

Notebooks are often equipped with an ExpressCard slot. **ExpressCard** (shown in Figure 6.3) can add a solid state drive (SSD), eSATA and FireWire ports, and other capabilities to your system. You can add an ExpressCard that allows you to read flash memory cards such as CompactFlash, Memory Sticks, and Secure Digital cards. As new types of ports and devices are introduced, like those for the new USB 3.0 standard, they will be manufactured in ExpressCard formats so you can make sure your notebook does not become obsolete before its time. Figure 6.4 summarizes the advantages and disadvantages of each style of computer.

Assessing Your Hardware: Evaluating Your System

With a better picture of your ideal computer system in mind, you can make a more informed assessment of your current computer. To determine whether your computer system has the right hardware components to do what you ultimately want it to do, you need to conduct a **system evaluation**. To do this, you look at your computer's subsystems, see what they do, and check how they perform. These subsystems include the following:

- CPU subsystem
- Memory subsystem (the computer's random access memory, or RAM)
- Storage subsystem (hard drive and other drives)
- Video subsystem (video card and monitor)
- Audio subsystem (sound card and speakers)
- Ports

In the rest of this chapter, we will examine each subsystem. At the end of each section, you'll find a small worksheet you can use to evaluate each subsystem on your computer. *Note:* This chapter discusses tools you can use to assess a Windows-based PC. For information on how to assess a Mac, refer to the Technology in Focus feature "Computing Alternatives" on page 252.

Evaluating the CPU Subsystem

Early in the process of determining whether your computer system adequately meets your needs, you'll want to consider the type

Figure 6.4 DESKTOP VERSUS NOTEBOOK COMPUTERS—WHICH FITS YOU?

Notebooks	Desktops
Portable—lightweight, thin	Best value: more processing power, memory, and storage capacity for lower price
Take up less physical space	More difficult to steal, less susceptible to damage from dropping or mishandling
Easier to ship or transport if the system needs repair	Easier to expand and upgrade
Smaller video display (17 inches or smaller)	Large monitors available (19 inches or larger)

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of processor in your system. As mentioned in chapter 2, your computer's central processing unit (CPU or processor) is critically important because it processes instructions, performs calculations, manages the flow of information through a computer system, and is responsible for turning raw data into valuable information through processing operations. The CPU is located on the motherboard, the primary circuit board of the computer system. There are several types of processors on the market including Intel processors (such as the Core family with the i7, i5, i3, and the Centrino line) and AMD processors (such as the Athlon and Phenom). The Intel Core i7 is the most advanced desktop CPU ever made by Intel. Figure 6.5 shows the i7 as well as the three-core PowerPC processor used in the Microsoft Xbox 360 gaming console, the Xenon.

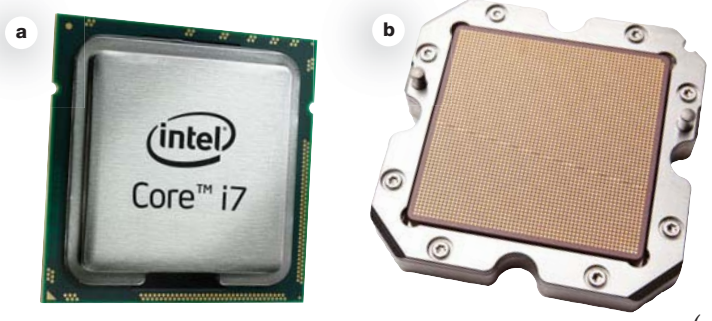

Figure 6.5
(a) The Intel i7 is the most advanced desktop CPU ever made by Intel. (b) The Microsoft Xbox 360 gaming console uses a custom PowerPC–based CPU to perform 115 billion calculations per second.

How does the CPU work? The CPU is comprised of two units: the control unit and the arithmetic logic unit (ALU). The control unit coordinates the activities of all the other computer components. The ALU is responsible for performing all the arithmetic calculations (addition, subtraction, multiplication, and division). The ALU also makes logic and comparison decisions such as comparing items to determine if one is greater than, less than, equal to, or not equal to another.

Every time the CPU performs a program instruction, it goes through the same series of steps. First, it fetches the required piece of data or instruction from RAM, the temporary storage location for all the data and instructions the computer needs while it is running. Next, it decodes the instruction into something the computer can understand. Once the CPU has decoded the instruction, it executes the instruction and stores the result to RAM before fetching the next instruction. This process is called a machine cycle. (We will discuss the machine cycle in more detail in the Technology in Focus feature "Under the Hood" on page 346.)

What makes one CPU different from another? The primary distinction between CPUs is processing power, which is determined by a number of factors. One such factor is the design of the CPU in terms of the number of cores. A **core** is a complete processing section from a CPU embedded into one physical chip. In addition to core design, other factors differentiate CPUs, including how quickly the processor can work (called its **clock speed**) and the amount of immediate access memory the CPU has (called its cache memory).

How will a multiple-core CPU help me? CPUs began to execute more than one instruction at a time quite a while ago, when hyperthreading was introduced. **Hyperthreading** provides quicker processing of information by enabling a new set of instructions to start executing before the previous set has finished. The most recent design innovation for PC processors, an improvement upon hyperthreading, is the use of multiple cores on one CPU chip. With core technology, two or more processors reside on the same chip, enabling the execution of two sets of instructions at the same time. Now applications that are always running behind the scenes, such as virus protection software and your operating system, can have their own processor, freeing the other processor to run other applications such as a Web browser, Word, or iTunes more efficiently. Figure 6.6 shows these different approaches.

In Figure 6.6c, hyperthreading allows two different programs to be processed at one time, but they are sharing the computing resources of the chip. With multiple cores, each program has the full attention of its own processing core (see Figure 6.6a and Figure 6.6b). This results in faster processing

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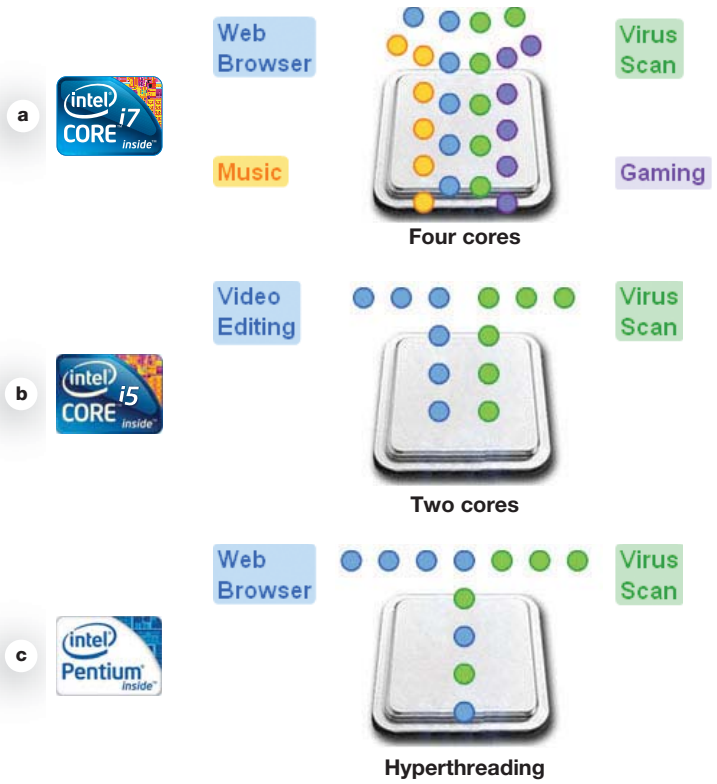

Figure 6.6

(a) Some Intel processors have four cores able to run four programs simultaneously. (b) Some Intel processors have two cores. (c) The Intel Pentium 4 Hyperthreading operates with only one core but it hyperthreads (working on two processes at once).

and smoother multitasking. It is possible to design a CPU to have multiple cores *and* hyperthreading. The Intel i7-980x has six cores, each one using hyperthreading, so it simulates having twelve processors!

How do I pick the fastest processor? While clock speed is an important consideration when determining processor performance, CPU performance also is affected by the amount of cache memory and the speed of the front side bus (FSB). **Cache memory** is a form of random access memory that is more accessible to the CPU than regular RAM. Because of its ready access to the CPU, cache memory gets data to the CPU for processing much faster than bringing the data in from RAM.

There are several levels of cache memory. These levels are defined by a chip's proximity to the CPU. Level 1 cache is a block of memory that is built onto the CPU chip for the storage of data or commands that have just been used. Level 2 cache is located on the CPU chip but is slightly farther away from the CPU, or it's on a separate chip next to the CPU and therefore takes somewhat longer to access. Level 2 cache contains more storage area than does level 1 cache. In the same way, some chips continue on to have a third cache, Level 3. Again, this level of cache is slower for the CPU to reach but larger in size.

Another factor that impacts overall performance is the FSB speed. The **front side bus (FSB)** connects the processor (CPU) in your computer to the system memory. Think of the front side bus as the highway on which data travels between the CPU and RAM. With a wider highway, traffic can move faster because more cars can travel at the same time. Consequently, the faster the FSB is, the faster you can get data to your processor. The faster you get data to the processor, the faster your processor can work on it. FSB speed is measured in megahertz (MHz). The speed of the front side bus is an important consideration that determines CPU performance.

Modern processors are defined by the combination of processor speed, front side bus speed, and the amount of cache memory. For example, Intel has several processor families, in a range of clock speeds, cache memory sizes, and FSB speeds, as shown in Figure 6.7. Even within one processor family, there is a variety of choices. For example, the i7-980X processor has six cores, and a 12 MB cache, whereas the i7-860S processor has four cores and an 8 MB L3 cache.

Figure 6.7 PROCESSOR SPECIFICATIONS

		Number of Cores	Max Clock Speed	Max FSB	Max L3 Cache
Desktop Processors	i3-530	2	2.93 GHz	1333 MHz	4 MB
	i5-750	4	2.66 GHz	1333 MHz	8 MB
	i7-980X	6	3.30 GHz	1600 MHz	12 MB
Notebook Processors	Celeron 585	1	2.16 GHz	666 MHz	1 MB
	i5 mobile 520	2	1.07 GHz	1066 MHz	3 MB
	i7 mobile 820	4	1.73 GHz	1333 MHz	8 MB

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There are many factors that influence CPU design, so picking the fastest CPU for the kind of work you do often involves researching some performance benchmarks. **Benchmarks** are measurements used to compare CPU performance between processors. Benchmarks are generated by running software programs specifically designed to push the limits of CPU performance. Articles are often published comparing a number of chips, or complete systems, based on their benchmark performance. Investigate a few, like **cpubenchmark.net**, before you select the chip that is best for you.

Why are there different CPU choices for notebooks and desktops? Both Intel and AMD make processors that are specifically designed for notebook computers. Notebook processors not only need to perform quickly and efficiently, like their desktop counterparts, but also need better power savings to improve battery life. Processors used in notebooks work to combine low power consumption, to support long battery life, and more flexible wireless connectivity options. AMD features notebook processors like the Turion X2 Mobile and the Mobile AMD Sempron, while Intel has mobile versions of the i5 and i7 series.

What CPU does my current computer have? You can easily identify the type of CPU in your current system by accessing the System Properties. As shown in Figure 6.8, you can view basic information about your computer, including which CPU is installed in your system as well as its speed. More detailed information, like the FSB speed and the amount of cache memory, is not shown in this screen. You can find those values by checking the manufacturer's Web site for the specific model number of CPU shown. For example, the CPU illustrated here is the Intel i7, version 960.

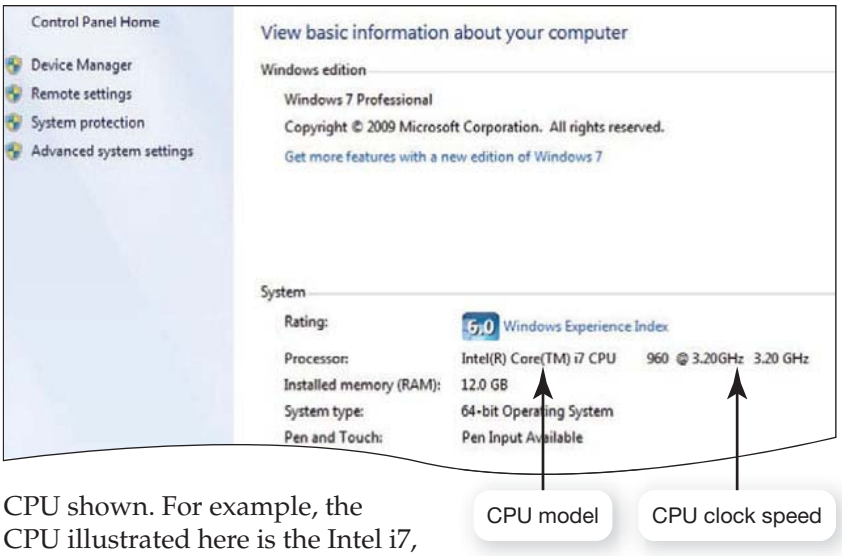

Figure 6.8

The System Properties window identifies which CPU you have, as well as its speed.

>Click the **Start** button and then click **Computer** on the right panel of the **Start** menu. On the top toolbar, click **System Properties**.

How can I tell whether my CPU is meeting my needs? As shown in Figure 6.9, several factors determine whether your CPU is meeting your needs. Even if your CPU meets the minimum requirements specified for a particular software application, if you're running other software at the same time (in addition to the operating system, which is always running), you'll need to check to see how well the CPU is handling the entire load. You can tell whether your CPU speed is limiting your system performance if you periodically watch how busy it is as you work on your computer. Keep in mind that the workload your CPU experiences will vary considerably depending on what you're doing. Even though it might run Word just fine, it may not be able to handle running Word, Photoshop, iTunes, and IM at the same time. The percentage of time that your CPU is working is referred to as **CPU usage**.

A utility that measures information such as CPU usage and RAM usage is incredibly

Figure 6.9 | HOW IS YOUR CPU PERFORMING?

	Current System	My Ideal System
What is my computer's CPU speed?		
How much cache memory is on the CPU*?		
What is the FSB speed*?		
What kind of multilevel processing does the CPU have—multiple cores, hyperthreaded, etc.?		
Is the CPU usage value below 90% during most of my daily tasks?		

*You can find these by checking the manufacturer's specifications for your model of CPU.

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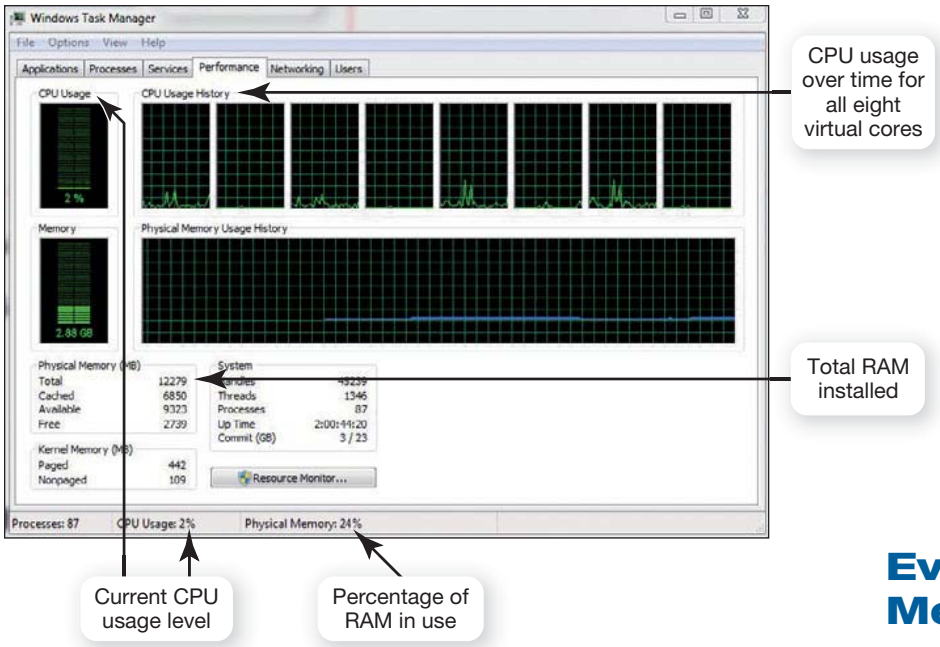


Figure 6.10

The Performance tab of the Windows Task Manager utility shows you how busy your CPU actually is.

>In an empty area of the taskbar, right-click, select **Start Task Manager**, and click the **Performance** tab.

useful, both for considering whether you should upgrade and for investigating if your computer's performance suddenly seems to drop off for no apparent reason. On Windows systems, a program called Task Manager gives you easy access to all this data. Mac OS X has a utility similar to Task Manager called Activity Monitor, which is located in the Utilities folder in your Applications folder.

To view information on CPU usage, right-click an empty area of the taskbar, select Start Task Manager, and click the Performance tab, as shown in Figure 6.10. The CPU Usage graph records your CPU usage for the past several seconds. (Note: If you have multiple cores and hyperthreading, you will see several CPUs listed.) Of course, there will be periodic peaks of high CPU usage, but if you see that your CPU usage levels are greater than 90 percent during most of your work session, a faster CPU will contribute a great deal to your system's performance. If you are using the Windows Sidebar, there is a CPU Meter gadget you can add to track both CPU and RAM usage. To see exactly how to use the Task Manager and the Sidebar gadget, watch the Sound Byte "Using Windows 7 to Evaluate CPU Performance."

Will improving the performance of the CPU be enough to improve my computer's performance? You may think that if you have the best processor, you will have a system with the best performance. However, upgrading your CPU will affect only the processing portion of the system performance, not how quickly data can move to or from the CPU. Your system's overall performance depends on many factors, including the amount of RAM installed as well as hard drive speed. Therefore, your selection of a CPU may not offer significant improvements to your system's performance if there is a bottleneck in processing because of insufficient RAM or hard drive capacity.

Evaluating RAM: The Memory Subsystem

Random access memory (RAM) is your computer's temporary storage space. Although we refer to RAM as a form of storage, it really is the computer's short-term memory. As such, it remembers everything that the computer needs to process the data into information, such as data that has been entered and software instructions, but only when the computer is on. RAM is an example of **volatile storage**. When the power is off, the data stored in RAM is cleared out. This is why, in addition to RAM, systems always include **nonvolatile storage** devices for permanent storage of instructions and data when the computer is powered off. ROM memory, for example, holds the critical startup instructions. Hard drives provide the greatest nonvolatile storage capacity in the computer system.

Why not use a hard drive to store the data and instructions? It's about one million times faster for the CPU to retrieve a piece of data from RAM than from a hard drive. The time it takes the CPU to retrieve data from RAM is measured in

SOUND BYTE Using Windows 7 to Evaluate CPU Performance

In this Sound Byte, you'll learn how to use the utilities provided by Windows 7 to evaluate your CPU's performance. You'll also learn about shareware utilities (software that you can install and try before you purchase it) that expand on the capabilities the Task Manager utility provides.

ISBN: 978-1-256-30685-6

nanoseconds (billionths of seconds), whereas retrieving data from a fast hard drive takes an average of 10 milliseconds (ms), or thousandths of seconds. Figure 6.11 shows the various types of memory and storage that are distributed throughout your system: CPU registers, cache, RAM, and hard drive. Each of these has its own tradeoff of speed vs. price. Because the fastest memory is so much more expensive, systems are designed with much less of it. This principle is influential in the design of a balanced computer system and can have a tremendous impact on system performance.

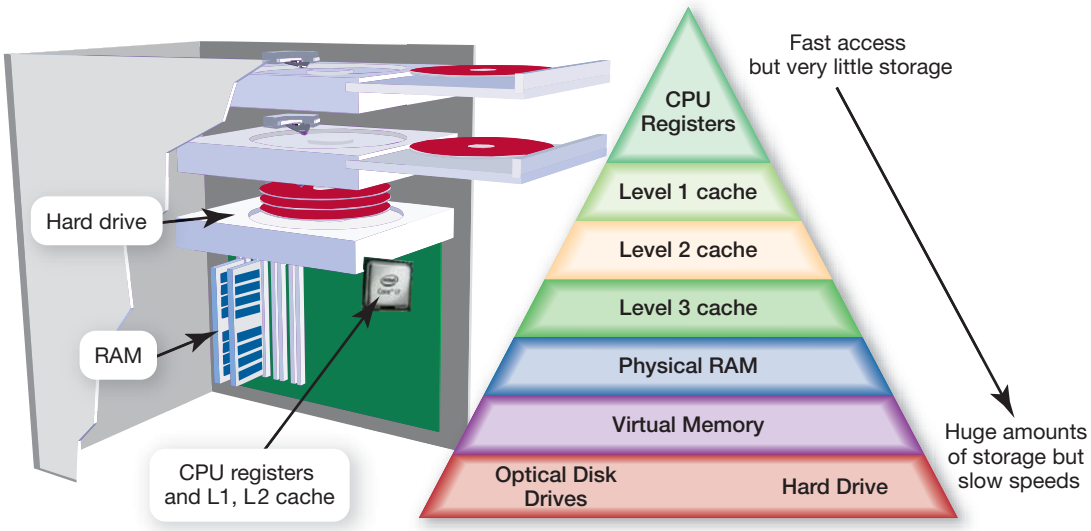


Figure 6.11
A computer system's memory has many different levels, ranging from the small amounts in the CPU to the much slower but more plentiful storage of a hard drive.

Are there different types of RAM? Like most computer components, RAM has gone through a series of transitions. In current systems, the RAM used most often comes in the form of double data rate 2 (DDR2) memory modules. Double data rate 3 memory (DDR3), which has an even faster data transfer rate, is seen in high-performance systems. In older systems, other types of RAM may have been used, including dynamic RAM (DRAM), static RAM (SRAM), and synchronous DRAM (SDRAM). RAM appears in the system on **memory modules** (or **memory cards**), small circuit boards that hold a series of RAM chips and fit into special slots on the motherboard (see Figure 6.12). Most memory modules in today's systems are called *dual inline memory modules* (DIMMs).

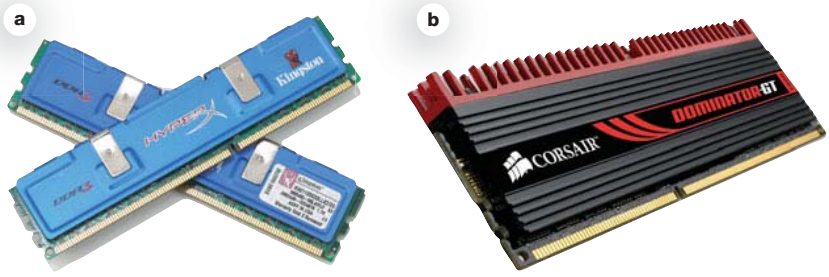
Types of RAM are slightly different from each other in how they function and in the speed at which they access memory. On high-end systems, manufacturers may offer an option to purchase Corsair Dominator DDR3 modules. These are tested to high levels to guarantee optimum performance. A special heat exchanger is designed into the RAM module to help it operate at a lower temperature, making it more stable and more reliable. All of these factors boost the performance of the memory and make it popular with demanding video gamers.

If you're adding RAM to any system, you must determine what type your system needs. Consult your user's manual or the manufacturer's Web site. In addition, many online RAM resellers, such as Crucial (**crucial.com**), can help you determine the type of RAM that is compatible with your system by running an automated system scan program on your computer.

How can I tell how much RAM is installed in my computer and how it's being used? The amount of RAM that is actually sitting on memory modules in your computer is your computer's **physical memory**. The easiest way to see how much RAM you have is to look in the System Properties window. (On the Mac, choose the Apple menu and then About This Mac.) This is the same tab you looked in to determine your system's CPU type and speed, and is shown in Figure 6.8. RAM capacity is measured in gigabytes (GB), and most machines sold today, especially those running Windows, have at least 2 GB of RAM. The computer in Figure 6.10 has 12 GB of RAM installed.

Windows 7 uses a memory-management technique known as SuperFetch. SuperFetch monitors which applications you use the

Figure 6.12
(a) Memory modules hold a series of RAM chips. (b) This Corsair memory module has an aluminum plate called a heat sink to cool the chips beneath it.



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ACTIVE HELP-DESK Evaluating Your CPU and RAM

In this Active Helpdesk call, you'll play the role of a helpdesk staffer, fielding calls about what the CPU does and how to evaluate its performance. You'll also field calls about how memory works and how to evaluate how much memory a computer needs.

most and preloads them into your system memory so that they'll be ready to go. For example, if you have Word running, Windows 7 stores as much of the information related to Word in RAM as it can, which speeds up how fast your application responds, because pulling information from RAM is so much faster than pulling it from the hard drive. This idea of caching the data you need in RAM, having it ready to use quickly when it is asked for, is different from how memory was used in earlier operating systems. You can watch this work using the Resource Monitor, which shows in Figure 6.13 how the 12 GB of installed RAM is being used: 3 GB is running programs, 6 GB is holding cached data and files ready to be quickly accessed, and 3 GB is currently unused.

How much memory does the operating system need to run? The memory that your operating system uses is referred to as **kernel memory**. This memory is listed in a separate Kernel Memory table in the Performance tab. In Figure 6.10, the Kernel Memory table tells you that approximately 555 MB (total kernel memory) of the total 12 GB of RAM is being used to run the operating system.

Figure 6.13

The Resource Monitor's Memory tab shows a detailed breakdown of how the computer is using memory.

>In the **Resource Monitor**, click the **Memory** tab.

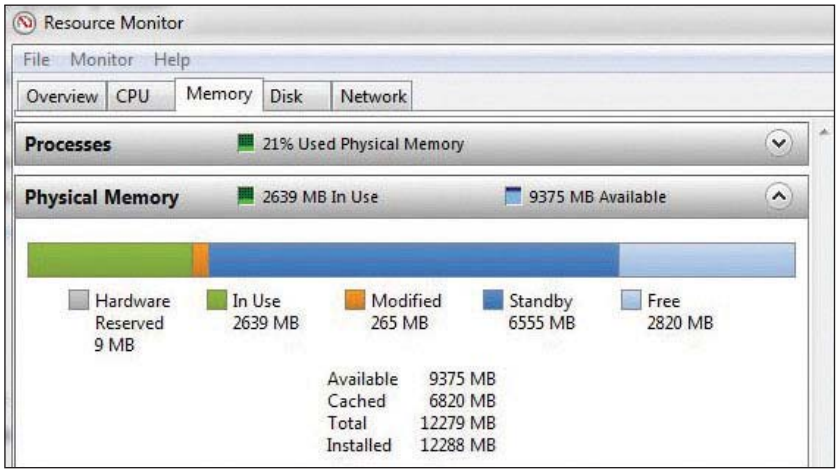

Figure 6.14 SAMPLE RAM ALLOCATION

Application	RAM Recommended
Windows 7	2,000 MB (or 2 GB)
Microsoft Office Professional 2010	512 MB
Internet Explorer 8	512 MB
iTunes 9	512 MB to 1,000 MB (1 GB)
Adobe Photoshop Elements 8	1,000 MB (1 GB)
Total RAM required to run all programs simultaneously	4,536 MB to 5,024 MB (or 4.5 GB to 5.0 GB)

As you know from Chapter 5, the operating system is the main software application that runs the computer. Without it, the computer does not work. At a minimum, the system needs enough RAM to run the operating system. However, because you run additional applications, you need to have more RAM than the minimum.

How much RAM do I need? Because RAM is the temporary holding space for all the data and instructions that the computer uses while it's on, most computer users need quite a bit of RAM. In fact, systems running all the new features of Windows 7 should have a minimum of 1 GB of RAM, but for peak performance, systems are recommended to have at least 2 GB of RAM.

To determine how much RAM you need, list all the software applications you might be running at one time. Figure 6.14 shows an example of RAM requirements. In this example, if you are running your operating system, word processing and spreadsheet programs, a Web browser, a music player, and photo editing software simultaneously, then you will need a minimum of 4.5 GB of RAM. It's always best to check the system requirements of any software program

SOUND BYTE Memory Hierarchy Interactive

In this Sound Byte, you'll learn about the different types of memory used in a computer system.

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before you buy it to make sure your system can handle it. System requirements can be found on the software packaging or on the manufacturer's Web site.

It's a good idea to have more than the minimum amount of RAM you need now, so you can use more programs in the future. Remember, too, that "required" means these are the minimum values recommended by the manufacturers, and having more RAM often helps programs run more efficiently. When upgrading RAM, the rule of thumb is to buy as much as you can afford but no more than your system will handle.

Adding RAM

Is there a limit to how much RAM I can add to my computer? Every computer has a maximum limit on the amount of RAM it can support. A motherboard is designed with a specific number of slots into which the memory cards fit, and each slot has a limit on the amount of RAM it can hold. To determine your specific system limits, check your owner's manual or the manufacturer's Web site.

In addition, the operating system running on your machine imposes its own limit. For example, the maximum amount of RAM for the 32-bit version of Windows 7 is 4 GB, while the 64-bit version of Windows 7 Ultimate can address up to 192 GB.

Once you know how much RAM your computer can support, you can determine the best configuration of memory modules to achieve the greatest amount of RAM. For example, say you have a total of four memory card slots: two are already filled with 512 MB RAM cards and the other two are empty. The maximum RAM allowed for your system is 4 GB. This means you can buy two more 512 MB RAM modules for the two empty slots, for a total of 2 GB (4 × 512 MB) of RAM. Alternatively, you could throw away the 512 MB cards you have and purchase four new 1 GB cards, filling the system up to its capacity of 4 GB.

Review the considerations presented in Figure 6.15 to see if your system could benefit from an upgrade of additional RAM.

Figure 6.15 DO YOU NEED TO UPGRADE YOUR RAM?

	Application	Current System	Ideal System
How much RAM does my system have?			
What is the maximum amount of RAM I need for the applications I currently run?			
What is the maximum amount of RAM the system can hold*?			
Would I be willing to upgrade to a 64-bit operating system and 64-bit CPU to support having 4 GB or more of RAM?			

*Check the manufacturer's specifications for your system.

Is it difficult or expensive to add RAM? Adding RAM to a computer is fairly easy (see Figure 6.16). RAM comes with installation instructions, which you should follow carefully. RAM is also relatively inexpensive compared with other system upgrade options. Still, the cost of RAM fluctuates in the marketplace as much as 400 percent over time, so if you're considering adding RAM, you should watch the prices of memory in online and print advertisements.

Adding RAM to a personal computer is quite simple and relatively inexpensive. You simply line up the notches and push in the memory module. Just be sure that you're adding a memory module that's compatible with your computer. For a video demonstration and more details, watch the Sound Byte, "Installing RAM."

SOUND BYTE Installing RAM

In this Sound Byte, you'll learn how to select the appropriate type of memory to purchase, how to order memory online, and how to install it yourself. As you'll discover, the procedure is a simple one and can add great performance benefits to your system.

Evaluating the Storage Subsystem

As you've learned, there are two ways data is stored on your computer: temporary storage and permanent storage. RAM is a form of temporary (or volatile) storage. Thus, anything that resides in RAM is not stored permanently. It's critical to have the means to store data and software applications permanently.

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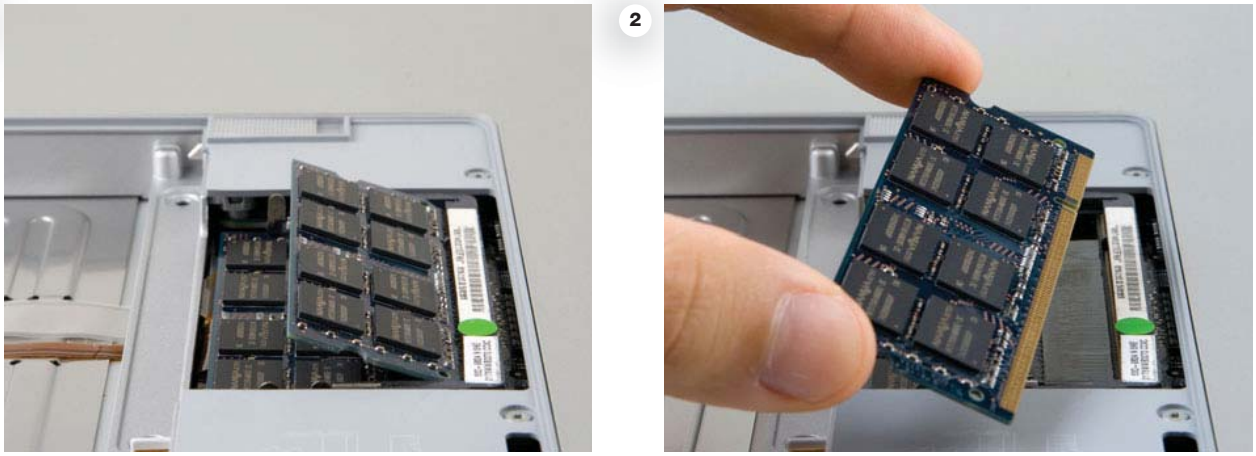

Figure 6.16
Adding RAM to a computer is quite simple and relatively inexpensive.

Fortunately, several storage options exist within every computer system. Storage devices for a typical personal computer include the hard drive, USB flash drives, optical drives, and external hard drives. When you turn off your computer, the data that has been written to these devices will be available the next time the machine is powered on. These devices are therefore referred to as *nonvolatile* storage devices.

The Hard Drive

What makes the hard drive the most popular storage device? With storage capacities exceeding 2 terabytes (TB), a **hard drive** has the largest storage capacity of any storage device. The hard drive is also a much more economical device than other storage options, because it offers the most gigabytes of storage per dollar. Most system units are designed to support more than one internal hard drive. The Apple Mac Pro, shown in Figure 6.17, has room for four hard drives. Each one simply slides into place when you want to upgrade.

Another reason the hard drive is so useful for storage is that the hard drive's **access time**, the time it takes a storage device to locate its stored data and make it available for processing, is faster than that of other permanent storage devices, like optical drives. Hard drive access times are measured in milliseconds (ms), meaning thousandths of seconds. For large- capacity drives, access times of approximately 12–13 milliseconds—that's less than one-hundredth of a second—are typical. A DVD drive can take over 150 milliseconds to access data.

Solid state drives offer even faster access times. A **solid state drive (SSD)** uses the same kind of memory that flash drives use, but whereas flash drives have access times of about 1 ms, SSD drives can reach data in only a tenth of that time (around 0.1 ms). Because there are no spinning platters or motors needed, SSDs run with no noise, very little heat, and require very little power. As the storage capacities for SSDs continue to increase and the prices for SSDs continue to drop, you'll start to see them in a wide range of systems.

Figure 6.18 provides a listing of the various storage options and compares their access times.

Another key performance specification for a hard drive is the speed at which it can transfer data to other computer components (such as RAM). This speed of transfer is referred to as **data transfer rate**. Depending on the manufacturer, the rate is expressed in either megabits or megabytes per second.

How is data stored on a hard drive? A hard drive is composed of several coated round, thin plates of metal stacked on a spindle. Each plate is called a **platter**. When data is saved to a hard drive platter, a pattern of magnetized spots is created on the iron oxide coating of each platter. When the spots are aligned in one

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Figure 6.17
The Mac Pro allows you to slide a new hard drive into place easily. In all, the Mac Pro can hold up to 4 hard drives.

direction, they represent a 1; when aligned in the other direction, the represent a 0. These 0s and 1s are bits (or binary digits) and are the smallest pieces of data that computers can understand. When data stored on the hard drive platter is retrieved (or read), your computer translates these patterns of magnetized spots into the data you have saved.

How do I know how much storage capacity I need? Typically, hard drive capacity is measured in gigabytes (GB), although hard drives with capacity in the terabytes (TB) are now available. To check how much total capacity your hard drive has, as well as how much is being used, click the Start button and select Computer from the right side of the Start menu. Windows displays the hard drives, their capacity, and usage information, as seen in Figure 6.19. To get a slightly more detailed view, select a drive; then right-click and choose Properties.

To determine the storage capacity your system needs, calculate the amount of storage required by all the types of files you will be keeping on your system. If you have a large digital music library, that alone could require 30 to 50 GB. Do you keep all of your photographs on your hard drive? You may need another 40 GB or more for them. If you store digital video of television shows and movies, that could easily be 100 to 200 GB more, even higher if the videos are all high definition. Of course, the operating system also requires storage space. The demands on system requirements have grown with new versions of operating systems. Windows 7, the latest Microsoft operating system, can require up to 20 GB of available hard drive capacity, depending on the configuration.

In addition to having space for the operating system, you need enough space to store the software applications you use, such as Microsoft Office, music, and games.

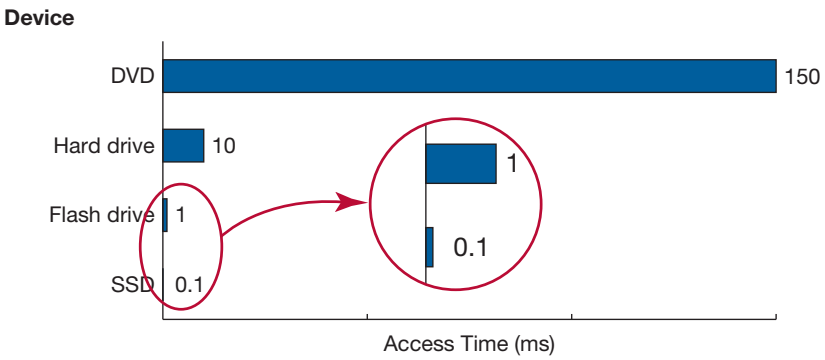

Figure 6.18
Access times for non-volatile storage options.

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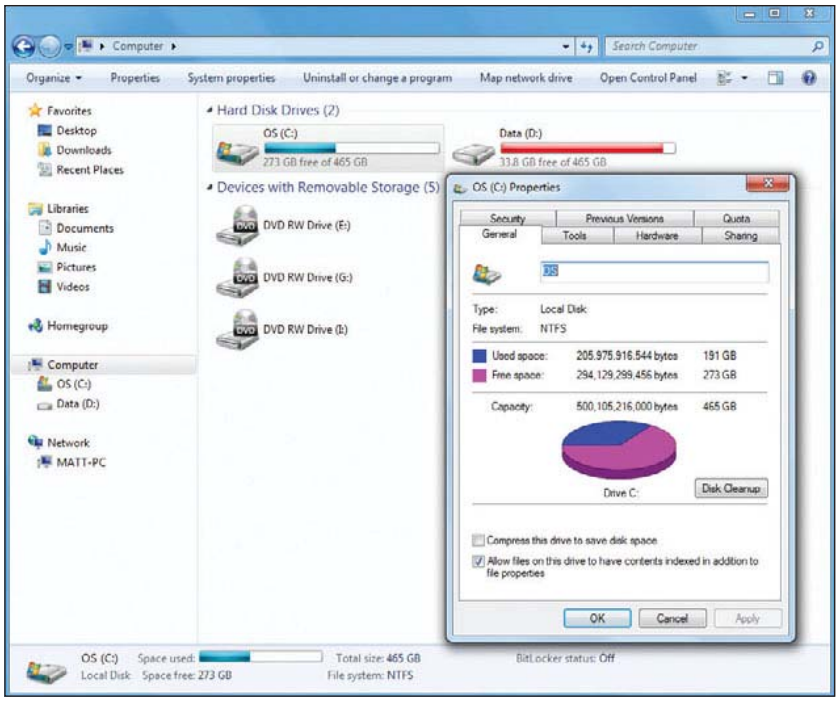

Figure 6.19

In Windows, the free and used capacity of each device in the computer system are shown in the Computer window. The General tab of the Properties dialog box gives you information that is more detailed.

>To view the Computer window, click **Start**, and click **Computer**. To view the pie chart, right-click the C drive, and select **Properties**.

BITS AND BYTES HDTV on Your Notebook

If you are moving through your day with a notebook in tow, why not use it to pull up your favorite television shows? There are now several USB devices that allow your notebook or desktop to receive the high-definition television (HDTV) signals whizzing by in the airwaves.

Devices like the Hauppauge HDTV stick (see Figure 6.20) are USB digital TV tuners. One end plugs into any available USB port. The other end connects to the provided digital antenna. Software is included that allows you to schedule shows to record onto your hard drive, so your notebook essentially becomes a time-shifting digital video recorder. If you are at home, you can remove the antenna and connect to your home cable television signal. It's enough to make you think about buying a larger hard drive on your next computer!

Figure 6.20

The Hauppauge HDTV stick allows you to watch and record high-definition television shows on your computer.

Figure 6.21 shows an example of hard drive requirements for someone storing a few programs on a hard drive. If you plan to have a system backup on the same drive, be sure to budget for that room as well.

How do hard drives compare for speed? There are several types of hard drives. Integrated Drive Electronics (IDE), which is also called *parallel advanced technology attachment (PATA)*, is an older style that uses wide cables to connect the hard drive to the motherboard. **Serial Advanced Technology Attachment (Serial ATA)** hard drives use much thinner cables, and can transfer data more quickly than IDE drives. A slower drive is fine if you use your computer primarily for word processing, spreadsheets, e-mail, and the Internet. However, "power users" such as graphic designers and software developers will benefit from the faster Serial ATA hard drive.

Another factor that affects a hard drive's performance is access time (the speed with which it locates data for processing). As noted earlier, access time is measured in milliseconds. The faster the access time the better, although many hard drives have similar access times.

The latest and fastest hard drive option is the solid state drive (SSD). These are popular in the netbook market because they require so little power to run and are so cool and quiet. With access times of merely a tenth of a millisecond, SSDs can deliver data many times more quickly than mechanical hard drives. SSD drives as large as 1 TB are available, but right now, all SSD drives are still much more expensive than mechanical drives. Currently, some machines compromise by using an SSD just to hold the operating system. This takes advantage of their great speed, making the boot-up time for the system very quick. Watch for further integration of SSD drives into systems as the cost of SSDs continues to drop.

Evaluate hard drive transfer rate when looking for the best performing drive. The data transfer rate is the speed at which a hard drive can transfer data to other computer components (such as RAM). Depending on the manufacturer, the rate is expressed in either megabits or megabytes per second. You can compare the average read and write data transfer rates of hard drives at sites that do performance benchmarking, like Tom's Hardware (**tomshardware.com**).

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If you are adding an external hard drive to your system, there are two popular ports to use. Many hard drives use a USB 2.0 port to connect, which limits the transfer rate of data to 400 Mbps. The USB 3.0 standard has raised that limit to 5 Gbps (5,000 Mbps). In addition, some computer systems now offer an eSATA port, shown in Figure 6.22. This is an external SATA port that will connect to some external hard drive models. It allows a data transfer rate of up to 3 Gbps.

Do I want one huge drive or several smaller drives? It depends on what is important to you: speed or security. If you purchase two smaller drives, you can combine them using RAID technology. RAID (redundant array of independent disks) is a set of strategies for using more than one drive in a system. RAID 0 and RAID 1 are the most popular for consumer machines.

In RAID 0 configuration, every time data is written to a hard drive, it is actually spread across two physical drives (see Figure 6.23a). The write begins on the first drive, and while the system is waiting for that write to be completed, the system jumps ahead and begins to write the next block of data to the second drive. This makes writing information to disk almost twice as fast as using just one hard drive. The downside is that if either of these disks fail, you lose all your data, because part of each file is on each drive. So RAID 0 is for those most concerned with performance.

Figure 6.22
An eSATA port allows you to connect an external hard drive that can transfer data at speeds faster than USB 2.0 but slower than USB 3.0.

In RAID 1 configuration, all the data written to one drive is perfectly mirrored and written to a second drive (see Figure 6.23b). This provides you a perfect, instant by instant backup of all your work. It also means that if you buy two 1 TB drives, you only have room to store 1TB of data because the second 1 TB drive is being used as the "mirror."

RAID 0 and RAID 1 systems are available on many consumer systems and are even beginning to appear on notebook computers. The Sony Vaio Z is a notebook available with two 256 GB SSDs, connected in RAID 0. This gives you access to 500 GB of storage and incredibly quick access speeds, with very little power consumption or noise.

Figure 6.21 SAMPLE HARD DRIVE SPACE REQUIREMENTS

Application	Hard Drive Space Required
Windows 7	16–20 GB
MS Office 2007 Professional	3.5 GB
Adobe Photoshop Elements 8	2 GB
Roxio Easy Media Creator 2010	3 GB installation space and up to several 10's of GB to copy BDs or DVDs
Total required	At least 24.5 GB

Optical Storage

Optical drives are disc drives that use a laser to store and read data. Data is saved to a compact disc (CD), digital video disc (DVD), or **Blu-ray disc (BDs)** within established tracks and sectors, just like on a hard drive. However, unlike hard drives, which store their data on magnetized platters, optical discs store data as tiny pits that are burned into the disc by a high-speed laser. These pits are extremely small. For CDs and DVDs, they are less than 1 micron in diameter, so nearly 1,500 pits fit across the top of a pinhead. The pits on a Blu-ray disc are only 0.15 microns in diameter, more than twice as small as the pits on a DVD. As

SOUND BYTE CD, DVD, and Blu-ray Reading and Writing Interactive

In this Sound Byte, you'll learn about the process of storing and retrieving data from CD-RW, DVD, and Blu-ray discs. You'll be amazed to see how much precision engineering is required to burn MP3 files onto a disc.

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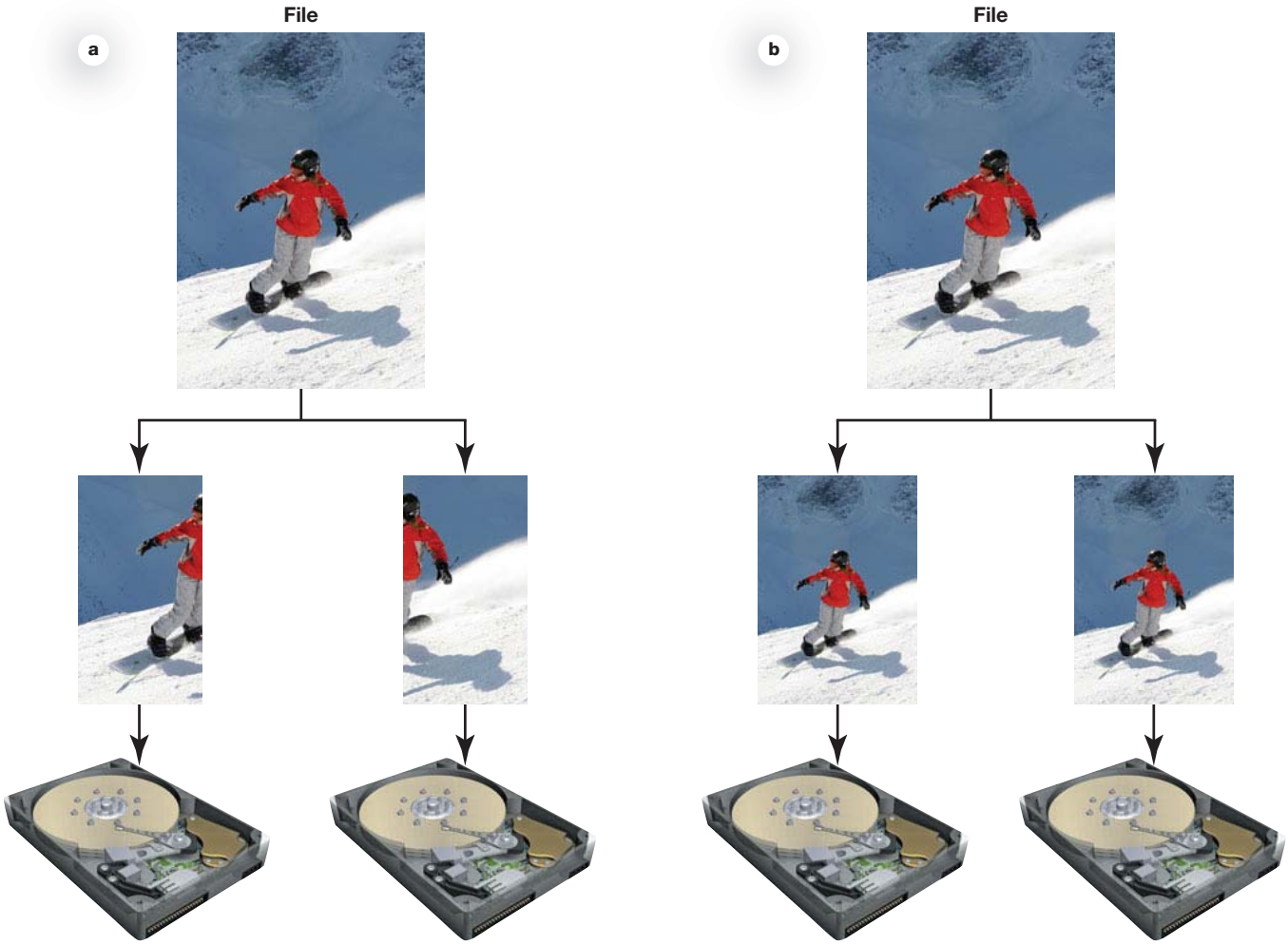

Figure 6.23

(a) RAID 0 speeds up file read/write time. (b) RAID 1 gives you an instant backup.

you can see in Figure 6.24, data is read from a disc by a laser beam, with the pits and nonpits (called *lands*) translating into the 1s and 0s of the binary code computers understand. CDs and DVDs use a red laser to read and write data. Blu-ray discs get their name because they are read with a blue laser light. All of them collectively are referred to as **optical media**.

Why can I store data on some discs but not others? All forms of optical media come in prerecorded, recordable, and rewritable formats. The prerecorded discs—known as CD-ROM, **DVD-ROM**, and **BD-ROM discs**—are read-only optical discs, meaning you can't save any data onto them. Pre-recorded CDs usually contain audio content, software programs, or games, whereas DVD-ROMs and BD-ROMs typically contain movies or prerecorded TV shows in regular or high definition, respectively. Recordable formats such as CD-R, DVD-R, and BD-R allow data to be written (saved or burned) to them. If you want to be able to use a form of optical media repetitively, writing and rewriting data to it many times, read/writeable formats such as CD-RW, DVD-RW, and BD-RE are available.

Do I need separate players and burners for CD, DVD, and now BD formats? Although CDs and DVDs are based on the same optical technology, CD drives cannot read DVDs. If your system has only a CD drive, you will need to add a DVD drive to view DVDs. However, if your system has a DVD drive, that is all you need, even just to listen to CDs, because DVD drives can read them. Although Blu-ray discs are read with a different type of laser than CDs and DVDs, most Blu-ray players are backward compatible and can play DVDs and CDs. There are different types of optical drives for playing or recording to discs. If you want to record to CDs, DVDs, or Blu-ray discs, you need to make sure your drive is capable of recording (or burning) and not just playing.

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Because recording drives are also backward compatible, you do not need separate burners for each form of media. A DVD burner will also record CDs, and a Blu-ray burner will most likely record both CDs and DVDs (although there may be some compatibility issues).

Are there different standards of optical media? Unfortunately, technology experts have not agreed on a standard DVD format. Currently, there are multiple recognized formats, **DVD-R/RW** (pronounced "DVD dash") and **DVD+R/RW** (pronounced "DVD plus"). **DVD-RAM** is a third format. You can record, erase, and rewrite on DVD-RAM, as you can with the plus and minus formats, but DVD-RAM discs are generally encased in a plastic cartridge. Web sites such as Video Help (**videohelp.com**) list the compatibility of various DVD players with the various DVD formats. However, you must make sure you purchase blank DVD discs that match the type of drive you own. Most new systems come equipped with a DVD +/– RW drive that supports both the plus and minus formats.

There were "format wars" like this for high-definition discs as well. Blu-ray competed against another storage format called HD-DVD (high-definition DVD). Some movie companies would only provide their films on HD discs, while other films were exclusive to Blu-ray. Different players were required to view each kind of disc. In 2008, HD-DVDs were retired, and HD discs and players are no longer in production.

Are some CD and DVD drives faster than others? When you buy an optical drive, knowing the drive speed is important. Speeds are listed on the device's packaging. Record (write) speed is always listed first, rewrite speed is listed second (except for CD-R drives and DVD-R, which cannot rewrite data), and playback speed is listed last. For example, a CD-RW drive may have speeds of 52X32X52X, meaning that the device can record data at 52X speed, rewrite data at 32X speed, and play back data at 52X speed. For CDs, the X after each number represents the transfer of 150 KB of data per second. For example, a CD-RW drive with a 52X32X52X rating records data at 52 times 150 KB per second, or 7,800 KB per second.

DVD drives are much faster than CD drives. For example, a 1X DVD-ROM drive provides a data transfer rate of approximately 1.3 MB of data per second, which is roughly equivalent to a CD-ROM speed of 9X. CD and DVD drives are constantly getting faster. If you're in the market for a new CD or DVD burner, then you'll want to investigate the drive speeds on the market and make sure you get the fastest one you can afford.

Blu-ray drives are the fastest optical devices on the market. Blu-ray technology defines 1X speed as 36 MB per second.

To read information stored on a disc, a laser inside the disk drive sends a beam of light through the spinning disc.

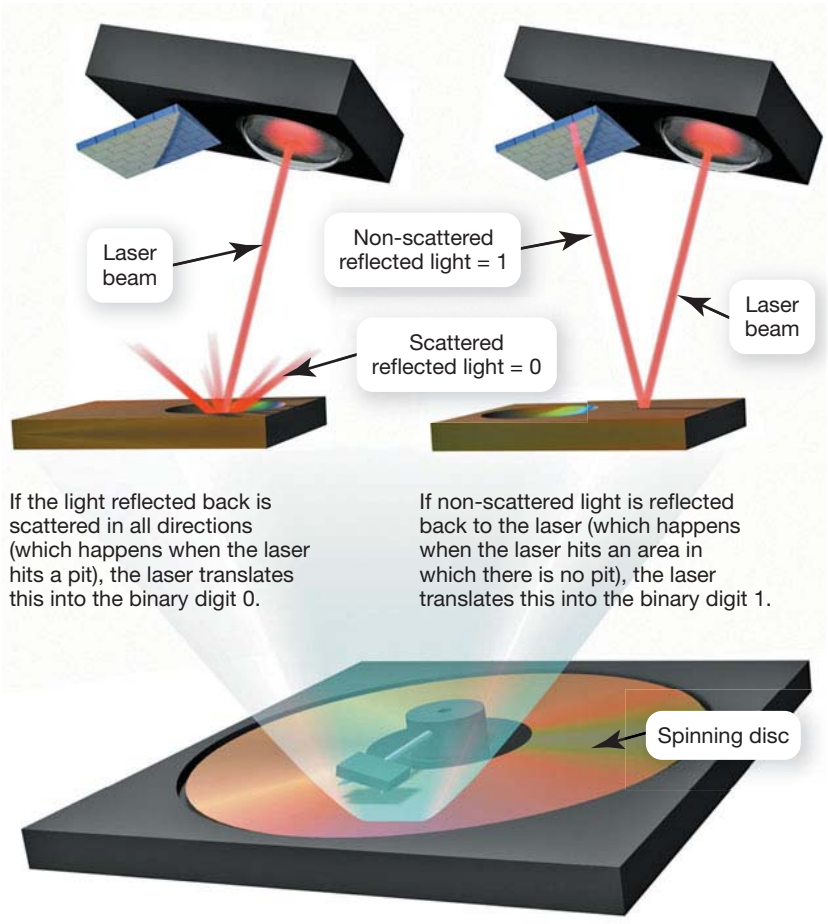

Figure 6.24
Data is read from a disc using focused laser light.

SOUND BYTE Installing a Blu-ray Drive

In this Sound Byte, you'll learn how to install a Blu-ray drive in your computer.

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DIG DEEPER How a Mechanical Hard Drive Works

The thin metal platters that make up a hard drive are covered with a special magnetic coating that enables the data to be recorded onto one or both sides of the platter. Hard drive manufacturers prepare the disks to hold data through a process called *low-level formatting*. In this process, concentric circles, each called a **track**, and pie-shaped wedges, each called a **sector**, are created in the magnetized surface of each platter, setting up a gridlike pattern that identifies file locations on the hard drive. A separate process called *high-level formatting* establishes the catalog that the computer uses to keep track of where each file is located on the hard drive. More detail on this is presented in the Dig Deeper feature "How Disk Defragmenter Utilities Work" on page 238.

Hard drive platters spin at a high rate of speed, some as fast as 15,000 revolutions per minute (rpm). Sitting between the platters are special "arms" that contain read/write heads (see Figure 6.25). A **read/write head** moves from the outer edge of the spinning platter to the center, as frequently as 50 times per second, to retrieve (read) and record (write) the magnetic data to and from the hard drive platter. As noted earlier, the average total time it takes for the read/write head to locate the data on the platter and return it to the CPU for processing is called its access time. A new hard drive should have an average access time of approximately 12 ms.

Access time is mostly the sum of two factors: seek time and latency. The time it takes for the read/write heads to move over the surface of the disk, moving to the correct track, is called the **seek time**. (Sometimes people incorrectly refer to this as access time.) Once the read/write head locates the correct track, it may need to wait for the correct sector to spin to the read/write head. This waiting time is called **latency** (or *rotational delay*). The faster the platters spin (or the faster the rpm), the less time you'll have to wait for your data to be accessed. Currently, most hard drives for home systems spin at 7,200 rpm. Some people design their systems to have a faster hard drive run the operating system, such as the Western Digital Velociraptor, which spins at 10,000 rpm. They then add a slower drive with greater capacity for storage.

The read/write heads do not touch the platters of the hard drive; rather, they float above them on a thin cushion of air at a height of 0.5 microinches. As a matter of comparison, a human hair is 2,000 microinches thick and a particle of dust is larger than a human hair. Therefore, it's critical to keep your hard drive free from all dust and dirt, because even the smallest particle could find its way between the read/write head and the disk platter, causing a **head crash**—a stoppage of the hard drive that often results in data loss.

Capacities for hard drives in personal computers can exceed 2000 GB (2 TB). Increasing the amount of data stored in a hard drive is achieved either by adding more platters or by increasing the amount of data stored on each platter. How tightly the tracks are placed next to each other, how tightly spaced the sectors are, and how closely the bits of data are placed affect the measurement of the amount of data that can be stored in a specific area of a hard drive platter. Modern technology continues to increase the standards on all three levels, enabling massive quantities of data to be stored in small places.

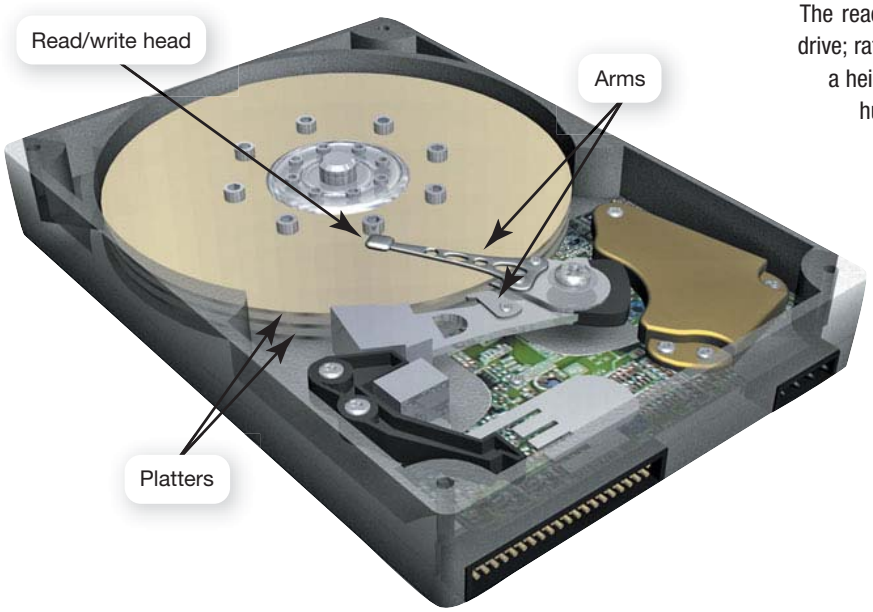

Figure 6.25
The hard drive is a stack of platters enclosed in a sealed case. Special arms fit in between each platter. The read/write heads at the end of each arm read from and save data to the platters.

Because BD movies require data transfer rates of at least 54 MB per second, most Blu-ray disc players have a minimum of 2X speeds (72 MB per second). Many units are available with 12X speeds.

So how do my storage devices measure up? The table in Figure 6.26 will help you determine if your computer's storage subsystem needs upgrading.

Evaluating the Video Subsystem

How video is displayed depends on two components: your video card and your monitor. It's important that your system have the correct monitor and video card to meet your needs. If you are considering loading Windows 7 on your system, or

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Figure 6.26 DO YOU WANT TO UPGRADE YOUR STORAGE SUBSYSTEM?

	Current System	Ideal System
What is my current hard drive capacity?		
Do I want to have a very fast startup time (i.e., use an SSD drive for my operating system)?		
Do I want to implement multiple drives in RAID 0 for performance?		
Do I want to implement multiple drives in RAID 1 for instant backup?		
Do I have a DVD-ROM drive?		
Can I burn DVDs (i.e., do I have a DVD-/+RW drive)?		
Can I play Blu-ray discs (i.e., do I have a Blu-ray drive)?		
Can I burn my own Blu-ray discs (i.e., do I have a Blu-ray burner installed)?		
Do I have a working data backup solution such as external backup drives or remote data storage?		
Do I use any portable storage devices such as flash drives or external hard drives?		

using your computer system to display files that have complex graphics, such as videos on Blu-ray or from your camcorder, or even playing graphics-rich games with a lot of fast action, you may want to consider upgrading your video subsystem.

ACTIVE HELP-DESK Evaluating Computer System Components

In this Active Helpdesk call, you'll play the role of a helpdesk staffer, fielding calls about the computer's storage, video, and audio devices and how to evaluate whether they match your needs, as well as how to improve the reliability of your system.

Video Cards

What is a video card? A **video card** (or **video adapter**) is an expansion card that is installed inside your system unit to translate binary data into the images you view on your monitor. Modern video cards like the ones shown in Figure 6.27 and

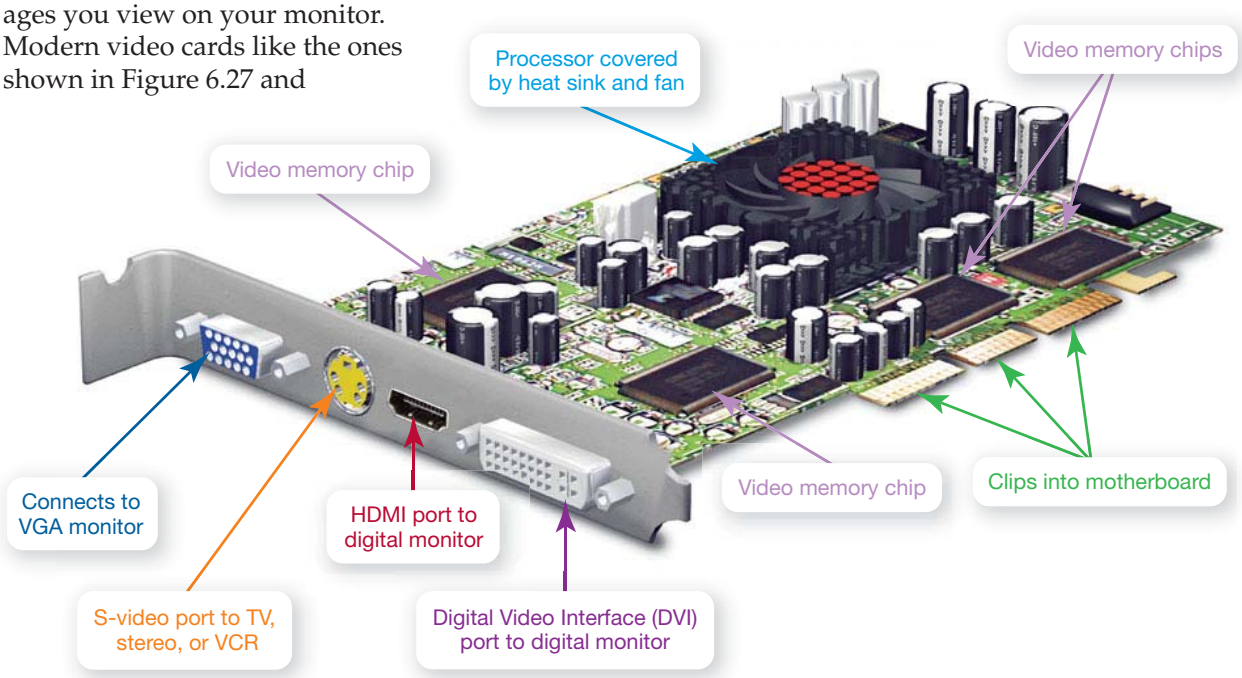

Figure 6.27
Video cards have grown to be highly specialized subsystems.

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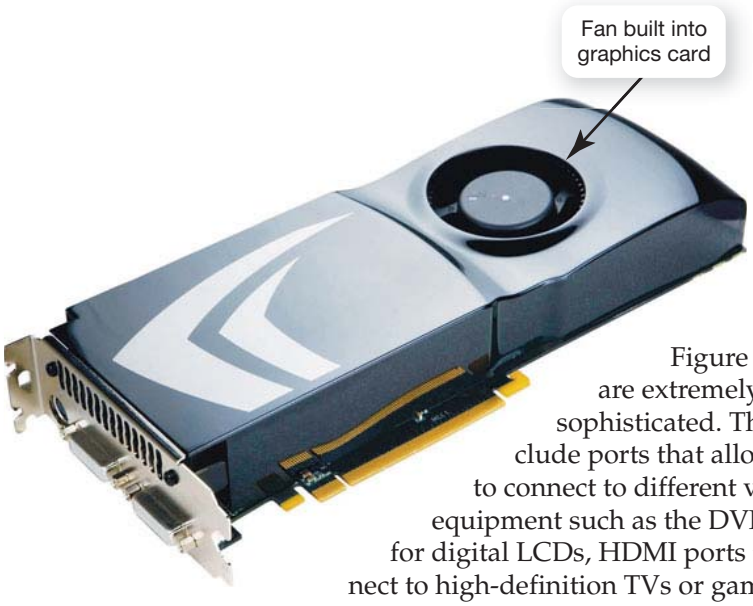

Figure 6.28
Because of the large amount of graphics memory and the fast graphics processing units on modern video cards, they have their own fan to remove heat.

Figure 6.28 are extremely sophisticated. They include ports that allow you to connect to different video equipment such as the DVI ports for digital LCDs, HDMI ports to connect to high-definition TVs or gaming consoles, lower-resolution S-video ports for connecting your computer to a TV, and Super VGA ports for CRT and analog LCD monitors. In addition, video cards include their own RAM, called **video memory**. Several standards of video memory are available, including graphics double data rate 3 (GDDR3) memory and the newer graphics double data rate 5 (GDDR5) memory. Because displaying graphics demands a lot of the CPU, video cards also come with their own graphics processing units (GPUs). When the CPU is asked to process graphics, those tasks are redirected to the GPU, significantly speeding up graphics processing.

Is a GPU different from a CPU? The **graphics processing unit (GPU)** performs the same kind of computational work that a CPU performs. However, a GPU is specialized to handle 3-D graphics and image and video processing with incredible efficiency and speed. Figure 6.29 shows that the CPU can run much more efficiently when a GPU does all of the graphics computation.

Special lighting effects can be achieved with a modern GPU. Designers can now change the type of light, the texture, and the color of objects based on complex interactions. Some GPU designs incorporate dedicated hardware to allow high-definition movies to be decoded.

Does the GPU live on the motherboard or on the video card? Basic video processing is sometimes integrated into the motherboard. However, high-end video cards that have their own GPUs are separate from the motherboard. These sophisticated video cards connect through the ultrafast PCI Express bus. The ATI Radeon HD 5970, a top-end card, is a multi-GPU card with two GPUs that work together to add even more processing punch. Cards like this one carry their own processing RAM space, which can range between 512 MB and 2 GB, depending on the model. Together they provide an unprecedented level of realism and detail in gaming environments.

How can I tell how much memory my video card has? Information about your system's video card can be found in the Advanced Settings of the Screen resolution dialog box. To get to the Screen resolution dialog box, right-click on your desktop and select Screen resolution. In the Screen resolution dialog box, click the Advanced Settings link. A window will appear that shows you the type of graphics card installed in your system, as well as memory information including total available graphics memory, dedicated video memory, system video memory, and shared system memory. The documentation that came with your computer should also contain specifications for the video card, including the amount of video memory it has installed.

How much memory does my video card need? The amount of memory your

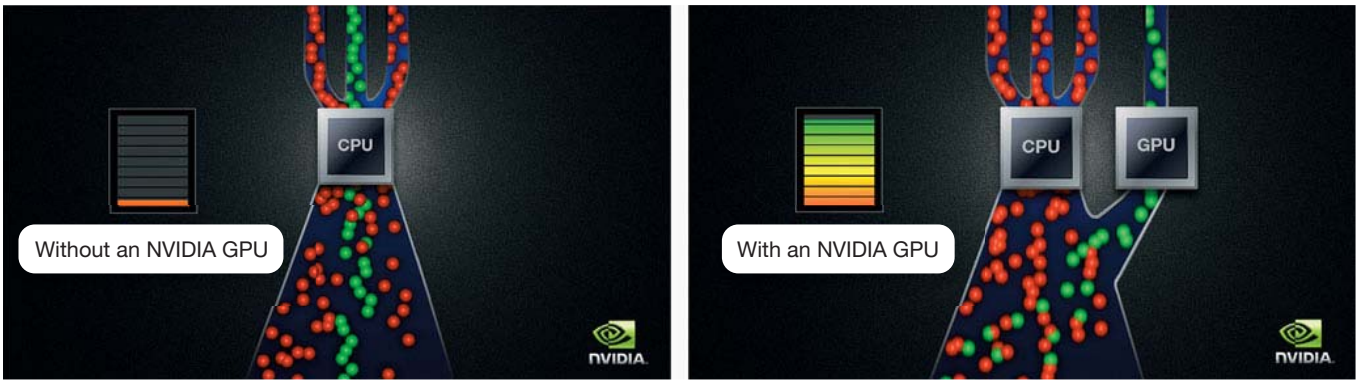

Figure 6.29
The graphics processing unit (GPU) is specialized to handle processing of photos, videos, and video game images. It frees the CPU to work on other system demands.

Without a GPU **With a GPU**

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video card needs depends on what you want to display on your monitor. If you work primarily in Microsoft Word and conduct general Web searches, 128 MB is a realistic minimum. For the serious gamer, a 512 MB or greater video card is essential, although cards with as much as 1 or 2 GB are available in the market and are preferred. These high-end video cards, which have greater amounts of memory, allow games to generate smoother animations and more sophisticated shading and texture. Before purchasing new software, check the specifications to ensure your video card has enough video memory to handle the load.

How many video cards can I add to a system? For users who are primarily doing text processing or spreadsheet work, one video card is certainly enough. However, computer gamers and users of high-end visualization software often take advantage of the ability to install more than one video card at a time. Two or even three video cards can be used in one system. The two major video card manufacturers, Nvidia and ATI, have each developed their own standards supporting the combining of multiple video cards. For Nvidia this standard is named SLI and for ATI it is called CrossFire. When the system is running at very high video resolutions, such as 1920 × 1200 or higher, multiple video cards working together provide the ultimate in performance. If you are buying a new system and might be interested in employing multiple video cards, be sure to check whether the motherboard supports SLI or CrossFire.

What else does the video card do? The video card also controls the number of colors your monitor can display. The number of bits the video card uses to represent each pixel (or dot) on the monitor, referred to as **bit depth**, defines the color quality of the image displayed. The more bits, the better an image's color detail. A 4-bit video card displays 16 colors, the minimum number of colors your system works with (referred to as Standard VGA). Most video cards today are 24-bit cards, displaying more than 16 million colors. This mode is called *true color mode* (see Figure 6.30).

Figure 6.30 BIT DEPTH AND COLOR QUALITY

Bit Depth	Color Quality Description	Number of Colors Displayed
4-bit	Standard VGA	16
8-bit	256-color mode	256
16-bit	High color	65,536
24-bit	True color	16,777,216
32-bit	True color	16,777,216 plus 8 bits to help with transparency

The most recent generation of video cards can add some great features to your computer if you are a TV fan. Multimedia cards such as the ATI All-In-Wonder Radeon HD 3650 can open a live TV window on your screen, including features such as picture-in-picture. Using this video card, you can record programs to your hard drive or pause a live TV broadcast. The card even comes with a wireless remote control.

When is it time to get a new video card? If your monitor takes a while to refresh when you are editing photos, surfing the Web, or playing a graphics-rich game, then the video card could be short on memory or the GPU is being taxed to beyond its capacity.

You also may want to upgrade if added features such as television viewing or importing analog video are important to you. If you want to use multiple monitors at the same time, you also may need to upgrade your video card. Working with multiple monitors is a great advantage if you often have more than one application running at a time (see Figure 6.31). ATI has introduced a

Figure 6.31
Cards like the (a) ATI 5870 Eyefinity support (b) six monitors, which can be combined in any way.

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BITS AND BYTES

3D Explosions

Most video games produced since 2007 are now ready to be seen in 3D, but the market of 3D monitors has been slow in coming. Currently, several computer monitors and televisions that support 3D are being released. Most video cards that support at least two monitors are capable of running 3D imagery. Sony PlayStation has updated its firmware to support 3D games and movies. So by adding a 3D monitor, and the snazzy glasses that come along, you can move from two dimensions forward into three!

single card that can support up to six monitors. "Surround sight" allows you to merge all six monitors to work as one screen or to combine them into any subset—for example, displaying a movie on two combined screens, Excel on one monitor, Word on another, and a browser spread across the final two.

Review the considerations listed in Figure 6.32 to see if it might be time for you to upgrade. On a desktop computer, replacing a video card is fairly simple: just insert the new video card in the correct expansion slot on the motherboard.

Evaluating the Audio Subsystem

Computers output sound by means of speakers (or headphones) and a sound card. For many users, a computer's preinstalled speakers and sound card are adequate for the sounds produced by the computer itself—the beeps and so on that the computer makes. However, if you're listening to music, viewing DVDs, hooking into a household stereo system, or playing games with sophisticated sound tracks, you may want to upgrade your speakers or your sound card.

Sound Cards

What does the sound card do? Like a video card, a **sound card**, is an expansion card that attaches to the motherboard inside your system unit. Just as the video card enables your computer to produce images on the monitor, a sound card enables the computer to produce sounds. Most systems have a separate sound card, although low-end computers often have integrated the job of managing sound onto the motherboard itself.

Can I hook up a surround-sound system to my computer? Many computers ship with a basic sound card, which is often a **3D sound card**. The 3D sound technology advances sound reproduction beyond traditional stereo sound (where the human ear perceives sounds as coming from the left or the right of the performance area) and is better at convincing the human ear that sound is omnidirectional, meaning that you can't tell from which direction the sound is coming. This tends to produce a fuller, richer sound than stereo sound. However, 3D sound is not surround sound.

What is surround sound then? **Surround sound** is a type of audio processing that makes the listener experience sound as if it were coming from all directions. The current surround sound standard is from Dolby. There are many formats available, including Dolby Digital EX and Dolby Digital Plus for high-definition audio. Dolby TrueHD is the

Figure 6.32 DO YOU NEED TO UPGRADE YOUR VIDEO CARD?

	Current System	Ideal System
Is my video card able to refresh the screen fast enough for the videos and games I play?		
What is the total amount of video memory on my video card?		
How many monitors can this card support?		
Can I import video through my video card?		
Can I send a cable television signal to my video card?		
Does my video card support the highest quality port for my monitor—DVI? HDMI?		

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ETHICS IN IT

Optical Technology: A Free Lunch—Or at Least a Free Copy

Decades ago, when the electronic photocopier made its debut, book publishers and others who distributed the printed word feared they would be put out of business. They were worried that people would no longer buy books and other printed matter if they could simply copy someone else's original. Years later, when audiocassette and VCR players and recorders arrived on the market, those who felt they would be negatively affected by these new technologies expressed similar concerns. Now, with the arrival of CD-RW, DVD-RW, and BD-RE technology, the music and entertainment industries are worried because users can copy CDs, DVDs, and Blu-ray discs in a matter of minutes.

Although photocopiers and VCRs certainly didn't put an end to the industries they affected, some people still say the music and entertainment industries will take a significant hit with CD-RW, DVD-RW, and BD-RE technology. Industry insiders are claiming that these technologies are unethical, and they're pressing for increased federal legislation against such copying. It's not just the CD-RW, DVD-RW, BD-RE technology that's causing problems, either, because "copies" are not necessarily of the physical sort. Thanks to the Internet, file transfers of copyrighted works—particularly music and films—is now commonplace. According to Music United (**musicunited.org**), more than 243 million files are downloaded illegally every month, and about one-quarter of all Internet users worldwide have downloaded a movie from the Internet.

In a separate survey, the Recording Industry Association of America (RIAA), a trade organization that represents the interests of recording giants such as Sony, Capitol Records, and other major producers of musical entertainment, reported that 23 percent of music fans revealed they were buying less music because they could download it or copy a CD-ROM from a friend.

As you would expect, the music and entertainment industries want to be fairly compensated for their creative output. They blame the technology industry for the creation of means by which artists, studios, and the entertainment industry in general are being "robbed." Although technology that readily allows consumers to transfer and copy music and videos exists, the artists who produce these works do not want to be taken advantage of. However, others claim that the technology industry should not bear the complete burden of protecting entertainment copyrights. The RIAA sums up the future of this debate nicely: "Goals for the new millennium are to work with [the recording] industry and others to enable technologies that open up new opportunities but at the same time to protect the rights of artists and copyright owners."

newest standard. It features high-definition and lossless technology, in which no data is lost in the compression process. To create surround sound, Dolby takes digital sound from a medium (such as a DVD-ROM) and reproduces it in eight channels. Seven channels cover the listening field with placement to the left front, right front, and center of the audio stage, as well as the left rear and right rear, and then two extra side speakers are added, as shown in Figure 6.33. The eighth channel holds extremely low-frequency sound data and is sent to a subwoofer, which can be placed anywhere in the room. To set up surround sound on your computer, you need two things: a set of surround-sound speakers and, for the greatest surround-sound experience, a sound card that is Dolby Digital–compatible.

I don't need surround sound on my computer. Why else might I need to buy an upgraded sound card? Most basic sound cards contain the following input and output jacks (or ports): microphone in, speaker out, and line in. This allows you to hook up a set of stereo speakers and a microphone. But what if you want to hook up a right and left speaker individually, or attach other audio devices to your computer? To do so, you need more ports, which are provided on upgraded sound cards like the one shown in Figure 6.34.

With an upgraded sound card, you can connect portable minidisc players, portable media players, portable jukeboxes, headphones, and CD players to your computer. Musicians also create music on their computers by connecting special devices (such as keyboards) directly to sound card ports. To determine whether your audio subsystem is meeting your needs, review the table in Figure 6.35.

Evaluating System Reliability

Many computer users decide to buy a new system not necessarily because they need a faster CPU, more RAM, or a bigger hard drive, but because they are experiencing problems such as slow performance, freezes, and crashes. Over time, even normal use can cause your computer to build up excess files and to become internally disorganized. This excess, clutter, and disorganization can lead to deteriorating performance or, far worse, system failure. If you think your system is

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Figure 6.33
Dolby Digital 7.1 surround sound gives you better-quality audio output.

unreliable, see if the problem is one you can fix before you buy a new machine. Proper upkeep and maintenance also may postpone an expensive system upgrade or replacement.

What can I do to ensure my system performs reliably? Here are several procedures you can follow to ensure your system performs reliably:

1. **Clean out your Startup folder.** Some programs install themselves into your Startup folder and run automatically each time the computer starts up, whether you are using them or not. This unnecessary load uses up RAM, leaving less for other programs. To minimize this problem, check your Startup folder by clicking Start > All Programs. Then click on the Startup folder and make sure all the programs listed are important to you. Right-click on any unnecessary program and select Delete to remove it from the Startup folder. Make sure you delete *only* programs you are absolutely sure are unnecessary. Another way programs sneak their way in is to load themselves into your system tray. Keep an eye on how many icons are in the system tray and uninstall any that you do not use frequently.
2. **Clear out unnecessary files.** Temporary Internet files can accumulate quickly on your hard drive, taking up unnecessary space. Running the Disk Cleanup utility is a quick and easy way to ensure your temporary Internet files don't take up precious hard drive space. Likewise, you should delete any unnecessary files from your hard drive regularly, because they can make your hard drive run more slowly.
3. **Run spyware and adware removal programs.** These often detect and remove different pests and should be used in addition to your regular antivirus package. You can find more details on how to keep your system safe from spyware, adware, and viruses in Chapter 9.
4. **Run the Disk Defragmenter utility on your hard drive.** When your hard drive becomes fragmented, its storage capacity is negatively affected. When you defragment (defrag) your hard drive, files are reorganized, making the hard drive work more efficiently. For a more complete discussion of the Disk Defragmenter, refer to Chapter 5.

The utilities that need to be run more than once, like Disk Cleanup, Disk Defragmenter, and the antivirus and spyware programs, can be configured to run automatically at any time interval you want. You can set up a sequence of programs to run one after the other every evening while you sleep, and wake up each day to a reliable, secure system.

My system crashes often during the day. What can I do? Computer systems are complex. It's not unusual to have your system stop responding occasionally. If rebooting the computer doesn't help, you'll need to begin troubleshooting:

1. Check that you have enough RAM, which you learned how to do in the section "Evaluating RAM: The Memory Subsystem" earlier in this chapter.

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Systems with insufficient amounts of RAM often crash.

2. Make sure you have properly installed any new software or hardware. If you're using a Windows system, use the System Restore utility to "roll back" the system to a time when it worked more reliably. (To find System Restore, just type "restore" into the Start menu search box.) For Mac systems, Mac OS X Time Machine, shown in Figure 6.36, provides automatic backup and enables you to look through and restore (if necessary) files, folders, libraries, or the entire system.
3. If you see an error code in Windows, visit the Microsoft Knowledge Base (**support.microsoft.com**), an online resource for resolving problems with Microsoft products. This may help you determine what the error code indicates and how you may be able to solve the problem. If you don't find a satisfactory answer in the Knowledge Base, try copying the entire error message into Google and searching the larger community for solutions.

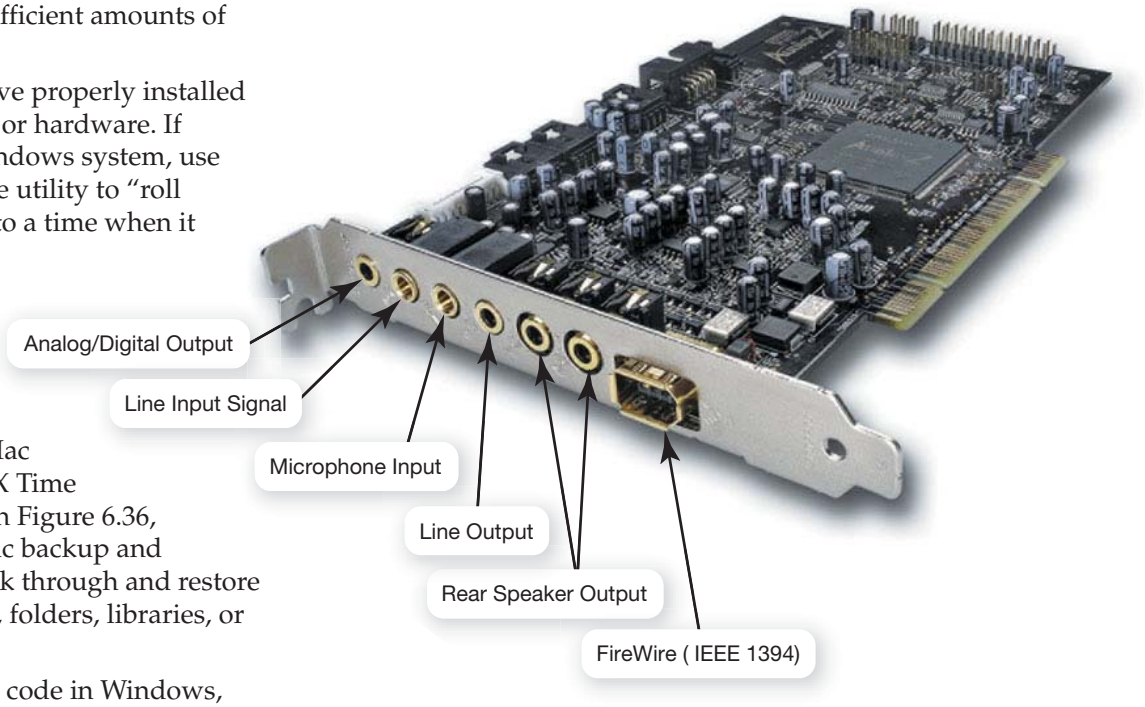

Figure 6.34
In addition to improving sound quality, upgraded sound cards can provide additional ports for your audio equipment.

Can my software affect system reliability? Having the latest version of software products makes your system much more reliable. You should upgrade or update your operating system, browser software, and application software as often as new patches (or updates) are reported for resolving errors. Sometimes these errors are performance-related; sometimes they are potential system security breaches.

If you are having a problem that can be replicated, use the Problem Steps Recorder to capture the exact steps that lead to it. In Windows 7, go to the Start menu and search for "psr." Run the Problem Steps Recorder and go through the exact actions that create the problem you are having. At any particular step, you can click the Annotate button and add a comment about any part of the screen. PSR then produces a documented report, complete with images of your screen and descriptions of each mouse movement you made. You can then e-mail this report, which is compressed in the WinZip format, to customer support to help technicians resolve the problem.

How do I know whether updates are available for my software? You can configure Windows so that it automatically checks for, downloads, and installs any available updates for itself, Internet Explorer, and other Microsoft applications such as Microsoft Office. Many other applications now also include the ability to check

Figure 6.35 | DO YOU NEED TO UPGRADE YOUR AUDIO SUBSYSTEM?

	Current System	Ideal System
Is the speaker quality high enough for the way I am using my computer?		
Is my sound card capable of 3D sound?		
Does my sound card support Dolby Digital surround sound?		
Do I have 5.1-channel surround sound or 7.1-channel surround sound?		
Do I have an HDMI port on the audio card?		

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Figure 6.36
Mac's Time Machine restores files, folders, libraries and, if necessary, the entire system.

for updates. Check under the Help menu of the product, and often you will find a Check for Updates command.

What if none of this helps? Is buying a new system my only option? If your system is still unreliable after these changes, then you have two options:

1. **Upgrade your operating system to the latest version.** There are substantial increases in reliability with each major release of a new operating system. However, upgrading the operating system may require hardware upgrades such as additional RAM, an updated graphics processor, and an even larger hard drive. The Microsoft Windows 7 Upgrade Advisor (a free download from (**microsoft.com**) will scan your system to determine what upgrades might be required before you convert to Windows 7. Be sure to examine the *recommended* (not required) specifications of the new operating system.
2. **Reinstall the operating system.** As a last resort, you might need to reinstall the operating system. To do so, you'll want to back up all of your data files before the installation and be prepared to reinstall all your software after the installation. Make sure you have all of the original discs for the software installed on your system, along with the product keys, serial numbers, and any other activation codes so that you can reinstall them.

Making the Final Decision

Now that you have evaluated your computer system, you need to shift to questions of *value*. How closely does your system come to meeting your needs? How much would it cost to upgrade the system you have to match what you'd ideally like your computer to do, not only today but also a few years from now? How much would it cost to purchase a new system that meets these specifications?

To decide whether upgrading or buying a new system has better value for you, you need to price both scenarios. Figure 6.37

Figure 6.37 UPGRADE/NEW PURCHASE COMPARISON WORKSHEET

Needs	Hardware Upgrade Cost	Included on New System?	Additional Expense If Not Included on New System
CPU and Memory Subsystems			
CPU upgrade			
RAM upgrade			
Storage Subsystem			
Hard drive upgrade			
SSD drive			
DVD+/-RW burner			
Blu-ray burner			
Video and Audio Subsystems			
Video card upgrade			
Sound card upgrade			

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TRENDS IN IT

Computers in Society: How to Donate Your Old Computer Safely

What happened to your last computer? If you threw it away hoping it would be safely recycled with your empty water bottles, think again. Mercury in LCD screens, cadmium in batteries and circuit boards, and flame retardant in plastic housings all are toxic. An alarming, emerging trend is that discarded machines are beginning to create an e-waste crisis.

Instead of throwing your computer away, you may be able to donate it to a nonprofit organization. Many manufacturers, such as Dell, offer recycling programs and have formed alliances with nonprofit organizations to help distribute your old technology to those who need it. Sites like Computers With Causes (**computerswithcauses.org**) organize donations of both working and nonworking computers, printers, and mice. You can also take your computer to an authorized computer recycling center in your area (see Figure 6.38). The Telecommunications Industry Association provides an e-cycling information site you can use to find a local e-cycling center (**eiae.org**).

However, before donating or recycling a computer, make sure you carefully remove all data from your hard drive, or you may end up having your good deed turn bad by becoming the victim of identity theft. Credit card numbers, bank information, Social Security numbers, tax records, passwords, and personal identification numbers (PINs) are just some of the types of sensitive information that we casually record to our computers' hard drives. Just deleting files that contain proprietary personal information is not protection enough. Likewise, reformatting or erasing your hard drive does not totally remove data, as was proved by two MIT graduate students. In 2003, they bought more than 150 used hard drives from various sources. Although some of the hard drives had been reformatted or damaged so the data was supposedly irrecoverable, the two students were able to retrieve medical records, financial information, pornography, personal e-mails, and more than 5,000 credit card numbers!

The U.S. Department of Defense suggests a seven-layer overwrite for a "secure erase." In other words, they suggest that you fill your hard drive *seven times over* with a random series of 1s and 0s. Fortunately, several programs exist for PCs running Windows, such as Active@ Kill Disk, Eraser, and CyberScrub. Wipe is available for Linux, and ShredIt X can be used for OS X. These programs provide secure hard drive erasures, either of specific files on your hard drive or of the entire hard drive.

Keep in mind that even these data erasure programs can't provide the ultimate level in security. Computer forensic specialists or supercybercriminals can still manage to retrieve some data from your hard drive if they have the right tools. The ultimate level of protection comes from destroying the hard drive altogether. Suggested methods include drilling holes in the hard drive, burning or melting it, or just taking an old-fashioned sledgehammer to it! For large companies that need to upgrade large quantities of computers and have the options of destroying or recycling their old computers, the problem becomes much worse. In these cases, recycling isn't a good option, and throwing the computers away can create an environmental hazard. Companies such as GigaBiter (**gigabiter.com**) eliminate security and environmental risks associated with electronic destruction by first delaminating the hard drive and then breaking down the computer e-waste into recyclable products. The result of the final step is a sandlike substance that is 100 percent recyclable.

Figure 6.38

An electronics scrap recycler "demanufactures" printers, computers, and other electronics and then resells the usable parts.

provides an upgrade worksheet you can use to evaluate both the upgrade path and the new purchase path. Be sure to consider what benefit you might obtain by having two systems if you were to buy a new computer. Would you have a use for the older system? Would you donate it to a charitable organization? Would you be able to give it to a family member? Purchasing a new system is an important investment of your resources, and you want to make a well-reasoned, well-supported decision.

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chapter six

summary

1. How can I determine whether I should upgrade my existing computer or buy a new one?

To determine whether you need to upgrade your system or purchase a new one, you need to define your ideal system and what you want it to do. Then you need to perform a system evaluation to assess the subsystems in your computer, including the CPU, memory, storage, video, and audio. Finally, you need to determine if it's economical to upgrade, or whether buying a new computer would be better.

2. What does the CPU do, and how can I evaluate its performance?

Your computer's CPU processes instructions, performs calculations, manages the flow of information through the computer system, and is responsible for processing the data you input into information. CPU speed is measured in gigahertz (billions of machine cycles per second). You can tell whether your CPU is limiting your system performance by watching how busy it is as you work on your computer. The percentage of time that your CPU is working is referred to as CPU usage, which you can determine by checking the Task Manager. Benchmarking software offers direct performance comparisons of different CPUs.

3. How does memory work in my computer, and how can I evaluate how much memory I need?

RAM is your computer's temporary memory. It remembers everything that the computer needs to process data into information. However, it is an example of volatile storage. When the power is off, the data stored in RAM is cleared out. The amount of RAM sitting on memory modules in your computer is your computer's physical memory. The memory your OS uses is kernel memory. At a minimum, you need enough RAM to run the OS plus the software applications you're using, plus a bit more to hold the data you will input.

4. What are the computer's main storage devices, and how can I evaluate whether they match my needs?

Storage devices for a typical computer system may include a hard drive, an SSD drive, a flash drive, and CD and DVD drives. Blu-ray drives are gaining in popularity for viewing and burning high-density media. When you turn off your computer, the data stored in these devices remains. These devices are referred to as *nonvolatile* storage devices. Hard drives have the largest storage capacity of any storage device and are the most economical. Newer SSD drives have the fastest access time and data transfer rate of all nonvolatile storage options. CDs and DVDs have capacities from 700 MB to 17 GB, while Blu-ray discs can hold up to 50 GB. Portable flash drives allow easy transfer of 64 GB or more of data from machine to machine. To determine the storage capacity your system needs, calculate the amount of storage your software needs to reside on your computer. To add more storage or to provide more functionality for your system, you can install additional drives, either internally or externally.

5. What components affect the output of video on my computer, and how can I evaluate whether they match my needs?

How video is displayed depends on two components: your video card and your monitor. A video card translates binary data into the images you see. These cards include their own RAM (video memory) as well as ports that allow you to connect to video equipment. The amount of video memory you need depends on what you want to display on the monitor. A more powerful card will allow you to play graphics-intense games and multimedia.

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6. What components affect the quality of sound on my computer, and how can I evaluate whether they match my needs?

Your computer's sound depends on your speakers and sound card. A sound card enables the computer to produce sounds. Users upgrade their sound cards to provide for 3D sound, surround sound, and additional ports for audio equipment.

7. How can I improve the reliability of my system?

Many computer users decide to buy a new system because they are experiencing problems with their computer. However, before you buy a new system because you think yours may be unreliable, make sure the problem is not one you can fix. Run a full scan with antispyware software. Make sure you have installed any new software or hardware properly, check that you have enough RAM, run system utilities such as Disk Defragmenter and Disk Cleanup, clean out your Startup folder, remove unnecessary files from your system, and keep your software updated with patches. If you continue to have troubles with your system, reinstall or upgrade your OS, and, of course, seek technical assistance.

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chapter six

key terms

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Word Bank

- access time
- Blu-ray disc
- cache memory
- CPU usage
- data transfer rate
- eSATA
- express cards
- front side bus
- GPU
- hard drive
- memory module
- Moore's law
- RAM
- sound card
- SSD
- surround sound
- system evaluation

Instructions: Fill in the blanks using the words from the Word Bank above.

Joe already has a PC but just heard about a great deal on a new one. He decides to perform a(n) (1) _____ on his computer to see whether he should keep it or buy the new one. First, he runs the Task Manager in Windows. By doing so, he can check the history of (2) _____ as he works through his day. Because he is often over 90 percent, he begins to suspect his system is suffering from too little (3) _____. He has room for an additional two (4) _____ on his motherboard. Adding memory is something he learned how to do this semester, but would that be enough to make this machine do all he needs?

He visits the Intel Web site to check two other important factors on his model of CPU: the amount of (5) _____ memory and the speed of the (6) _____. It looks like the newer i7 processor would be much faster overall. It seems each generation of processors is so much faster than the last. That rule, (7) _____, is still holding true!

He continues to evaluate his system by checking out which components he has and which ones he'll need. He notes the storage capacity of the (8) _____. Recently, he has been wishing his system had a(n) (9) _____ port because adding an external hard drive would give him enough space to start to record HD television shows. As it is, he is running out of space to store files. But the (10) _____, or the amount of time it takes to retrieve data from the disk drive, on any mechanical drive is slow compared to the (11) _____ in the new computer he's eyeing, which has no moving parts at all. Joe also notes that he is unable to do a complete backup of his music library onto optical media now that he has 40 GB of music data. His current system can't burn a (12) _____, but the new system could. The new video card would also include several (13) _____ ports so that six digital monitors can be connected simultaneously. It would be great if he could take advantage of the 5.1 (14) _____ that is on the soundtrack of most of the movies he watches on DVD.

He also has a lot of friends who play video games on their computer systems. However, his current system doesn't meet the minimum requirements for a video card. Newer cards have blindingly fast (15) _____, and some cards even have multiple processors. Overall, with prices dropping, it seems like time to go buy that new system!

Rebecca has already built five or six PCs and tells you she can make a killer desktop system for you for under $1,300. But you do love the idea of having a light, compact notebook computer that could travel with you around campus and back and forth to work.

Instructions: Using the preceding scenario, write an e-mail to Rebecca describing to her what you need in your new system. Examine the specifications for both notebook and desktop systems in this price range and decide which one is best suited to you. Use key terms from the chapter and be sure your sentences are grammatically correct and technically meaningful.

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chapter six

self-test

Instructions: Answer the multiple-choice and true–false questions below for more practice with key terms and concepts from this chapter.

Multiple Choice

1. Which statement about notebook computers is FALSE?
   a. Notebooks typically have a longer lifespan.
   b. Notebooks are typically less reliable.
   c. Notebooks can be docked to larger monitors.
   d. Notebook are more difficult to expand or upgrade.
2. ROM is classified as what type of storage?
   a. Volatile c. Flash
   b. Nonvolatile d. Cache
3. To document a problem you are having, you can use
   a. Disk Cleanup.
   b. Problem Step Recorder.
   c. PC DeCrapifier.
   d. Resource Monitor.
4. If you want your system to run reliably, you should
   a. delete all programs from the Startup folder.
   b. save all of your temporary Internet files.
   c. install programs in the system tray.
   d. defragment the hard drive.
5. Which bests describes RAID 0 technology?
   a. Saved data is spread across two hard drives.
   b. Data is written to one drive and mirrored to a second drive.
   c. RAID 0 allows you to store twice the data.
   d. RAID 0 provides an instant backup of your work.
6. What allows two different programs to be processed at one time?
   a. Hyperthreading
   b. SSD
   c. Benchmarking
   d. GPU
7. Which is *not* a type of memory stored in your system?
   a. RAM
   b. Cache
   c. CPU register
   d. ALU
8. The optimal amount of memory for a video card depends on
   a. the quality of video you will be watching.
   b. the resolution of the monitor.
   c. the number of monitors you have.
   d. All of the above.
9. SuperFetch is a memory-management technique that
   a. determines the type of RAM your system requires.
   b. makes the boot-up time for the system very quick.
   c. preloads the applications you use most into system memory.
   d. defragments the hard drive to increase performance.
10. What is the name for the time it takes a storage device to locate its stored data and make it available for processing?
    a. Clock speed
    b. Access time
    c. Data transfer rate
    d. Seek time

True–False

_____ 1. A single CPU can have multiple cores but cannot also use hyperthreading.

_____ 2. The memory that your operating system uses is referred to as kernel memory.

_____ 3. Motherboards are designed with a specific number of memory card slots.

_____ 4. Cache memory is a form of read-only memory that can be accessed more quickly by the CPU.

_____ 5. Solid state drives are faster than hard drives and eSATA drives.

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making the transition to... next semester

1. Personalize Your System

Likely you spend many hours each day working on your computer using it for school, work, communication, research, and entertainment. Your computer should be a device that fits you, fits your needs, and expresses who you are.

a. Begin with the computer's form. Would you select a notebook or a desktop? What features determine that decision?
b. Next consider performance. Which type of CPU do you need? How much RAM should be installed? What kind of hard drive storage would you select? Give specific price-to-value arguments for each decision.
c. Now consider expandability. If you need this system to last for four years, what kind of ports and expansion capability are necessary?
d. Finally, consider style. What components or design decisions can you make so that this system uniquely suits you and represents you?

2. Desktop Replacement

The line between the capabilities of a desktop system and a powerful notebook have become more and more blurred with the arrival of "desktop replacement" systems. These systems often have 17-inch, 18-inch, or larger monitors, weigh 10 pounds or more, and have a battery life of less than two hours. Research the most current entries in the "desktop replacement" category and evaluate them. What kind of user would find this an ideal solution? Do you anticipate this category of computer becoming more popular?

3. Go Small or Stay Home

Manufacturers are releasing a number of systems that are trying to capitalize on size—or the lack of size! Explore some of the small form factor (SFF) computers appearing on the market.

a. Research the Falcon NorthWest FragBox (falcon-nw.com).
b. Examine the Apple MacMini (apple.com).
c. Compare those systems with the Dell Zino HD (dell.com).

Why are these SFF computers appearing? What role do you see these systems fulfilling? What kind of performance and hardware would you recommend for such a system?

4. Do-It-Yourself Computer Design

Visit NewEgg (**newegg.com**) and do a search on "do it yourself". You will find that NewEgg has created a number of bundles, which are a set of components that cover the categories outlined in this chapter: the computer case, processor, RAM, storage, video, and audio.

a. Which system looks like the best match for your needs for school next semester? Why?
b. What is the price difference between building the system and purchasing a similar unit from a major manufacturer?
c. What skills would you need before you could assemble the computer yourself?
d. What additional components (hardware and software) would you need to complete the system?
e. What kind of support exists to train you in these skills or to help with questions you might have along the way?

5. How Does Your System Measure Up?

A number of tools are available to measure your system's performance. Explore the following tools and use one to gather data on your current system's performance.

a. Windows 7 Gadgets: Visit the Windows 7 Personalization Gallery (**windows.microsoft.com**) and find gadgets to help you monitor system performance.
b. Windows 7 Resource Monitor: Use the Resource Monitor to collect data on CPU utilization and memory usage over a typical school day.
c. Benchmarking suites: Examine a sample of consumer benchmarking programs like the PassMark's PerformanceTest, Primate Lab's Geekbench, and Maxon's Cinebench. Which subsystems do each of these products evaluate? How do they present their results? Which seems easiest to use?

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making the transition to... the workplace

1. In the "Real World"

As you move from an educational environment to a business environment, how you use your computer will inevitably change. Write a description of your ideal computer system for school and for once you are in the workforce. Defend the position you take with information covered in this chapter. To help you in your decision, fill out the worksheet, similar to Figure 6.2, that is available on the book's companion Website (**pearsonhighered.com/techinaction**).

2. Judging System Performance

As you learned in this chapter, the Resource Monitor provides a detailed breakdown of how the computer is using memory at any given time.

a. Open the Resource Monitor, move to the CPU tab, and open the Processes frame. What is your total CPU Usage? How many "virtual" CPUs does your machine have? Clicking on any of the column titles sorts that column, so clicking the Average CPU column shows you the applications currently using most of the CPU resources. What are the top two most intensive applications?
b. Move to the Memory tab. How much memory is in use? How much is available? Of the memory available, how much has been preloaded with data and files that Windows "thinks" you will need soon?
c. Move to the Disk tab. Click on the Processes With Disk Activity panel. Which programs are making the greatest total demand to read and write to the disk?

3. My Mother(board)

This chapter discussed the qualities of a CPU that are important to consider for system performance. Now examine the features of a motherboard that are critical to the performance and expandability of a system. Visit NewEgg (**newegg.com**) and search for "Intel Motherboards"; then sort by "Best Rated".

a. Which model has the best reviews?
b. How many ports and what type of ports does it have?
c. What kind of CPU does it support?
d. What kind of memory does it use, and what is the maximum memory it supports?
e. How many hard drives can it run? Does it support both RAID 0 and RAID 1?
f. Does it have integrated video? Audio?

4. Room to Move

You are responsible for specifying the storage solution for an accounting customer's computer system. Your customer needs to always have redundancy—that is, multiple copies of the work they are doing—because of the secure nature of the records they keep and the length of time they are required to keep records. Prepare a report that describes the type of hard drive and optical storage you would recommend. Be sure to include performance specifications and price. Devise a list of additional questions you would need to ask your customer to be sure they have a system that meets their expectations.

5. A Picture Is Worth a Thousand Words

You work in a financial analysis firm. It is necessary to watch small fluctuations in many different international monetary funds and markets each day. This data is then fed into your own prediction software, tied to Excel calculations, and then plotted with three different statistical analysis packages. What video solution would be ideal for this environment? Would it require a video card with a single or dual GPU? Multiple video cards? Multiple monitors?

6. Let Me Tell You My Problem

You may be responsible for helping others solve various computer problems. Test out the Problem Steps Recorder in Windows 7 to see how the program can help you help them. Click the Start button and search for "psr". Run the program and click Record. Then just click between different applications, visit the Control Panel, and add an annotation. Save the file to your desktop and close the Problem Steps Recorder. View the annotated report. How could you use the Problem Steps Recorder to describe a problem or to gather information?

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Instructions: Albert Einstein used *Gedankenexperiments*, or critical thinking questions, to develop his theory of relativity. Some ideas are best understood by experimenting with them in our own minds. The following critical thinking questions are designed to demand your full attention but require only a comfortable chair—no technology.

1. And Google Says...

In a presentation in Dublin, Ireland in March 2010, Google sales chief Jim Haley stated that desktops would be irrelevant in three years (**SiliconRepublic.com**). Smartphones, notebooks, and the amount of information available online will converge to create a different kind of future than what we've known, according to Haley. Do you agree? Why or why not? What impact would that have on the types of hardware and software that are the most in demand?

2. Emerging Technologies

Touchscreens are now available in a range of sizes, from smartphones to iPads to larger products like the Microsoft Surface. Windows 7 has integrated support for touchscreens. "Surround Sight" and 3D monitors are available in increasing numbers. What new technologies will last and become part of our collective experience? How will these technologies and devices change entertainment and how people interact with information? What future technologies that would be on your wish list?

3. The Early Adopter

We are all aware of the technology price curve: when first introduced, products have the highest prices and the most instability. As these products settle into the market, they become more reliable and the price falls, sometimes very quickly. People who make those first release purchases are called *early adopters*. What are the advantages to being an early adopter? What are the disadvantages? How do you decide at what point you should step into the technology price curve for any given product?

4. A Green Machine

Review the impacts of your computer during its entire lifecycle. How do the production, transportation, and use of the computer impact the increase of greenhouse gas emissions? How does the selection of materials and packaging impact the environment? What restricted substances (like lead, mercury, cadmium, and PVC) are found in your machine? Could substitute materials be used? How would the ultimate "Green Machine" be designed?

5. System Longevity

If you purchase a computer system for business purposes, the Internal Revenue Service (IRS) allows you to depreciate its cost over five years. The IRS considers this a reasonable estimate of the useful lifetime of a computer system. What do you think most home users expect in terms of how long their computer systems should last? How does the purchase of a computer system compare with other major household appliances in terms of cost, value, benefit, life span, and upgrade potential?

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chapter six

team time

Many Different Computers for Many Different Needs

Problem

Even within one discipline, there are needs for a variety of types of computing solutions. Consider the Communications department in a large university. Because it is such an interdisciplinary area, there are some groups involved in video production, some groups producing digital music, and some groups responsible for creating scripts and screenplays. The department as a whole needs to decide on a complete computing strategy.

Process

Split your class into teams.

1. Select one segment of the Communications department that your team will represent: video production, digital music, or scripting. The video production team requires their labs to be able to support the recording, editing, and final production and distribution of digital video. The digital music group wants to establish a collegiate recording studio (in the model of the Drexel University recording label, Mad Dragon Records). The scripting group needs to support a collaborative community of writers and voice-over actors.
2. Analyze the computing needs of that division, with particular focus on how they need to outfit their computer labs.
3. Price the systems you would recommend and explain how they will be used. What decisions have you made to guarantee they will still be useful in three years?
4. Write a report that summarizes your findings. Document the resources you used and generate as much enthusiasm as you can for your recommendations.

Conclusion

The range of available computing solutions has never been so broad. It can be a cause of confusion for those not educated in technology. But with a firm understanding of the basic subsystems of computers, it is precisely the pace of change that is exciting. Being able to evaluate a computer system and match it to the current needs of its users is an important skill.

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In this exercise, you will research and then role-play a complicated ethical situation. The role you play might or might not match your own personal beliefs; in either case, your research and use of logic will enable you to represent the view assigned. An arbitrator will watch and comment on both sides of the arguments, and together the team will agree on an ethical solution.

Topic: Light Peak

We have seen many dramatic increases in connectivity speed. The USB standard is now in its third revision, with each being many fold faster than its predecessor. Currently, Intel is developing a technology named Light Peak that could replace all of the cables you currently see dangling from computers with one fiber-optic cable—one very fast fiber-optic cable. This technology will allow for smaller notebook computer designs, because they won't need to have a huge set of ports along the side. Intel feels Light Peak could become the universal port, replacing USB, HDMI, FireWire, DVI, and others. And using Light Peak, an entire high-definition movie could be transferred in 30 seconds.

Research Areas to Consider

- Durability of fiber-optic cables for consumers
- Protection of intellectual content as transfer speeds increase
- Building consensus in the market for new technologies
- 2009 Nobel Prize for Physics

Process

Divide the class into teams.

1. Research the areas cited above from the perspective of either an Intel engineer working on Light Peak, a notebook designer, a producer of high-definition videos, or an arbitrator.
2. Team members should write a summary that provides factual documentation for the positions and views their character takes around the issue of increasingly high speed data transfer and intellectual property rights. Then, team members should create an outline to use during the role-playing event.
3. Team members should arrange a mutually convenient time to meet for the exchange, either using the chat room feature of MyITLab, the discussion board feature of Blackboard, or meeting in person.
4. Team members should present their case to the class, or submit a PowerPoint presentation for review by the rest of the class, along with the summary and resolution they developed.

Conclusion

As technology becomes ever more prevalent and integrated into our lives, more and more ethical dilemmas will present themselves. Being able to understand and evaluate both sides of the argument, while responding in a personally or socially ethical manner, will be an important skill.

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