# 5 System Software: The Operating System, Utility Programs, and File Management

## Understanding System Software

### Operating System Fundamentals


OBJECTIVES

1. What software is included in system software? **(p. 160)**
2. What are the different kinds of operating systems? **(pp. 160–163)**
3. What are the most common operating systems? **(pp. 162–165)**

**Sound Byte:** Customizing Windows

### What the Operating System Does

OBJECTIVES

4. How does the operating system provide a means for users to interact with the computer? **(p. 166)**
5. How does the operating system help manage resources such as the processor, memory, storage, hardware, and peripheral devices? **(pp. 167–171)**
6. How does the operating system interact with application software? **(p. 171)**

### The Boot Process: Starting Your Computer

OBJECTIVE

7. How does the operating system help the computer start up? **(pp. 172–174)**

**Active Helpdesk:** Starting the Computer: The Boot Process

## Using System Software

### The Windows Interface


OBJECTIVE

8. What are the main features of the Windows interface? **(pp. 178–183)**

### Organizing Your Computer: File Management

OBJECTIVE

9. How does the operating system help me keep my computer organized? **(pp. 184–188)**

**Sound Byte:** File Management

**Active Helpdesk:** Organizing Your Computer: File Management

### Utility Programs

OBJECTIVE

10. What utility programs are included in system software and what do they do? **(pp. 189–195)**

**Active Helpdesk:** Using Utility Programs

**Sound Byte:** File Compression

**Sound Byte:** Hard Disk Anatomy

**Sound Byte:** Letting Your Computer Clean Up After Itself

**Make This:** Explore an App Builder Skill on **page 177**

The information in this text is written for Windows 8.1, Update 2. If you are still running a different version of Windows 8, your screens and task instructions may vary slightly.

For all media in this chapter go to **pearsonhighered.com/techinaction** or **MyITLab**.

*(Mary Anne Poatsy; Ferenc Szelepcsenyi/Shutterstock; Revers/Shutterstock; Stanislav Popov/Shutterstock; Reji/Fotolia)*

## Solve This

MyITLab® grader

# Analyzing Benchmark Data

You work for a design firm that uses many of the software applications in the Adobe Creative Suite, especially Photoshop, Illustrator, and InDesign. You have been asked to evaluate whether it would be worthwhile to upgrade the software to the latest version. In addition to reviewing any new or revised features, you also want to provide an analysis on any improvements in product efficiency and performance, so you have repeated doing the same skills with the current and new data and have recorded the results. Now you just need to analyze it.

| You will use the following skills as you complete this activity: | |
|---|---|
| • AutoFill Data | • Align and Wrap Text |
| • Insert AVERAGE Function | • Apply Conditional Formatting |
| • Add Borders | • Create Bar Chart |

## Instructions:

1. Open *TIA_Ch4_Start* and save as **TIA_Ch4_LastFirst**.
2. In cell F1, enter **Current Average**, and in cell J1 enter **New Average**
3. In cell F2, use the AVERAGE function to compute the average of the range C2:E2. In cell J2, use the AVERAGE function to compute the average of the range G2:I2.
4. Select cell F2, then drag the Fill Handle to cell F13. Select cell J2, then drag the Fill Handle to cell J13.
5. Select the cells in C2:J13, then format the cell contents with Number format with one decimal.
6. Select cell A2, and Merge and Center across cells A2:A5. Then adjust the orientation of the text to Rotate Text Up (90 degrees). Middle Align cell contents and Bold text.
7. Use Format Painter to copy these formats to cell A6 and cell A10.
8. Select range A2:J5, then apply Thick Box Border. Repeat with ranges A6:J9 and A10:J13.
9. Select range F1:F13, then apply Thick Box Border. Repeat with range J1:J13.
10. Select J2:J13, then apply a Conditional Format that will format cells that are Less Than those cells in range F2:F13 with Green Fill and Dark Green Text.
    a. Hint: In the Format cells that are LESS THAN box enter =F2 (*not* $F$2). The rest of the cells in the range will update automatically.
11. Create a Clustered Bar Chart using ranges B1:B13, F1:F13, J1:J13.
    a. Hint: Hold down the CTRL button as you select ranges F1:F13 and J1:J13.
12. Modify the Clustered Bar Chart with a title "Benchmark Comparison: New and Current Versions of CS Software", add a title to the Horizontal Axis that reads "Seconds". Position and resize chart so it fits A16:J34.
13. Save the workbook, and submit based on your instructor's directions.


# HOW COOL IS THIS?

Thought watches were going the way of the dinosaurs? Think again! Fumbling for your smartphone in your pocket is so yesterday. **Android Wear smartwatches** are the wave of the future. Android Wear devices aim to **simplify your life** by freeing up your hands and allowing you to make more face-to-face contact with your friends. Running to board your flight with your hands full of carryon luggage? **Your watch can flash a QR code** to the boarding attendant. Need some quick info? **OK Google is on your watch,** so just say "Ok Google, what's the score in the Villanova game?" and you'll have the answer. Always forgetting your phone when you run (or wondering where to put it)? Your smartwatch is always on your wrist so it can **host apps that are constantly monitoring your physical activity.** So leave that phone in your pocket—Android Wear has you covered! *(Koya979/Fotolia; Google, Inc.)*

Scan here for more info

# Understanding System Software

As discussed in the previous chapter, your computer uses two basic types of software: application software and system software. **Application software** is the software you use to do everyday tasks at home and at work. **System software** is the set of programs that helps run the computer and coordinates instructions between application software and the computer's hardware devices. From the moment you turn on your computer to the time you shut it down, you're interacting with system software.


## operating system FUNDAMENTALS

System software consists of two primary types of programs: the *operating system* and *utility programs*. The **operating system (OS)** is a group of programs that controls how your computer functions. The OS:

- Manages the computer's hardware, including the processor, memory, and storage devices, as well as peripheral devices such as the printer;
- Provides a consistent means for application software to work with the central processing unit (CPU); and
- Is responsible for the management, scheduling, and coordination of tasks

You interact with your OS through the **user interface**—the *desktop, icons,* and *menus* that let you communicate with your computer.

A **utility program** is a small program that performs many of the general housekeeping tasks for your computer, such as system maintenance and file compression. A set of utility programs is bundled with each OS, but you can also buy standalone utility programs that often provide more features.

**Do all computers have operating systems?** Every computer, from the smallest laptop to the largest supercomputer, has an OS. Even cell phones, game consoles, cars, and some appliances have operating systems. The role of the OS is critical; the computer can't operate without it.

**Are all operating systems alike?** You're probably familiar with Microsoft Windows, Apple OS X, and perhaps the Android operating system if it's on your phone, but many other operating systems exist. Laptops, tablet computers, and smartphones all need specific operating systems designed to take advantage of their unique characteristics. However, as devices begin to converge in terms of functionality, and operating systems continue to become more powerful, developers such as Microsoft and Apple are making operating systems that have similar functionality (such as OS X and iOS) or single operating systems (such as Windows 8) that can run on multiple devices. Figure 5.1 lists a number of common operating systems.

When operating systems were originally developed, they were designed for a single user performing one task at a time

FIGURE 5.1

**Common Operating Systems**

| OS NAME | DEVELOPED BY | AVAILABLE ON |
|---|---|---|
| **Windows**   | Microsoft | Laptops, tablets, desktops, all-in-ones, cell phones |
| **OS X**  | Apple | Laptops, desktops, all-in-ones |
| **iOS**   | Apple | Tablets, iPhones, iPod Touches |
| **Android**  | Google | Cell phones, tablets |
| **Linux**  | Open source | Laptops, desktops |

(that is, they were *single-user, single-task operating systems*). However, modern operating systems allow a single user to **multitask**—to perform more than one process at a time. And operating systems such as Windows and OS X provide networking capabilities as well, essentially making them *multiuser, multitasking operating systems*.

Operating systems can be categorized by the type of device in which they're installed, such as robots and specialized equipment with built-in computers, mainframes and network computers, mobile devices, and personal computers. Next, we'll look at these different types of operating systems.

## Real-Time Operating Systems

**Why do machines with built-in computers need an OS?** Machinery that performs a repetitive series of specific tasks in an exact amount of time requires a **real-time operating system (RTOS)**. Also referred to as *embedded systems,* RTOSs require minimal user interaction. This type of OS is a program with a specific purpose, and it must guarantee certain response times for particular computing tasks; otherwise, the machine is useless. The programs are written specifically for the needs of the devices and their functions. Therefore, there are no commercially available standard RTOS software programs. Devices that must perform regimented tasks or record precise results—such as measurement instruments found in the scientific, defense, and aerospace industries—require RTOSs. Examples include digital storage oscilloscopes and the Mars Reconnaissance Orbiter.

**Where else are RTOSs used today?** You also encounter RTOSs every day in devices such as fuel-injection systems in car engines, automobile "infotainment" systems, and some common appliances. RTOSs are also found in many types of robotic equipment. Television stations use robotic cameras with RTOSs that glide across a suspended cable system to record sports events from many angles (see Figure 5.2).

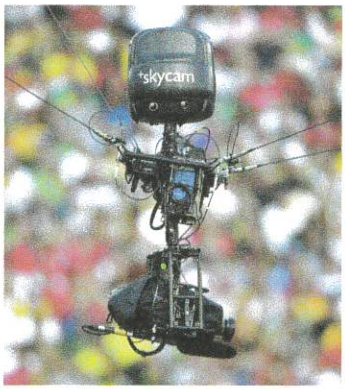



**FIGURE 5.2** Devices such as TV sky cameras, cars, and medical equipment use RTOSs. *(John Pyle/Cal Sport Media/Newscom; Mark Gail/The Washington Post/Getty Images; David Elfstrom/Getty Images)*

## Operating Systems for Networks, Servers, and Mainframes

**What kind of operating systems do networks use?** A **multiuser operating system** (or **network operating system**) lets more than one user access the computer system at a time by handling and prioritizing requests from multiple users. Networks (groups of computers connected to each other so that they can communicate and share resources) need a multiuser OS because many users simultaneously access the server (the computer that manages network resources such as printing and communications). The latest versions of Windows and OS X can be considered network operating systems: They enable users to set up basic networks in their homes and small businesses.

In larger networks, a more robust network OS is installed on servers and manages all user requests. For example, on a network where users share a printer, the network OS ensures that the printer prints only one document at a time in the order the requests were made. Examples of network operating systems include Windows Server, Linux, and UNIX.

**What is UNIX? UNIX** is a multiuser, multitasking OS that is used as a network OS, although it can also be found on PCs. Developed in 1969 by Ken Thompson and Dennis Ritchie of AT&T's Bell Labs, the UNIX code was initially not proprietary—in other words, no company owned it. Rather, any programmer was allowed to use the code and modify it to meet his or her needs. UNIX is now a brand that belongs to the company The Open Group, but any vendor that meets testing requirements and pays a fee can use the UNIX name. Individual vendors then modify the UNIX code to run specifically on their hardware.

**What other kinds of computers require a multiuser OS?** Mainframes and supercomputers also require multiuser operating systems. Mainframes routinely support hundreds or

thousands of users at time, and supercomputers are often accessed by multiple people working on complex calculations. Examples of mainframe operating systems include UNIX, Linux on System z, and IBM's z/OS, whereas the vast majority of supercomputers use Linux.

## Operating Systems for Mobile Devices

**What kind of OS does a smartphone use?** Figure 5.3 shows the most common operating systems found on smartphones such as the iPhone. Most smartphones have at least modest multitasking capabilities, such as letting you check e-mail while you're on a phone call. More advanced smartphones provide greater multitasking, such as letting you talk and use apps at the same time.

**What OS do tablets use?** Popular tablet operating systems include iOS, Android, and Windows (see Figure 5.4). iPads use iOS, whereas a number of different tablets (such as the Samsung Galaxy Tab and the Google Nexus) use versions of Android. The Kindle Fire also runs a customized version of Android. Until the release of Windows 8 in 2012, Microsoft didn't have a popular tablet OS, but the company has managed to grab a 5% market share releasing Windows 8, which is optimized for tablet devices.

**Do gaming consoles and iPods use an OS?** Gaming systems such as Microsoft's Xbox 360, the Nintendo Wii, and the Sony PlayStation, as well as personal media players such as the iPod, all require system software developed specifically for the particular device. The system software controls the physical aspects of the device (such as game controllers) as well as other application programs that come with the device. For example, the operating systems on gaming consoles control web browsing and file storage of media and photos as well as playing of DVDs and games.

## Operating Systems for Personal Computers

**What are the most popular operating systems for personal computers?** Microsoft Windows, OS X, and Linux (an open source OS) are the top three operating systems for personal computers. Although they share similar features, each is unique.

**What's special about Windows?** Microsoft **Windows** is an operating environment that incorporates a user-friendly, visual interface like the one that was first introduced with Apple's OS. Over time, improvements in Windows have concentrated on increasing user functionality and friendliness, improving Internet capabilities, supporting home networks, and enhancing file privacy and security. The newest release of Microsoft's OS, **Windows 8**, provides a new interface optimized for touch-screen devices.

**What's the difference between the various editions of Windows 8 operating systems?** Windows 8 simplifies consumer choices because it's offered in only two versions: Windows 8 and Windows 8 Pro. For most users, Windows 8 is sufficient, as it now includes many features (such as remote access) that weren't included in Windows 7 Home Premium. However, Windows 8 doesn't include Media Center, which you may be used to seeing in previous versions of Windows. Media Center is now available only as an add-on package for Windows 8 Pro. Windows 8.1 is the latest release currently available of the Windows 8 OS.

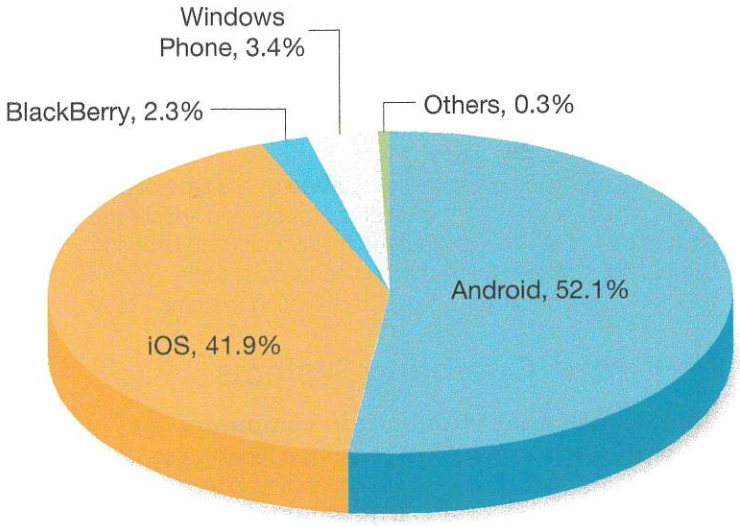



FIGURE 5.3 Popular Smartphone Operating Systems

**What's special about the Mac OS?** In 1984, **Mac OS** became the first commercially available OS to incorporate a **graphical user interface**, or **GUI**, with user-friendly point-and-click technology. Many Mac users have switched from Windows because of the "coolness" of the Mac OS, OS X. With the release of the Mountain Lion version, Apple added many of the popular and innovative features loved by iOS

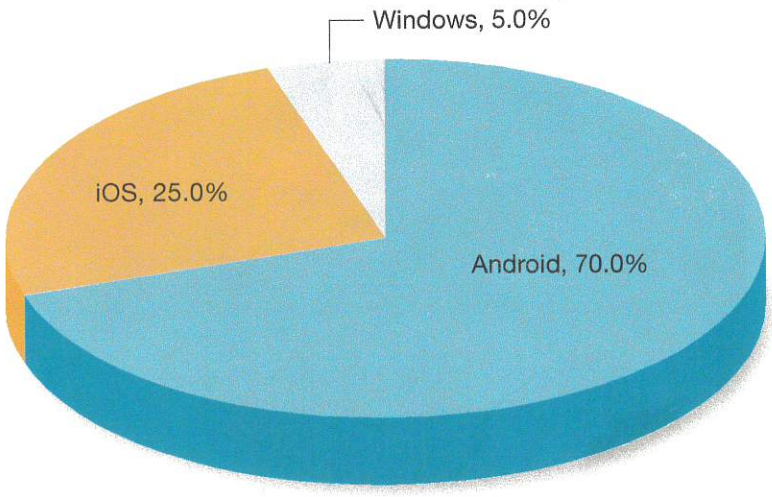



FIGURE 5.4 Popular Tablet Operating Systems

users, such as messages, reminders, notes, and a notification center. The latest version, Yosemite, was released in fall 2014 and features interface and usability enhancements designed to dovetail with the iOS 8 upgrade released just a few months earlier. If you've been using Windows for a while, you shouldn't have any problems making the transition to OS X. You'll notice immediately that OS X uses the same desktop metaphors as Windows, including icons for folders and a Trash Can (similar to a Recycle Bin) for deleted documents. OS X also includes a window-based interface like the one in Windows.

OS X is based on the UNIX operating system, which is exceptionally stable and reliable. However, just as with any other OS, you still need to install updates as they become available and protect yourself from viruses, spyware, and other malicious software.

**What is Linux? Linux** is an open source OS designed for use on personal computers and as a network OS. Open source software is freely available for anyone to use or modify as he or she wishes. Linux began in 1991 as a part-time project of Finnish university student Linus Torvalds. It has since been tweaked by scores of programmers as part of the Free Software Foundation GNU Project (**gnu.org**).

Linux has a reputation as a stable OS that is not subject to crashes or failures. Because the code is open and available to anyone, Linux can be modified or updated quickly by hundreds of programmers around the world.

**What computers use Linux?** Linux is gaining popularity among computer manufacturers, which have begun to ship it with some of their latest PCs. Android, the tablet and phone OS, is Linux based. Because the overall size of Android is much smaller than that of Windows, some ultrabook users choose to use it in place of the factory-installed Windows OS (see Figure 5.5). Some Linux-based operating systems have been modified to run on iPods and gaming systems.

**Where can I get Linux?** Linux is available for download in various packages known as **distributions**, or **distros**. Distros include the underlying Linux kernel (the code that provides Linux's basic functionality) and special modifications to the OS, and may also include additional open source software (such as OpenOffice). A good place to start researching distros is **distrowatch.com**. This site tracks Linux distros and provides helpful tips for beginners on choosing one.

# BITS&BYTES

## Upgrading Your Operating System

If you've had your computer for a year or two, you may be wondering whether you should upgrade to the newest release of your OS (such as going from Windows 7 to Windows 8.1). Here are a few key things to consider before taking the plunge:

- **Is your current OS still supported?** When the company deploys new versions of operating systems, it may stop supporting older versions. If your current version will no longer be supported, it's best to upgrade to a newer version.
- **Are there significant features in the new version that you want?** Operating systems are often upgraded to provide extra security, better performance, and additional features intended to make your computer experience more efficient, and perhaps even more fun. But if the only features the new version offers are ones you don't need, you should reconsider upgrading.
- **Will your hardware work with the new version of the OS?** Check the minimum operating requirements (required RAM, processor speed, hard drive space, etc.) of the new version to ensure that your computer can handle the workload of the new OS. You'll also need to make sure drivers for the new OS are available for all your hardware devices and peripherals to ensure they'll work with it. Microsoft has made this easy with Windows 8.1 Upgrade Assistant, which you can download from Microsoft's website. The Upgrade Assistant scans your hardware, devices, and installed programs for compatibility, advises you on how to resolve any issues, and recommends what you should do before upgrading.
- **Is your application software compatible with the new version of the OS?** Usually, application software works fine with a new version of an OS. Sometimes it doesn't. Check with software vendors regarding compatibility. Most programs that run under Windows 7 will run from the desktop in Windows 8.1. And Windows 8.1 has an upgrade option in its install program that lets you install Windows 8.1 over an existing installation of Windows 7. This relieves you from having to install all your application software after upgrading.

Before starting the upgrade, back up all your data files so you won't lose anything accidentally during the upgrading process. File Recovery and other backup features in Windows make this job less of a hassle.

**Does it matter what OS is on my computer?** An OS is designed to run on specific CPUs. CPUs have different designs, which can require modifying the OS software to allow it to communicate properly with each CPU. The combination of an OS and a specific processor is referred to as a computer's **platform**.

For user convenience, computers and other devices usually come with an OS already installed. However, with some PCs, you can specify which OS you'd like installed when you order your device. For example, Windows and Linux can run on most of the hardware being sold today. Your choice of an OS in this case is mostly a matter of price and personal preference. However, Apple equipment—computers, iPhones, iPads, and iPod Touches—comes with Apple operating systems preinstalled.

Note that most *application software* is OS dependent. You need to make sure you get the correct version of the application software for your OS, such as Microsoft Office 2013 for Windows and Microsoft Office 2011 for OS X.

**Can I have more than one OS on my computer?** Many people run more than one OS on their computers because different operating systems offer different features. For example, Windows and Linux both run well on Apple computers. A standard utility included in OS X called Boot Camp lets you boot into either Windows or OS X. And if you want to run both OS X and Windows OS at the same time, you can create "virtual drives" using virtualization software such as Parallels or VMware Fusion.

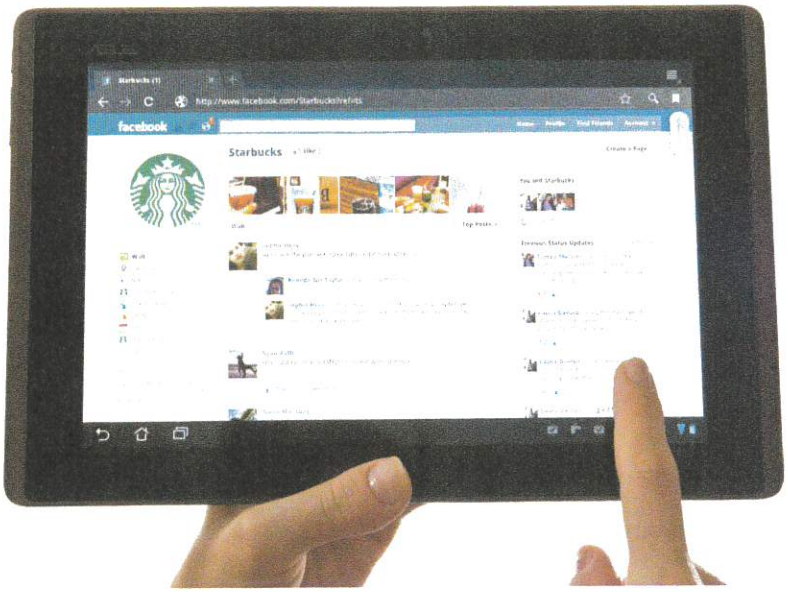



**FIGURE 5.5** Developed by Google, the Android OS is based on Linux and runs easily on laptops and tablets. *(Andrew Rubtsov/Alamy)*

In Windows, you can create a separate section of your hard drive (called a *partition*) and install another OS on it while leaving your original Windows installation untouched. After installing the second OS, when your computer starts, you're offered a choice of which OS to use.

**How do operating systems use the "cloud"?** Now that broadband Internet access and providing computer resources via the Internet (so-called *cloud computing*) are becoming more commonplace, operating systems have features that are tied to cloud computing. Here are a few examples:

- Windows 8 features tighter integration with the cloud. Using your *Microsoft account*, Windows 8 stores your settings and keeps track of applications you've purchased from the Windows store online. You can easily access and store files online in your *OneDrive account*. You can also log into your Windows account from any Windows 8 machine and be able to see your familiar desktop and applications.
- Similarly, OS X allows you to sign in with your *Apple ID*, which provides access to Apple's *iCloud* system. iCloud stores your content online and automatically pushes it out to all your Apple devices.
- Google has launched the *Google Chrome OS* (see Figure 5.6), which is a web-based OS. With the Chrome OS, virtually no files are installed on your computing device. Rather, the main functionality of the OS is provided by accessing the web through a web browser. Chrome OS is only available on certain hardware from Google's manufacturing partners, and these devices are called *Chromebooks*. The Chrome OS should not be confused with the *Google Chrome browser*. The browser is application software that can run in many different operating systems.

Another pioneer in accessing cloud-based storage and applications with a browser is the open source product eyeOS (**eyeos.com**). eyeOS allows companies to set up private clouds containing data and applications that can be accessed by their employees, partners, or customers. Using almost any computing device with a browser, users can access their data and applications through an Internet connection. ■

SOUND BYTE
**Customizing Windows**

In this Sound Byte, you'll find out how to customize your desktop. You'll learn how to configure the desktop, set up a screen saver, change pointer options, customize the Start screen, and manage user accounts.

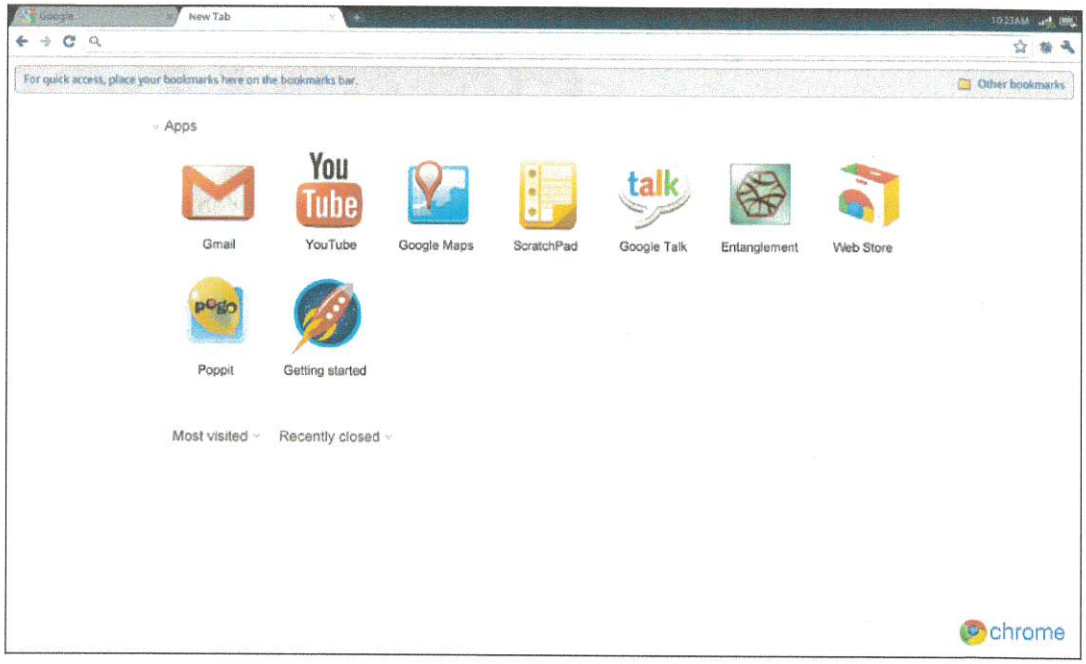



**FIGURE 5.6** The Google Chrome OS has a very minimalist look. *(Courtesy of Google, Inc.)*

# BITS&BYTES

## OS Market Share Battle: It's Still a Windows World

So who is winning the OS market share war? It depends on the type of device. For conventional desktop and laptop computers, hands down the winner is still various versions of Windows, with 91.6% of the market (see Figure 5.7). But as of July 2014, Windows only had a 3.4% market share on smartphones vs. Android's 52.1%. Clearly Microsoft is losing the phone OS wars.

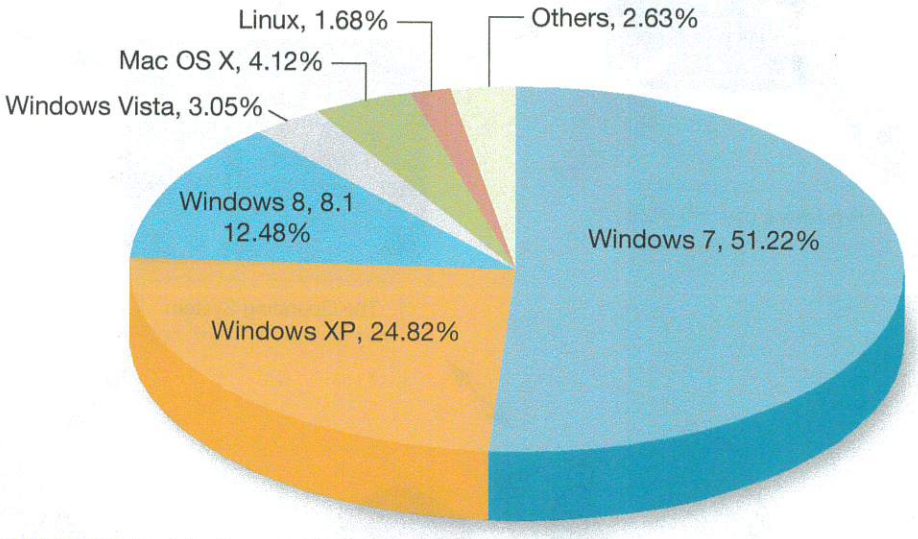



**FIGURE 5.7** Desktop/Laptop Operating Systems

# what the operating SYSTEM DOES

As shown in Figure 5.8, the OS is like an orchestra's conductor. It coordinates and directs the flow of data and information through the computer system. In this section, we explore the operations of the OS in detail.

## The User Interface

**How does the OS control how I interact with my computer?** The OS provides a user interface that lets you interact with the computer. The first personal computers used *Microsoft Disk Operating System* (*MS-DOS,* or just *DOS*), which had a command-driven interface, as shown in Figure 5.9a. A **command-driven interface** is one in which you enter commands to communicate with the computer system. The DOS commands were not always easy to understand; as a result, the interface proved to be too complicated for the average user. Therefore, PCs were used primarily in business and by professional computer operators.

The command-driven interface was later improved by incorporating a menu-driven interface, as shown in Figure 5.9b. A **menu-driven interface** is one in which you choose commands from menus displayed on the screen. Menu-driven interfaces eliminated the need for users to know every command because they could select most of the commonly used commands from a menu. However, they were still not easy enough for most people to use.

**What kind of interface do operating systems use today?** Current personal computer operating systems such as Microsoft Windows and OS X use a graphical user interface, or GUI (pronounced "gooey"). Unlike command- and menu-driven interfaces, GUIs display graphics and use the point-and-click technology of the mouse and cursor (or human finger), making them much more user-friendly.

Linux-based operating systems do not have a single default GUI interface. Instead, users are free to choose among many commercially available and free interfaces, such as GNOME and KDE, each of which provides a different look and feel.

## Processor Management

**Why does the OS need to manage the processor?** When you use your computer, you're usually asking the processor (also called the CPU) to perform

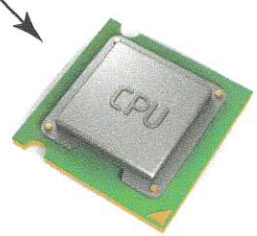
Manages computer hardware and peripherals

Provides a user interface

The Operating System


Provides a consistent interaction between applications and the CPU

Manages memory and storage




Manages the processor

**FIGURE 5.8** The OS is the orchestra conductor of your computer, coordinating its many activities and devices.

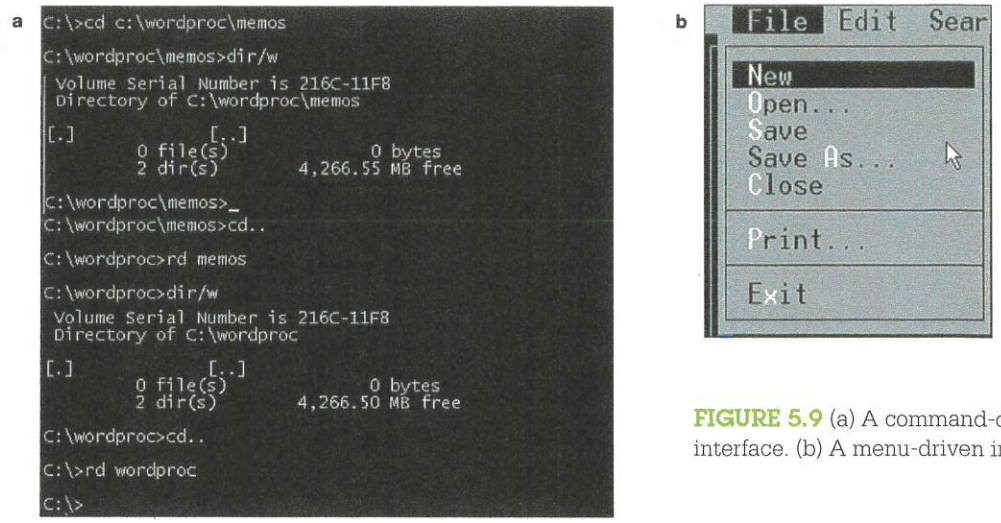



**FIGURE 5.9** (a) A command-driven interface. (b) A menu-driven interface.

several tasks at once. For example, you might be printing a Word document, chatting with your friends on Facebook, and watching a movie using the Blu-ray drive—all at the same time, or at least what appears to be at the same time. Although the CPU is powerful, it still needs the OS to arrange the execution of all these activities in a systematic way.

To do so, the OS assigns a slice of its time to each activity that requires the processor's attention. The OS must then switch among different processes millions of times a second to make it appear that everything is happening seamlessly. Otherwise, you wouldn't be able to watch a movie and print at the same time without experiencing delays in the process.

**How exactly does the OS coordinate all the activities?** When you create and print a document in Word while also watching a Blu-ray movie, for example, many different devices in the computer are involved, including your keyboard, mouse, Blu-ray drive, and printer. Every keystroke, every mouse click (or touch on the screen), and each signal to the printer and from the Blu-ray drive creates an action, or **event**, in the respective device (keyboard, mouse, Blu-ray drive, or printer) to which the OS responds.

Sometimes these events occur sequentially (such as when you type characters one at a time), but other events involve two or more devices working concurrently (such as the printer printing while you type and watch a movie). Although it looks as though all the devices are working at the same time, the OS in fact switches back and forth among processes, controlling the timing of events on which the processor works.

For example, assume you're typing and want to print a document. When you tell your computer to print your document, the printer generates a unique signal called an **interrupt** that tells the OS that it's in need of immediate attention. Every device has its own type of interrupt, which is associated with an **interrupt handler**, a special numerical code that prioritizes the requests. These requests are placed in the interrupt table in the computer's primary memory (RAM). The OS processes the task assigned a higher priority before processing a task assigned a lower priority. This is called **preemptive multitasking**.

In our example, when the OS receives the interrupt from the printer, it suspends the CPU's typing activity and Blu-ray activity and puts a "memo" in a special location in RAM called a *stack*. The memo is a reminder of what the CPU was doing before it started to work on the printer request. The CPU then retrieves the printer request from the interrupt table and begins to process it. On completion of the printer request, the CPU goes back to the stack, retrieves the memo it placed about the keystroke or Blu-ray activity, and returns to that task until it is interrupted again, in a very quick and seamless fashion, as shown in Figure 5.10.

**What happens if more than one document is waiting to be printed?** The OS also coordinates multiple activities for peripheral devices such as printers. When the processor receives a request to send information to the printer, it first checks with the OS to ensure that the printer is not already in use. If it is, the OS puts the request in another temporary storage area in RAM, called the *buffer*. The request then waits in the buffer until the **spooler**, a program that helps coordinate all print jobs currently being sent to the printer, indicates the printer is available. If more than one print job is waiting, a line (or *queue*) is formed so that the printer can process the requests in order.

## Memory and Storage Management

**Why does the OS have to manage the computer's memory?** As the OS coordinates the activities of the processor, it uses RAM as a temporary storage area for instructions and data the processor needs. The processor then accesses these instructions and data from RAM when it's ready to process them. The OS is therefore responsible for coordinating the space allocations in RAM to ensure there's

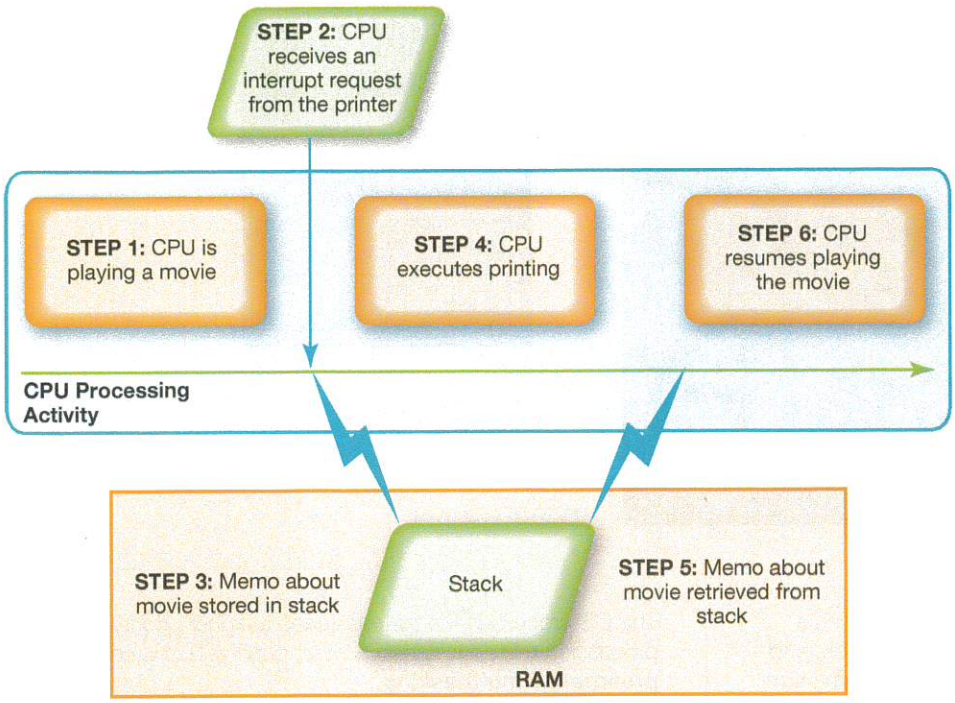



FIGURE 5.10 How Preemptive Multitasking Works

enough space for all the pending instructions and data. The OS then clears the items from RAM when the processor no longer needs them.

**Can my OS ever run out of RAM?** RAM has limited capacity. Like most users, you'll add new software and peripherals to your computer over time. Most computers sold for home use have between 4 and 16 GB of RAM. If you have an older computer system with less RAM, it might be time to consider buying a new computer or adding more RAM. As you add and upgrade software and increase your usage of the computer system, you might find that the amount of RAM you have is no longer sufficient for your needs.

**What happens if my computer runs out of RAM?** When there isn't enough RAM for the OS to store the required data and instructions, the OS borrows from the more spacious hard drive. This process of optimizing RAM storage by borrowing hard drive space is called **virtual memory**. As shown in Figure 5.11, when more RAM is needed, the OS swaps out from RAM the data or instructions that haven't recently been used and moves them to a temporary storage area on the hard drive called the **swap file** (or **page file**). If the data or instructions in the swap file are needed later, the OS swaps them back into active RAM and replaces them in the hard drive's swap file with less active data or instructions. This process of swapping is known as **paging**.

**Can I ever run out of virtual memory?** Only a portion of the hard drive is allocated to virtual memory. You can manually change this setting to increase the amount of hard drive space allocated, but eventually your computer will become sluggish as it is forced to page more often. This condition of excessive paging is called **thrashing**. The solution to this problem is to increase the amount of RAM in your computer so that it won't be necessary for it to send data and instructions to virtual memory.

**How does the OS manage storage?** If it weren't for the OS, the files and applications you save to the hard drive and other storage locations would be an unorganized mess. Fortunately, the OS has a file-management system that keeps track of the name and location of each file you save and the programs you install. We'll talk more about file management later in this chapter.

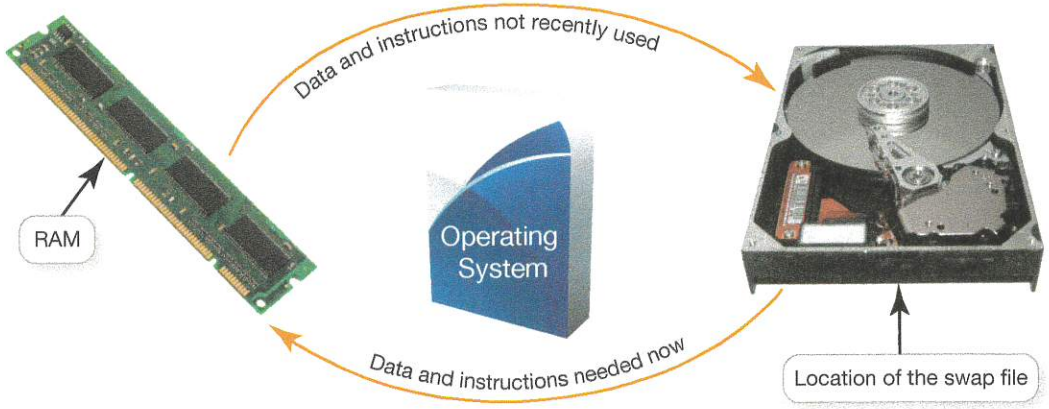



FIGURE 5.11 Virtual memory borrows excess storage capacity from the hard drive when there isn't enough capacity in RAM. *(brontazavra/ Shutterstock; aPERFECT/Fotolia; Tim Dobbs/Shutterstock)*

## Hardware and Peripheral Device Management

**How does the OS manage the hardware and peripheral devices?** Each device attached to your computer comes with a special program called a **device driver** that facilitates communication between the device and the OS. Because the OS must be able to communicate with every device in the computer system, the device driver translates the device's specialized commands into commands the OS can understand, and vice versa. Devices wouldn't function without the proper device drivers because the OS wouldn't know how to communicate with them.

**Do I always need to install drivers?** Today, most devices, such as flash drives, mice, keyboards, and digital cameras, come with the driver already installed in Windows. The devices whose drivers are included in Windows are called Plug and Play devices. **Plug and Play (PnP)** is a software and hardware standard designed to facilitate the installation of new hardware in PCs by including in the OS the drivers these devices need in order to run. Because the OS includes this software, incorporating a new device into your computer system seems automatic. PnP lets you plug a new device into your computer, turn it on, and immediately play (use) the device (see Figure 5.12).

**What happens if the device is not PnP?** Sometimes you may have a device that is so new the drivers aren't yet available automatically in Windows. You'll then be prompted to insert the driver that was provided with the device or downloaded from the Internet. If you obtain a device secondhand and don't receive the device driver, or if you're required to update the device driver, you can often download the necessary driver from the manufacturer's website. You can also go to websites such as DriverZone (**driverzone.com**) to locate drivers.


FIGURE 5.12 A Windows message showing a successful driver installation the first time an external hard drive was connected to the computer.

**Can I damage my system by installing a device driver?** Occasionally, when you install a driver your system may become unstable (that is, programs may stop responding, certain actions may cause a crash, or the device or the entire system may stop working). Although this is uncommon, it can happen. Fortunately, to remedy the problem, Windows has a Roll Back Driver feature that removes a newly installed driver and replaces it with the last one that worked (see Figure 5.13).

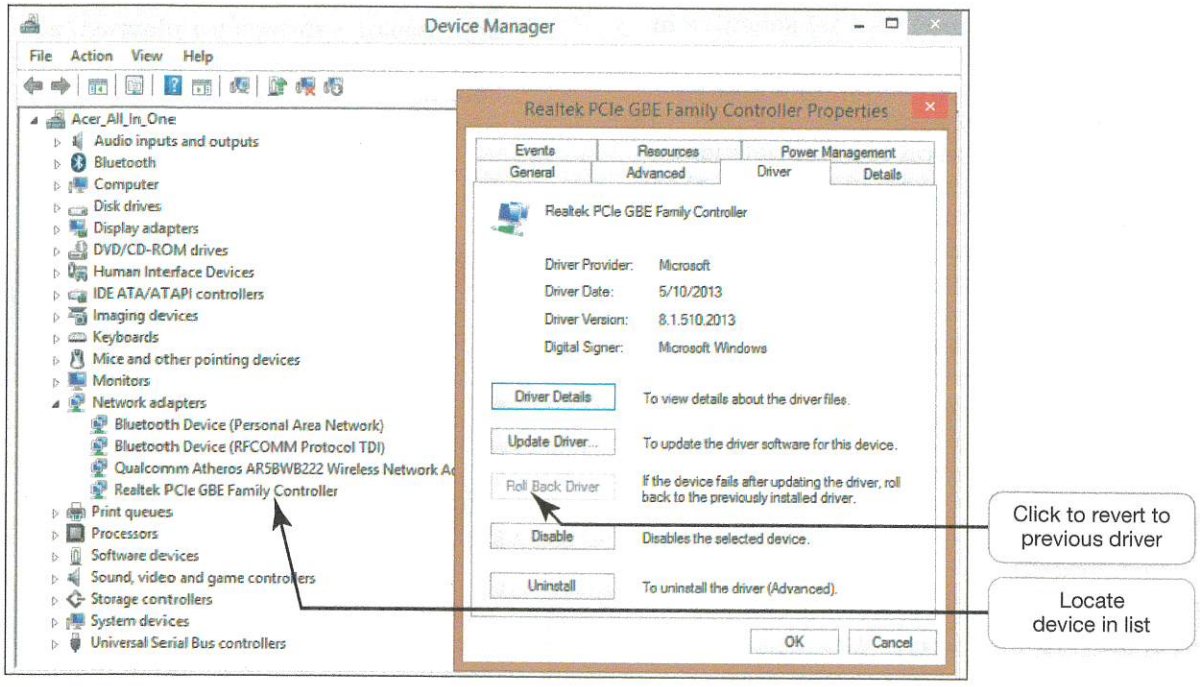



FIGURE 5.13 The Roll Back Driver feature in Windows removes a newly installed driver and replaces it with the last one that worked.

*>To access the Device Manager window, navigate to the desktop, right-click the Start button to display the shortcut menu, and select* **Device Manager**. *To display the Properties dialog box, double-click on a device. Click the* **Driver** *tab.*

# ethics in IT

# The Great Debate: Is Mac OS X Safer than Windows?

Many Mac users feel they are impervious to viruses and malware (software that can disable or interfere with the use of a computing device) because those are "just Windows problems." This means that Mac users often run their computers with only the basic protection provided by Apple in its operating system software. Are Mac users wild risk takers, or are they actually safe from hackers? As with many issues, it's a little bit of both.

## Threats Are Out There

Windows users have been bombarded by malware and virus attacks for decades. When you bought your last Windows machine, it invariably came with a trial version of third-party antivirus/anti-malware software. Running a Windows computer without antivirus/anti-malware software is just asking for trouble.

However, over the last several years, the attacks against Macs have also increased. Why weren't Macs attacked frequently in the past? Most malware is designed to steal sensitive information such as credit card numbers. When thieves expend the time, money, and effort to develop malware, they want to ensure that it targets the largest population of potential victims. Up until recently, Windows had over 90% of the market share for desktop and laptop computers. However, as OS X gains market share, Mac users are becoming a larger group of potential targets. In fact, in many affluent nations, Mac ownership has reached 20% of the market. And since Macs tend to cost more than Windows machines, it can be argued that Mac users may have more disposable income than other computer buyers. And wealthy people always make attractive targets for thieves.

## But Isn't OS X Just Safer Than Windows by Design?

To a certain extent, this is true. OS X does have certain design features that tend to prevent the installation and spread of malware. Apple has also designed current versions of iOS and OS X to prevent the installation of unapproved software (i.e., software not available on Apple's approved online outlets like the App Store). In addition, apps sold on the App Store are required to be designed using the access control technology known as *App Sandbox*.

When most software programs or apps are running, they have broad latitude to interact with the OS (such as Windows or OS X). Usually they have all the rights that the user has over the OS. So if hackers can design an exploit that takes advantage of a security flaw in an app, they can potentially gain extensive control over the computer using the access that the user has to the OS. As noted, Apple requires all approved apps to be "sandboxed" (developed to run in the App Sandbox environment). When an app is sandboxed, the developer defines what the app needs to do in order to interact with the OS. The OS then grants only those specific rights and privileges to the app and nothing else. By doing this, it severely limits what hackers can do in an OS if they breach the security of an app. It's like being in a high-walled sandbox (or playpen) as a child (see Figure 5.14). You can play within the confines of your space, but you can't make mischief outside certain limits.

**FIGURE 5.14** Just as sandboxes are designed to constrain children, toys, and sand to a specific area, Mac apps are also designed to limit access to the OS. *(EduardSV/Fotolia)*

## So I'll Buy a Mac and Be Safe Forever, Right?

Alas, it's not that simple. Although it's more difficult to design exploits for OS X and iOS, it's not impossible. And a great deal of cybercrime relies on social engineering techniques like those used in scareware scams. *Scareware* is software designed to make it seem as if there is something wrong with your computer. The author of the scareware program then "persuades" you to buy a solution to the problem, acquiring your credit card number in the process. Scareware victims can be both Mac and PC users, so even if you own a Mac, you need to be aware of such scams and avoid falling prey to them (see Chapter 9).

## The Solution: Extra Security Precautions!

The current versions of OS X, iOS, and Windows all include some level of security tools and precautions. But there are a few things you should do to protect yourself:

1. **Make sure your software is set to download and install updates automatically**—As OS developers discover holes in their software's security, they provide updates to repair these problems.
2. **Use third-party antivirus/anti-malware software (even on a Mac).** Although no product will detect 100% of malware, detecting some is better than detecting none.
3. **Be aware of social engineering techniques.** Use vigilance when surfing the Internet so you don't fall prey to scams.

So, no OS is 100% safe. But if you're informed and proceed with caution, you can avoid a lot of schemes perpetrated by hackers and thieves.

## Software Application Coordination

**How does the OS help application software run on the computer?** Every computer program, no matter what its type or manufacturer, needs to interact with the CPU using computer code. For programs to work with the CPU, they must contain code the CPU recognizes. Rather than having the same blocks of code for similar procedures in each program, the OS includes the blocks of code—each called an **application programming interface (API)**—that application software needs in order to interact with the CPU. Microsoft DirectX, for example, is a group of multimedia APIs built into the Windows OS that improves graphics and sounds when you're playing games or watching videos on your PC.

**What are the advantages of using APIs?** To create applications that can communicate with the OS, software programmers need only refer to the API code blocks when they write an application. They don't need to include the entire code sequence. APIs not only prevent redundancies in software code, they make it easier for software developers to respond to changes in the OS. Software companies also take advantage of APIs to make applications in software suites (such as Microsoft Office) that have a similar interface and functionality. And since these applications share common APIs, data exchange is facilitated between two programs, such as inserting a chart from Excel into a Word document. ■

# the boot process: starting YOUR COMPUTER

Many things happen quickly between the time you turn on your computer and the time it's ready for you to start using it. As we discussed earlier, all data and instructions (including the OS) are stored in RAM while your computer is on. When you turn off your computer, RAM is wiped clean of all its data (including the OS). How does the computer know what to do when you turn it on if there is nothing in RAM? It runs through a special boot process (or start-up process) to load the OS into RAM. The term *boot,* from *bootstrap loader* (a small program used to start a larger program), alludes to the straps of leather, called *bootstraps,* that people used to use to help them pull on their boots. This is also the source of the expression "pull yourself up by your bootstraps."

**What are the steps involved in the boot process?** As illustrated in Figure 5.15, the **boot process** consists of four basic steps. Let's look at each step in detail.

## Step 1: Activating BIOS

**What's the first thing that happens after I turn on my computer?** In the first step of the boot process, the CPU activates the **basic input/output system (BIOS)**. BIOS is a program that manages the exchange of data between the OS and all the input and output devices attached to the system. BIOS is also responsible for loading the OS into RAM from its permanent location on the hard drive. BIOS itself is stored on a read-only memory (ROM) chip on the motherboard. Unlike data stored in RAM, data stored in ROM is permanent and is not erased when the power is turned off.

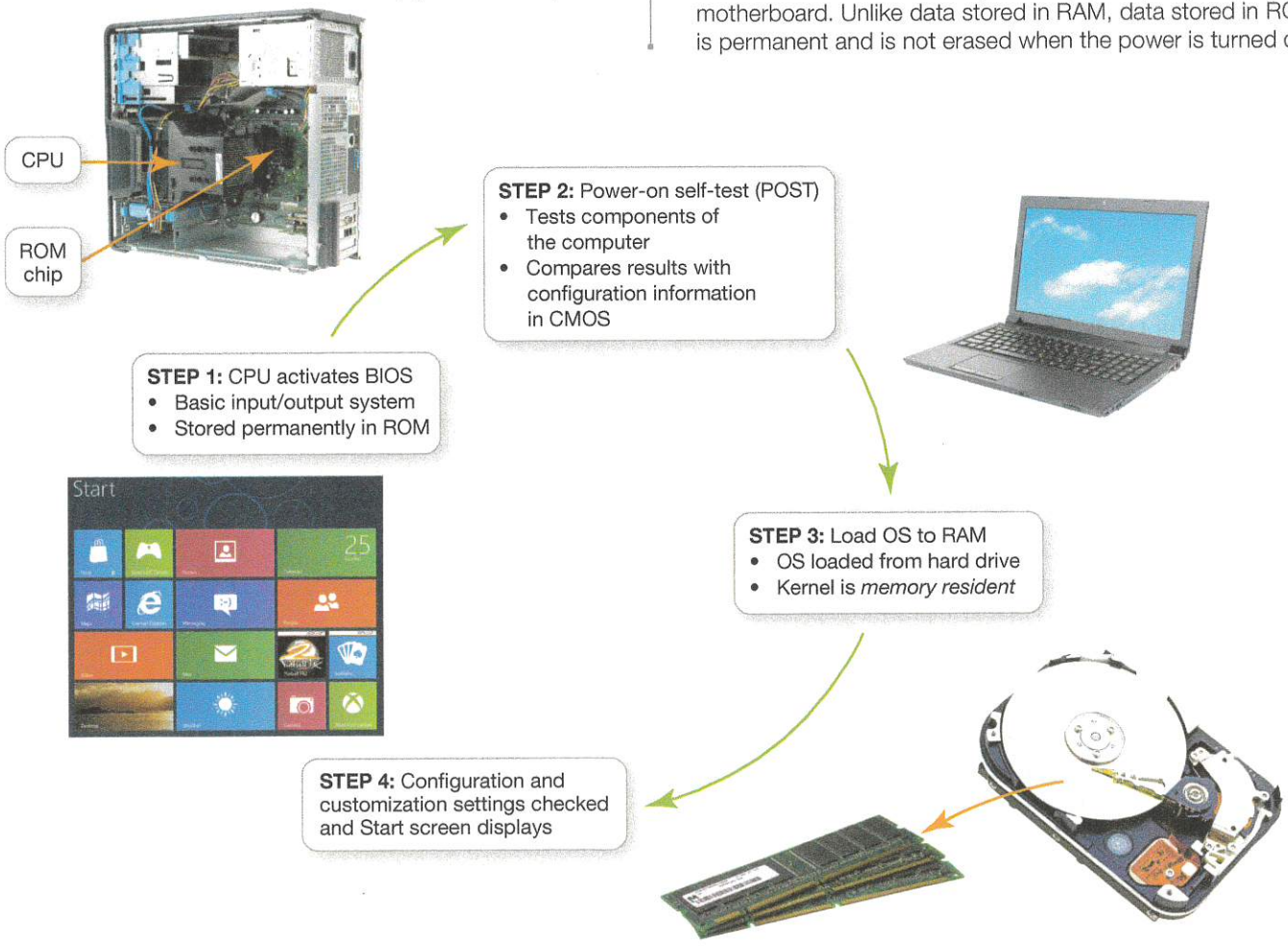



FIGURE 5.15 The Boot Process

## Step 2: Performing the Power-On Self-Test

**How does the computer determine whether the hardware is working properly?** The first job BIOS performs is to ensure that essential peripheral devices are attached and operational—a process called the **power-on self-test**, or **POST**. The BIOS compares the results of the POST with the various hardware configurations permanently stored in CMOS (pronounced "see-moss"). CMOS, which stands for *complementary metal-oxide semiconductor,* is a special kind of memory that uses almost no power. A small battery provides enough power so that the CMOS contents won't be lost after the computer is turned off. CMOS contains information about the system's memory, types of disk drives, and other essential input and output hardware components. If the results of the POST compare favorably with the hardware configurations stored in CMOS, the boot process continues.

## Step 3: Loading the OS

**How does the OS get loaded into RAM?** Next, BIOS goes through a preconfigured list of devices in its search for the drive that contains the **system files**, the main files of the OS. When it is located, the OS loads into RAM from its permanent storage location on the hard drive.

Once the system files are loaded into RAM, the **kernel** (or **supervisor program**) is loaded. The kernel is the essential component of the OS. It's responsible for managing the processor and all other components of the computer system. Because it stays in RAM the entire time your computer is powered on, the kernel is said to be *memory resident*. Other, less critical, parts of the OS stay on the hard drive and are copied over to RAM on an as-needed basis so that RAM is managed more efficiently. These programs are referred to as *nonresident*. Once the kernel is loaded, the OS takes over control of the computer's functions.

## Step 4: Checking Further Configurations and Customizations

**Is that it?** Finally, the OS checks the registry for the configuration of other system components. The **registry** contains all the different configurations (settings) used by the OS and by other applications. It contains the customized settings you put into place, such as mouse speed, as well as instructions as to which programs should be loaded first.

**Why do I sometimes need to enter a login name and password at the end of the boot process?** The verification of your login name and password is called **authentication**. The authentication process blocks unauthorized users from entering the system. You may have your home computer set up for authentication, especially if you have multiple users accessing it. All large networked environments, like your college, require user authentication for access.

On a Windows 8 computer, the default setting is to input a password to log in to your **Microsoft account** after your computer has completely booted up. Because configuration settings are stored online and associated with a particular Microsoft account, this makes it easy for multiple people to share any Windows 8 computer while maintaining access to their individual settings and preferences.

**How do I know if the boot process is successful?** The entire boot process takes only a few minutes to complete. If the entire system is checked out and loaded properly, the process completes by displaying the login screen or the Start screen. The computer system is now ready to accept your first command.

## Handling Errors in the Boot Process

**What should I do if my computer doesn't boot properly?** Sometimes problems occur during the boot process. Here are some suggestions for solving a boot problem:

- If you've recently installed new software or hardware, try uninstalling it. (Make sure you use the Uninstall a program feature in the Control Panel to remove the software.) If the problem no longer occurs when rebooting, you can reinstall the device or software.
- Try accessing the Windows Advanced Options Menu (accessible by pressing the F8 key during the boot process). If Windows detects a problem in the boot process, it will add Last Known Good Configuration to the Windows Advanced Options Menu. Every time your computer boots successfully, a configuration of the boot process is saved. When you choose to boot with the Last Known Good Configuration, the OS starts your computer by using the registry information that was saved during the last shut down.
- Try refreshing your computer (new in Windows 8).

**What happens when a PC is "refreshed"?** Sometimes Windows does not boot properly or the system does not respond properly. You may even see messages related to "fatal exceptions." **Refresh your PC** is a new utility

> ACTIVE HELPDESK
> **Starting the Computer: The Boot Process**
> In this Active Helpdesk, you'll play the role of a helpdesk staffer, fielding questions about how the operating system helps the computer start up.

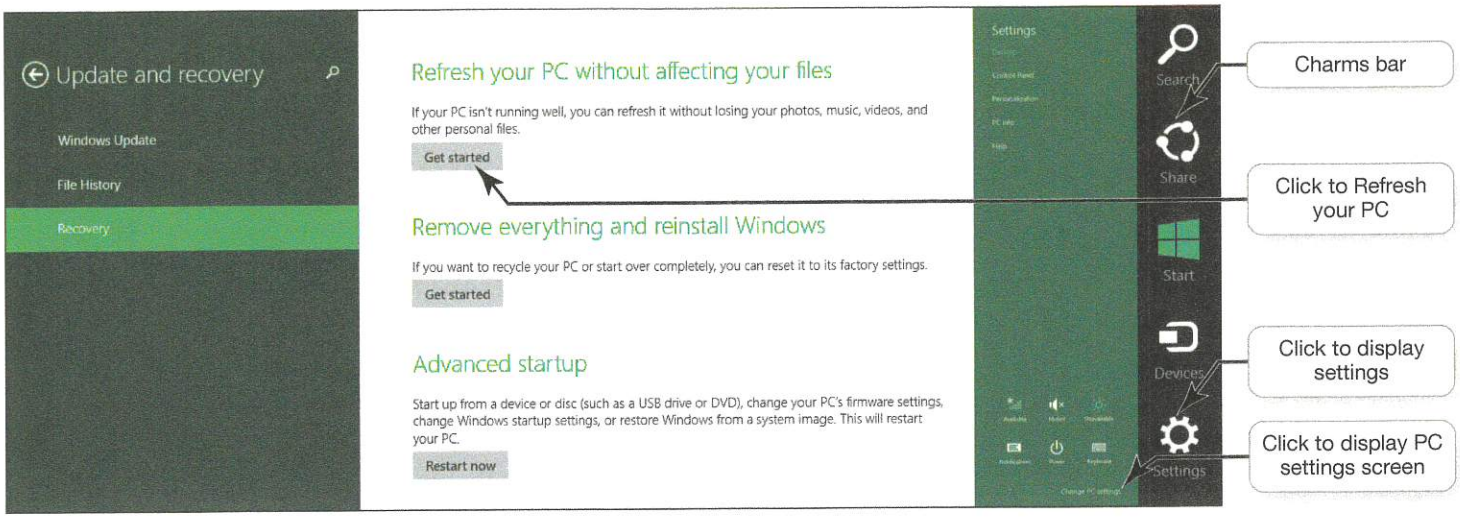



**FIGURE 5.16** The Update and recovery screen (an option on the PC settings screen) in Windows 8.1 provides access to the Refresh your PC option. *To access the Update and recovery screen, display the Charms bar on the Start screen (swipe from right, or point cursor to upper-right corner of screen), click* **Settings**, *then click* **Change PC settings**. *On the PC settings screen, click* **Update and recovery**, *then select* **Recovery**.

program in Windows 8 that attempts to diagnose and fix errors in your Windows system files that are causing your computer to behave improperly (see Figure 5.16). When a PC is refreshed, the following occurs:

- Your data files (documents, music, videos, etc.) and personalization settings are not removed or changed.
- Apps that you have downloaded from the Windows Store are kept intact.
- Apps that you have downloaded from the Internet or installed from DVDs will be removed from your PC. Therefore, you'll need to reinstall them after the refresh.

It's recommended that you back up your PC prior to refreshing it as a precautionary measure. Finally, if all other attempts to fix your computer fail, try a System Restore to roll back to a past configuration. System Restore is covered in more detail later in this chapter.

**What should I do if my keyboard or another device doesn't work after I boot my computer?** Sometimes during the boot process, BIOS skips a device (such as a keyboard) or improperly identifies it. Your only indication that this problem has occurred is that the device won't respond after the system has been booted. When that happens, try rebooting. If the problem persists, check the OS's website for any patches (or software fixes) that may resolve the issue. If there are no patches or the problem persists, you may want to get technical assistance. ■

**Before moving on to Part 2:**
- **Watch Replay Video 5.1** .
- Then check your understanding of what you've learned so far.

# check your understanding// review & practice

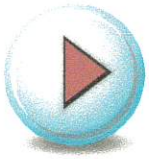
For a quick review to see what you've learned so far, answer the following questions. Visit **pearsonhighered.com /techinaction** to check your answers.

## multiple choice

1. Which is NOT an example of a network operating system?
   - **a.** Linux
   - **b.** UNIX
   - **c.** Android
   - **d.** Windows
2. You are most likely to find an RTOS
   - **a.** in a robotic camera.
   - **b.** on a supercomputer.
   - **c.** on a mainframe.
   - **d.** on an iPad.
3. Which of the following is an example of a web-based OS?
   - **a.** OS X
   - **b.** Windows
   - **c.** Linux
   - **d.** Chrome
4. Early operating systems such as MS-DOS used a _____ interface.
   - **a.** command-driven
   - **b.** graphical user
   - **c.** menu-driven
   - **d.** magnetic tape–based
5. The OS can optimize RAM storage by using
   - **a.** thrashing.
   - **b.** virtual memory.
   - **c.** an interrupt handler.
   - **d.** a spooler.

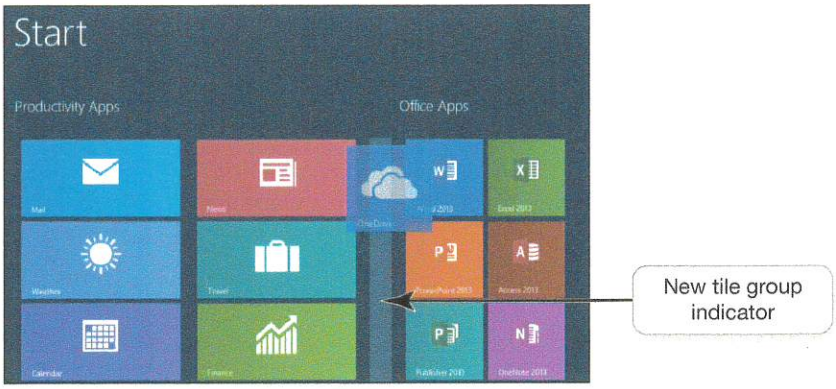
To take an autograded version of this review, please go to the companion website at **pearsonhighered.com/techinaction**, or go your MyITLab course.

Continue

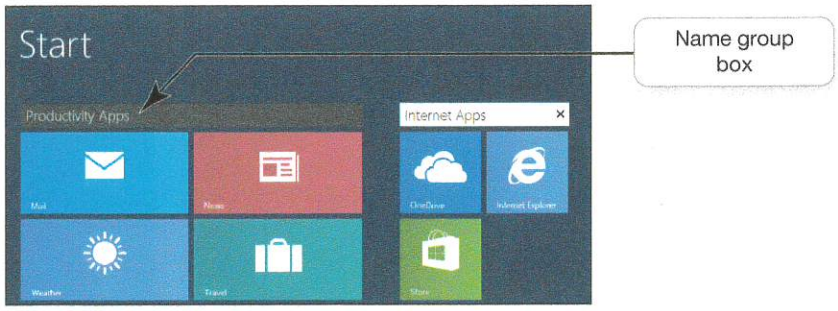
# TRY THIS  Organizing Tiles on the Start Screen in Windows 8.1

The Start screen in Windows 8.1 is similar to the desktop in Windows 7 in that you can arrange the tiles on the Start screen to suit your needs, much like you can move around the icons on the Windows 7 desktop. You can even create groups of tiles and give each group a name. On a busy Start screen, this helps you keep your tiles organized so you can find the right app quickly. Let's create a small group for app tiles that take us out to the Internet.

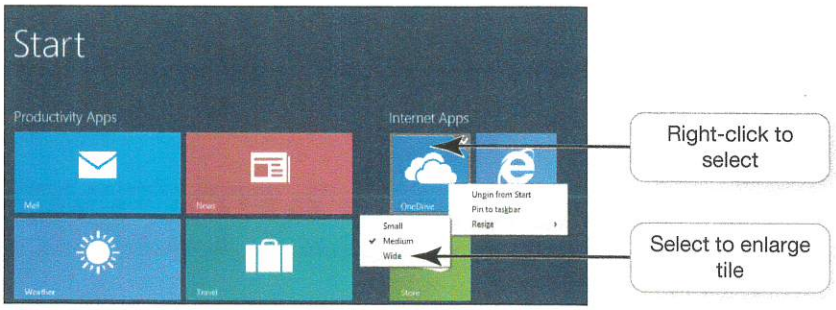
**Step 1** Locate the OneDrive tile on your Start screen. Left-click the tile (or press and hold) and drag it to the space between two groups of tiles. A faint vertical bar will appear, indicating that you wish to place that tile in its own group. Release the mouse button (or stop touching the screen). The OneDrive tile should now be alone in its own group.




**Step 2** Locate the Internet Explorer and Store tiles. Left-click and drag (or press and drag) these tiles so they are in close proximity to the OneDrive tile. Release the mouse button (or stop pressing the screen) and these tiles should join the OneDrive tile in their own group. To name the group, right-click on a blank area of the Start screen and select **Name groups**. In the **Name group box** that appears above the group, enter *Internet Apps*. Left-click (or press) on any blank area of the Start screen.



**Step 3** Perhaps you use OneDrive quite frequently. You may wish to make that tile larger. Right-click (or press and hold) the OneDrive tile to select it. From the shortcut menu that displays, select **Resize**, and then **Wide**. Notice that the OneDrive icon is now twice the size of the other two icons.



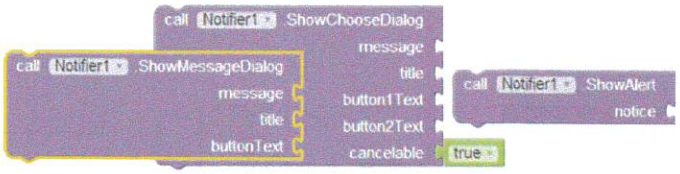

# Make This

**TOOL: App Inventor 2**

## MAKE: A Notification Alert

Does your app need to communicate with or provide feedback to the user? With the Notifier component of **App Inventor**, you can make your program generate message boxes or ask for a response from the user.

In this exercise, you'll use the Notifier component of **App Inventor** to show a message box, post a user choice with two buttons for response, or post an alert. Your apps can now use more of the features of the Android operating system to communicate!




The *Notifier component allows you to communicate with alerts, message boxes, and text choice popups within your mobile app.*

**For the instructions for this exercise, please go to pearsonhighered.com/techinaction or MyITLab.**

# Using System Software

Now that you know how system software works, let's explore how specific operating systems and their tools function.

## the windows INTERFACE

As we mentioned earlier, Windows 8 is a departure from previous versions of Windows because it's designed for a variety of devices, including laptops, phones, and tablets. To enable Windows 8 to function on all types of devices, there are often three different ways to accomplish tasks in Windows 8:

1. Using a mouse
2. Touching the screen (on touch-enabled devices)
3. Using keystrokes

Which method you use depends on the type of device you're using and, to a large extent, on your personal preferences.

The **Start screen** is the first interaction you have with the OS and the first image you see on your display. As its name implies, the Start screen is the place where you begin all of your computing activities. The Windows 8 Start screen provides you with access to your most used applications in one convenient screen.

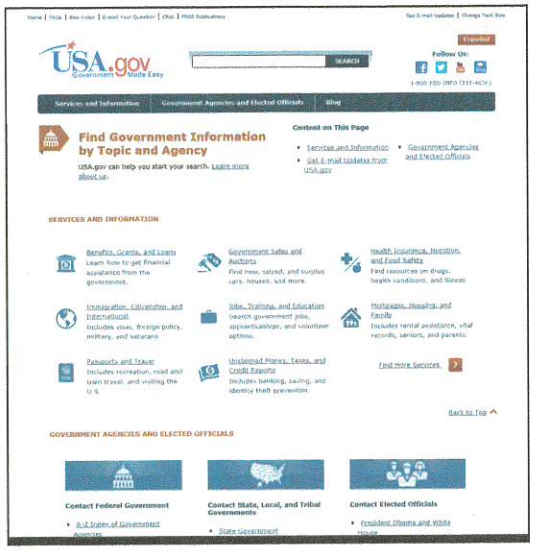
**How do Windows 8 "optimized" programs differ from older Windows apps? Windows 8 apps** are applications specifically designed to run in the interface of Windows 8. The **Windows 8 interface** features large type with clean, readable block images inspired by metropolitan service signs such as those found on bus stations and subways.

Windows 8 apps either are preinstalled with Windows 8 (such as Photos, Messaging, and Calendar) or are available for download from the Windows Store (Microsoft's apps marketplace). You can launch Windows 8 apps by clicking or tapping on their icons on the Start screen.

Windows 8 apps are displayed full screen, without the distractions of borders or controls (such as toolbars or menus). For example, Figure 5.17 shows Internet Explorer 11, which is a Windows 8 app. Notice that unlike older versions of Internet Explorer, there are no window borders or menus visible (see Figure 5.17a), as the application fills the entire screen. Controls and settings are contained on **app bars**, such as the Tabs bar (see Figure 5.17b), that float on the screen above the app when you summon them or you need them. Right-clicking on a Windows 8 app screen (or swiping up from the bottom) usually displays the app bars.

**What are the main features of the Windows 8 Start screen?** The Start screen is based on the interface for Windows smartphones. The most useful feature of the Start

a




b

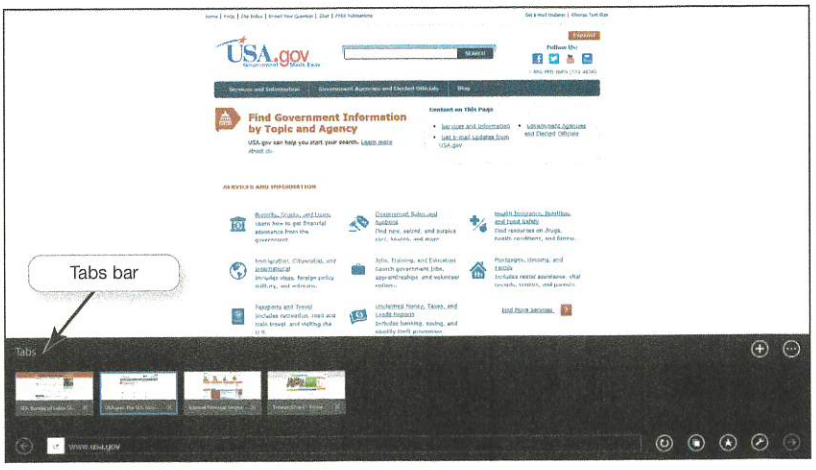



FIGURE 5.17 (a) Internet Explorer 11, a Windows 8 app, displays full screen. (b) Right-clicking on the Internet Explorer 11 screen displays the open Tabs bar.

screen is that it lets you customize it to meet your needs. (For more on customizing the Start screen, see the Try This feature on pages 176–177.) As such, the Start screen on your computer may be different from the Start screen on your friend's computer. And because your Windows 8 settings and preferences are saved in your Microsoft account, when you log on to any Windows 8 computer, you'll see your own personal settings, preferences, and applications reflected on the Start screen (see Figure 5.18).

For performing common tasks, such as searching or sharing information, Windows 8 has created special shortcuts called **charms**. Charms are located on the *Charms bar* (see Figure 5.18b), which you access by moving your cursor to the upper-right corner of the screen, swiping in from the right edge of the screen, or pressing the Windows key+C.

**Why can't I see tiles for certain applications on my Start screen?** Not all the Windows 8 apps and programs installed on your computer are visible on the Start screen. You can choose which applications are visible on the Start screen through a process called **pinning**. Usually, when you install a Windows 8 app or any other program on your computer, it pins the program (displays it) on the Start screen by default. If there is a tile on the Start screen you don't need, just right-click on it (or touch and hold) and select the Unpin from Start option that appears on the shortcut menu.

If you want to see all the applications installed on your computer, not just the ones pinned to your Start screen, click the All programs (apps) button that appears at the bottom of the Start screen (see Figure 5.18a). This displays the Apps screen (see Figure 5.19), which shows all Windows 8 apps and other programs installed on your computer.

**What happened to the Start button from Windows 7?** When using Windows 8.1 for the first time, you might be looking for the Start button, which is not initially displayed on the Start screen. If you leave the Start screen and go to the desktop, you will see the Start button (represented by the Windows 8 logo) in its familiar spot on the taskbar. However, this does not have the functionality of the old Windows 7 Start button. Instead of displaying a list of installed applications, the new Start button merely returns you to the Start screen. Once you have returned to the Start screen from the desktop, moving your cursor to the lower left-hand corner of the Start screen will display the Start button.

**How can I quickly access useful programs and tools that were available from the Windows 7 Start button?** Right-clicking on the Windows 8.1 Start button displays a menu of quick links to common administrative tasks and programs, such as Control Panel, File Explorer, and shutdown options.

**Where is the Windows desktop?** If you've been using versions of Windows prior to Windows 8, you're used to the desktop being the first screen you see on your computer. The desktop from Windows 7 still exists, just in a slightly modified version. You can access the Windows 8 desktop via the

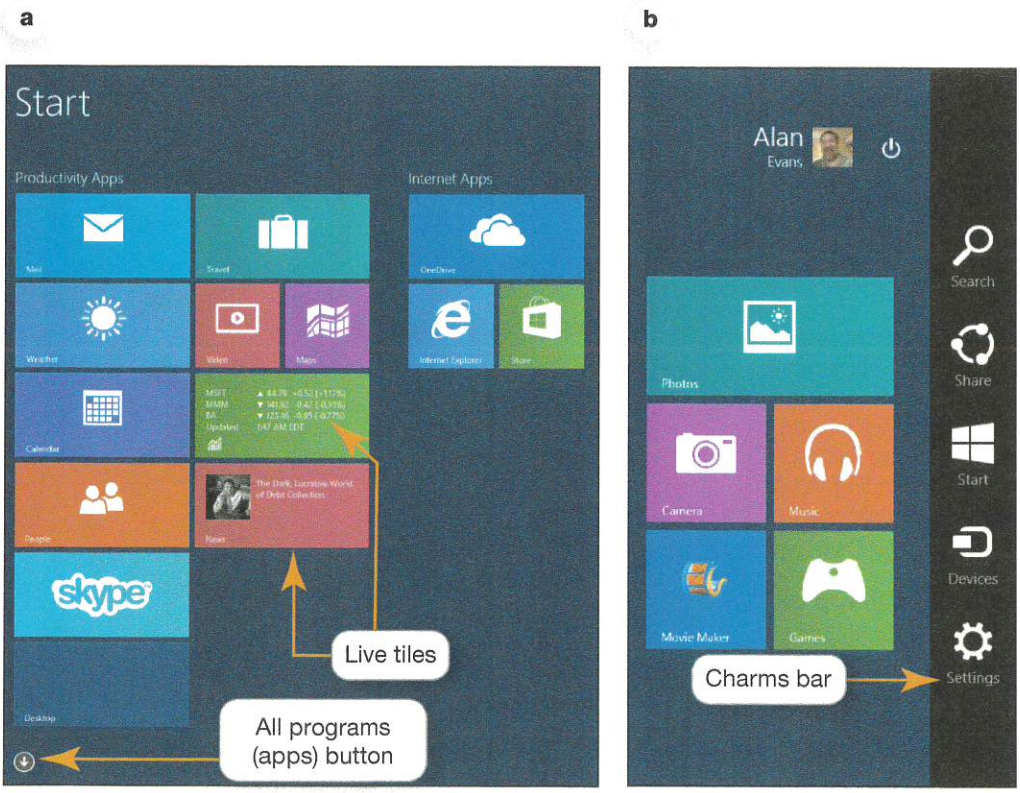



**FIGURE 5.18** (a) The Windows 8 Start screen is the new point of entry to the OS. (b) The Charms bar provides access to common tasks.


**FIGURE 5.19** The Windows 8 Apps screen shows all Windows 8 apps and other programs installed on your computer.

Desktop icon on the Start screen or by pressing the Windows key+D. Programs that have not been designed to run in the Windows 8 interface (like Microsoft Office 2013) will run on the Windows 8 desktop.

The desktop still has features like the taskbar. The **taskbar** displays open and favorite applications for easy access. You can point to an icon to preview windows of open files or programs, or move your mouse over a thumbnail to preview a full-screen image. Or, you can right-click an icon to view a Jump List—the most recently or commonly used files or commands for that application.

**How can I switch between apps in Windows 8?** If you want to go back to the last program you were using, just point your cursor to the upper-left corner of the screen and drag (or swipe) from the left. Drag the thumbnail image of your previous program to the middle of your screen and it will be available. Repeatedly swiping from the left will scroll backward through all your open programs.

For a list of open programs—so you can jump right to the correct one—position your cursor in the upper-left corner until the thumbnail appears, then move the cursor down (or swipe in from the left, and before you let go, swipe out again) to display a list of thumbnails of previous programs called a *switch list* (see Figure 5.20). Alternatively, pressing and holding the Alt key and then pressing the Tab key repeatedly also allows you to scroll through open apps.

**How can I see more than one Windows 8 app on my screen at a time?** Windows 8 apps can snap into place on either the left or right side of the screen, so you can easily display two (or more) apps at the same time. Just display the thumbnail list of running apps and click and drag the thumbnail of the second app you want to display to the left or right side of the screen. The app will snap into place while

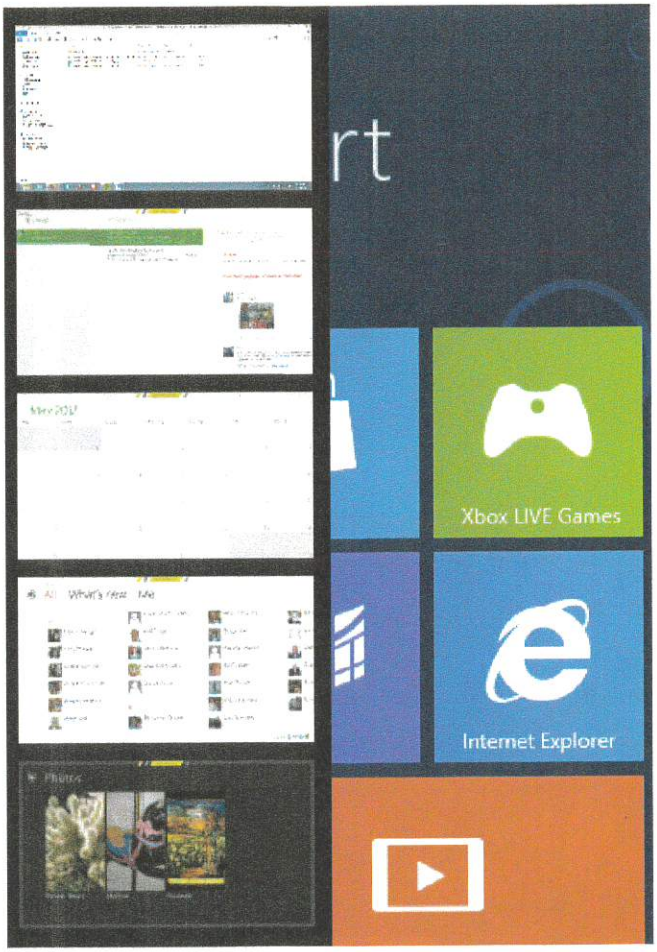



**FIGURE 5.20** Thumbnails of open programs allow you to switch quickly between them.