chapter 1

Introduction to Operating Systems

"Physics is the universe's operating system."

—Steven R. Garman

"I do not fear computers. I fear lack of them."

—Isaac Asimov

"The computer was born to solve problems that did not exist before."

—Bill Gates

Understanding operating systems (OSs) is critical to your future success in life. It is. Just believe us. You don't? You say you drive a car just fine, but you don't understand its engine, transmission, or other systems? So why can't you just use your computer? Why do you have to even know it has an OS? If you can successfully operate a car, you actually know more about its internal workings than you realize. You turn on the ignition, shift to the correct gear, press the accelerator, and drive down the street without hitting anything. You stop it (in time, usually). You use your car to go somewhere, thus making the car your transportation tool. Having only superficial knowledge of the workings of your car is adequate if you never intend to repair your car or to explain to a mechanic the symptoms of a problem. And just as you can use a car without in-depth knowledge of how it works, you can use your computer to write a letter, send email, create a report, surf the Internet, participate in social networking, and much more without understanding operating systems. You only have to know how to turn it on, call up the application program you wish to use, do tasks, and turn it off.

Learning Outcomes

In this chapter, you will learn how to:

- LO **1.1** Describe the purpose and functions of operating systems.
- LO **1.2** Describe major events in the evolution of operating systems.
- LO **1.3** List and compare the common desktop operating systems in use today.
- LO **1.4** List the most common mobile OSs, the devices associated with them, and the features found in most of these devices.

But if you ever want to understand how your car actually works, you need to spend time studying it. And if you want to get the most out of the computers you use in your work, school, and private life, you need to understand how the most critical software component, the computer's operating system, works.

This chapter provides an overview of microcomputer operating systems—specifically, those commonly found on desktop and laptop computers and the personal mobile devices we use today. We'll begin with a brief look at microcomputers—their components and their general types. Then we'll explore the functions that operating systems perform, as well as describe the classic categories of operating systems. Finally, we introduce you to the OSs in all types of microcomputers including those in home and office computers as well as tablets and smartphones.

LO 1.1 An Overview of Microcomputer Operating Systems

An **operating system (OS)** is a collection of programs that controls all of the interactions among the various system components, freeing application programmers from needing to include such functions in their programs. An **application** is software that allows a user to perform useful functions, such as writing a report, picking up email, editing graphics, calculating a budget, and much more. Microsoft Word is an application. Applications only need to send commands to the OS to interact with the hardware. This book explores the common operating systems used in microcomputers, but before we do, let's answer a few general questions you may have: What is a microcomputer? What types of microcomputers are in use today?

A typical PC with components.
Product photo courtesy of Hewlett-Packard.

About Microcomputers

Our friend Brianna uses a PC at work and an Apple iMac at home, and she always has her smartphone handy. She will soon take night classes in which she will use either a tablet or laptop that she will carry to and from school. She wants to learn more about the computers she uses each day, beginning with the hardware.

To understand microcomputers, you need to learn a few technical terms, such as computer, integrated circuit, and microprocessor. A **computer** is a device that performs calculations. Early computers had many mechanical components, but a typical modern computer is an electronic device that can perform a huge number of useful tasks for its owner. Any computer, small or large, has a **central processing unit (CPU)** that performs the calculations, or processing for the computer.

A **microcomputer** is a computer small enough and cheap enough for the use of one person. The CPU in a microcomputer is a **microprocessor**, although many still refer to it simply as a CPU or processor. This miniaturization of computer components became possible through the invention and development of many technologies. One of the most important of those inventions was the **integrated circuit (IC)**, a small electronic component made up of transistors (tiny switches) and other miniaturized parts. These replaced the bulky vacuum tubes in older minicomputers and TVs and in mainframe computers, which were often huge, weighed tons, and used large amounts of power.

Note: Common slang for an integrated circuit is "chip."

Each computer that Brianna and the rest of us use consists of many components, some of which allow us to interact with it. In techie talk, we call interaction with a computer **input/output (I/O)**. When we send something into the computer we call it input. For instance, you are inputting when you type

on the keyboard or tap on a touch screen, and that makes a keyboard or a touch screen an input device. When something comes out of the computer, such as the text and graphics that displays on a screen, the printed results on paper, or music and other sounds, we call it output. That makes both the display screen, printer, and speakers output devices.

In a microcomputer the internal components include at least one microprocessor, **random-access memory (RAM)** that acts as the main **memory** for holding active programs and associated data, **firmware** (software resident in integrated circuits), and various other supporting circuitry, all installed onto a **motherboard**. This last is a circuit board on which the microprocessor, memory, and other components reside and connect to each other. It also has some form of storage, such as a hard drive. Additionally, it has at least one means each for input and output.

System firmware contains program code that informs the processor of the devices present and how to communicate with them. Firmware is an interface between the hardware and the operating system. The system firmware in PCs for most of the last three decades has been **read only memory basic input output system (ROM BIOS)**, which has been replaced by a new standard for system firmware called **Unified Extensible Firmware Interface (UEFI)**. UEFI supports modern computers, while ROM BIOS had many technical limits because it was designed to work with the original IBM PC. UEFI is faster and includes security features that protect the computer during that vulnerable time while an operating system is just starting up and not entirely in control.

Additionally, most components and peripheral devices that connect to a computer (such as the video and network adapters, USB ports, and digital cameras) have their own firmware, which is often limited to small programs for providing basic communication between the operating system and the component. Supplementing or replacing the firmware—even parts of the central system firmware—are device drivers. A **device driver** is a special program installed into an operating system. Each device driver contains code for controlling a component and it is an extension of the firmware, usually allowing much more control of a device than the small programs stored in that device's firmware.

Note: Fortunately, you may never need to be concerned about device drivers because they install automatically in most operating systems.

Although you may never be aware of the firmware on your mobile devices, on an older PC or laptop you may see evidence of the system and other firmware as they perform tests of the hardware. The traditional system firmware test is known as the power on self-test (POST). Carefully watch the screen as you power up the computer, as shown in Figure 1–1 and if status and error messages display in plain text on a black background during startup, they are the result of the POST and the tests of additional firmware on the computer's components. More recent computers may show a message only if there is a serious problem with the computer.

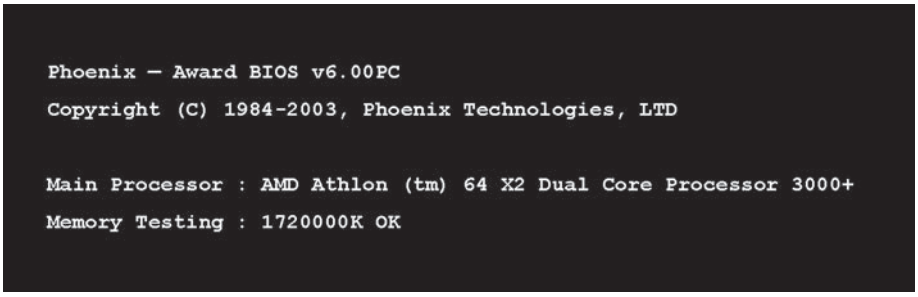


FIGURE 1–1 An example of a firmware start-up message on an older PC.

In general, consumers encountered their first microcomputers in 1977 with the introduction of Apple's Apple II, Radio Shack's TRS-80, and Commodore's PET. It was the Apple II that best combined the critical elements that make up what we considered a microcomputer at the time; these included a keyboard, a monitor, available peripherals, an operating system, desirable and useful applications, and a reasonable price tag.

What Types of Microcomputers Do You Use?

The miniaturization of computers led to computers being built into all types of machinery, including vehicles, aircraft, and appliances. And that is just the short list. Computers touch our lives 24/7, and each has some form of operating system. For our purposes, we will concentrate on the operating systems in desktops, laptops, and mobile devices. We will limit the mobile device OSs to those in tablets and smartphones. Another type of computer that you use less directly is a server. You connect to a server via your personal computers and devices. A server also uses microcomputer technology, but on a larger scale. We describe these types of microcomputers next.

A PC laptop.
Product photo courtesy of Toshiba.

A MacBook laptop.
Product photo courtesy of Apple.

Desktops and Laptops. A desktop computer is a computer designed to spend its useful life in one location—on a desk. A laptop computer has a flat screen and a keyboard, each integrated into a panel with a hinge holding the two together and allowing you to close the laptop and slip it into a case for easy portability. There are many sizes and types of laptop computers. Our discussion of operating systems in this book includes the most common operating systems that run on modern desktop and laptop computers as well as in those in consumer mobile devices. They include Microsoft Windows and Linux for PCs and laptops, and Apple's Mac OS X, which runs on Apple desktop and laptop computers. The same version of the Windows OS will run on a desktop, a compatible laptop computer, or a compatible tablet.

In the decades since the introduction of the IBM PC in 1981, the majority of desktop and laptop computers used in private and public organizations have used Microsoft operating systems, with computers running versions of Apple's operating systems a distant second. In recent years however, Apple desktop and laptop computers have made great gains in market share, but Apple's real advances have been in their mobile products.

Mobile Devices. Microcomputers today include a long list of devices that don't have *computer* in their name, including mobile devices that are often proprietary, comply with no, or very few, standards in their design, but are still microcomputers because they contain microprocessors. They use wireless technologies and include a wide variety of products ranging from simple handheld computers to multifunction mobile devices, such as those used in grocery stores to track inventory. Many mobile devices run proprietary OSs, while others run scaled-down versions of desktop OSs. A mobile device stores its OS in firmware, as an **embedded OS**.

The most popular mobile devices are smartphones. A **smartphone** works as a cell phone, but also lets you connect to the Internet, view your email, and install and run a variety of apps for entertainment, education, and work. Modern smartphones have high-quality touch screens. Examples of smartphones are Apple's iPhones, RIM's BlackBerry products, and various models by Motorola, Nokia, HTC, Samsung, LG, and others. Examples of operating systems designed specifically for use on smartphones include Google's Android,

Note: In this book we use the term **personal computer (PC)** for a desktop computer running Windows or Linux and **Mac** for the Apple iMac desktop computer as well as the MacBook laptop computer. Both types of Apple computers run Mac OS X.

Palm's webOS, Apple's iOS, and Windows Phone.

Another very popular type of mobile device is a tablet. A **tablet** has a touch screen, no integrated keyboard (usually), is larger than a smartphone, and is much more portable than a laptop. There are many lines of tablet products, including the Apple iPad, Microsoft's Surface and Surface Pro, Samsung Galaxy Tab, Nexus 7, Sony Xperia, Asus Transformer, Kindle Fire, BlackBerry Playbook, and HP Slate2. The tablet operating systems we will study in this book are Apple iOS, Google Android, and Microsoft Windows 8.

try this!

More About Tablets

The tablet market changes quickly. Check out what is happening with tablets. Try this:

1. Using your PC, laptop, tablet, or smartphone, open a browser and (using a search engine such as Google, Bing, or Yahoo) search on the key words "tablet reviews."
2. Browse through the sites you find in the list of results, selecting recent reviews.
3. Read a few of the reviews to learn about the latest tablet features and comparative pricing.
4. Describe to a classmate how you would (or do) use a tablet at school or work.

Servers. On a small network you can use a PC or Mac as a **server**, a computer that provides one or more services to other computers, which is why it is called a server. What services do servers provide? When we use a server to store data files for network-connected users, we call it a file server. If a server has one or more printers connected to it that it shares with users on the network, it is a print server. We call a server doing both tasks a file and print server; even though it sounds like two services, they combine into one service called a file and print service.

Other services include messaging services (email and fax), Web services, and many, many others. It takes specialized software to provide each type of server service, and complementary client software to request each type of service over a network. A server can offer multiple services at the same time while also being a client to other servers.

We call a computer on the user end of network services a **client**. Today's client computers include the PCs, laptops, tablets, and smartphones discussed in this book.

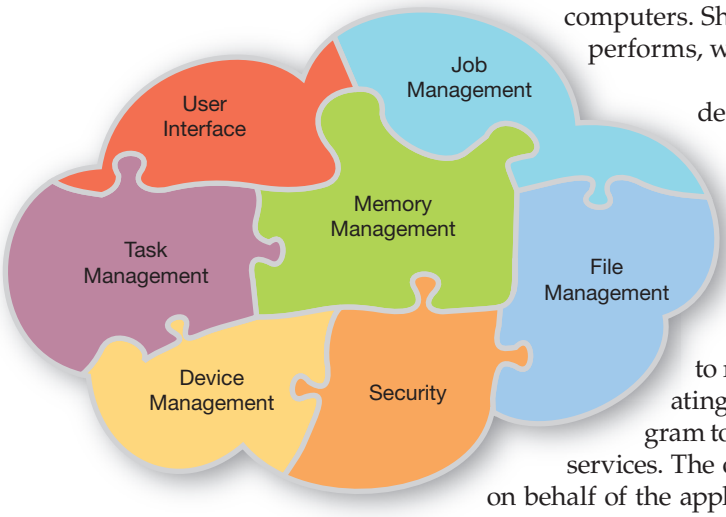
A desktop or laptop computer can act as a server for a few network clients. However, a server to which hundreds or thousands of clients must connect requires much more capable hardware to provide more storage, faster processing, and faster network access. Such a server also requires specialized software, beginning with the operating systems. There are versions of Windows, Apple Mac OS X, Linux, and UNIX especially designed for servers. The hardware for a high-quality server can run into the tens of thousands of dollars and upward, versus the much lower cost of a consumer-grade PC at a few hundred dollars.

Note: Nokia Corporation is the manufacturer of the popular Lumia line of Windows 8 phones. In September 2013 Microsoft Corporation and Nokia Corporation announced Microsoft's planned purchase of all of Nokia's Devices and Services business, as well as their planned licensing of Nokia's patents, and licensing and use of Nokia's mapping services. At this writing, the transaction is expected to close in the first quarter of 2014.

Note: The focus of this book is on using common desktop, laptop, and mobile operating systems. Therefore, it does not include details of server operating systems.

Functions of Microcomputer Operating Systems

When using her PC at work or her Mac at home our friend Brianna spends much of her time in a specific application, such as a word processor, a graphical drawing program, or a Web browser. However, she must also perform tasks outside of these applications, beginning with the simple task of logging onto the computer, launching an application, and managing files. But, because each of these different computers requires different ways of doing things, she wants to gain a better understanding of the OSs so that she can both perform better on the job and feel more comfortable while working on the various



The functions of an operating system.

computers. She wants to learn what an OS is and what functions it performs, which we describe in the following sections.

An operating system is loaded (or "booted up," a derivation of the expression "lifting yourself by your own bootstraps") when a computer is turned on. Its main component, the **kernel**, remains in memory while the computer is running, managing low-level (close-to-the-hardware) OS tasks.

When a programmer, also known as a "developer," writes an application, he or she designs the application to interact with the operating system and to make requests for hardware services through the operating system. To do this, a programmer must write the program to use the correct commands to request operating system services. The operating system, in turn, interacts with the hardware on behalf of the application and fulfills the requests the application made. An operating system performs several functions. We'll study them next.

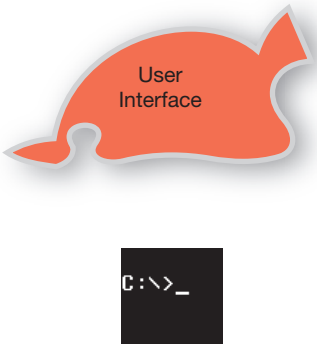


FIGURE 1–2 The DOS prompt.

User Interface

The **user interface (UI)** is the software layer, sometimes called the shell, through which the user communicates with the OS. The UI includes the command processor, which loads programs into memory, as well as the many visual components of the operating system (what you see when you look at the display). On a computer running DOS (a legacy OS) or Linux (without a graphical shell), this visual component consists of a character-based command line that provides only sparse amounts of information. This is the **command-line interface (CLI)**. Figure 1–2 shows the classic DOS prompt: white characters against a black screen, with a blinking **cursor** waiting for you to type a command at the keyboard. A cursor in a CLI is merely a marker for the current position where what you type on the keyboard will go. Further, only a limited set of characters can appear on the screen, each in its own little equal-sized grid of space.

To become proficient at working in a CLI, you must memorize the commands and their modifiers and subcommands. On the other hand, Apple's Mac OS, Microsoft's Windows, and even mobile operating systems each provides an information-rich **graphical user interface (GUI)**, fully integrated into the operating system. It is through this GUI that you communicate with the OS and the computer. The GUI offers menus and graphical icons (small graphics) that allow you to use a pointing device to select programs to run and to perform many other tasks, such as opening a word processor file.

Although you do not have to memorize commands, working within a GUI does require learning the meaning of the various graphical pieces that make up the GUI and how to navigate among them to access your programs and data. In addition, you must learn how to activate a program (start it running) so that you can get your work or play done. Figure 1–3 shows a GUI screen. Notice the icons and other graphical components, such as the bar at the bottom containing the button showing the Microsoft logo and the arrow-shaped pointer in the open menu at left above the bar. In a GUI you move a graphical pointer around using a pointing device—usually a mouse, trackball, or touch pad. The pointer allows you to select or manipulate objects in the GUI to accomplish tasks. For example, to delete an item, you drag it into the recycle bin. By contrast, in a CLI, you would type a command such as "delete report.txt."

Note: Although Linux traditionally had a CLI, most current versions of Linux for the desktop come with both CLIs and GUIs.

Job Management

Job management is an operating system function that controls the order and time in which programs run. Two examples of programs that may take

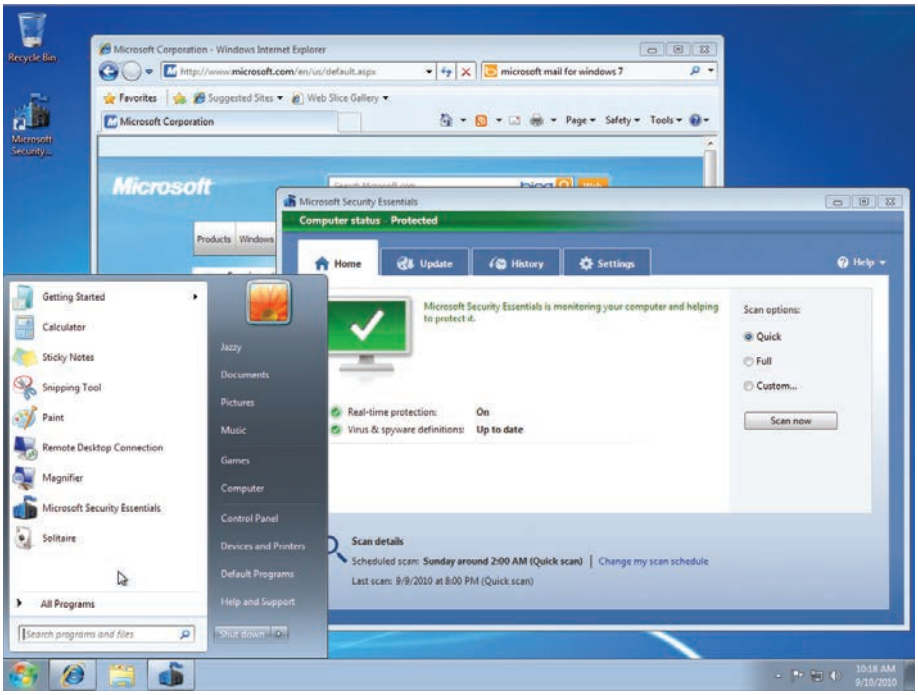


FIGURE 1–3 A typical GUI screen.

advantage of this function are a scheduling program that schedules other programs or batch files to run on a certain day and time, and a print program that manages and prioritizes multiple print jobs.

Task Management

Task management is an operating system function found in multitasking operating systems. **Multitasking** implies that a computer is running two or more programs (tasks) at the same time. In reality, a computer cannot simultaneously run more tasks than the number of processors that exist within the computer. Until recently, most microcomputers had only a single processor, so they accomplish multitasking through a scheme that makes order out of chaos by determining which program responds to the keystrokes and mouse movements. New processors can have multiple CPUs within a single chip, so they have true multitasking.

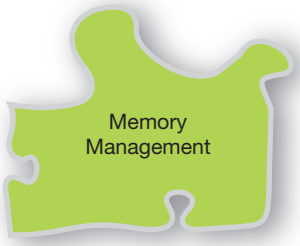
Task management controls the focus (where the system's attention is at any given moment). It also allows the user to switch between tasks by giving the focus to the application the user brings to the foreground. In most graphical operating systems, the foreground application runs in the current window, the window that is on top of other windows on the screen and the window that receives input from the keyboard when the user types. Any program or application may include many small components called **processes** when they are active in memory. The OS's task management function manages individual processes.

try this!

View Active Tasks in Windows or Mac OS X

You can see what tasks are running on your Windows or Mac OS X computer. Try this:

1. On a Windows computer with a keyboard, press Ctrl-Shift-Esc to open Task Manager, a utility that lets you view tasks as running applications and their processes. Select the Processes tab and notice the large number of active processes.
2. On a Mac OS X computer press Command+Spacebar to open the Spotlight search box, and then type "activity" and select Activity Monitor from the results list. Notice the list of processes in the column labeled Process Name.



Memory Management

Memory management is an operating system function that manages the placement of programs and data in memory, while keeping track of where it put them. Modern operating systems use a scheme for making optimal use of memory, even allowing more code and data to be in memory than what the actual physical system memory can hold. Using a memory management OS component called the virtual memory manager, operating systems move code and data, as necessary, to a portion of the disk defined as **virtual memory**, meaning that this disk space is used as if it were memory, not just disk storage space. The OS performs this transfer for code and data that are part of any program that currently does not have the user's attention because this now-unneeded information does not have to be kept in RAM for immediate use, so other programs that do need to use the memory can do so.

Note: The memory management function may not be included in every definition of an operating system, but it is a very important function, especially in the Windows, Macintosh, and Linux operating systems described in this book.

File Management

File management, also referred to as data management, is an operating system function that allows the operating system to read, write, and modify data, while managing the logical storage of the data. Each operating system has at least one scheme of logical organization, called a file system. A **file system** is the logical structure used on a storage device (hard disk, optical disc, thumb drive, etc.) for managing and storing files. The file system also includes the program within an operating system that allows the OS to store and manage files on a storage device. When an operating system uses a technique called **formatting**, it writes the logical structure to a storage device. The operating system maps the logical organization of the file system to physical locations on the storage device, most often a conventional hard disk drive or **solid-state drive (SSD)**, so that it can store and retrieve the data. The logical structure of a file system stores metadata, which is data about the stored files.

Solid-state drives (SSDs) use integrated circuits, which the computer can write to and read from much faster than conventional hard disk drives and optical drives. We also call such storage solid-state storage. SSDs come in many forms, such as a tiny card installed inside the case of your tablet or smartphone, or a flat device, measuring about ¾ inch by 2 inches (or smaller) that you plug into a computer's USB connector. These are often called a thumb drive, jump drive, or flash drive.

Normally, a single storage device will have only a single file system, residing in a single area defined as a **partition**, but some operating systems allow a storage device to have more than one partition. A partition may be an entire drive volume or just a portion of a drive, and an operating system automatically assigns some identifier, such as C for the first hard drive recognized by DOS and Windows. These OSs follow the drive letter with a colon, so that a complete drive name may be C:. We call this a logical drive.

Within the logical structure of a file system, data is organized into entities called files that are saved to storage devices. File management also allows users to organize their files, using other special files that act as containers. One of these special files, called a **folder** or **directory**, can contain lists of files as well as other folders, along with the physical location of the files and folders.

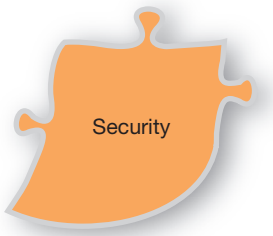
Device Management

The **device management** function controls hardware devices by using special software called device drivers that are installed in the operating system. Device drivers are unique to the device, and the manufacturer of the device creates them to work with a specific operating system. For instance, a printer or video adapter will come with drivers for several different operating systems.

The device driver contains the commands understood by the device and uses these commands to control the device in response to requests it receives from the operating system. An operating system needs a component-specific device driver for each unique hardware component with which it interacts.

Security

The **security** function of an operating system provides password-protected authentication of the user before allowing access to the local computer and may restrict what someone can do on a computer. This protects the computer and the data it contains from unauthorized access. For example, Rachel is the accounting clerk in a small company. She has confidential information on her computer, and she doesn't want just anyone to be able to walk up to her computer and access the information stored there. Rachel can set up her computer so that anyone getting into it must log on with a user name and password from a user account. A user account is nothing more than a name and an associated password stored inside the PC. Security is a large topic—one that would take many books and weeks of your time to really master—but to go much farther in this book without addressing computer security would be foolish, so Chapter 2 is devoted to computer security basics. There you will learn about threats to computers, what security is built in to the operating systems discussed in this book, and the steps you can take to protect yourself from threats.



How Much Memory Can an Operating System Use?

We call an operating system that can take advantage of the addressing and processing features of a processor an *x*-bit OS, referring to the number of bits the OS (using the processor) can manipulate at once. The original MS-DOS was a 16-bit OS, as was Windows 3.0 and its sub-versions. Windows 95, Windows 98, and Windows Millennium edition were really hybrids, with mostly 32-bit pieces but some 16-bit pieces for downward compatibility. Windows XP had a 64-bit version, but it was not widely used, and you are unlikely to encounter it. The Windows versions, Mac OS X, and Linux OSs we discuss in this book are available in both 32-bit and 64-bit versions.

All things being equal, the 64-bit version of an operating system will be faster than its 32-bit counterpart, but the biggest difference between the 32-bit and 64-bit versions of Windows is in the number of unique locations (the address space) a CPU can assign to both system RAM and other RAM and ROM in your computer. A 64-bit CPU can have a theoretical address space of 2^{64}, or 9.2 quintillion (nine followed by 18 digits). Windows does not use the maximum theoretical address space of a CPU, as shown in Table 1–1.

try this!

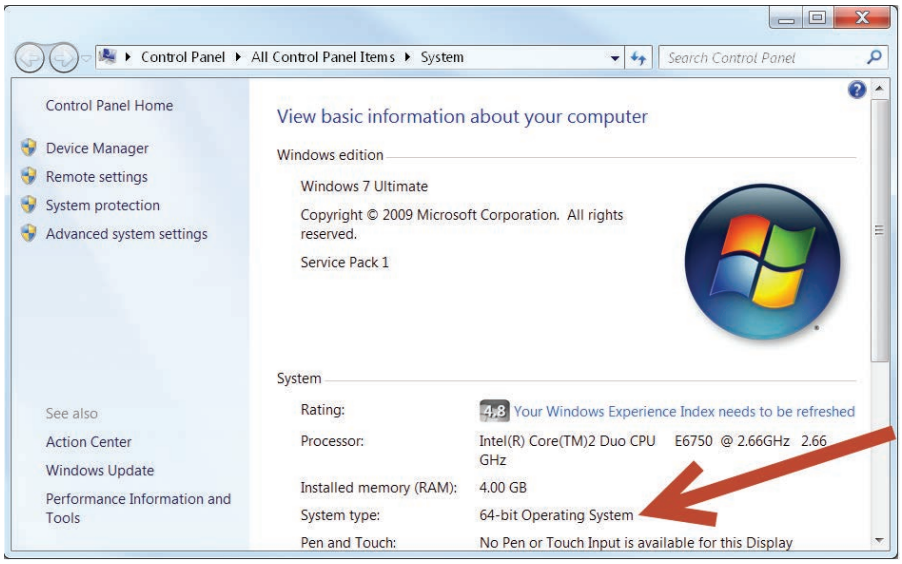
Are You Running 32-bit or 64-bit Windows?

If you have a Windows 7 computer handy, see if it is running a 32-bit or 64-bit version. Try this:

1. In the Start menu's Search box type "system."
2. In the search results list locate Control Panel and select "System." Do *not* select System Information.
3. This opens Control Panel to the System page.
4. The System Type field will say "32-bit Operating System" or "64-bit Operating System."

TABLE 1–1 Windows Memory Limits

Edition	RAM Limit in 32-Bit Version	RAM Limit in 64-Bit Version
Windows 7 Ultimate/Enterprise/Professional	4 GB	192 GB
Windows 7 Home Premium	4 GB	16 GB
Windows 7 Home Basic	4 GB	8 GB
Windows 8	4 GB	192 GB



Find the operating system type in the System page of Control Panel.

A 64-bit operating system requires 64-bit drivers, and some 32-bit applications may not run, although Microsoft has offered ways to support older applications in each upgrade of Windows. If you purchase a new computer today with either Windows or the Mac OS preinstalled, it is most likely to be a 64-bit OS.

Note: The timeline running along the bottom of the next several pages shows highlights of computing history. Some are described in this chapter. Many are not.

LO 1.2 Yesterday's Operating Systems

Sometimes people think that they can simply take the newest and best computer or other gadget and make it work without understanding anything about how it came to be. Well, they probably can. But they probably can't fix

1968 At the Fall Joint Computer Conference in San Francisco, Douglas Engelbart of Stanford Research Institute demonstrates the use of a mouse to move a "bug" around a screen.

1969 A small group at Bell Labs works on what eventually becomes the UNIX operating system.

ARPANET is created, the first step in the building of the Internet.

1970 Xerox opens Palo Alto Research Center (PARC).

Intel creates the 4004 processor, leading the way to the birth of the microcomputer.

IBM introduces the floppy disc.

1973

PARC creates the Altos, the first "personal computer" with a GUI, laser printer, and a connection to the first Ethernet network.

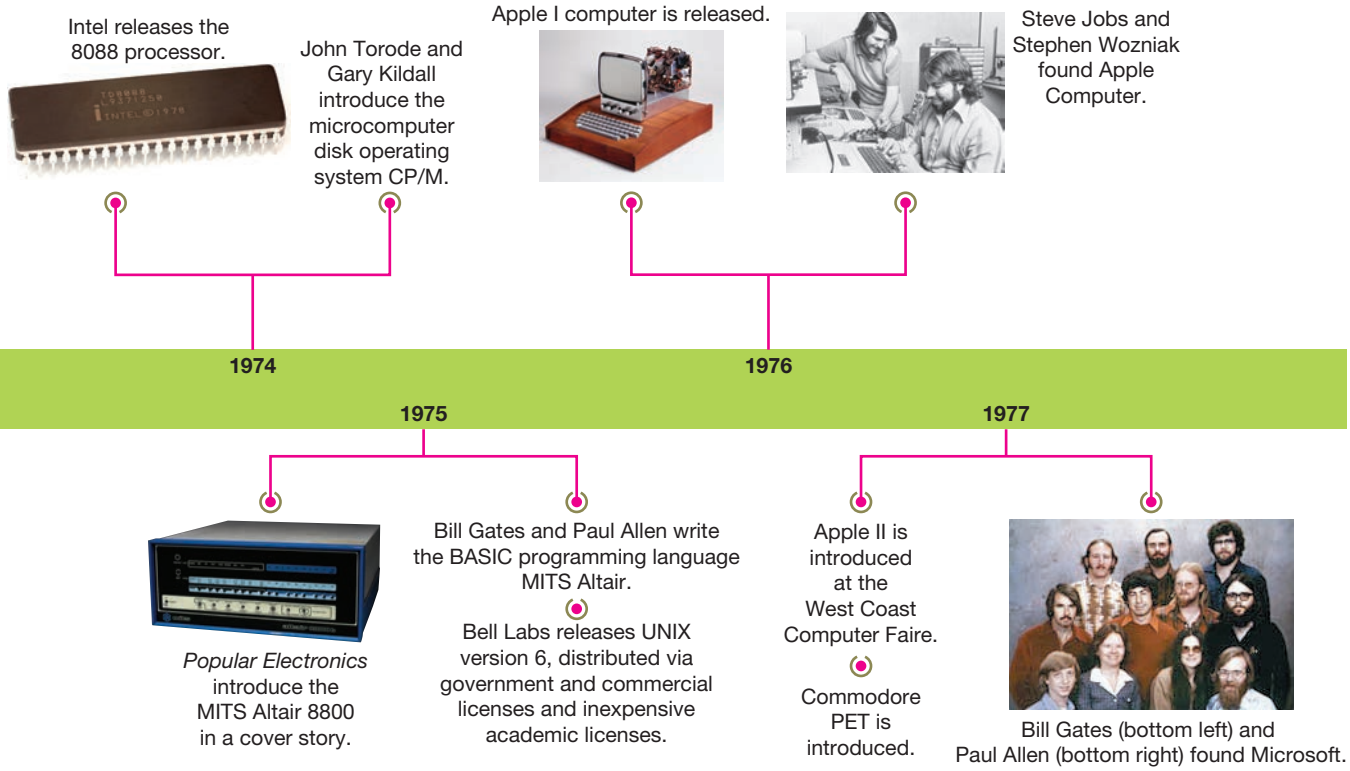
The first portable telephone handset is invented at Motorola by Dr. Martin Cooper.

it, modify it, or use it effectively without understanding how and why it came to be in the form it's in now. One really can't understand current PC technology without having a grasp of older PC technology. In other words, studying history is important to understand how we arrived at today. We'll begin with UNIX, arguably the oldest OS still in use today, with beginnings that predate microcomputers. Then we'll explore the history of computers leading to today's PCs and Mac desktop computers and the operating systems that evolved for each of these hardware platforms.

UNIX—The OS for All Platforms

UNIX has a longer history than any other popular operating system, and it is still in use today. In fact, Apple's Mac OS X is a certified UNIX operating system. UNIX grew out of an operating system developed for an early Digital Equipment Corporation (DEC) computer and went through several generations of changes before it emerged from the Bell Labs Computing Science Research Center (Bell Labs) as UNIX version 6 in 1975, a portable operating system for minicomputers and mainframe computers. A **portable operating system** is one that you can use on a variety of computer system platforms, with only minor alterations required to be compatible with the underlying architecture. Minicomputers and mainframe computers allowed multiple remote users to connect and use the computer's resources, and UNIX supported the time-sharing and multitasking features that made this possible.

The University of California at Berkeley licensed UNIX, modified it, and distributed it to other schools as Berkeley Software Distribution (BSD) version 4.2. Later versions followed. The schools paid licensing fees to Bell Labs. Students and others improved on and added to UNIX, freely sharing their code with each other. This tradition still prevails today with such versions of UNIX as Free BSD, Net BSD, Open BDS, and Open Solaris. Commercial versions of UNIX today include AIX, OpenServer (derived from SCO UNIX), and HP/UX.



try this!

Research the History of UNIX

Read a history of the UNIX operating system.
Try this:

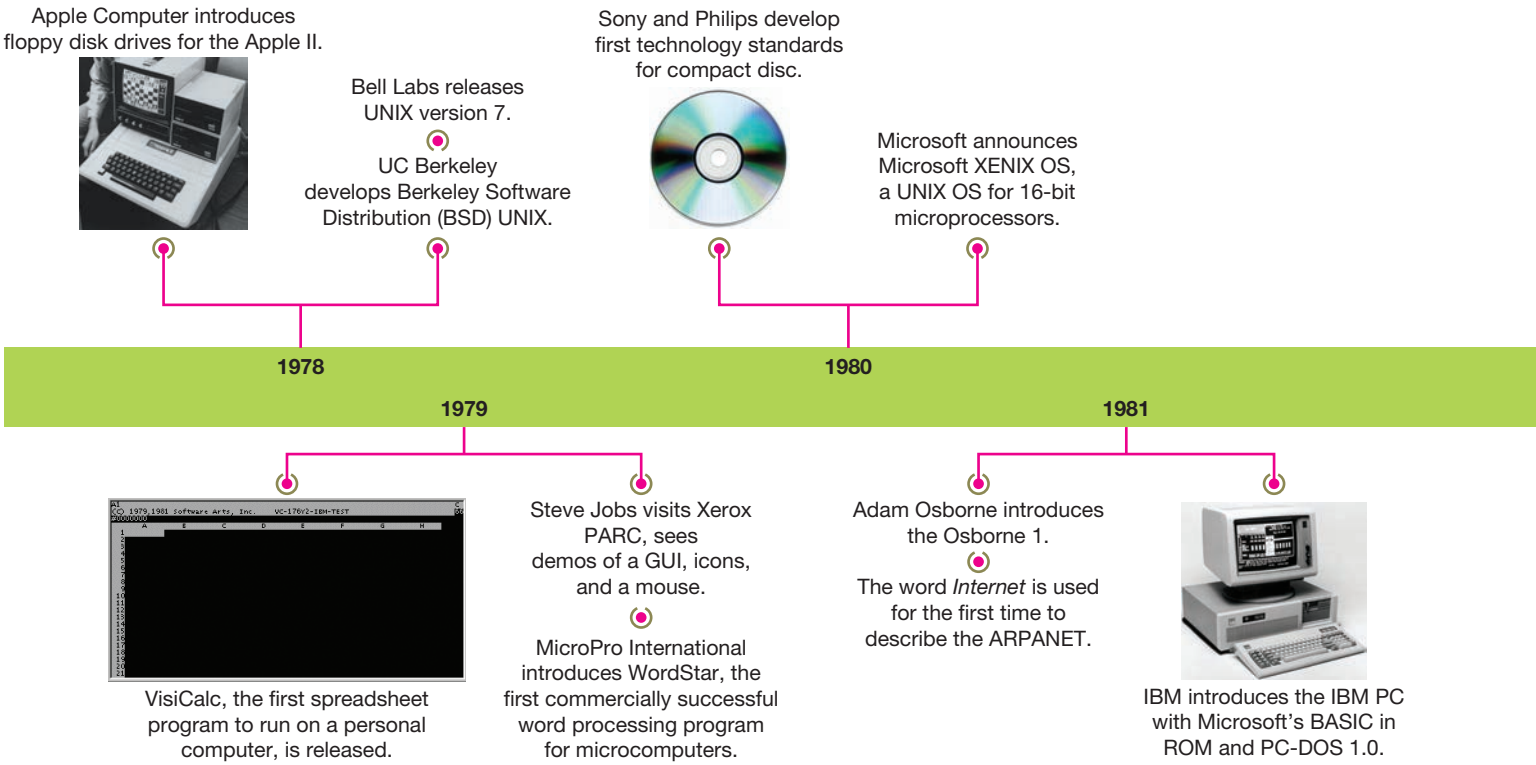
1. Enter **www.bell-labs.com/history/unix** into the address box of your Web browser.
2. Read the article "The Creation of the UNIX Operating System."
3. Read about the contributions of Dennis Ritchie and Ken Thompson.
4. Then point your browser to **www.unix.org/what_is_unix/history_timeline.html** to see a timeline of UNIX history.

Today UNIX is still used on very large computer systems (referred to as mainframes) and less commonly on Intel desktop systems, as well as on a variety of midsize computers. Versions of UNIX run on many of the world's Internet servers. Most versions of UNIX also offer several different user interfaces. Some use character mode, like the traditional shells, such as the Bourne shell and the C shell. Others use a graphical interface such as GNOME or KDE. As mentioned earlier, Apple's Mac OS X operating system is based on a version of UNIX, and it has a graphical user interface.

Even fierce UNIX advocates do not see UNIX taking over the desktop any time soon. However, it is very secure and stable. Versions of UNIX run on many of the world's Internet servers.

The Evolution of Desktop Operating Systems

The complex and powerful operating system like what you see on your desktop, laptop, or mobile devices didn't just magically pop into someone's head. An operating system as a separate entity didn't exist in the early years of digital computing (defined roughly as from World War II into the 1950s). Each computer was dedicated to a single purpose, such as performing trajectory calculations for weapons or mathematical analysis for a science lab, in addition to the system I/O functions. Loading a new program into a computer was a time-consuming process, and the software had to include system functions as well as the main purpose of the computer.



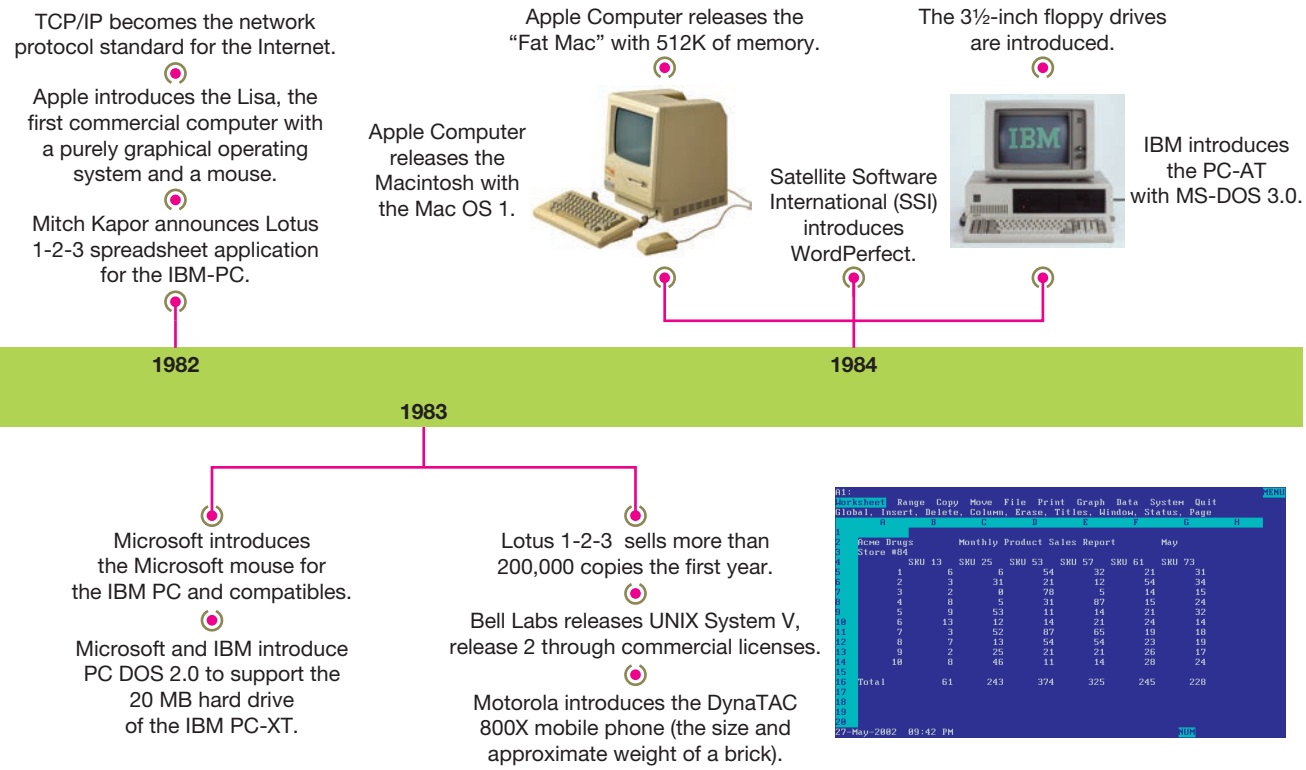
Operating systems evolved through many small steps over several decades, some in the form of technical advances and others in evolutionary changes in how people used computers, especially as they saw the need to use computers as multipurpose devices. The "user," at first a government agency, research institute, or large business, would define the computer's purpose at any given time by the program chosen to run. In the 1950s, some early "operating systems" managed data storage on tape for mainframe computers, but it was much more common for application programmers to write system I/O routines (the stuff of today's OSs) right into their programs. By the mid-1960s, as disk systems became more common on large computers, we needed operating systems to manage these disks and to perform other common system-level routines.

The computer enthusiasts who bought the earliest microcomputers of the 1970s, such as the MITS Altair 8800, were infatuated with the technology. What we now consider slow CPU speeds, very limited memory, clumsy I/O devices, and lack of software was exciting and new technology at the time. They would network with like-minded people, have informal meetings and discussions, and then gather in self-help groups and form clubs such as the Home Brew Computer Club in California's Silicon Valley. They shared their techniques for creating hardware and programming language software for these computers. Almost every one of these early microcomputers exceeded the expectations of their makers and users, but before long, and for a variety of reasons, most of the early entrepreneurial companies and their products disappeared.

Note: The MITS Altair 8800 was an important predecessor to the Apple II, TRS-80, and PET computers. Although featured in a cover article of the January 1975 issue of *Popular Mechanics*, it was not for ordinary people. Whether you bought the $395 kit or the fully assembled $495 version, the input method was switches that you flipped to program it, and the result of these efforts (the output) was a pattern of blinking lights. As a portent of the future, the Altair 8800 gave Bill Gates and Paul Allen their very first sale of the computer language of BASIC.

Software Versions

A software **version** is a unique level of an operating system. When a software publisher creates an entirely new OS, they give it a version number, usually 1.0. Software publishers constantly receive feedback from customers about problems and the need for particular additional features in each OS. In response,



Note: A software version by any other name, such as Snow Leopard or Windows 7, is still a version and still has a number. Sometimes you just need to look for the number.

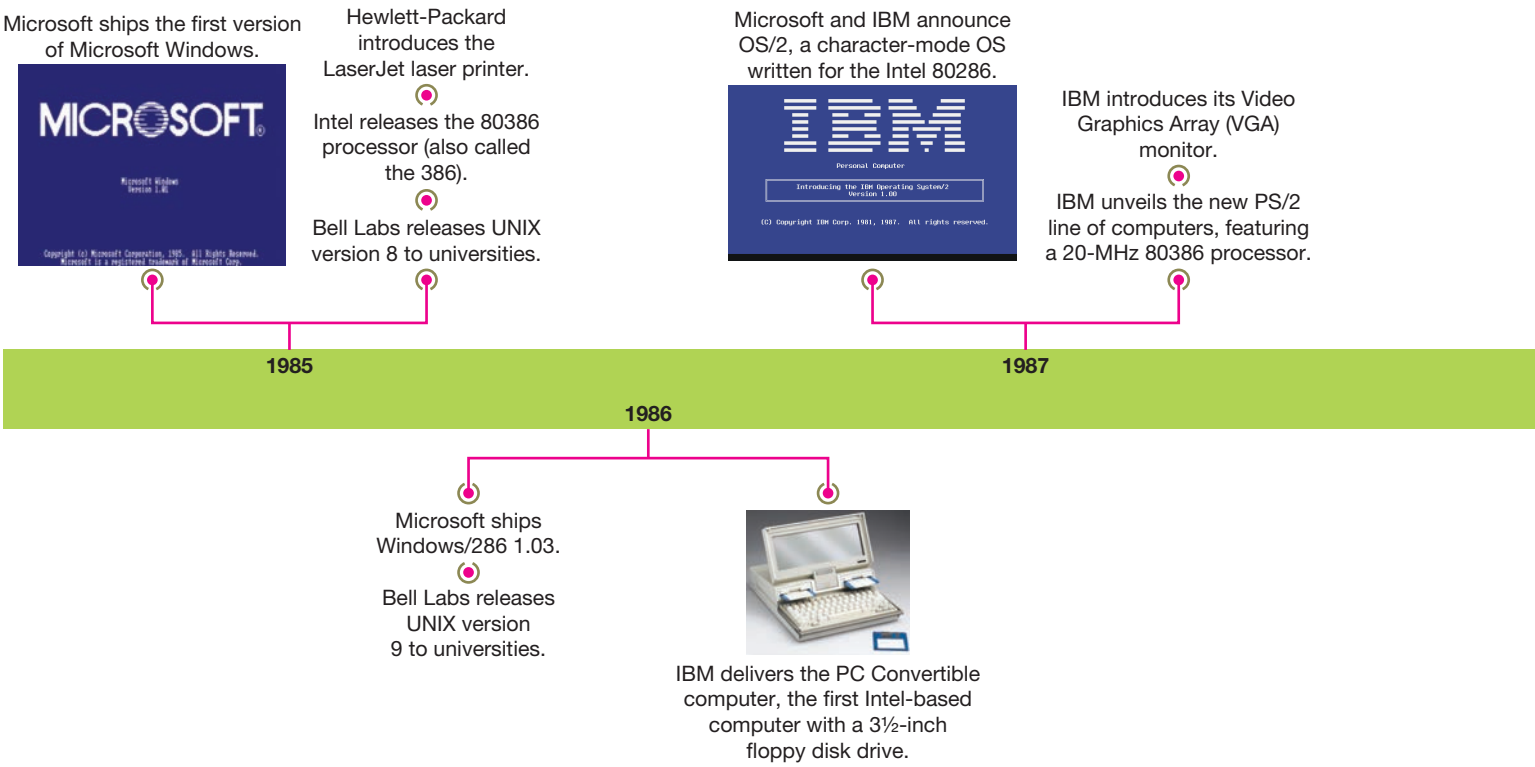
a publisher often introduces a modified version of the original product, in which case the number to the right of the decimal point will probably change (say, from version 1.0 to version 1.1—people often abbreviate *version* as simply "v"). An entirely new version number (2.0, 3.0, . . .) generally reflects an important change to an OS with major changes to the core components of the operating system as well as a distinctive and unifying look to the GUI.

The Killer App for PCs

For a microcomputer to truly become a successful, widely accepted product—used in businesses as well as by hobbyists—it had to be a tool that performed an important task; it had to have an application that many people needed enough to purchase a computer. We call that application a killer app.

One of these important tasks was spreadsheet calculations. Before microcomputers, people created spreadsheets manually, on large sheets of paper. They would enter a column of numbers—say, sales for one product in a drugstore—day-by-day for a month. Then they would add up the daily columns to get the total sales for that product for that month. The next column was for the next product, and so on. The process was tedious and error prone, but very valuable to the manager of the drugstore.

Thus, when VisiCalc, an electronic spreadsheet program, appeared it became a very successful application. It automated this thankless job, remembered the formulas for the calculations, and allowed people to recalculate a whole column of numbers after a single change was made. VisiCalc did more than this. It gave people a reason to want a personal computer. Many people were introduced to VisiCalc on the Apple II computer (running the Apple OS), and this contributed to the success of the Apple II in the late 1970s. However, as the 1980s arrived, Apple failed to come out with a successor to the Apple II in a timely fashion. So, when IBM introduced the IBM PC in 1981, the market was ready for a new microcomputer and VisiCalc was modified to run on the IBM PC.



The IBM PC Operating System

Another fateful series of events revolved around the choice of an OS for the IBM PC. IBM representatives came to Microsoft, then a fledgling software company, for the Microsoft BASIC interpreter, which other machines were using at that time. The result of that visit was that IBM licensed Microsoft's BASIC interpreter and installed it in the ROM of the IBM PC. The IBM folks also talked to Bill Gates about providing an OS; but he did not have one, and so he sent them to another company, Digital Research, the creators of the then-popular CP/M OS. Digital Research, however, refused to sign a contract with IBM, so the IBM guys went back to Bill Gates for the OS. Consequently, Microsoft bought an OS from another company, and this was the basis of the first versions of IBM PC DOS.

The IBM PC far exceeded IBM's sales forecast, which was for about a quarter of a million units during the predicted five-year lifetime of the product. According to one account, IBM took orders for half a million computers in the first few days after introducing the IBM PC. At first many enthusiasts bought it despite its roughly $5,000 price tag for a typical configuration. Additionally, the IBM name behind the product also inspired many business users to buy it because this name implied that it was a serious business computer.

Note: Want to learn more about the early history of PCs? Our favorite book on the subject is *Fire in the Valley: The Making of the Personal Computer* (ISBN 0-07-135892-7).

try this!

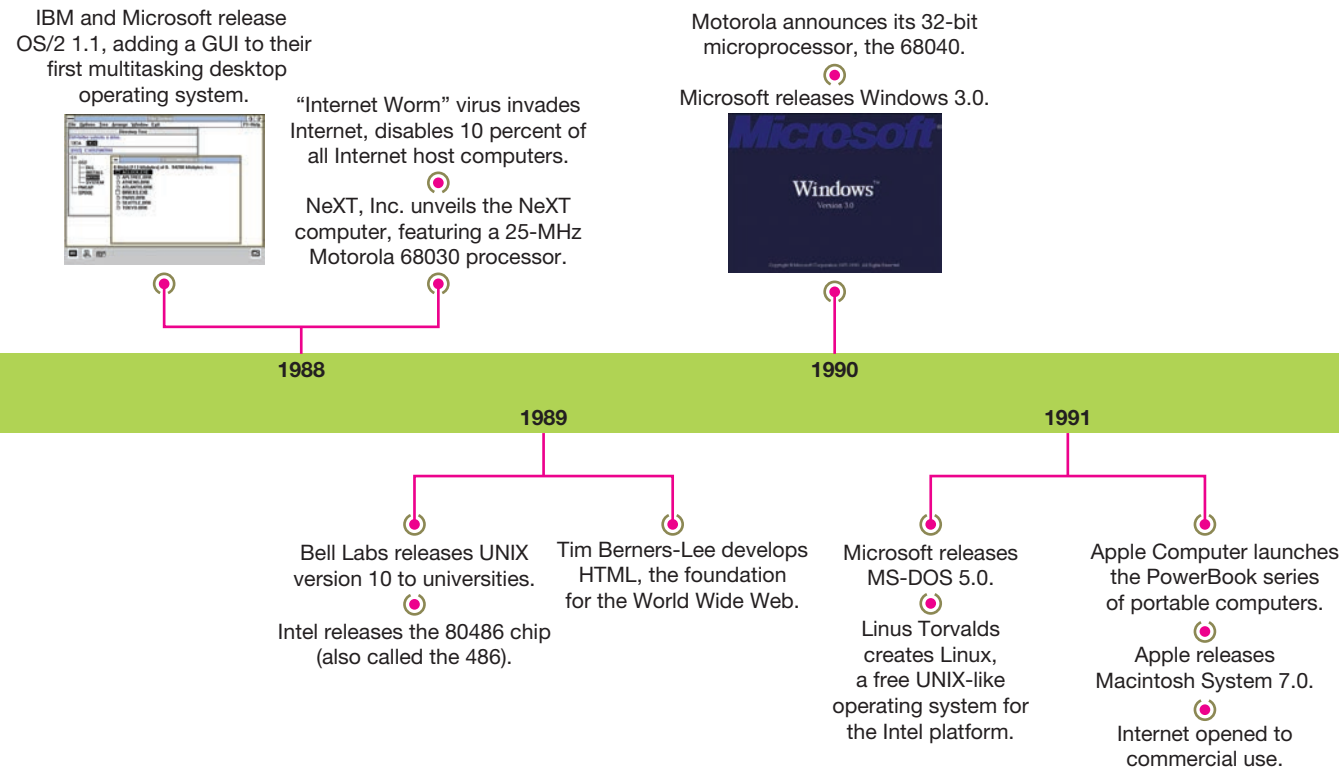
Watch Old TV Commercials for the IBM PC and Lotus 1-2-3

It has been over 30 years since the introduction of the IBM PC in 1981 and the killer app Lotus 1-2-3 in 1983. See how these products were introduced to the public in TV advertisements. Try this:

1. Point your browser to http://mentalfloss.com/article/48627/lotus-1-2-3-three-decades
2. Read the article and watch the first two videos. Some of us can verify the accuracy of the portrayal of office workers at the time (except for the singing and dancing part).
3. The third video is a 30-minute Lotus 1-2-3 training video. Watch at least enough of the video to see some of the features in Lotus 1-2-3.
4. The fourth video reviews the history of Lotus 1-2-3 with great clips of the news coverage and events and people behind the product.

The Second Killer App for PCs

Although many say that just having the letters *IBM* on the box was what sold that computer, the groundwork laid by VisiCalc left people ready for what was arguably the second



Note: Through the 1980s, PCs with DOS and a variety of DOS applications made great inroads into organizations of all sizes. In the decade after its introduction, thousands of applications were written for DOS, but Lotus 1-2-3, dBase (database management), and WordPerfect (word processing) were the de facto business standards at the end of that decade. All contributed to the mass adoption of PCs at work, at school, and at home.

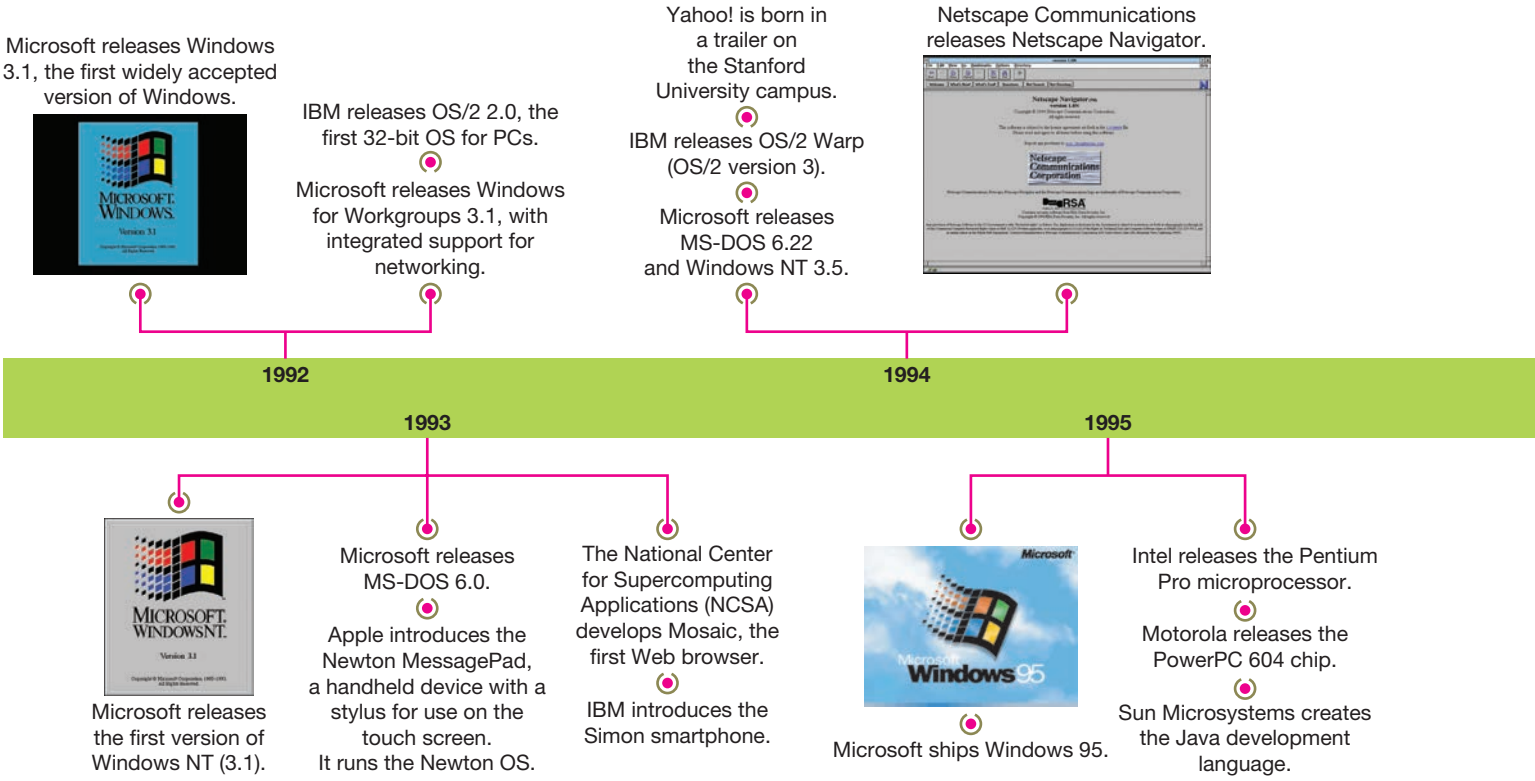
killer app, Lotus 1-2-3 by Lotus Corporation. Introduced in 1983, this spreadsheet application ran on the DOS operating system and used all of the 640KB of memory available to software (OS plus application) on the IBM PC. Both the 1-2-3 program and the spreadsheet were in memory while the user worked. It was very fast compared to VisiCalc, which was written to run under the CP/M OS and designed to use much less memory. And 1-2-3 had additional features, including database functions and a program that could create and print graphs from the spreadsheet data. Lotus 1-2-3 was the real killer app, the software that made the IBM PC and PC DOS a must-have combination for people who worked all day crunching numbers and doing what-if calculations.

Apple OS

In 1976 Steve Jobs and Stephen Wozniak—two guys working out of a garage—founded Apple Computer, based on their first computer, the Apple I. Their real notoriety began in 1977 when they introduced the Apple II at the West Coast Computer Faire in San Francisco. This created interest in the brand, and the addition of disk drives in 1978 made it a sought-after product for the technically adventurous consumer. But the OS for the Apple computers at this point did not have a GUI interface—that showed up on the short-lived Apple Lisa computer.

In 1982 Apple introduced the Lisa, the first commercially available computer with a purely graphical operating system—and a mouse. However, this computer lacked something very important for consumers—applications. It was unsuccessful, and Apple's own Macintosh computer, released in 1984, overshadowed the Lisa and marked the beginning of consumer excitement and the near-cult following of the Apple computer products. The Macintosh came with Mac OS System 1, a GUI operating system that used a mouse. Apple improved the Mac OS over the years to include many easy-to-use features.

The final release of the classic Mac OS family was Mac OS 9, introduced in 1999. With its roots in the original 1984 OS, Apple revised and improved the operating system to support multiple users, but it was weak in memory



management and full multitasking. In 2001 it was replaced by a completely new operating system—Mac OS X, based on UNIX. There is a brief overview of OS X later in this chapter and more detail on this OS in Chapter 7.

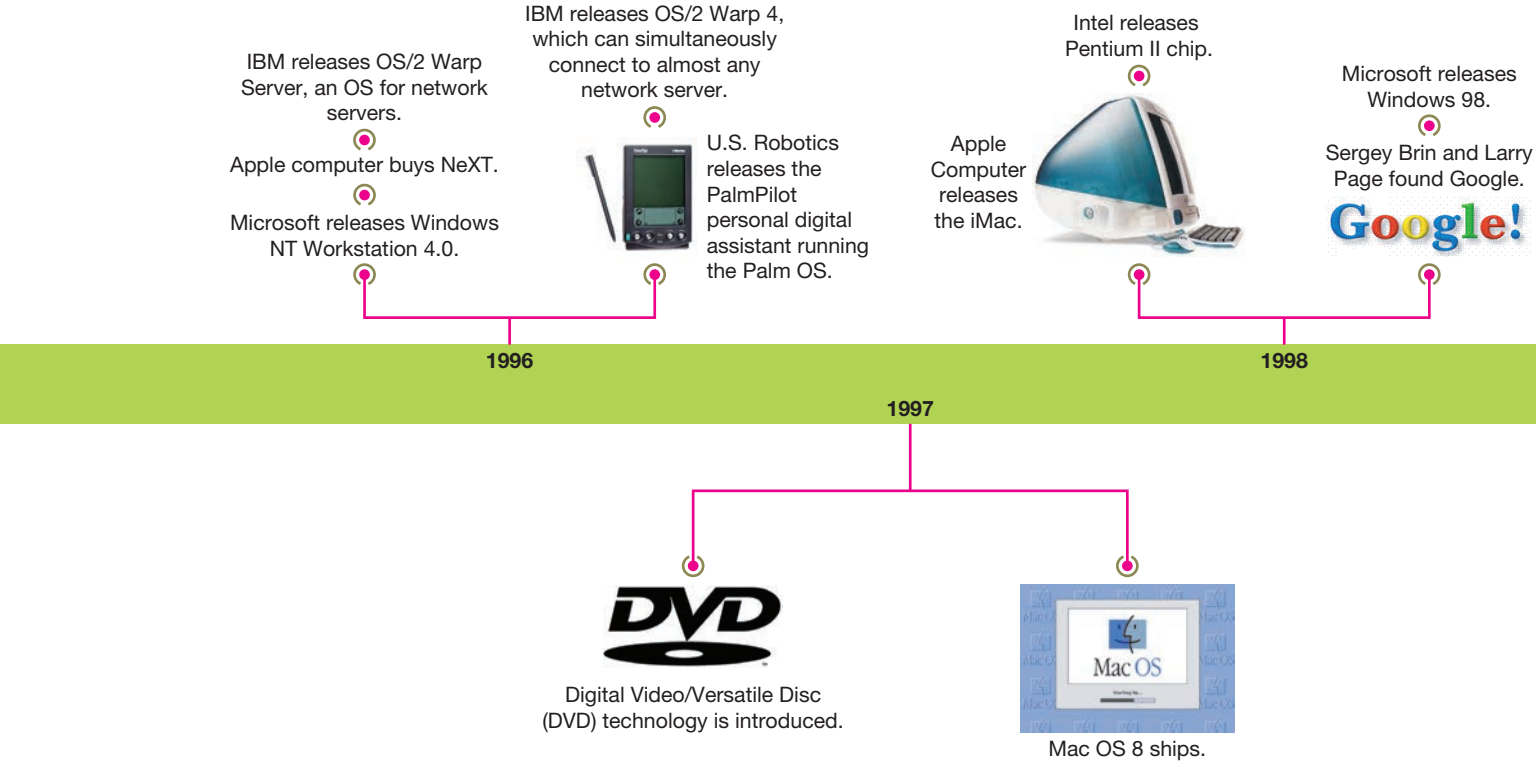
MS-DOS

DOS, which stands for "disk operating system," provides support for interaction, or input and output (I/O), between the memory and disk drives. It is a single-tasking OS with very limited memory support, no support for virtual memory, no native GUI, and no built-in security function. *MS-DOS* refers to the several versions of DOS developed by Microsoft and made available to non-IBM PC manufacturers. PC DOS is the version for IBM computers. Each major version of DOS was released to support new disk capacities. PC DOS 1.0 supported single-sided 5¼-inch floppies; PC DOS 1.1 added support for double-sided 5¼-inch floppies; and PC DOS 2.0, released with the IBM PC-XT, included support for the XT's 10MB hard drives. DOS 3.0 was released with the IBM PC-AT and included support for the larger AT hard drives. Support for 3½-inch floppies and the larger hard drives of the IBM PS-2 computers were added in DOS 4.0. MS-DOS 6.22 was the last widely used version of MS-DOS. Some forms of DOS are now available from third-party sources, but these sources are dwindling.

DOS has a text-mode command-line interface that requires users to remember cryptic commands and their subcommands to perform file management functions and to launch DOS applications. Figure 1–4 shows a good example of how cryptic DOS can be to the uninitiated.

Although you will not find DOS as the preferred OS on desktop computers, you might find a variation of it as the OS on some handheld devices that do not require a GUI interface. In the past, computer professionals often found DOS handy as a very small OS that fit on a floppy disk, to which they added various utilities for troubleshooting computers. This practice has all but disappeared today, as have floppy disks and floppy disk drives. Those same techs are now more likely to carry either optical discs or a flash drive loaded with specialized software for their work.

Note: Many of us still open a command line interface (CLI) in Windows to use certain advanced troubleshooting tools. There are two that come with Windows: the Command Prompt and the Windows Power Shell. There's more on these CLIs, as well as the CLIs in Linux and OS X, in Chapter 9.

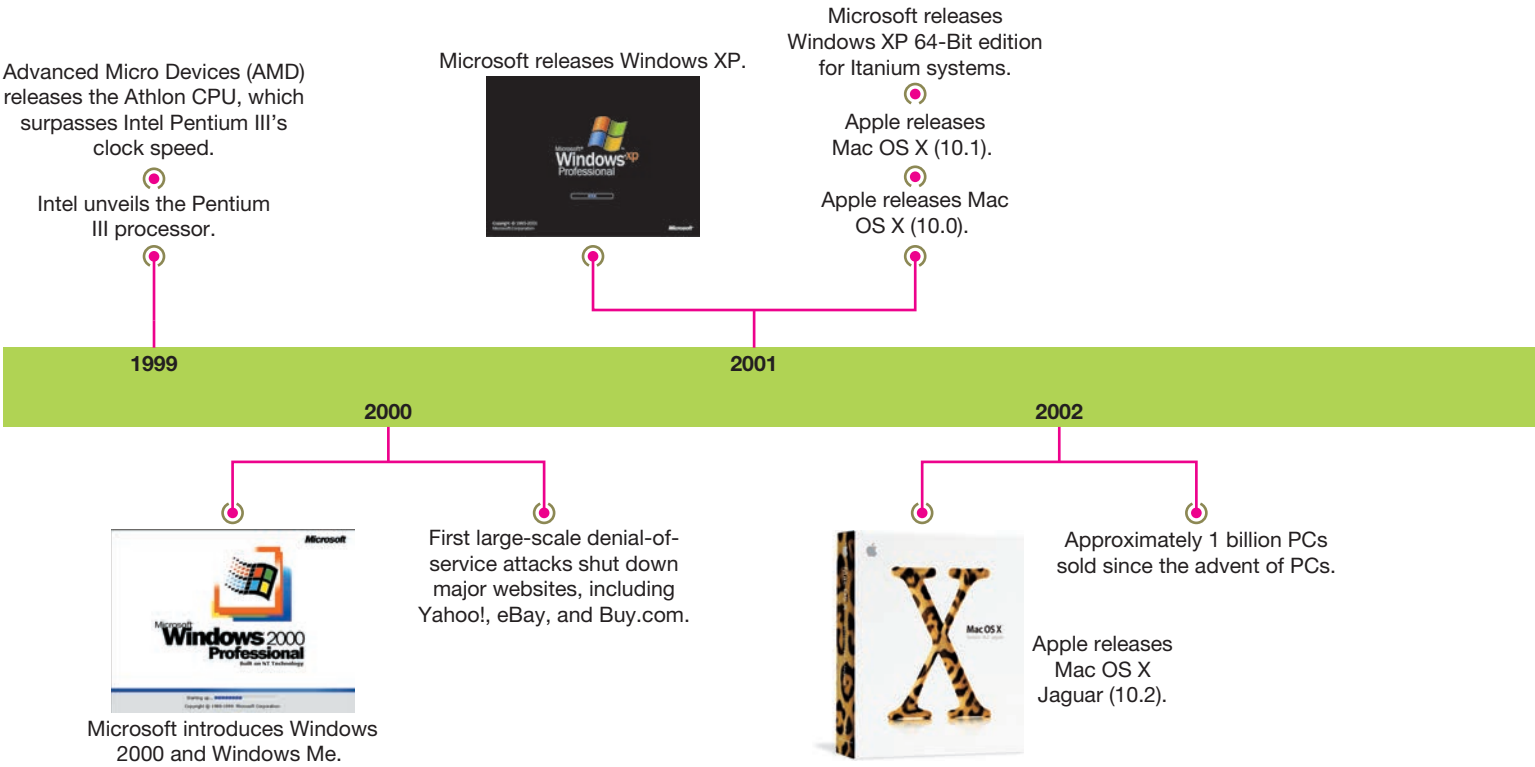


```
A:\>format c: /s /u

WARNING: ALL DATA ON NON-REMOVABLE DISK
DRIVE C: WILL BE LOST!
Proceed with Format (Y/N)?y


Formatting   502M
Format complete.
System transferred

Volume label (11 characters, ENTER for none)?

  526,106,624 bytes total disk space
      212,992 bytes used by system
  525,893,632 bytes available on disk

        8,192 bytes in each allocation unit.
       64,196 allocation units available on disk.

Volume Serial Number is 3A4E-17DA


A:\>_
```

FIGURE 1–4 The MS-DOS prompt with the Format command.

OS/2

In 1987, Microsoft and IBM introduced their jointly developed Operating System/2 (OS/2), intended to replace DOS. However, version 1.0 was written for the Intel 80286 processor, which had serious memory and operating limits. Despite the memory limits, it still required much more memory and disk space (2MB of memory and 8MB of disk space) than either PC DOS or MS-DOS. This was at a time when 2MB of memory and a 40MB hard drive (considered large in the late 1980s) cost several thousand dollars. Although the first version of OS/2 could multitask applications in memory, it did not have a GUI, and only one application could be visible on the screen at a time. Also, people had to write applications specifically for OS/2, because it had very limited support for DOS applications.



In the 1990s, IBM introduced OS/2 Warp, a greatly improved version of OS/2 with a very nice GUI. After about 18 months, however, IBM retreated from the battle for the desktop and targeted sales of OS/2 Warp to the high-end server market. It never rivaled Windows or UNIX in terms of sales. In 2003, IBM announced it would not develop any future versions of OS/2, and in December 2004 IBM sold its PC division to China-based Lenovo Group. In 2005 they discontinued support for OS/2.

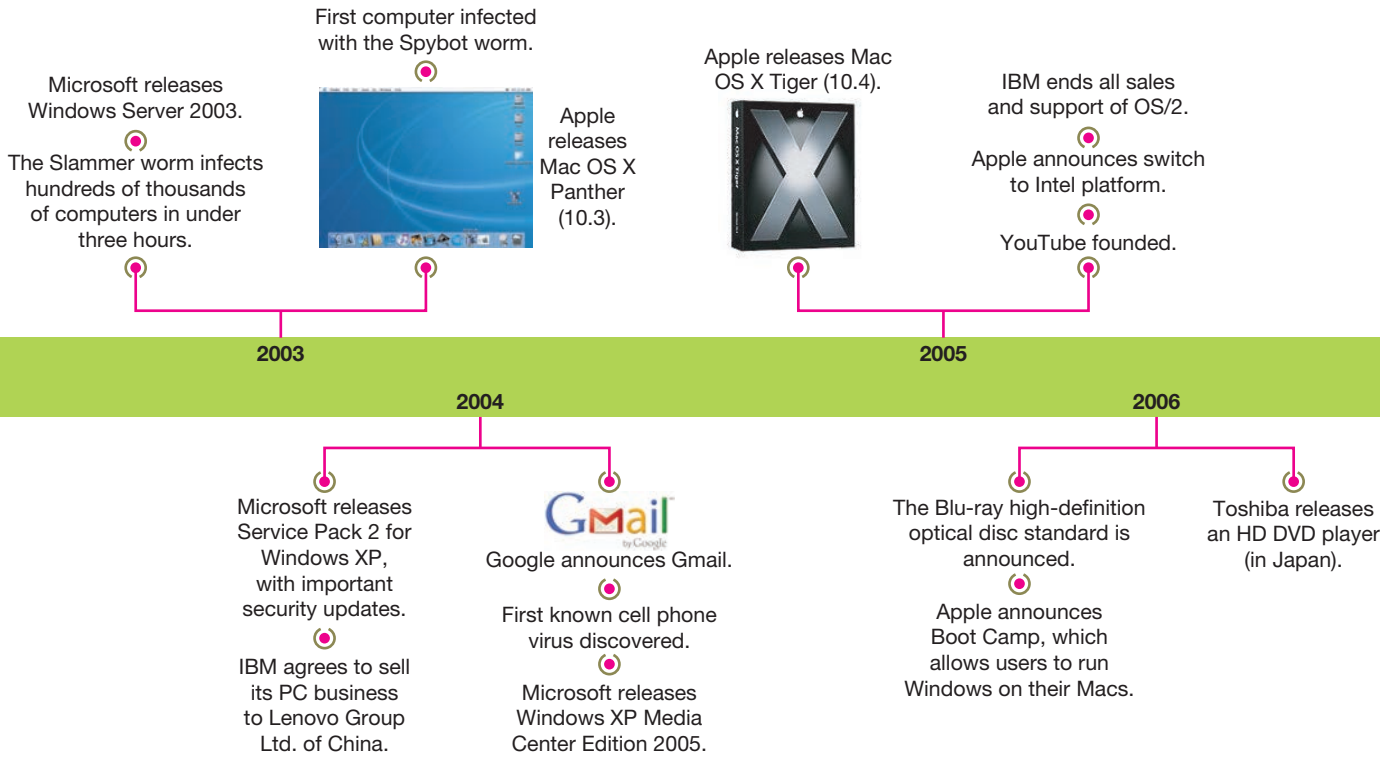
Note: While OS/2 was not a success in terms of sales, an April 2, 2012, article by Harry McCracken, "25 Years of IBM's OS/2: The Strange Days and Surprising Afterlife of a Legendary Operating System" at techland.time.com reported that OS/2 was still used on some New York City subway system servers and on some supermarket checkout systems.

Microsoft Windows

We'll begin our discussion of Windows by explaining Windows versions and editions, and then briefly go through the versions in chronological order.

Windows Versions and Editions. A Microsoft Windows version sometimes has a simple ordinal number, as in Windows 1 or Windows 2 (versions from the 1980s). Then some sub-versions appeared, such as Windows 3.1. In the mid-1990s, Microsoft moved away from the old convention and modified the names of several OSs to coincide with the calendar year of release, as in Windows 95, Windows 98, and Windows 2000. Then it created names such as Windows XP and Windows Vista, but underneath it all Microsoft still maintained a numeric version number, which resurfaced in the naming of Windows 7 and Windows 8. We will cover the Windows 7 and Windows 8 versions in detail in this book.

Then there is the issue of editions. In recent years, each version of Microsoft Windows included separate products, each called an **edition**. Just a sampling of edition names includes Windows XP Professional, Windows Vista Business, and Windows 7 Professional. The differences among the editions for the same version are in the features. The more feature-rich editions cost more. But we are getting ahead of ourselves. We'll start our discussion of yesterday's Windows versions with the first version and make our way to Windows XP. Then we will pick up the discussion of Today's Desktop OSs with Windows 7 and Windows 8.



Windows 1 through 3. In 1985, when the first version of Windows appeared, it was more smoke than OS. It consisted of a not-very-good GUI by today's standards, balanced precariously on top of MS-DOS. The GUI code was separate from the OS code. It was slow and had a flat look—you couldn't lay one graphic on top of another. The ability to overlap graphical elements, such as windows and icons, did not show up until a later version.

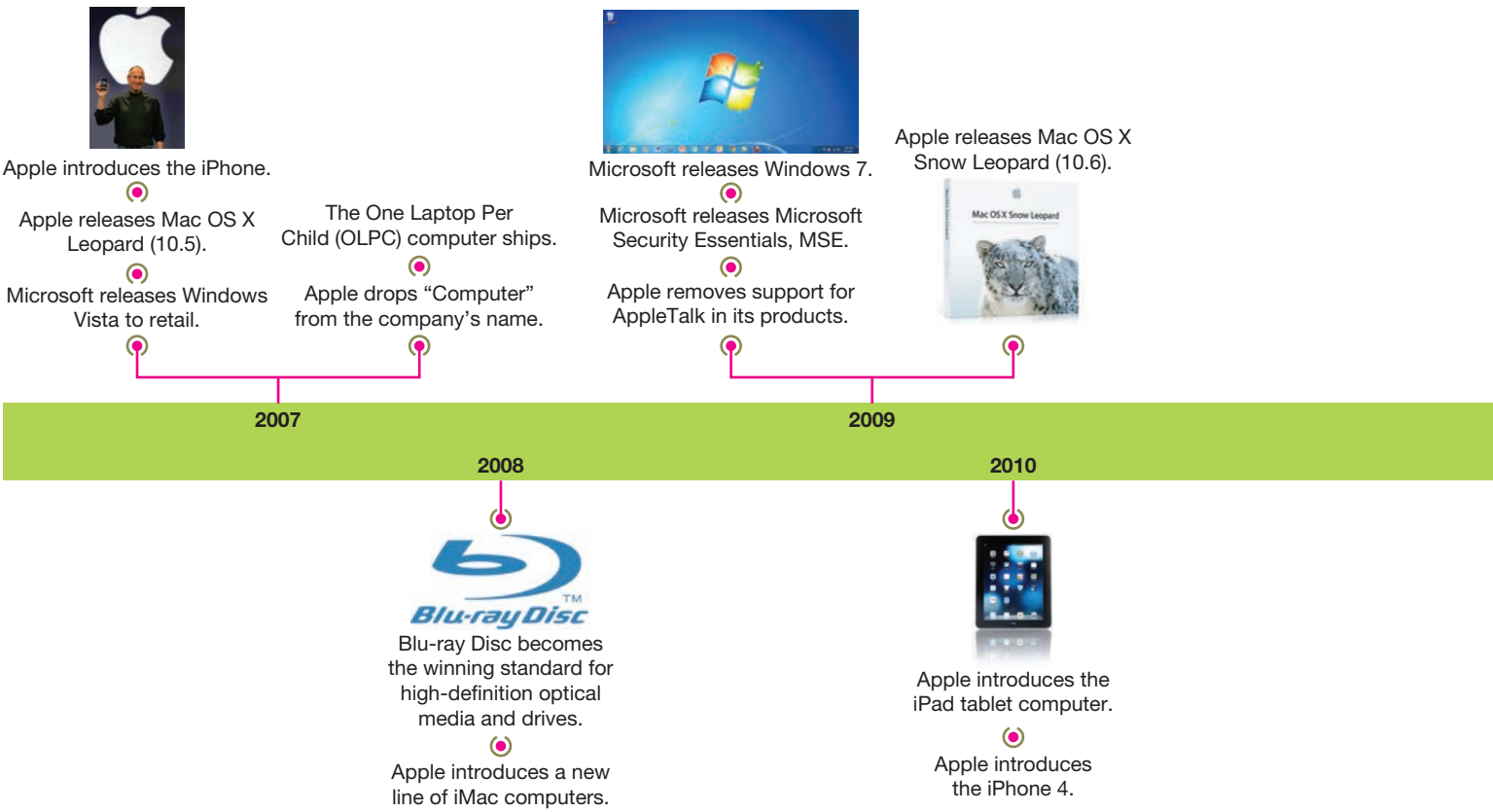
From 1985 to 1990, Microsoft continued to work on both Windows and DOS, but Windows was not much more than a pretty face until 1990 and Windows 3.0, which supported the three Intel processor modes of operation available at that time. Microsoft called these modes, as supported in Windows, Real mode, Standard mode, and 386 Enhanced modes. In Real mode, Windows 3.0 was just a GUI that ran on top of DOS. In the other two modes, it added functionality to DOS to take advantage of the 286 (Standard mode) and 386 (386 Enhanced mode) processor modes.

The most important feature of Windows 3.0 was better support for legacy DOS applications within Windows. This was possible in the 386 Enhanced mode. This meant that both DOS apps and Windows apps could run simultaneously. This version still had its quirks, but for the first time, IT managers saw a potential GUI replacement for DOS as the desktop OS of choice.

In the spring of 1992, Microsoft brought out a minor upgrade, Windows 3.1, which many organizations adopted as the standard desktop OS. The fact that Microsoft's entire suite of productivity applications was also available in versions for Windows 3.*x* helped encourage adoption.

Figure 1–5 shows the Windows 3.1 desktop. Notice that there is no task bar at the bottom of the screen, just the Program Manager window (the main window) with other windows nested in it.

Windows for Workgroups. DOS and Windows OSs through Windows 3.*x* included only the operating system functions. If you wanted to connect to



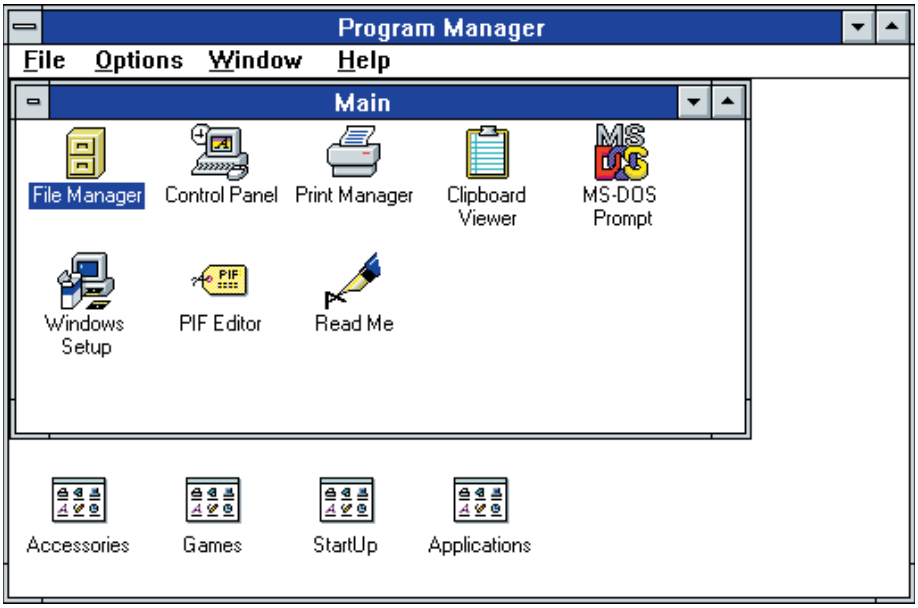
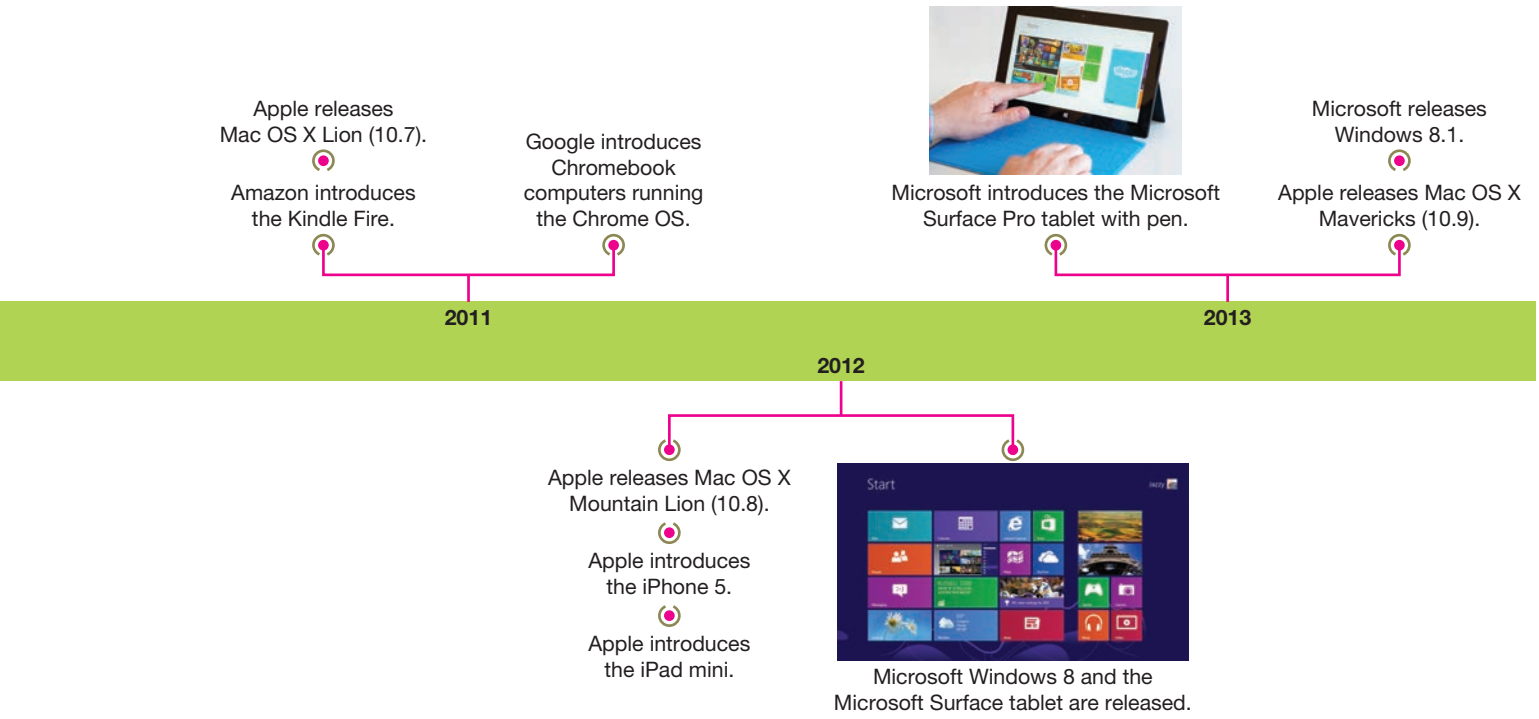


FIGURE 1–5 The Windows 3.1 desktop.

a network, you added a network operating system (NOS) on top of your installed OS. This separate network operating system might be from 3COM or Novell, or it might be Microsoft's LAN Manager NOS, developed in the late 1980s. You had to install the correct client software for the type of network and servers to which you connected.

Novell and LAN Manager were both network server operating systems that combined the operating system functions with the networking functions and also provided file and print sharing services to other computers. Additionally, to connect to a server, a client computer needed special client software so it could connect and request services from it.

Note: Windows for Workgroups 3.1 was followed a year later by Windows for Workgroups 3.11, with the usual obligatory fixes and improvements including faster network and disk I/O operations. However, users were still working with a Windows OS that was running on top of DOS; that is, first DOS would start and then Windows. Windows depended on DOS, which had to be installed on the computer.



However, beginning in October 1992 with Windows for Workgroups 3.1, Microsoft included both the client and server software in all of its Windows OS products. This enabled peer-to-peer networking, meaning desktop computers could act as servers to their peers. This worked well in a small work group environment of 10 or fewer computers.

Windows NT. Because it had the same user interface as Windows 3.1, Windows NT was introduced in 1993 as Windows NT 3.1. That was where the similarity ended. To begin with, it was a server operating system, which included server protocols in its integrated network support. Furthermore, unlike Windows 3.*x* and Windows for Workgroups, the GUI did not sit on top of DOS, but was an entirely new operating system.

With Windows NT Microsoft introduced the NTFS file system with an entirely new logical structure. It has unique security features that continue to be improved in each new version of Windows.

Windows NT was the first Microsoft OS to take full advantage of the capabilities of the special protected mode that Intel introduced in its processors manufactured after 1986. A major benefit of this was more stability and security in the OS. In fact, NT was so powerful that Microsoft decided to make two versions of NT: one designed mainly for servers, and another geared more toward individual user systems—what some folks call workstations. Thus, the next version, Windows NT 3.5, released in 1994, was also the first Windows OS to have separate editions: Windows NT Workstation and Windows NT Server. Both of these used the same kernel and interface, but the Server version had enhancements and components that were needed only on a network server. Microsoft configured the Workstation version as a robust desktop operating system targeted to corporate and advanced users. It had a higher price tag than Windows 95 (introduced in 1995), which was intended for consumers.

In 1996, Microsoft introduced Server and Workstation editions of Windows NT 4.0, which had a GUI similar to that of Windows 95 as well as other improvements and enhancements to the OS. Figure 1–6 shows the Windows NT desktop. Microsoft no longer sells or supports Windows NT.

Windows 95. Windows 95, released in 1995, predated Windows NT 4.0 Workstation. It was still a continuation of the Windows 3.*x* model with the graphical environment simply "sitting" on top of the DOS operating system. It did have some improvements in the operating system, including both 16-bit and 32-bit code. The greatest improvements were in the GUI, which made it the most popular microcomputer operating system up to that time.

Windows 98. Windows 98 was an evolutionary development in the Windows desktop operating system, including improvements in both visible and under-the-hood components. It offered more stability than its immediate predecessor, Windows 95, meaning that it was less likely to stop in its tracks just when you were about to complete that book order on Amazon. Although improved, Windows 98 was not as stable as the newer Windows OSs. Figure 1–7 shows the Windows 98 desktop. Its biggest drawback was lack of security. It did not have a local security accounts database for local authentication, and it lacked support for the NTFS file system for file and folder security.

Windows 98 offered new options for customizing the GUI, including tighter integration with Microsoft's Web browser, Internet Explorer (IE). Windows 98 came with drivers and support for devices, such as DVD drives,

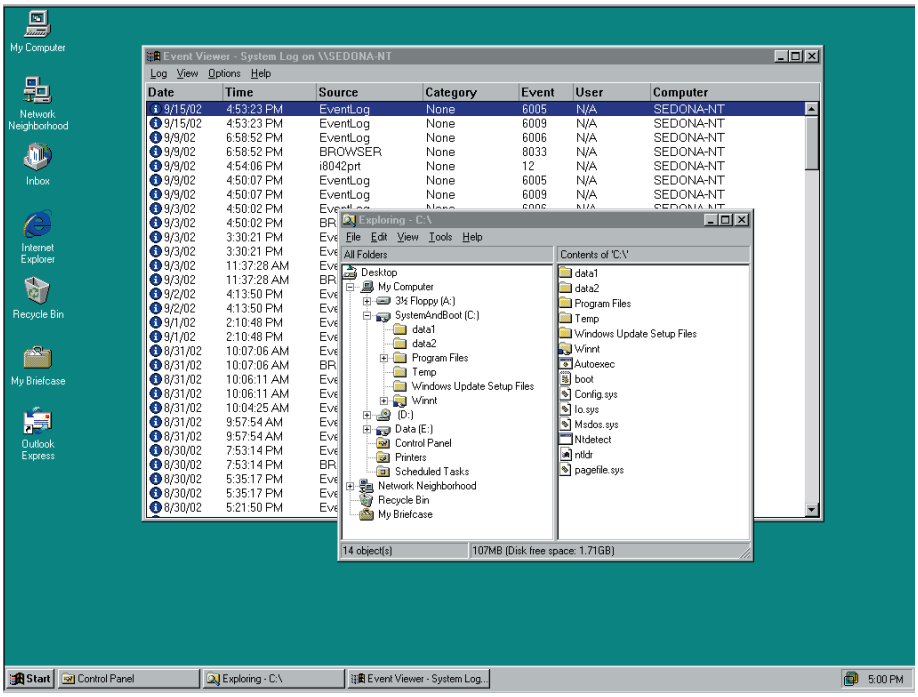


FIGURE 1–6 The Windows NT 4.0 desktop with open windows.

that were not included in Windows 95. As usual with an upgrade to an OS, Microsoft cleaned up existing problems and made the OS run faster.

Windows Me (Millennium Edition). Windows Me (Millennium edition), introduced in 2000, targeted the home market, especially the home game user. It was essentially Windows 98 with improved music, video, and home

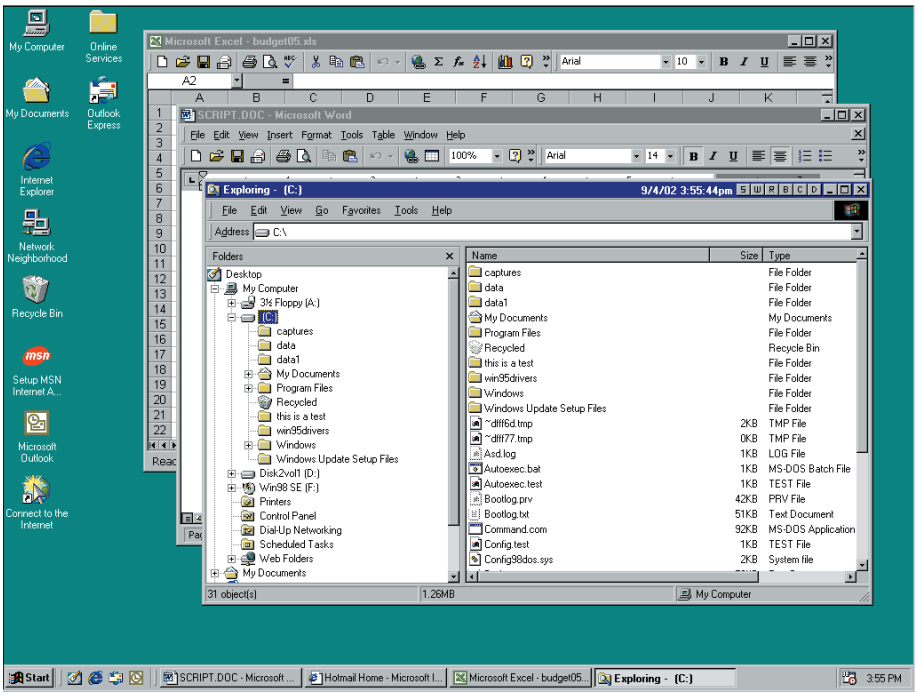


FIGURE 1–7 The Windows 98 desktop with open windows.

FIGURE 1–8 The Windows 2000 desktop.

networking support. The Windows Movie Maker allowed users to digitally edit, save, and share their home videos, and the Windows Media Player gave users a tool for organizing digital music and video. This was the last Microsoft OS based on the Windows 95 internals. Windows Me was installed on many computers that were sold to individuals, but it is not an OS that organizations adopted. You are not likely to encounter it in a work environment.

Windows 2000. In 2000, Microsoft introduced the Windows 2000 family of OS products, which brought together the best of Windows 98 (the GUI) and Windows NT. Windows 2000 was available in several editions that all shared the same kernel and covered OS needs from the desktop to the enterprise server. Figure 1–8 shows the Windows 2000 desktop.

Windows XP. With its Windows 2000 products, Microsoft brought all of its OSs together, building them on top of the same core internal piece (the kernel). Some of us, especially those whose jobs included support of both desktop and server computers, thought it would simplify our lives. We really liked that idea because we could learn just one OS for both the desktop and server. However, in 2001 Microsoft departed from that model when the company introduced Windows XP, intended only for the desktop or other consumer-type computer, not for the server environment. The new server products, introduced after Windows XP, began with Windows Server 2003.

There were several Windows XP editions, but the three most common were Windows XP Home edition, Windows XP Professional, and Windows XP Media Center. All were 32-bit OSs, had the same improved GUI, and shared many of the same features, but only Windows XP Professional included several important network- and security-related features. Additionally, Microsoft offered Windows XP 64-bit edition, which supported only 64-bit software and was limited to computers with the Intel Itanium processors.

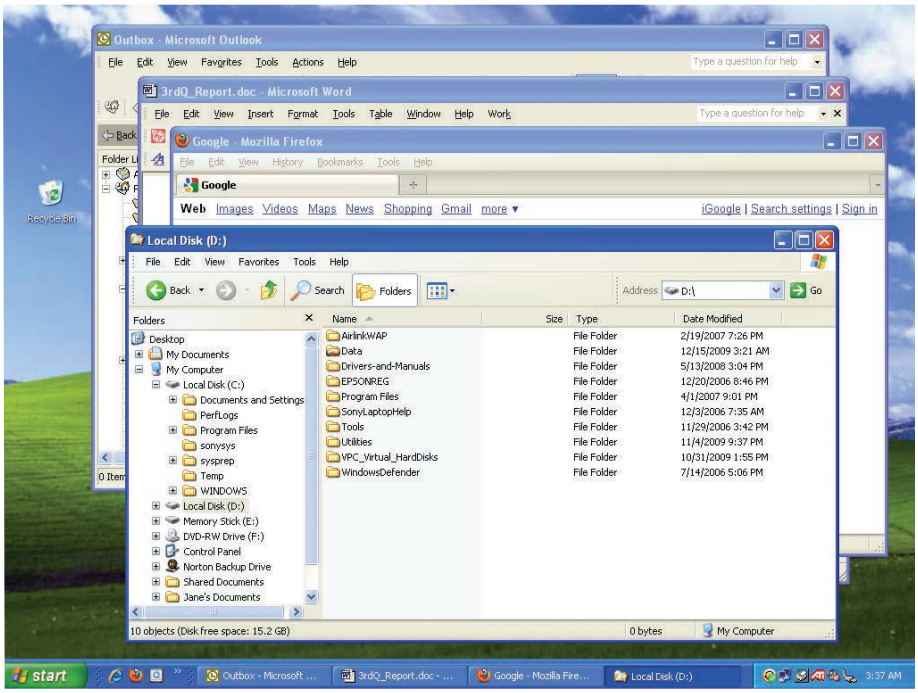


FIGURE 1–9 The Windows XP desktop with open windows.

The Windows XP desktop was very different from that of its main predecessor, Windows 98, in that by default the recycle bin (where deleted files go) was the only icon on the desktop. Figure 1–9 shows the Windows XP desktop with several open windows. Microsoft redesigned and reorganized the Start menu, shown here.

The last service pack for the 32-bit version of Windows XP was SP 3, and October 22, 2010, marked the last day you could buy a new PC with Windows XP preinstalled. This date was one year after the introduction of Windows 7. Support for Windows XP Service Pack 2 (SP2) ended July 13, 2010. If you are still using Windows XP, ensure that you have Service Pack 3 installed. Microsoft will support Windows XP with Service Pac 3 (SP3) until April 2014. Service pack 3 is for 32-bit Windows XP; there was no Service Pack 3 for 64-bit Windows XP. Support for the 64-bit version of XP SP 2 also ends in April 2014. This is Microsoft's published policy, called the Microsoft Support Lifecycle.

The Windows XP Start Menu.

Windows Vista. Microsoft released the first retail edition of Windows Vista early in 2007. Seen more as an upgrade of Windows XP, it included improvements in how Windows handles graphics, files, and communications. The GUI had a new look compared to previous versions of Windows (see Figure 1–10). It also had a feature called Aero, which included translucent windows, live thumbnails, live icons, and other enhancements to the GUI. Windows Vista was not widely adopted due to problems with speed on older hardware as well as high hardware requirements. Mainstream support for Windows Vista ended in April 2012.

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Learn About the Microsoft Support Lifecycle

The Microsoft Lifecycle fact sheet describes the types of support Microsoft provides for its products and how long each support type will be available. Learn more about it. Try this:

1. Point your browser to **support.microsoft.com/lifecycle**
2. On the Microsoft Support Lifecycle page there are links to general information on the Support Lifecycle Policy and to the life cycle of specific products.
3. Explore this Lifecycle information for Microsoft products you use.

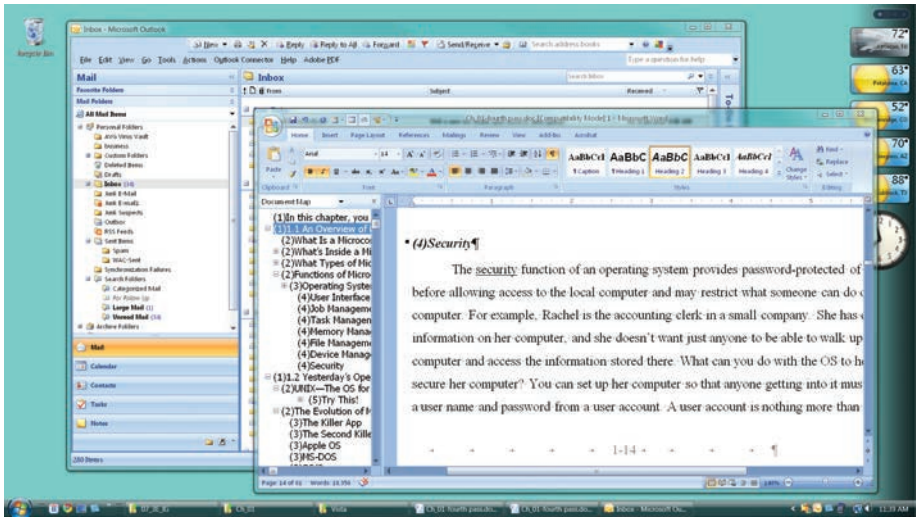

FIGURE 1–10 The Windows Vista desktop.

LO 1.3 Today's Desktop OSs

Today's desktop microcomputer operating systems include Windows 7, Windows 8, Mac OS X, and Linux. The latest versions of all of these OSs are multiuser/multitasking operating systems, with support for virtual memory and security, and each comes in versions that support either 32-bit or 64-bit processors.

Table 1–2 summarizes the current desktop OSs covered in later chapters of this book, listing the publisher, platform, and types of applications that you can run natively on each OS. All of these OSs can run virtualization software that will run other OSs, and therefore other types of applications, but we will defer discussion of virtualization to Chapter 3.

What follows is a brief description of these OSs, with more detail in the chapters devoted to each OS.

Microsoft Windows for the Desktop

Today's Windows for the desktop include both Windows 7 and Windows 8. Whereas many organizations have or are transitioning to Windows 7, Windows 8 is meeting some resistance, discussed in the Windows 8 section.

Windows 7

Released in October 2009, Windows 7 includes several improvements correcting the shortcomings that kept Windows Vista from being widely accepted. Windows 7 is faster than Windows Vista in several ways, from starting up, to going into and out of sleep mode, to recognizing new devices when you connect

TABLE 1–2 Summary of Current Desktop/Laptop OSs

Desktop/Laptop OS	Company	Platform	Applications Supported
Windows 7	Microsoft	Intel/Microsoft	DOS, 16-bit Windows, 32-bit Windows, 64-bit Windows applications
Windows 8	Microsoft	Intel/Microsoft	DOS, 16-bit Windows, 32-bit and 64-bit Windows applications for the Desktop and for the new Windows 8 GUI, available only through the Windows Store.
OS X	Apple	Apple Mac	Macintosh applications
Linux	Various	Intel/Microsoft	UNIX/Linux applications

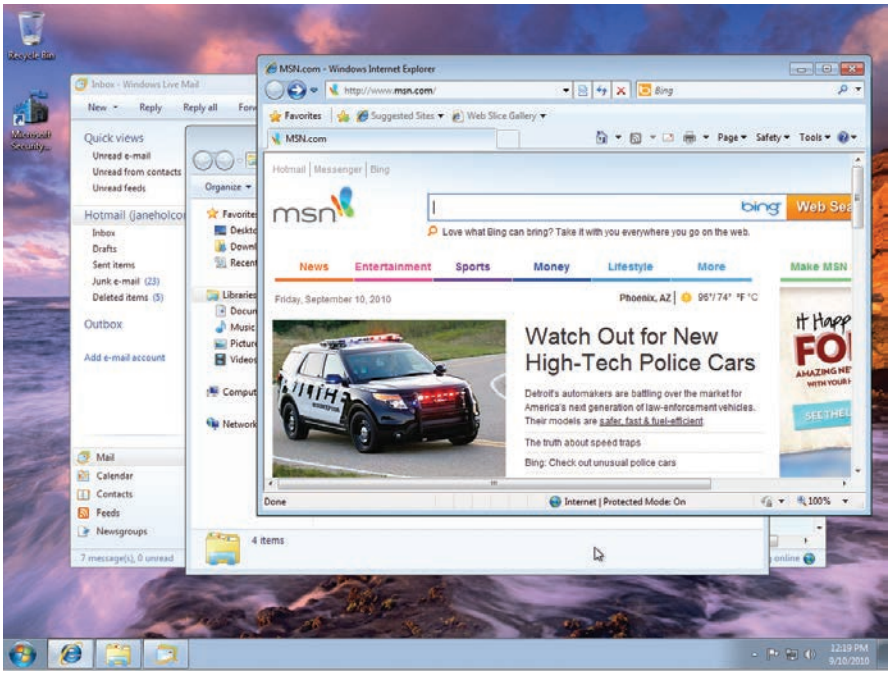

FIGURE 1–11 The Windows 7 desktop.

them. Windows 7 has many new features. The short list includes a redesigned desktop (see Figure 1–11) with a new taskbar that has many new features of its own, such as jump lists. Learn more about Windows 7 in Chapter 4.

Windows 8

Like many technically minded people, we worked with prerelease versions of Windows 8 for many months previous to its final availability in October 2012, so we were able to become familiar with Windows 8 before it was released. Predictably, it is faster than previous versions and includes better security and improved wireless connectivity. It includes support for some newer hardware, such as USB 3.0 ports and improved touch screen support that includes recognition of simultaneous multiple touches and gestures.

The most controversial changes to Windows 8 are to the GUI, or rather GUIs. The default GUI, centered around the Start screen shown in Figure 1–12,

FIGURE 1–12 The Windows 8 Start screen.

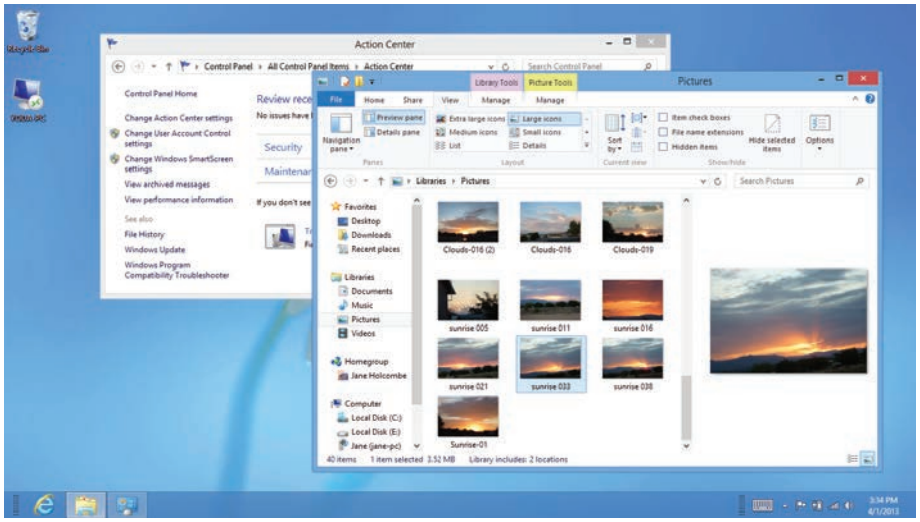

FIGURE 1–13 The Windows 8 desktop.

Note: One frustration for us is that Microsoft does not have an official name for this GUI, and refers to it only as "Windows 8." This is also the name of the version and the name of a unique edition of Windows 8.

is a departure from the Windows 7 desktop with its three-dimensional look. Objects in this new GUI appear flat, without shading and borders so that they do not take up unnecessary screen space. This is necessary because Windows 8 is intended to run on a wide range of computing devices: PCs, laptops, and tablets. The new Windows 8 GUI inherited much of its look from the Metro user interface found in the Microsoft Windows Phone 7.5 OS. The Windows 8 Start screen contains tiles that represent apps. Each tile can show active contents, such as newsfeeds, stock quotes, slideshows, and more, depending on the tile's app.

The second Windows 8 GUI, a modified version of the Windows 7 desktop, without the Start menu, also has a very flat look to it in spite of having overlapping windows. Figure 1–13 shows the Windows 8 desktop. Learn more about Windows 8 on Desktops and Laptops in Chapter 5, and Windows 8 on mobile devices in Chapter 11.

Apple Mac OS X

Whereas the Linux and Microsoft OSs are available to install on hardware from many manufacturers, the Apple Inc. strategy has been to produce proprietary hardware and software for better integration of the OS and the hardware. They do not license Mac OS X to run on other manufacturers' computers. This has historically resulted in a higher price for a Mac than for a comparable PC. For several years, beginning in the mid-1990s, Macintosh computers used the Motorola PowerPC chip with an architecture enhanced for graphics and multimedia. Since 2005 the Apple Mac line of computers are Intel-based.

The Mac OSs in common use today are versions of Mac OS X (*X* is the Roman numeral for 10). OS X is a revolutionary change from the previous Mac OS 9 because Apple based OS X on NextStep, an OS with a UNIX kernel. Until Mac OS X, the Macintosh OSs were strictly GUI environments, with no command-line option. Mac OS X, with its UNIX origins, gives you the option of a character-based interface, but most users will happily work solely in the GUI (see Figure 1–14). OS X v10.8 (aka Mountain Lion) is current as of this writing, but OS X v10.9 (Mavericks) was announced and will be available in the fall of 2013. Chapter 7 is devoted to Mac OS X.

Linux

Linux is an operating system modeled on UNIX and named in honor of its original developer, Linus Benedict Torvalds. He began it as a project in 1991

FIGURE 1–14 Macintosh OS X GUI.

while a student at the University of Helsinki in his native Finland. He invited other programmers to work together to create an open-source operating system for modern computers. They created Linux using a powerful programming language called C, along with a free C compiler developed through the GNU project called GNU C Compiler (GCC). Linux has continued to evolve over the years, with programmers all over the globe testing and upgrading its code. Linus Torvalds could not have predicted in 1991 how well accepted the new operating system would be over 20 years later.

Linux is available in both 32-bit and 64-bit distributions, and it can be modified to run on nearly any computer. A **distribution** or "distro," is a bundling of the Linux kernel and software—both enhancements to the OS and applications, such as word processors, spreadsheets, media players, and more. The person or organization providing the distribution may charge a fee for the enhancements and applications, but cannot charge a fee for the Linux code itself. Many distributions are free or very inexpensive.

Linux natively uses a command-line interface, and Figure 1–15 shows an example of a Linux directory list at the command line. Windows-like GUI environments, called shells, are available that make it as accessible to most users as Windows or Mac OS X. We'll discuss selecting a Linux distribution in Chapter 8 along with other Linux-specific details.

```
[cottrell@localhost ppp]$ ls -l
total 56
-rw-------    1 root     root           78 Feb 27 17:09 chap-secrets
-rw-r--r--    1 root     root          927 Apr 14 12:38 firewall-masq
-rw-r--r--    1 root     root          825 Apr 14 12:38 firewall-standalone
-rw-r--r--    1 root     root            0 Apr  8 09:08 ioptions
-rwxr-xr-x    1 root     root          310 Dec 26  2000 ip-down
-rwxr-xr-x    1 root     root         3564 Mar 20 22:17 ip-down.ipv6to4
-rwxr-xr-x    1 root     root          362 Dec 26  2000 ip-up
-rwxr-xr-x    1 root     root         5745 Mar 11 17:42 ip-up.ipv6to4
-rwxr-xr-x    1 root     root          918 Mar 11 17:43 ipv6-down
-rwxr-xr-x    1 root     root          918 Mar 11 17:43 ipv6-up
-rw-r--r--    1 root     root            5 Feb 27 17:09 options
-rw-------    1 root     root           77 Feb 27 17:09 pap-secrets
drwxr-xr-x    3 root     root         4096 Jul  5 15:02 peers
-rw-r--r--    1 root     root           93 Apr 14 12:38 pppoe-server-options
[cottrell@localhost ppp]$
```

FIGURE 1–15 A Red Hat Linux directory listing (the ls command).

LO 1.4 Today's Mobile OSs

Mobile computing today has followed the trajectory of all computing, thanks to the miniaturization of components and new technologies. And like PCs, mobile devices became more desirable thanks to apps. However, don't look for a single "killer app" for mobile devices. Rather, the most popular mobile devices are those with a large number of compelling apps. Also, unlike the early PCs, which were seen more as office productivity tools, today's mobile devices are very personal devices used for communicating and entertainment as well as for work- and school-related tasks.

Of the three mobile OSs featured in this book, Apple licenses iOS only for use on Apple mobile devices, Microsoft charges manufacturers licensing fees for each device on which they install a Windows OS, adding to the cost of each device. Only Google does not charge manufacturers licensing fees for using Android, at least not on smartphones. They license it for free under the Android Open Source Project. This helps hold down the cost of Android smartphones, but this is changing because several companies hold patents on the technology in mobile devices and some of them have successfully sued manufacturers of Android devices for patent licensing fees, in some cases, collecting fees of $5 per device.

Note: Manufacturers are expected to ship over 1 billion smartphones globally in 2014. This is according to a research report by Nokia Corporation cited in an article published on *The Wall Street Journal* website on February 19, 2013, titled "The Smartphones, the Networks, and the Suppliers: The Mobile Triumvirate—Research Report on Nokia Corporation, Ericsson, Juniper Networks, Inc., Alcatel Lucent, and Corning."

Mobile Devices

There are many manufacturers of mobile devices, but the ones we will focus on are those that use the Apple iOS, Android, or Windows operating systems. Two things they all have in common is support of a variety of wireless technologies and the ability to customize them with a variety of apps. Table 1–3 gives a summary of these OSs and the devices that use them. Following is a brief description of the hardware features of these devices.

In general, mobile devices today include these hardware features:

- Network adapters for various types of wireless networks.
- Great high-quality color touch screens that allow the OS to respond to several types of touch gestures.
- One or two (front and back) digital cameras.
- Built-in speakers and/or speaker ports for external speakers.
- Rechargeable batteries with battery life to get you through a normal day of use.
- An **accelerometer** that detects the physical tilt and acceleration of the device.
- Solid-state drives (SSDs).

Note: The iPod Touch also runs iOS, but we are not covering this device. With its small (4-inch) screen and NO cell phone support, it is simply a digital music player with tablet features.

TABLE 1–3 Summary of Current Mobile OSs and Related Devices Featured in This Book

Mobile OS	Source of OS	Smartphones/Tablets	Sources for Apps
Apple iOS	Apple	Apple iPhone and iPad	Apple Apps Store
Android	Google	Smartphones and tablets from various manufacturers	Apps from Google and many other sources
Windows Phone 8	Microsoft	Smartphones from various manufacturers	Microsoft App Store
Windows 8	Microsoft	Tablets from many sources	Apps from the Microsoft software store—both Windows 8 (Metro) and Desktop apps—and many other sources for Desktop apps

Connectivity

The "smart" in smartphone comes from the computing ability that makes it a tool for work, home, and school. The "phone" in smartphone recognizes the ability to connect to a cellular network for voice communication. Typically you purchase a smartphone from a cellular provider, and connect the phone to the provider's network as your first ownership task. The cellular network is a form of wide area network (WAN), allowing you to make and receive voice calls as well as giving you a data connection to the Internet—both for a price. Your cellular plan usually separates usage by voice (connection time during voice calls), data (quantity of data downloaded from the Internet), and text. These plans can be very expensive depending on how you use your smartphone.

Many tablets also have cellular network support for which you pay a premium—both for the cellular hardware in the tablet and for the cellular service. Most tablets with cellular support only offer data connections. We once wrote, "Imagine holding a tablet up to your ear to make a voice call." You don't have to imagine it because there are now tablets that offer voice as well as data cellular connections.

To help control the cost of cellular data plans, we are fortunate to also have Wi-Fi connectivity in virtually all smartphones and tablets. Wi-Fi is a type of local area network (LAN), and on its own, it allows you to connect to a wireless network covering a small area, such as a house, office building, or small campus. But most Wi-Fi networks, such as those in coffee shops, offices, and homes, connect to a router that in turn connects to the Internet. Therefore, if you enable Wi-Fi on your smartphone, you can save on your cellular data usage by connecting to an Internet-connected Wi-Fi network.

Another common wireless option is Bluetooth, a wireless networking technology for connecting over very short distances (a few yards or meters). Bluetooth is used to connect a mobile device to other computers and to wireless devices, such as keyboards and printers.

We will discuss how to enable and configure different types of network connections for mobile devices in Chapter 11.

Mobile OS Features

When discussing mobile OSs it is difficult to separate the OS from the hardware, so the OS features we describe are closely tied to the previously listed hardware features of the mobile device.

Touch Screen and Virtual Keyboard Support

A mobile OS supports the touch screen by interpreting the various screen gestures we make. It also supports a feature called **virtual keyboard**. When you touch an area of screen that requires input from a keyboard, the OS will display the virtual keyboard, an on-screen image of a keyboard with labeled keys that you can tap. Figure 1–16 shows the virtual keyboard on an iPad. Many mobile devices will optionally connect to an external keyboard—usually via a Bluetooth wireless connection. Learn more about these features in Chapter 11.

Screen Rotation

Mobile operating systems take advantage of the hardware accelerometer by rotating the image on the screen to accommodate the position and allow you to read the screen. This feature is called **screen rotation** or **screen acceleration**. Figure 1–17 shows the screen of an iPad tablet running in "portrait" orientation,

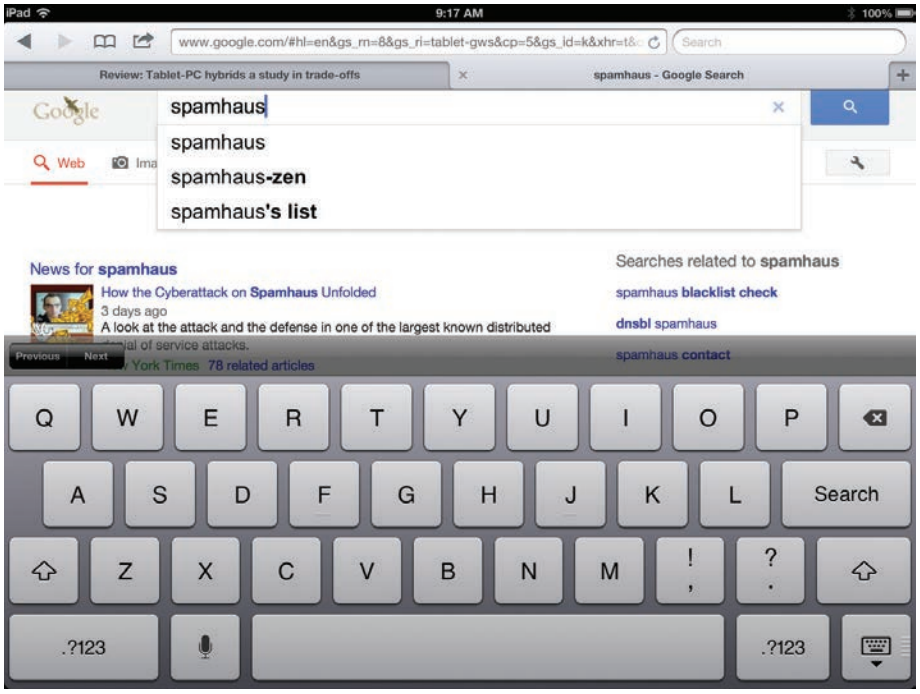

FIGURE 1–16 The virtual keyboard on an iPad.

FIGURE 1–17 An iPad home screen in portrait orientation.

and Figure 1–18 shows the screen of the same tablet in "landscape" orientation.

Updateable

As with desktop operating systems, the ability to update a mobile OS is important to the usability and security of the mobile device. While Microsoft's OSs are updateable during their clearly-defined life span, that is not quite as clear with mobile operating systems. In general, you can update an OS depending on the constraints of the hardware and limits imposed by the manufacturer. In Chapter 11 we will describe the differences in how and when you can update mobile OSs.

Availability of Apps

As we stated earlier, today's devices sell in part because of the number of useful apps, making the availability of a large selection of compelling apps more important than a single killer app that millions desire. All of the mobile OSs in this book have a large number of quality apps available to them, as well as many trivial and nonessential apps. Each mobile OS has one or more online sources, such as the Windows Store, shown in Figure 1–19, for Windows 8 apps. In Chapter 11 we describe and compare sources of apps for your mobile devices.

Security

Mobile devices are targeted by the same security threats that target other computers. Being able to

FIGURE 1–18 An iPad home screen in landscape orientation.

update the OS is only part of what you need to do to protect yourself and your data. Third-party solutions are available for some mobile OSs, and all of them come with some built-in security features. We will explore the security options for the various mobile operating systems in Chapter 11.

Synchronizing Data

Data synchronization is an important feature supported by mobile OSs, especially for people who use multiple devices and wish to access the same data across all devices. For instance, you can access your contacts list and other data from anywhere with whatever device you are using. We will examine the synchronization options for mobile devices in Chapter 11.

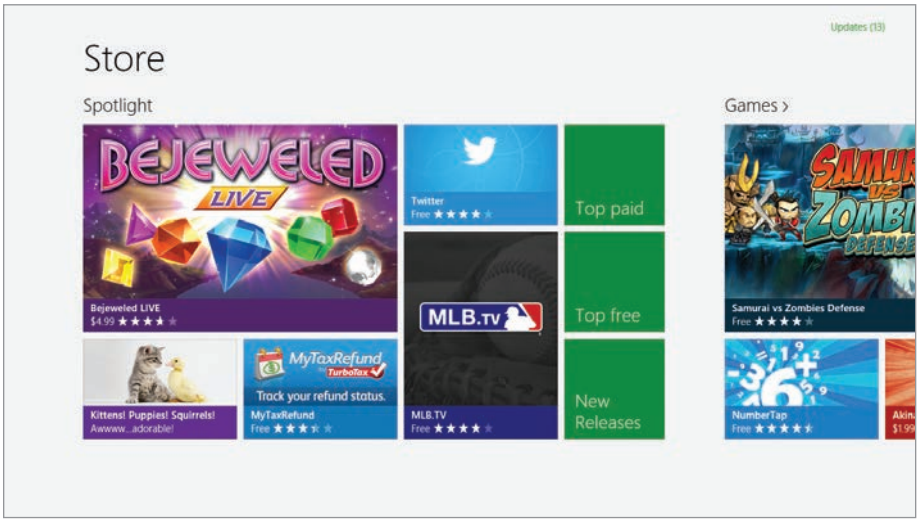

FIGURE 1–19 Microsoft Store for Windows 8 apps.

Chapter 1 REVIEW

Chapter Summary

After reading this chapter and completing the exercises, you should know the following facts about operating systems.

An Overview of Microcomputer Operating Systems

- An operating system is a collection of programs that controls all of the interactions among the various system components, freeing application programmers from needing to include such functions in their programs.
- A computer is a device that calculates. A central processing unit (CPU) is the component that performs the calculation for a computer.
- A microcomputer is a computer small enough and cheap enough for the use of one person. The integrated circuit (IC) is one of the inventions that made microcomputers possible.
- Interaction with a computer is called input/output (I/O).
- The CPU in a microcomputer is a microprocessor, which, along with several other important components (memory, firmware, and more), is installed onto a motherboard.
- System firmware contains the program code that informs the CPU of the devices present and how to communicate with them.
- Read only memory basic input output system (ROM BIOS) is a type of firmware used since the first IBM PC (circa 1981), and recently replaced by firmware that complies with a new standard, Unified Extensible Firmware Interface (UEFI). It is faster and includes security features.
- A device driver is a special program installed into an operating system containing code for controlling a component.
- Common microcomputers in use today include desktops, laptops, tablets, and smartphones.
- The same version of the Windows or Linux OS will run on a desktop and compatible laptop computer. The same is true of Mac OS X and the iMac desktop and MacBook laptop models.
- A server is a computer that provides one or more services to other computers.
- Smartphones and tablets are the two most popular mobile devices.
- Operating systems provide these functions:
  - User interface
  - Job management
  - Task management
  - Memory management
  - File management
  - Device management
  - Security
- Today's popular operating systems for desktops and laptops come in versions for 32-bit and 64-bit processing. The biggest advantage of a 64-bit OS over a 32-bit version of the same OS is that a 64-bit OS supports a much greater amount of memory.

Yesterday's Operating Systems

- UNIX is the oldest popular operating system and comes in versions for very large computers, as well as microcomputers. It is a portable OS that is usable on a variety of computer system platforms, with only minor alterations required for the underlying architecture.
- The complex and powerful OSs we now use evolved over many decades and how people used computers changed.
- Early microcomputers included the MITS Altair 8800, the Apple I and Apple II, Radio Shack's TRS-80, and the Commodore, all introduced in the 1970s. The Apple computers came with the Apple OS.
- Software is created in versions, and some versions come in separate editions, products with bundled capabilities.
- Certain "killer apps," notably VisiCalc and Lotus 1-2-3, made microcomputers appeal to organizations and ordinary people who were attracted to programs that automated formerly manual tasks.
- IBM introduced the IBM PC in 1981, and its sales far exceeded the expectations of IBM with Microsoft BASIC in ROM. They offered PC DOS for computers with a floppy disk drive.
- Microsoft made MS-DOS available to third-party PC manufacturers and no longer supports or sells MS-DOS. Other sources continued the development of non-Microsoft DOS.
- OS/2 was first developed in a joint effort between Microsoft and IBM, and IBM soon continued development of it without Microsoft, bringing out OS/2 Warp, a GUI version. IBM discontinued support for OS/2 in 2005.
- Microsoft Windows evolved from the first version in 1985 to Windows 8, introduced in 2012. Each of

the newer versions comes in multiple products, called editions.

- The Apple Mac computer, introduced in 1984, came with the MAC OS System. This OS line continued through Mac OS 9, introduced in 1999, and phased out after Mac OS X was introduced 2001. OS X v10.8 (aka Mountain Lion) is current as of this writing.

Today's Desktop Operating Systems

- Today's desktop operating systems include Windows 7, Windows 8, Mac OS X, and Linux.
- Windows 7, released in 2009, included many improvements over Windows Vista, convincing many businesses to migrate their desktops to this OS.
- Windows 8 was introduced in October 2012 with two GUIs: the new Metro-style GUI and a Desktop GUI that is a modified version of the Windows 7 desktop, without the Start menu. It is faster and includes more security features than Windows 7.
- Apple's Mac OS X, based on NextStep, an OS with a UNIX kernel, runs only on Apple Mac desktop and laptop computers.
- Linus Torvalds developed Linux as a collaborative effort beginning in 1991. It is available in both 32-bit and 64-bit distributions and can run on nearly any computer. It natively uses a command-line interface, but GUI shells are available for most distributions.

Today's Mobile OSs

- People use mobile devices for communicating and personal entertainment as well as for work- and school-related tasks.
- Apple's iOS runs on Apple's iPhone and iPad products (as well as on the iPod touch). Apps are only available from the Apple Apps Store.
- Google's Android OS runs on smartphones and tablets from many manufacturers. Apps are available from Google and from many other sources.
- Windows Phone 8 runs on smartphones from several manufacturers with apps available from the Microsoft App Store.
- Windows 8 runs on tablets from many sources with apps available from the Microsoft App Store and many other sources.
- Features in mobile devices include:
  - Multiple types of wireless network adapters.
  - High-quality color touch screens.
  - One or two (front and back) digital cameras.
  - Built-in speakers and/or speaker ports.
  - Rechargeable batteries with battery life sufficient for a normal day of use.
  - An accelerometer that detects the physical tilt and acceleration.
  - Solid-state drives (SSDs).
- Smartphones and some tablets support cellular connections and are usually bought through a cellular provider who usually charges for voice usage by connection time and data usage by amount of data downloaded from the Internet.
- Smartphones and tablets also offer Wi-Fi connections, which give you a cheaper option for accessing the Internet with the device.
- Bluetooth is a wireless networking technology for connecting over very short distances (a few yards or meters) that is used to connect a mobile device to other computers and to wireless devices, such as keyboards and printer.
- A mobile OS interprets screen gestures and displays a virtual keyboard when you touch an area of screen that requires input from a keyboard.
- A mobile OS takes advantage of the hardware accelerometer in a device by rotating the image on the screen to accommodate the position of screen so that it is readable to you.
- Most mobile operating systems can be updated to some degree.
- Popular mobile OSs have a large number of apps available to them.
- All mobile OSs have security features, and third-party solutions are available for some mobile OSs.
- It is important to have good options for synchronizing data across all devices used by an individual.

Key Terms List

accelerometer *(30)*
application *(2)*
central processing unit (CPU) *(2)*
client *(5)*
command-line interface (CLI) *(6)*
computer *(2)*
cursor *(6)*
device driver *(3)*
device management *(8)*
directory *(8)*
distribution *(29)*
edition *(19)*
embedded OS *(4)*
file management *(8)*
file system *(8)*

firmware *(3)*
folder *(8)*
formatting *(8)*
graphical user interface (GUI) *(6)*
input/output (I/O) *(2)*
integrated circuit (IC) *(2)*
job management *(6)*
kernel *(6)*
Mac *(4)*
memory *(3)*
memory management *(8)*
microcomputer *(2)*
microprocessor or processor *(2)*
motherboard *(3)*
multitasking *(7)*
operating system (OS) *(2)*
partition *(8)*
personal computer (PC) *(4)*
portable operating system *(11)*
processes *(7)*
random-access memory (RAM) *(3)*
read only memory basic input output system (ROM BIOS) *(3)*
screen acceleration *(31)*
screen rotation *(31)*
security *(9)*
server *(5)*
smartphone *(4)*
solid-state drive (SSD) *(8)*
tablet *(5)*
task management *(7)*
Unified Extensible Firmware Interface (UEFI) *(3)*
user interface (UI) *(6)*
version *(13)*
virtual keyboard *(31)*
virtual memory *(8)*

Key Terms Quiz

Use the Key Terms List to complete the sentences that follow. Not all terms will be used.

1. A/an _____ takes care of the interaction between a program and a computer's hardware, freeing application programmers from the task of including such functions in their programs.
2. The _____ is the main component of an OS that always remains in memory while the computer is running, managing low-level OS tasks.
3. If you save confidential data on your local hard drive, you should be using an operating system that includes a/an _____ function, which protects the computer and the data it contains from unauthorized access.
4. An operating system that uses _____ will allow you to simultaneously run more programs than the physical memory of the computer will hold.
5. When you run several applications at once and switch between them, you are experiencing the _____ feature of an operating system.
6. Interaction with a computer involving getting data and commands into it and results out of it is called _____.
7. The role of a _____ is to provide services to other computers on a network.
8. Software that allows the operating system to control a hardware component is a/an _____.
9. A/an _____ is a hardware component in a mobile device that an OS uses when it rotates the image on the screen so that it is readable in its current position.
10. The _____ function of an OS includes the visual components as well as the command processor that loads program into memory.

Multiple-Choice Quiz

1. Which of the following operating systems cannot be licensed for a PC?
   a. Mac OS X
   b. Windows Vista
   c. Windows 7
   d. Linux
   e. Windows 8
2. Which of the following is a small electronic component made up of transistors (tiny switches) and other miniaturized parts?
   a. Peripheral
   b. Integrated circuit (IC)
   c. Tablet
   d. Mouse
   e. Vacuum tube
3. Introduced in 1983, this application program became the "killer app" that made the IBM PC a must-have business tool.
   a. MicrosoftW ord
   b. VisiCalc
   c. BASIC
   d. PC DOS
   e. Lotus 1-2-3

4. Which of the following is not available as a desktop operating system?
   a. Windows 8
   b. Macintosh OS X
   c. Windows 7
   d. Linux
   e. iOS
5. Which of the following is a computer input device? Select all correct answers.
   a. Mouse
   b. Printer
   c. Keyboard
   d. RAM
   e. ROM
6. On a network, the purpose of this type of computer is to allow end users to connect over the network to save and access files stored on this computer, as well as to print to printers connected to this computer.
   a. Desktop computer
   b. File and print server
   c. Tablet
   d. Laptop
   e. Smartphone
7. Which desktop OS now has a GUI optimized for touch screens with screen objects that appear flat and borderless so that they take up less screen space?
   a. Linux
   b. UNIX
   c. Mac OS X
   d. Windows 8
   e. Windows 7
8. Max OS X is built on NextStep, an OS based on what kernel?
   a. Linux
   b. UNIX
   c. DOS
   d. Windows
   e. BASIC
9. In the early 1950s, a typical computer end user would have been a _____.
   a. computer gamer
   b. medical doctor
   c. politician
   d. government agency
   e. secretary
10. An operating system is to a computer as a _____ is to a department.
   a. salesman
   b. spreadsheet
   c. steering wheel
   d. ignition
   e. manager
11. Which of the following accurately describes the overall trend in computing during the past 60-plus years?
   a. Toward physically larger, more powerful computers.
   b. Toward physically larger, less powerful computers.
   c. Toward physically smaller, less powerful computers.
   d. Toward physically smaller, more powerful computers.
   e. Toward physically smaller, single-use computers.
12. When working with a mobile device, if you touch an area of screen that requires input from a keyboard, the OS will display this for your use.
   a. Help screen
   b. Virtualk eyboard
   c. A Bluetooth button so that you can connect a keyboard.
   d. CLI
   e. Screen gestures
13. Using this type of wireless network connection when browsing the Internet with a smartphone or tablet can save you data fees.
   a. Bluetooth
   b. Wi-Fi
   c. USB
   d. Cellular
   e. Ethernet
14. This type of chip contains the basic input/output system for a computer.
   a. Microprocessor
   b. IC
   c. RAM
   d. ROM BIOS
   e. Floppy disk
15. What is the very first thing a user must do to gain access to a secure computer?
   a. Back up all data.
   b. Connect to the Internet.
   c. Log on with a user name and password.
   d. Double-click the Start menu.
   e. Reboot.

Essay Quiz

1. Describe the interactions you have had with computers in the past 24 hours.
2. If you use both a desktop computer and mobile device, describe some of the similarities and differences you have noticed in working with the GUI on each device. If you do not use both types of computers, find someone who does (classmate or other) and interview that person to answer this question.
3. Describe virtual memory and list an OS described in this chapter that does not use it.
4. Linux comes in distributions from many sources. Define the term *distribution* in this context.
5. In general terms, describe a mobile OS's use of a device's accelerometer.

Lab Projects

LAB PROJECT 1.1

To understand the relative cost of each of the desktop operating systems you are studying and the availability of each, research the price of each of the operating systems listed in the table below. You are not bargain hunting, so you don't need to look for the lowest price; just find the relative cost of the operating systems, packaged with an optical disc, if possible. Some are only available as downloads. You will also find that some are not available as new retail products, although you may find them at other sources. We have listed the full retail versions separately from the upgrade versions. You can install the full versions on a computer that does not have a previous version of Windows installed. The upgrade versions are cheaper than the full versions, but will not install without a previous version of Windows. In Table 1–4, enter the cost of each product.

TABLE 1–4 Price and Availability Comparison

Operating System	Cost	Operating System	Cost
Windows 7 Professional Full Version		Windows 8 Pro Upgrade	
Windows 7 Professional Upgrade		Windows 8 Pro OEM Full Version	
Windows 7 Ultimate Full		Windows 8 Pro Pack—Download	
Windows 7 Ultimate Upgrade		Ubuntu Linux—Download	
Windows 8 OEM Full Version		Mac OS X Mountain Lion Upgrade	

LAB PROJECT 1.2

In studying the common operating systems, you have considered the availability of software that runs on each OS and the general reasons you may choose one over the others. Put yourself in the position of an information technology professional in a new company that will open its doors on day one with 50 employees who will need computers on their desks connected to a corporate network and will need to work with standard business applications. What are some other practical considerations that you can think of that must come into play when making this decision? Your answer does not need to specify a particular OS.