1

Introduction to Operating Systems

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.

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? 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, perform tasks, and turn it off.

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. 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 | Overview of Microcomputer Operating Systems

This section is an introduction to the common operating systems used in today's computing devices (microcomputers). We begin by answering a few general questions you may have: What is an operating system? What is a microcomputer? What microcomputers are you using today? Then we briefly explore the events that led to the devices we use today as well as the operating systems that make them useable to us.

Operating Systems Defined

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 (app)** 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 and Adobe Photoshop are applications. Applications send commands to the OS to interact with the hardware.

Microcomputers Defined

Consumers encountered their first microcomputers in 1977 with the introduction of the Apple II, Radio Shack TRS-80, and the Commodore PET. The Apple II best combined the critical elements that defined a microcomputer at the time: these included a keyboard, monitor display, available peripherals, an operating system, useful applications, and a reasonable price tag. Today, microcomputers are everywhere, and many of us have them in various forms.

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 a laptop that she will carry to and from school. She is considering a Chromebook, running the Chrome OS, because the school requires that students use the Internet-based Google Cloud and its associated apps. She wants to learn more about the computers she uses each day, beginning with the hardware.

A typical PC with components.
©Denis Rozhnovsky/Alamy

Hardware Components

- A **computer** is a device that performs calculations. 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.
- An important invention that led to the miniaturization of computers was the **integrated circuit (IC)**, a small electronic component made up of transistors (tiny switches) and other miniaturized parts.
- Interaction with a computer is **input/output (I/O)**. When we send something into the computer, we call it input. You are inputting through input devices when you type on the keyboard, tap on a touch screen, or talk to a computer through a microphone. Output is processed information of many types: sounds sent

through the speakers, visual output to the display screen or printer and data files saved or sent over a network.

- 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, and various other supporting circuitry, all installed onto a **motherboard**.
- The typical microcomputer also has some form of storage, such as a hard drive, and it has at least one means each for input and output.

Firmware

Each computer device you use has special software resident in integrated circuits called **firmware** containing small programs for providing basic communications between the operating system and the hardware.

- **System firmware** contains program code that informs the processor of the devices present and how to communicate with them.
- 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.

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

Today's Microcomputers

The miniaturization of computers led to computers being built into all types of machinery, including vehicles, aircraft, and appliances. Computers touch our lives 24/7, and each has some form of operating system.

Servers. A **server** is a computer that provides one or more services to other computers over a network. What services do servers provide? A file server stores data files for network-connected users. 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.

```
Phoenix — Award BIOS v6.00PC
Copyright (C) 1984-2003, Phoenix Technologies, LTD


Main Processor : AMD Athlon (tm) 64 X2 Dual Core Processor 3000+
Memory Testing : 1720000K OK
```

FIGURE 1–1 An example of a firmware start-up message on an old PC.
Source: Phoenix Technologies Ltd.

A PC laptop.
©Rashevskyi Viacheslav/Shutterstock

A MacBook laptop.
©Norman Kin Hang Chan/123RF

©Zeynep Demir/Shutterstock

Other services include messaging services (email and fax), Web services, and 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 computer on the user end of these services is a **client**. Today's client computers include the PCs, laptops, tablets, and smartphones discussed in this book. A server can offer multiple services at the same time while also being a client to other servers.

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. It also requires specialized software, beginning with the operating systems. There are versions of Windows, Apple macOS, Linux, and UNIX especially designed as 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.

Desktops and Laptops. A desktop computer, often called a personal computer (PC), is a computer designed to spend its useful life in one location—on a desk. A typical desktop computer consists of a box containing the main components, a display screen, a keyboard, and a pointing device (mouse). The box and the display screen may be combined into one case—referred to as an all-in-one.

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. Laptops are often used as portable replacements for desktop PCs. The common operating systems for desktops and laptops are Apple's macOS (previously named OS X) for Apple brand desktop and laptops, Microsoft Windows, and Linux for other brands of PCs and laptops, the Chrome OS for Chromebox system units that are essentially PCs that come configured with the Chrome OS, and the Chrome OS for the Chromebook laptops. There are several manufacturers who sell Chromebooks, but Google does not provide Chrome OS as a separate consumer product.

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 computers as well as the MacBook laptop computers. Both types of Apple computers run macOS.

Mobile Devices. Microcomputers today include a long list of devices that don't have *computer* in their name, including mobile devices. A **mobile device** has all or most of its electronic circuitry, such as the microprocessor, controllers, and memory, on a single microchip. This is known as **system-on-a-chip (SoC)**. Mobile devices use wireless technologies and include a wide variety of products ranging from single-purpose computers to multifunction mobile devices. Some mobile devices run proprietary OSs, while others run scaled-down versions of desktop OSs. A mobile device commonly 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 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 and Apple iOS Windows Phone (versions 7, 8, and 8.1), and Windows 10 Mobile.

Another very popular type of mobile device is a tablet. A **tablet** has a touch screen, has no integrated keyboard (usually), is larger than a smartphone, and is much more portable than a laptop. There are many lines of tablet products, such as the Apple iPad, Microsoft Surface, Samsung Galaxy, Google Nexus, Sony Xperia, and Kindle Fire.

Based on your preferences and needs, you can purchase a tablet with one of these OSs preinstalled: Apple iOS, Microsoft Windows, Android, or Chrome OS.

Internet of Things. And lastly, microcomputers exist in devices belonging to the **Internet of things (IoT)**. These are devices we don't normally think of as computing devices. They include kitchen appliances, thermostats, utility meters, components in automobiles, light bulbs, and industrial control devices. They are not necessarily mobile, but they communicate on networks, often the Internet. IoT devices are increasingly used in industrial automation, connecting wirelessly, or via Ethernet, to automation networks.

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 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.

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. Since each type of computer requires different skills to complete tasks, she wants to gain a better understanding of the OSs to perform better on the job and be more comfortable working with the different computers. She wants to learn what an OS is and what functions it performs, which we describe in the following sections.
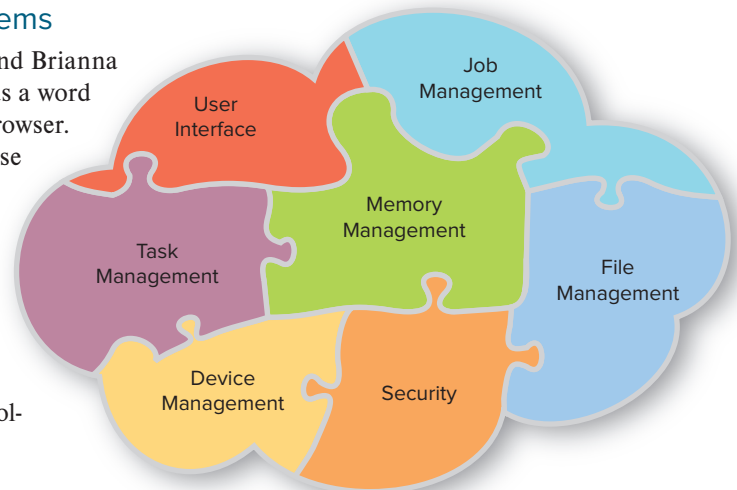
The functions of an operating system.

The Big Picture

When a computer is turned on an operating system starts up (or "boots up," a derivation of the expression "lifting yourself by your own bootstraps"). 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.

User Interface

The **user interface (UI)** is the software layer, sometimes called the shell, through which the user interacts 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).

Command-line Interface. On a computer running Linux (without a graphical shell), this visual component consists of a character-based command line that requires text input. This is the **command-line interface (CLI)**. Windows and macOS both have an
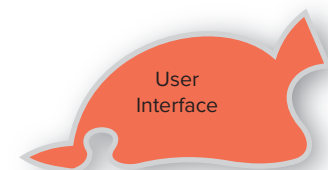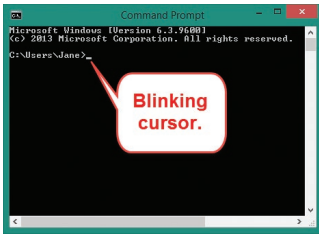
FIGURE 1–2 The Windows Command Prompt.
Source: Microsoft Corporation

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

Job Management

Task Management

optional CLI that runs in a window. Figure 1-2 shows the Windows 10 Command Prompt for the user Jane: 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 appear. Only a limited set of characters can display on the screen. To become proficient at working in a CLI, you must memorize the commands and their modifiers and subcommands.

Graphical User Interface. Apple's macOS, 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 small graphical icons 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 the Apple's macOS GUI. Notice the icons and other graphical components, such as the bar at the bottom containing icons for starting apps. Three windows are open on the desktop. In a GUI, you move a graphical pointer around using a pointing device—usually a mouse, trackball, touch pad, or touch screen. The pointer allows you to select or manipulate objects in the GUI to accomplish tasks. For example, to delete an item in macOS drag it into the Trash, shown on the bottom right of Figure 1-3. By contrast, in a CLI, you would type a command such as "delete report.txt."

Job Management

Job management, also known as process scheduler, is an operating system function that controls the order and time in which programs run. Two examples of programs that may take advantage of this function are a scheduling program that schedules other programs 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)
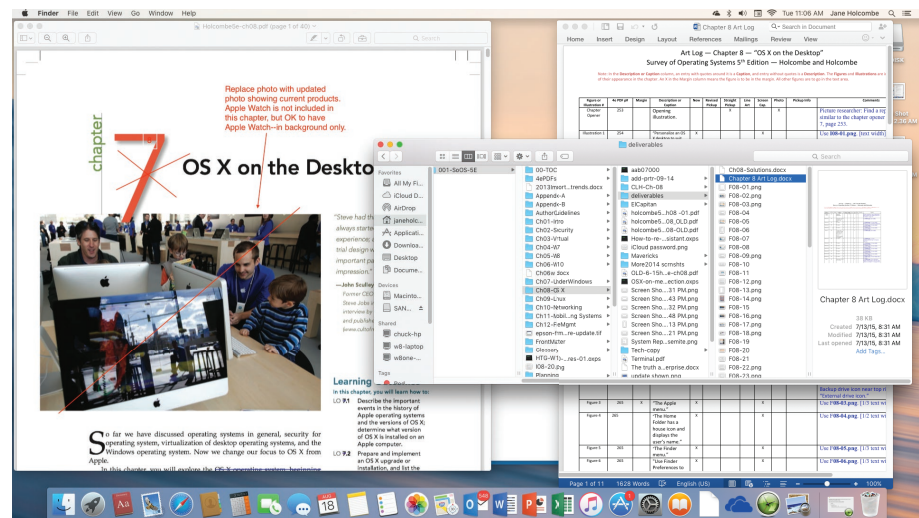

FIGURE 1–3 The macOS GUI.
Source: Apple Inc.

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 coexisting with task switching.

View Active Tasks in Windows or macOS

You can see what tasks are running on your Windows or macOS 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 an macOS 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.

Task management controls the focus (where the system's attention is at any given moment). It allows the user to switch between tasks by giving the focus to the application the user brings to the foreground. In graphical operating systems, the foreground application runs in the current window, the window that is on top of other windows on the screen. This window receives input from the keyboard, mouse, and/or touch screen when the user types. While active in memory, a program runs as one or more small components called **processes**. The OS's task management function manages these processes.

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 code that performs these tasks. An operating system uses a technique called **formatting** to write 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.

Normally, a single storage device will have only a single file system, residing in an 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 Windows. Windows follows the drive letter with a colon, so that a complete drive name is 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. Figure 1–4 shows the Windows 10 File Explorer with folder icons identifying various folders. The Navigation pane on the left includes two drive icons for the local disks C: and D:.

File Management

Note: As a rule, the term *folder* is used in a GUI, while the term *directory* is used in a non-GUI operating system.

Device Management

The **device management** function controls hardware devices by using special software called device drivers that are installed in the operating system. A **device driver** supplements or replaces firmware—even parts of the system firmware. It contains code for controlling a component; usually allowing much more control of a device than the device's firmware alone. A device driver is unique to a device; the manufacturer of the device creates it to work with a specific operating system. For instance, a printer

Device Management

FIGURE 1–4 The File Explorer app in Windows 10.
Source: Microsoft Corporation

Xerox opens Palo Alto Research Center (PARC).

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.

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

IBM introduces the floppy disk.

1968

1970

1969

1973

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.

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.

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or video adapter may come with separate device drivers for Windows, macOS, and Linux. OSs today are **plug- and- play (PNP)**, which makes them intelligent enough to detect an installed or connected device and automatically search for and install the needed device driver.
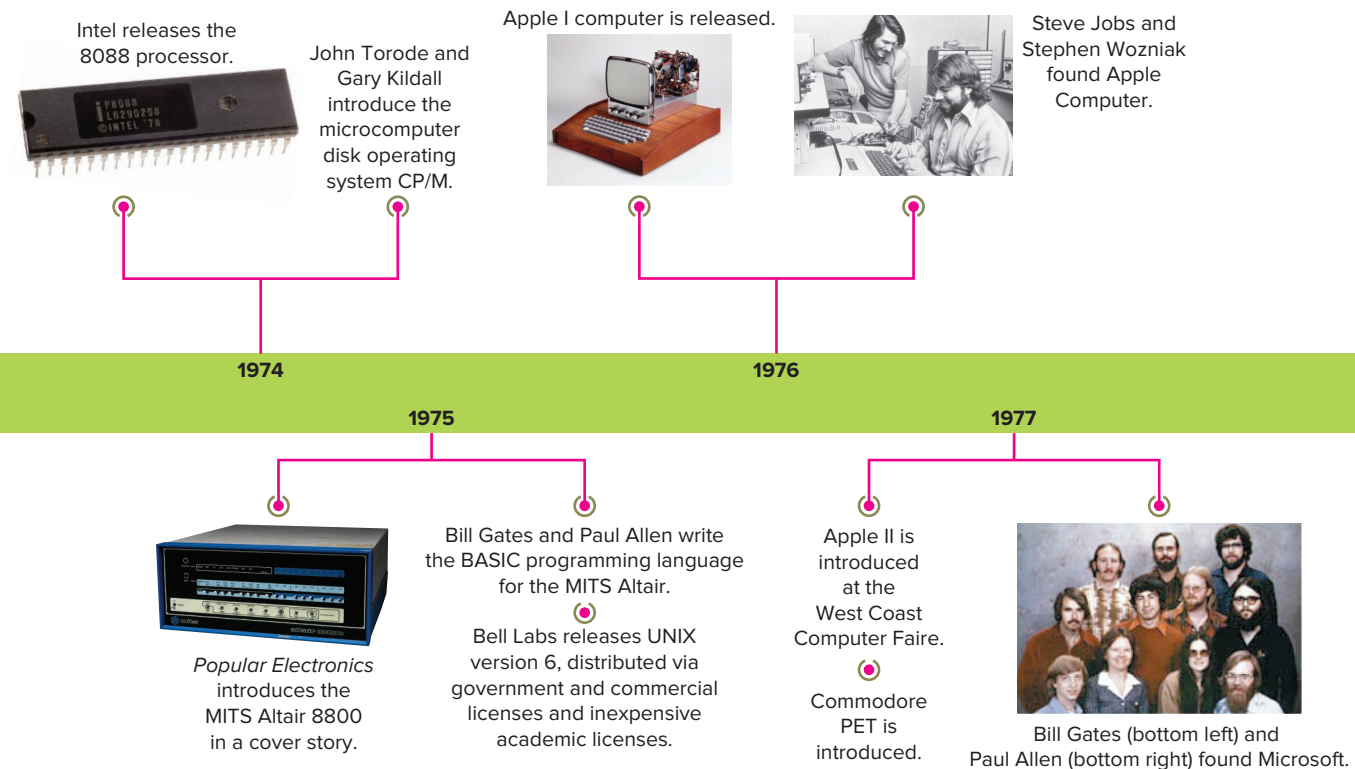
Memory Management

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 physical RAM used as system memory can hold. However, if you have insufficient memory for the type and number of apps you use, you may notice your computer slowing down. Adding more memory to a computer will usually allow you to run applications faster. However, there is a limit to how much RAM memory you can physically install in a computer, and there is also a limit to how much memory each operating system can use. We will address the limits for each operating system in upcoming chapters.

Memory Management

Security

The built-in **security** features of an operating system provide 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 others cannot access the data on

Security

Intel releases the 8088 processor.

John Torode and Gary Kildall introduce the microcomputer disk operating system CP/M.

Apple I computer is released.

Steve Jobs and Stephen Wozniak found Apple Computer.

1974

1976

1975

1977

Popular Electronics introduces the MITS Altair 8800 in a cover story.

Bill Gates and Paul Allen write the BASIC programming language for the MITS Altair.

Bell Labs releases UNIX version 6, distributed via government and commercial licenses and inexpensive academic licenses.

Apple II is introduced at the West Coast Computer Faire.

Commodore PET is introduced.

Bill Gates (bottom left) and Paul Allen (bottom right) found Microsoft.

her computer. 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.

LO 1.2 | Yesterday's Operating Systems

The complex operating systems you see on your desktop, laptop, and mobile devices didn't just magically appear one day. They evolved through many small steps over several decades. 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). At that time, each computer was dedicated to a single purpose, such as performing trajectory calculations for weapons or mathematical analysis for a science lab. Each program included system functions as well as the main function of the computer.

In those early days, the "user" was a government agency, research institute, or large business. Each organization ordered computers to meet their needs, as narrow as they may seem today. It was common for programmers to write the system I/O routines (the stuff of today's OSs) right into their programs. By the mid-1960s, as data storage on disk systems became more common, we needed operating systems to manage these disks and to perform other common system-level routines. As new technologies emerged, computers became more capable, leading to the need for an underlying operating system.

In this section, we explore the history of present-day computing devices and their operating systems. We start with UNIX, arguably the oldest OS still in use today. Its beginnings predate microcomputers.

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 everyday use. 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 a ROM-based interpreter for the BASIC programming language.

Apple Computer introduces floppy disk drives for the Apple II.

Bell Labs releases UNIX version 7.

UC Berkeley develops Berkeley Software Distribution (BSD) UNIX.

Sony and Philips develop first technology standards for compact disc.

Microsoft announces Microsoft XENIX OS, a UNIX OS for 16-bit microprocessors.

1978

1980

1979

1981

VisiCalc, the first spreadsheet program to run on a personal computer, is released.

Steve Jobs visits Xerox PARC, sees demos of a GUI, icons, and a mouse.

MicroPro International introduces WordStar, the first commercially successful word processing program for microcomputers.

Adam Osborne introduces the Osborne 1.

The word *Internet* is used for the first time to describe the ARPANET.

IBM introduces the IBM PC with Microsoft's BASIC in ROM and PC-DOS 1.0.

©Ralph Morse/Getty Images, ©ANATOL/Shutterstock, Source: Visicorp, ©Bettmann/Getty Images

UNIX—The Operating System for All Platforms

UNIX has a longer history than the other operating systems described in this book, and it is still in use today. In fact, Apple's Mac macOS 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 FreeBSD, NetBSD, OpenBSD, and OpenSolaris. Commercial versions of UNIX today include AIX, OpenServer (derived from SCO UNIX), and HP/UX.

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

try this!

Research the History of UNIX

Learn more about the UNIX operating system.
Try this:

1. Point your browser to **opengroup.org/unix**.
2. Look for a link to The UNIX Evolution: An Innovative History. There is also a link to the UNIX Infographic that summarizes the history up to just a few years ago.
3. Browse through the list of topics to learn more about what is currently happening with UNIX.

TCP/IP becomes the network protocol standard for the Internet.

Apple introduces the Lisa, the first commercial computer with a purely graphical operating system and a mouse.

Mitch Kapor announces Lotus 1-2-3 spreadsheet application for the IBM-PC.

Apple Computer releases the "Fat Mac" with 512K of memory.

Apple Computer releases the Macintosh with the Mac OS 1.

The 3½-inch floppy drives are introduced.

Satellite Software International (SSI) introduces WordPerfect.

IBM introduces the PC-AT with PC-DOS 3.0.

1982

1984

1983

Microsoft introduces the Microsoft mouse for the IBM PC and compatibles.

Microsoft and IBM introduce PC DOS 2.0 to support the 20 MB hard drive of the IBM PC-XT.

Lotus 1-2-3 sells more than 200,000 copies the first year.

Bell Labs releases UNIX System V, release 2 through commercial licenses.

Motorola introduces the DynaTAC 800X mobile phone (the size and approximate weight of a brick).

©Interfoto/Alamy, ©Twin Design/Shutterstock, Source: Convergent Technologies, Unix system

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 macOS 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.
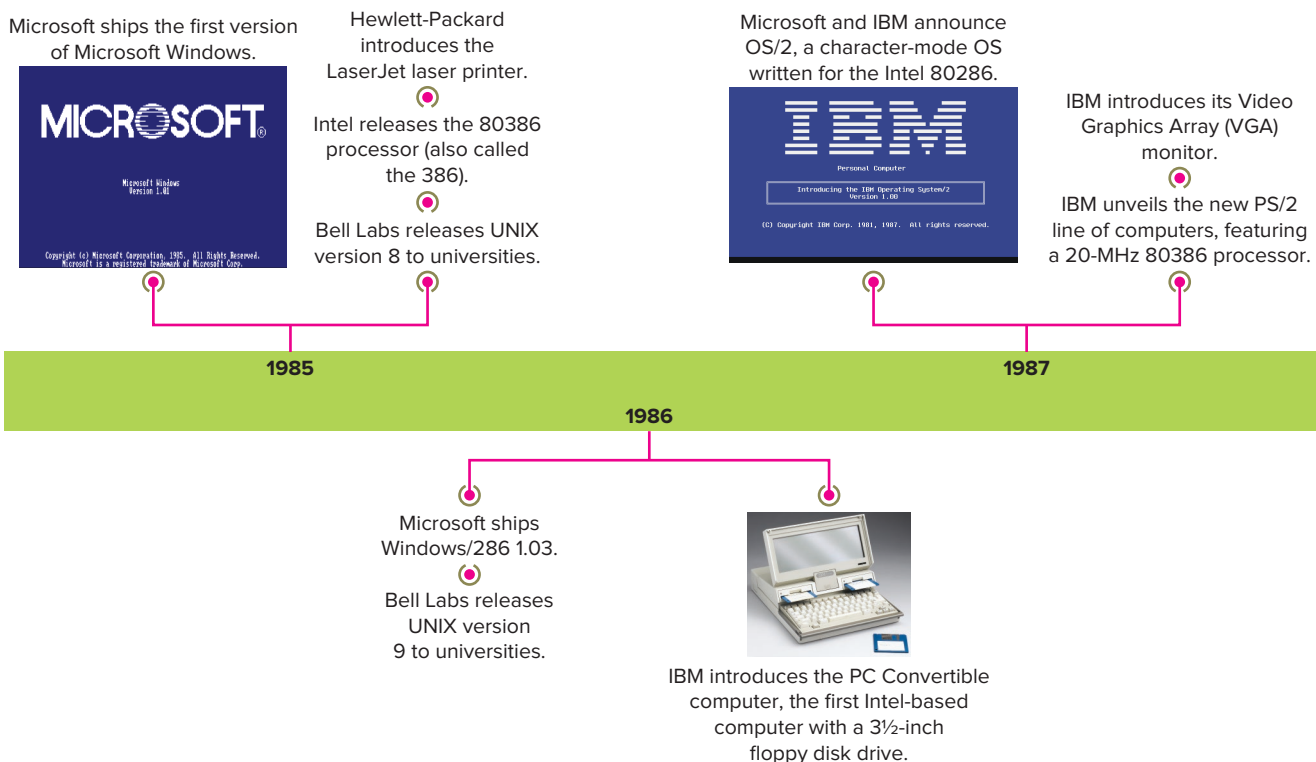
The Evolution of Desktop Operating Systems

The miniaturization of computer components inevitably led to the evolution of desktop operating systems available to consumers.

Small Steps

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

Microsoft ships the first version of Microsoft Windows.

Hewlett-Packard introduces the LaserJet laser printer.

Intel releases the 80386 processor (also called the 386).

Bell Labs releases UNIX version 8 to universities.

Microsoft and IBM announce OS/2, a character-mode OS written for the Intel 80286.

IBM introduces its Video Graphics Array (VGA) monitor.

IBM unveils the new PS/2 line of computers, featuring a 20-MHz 80386 processor.

1985

1987

1986

Microsoft ships Windows/286 1.03.

Bell Labs releases UNIX version 9 to universities.

IBM introduces the PC Convertible computer, the first Intel-based computer with a 3½-inch floppy disk drive.

Sources: Microsoft Corporation, IBM Corporation, ©Science & Society Picture Library/Getty Images

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.

Early Apple Computers and Their OSs

In 1976, Steve Jobs and Stephen Wozniak—two friends 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. The OS for the Apple II did not have a GUI interface—which first appeared in later Apple computers.

The Killer App for the Apple II 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 such killer app was VisiCalc, an electronic spreadsheet program introduced in 1979 for the Apple II computer (running the Apple OS). Before microcomputers and programs like VisiCalc, people created spreadsheets manually, on large grid-printed sheets of paper. Consider one scenario: the manager of a small retail store would enter a column of numbers—say, sales for one product in the store—day-by-day for a month. Then he 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 store. VisiCalc automated this

IBM and Microsoft release OS/2 1.1, adding a GUI to their first multitasking desktop operating system.

Motorola announces its 32-bit microprocessor, the 68040.

Microsoft releases Windows 3.0.
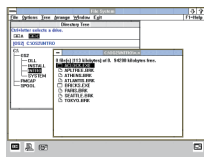
"Internet Worm" virus invades Internet, disables 10 percent of all Internet host computers.

NeXT, Inc. unveils the NeXT computer, featuring a 25-MHz Motorola 68030 processor.

1988

1990

1989

1991

Bell Labs releases UNIX version 10 to universities.

Intel releases the 80486 chip (also called the 486).

Tim Berners-Lee develops HTML, the foundation for the World Wide Web.

Microsoft releases MS-DOS 5.0.

Linus Torvalds creates Linux, a free UNIX-like operating system for the Intel platform.

Apple Computer launches the PowerBook series of portable computers.

Apple releases Macintosh System 7.0.

Internet opened to commercial use.

Sources: IBM Corporation and Microsoft Corporation

thankless job, remembered the formulas for the calculations, and allowed people to recalculate a whole column of numbers after changes were made.

VisiCalc gave people a reason to buy a personal computer, contributing to the success of the Apple II. However, as the 1980s arrived, Apple failed to come out with a successor to the Apple II in a timely fashion.

The Lisa Computer—a pretty face with no apps. In 1982, Apple introduced the Lisa, the first commercially available computer with a purely graphical operating system—and a mouse. However, this computer was not the needed successor to the Apple II because it lacked something very important for consumers—applications. It was not successful.

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 no longer available.
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.

Apple Macintosh and the Mac OS. Apple's 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. Most importantly, there were soon plenty of apps for this computer.

Apple revised and improved the operating system to support multiple users, but it was weak in memory management and lacked full multitasking.

Microsoft releases Windows 3.1, the first widely accepted version of Windows.
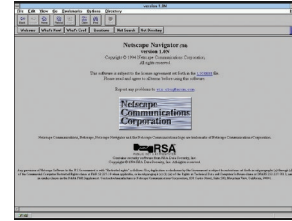
IBM releases OS/2 2.0, the first 32-bit OS for PCs.

Microsoft releases Windows for Workgroups 3.1, with integrated support for networking.

Yahoo! is born in a trailer on the Stanford University campus.

IBM releases OS/2 Warp (OS/2 version 3).

Microsoft releases MS-DOS 6.22 and Windows NT 3.5.
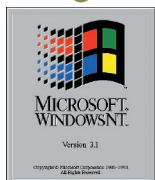
Netscape Communications releases Netscape Navigator.

1992

1994

1993

1995

Microsoft releases the first version of Windows NT (3.1).

Microsoft releases MS-DOS 6.0.

Apple introduces the Newton MessagePad, a handheld device with a stylus for use on the touch screen. It runs the Newton OS.

The National Center for Supercomputing Applications (NCSA) develops Mosaic, the first Web browser.

IBM introduces the Simon smartphone.

Microsoft ships Windows 95.

Intel releases the Pentium Pro microprocessor.

Motorola releases the PowerPC 604 chip.

Sun Microsystems creates the Java development language.

Sources: Microsoft Corporation and Netscape Communications Corporation

The final release of the classic Mac OS family was Mac OS 9, introduced in 1999. In 2001, it was replaced by a completely new operating system—Mac OS X, based on UNIX. This is the OS on the Apple desktop and laptop computers currently in use, although Apple officially changed the name to macOS in 2016. We will use this latest name throughout the book to refer to the OS for the Apple Mac.
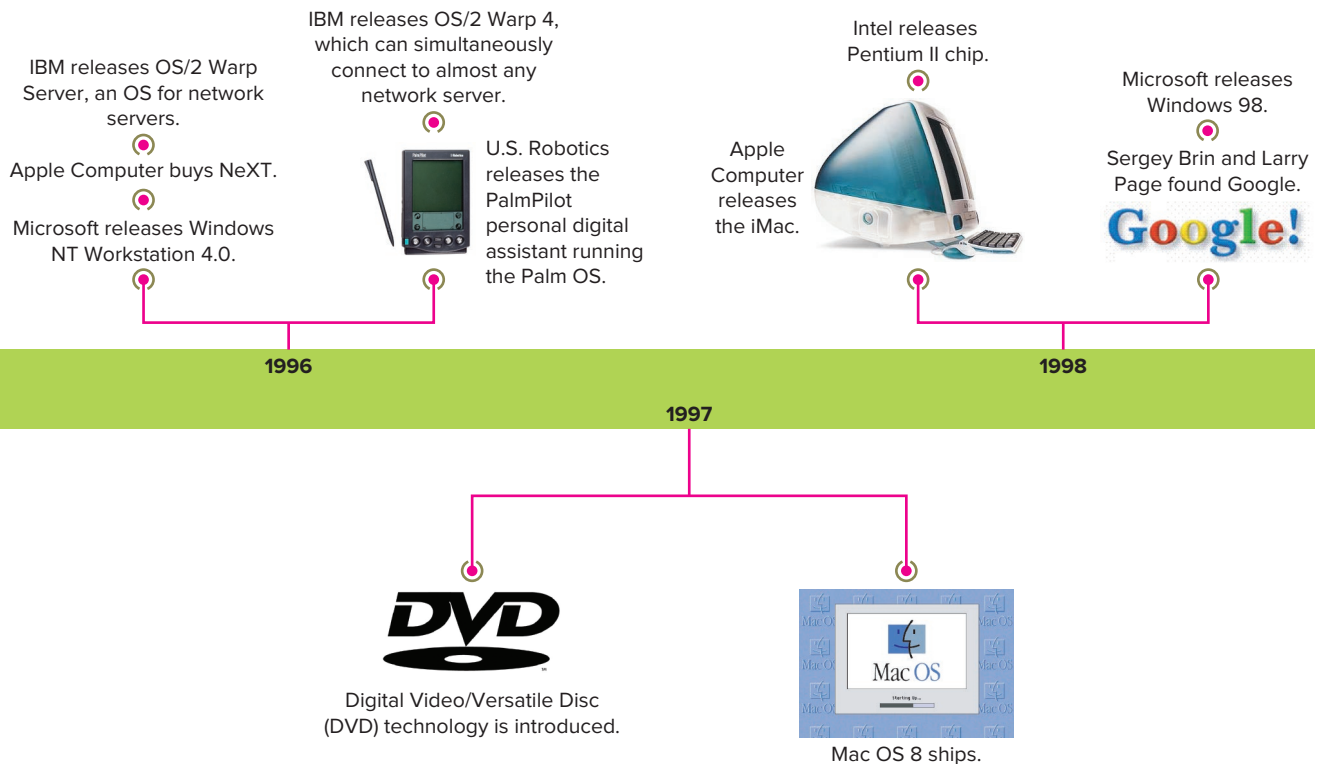
The IBM PC

IBM introduced the IBM PC in 1981, taking advantage of the void left by Apple, who had not introduced a true successor to their Apple II. The IBM PC far exceeded IBM's sales forecast of a quarter of a million units during its predicted 5-year product lifetime. According to one account, IBM took orders for half a million computers in the first few days after introducing the IBM PC. The early enthusiasts bought it despite the roughly $5,000 price tag for a typical configuration. The IBM logo on the product implied that it was a serious business computer, inspiring business users to buy it.

IBM PC DOS. The selection of an OS for the IBM PC came from a fateful series of events. IBM representatives visited Microsoft, then a fledgling software company, with two objectives. Acquire a BASIC interpreter to install in firmware on their PCs and find an OS that would start up from disk (diskette at first) on these new systems because Microsoft's BASIC interpreter was available on other microcomputers including the MITS Altair 8800, and it was popular with early users. IBM subsequently licensed Microsoft's BASIC interpreter and installed it in the firmware of the IBM PC.

When the IBM folks talked to Bill Gates about providing an OS, he sent them to another company, Digital Research, the creators of the then-popular CP/M OS. Digital Research refused to sign a contract with IBM, so the IBM guys went back to Bill Gates. Consequently, Microsoft bought an OS from another company, and this was the basis of the first version of the IBM PC Disk Operating System (DOS).

Note: In the years after its introduction, thousands of applications were written for PC DOS (and MS-DOS), but Lotus 1-2-3 (spreadsheet), 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.

Note: Many of us still open a command line interface (CLI) in Windows to use certain advanced troubleshooting tools. There are two CLIs that come with Windows: the Command Prompt and the Windows Power Shell.

IBM releases OS/2 Warp Server, an OS for network servers.

Apple Computer buys NeXT.

Microsoft releases Windows NT Workstation 4.0.

IBM releases OS/2 Warp 4, which can simultaneously connect to almost any network server.

U.S. Robotics releases the PalmPilot personal digital assistant running the Palm OS.

Intel releases Pentium II chip.

Apple Computer releases the iMac.

Microsoft releases Windows 98.

Sergey Brin and Larry Page found Google.

1996

1997

1998

Digital Video/Versatile Disc (DVD) technology is introduced.

Mac OS 8 ships.

©Science & Society Picture Library/Getty Images, ©Bloomberg/Getty Images, Sources: Google LLC, Philips, and Apple Inc.

The Killer App for the IBM PC. While VisiCalc, the killer app for the Apple II, was still an important app, it did not take full advantage of the increased memory in the IBM PC. The IBM PC still needed a killer app. That app was a spreadsheet app that ran on the DOS operating system and used all the 640 KB of memory available to software (OS plus application) on the IBM PC. This new app was Lotus 1–2–3, which was noticeably faster than VisiCalc and had additional features, including database functions and a program for creating graphs from the spreadsheet data.

PC DOS versus MS-DOS. PC DOS was the version for IBM computers. MS-DOS refers to the several versions of DOS developed by Microsoft and made available to non-IBM PC manufacturers. "DOS" in both names stands for "disk operating system." DOS did not have the more advanced capabilities of today's OSs. It was single-tasking, with no support for virtual memory, no native GUI, and no built-in security function. While it could use much more memory than the OSs that preceded it, DOS had very limited memory support compared to the OSs developed over the last three decades to support our much more advanced computer hardware.

DOS had a text-mode command-line interface that required users to remember cryptic commands and their subcommands to perform file management functions and to launch DOS applications. Figure 1–5 shows a good example of how cryptic DOS was.

PC DOS 1.0 supported single-sided 5.25-inch floppies. After that, each major version of DOS was released to support new disk capacities. MS-DOS 6.22 was the last widely used version of that OS. Some forms of DOS are now available from third-party sources, but the need for this type of OS is dwindling.

OS/2

In 1987, Microsoft and IBM introduced their jointly developed Operating System/2 (OS/2), intended to replace DOS. However, it required a much more advanced and expensive computer than DOS required, had very limited support for DOS apps, and lacked a killer app.

Advanced Micro Devices (AMD) releases the Athlon CPU, which surpasses Intel Pentium III's clock speed.

Intel unveils the Pentium III processor.

Microsoft releases Windows XP.

Microsoft releases Windows XP 64-Bit edition for Itanium systems.

Apple releases Mac OS X (10.0).

Apple releases Mac OS X (10.1).

1999

2000

2001

2002

Microsoft introduces Windows 2000 and Windows Me.

First large-scale denial-of-service attacks shut down major websites, including Yahoo!, eBay, and Buy.com.

Apple releases Mac OS X Jaguar (10.2).

Approximately 1 billion PCs sold since the advent of PCs.

Source: Microsoft Corporation

```
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:\>_
```
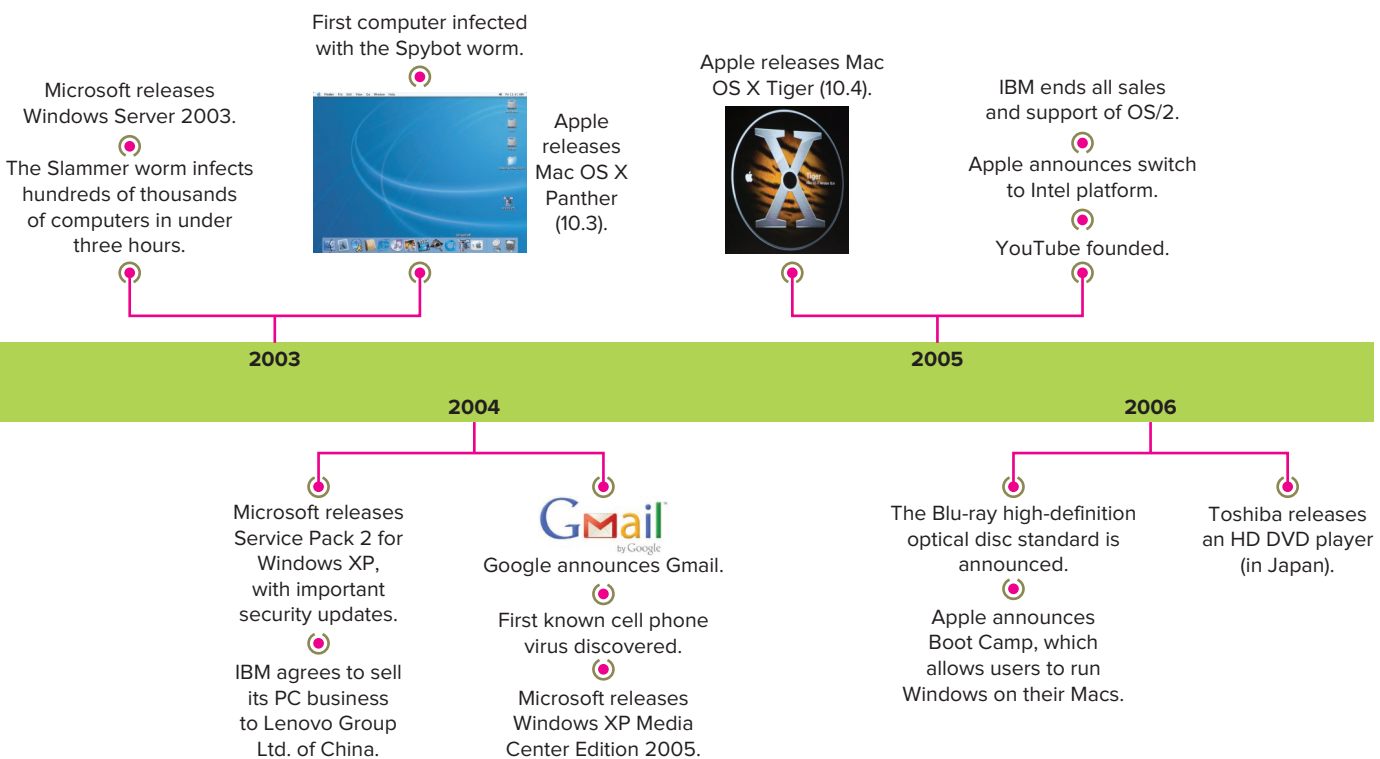
FIGURE 1–5 The MS-DOS prompt showing the Format command and the resulting output to the screen.
Source: Microsoft Corporation

   In 1994, IBM introduced OS/2 Warp, an improved version of OS/2 with a GUI. After about 18 months, 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 future versions of OS/2, and in December 2004 IBM sold its PC division to China-based Lenovo Group. OS/2 support was discontinued in 2005.

First computer infected with the Spybot worm.

Microsoft releases Windows Server 2003.

The Slammer worm infects hundreds of thousands of computers in under three hours.

Apple releases Mac OS X Panther (10.3).

Apple releases Mac OS X Tiger (10.4).

IBM ends all sales and support of OS/2.

Apple announces switch to Intel platform.

YouTube founded.

2003

2005

2004

2006

Microsoft releases Service Pack 2 for Windows XP, with important security updates.

IBM agrees to sell its PC business to Lenovo Group Ltd. of China.

Google announces Gmail.

First known cell phone virus discovered.

Microsoft releases Windows XP Media Center Edition 2005.

The Blu-ray high-definition optical disc standard is announced.

Apple announces Boot Camp, which allows users to run Windows on their Macs.

Toshiba releases an HD DVD player (in Japan).

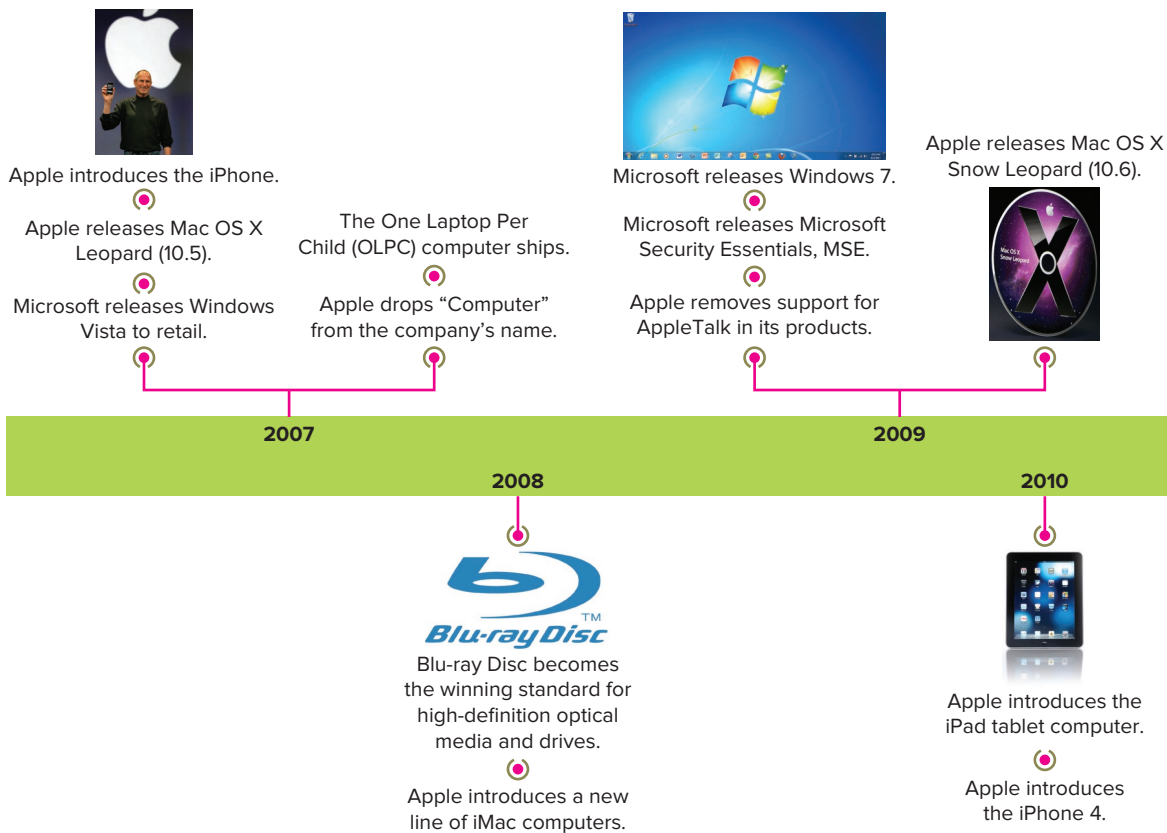Sources: Apple Inc., ©Kim Kulish/Corbis/Getty Images, Google LLC.

Microsoft Windows

Microsoft Windows is an OS with a GUI. It began life in 1985 as a simple GUI shell on top of MS-DOS. Since then, it has slowly evolved into a much more advanced OS, dominating the desktop for much of its life. Windows' fate is tied to the PC. Therefore, as more people use mobile devices for many of the functions previously assigned to PCs, PC sales have declined. Windows computers have also faced tough competition in the K-12 education market, where Apple iPads and Chromebooks are important tools for students. Following is a brief look at the various Windows versions.

Windows 1 through 3. In 1985, when the first version of Windows appeared, 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.

In 1990, Microsoft introduced Windows 3.0, which supported capabilities contained in the Intel processors in the latest PCs. The most important feature of Windows 3.0 was that it would run DOS apps better than previous versions, so that you could keep your old DOS apps, while gradually moving to the expanding number of Windows apps. Windows 3.0 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.

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

Note: The success of a new version of any OS depends heavily on its ability to run old applications.

Apple introduces the iPhone.

Apple releases Mac OS X Leopard (10.5).

Microsoft releases Windows Vista to retail.

The One Laptop Per Child (OLPC) computer ships.

Apple drops "Computer" from the company's name.

Microsoft releases Windows 7.

Microsoft releases Microsoft Security Essentials, MSE.

Apple removes support for AppleTalk in its products.

Apple releases Mac OS X Snow Leopard (10.6).

2007

2009

2008

2010

Blu-ray Disc becomes the winning standard for high-definition optical media and drives.

Apple introduces a new line of iMac computers.

Apple introduces the iPad tablet computer.

Apple introduces the iPhone 4.

©Tony Avelar/Stringer/Getty Images, Source: Microsoft Corporation, ©Tony Avelar/Bloomberg/Getty Images, Source: Blu-ray Disc Association, ©Simon Lees/PC Plus Magazine/Getty Images
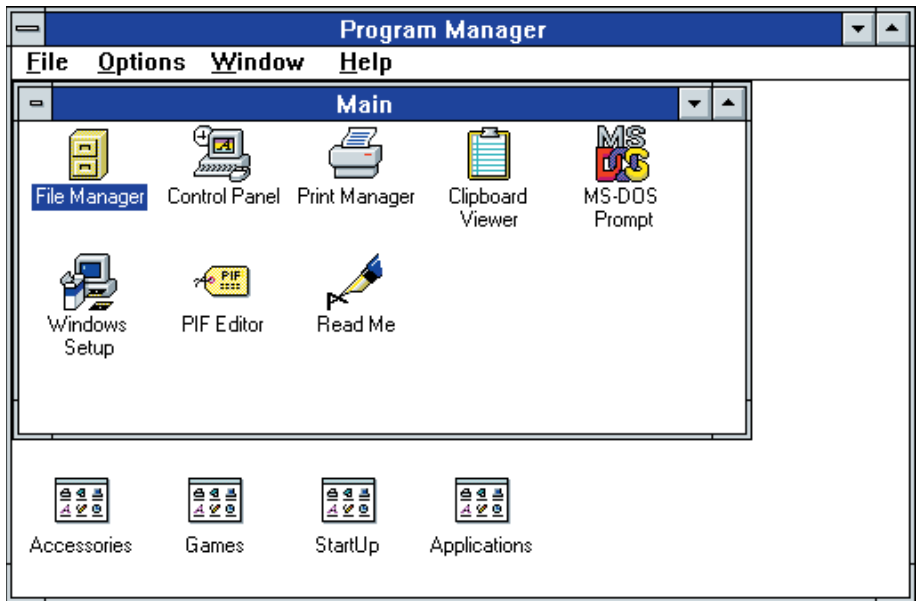
FIGURE 1–6 The Windows 3.1 desktop.
Source: Microsoft Corporation

Figure 1-6 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 a network, you added a network operating system (NOS) on top of your installed OS.
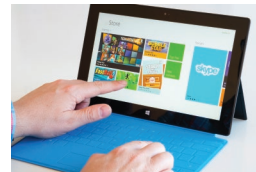

Google Glass Explorer "smart glasses" prototype available for $1,500 to a limited number of "Glass Explorers."

⊙

Microsoft releases Windows 8.1.
⊙

Apple releases Mac OS X Mavericks (10.9).

Apple releases Mac OS X Lion (10.7).
⊙

Amazon introduces the Kindle Fire.
⊙

Google introduces Chromebook computers running the Chrome OS.
⊙

Microsoft introduces the Microsoft Surface Pro tablet with pen.

2011

2013

2012

Apple releases Mac OS X Mountain Lion (10.8).
⊙

Apple introduces the iPhone 5.
⊙

Apple introduces the iPad mini.
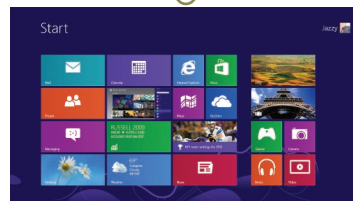
Microsoft Windows 8 and the Microsoft Surface tablet are released.

©FocusDigital/Alamy, ©Peppinuzzo/Shutterstock, Source: Microsoft Corporation.

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.

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 for Workgroups 3.1 was followed a year later by Windows for Workgroups 3.11, with some improvements. It was still a GUI running on top of MS-DOS.

Note: The acronym *NTFS* is the preferred usage when talking about the file system first introduced in Windows NT. The longer name for it, the "New Technology File System," is rarely used.

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. 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.

Apple releases OS X Yosemite (10.10).

Apple introduces the iPhone 6 and iPhone 6 Plus.

Apple introduces the iPhone 7 and iPhone 7 Plus.

Apple introduces the 9.7-inch iPad.

2014

2016

2018

2015

2017

Google Glass Explorer "smart glasses" prototype discontinued.

Apple releases the Apple Watch.

Microsoft releases Windows 10 with the Edge browser replacing Internet Explorer.

Apple introduces the iPhone 8, iPhone 8 Plus, and iPhone X.

Apple releases OS X El Capitan (10.11).

With Windows NT, Microsoft introduced the **New Technology File System (NTFS)** with an entirely new logical structure for storing files. This file system is expandable and uses a transaction processing system to track changes to files, so that it can roll back incomplete transactions. It also includes several other features, including file compression, file encryption, file and folder security, and indexing. NTFS is the default file system in the current versions of Windows.

The next version, Windows NT 3.5, released in 1994, was 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. The Workstation version was 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.

Windows 95. Windows 95, released in 1995, was 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 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. 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 did not support the NTFS file system; therefore, it did not have file and folder security.
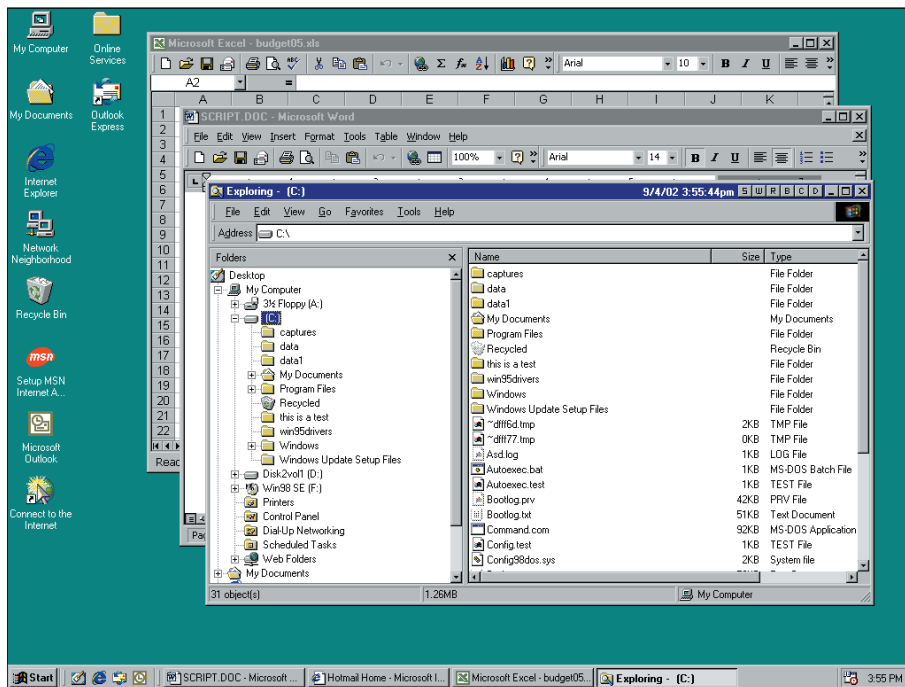
FIGURE 1–7 The Windows 98 desktop with open windows.
Source: Microsoft Corporation

The Windows XP Start Menu.
Source: Microsoft Corporation

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 networking support. Windows Me was installed on many computers that were sold to individuals, but it was not an OS that organizations adopted.

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 covered OS needs from the desktop (Windows 2000 Professional) to the enterprise server. Figure 1–8 shows the Windows 2000 desktop.

Windows XP. In 2001, Microsoft introduced Windows XP, intended only for the consumer desktop, not for the server environment.

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.

The Windows XP desktop was very different from that of its main predecessor, Windows 98. 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 SP3. Support for Windows XP Service Pack 3 (SP3) and for the 64-bit version with Service Pack 2 ended in April 2014, per Microsoft's published policy, the Microsoft Support Lifecycle.

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
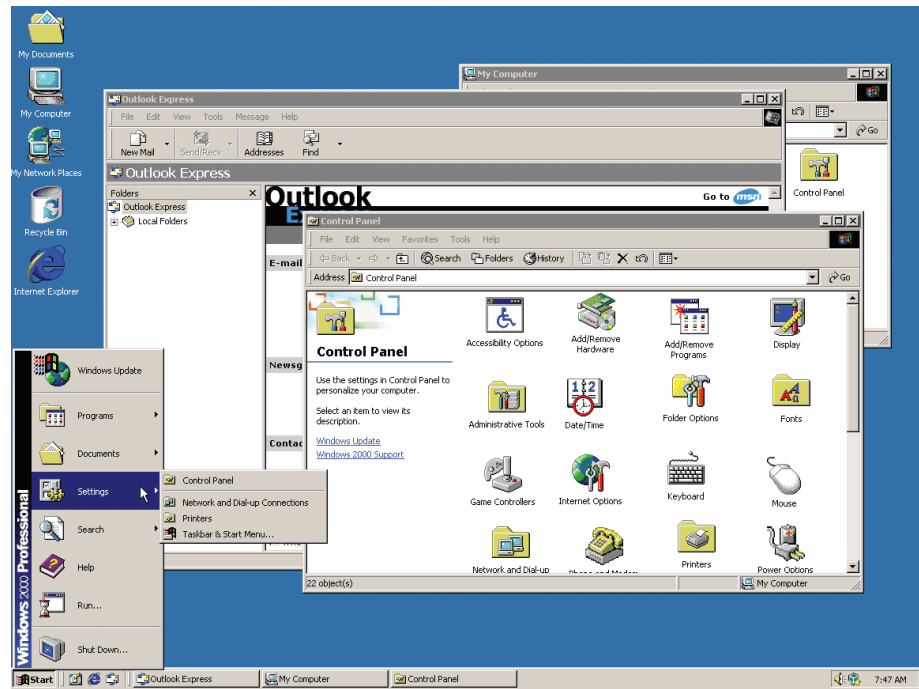
FIGURE 1–8 The Windows 2000 desktop showing the Start menu and open windows.
Source: Microsoft Corporation
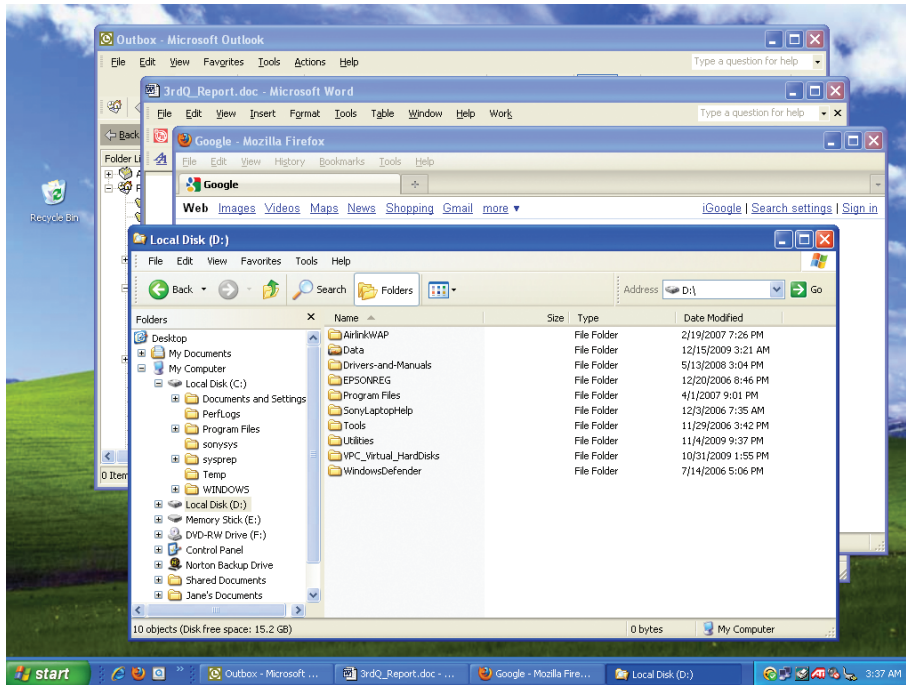
FIGURE 1–9 The Windows XP desktop with open windows.
Source: Microsoft Corporation
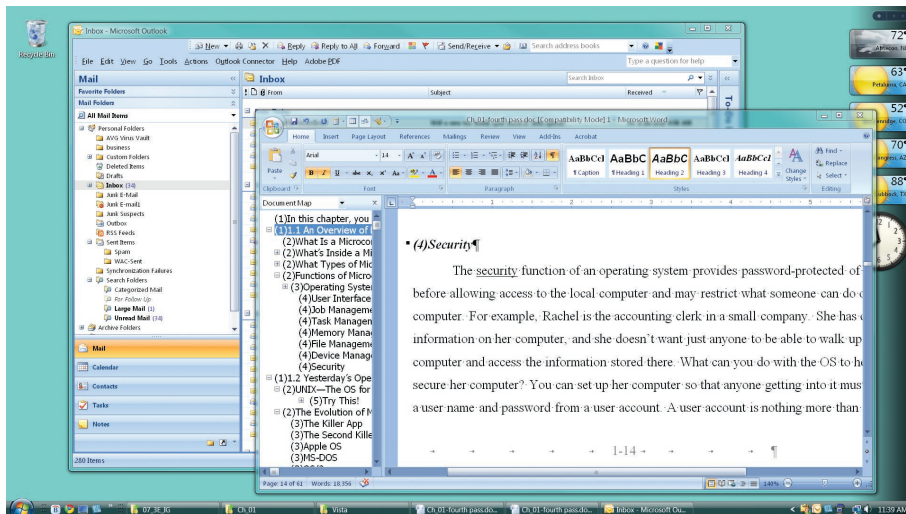
FIGURE 1–10 The Windows Vista desktop showing the transparent windows of the Aero feature.
Source: Microsoft Corporation; text ©Jane Holcombe

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.

try this!

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

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

1. In the Windows 7 or Windows 10 Start menu Search box (or in the Windows 8.*x* Start screen), type "system."
2. In the search results list, 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."

LO 1.3 | Today's Desktop Operating Systems

Today's desktop microcomputer operating systems include Windows 7, Windows 8, Windows 10, macOS, Chrome OS, and Linux. All of these OSs are multiuser/multitasking operating systems, with support for virtual memory and security. Each comes in versions that support either 32-bit or 64-bit processors.

Table 1–1 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.

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

Today's Windows for the Desktop

Today's Windows for the desktop include Windows 7, Windows 8, and Windows 10.

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 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 and 8.1

Windows 8, released in October 2012, came with better security and improved wireless connectivity as well as support for some newer hardware, such as USB 3.0 ports and improved touch screen support for simultaneous multiple touches and gestures.

The most controversial changes to Windows 8 were to the GUI, or rather GUIs. The default GUI, centered around the Start screen shown in Figure 1–12, 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 extra screen space. This is necessary because Windows 8 runs on a wide range of computing devices: PCs, laptops, and tablets. The Windows 8 Start screen contains tiles that represent apps. Each tile can show active content, 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) has a very flat look to it in spite of having overlapping

TABLE 1–1 Summary of Current Desktop/Laptop Operating Systems

| 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 and Windows 10	Microsoft	Intel/Microsoft	DOS, 16-bit Windows, 32-bit and 64-bit Windows applications for the Desktop and for the Windows 8 Modern GUI
macOS	Apple	Intel/Apple Mac	Mac applications
Linux	Various	Intel/Microsoft	UNIX/Linux applications
Chrome OS	Google (Alphabet)	Intel/Microsoft	Chrome Web Store apps and Android apps via Google Play
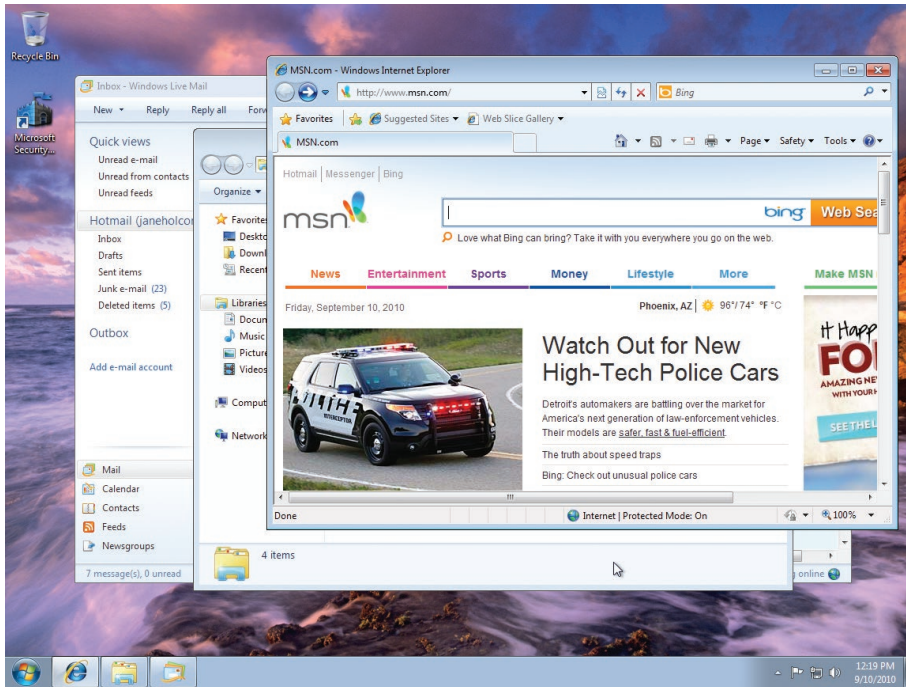
FIGURE 1–11 The Windows 7 desktop.
Source: Microsoft Corporation

FIGURE 1–12 The Windows 8 Start screen.
Source: Microsoft Corporation

windows. Figure 1-13 shows the Windows 8 desktop. In 2013, Microsoft released an update to Windows 8—Windows 8.1—with changes to the Start screen and the desktop that they hoped would satisfy critics of the Windows 8 GUIs.

Although Windows 8 came after Windows 7, it never sold sufficiently to match the market share achieved by Windows 7 (or Windows XP). This was despite the changes made in Windows 8.1. Therefore, this book does not include a separate chapter on Windows 8.*x*.

Note: In 2013, Windows 8 was followed by the important Windows 8.1 Update. Therefore, going forward in this book, we use the term Windows 8.*x* to refer to both releases.

Windows 10

In 2015, Microsoft introduced Windows 10, skipping the logical naming progression to Windows 9. Windows 10 includes a modified, but recognizable, Start menu on the
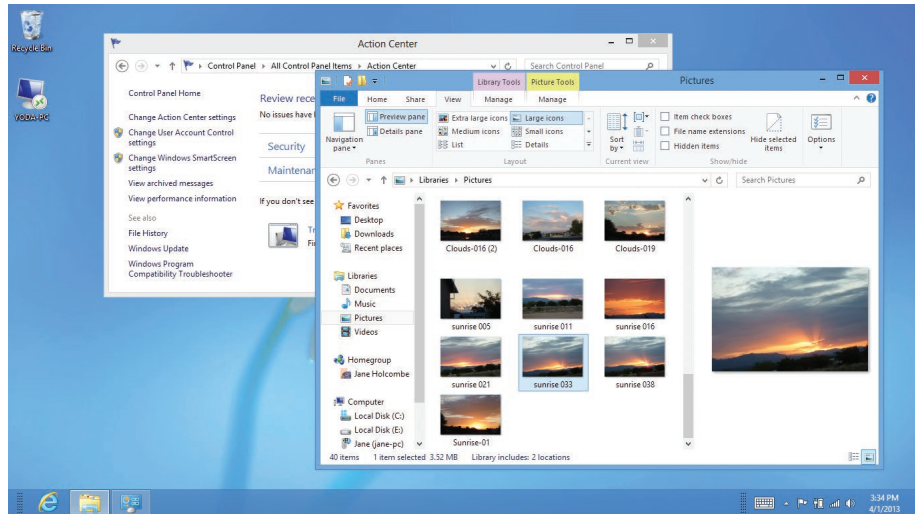
FIGURE 1–13 The Windows 8 desktop.
Sources: Microsoft Corporation; photos ©Jane Holcombe

desktop (returned by popular demand). It also includes new or improved features. Figure 1–14 shows the Windows 10 desktop. The short list of new features are:

- A new Start menu.
- Windows Hello biometric authentication using facial features or fingerprint.
- The Cortana personal assistant.
- The Microsoft Edge browser (replacing Internet Explorer).
- Universal apps that run on all Windows 10 systems.
- The Xbox app that brings game features to Windows 10.
- Support for multiple desktops within the GUI.

Further, for a period of one year after its introduction, Windows 10 was available as a free upgrade to consumers running Windows 7 Service Pack 1 (SP1) or Windows 8.1 Update on PCs, laptops, and tablets. Learn more about Windows 10 in Chapter 5.
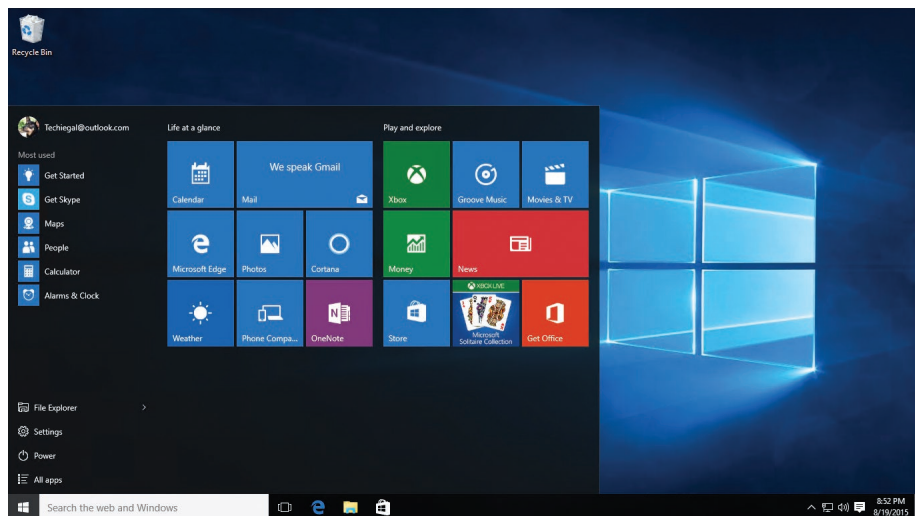
FIGURE 1–14 The Windows 10 desktop.
Source: Microsoft Corporation

Apple macOS

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 macOS 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 have been Intel-based.

The Mac OSs in common use today are versions of macOS (X is the Roman numeral for 10). When first introduced in 2001, it was named macOS and it was a revolutionary change from the previous Mac OS 9 because Apple based macOS on NextStep, an OS with a UNIX kernel. Until macOS, the Macintosh OSs were strictly GUI environments, with no command-line option. macOS, 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 1–15). Apple has released several versions of macOS renaming it macOS in 2016. Learn more about macOS and its features in Chapter 7.

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 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 a variety of distributions, and it can be modified to run on nearly any computer. A **distribution** 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.

Note: A distribution is also called a "distro" or "flavor."

Linux natively uses a command-line interface, and Figure 1–16 shows an example of a Linux directory list at the command line. Windows-like GUI environments,
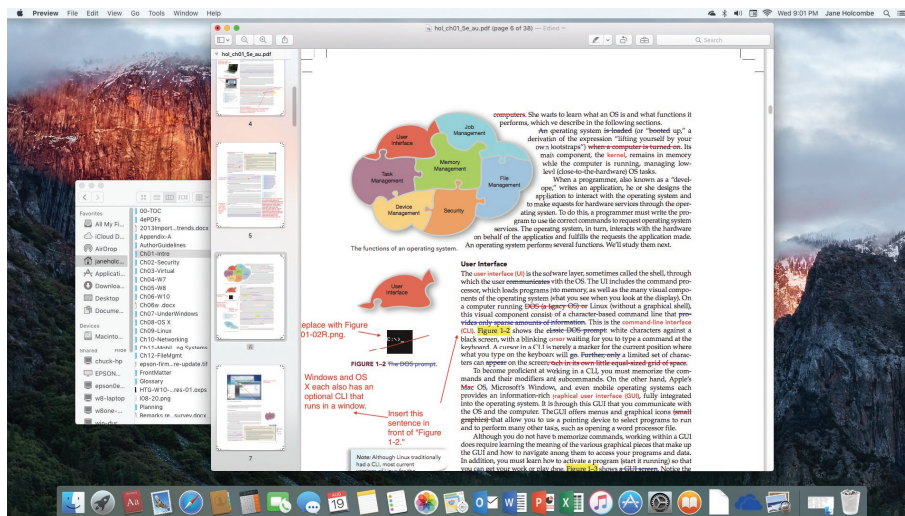
FIGURE 1–15 The macOS GUI.
Source: Apple Inc.; text ©Jane Holcombe

FIGURE 1–16 A Red Hat Linux directory listing (the ls command).
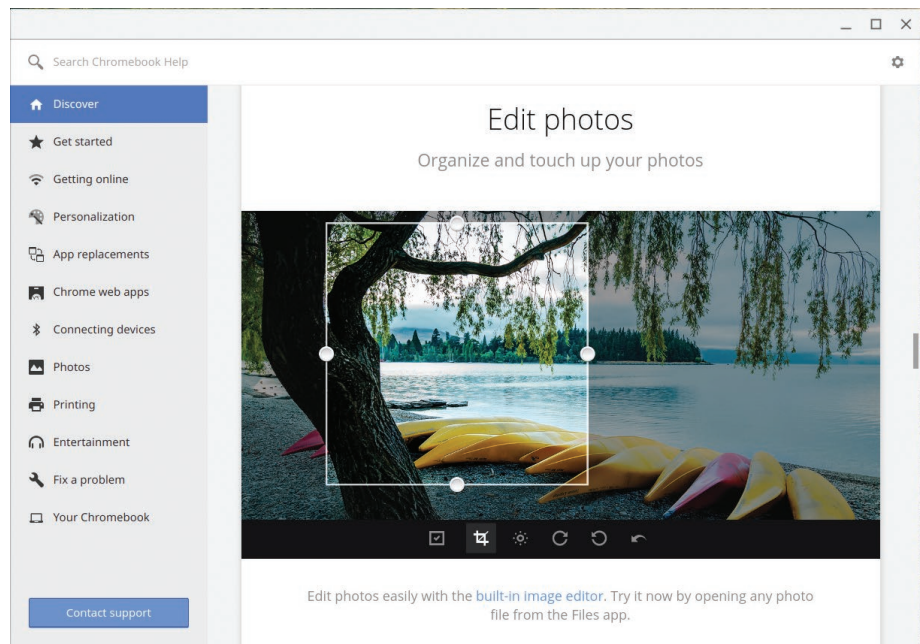Source: Red Hat Inc.

FIGURE 1–17 The Chrome OS GUI.
Source: Google LLC

called shells, are available that make it as accessible to most users as Windows or macOS. We will discuss selecting a Linux distribution in Chapter 8 along with other Linux-specific details.

Chrome OS

In the last three decades, computer-based work has gradually migrated away from our desktop computers and local networks to the cloud. We access cloud-based apps for online learning, completing projects and labs, submitting papers, collaborating with coworkers and fellow students, and for taking exams. At home, we connect to online services for entertainment, managing our finances, and much more. Recognizing this movement, Google created **Chrome OS**, an operating system based on a Linux kernel with a GUI based on the Chrome web browser. Of course, Chrome is also its default browser.

At first, it wasn't taken seriously by many professionals because it was not much more than a web browser, but Google has continued to improve the Chrome OS. Today, several manufacturers offer laptops, desktops, and tablets dedicated to the Chrome OS (see Figure 1-17).

LO 1.4 | Today's Mobile Operating Systems

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 two mobile OSs featured in this book, Apple licenses iOS only for use on Apple mobile. Google does not charge manufacturers licensing fees for using Android, but may require that certain Google apps and features be included. They license it for free under the Android Open Source Project. This helps hold down the cost of Android smartphones.

Mobile Devices

There are many manufacturers of mobile devices, but the ones we will focus on are those that use the Apple iOS or Android, operating systems. Two things they have in common are support for a variety of wireless technologies and the ability to customize them with a variety of apps. Table 1–2 gives a summary of these OSs and the devices that use them. Following is a brief description of the hardware features of these devices:

- 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 runs iOS, but we are not covering this device. With its small screen and NO cell phone support, it is simply a digital music player with tablet features.

Note: This book does not include coverage of the Watch OS, the operating system in the Apple Watch smartwatch.

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.

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.

To help control the cost of cellular data plans, we are fortunate to also have Wi-Fi connectivity in virtually all smartphones and tablets. If you enable Wi-Fi on your

TABLE 1–2 Summary of Current Mobile OSs and Related Devices Featured in This Book

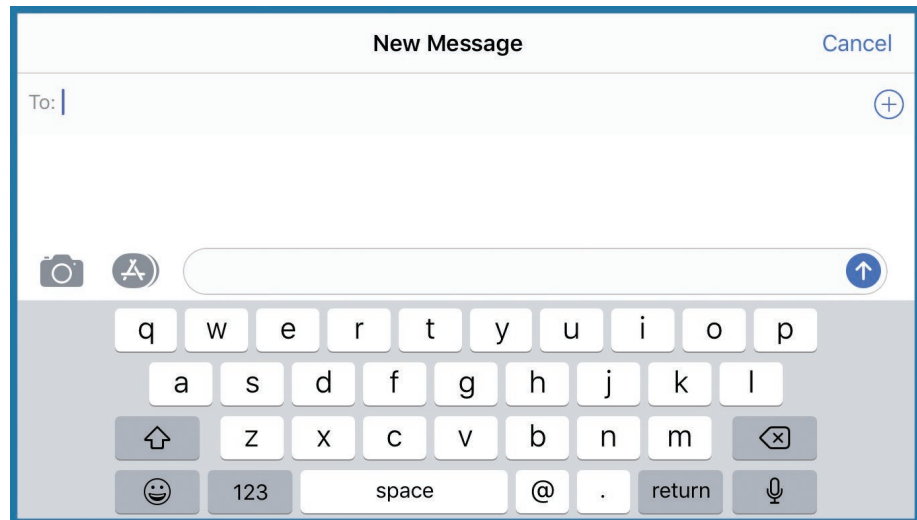| Mobile OS	Source of OS	Smartphones/Tablets	Sources for Apps
Apple iOS	Apple	Apple iPhone and iPad	Apple Apps Store
Android	Google	Smartphones and tablets from various manufacturers	Apps from Google Play and many other sources

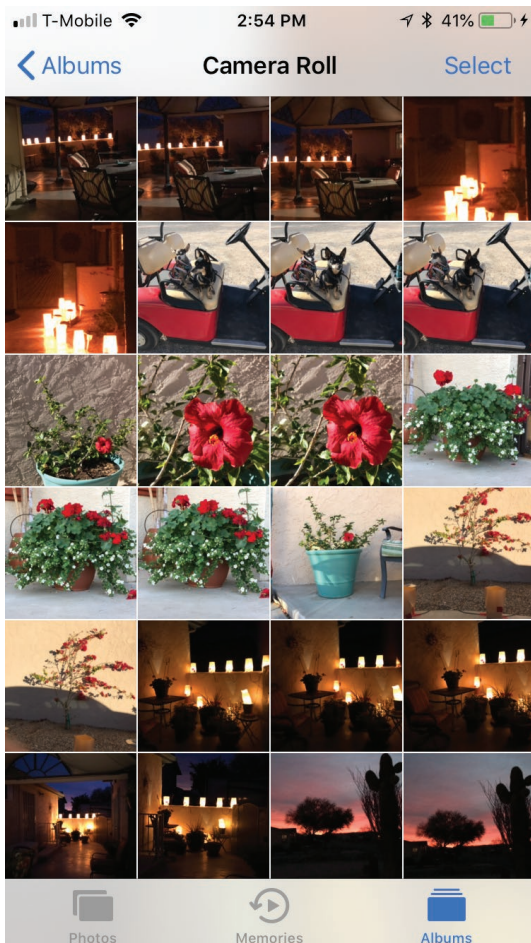**FIGURE 1–18** The virtual keyboard on an iPhone.
Source: Apple Inc.

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, headphones, speakers, and printers.

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

Mobile Operating System Features

When discussing mobile operating systems, 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 1–18 shows the virtual keyboard on an iPhone. Many mobile devices will optionally connect to an external keyboard—usually via a Bluetooth wireless connection. Learn more about these features in Chapters 10 and 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**. Figure 1-19 shows the screen of an iPhone in "portrait" orientation, and Figure 1-20 shows the screen of the same iPhone in "landscape" orientation.
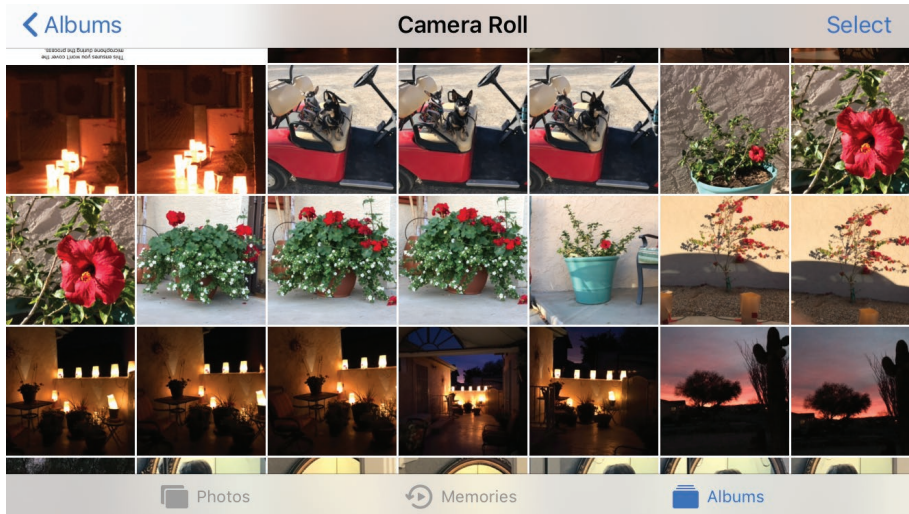

FIGURE 1–19 An iPhone screen in portrait orientation.
Sources: Apple Inc.; photos ©Jane Holcombe

FIGURE 1–20 An iPhone screen in landscape orientation.
Sources: Apple Inc.; photos ©Jane Holcombe

Updateable

As with desktop operating systems, the ability to update a mobile OS is important to the usability and security of the mobile device. In general, you can update an OS depending on the constraints of the hardware limits imposed by the cellular provider.

Availability of Apps

Today's mobile devices are desirable 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. Both Apple iOS and Google Android 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 Apple Store, shown in Figure 1–21.

Security

Mobile devices are targeted by the same security threats that target other computers. Being able to 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 iOS and Android mobile operating systems in Chapters 10 and 11.

Data Synchronization

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.
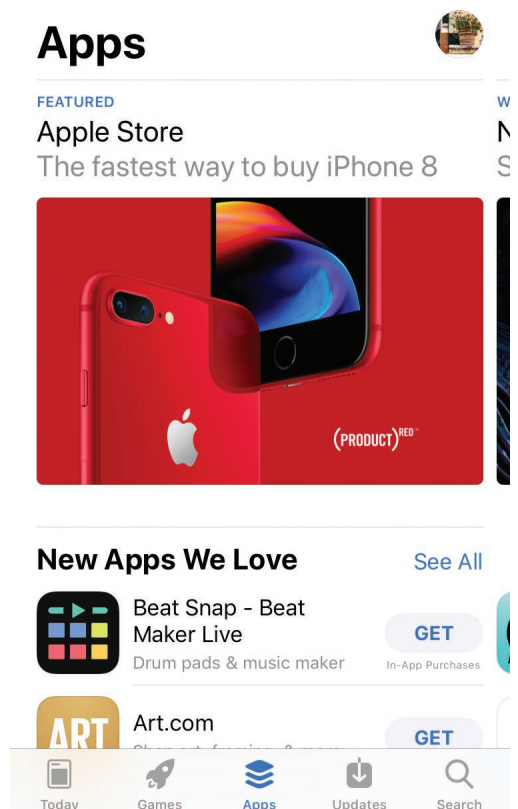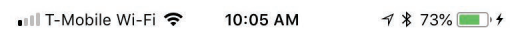

FIGURE 1–21 The Apple Store for iOS apps and other Apple products.
Source: Apple Inc.

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 control all of the interactions among the various system components.
- 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.
- A device driver is a special program containing code for controlling a component.
- Common microcomputers in use today include desktops, laptops, tablets, and smartphones.
- Windows, Chrome OS, and Linux will run on a desktop PC or compatible laptop computer. Mac OS runs on 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
  - File management
  - Device management
  - Memory management
  - Security

Yesterday's Operating Systems

- UNIX is the oldest operating system still in use. It comes in versions for large computers, as well as microcomputers.

- The complex and powerful OSs we now use evolved over many decades.
- Early microcomputers were introduced in the 1970s. The Apple computers came with the Apple OS.
- Certain "killer apps," notably VisiCalc and Lotus 1-2-3, made microcomputers appeal to organizations and ordinary people.
- IBM introduced the IBM PC in 1981 with Microsoft BASIC in ROM. They offered PC DOS for computers with a floppy disk drive.
- In the 1980s, Microsoft made MS-DOS available to third-party PC manufacturers.
- OS/2 was first developed in a joint effort between Microsoft and IBM. 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 10, introduced in 2015.
- 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 OS X was introduced in 2001.

Today's Desktop Operating Systems

- Today's desktop operating systems include Windows 7, Windows 8, Windows 10, macOS, Chrome OS, and Linux.
- Windows 7, released in 2009, included many improvements over Windows Vista; many businesses adopted this for their desktop PCs.
- Windows 8 was introduced in October 2012 with two GUIs. In 2013, Microsoft released the Windows 8.1 Update with changes to the Start screen and desktop.
- Windows 10 was introduced in 2015 with changes to the GUI and several new features.
- Apple's macOS based on NextStep, an OS with a UNIX kernel, runs only on Apple Mac desktop and laptop computers.
- Linux can run on nearly any computer. It natively uses a command-line interface, but GUI shells are available.
- Google's Chrome OS comes on Chromebooks and the Chromebox.

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.
- 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 cellular providers.

- Smartphones and tablets offer Wi-Fi connections, a cheaper alternative to cellular for accessing the Internet with the device.
- Bluetooth is a wireless networking technology for connecting over very short distances.
- A mobile OS displays a virtual keyboard when you touch an area of screen that requires text input.
- A mobile OS takes advantage of the hardware accelerometer in a device by rotating the image on the screen to accommodate the position of the screen so that it is readable to the user.
- Most mobile operating systems can be updated.
- Popular mobile OSs have a large number of available apps.
- All mobile OSs have security features, and third-party solutions are available.
- It is important to have good options for synchronizing data across all devices used by an individual.

Key Terms List

accelerometer *(29)*

application (app) *(2)*

central processing unit (CPU) *(2)*

client *(4)*

command-line interface (CLI) *(5)*

computer *(2)*

Chrome OS *(28)*

cursor *(6)*

device driver *(7)*

device management *(7)*

directory *(7)*

distribution *(27)*

embedded OS *(4)*

file management *(7)*

file system *(7)*

firmware *(3)*

folder *(7)*

formatting *(7)*

graphical user interface (GUI) *(6)*

input/output (I/O) *(2)*

integrated circuit (IC) *(2)*

Internet of Things (IoT) *(5)*

job management *(6)*

kernel *(5)*

killer app *(13)*

Mac *(4)*

memory *(3)*

memory management *(9)*

microcomputer *(2)*

microprocessor *(2)*

mobile device *(4)*

motherboard *(3)*

multitasking *(6)*

New Technology File System (NTFS) *(21)*

operating system (OS) *(2)*

partition *(7)*

personal computer (PC) *(4)*

plug-and-play (PNP) *(9)*

portable operating system *(11)*

processes *(7)*

random-access memory (RAM) *(3)*

screen rotation *(30)*

security *(9)*

server *(3)*

smartphone *(4)*

solid-state drive (SSD) *(7)*

system firmware *(3)*

system-on-a-chip (SoC) *(4)*

tablet *(4)*

task management *(6)*

user interface (UI) *(5)*

virtual keyboard *(30)*

Key Terms Quiz

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

1. A/an _____ controls 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. The desktop operating systems described in his chapter all have an optional character mode _____.

4. The Google _____ is based on their popular web browser. 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/an _____ 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 programs into memory.

Multiple-Choice Quiz

1. Which of the following operating systems cannot be licensed to run on a PC?
   a. macOS
   b. Windows 10
   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. Microsoft Word
   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. Chrome OS
   b. macOS
   c. Windows 10
   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 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 acronym describes technology in which all or most of a device's electronic circuitry is on a single microchip?
   a. IoT
   b. UI
   c. RAM
   d. SSD
   e. SoC

8. macOS is built on NextStep, an OS based on what kernel?
   a. Linux
   b. UNIX
   c. DOS
   d. Windows
   e. Chrome OS

9. In the 1950s, a typical computer end user would have been a _____.
   a. computer gamer
   b. medical doctor
   c. politician
   d. government agency
   e. secretary

10. What acronym describes networked devices that contain microcomputers but are not thought of as computing devices, such as refrigerators, automobile components, light bulbs, and industrial control devices?
    a. IoT
    b. RAM

c. NTFS

d. SSD

e. SoC

11. Which of the following accurately describes the overall trend in computing during the past 70-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 text input, the OS will display this for your use.

a. Help screen

b. Virtual keyboard

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. What file system is the default for current Windows OSs?

a. iOS

b. IC

c. RAM

d. NTFS

e. SSD

15. Which of the following is a technology you would use to connect your smartphone to a wireless headset?

a. Bluetooth

b. Wi-Fi

c. USB

d. Cellular

e. Ethernet

Essay Quiz

1. Describe the benefit to programmers of having an operating system when that programmer is creating a new application.

2. Based on your own observations, do you believe there are more differences or more commonalities among the different operating systems across devices: PCs, laptops, tablets, and smartphones?

3. Review the timeline provided in this chapter and select an event that you believe is the most significant event and give a reason for your choice.

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

Pick a typical day for you, and create a journal of all the interactions you have with computers from the time you wake up in the morning until you go to bed at night. *Hint:* Even a gas pump contains a computer.

LAB PROJECT 1.2

If you use both a desktop (or laptop) computer and a mobile device, describe the similarities and differences you notice in working with the GUI on each device. If you do not use both types of devices, find someone who does (classmate or other) and interview that person for this project. Create a report of these results to submit to your instructor or to use in a discussion of results with your classmates.

LAB PROJECT 1.3

Poll classmates or coworkers to determine how they use their mobile devices. Are they primarily entertainment devices? If so, describe why this is the case. How many people polled used a mobile device as a primary computer?

In that case, what tasks did they perform on the mobile devices? Were there tasks they preferred to do on a desktop or laptop? Create a report describing the results and be prepared to discuss with other students who completed this project separately.