FIFTH EDITION

Survey of
OPERATING SYSTEMS

JANE HOLCOMBE
CHARLES HOLCOMBE

Mc Graw Hill Education

survey of

Operating Systems

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About the Authors

JANE HOLCOMBE (MCSE, MCT, A+, Network+, CTT+, and Novell CNA) was a pioneer in the field of PC support training. In 1983, while working for a financial planning company, she moved the accounting and client-management operations to IBM PCs. This project included using three different operating systems to run the selected software and installing a local area network for sharing the accounting system and data. Although the network was not completely successful, this project showed the potential of networked PCs in business. Between 1984 and the mid-1990s she was an independent trainer, consultant, and course-content author, creating and presenting courses on PC operating systems nationwide and coauthoring a set of networking courses for the consulting staff of a large network vendor. In the early 1990s she worked with both Novell and Microsoft server operating systems, finally focusing on Microsoft operating systems. She achieved her Microsoft Certified Systems Engineer certification early, recertifying for new versions of Windows. Since 2000 she has worked primarily as a technical writer and technical editor.

CHARLES HOLCOMBE has a high-tech background in computing in the nuclear and aerospace fields. In his 15 years at Control Data Corporation, he was successively a programmer, technical sales analyst, salesman, and sales manager in the field marketing force. At corporate headquarters, he ran Control Data's Executive Seminar program, headed sales training for the corporation, was liaison to the worldwide university community, and was market development manager for the Plato computer-based education system. For the past 30 years, he has been an independent trainer and consultant. He has authored and delivered many training courses and is a skilled editor. Currently he is an independent editor for various clients and collaborates with Jane on writing projects. For a while, he claimed he was semi-retired, but, with his consulting and editing work, he cannot say that anymore.

Together the Holcombes have authored 12 books, beginning with the *MCSE Guide to Designing a Microsoft Windows 2000 Network Infrastructure* (Course Technology), and both the *A+ Certification Press Lab Manual* and the *MCSE Certification Press Windows 2000 Professional Lab Manual* (McGraw-Hill/Osborne). They wrote *Using Windows 8* (McGraw-Hill) and the sixth, seventh, and eighth editions of the *CompTIA A+ Certification Study Guide* (McGraw-Hill). The book you are holding is their fifth edition of *Survey of Operating Systems*. The Holcombes also contributed chapters to four other technical books published by McGraw-Hill.

About the Contributors

This book was greatly influenced by the comments, suggestions, and feedback from the following group of dedicated instructors. To them we give our heartfelt thanks.

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Acknowledgments

After completing work on the fourth edition of our *Survey of Operating Systems*, Jane took some time off from the intense pressure of meeting deadlines while Chuck continued his other editing work. Then, after realizing that she wasn't spending all that free time wisely or creatively (the urban fantasy novel never materialized and her oil paintings were "meh"), she went in search of a little work-for-hire project. She called Alan Palmer, our product developer at McGraw-Hill, who asked if we wanted to write the fifth edition of our *Survey of Operating Systems* book. Because much has happened with operating systems and with personal computing since we wrote the first four editions, we knew it would require a nearly complete rethinking of the content. Along with brand manager Wyatt Morris and Alan, we wrote a suggested Table of Contents that they sent to instructors—some of whom were still using the fourth edition. The results of this survey helped us create the outline for the fifth edition.

As with previous editions, knowledgeable peer reviewers scrutinized each chapter, giving us invaluable feedback on the relevancy and accuracy of the content. We can't imagine writing a book like this without these technical reviews.

We thank every member of the talented team of people at McGraw-Hill who ensured the book's integrity. They include Wyatt Morris, Alan Palmer, Mary Jane Lampe, and Ruma Khurana and Vivek Khandelwal from MPS Limited. We particularly want to thank Wyatt and Alan for their unstinting support, professionalism, and patience. We love the design of this edition, and we greatly appreciate the expertise of the members of the production group who all worked hard to make the book look wonderful. Creating and laying out the many elements of this complex book design was a huge task, and they handled it skillfully. We particularly offer thanks to our friend Walt, a retired master electrician. When Jane called him in a panic after her Android tablet was "really and truly dead," Walt showed up within minutes, Android smartphone in hand, and they spent the afternoon experimenting with settings and taking screen shots. Deadline salvation can come in many forms, and now we know it can look like Walt.

We appreciate all who worked so hard to make this book what it is.

Thank you!

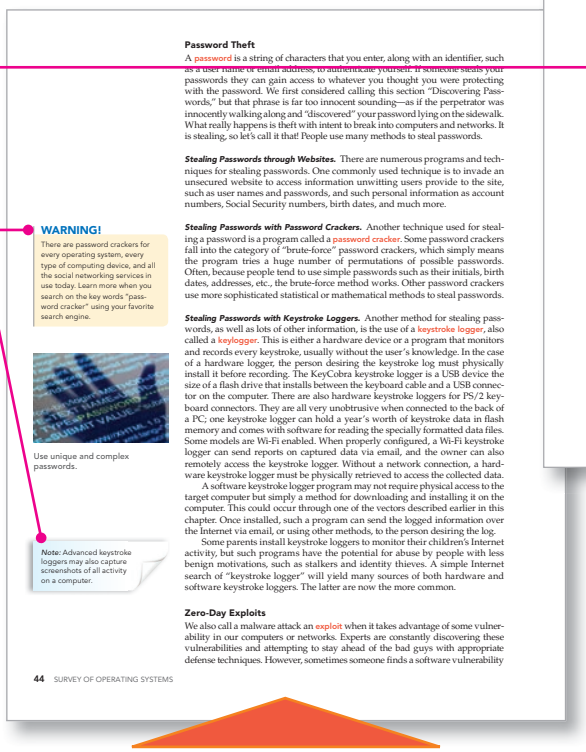
About This Book

Important Technology Skills

Information technology (IT) offers many career paths, leading to occupations in such fields as PC repair, network administration, telecommunications, Web development, graphic design, and desktop support. To become competent in any IT field, however, you need certain basic computer skills. This book will help you build a foundation for success in the IT field by introducing you to fundamental information about desktop operating systems, a needed basis for working with computers at any level.

Try This!
exercises reinforce the concepts.

Notes and Warnings
create a road map for success.



Password Theft

A password is a string of characters that you enter, along with an identifier, such as a user name or email address, to authenticate yourself. If someone steals your passwords they can gain access to whatever you thought you were protecting with the password. We first considered calling this section "Discovering Passwords," but that phrase is far too innocent sounding—as if the perpetrator was innocently walking along and "discovered" your password lying on the sidewalk. What really happens is theft with intent to break into computers and networks. It is stealing, so let's call it that! People use many methods to steal passwords.

Stealing Passwords through Websites. There are numerous programs and techniques for stealing passwords. One commonly used technique is to invade an unsecured website to access information unwitting users provide to the site, such as user names and passwords, and such personal information as account numbers, Social Security numbers, birth dates, and much more.

Stealing Passwords with Password Crackers. Another technique used for stealing a password is a program called a password cracker. Some password crackers fall into the category of "brute-force" password crackers, which simply means the program tries a huge number of permutations of possible passwords. Often, because people tend to use simple passwords such as their initials, birth dates, addresses, etc., the brute-force method works. Other password crackers use more sophisticated statistical or mathematical methods to steal passwords.

Stealing Passwords with Keystroke Loggers. Another method for stealing passwords, as well as lots of other information, is the use of a keystroke logger, also called a keylogger. This is either a hardware device or a program that monitors and records every keystroke, usually without the user's knowledge. In the case of a hardware logger, the person desiring the keystroke log must physically install it before recording. The KeyCobra keystroke logger is a USB device the size of a flash drive that installs between the keyboard cable and a USB connector on the computer. There are also hardware keystroke loggers for PS/2 keyboard connectors. They are all very unobtrusive when connected to the back of a PC; one keystroke logger can hold a year's worth of keystroke data in flash memory and comes with software for reading the specially formatted data files. Some models are Wi-Fi enabled. When properly configured, a Wi-Fi keystroke logger can send reports on captured data via email, and the owner can also remotely access the keystroke logger. Without a network connection, a hardware keystroke logger must be physically retrieved to access the collected data.

A software keystroke logger program may not require physical access to the target computer but simply a method for downloading and installing it on the computer. This could occur through one of the vectors described earlier in this chapter. Once installed, such a program can send the logged information over the Internet via email, or using other methods, to the person desiring the log.

Some parents install keystroke loggers to monitor their children's Internet activity, but such programs have the potential for abuse by people with less benign motivations, such as stalkers and identity thieves. A simple Internet search of "keystroke logger" will yield many sources of both hardware and software keystroke loggers. The latter are now the more common.

Zero-Day Exploits

We also call a malware attack an exploit when it takes advantage of some vulnerability in our computers or networks. Experts are constantly discovering these vulnerabilities and attempting to stay ahead of the bad guys with appropriate defense techniques. However, sometimes someone finds a software vulnerability

WARNING!
There are password crackers for every operating system, every type of computing device, and all the social networking services in use today. Learn more when you search on the key words "password cracker" using your favorite search engine.

Use unique and complex passwords.

Note: Advanced keystroke loggers may also capture screenshots of all activity on a computer.

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Makes Learning Fun!
Rich, colorful text and enhanced illustrations bring technical subjects to life.

requiring you to launch the app. With live tiles, a glance at the Start screen can tell you the local weather, how many new emails you have received, current news headlines, and much more. A few of the tiles in Figure 5–28 show active content. You can choose to disable active content for a tile.

Navigating and Customizing the Start Screen

The horizontal scroll bar appears at the bottom of the Start screen when it contains more tiles than it can display at one time on the screen. Move the bar with your mouse or use a swiping touch motion to look at the additional tiles.

Drag a tile around with your mouse or finger to change its position on the Start screen. Arrange tiles in groups that work for you. Beginning in Windows 8.1 you can name these groups (or not), as shown in Figure 5–28, where we named three groups but did not name the fourth. Drag a tile to the empty space on the far right of the Start screen. Then pause, and a gray vertical bar appears. Release and Windows 8.1 creates a new group. At this point on a touch screen, a gray horizontal box opens above the new group labeled *Name Group.* Enter a name for the group and then tap outside the name box. When using a mouse to name a new group, right-click on the Start screen background and select Name Groups. The horizontal box will open above all groups, allowing you to name or rename any group. If you do not wish to name this group, tap or click anywhere on the background of the Start screen and the boxes will disappear and just the names you have created will appear above groups.

In order to move entire groups around, you must shrink the Start screen tiles on the screen as shown in Figure 5–29. In the bottom right of the Start screen is the Zoom button that you click to shrink the Start screen. On a touch screen use a pinching motion. When the Start screen is zoomed out (reduced in size), you can manipulate the groups of tiles (but not individual tiles). This zoom feature is called semantic zoom, and it also works within apps that support it.

try this!

Zoom the Start Screen

Use the mouse or touch actions to zoom the Start screen and rearrange the tile groups. Try this:

1. From the Start screen, use a pinching action or move the mouse to the bottom-right corner and click the Zoom button.
2. While the Start screen tiles are small, use your mouse or touch actions to rearrange the groups.
3. When you are ready to return the Start screen tiles to full size click or tap on the background.

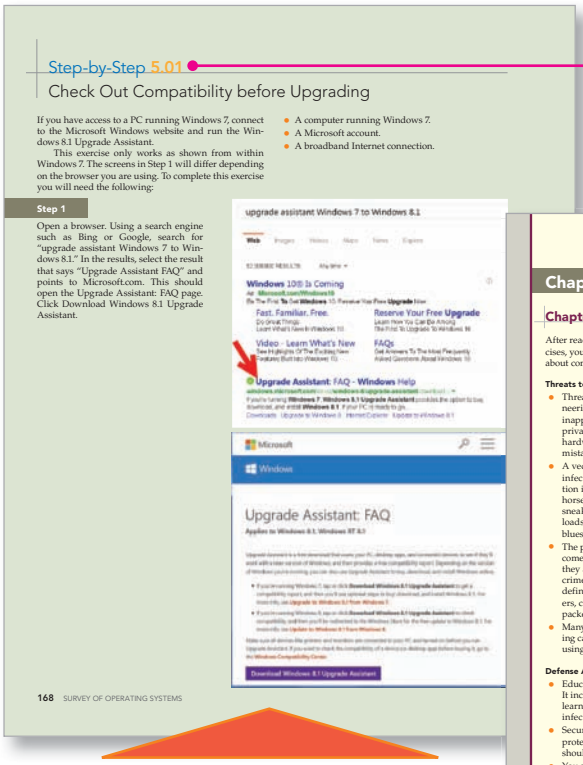
FIGURE 5–29 Shrink the tiles (zoom out) and drag a group of tiles to rearrange the groups.

Chapter 5 Windows 8.1 189

Engaging and Motivational!
Using a conversational style and proven instructional approach, the authors explain technical concepts in a clear, interesting way using real-world examples.

Effective Learning Tools

The design of this colorful, pedagogically rich book will make learning easy and enjoyable and help you develop the skills and critical thinking abilities that will enable you to adapt to different job situations and troubleshoot problems. Jane and Charles Holcombe's proven ability to explain concepts in a clear, direct, even humorous way makes this book interesting and motivational, and fun.


Step-by-Step 5.01

Check Out Compatibility before Upgrading

If you have access to a PC running Windows 7, connect to the Microsoft Windows website and run the Windows 8.1 Upgrade Assistant.

This exercise only works as shown from within Windows 7. The screens in Step 1 will differ depending on the browser you are using. To complete this exercise you will need the following:

- A computer running Windows 7.
- A Microsoft account.
- A broadband Internet connection.

Step 1

Open a browser. Using a search engine such as Bing or Google, search for "upgrade assistant Windows 7 to Windows 8.1." In the results, select the result that says "Upgrade Assistant FAQ" and points to Microsoft.com. This should open the Upgrade Assistant: FAQ page. Click Download Windows 8.1 Upgrade Assistant.

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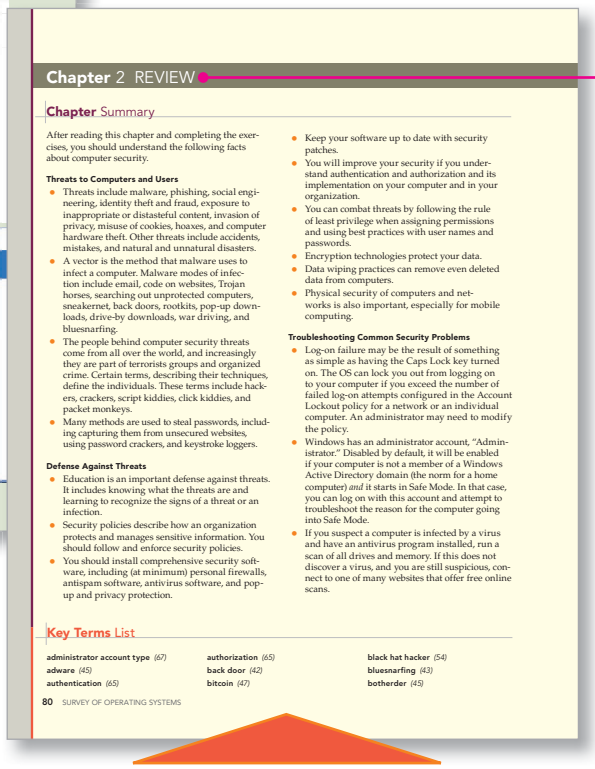
Step-by-Step exercises put concepts into practice.


Chapter 2 REVIEW

Chapter Summary

After reading this chapter and completing the exercises, you should understand the following facts about computer security.

Threats to Computers and Users

- Threats include malware, phishing, social engineering, identity theft and fraud, exposure to inappropriate or distasteful content, invasion of privacy, misuse of cookies, hoaxes, and computer hardware theft. Other threats include accidents, mistakes, and natural and unnatural disasters.
- A vector is the method that malware uses to infect a computer. Malware modes of infection include email, code on websites, Trojan horses, searching out unprotected computers, sneakernet, back doors, rootkits, pop-up downloads, drive-by downloads, war driving, and bluesnarfing.
- The people behind computer security threats come from all over the world, and increasingly they are part of terrorists groups and organized crime. Certain terms, describing their techniques, define the individuals. These terms include hackers, crackers, script kiddies, click kiddies, and packet monkeys.
- Many methods are used to steal passwords, including capturing them from unsecured websites, using password crackers, and keystroke loggers.

Defense Against Threats

- Education is an important defense against threats. It includes knowing what the threats are and learning to recognize the signs of a threat or an infection.
- Security policies describe how an organization protects and manages sensitive information. You should follow and enforce security policies.
- You should install comprehensive security software, including (at minimum) personal firewalls, antispam software, antivirus software, and pop-up and privacy protection.
- Keep your software up to date with security patches.
- You will improve your security if you understand authentication and authorization and its implementation on your computer and in your organization.
- You can combat threats by following the rule of least privilege when assigning permissions and using best practices with user names and passwords.
- Encryption technologies protect your data.
- Data wiping practices can remove even deleted data from computers.
- Physical security of computers and networks is also important, especially for mobile computing.

Troubleshooting Common Security Problems

- Log-on failure may be the result of something as simple as having the Caps Lock key turned on. The OS can lock you out from logging on to your computer if you exceed the number of failed log-on attempts configured in the Account Lockout policy for a network or an individual computer. An administrator may need to modify the policy.
- Windows has an administrator account, "Administrator." Disabled by default, it will be enabled if your computer is not a member of a Windows Active Directory domain (the norm for a home computer) *and* it starts in Safe Mode. In that case, you can log on with this account and attempt to troubleshoot the reason for the computer going into Safe Mode.
- If you suspect a computer is infected by a virus and have an antivirus program installed, run a scan of all drives and memory. If this does not discover a virus, and you are still suspicious, connect to one of many websites that offer free online scans.

Key Terms List

administrator account type (67)
adware (45)
authentication (65)
authorization (65)
back door (42)
bitcoin (47)
black hat hacker (54)
bluesnarfing (43)
botherder (45)

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Chapter Review sections provide concept summaries, key terms lists, and a variety of questions and projects for students.

Offers Practical Experience!
Step-by-Step tutorials and lab assignments develop essential hands-on skills and put concepts in real-world contexts.

Robust Learning Tools!
Summaries, key terms lists, quizzes, essay questions, and lab projects help you practice skills and measure progress.

Each chapter includes:

- **Learning Outcomes** that set measurable goals for chapter-by-chapter progress.
- **Four-Color Illustrations** that give you a clear picture of the technologies.
- **Step-by-Step Tutorials** that teach you to perform essential tasks and procedures hands-on.
- **Try This!** sidebars that encourage you to practice and apply the concepts in real-world settings.
- **Notes** and **Warnings** that guide you through difficult areas.
- **Chapter Summaries** and **Key Terms Lists** that provide you with an easy way to review important concepts and vocabulary.
- **Challenging End-of-Chapter Tests** that include vocabulary-building exercises, multiple-choice questions, essay questions, and on-the-job lab projects.

New to *Survey of Operating Systems*, Fifth Edition

General changes in this Fifth Edition:

- We removed *The Command-Line Interface*, the Fourth Edition's Chapter 9, and moved appropriate content into the Windows and OS X chapters.
- We added a new chapter, Chapter 6: *Windows 10*. This required renumbering the Fourth Edition Chapters 6, 7, and 8 to 7, 8, and 9. Because we also removed the Fourth Edition's Chapter 9, the next two chapters, 10 and 11, still have the same numbers and titles, although we updated them.
- In addition to reviewing and updating the content from the Fourth Edition, we worked to tighten the text throughout, improve the flow, and remove topics that are no longer relevant.
- Finally, you will find updated exercises, figures, and illustrations to support learning.

Chapter 1 Introduction to Operating Systems

- We added a short description of the Internet of Things (IoT) and system-on-a-chip (SoC).
- We updated content and images in the section titled *Today's Desktop Operating Systems* to include Windows 10.
- We updated text and images under *Mobile Operating System Features*.

Chapter 2 Computer Security Basics

- We updated chapter content and images, as appropriate.

Chapter 3 Desktop Virtualization

- We updated chapter content and images, and removed out-of-date content concerning *Microsoft Virtual PC 2007*.

Chapter 4 Windows 7

- This is now a leaner, more targeted chapter. In the Fourth Edition this chapter included some coverage of *Windows Vista*, which we removed in this Fifth Edition. We updated the text and appropriate images.

Chapter 5 Windows 8.1

- Because Windows 8 is no longer a new operating system, we removed, moved, updated, and scaled down content about the features of Windows 8 and Windows 8.1, and focused on the latter version. This reduced the Learning Outcomes from five to four, making the chapter more digestible.

Chapter 6 Windows 10 (New Chapter)

- This chapter introduces the latest version of Windows, beginning with selecting an edition, installing or updating it, and using the new desktop, universal apps, and other features.

Chapter 7 Under the Windows Desktop: Supporting and Troubleshooting Windows

- This chapter is an update to the Fourth Edition's Chapter 6, with coverage of Windows 10 added where appropriate. We moved the *Windows Command Prompt*, *PowerShell*, *Safe Mode with Command Prompt*, and *System Recovery Command Prompt* discussions into this chapter from the former *Command-Line Interface* chapter.

Chapter 8 Apple OS X on the Desktop

- This chapter is an update to the Fourth Edition's Chapter 7. The content and images in this chapter now include coverage of new features in the latest version of OS X: El Capitan (10.11).

Chapter 9 Linux on the Desktop

- This chapter is an update to the Fourth Edition's Chapter 8. After doing a major revision for the Fourth Edition, we only needed to update the content in this chapter.

Chapter 10 Connecting Desktops and Laptops to Networks

- This is an update to the Fourth Edition's Chapter 10. We updated content and images, where appropriate.

Chapter 11 Mobile Operating Systems

- This is a revision of the Fourth Edition's Chapter 11. We updated content and images to include new mobile OS features in Android, Apple iOS, and Windows.

Appendix: Windows Mouse and Keyboard Shortcuts

- We updated this revision of the Fourth Edition's Appendix B to include Windows 10.

Chapter 12 File Management in the Cloud (found at www.mhhe.com/holcombe5)

- This bonus chapter is an introduction to file management of personal data in the cloud.

Contents

Introduction

What Will You Learn?

The first four editions of this book were well received by instructors and students. This fifth edition updates the material and presents new information that is relevant to the topic of desktop operating systems, including Windows, Apple OS X, and Linux. In addition to these operating systems, this edition includes new information on mobile operating systems, as well as chapters on subjects peripheral to operating systems, such as computer security, desktop virtualization, and connecting computers and mobile devices to networks. We carefully revised every chapter as needed, with more illustrations and plenty of hands-on opportunities. We have added content throughout, while working to streamline the book in response to feedback we received from instructors.

How Will You Learn?

We don't want to simply give you an encyclopedia of information because it can feel like you're standing in front of an information fire hose, and we've been there ourselves many times in the past decades. Rather, keeping in mind that "less is more," we present just the key points about operating systems, and guide you in your own exploration of the specifics of the technology. One book simply can't give you everything you need to know about operating systems, but we do hope to empower you and to increase your ability to use widely available tools and resources to figure out the answers to your questions. Such tools as the Internet and the help program in your OS are aids you should turn to when you need to learn more about a topic, and when you want to enhance your skills in working with each of these operating systems—and with computers in general.

Each chapter uses many techniques to help you learn. We start by listing learning outcomes, follow that up with a lucid explanation of each topic, and support it with real-world experience and a liberal use of graphics and tables. To give you hands-on experience and to help you "walk the walk," each chapter contains detailed Step-by-Step tutorials and short Try This! exercises to reinforce the concepts. To build vocabulary to help you "talk the talk," each chapter contains computer term definitions, highlighted in a Key Terms List and compiled into a Glossary at the end of the book.

We've also included notes, which provide handy pieces of knowledge to use with your desktop OS. Warnings will help you prevent mishaps.

You can measure what you've learned with end-of-chapter Key Terms, Multiple-Choice, and Essay quizzes. In addition, Lab Projects challenge you to independently complete tasks related to what you've just learned.

Let's Get Down to Work

OK, enough of this introductory stuff. This is the last time in this book that you'll see so many words without illustrations. From now on it's downright exciting. Learn a lot and *have fun*!

Supplements

For teachers using this book in the classroom, a powerful collection of teaching tools written by the authors is available online at **www.mhhe.com/holcombe5**:

- An Instructor's Manual that maps to the organization of the textbook and provides additional instructor tips and activities to use with the book.
- A test bank for each chapter available online in either Word or EZ Test format.
- Engaging PowerPoint slides on the lecture topics, including key points and illustrations from the chapters.
- A bonus chapter entitled "File Management in the Cloud" with an overview of cloud services as well as the basics of using cloud storage for personal data.

Jane Holcombe

Charles Holcombe

chapter 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? If you can successfully operate a car, you actually know more about its internal workings than you realize. You turn on the ignition, shift to the correct gear, press the accelerator, and drive down the street without hitting anything. You stop it (in time, usually). You use your car to go somewhere, thus making the car your transportation tool. Having only superficial knowledge of the workings of your car is adequate if you never intend to repair your car or to explain to a mechanic the symptoms of a problem. And just as you can use a car without in-depth knowledge of how it works, you can use your computer to write a letter, send email, create a report, surf the Internet, participate in social networking, and much more without understanding operating systems. You only have to know how to turn it on, call up the application program you wish to use, perform tasks, and turn it off.

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

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

LO 1.1 An Overview of Microcomputer Operating Systems

Note: The OS is an interpretor between the user and the hardware.

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

A typical PC with components.

About Microcomputers

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

Hardware Components

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

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

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

Each computer that Brianna uses consists of many components, some of which allow her to interact with it. In techie talk, we call interaction with a

computer **input/output (I/O)**. When we send something into the computer we call it input. 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** (software resident in integrated circuits), 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.

Note: Random-access memory (RAM) is volatile: when you turn off the computer the contents in RAM disappear.

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

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

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

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

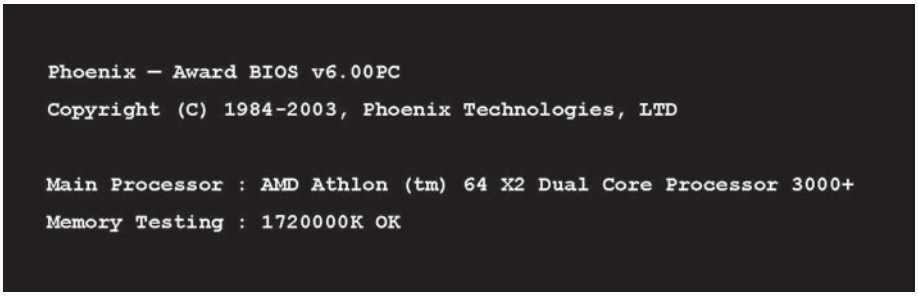


FIGURE 1–1 An example of a firmware start-up message on an old PC.

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

Today's Microcomputers

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

A PC laptop.

A MacBook laptop.

Desktops and Laptops. A desktop computer is a computer designed to spend its useful life in one location—on a desk. A laptop computer has a flat screen and a keyboard, each integrated into a panel with a hinge holding the two together and allowing you to close the laptop and slip it into a case for easy portability. There are many sizes and types of laptop computers. Laptops are often used as portable replacements for desktop PCs. The common operating systems for these computers are Microsoft Windows and Linux for PCs and laptops, and Apple's OS X, which runs on Apple's Mac desktop and laptop computers. The same version of the Windows OS will run on a desktop, a compatible laptop computer, or a compatible tablet.

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

Mobile Devices. Microcomputers today include a long list of devices that don't have *computer* in their name, including mobile devices. 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. Worldwide use of smartphones continues to grow significantly. Market research firm GfK reported 309.7 million smartphones sold in the first quarter of 2015, an increase of 7 percent over the first quarter of 2014. 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

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

include Google's Android, 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, 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. The tablet operating systems we will study in this book are Apple iOS, Google Android, Microsoft Windows 8.1, and Windows 10.

try this!

More About Tablets

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

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

Servers. 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.

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 Mac OS X, 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.

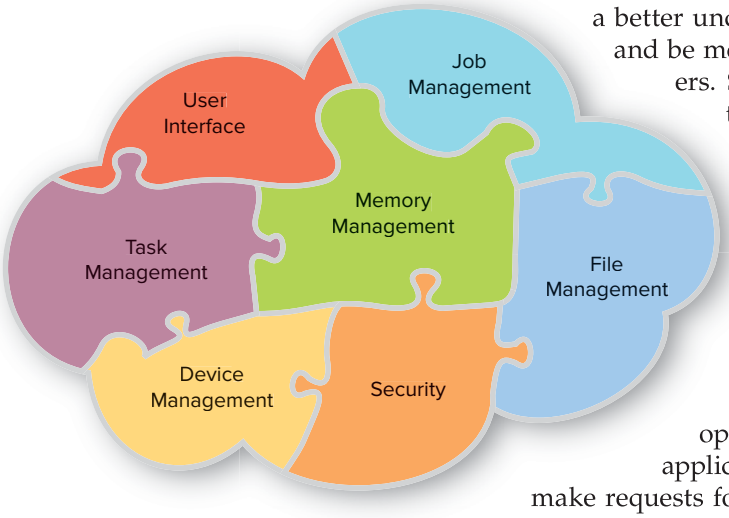
Note: In the spring of 2014 Microsoft purchased Nokia Corporation's devices business, including the Lumia line of smartphones.

Note: The focus of this book is on using common desktop, laptop, and mobile operating systems. Therefore, it does not include details of server operating systems. Nor does it discuss the operating systems in the various devices included in the Internet of Things (IoT).

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.

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



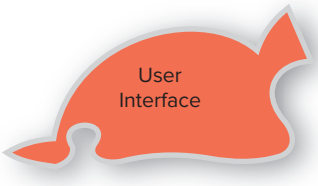
The functions of an operating system.

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.

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). 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 OS X both also have an 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.

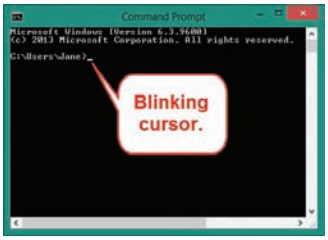


FIGURE 1–2 The Windows Command Prompt.

To become proficient at working in a CLI, you must memorize the commands and their modifiers and subcommands. On the other hand, Apple's OS X, 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.

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

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 OS X 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 OS X, drag it into the Trash, shown on the

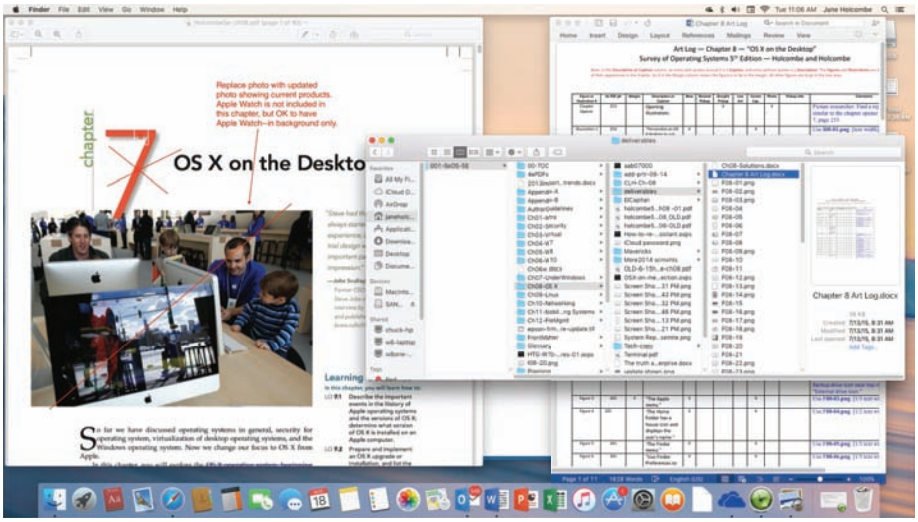


FIGURE 1–3 The OS X GUI.

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) 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.

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

try this!

View Active Tasks in Windows or OS X

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

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

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. The logical structure of a file system stores metadata, which summarizes data to facilitate searches.

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

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

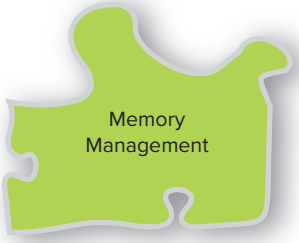
Normally, a single storage device will have only a single file system, residing in an area defined as a **partition**, but some operating systems allow a storage device to have more than one partition. A partition may be an entire drive volume or just a portion of a drive, and an operating system automatically 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.

Device Management

The **device management** function controls hardware devices by using special software called device drivers that are installed in the operating system. Device drivers are unique to the device, and the manufacturer of the device creates them to work with a specific operating system. For instance, a printer or video adapter may come with drivers for Windows, OS X, and Linux. The device driver contains the commands understood by the device and uses these commands to control the device in response to requests it receives from the operating system. An operating system needs a component-specific device driver for each unique hardware component with which it interacts. OSs today are plug and play (PNP)—they are intelligent enough to detect a device connected by an external port and automatically 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.

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

Operating System Memory Limits. We call an operating system that can take advantage of the addressing and processing features of a processor an *x*-bit OS, referring to the number of bits the OS (using the processor) can manipulate at once. The PC operating systems of the 1980s and 1990s, PC DOS and MS-DOS were 16-bit OSs, as was Windows 3.0. Windows 95, Windows 98, and Windows Millennium edition were really hybrids, with mostly 32-bit pieces but some 16-bit pieces for downward compatibility. Windows XP had a 64-bit version, but it was not widely used, and you are unlikely to encounter it. The Windows versions, OS X, and Linux OSs we discuss in this book are available in both 32-bit and 64-bit versions.

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

A 64-bit operating system requires 64-bit drivers, and some 32-bit applications may not run, although Microsoft supports older applications in each upgrade of Windows. If you purchase a new computer today with either Windows or the Mac OS preinstalled, it is most likely to be a 64-bit OS. Figure 1–4 shows the System type information for 64-bit Windows 10.

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."

TABLE 1–1 Windows Memory Limits

Edition	RAM Limit in 32-Bit Version	RAM Limit in 64-Bit Version
Windows 7 Home Premium	4 GB	16 GB
Windows 7 Ultimate/Enterprise/Professional	4 GB	192 GB
Windows 8.*x* and Windows 10 Home	4 GB	128 GB
Windows 8.*x* Pro/Enterprise	4 GB	512 GB
Windows 10 Pro/Enterprise/Education	4 GB	2 TB