NETWORKING

GUIDE TO

PARALLEL OPERATING SYSTEMS WITH WINDOWS 10 AND LINUX

THIRD EDITION

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Guide to Parallel Operating Systems with Windows 10 and Linux, 3rd Edition

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Brief Contents

Table of Contents

Preface

Welcome to *Guide to Parallel Operating Systems with Windows 10 and Linux, 3rd edition.* This book offers real-world examples and more than 100 hands-on activities that reinforce key concepts and help you prepare for a career in the information technology (IT) field.

This book offers in-depth study of the functions and features of two important operating systems: Microsoft Windows 10 and Red Hat CentOS 7. The book emphasizes how the two operating systems are used by computer programmers, database administrators, and network administrators. The book assumes that students have previously used a personal computer with either Windows or Linux.

Guide to Parallel Operating Systems uses a unique approach to explain operating systems. After a brief introduction to each concept, the book demonstrates virtualization, which allows students to switch instantly between the two operating systems and complete the numerous hands-on activities. Such activities reinforce the similarities and differences of the two operating systems.

The appendices provide setup instructions to use three popular virtualization software applications: Microsoft Hyper-V, Oracle VirtualBox, and VMware Workstation.

Because numerous colleges are integrating Windows and Linux into their curricula, this text provides a vehicle to learn about both operating systems in one course. This text is also designed to meet the needs of a wide range of disciplines, including programming, networking, and database administration. To succeed in class work and the workplace, students need to be competent in both Windows and Linux.

Throughout the book, detailed activities provide firsthand experience with Windows 10 and CentOS 7. Review Questions reinforce the concepts introduced in each chapter, and Case Projects prepare you to manage real-world situations in an IT environment.

Intended Audience

Guide to Parallel Operating Systems is intended both for students who are getting started in IT and for users who have experience with Windows 10 or CentOS 7 in a school or corporate environment. To best understand the material in this book, you should have a working knowledge of one of these operating systems.

Chapter Descriptions

This book has 12 chapters, as follows:

Chapter 1, “Hardware Components,” introduces virtual machine technology—the vehicle that permits Microsoft Windows 10 and CentOS 7 to operate in parallel. Chapter 1 also provides an overview of the components that make up a PC system and concludes with useful information for PC care.

Chapter 2, “Software Components,” covers the functions and characteristics of the two operating systems.

Chapter 3, “Using the Graphical User Interface,” explains how to interact with a PC by manipulating visual elements such as icons and windows.

Chapter 4, “Installing and Configuring Applications,” covers the access of Help information, use and configuration of a Web browser, and the installation of ActiveState Perl.

Chapter 5, “File Systems,” describes the use of file systems supported by the two operating systems.

Chapter 6, “Directory Commands,” introduces various commands and techniques for working with directories.

Chapter 7, “Files and File Attributes,” covers the files used by various applications and search techniques used to locate files.

Chapter 8, “The Command Line,” explains how to use the command-line interface in the two operating systems. The chapter also introduces Windows PowerShell.

Chapter 9, “Text Editors,” covers text editors that are used by the two operating systems. The chapter also describes the use of PowerShell Integrated Scripting Environment as a text editor.

Chapter 10, “Scripting in Windows 10 and CentOS 7,” explains Windows PowerShell and CentOS 7 scripting.

Chapter 11, “Local Network Access,” explains networking terminology, viewing TCP/IP settings, accessing network resources, and viewing folder and file sharing permissions.

Chapter 12, “Operating System Management,” explains how to manage processes executed on a PC, how to measure factors that indicate PC performance, and how to monitor reliability.

Appendix A, "Numbering Systems and Data Representation," explains how to convert numbers from one base to another, how data is represented by ASCII characters, and the representative storage of data in memory.

Appendix B, "Working with Hyper-V Virtualization," provides the setup instructions to use Windows 10 and CentOS 7 virtual machines with Microsoft Hyper-V virtualization.

Appendix C, "Working with VirtualBox," provides the setup instructions to use Windows 10 and CentOS 7 virtual machines with Oracle VirtualBox.

Appendix D, "Working with VMware," provides the setup instructions to use Windows 10 and CentOS 7 virtual machines with VMware Workstation.

Features and Approach

Guide to Parallel Operating Systems differs from other OS books in its unique integration of Windows 10, CentOS 7, and virtualization. To help you understand how to use both operating systems, the book covers them in parallel. In the interest of brevity, some references are missing from command descriptions throughout the text.

- **Chapter Objectives—**Each chapter begins with a list of the concepts to be mastered. This list provides a quick reference to the chapter's contents and can be a useful study aid.
- **Activities—**Activities are incorporated throughout the text to give you a strong foundation for carrying out tasks in the real world. Because the activities tend to build on each other, you should complete the activities in each chapter before moving to the end-of-chapter materials and subsequent chapters.
- **Chapter Summaries—**Each chapter's text is followed by a summary of concepts introduced in the chapter. These summaries provide a helpful way to recap and revisit the chapter's ideas.
- **Key Terms—**All of the terms that are introduced in boldface text in a chapter are listed together after the Chapter Summary. This list lets you check your understanding of the terms.
- **Review Questions—**The end-of-chapter assessment begins with a set of questions that reinforce the ideas introduced in the chapter. Answering these questions helps ensure that you have mastered important concepts.
- **Case Projects—**Each chapter closes with a section that asks you to evaluate real-world situations and decide on a course of action. This valuable tool helps you sharpen your decision-making and troubleshooting skills, which are important in IT.

Text and Graphic Conventions

Additional information and exercises have been added to this book to help you better understand what is being discussed in the chapters. Icons throughout the text alert you to these materials:

Notes present additional helpful material for the subject being discussed.

Activity icons precede each activity in this book.

Case Project icons mark the end-of-chapter case projects. These scenario-based assignments ask you to independently apply what you learned in the chapter.

Instructor Resources

Free to all instructors who adopt *Guide to Parallel Operating Systems* for their courses is a complete package of instructor resources. These resources are available from the Cengage Learning Web site, *www.cengagebrain.com*. Go to the product page for this book in the online catalog and choose "Instructor Downloads." Resources include:

- **Instructor's Manual—**This manual includes course objectives and additional information to help your instruction.
- **Solutions—**Solutions are provided for Review Questions and Case Projects.
- **Cengage Learning Testing Powered by Cognero—**A flexible, online system that allows you to import, edit, and manipulate content from the text's test bank or elsewhere, including your own favorite test questions; create multiple test versions in an instant; and deliver tests from your LMS, your classroom, or wherever you want.
- **PowerPoint Presentations—**A set of Microsoft PowerPoint slides is included for each chapter. These slides are meant to be used as a teaching aid for classroom presentations, to be made available to students for chapter review, or to be printed for classroom distribution. Instructors are also at liberty to add their own slides.
- **Figure Files—**Figure files allow instructors to create their own presentations using figures taken from the text.
- **Student Files—**All of the scripts and data files are available from the Cengage Web site. Download instructions are presented in the appendices for each virtualization application.

Minimum Lab Requirements

To install the three software components, you must have the following minimum hardware configuration:

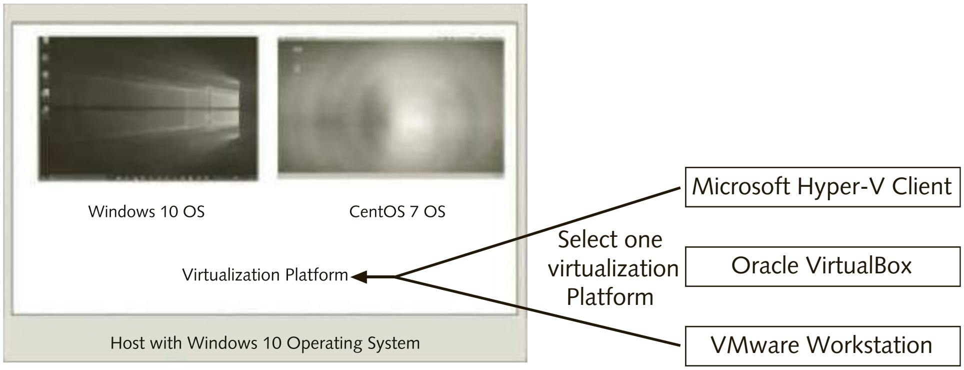
Component	Requirement
CPU	Intel or AMD 2 Core 2.0 GHz (4 Core 2.4 GHz or more is recommended) 64-bit processor
BIOS	Intel VT or AMD-V virtualization available
Memory	At least 4 GB of RAM (6 GB recommended)
Disk space	At least 24 GB of free space (30 GB recommended)
Drives	CD-ROM and USB drive
Networking	Network interface card

Virtual Machine Setup

To complete the lab activities in this text, special attention to setup is required:

- Windows 10 Professional or Education and CentOS 7 are required for the two virtual machines. The following figure provides an overview of the required environment.
- Windows 8 Pro 64-bit Edition, Windows 8.1 Pro 64-bit Edition, Windows 10 Professional, or Windows 10 Education is recommended for the host operating system.

A recommended source for Windows 10 is DreamSpark, a Microsoft program that supports technical education by providing access to Microsoft software for learning, teaching, and research purposes.



Choose one of the following three virtualization applications; the lab activities have been tested with each:

- Microsoft Client Hyper-V
- Oracle VirtualBox
- VMware Workstation

Specific instructions to set up the virtualization environments are provided in the appendices.

Author Team

Ron Carswell has more than 20 years of computer experience with both small and large organizations. Ron holds a bachelor's degree in business administration from the University of Texas and a master's degree in business administration from Baylor University. He has received A+, Network+, CTT+, MCSA, MCSE, CCNA, MCDST, MCITP, and MS:Server Virtualization with System Center certifications. He is currently a professor emeritus at San Antonio College, where he teaches MCSA and MS:Server Virtualization certification courses. Ron has written numerous textbooks for Cengage Learning. In addition, Ron authored *Test Drive the Microsoft Private Cloud* for Cengage PTR.

Mary Ellen Hardee has worked in the IT field for over 16 years and has extensive hands-on Linux/UNIX experience. She has written many technical documents that are still used in the industry. She has taught IT-related classes to many different types of students. She currently holds the following certifications: CCNA, Network+ and Security+, EC Council Certified Ethical Hacker, and Rackspace Certified OpenStack Technician. She has a bachelor of science degree in Computer Information Systems with an emphasis in networking from Regis University.

Shen (Sharon) Jiang has 11 years of experience with large organizations. Sharon holds a master's degree in Computer Information Systems from South Dakota State University and a master's degree in linguistics from Jilin University. She is currently an assistant professor at San Antonio College, where she instructs in all levels of database courses, CISCO, Program Logic and Design, basic programming, and fundamentals of networking. She has earned Oracle9i and Oracle10g certifications. She co-authored *Guide to Parallel Operating Systems with Windows and Linux, 2nd edition*.

Amita Mahajan has over 14 years of computer experience in different industries. Amita holds a master's degree in Information System Security from the University of Colorado and a master's degree in system administration. She has received the MCSE, CNA, and CCNA certifications and has presented at many technical conferences. Recently she acquired her PMP certification. She is currently working as a network analyst with Alamo Colleges and is an adjunct professor at San Antonio College and Northwest Vista College, where she teaches Microsoft certification courses.

Troy Touchette has 19 years of computing experience both in public and private organizations. He earned a bachelor of science degree in electrical engineering and a master's of engineering degree from McNeese State University. He also received the Committee on National Security Systems (CNSS) Senior Systems Managers CNSSI 4012 certificate from Texas A&M University-San Antonio. He is currently a professor and department chair of the Computer Information Systems department at San Antonio College, where he has taught since 1999.

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Amita Mahajan

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Troy Touchette

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- Mark Turner, Central Piedmont Community College, Charlotte, North Carolina

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- Amy Savino, Associate Product Manager

chapter 1

Hardware Components

After reading this chapter and completing the exercises, you will be able to:

- Explain the use of virtual machine technology to run multiple operating systems concurrently
- Describe the hardware components of a personal computer system
- Describe the peripheral components that may be attached to a personal computer system
- Describe the preventive maintenance for a computer system

This text covers the use of Windows and Linux—two prevalent operating systems (OSs) for the personal computer (PC). Using virtual machine technology, these two seemingly incompatible operating systems can work in parallel.

You will undoubtedly purchase numerous PCs in your lifetime. Some will be for your job, and others will be for personal use. The goal of this chapter is to provide an overview of the components that make up a PC system. Some of these components are within the PC, and some are attached to it. Whether you purchase a major brand or decide to "build your own," knowing these components will help you understand the day-to-day workings of your OS.

When using a PC, proper maintenance is important. This chapter provides information to help you care for your PC and offers guidance on the proper way to dispose of it when the time comes.

Virtual Machine Technology

Virtualized systems—systems that appear to be real but are actually simulations—are used in many environments. Airline pilots use flight simulators for flight practice and testing, whereas computer games like SimCity let the player create a virtual city in a game environment that feels real but actually exists in the hardware and software of the game.

In the information technology (IT) world, **virtualization** refers to the use of virtualization software that allows the physical hardware of a single PC to run multiple operating systems simultaneously in **virtual machines (VMs)**. The virtualization software simulates enough hardware to create an environment that allows an unmodified **guest operating system** (the one running inside a VM) to be run in isolation on a **host operating system** (the one running on the physical computer system).

This text uses examples of virtual machine technology, which allows multiple operating systems to run concurrently on a single PC. With virtual machine technology, you can run various Microsoft Windows operating systems as well as Linux within another host operating system. In this text, you will work with both Windows and Linux in a virtual environment. Figure 1-1 shows Windows 10 and Linux images on the Windows 10 desktop within Microsoft Hyper-V virtualization software. Hyper-V requires the Windows 10 desktop operating system. Both Windows and Linux can be used as a guest operating system. This text uses the CentOS 7 distribution of Linux.

Virtualization means that you can concurrently operate seemingly incompatible operating systems in one hardware environment, as shown in Figure 1-2. Consider the following:

- The host computer—in this case a laptop—is running Windows 10 with one hard drive, 4 GB of memory, and a network adapter, keyboard, touch pad, and liquid crystal display (LCD) screen.
- The first virtual machine is running Windows 10 with three hard drives, 1 GB of memory, and a network adapter, keyboard, mouse, and monitor. (All hardware is virtualized.)
- The other virtual machine is running CentOS 7 with three hard drives, 1 GB of memory, and a network adapter, keyboard, mouse, and monitor. (Again, all hardware is virtualized.)

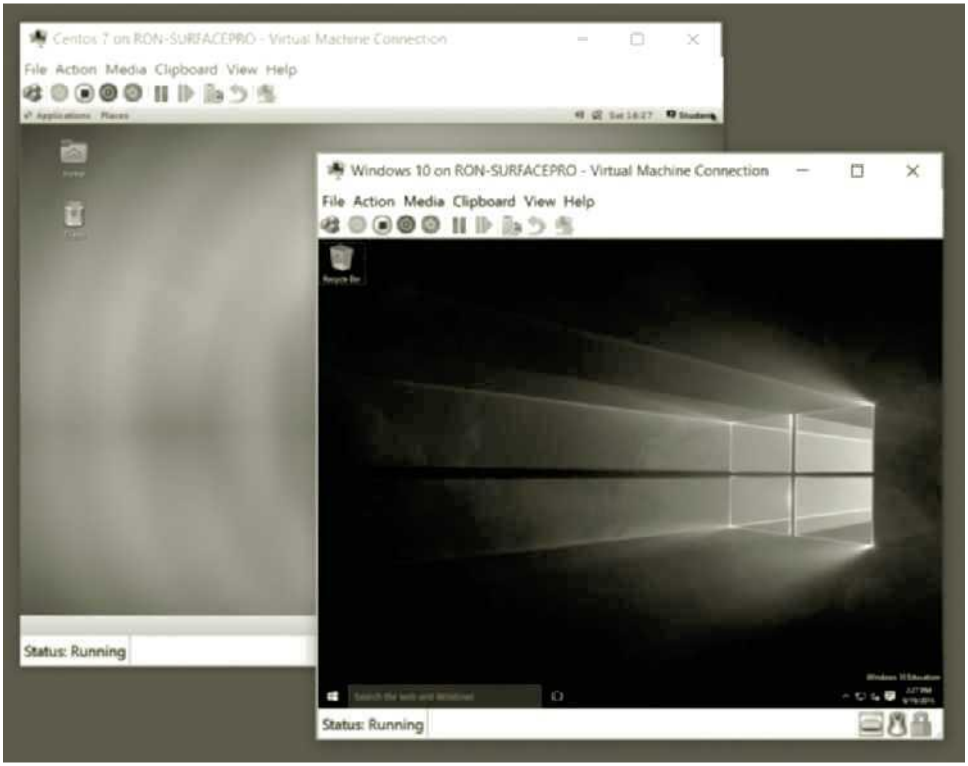

Figure 1-1 Linux and Windows virtual machines on desktop

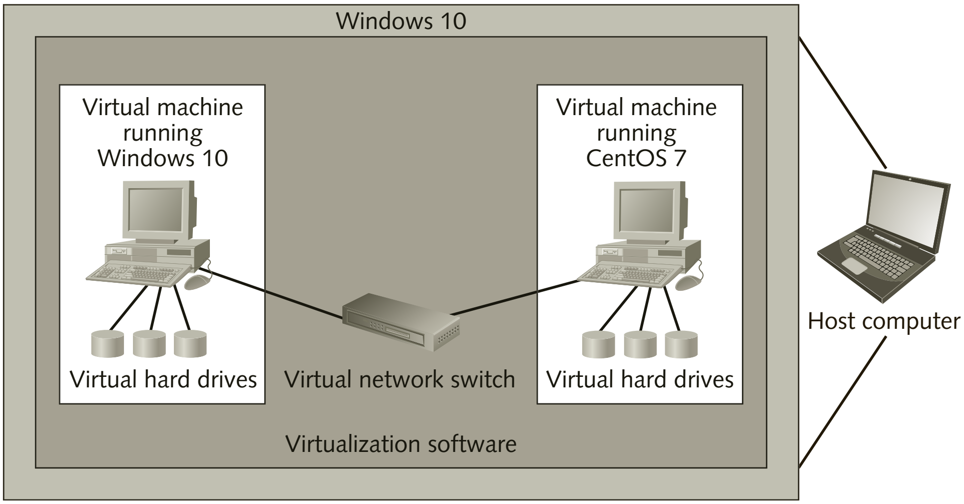

Figure 1-2 Virtual machine technology

- The virtualization software provides the hardware environment for the two virtual machines for a total of six hard drives, 2 GB of memory, two network adapters, two keyboards, two mice, and two monitors.

How does the virtualization software do this?

- The six hard drives are six files on the laptop; these files appear to the virtual machines as real hard drives.
- The two network adapters appear as virtualized network adapters to the virtual machines. These adapters are connected to the virtual network switch. Within the host, software exists to provide network connections from the virtual network switch to the laptop's network.
- The 2 GB of memory comes from the 4 GB of physical memory on the laptop.
- The keyboards, mice, and monitors are switched between the two virtual machines by clicking the window of the desired virtual machine. You can only interact with one virtual machine at a time.

Of course, given enough memory and processor cycles, virtualization software will scale to run more than two virtual machines. It is not unreasonable for a powerful server to run 100 or more virtual machines.

To summarize, you can install multiple guest operating systems in virtual machines, which look like any other applications you would use on your physical computer. Virtualization software mimics physical PCs so closely that the operating systems installed in them do not distinguish the virtual machine from a physical computer. Instead of installing operating systems on multiple costly computers or creating unwieldy multiboot installations, you can install the operating systems in multiple inexpensive virtual machines. Another benefit is that changes you make in virtual machines do not affect your physical computer. Snapshots of the virtual machine's state can also be saved. This allows you to revert back to a previous point in time, reversing any changes made inside the guest operating system since that snapshot.

Microsoft Hyper-V is not the only virtualization software on the market. This text is written to allow you to select from three different virtualization products:

- Microsoft Hyper-V
- Oracle VirtualBox
- VMware Workstation or VMware Player

The text of the main book uses Microsoft Hyper-V, but you can consult the appendices to see how to use the other virtualization products.

Activity 1-1: Starting Virtual Machines

Time Required: 10 minutes

Objective: Use the virtualization console to start the two virtual machines.

Description: In this activity, you will open the virtualization console installed on the host computers that you will use in your class, and then you will start the two virtual machines. Recall that you will use one of the three virtualization solutions.

1. If necessary, log on to your host PC with **user01** and a password of **Pa$$w0rd**.

If you are not sure which virtualization software you are using, ask your instructor.

2. Start your virtualization software by selecting one of the following choices:
   - To start Microsoft Hyper-V, click the **Manage Virtual Machines** icon on the desktop (the icon has two green servers).
   - To start the Oracle VM VirtualBox console, click the **Oracle VM VirtualBox** icon on the desktop (the icon is a blue cube).
   - To start the VMware console, click **Start**, point to **All Programs**, and then double-click **VMware Workstation**.

   Wait for the PowerShell script to start the virtual machines and display a connection window. Steps 3 and 4 are not required when Hyper-V virtualization is installed.
3. To start the CentOS 7 virtual machine, double-click the **CentOS 7 Virtual Machine** icon.
4. To start the Windows 10 virtual machine, double-click the **Windows 10 Virtual Machine** icon.
5. To log on to the Windows 10 virtual machine, click the **user01** icon within the Windows 10 virtual machine window, type **Pa$$w0rd**, and then press **Enter**.
6. To switch to the CentOS 7 virtual machine, click within the CentOS 7 virtual machine window.
7. To log on to the CentOS 7 virtual machine, click the **User01** icon within the CentOS 7 virtual machine window, type **Pa$$w0rd**, and then press **Enter**.
8. Leave the virtual machines logged on for future activities.

Hardware Components of a PC System

A desktop computer is a PC that is designed to fit conveniently on a typical office desk. The desktop computer typically contains several devices that are assembled in a computer case:

- Power supply—Provides the necessary voltages
- Cooling system—Removes the heat generated by the PC
- System board—The main circuit board for the PC
- Microprocessor—The central processing unit (CPU) for the PC
- Memory—The electronic holding area for programs and data
- Firmware—Computer programming instructions in read-only memory, used to test and start the PC
- Ports—Used to connect external devices to the PC
- Adapters—Cards that provide capabilities to the PC

These components are explained in more detail in the following sections.

Cases

In a PC, the case houses and protects the main electronic components. You may purchase a PC in various sizes and shapes. The **form factor** is the size, configuration, or physical arrangement of a computer case or one of its internal components, such as a system board (which contains basic electronic circuitry and components).

The IBM XT PC set an early, de facto standard for case configuration. The desktop computer has since evolved through the ATX (advanced technology extended) model, the Micro-ATX, and the small-footprint PC. Some configurations include horizontal or flat desktop, vertical or tower, and rack-mounted. Later improvements reduced the size of the PC for laptop, notebook, and tablet computers. All-in-one desktop designs integrate the monitor into the same case as the PC components. Figure 1-3 illustrates various form factors.

The style of PC case that you purchase determines a number of factors. For example, what system board will be supported by the case?

A portable computer is a PC designed to be easily transported and relocated. The earliest portable computers were simply called *portables*. As the size and weight of most portables decreased, they became known as laptop or notebook computers. Eventually, keyboards could be replaced with touch-screen interfaces, which led to tablet computers.

A laptop computer is a battery- or AC-powered PC, generally smaller than a briefcase, that can be used on airplanes, in libraries, in temporary offices, at meetings, and so on. A laptop typically weighs less than five pounds.

Netbooks are a smaller, lightweight, inexpensive version of notebook computers suited for both general PC and Web-based applications. Typically, Netbooks have smaller displays, less memory, and less powerful processors. Tablets are similar in function to laptops, but they use a touch-screen interface that eliminates the need for a keyboard. Tablets usually weigh less than two pounds.

Laptops usually come with displays that use LCD-screen technology. Laptops use several approaches for integrating a mouse into the keyboard, including the touch pad and the trackball. Your laptop computer may not possess the same ports as a desktop computer; for example, laptops may be restricted to using video and USB ports. However, many laptops have built-in network adapters and wireless access. CD-ROM and DVD disc drives may be built in or attachable. This is explained in the following sections.

Desktop Tower box Laptop Tablet All-in-one

Figure 1-3 Form factors

Power Supplies

Your computer's power supply, as shown in Figure 1-4, is a sealed metal box that contains power conversion hardware. The power supply converts the 110-volt alternating current (AC) in your office or household (220 volts in some countries) to the various direct current (DC) levels required by your PC. The power supply provides clean power feeds to the components in your computer: the system board, disk drives, cooling fans, and so on. Power supplies have standardized plugs that work with all kinds of components; if you use a plug that fits the device, you are sure to get a correct voltage. PC power supplies often have an input voltage selector that can be set to 115 volts (for 110 volts) or 230 volts. In the United States, 115 volts is usually set by default by the manufacturer before shipping.

Do not open the power supply! The internal components are not user-serviceable.

Older computer power supplies are not very efficient. 80 PLUS is an initiative to promote more electrical energy-efficient computer power supplies; it certifies products that have more than 80 percent energy efficiency at rated loads. That is, units that waste 20 percent or less electric energy as heat at the specified load reduce electricity use. Multiple levels of certification have been established for higher efficiency, including bronze, silver, gold, platinum, and titanium.

Cooling Systems

Computers generate heat—lots of it. A PC's microprocessor produces 75 to 100 watts of heat, which is as much as a regular household incandescent lightbulb. Other internal computer components generate more heat; in sum, your desktop PC could generate more than 300 watts. Poor heat dissipation can cause many problems ranging from mysterious system crashes to major hardware damage. Overheating increases the risk that your computer's components will fail prematurely.

Figure 1-4 Power supply

Air is circulated within the case to dissipate the heat generated by the computer's electronic components. Air enters the case and is pulled out with one or more fans in the front or back of the case. Although most PCs rely on the circulated air to remove the generated heat, some faster PCs resort to liquid cooling for the microprocessor.

The microprocessor in your PC has a **heat sink** attached to dissipate the generated heat. Generally, your microprocessor's temperature should not run in excess of 130 to 140 degrees Fahrenheit (hot even for south Texas) while under a full load. The heat sink is attached to the microprocessor chip, is usually made of aluminum, and has extended fins. Thermal paste is used between the microprocessor and heat sink during installation to ensure proper heat transfer. An active heat sink is one that comes with a fan; it is sometimes called a *heat sink/fan (HSF) combo*.

System Boards

The **system board** is the main circuit board inside a PC case. It contains the processor socket, memory slots, hard drive connectors, expansion slots, and other components. Additional boards, called *daughter boards*, can be plugged into the system board (see Figure 1-5).

The following sections explain the numerous components of a system board.

Microprocessor The heart of the PC system is the **microprocessor** (see Figure 1-6). It contains the logic circuitry that performs the instructions of a computer's programs. Microprocessors were once known as central processing units; today, a microprocessor is a CPU on a single chip. This "electronic engine" is activated when you turn on your computer. The microprocessor contains a set of instructions designed to perform such tasks as

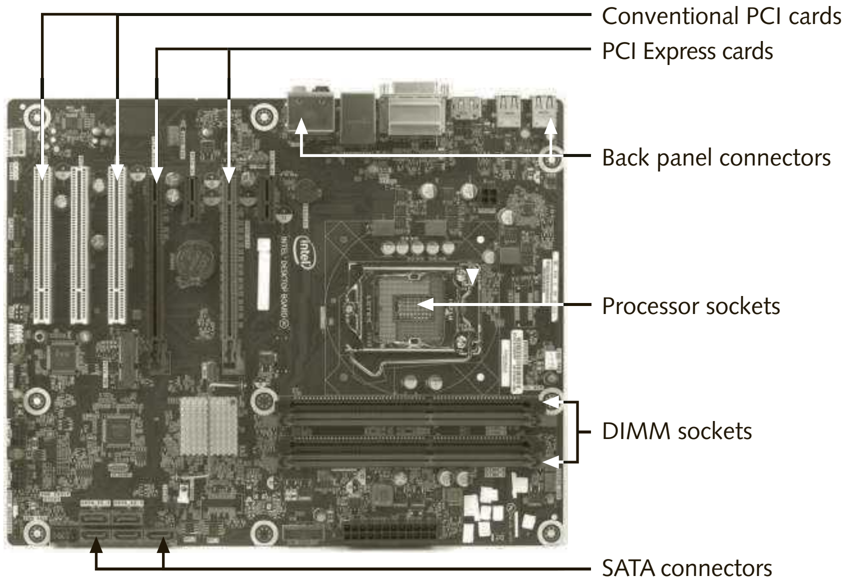

Figure 1-5 System board

Figure 1-6 AMD microprocessor

Source: AMD

arithmetic (adding, subtracting), logic operations (comparing two numbers), and transferring numbers from one register to another. A **register** is a small amount of high-speed memory.

Buses The **bus** is a set of circuits on the system board through which data is transferred from one part of a computer to another. You can picture the metaphor of data hopping aboard a bus to travel within a computer. The term *bus* usually refers to an internal bus that connects all the internal computer components to the microprocessor and main memory. In addition, an expansion bus permits adapter boards to access the microprocessor and memory.

All buses consist of two parts: a data bus and an address bus. The data bus transfers actual data, whereas the address bus transfers information about where the data should go.

The size of a bus—known as its width—is important because it determines how much data can be transmitted at one time. For example, a 32-bit bus can transmit 32 bits (4 bytes) of data, whereas a 64-bit bus can transmit 64 bits (8 bytes) of data.

Memory **Memory** is an electronic holding area for your programs and data. Memory usually contains the main parts of the OS and some or all of the applications and related data that are being used. Memory is often used as a shorter synonym for random access memory (RAM). This kind of memory, as shown in Figure 1-7, is located in the memory slots on the system board. You can think of RAM as an array of boxes, each of which can hold a single byte of information. A computer that has 4 GB of memory can hold about 4,096 million bytes (or characters) of information.

Several types of memory can be used in your PC:

- **RAM** (random access memory)—The term *RAM* refers to read-and-write memory, meaning that you can write data into RAM and read data from it. Most RAM is volatile—it requires a steady flow of electricity to maintain its contents. When power is turned off on the PC, any data that was in RAM is lost.

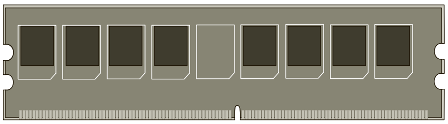

Figure 1-7 Memory module

- **ROM** (read-only memory)—A PC almost always contains a small amount of ROM that holds instructions for starting the PC. Unlike RAM, you cannot write to ROM.
- **PROM** (programmable read-only memory)—A PROM is a memory chip on which you can store a program. Once the PROM has been used, you cannot erase it and store something else on it. Like ROMs, PROMs are nonvolatile.
- **EPROM** (erasable programmable read-only memory)—An EPROM is a special type of PROM that you can erase by exposure to ultraviolet light.
- **EEPROM** (electrically erasable programmable read-only memory)—An EEPROM is a special type of EPROM that you can erase by applying an electrical charge.

Firmware ROMs, PROMs, EPROMs, and EEPROMs that contain recorded programs are called firmware. **Firmware** is a combination of software and hardware.

The **BIOS** (basic input/output system) is firmware that supports the PC during start-up. In addition, the BIOS contains the program code required to control the keyboard, display text on the screen, read from disk drives, and perform a number of miscellaneous functions.

The BIOS is typically placed in a firmware chip that comes with the computer; it is often called a *ROM BIOS*. This placement ensures that the BIOS will always be available and will not be damaged by disk failures; it also enables a computer to start itself. PCs have a flash BIOS, which means that the BIOS has been recorded on a flash memory chip (normally an EEPROM) that can be updated if necessary.

Input/Output Ports

A PC typically comes with standard input-output ports, as shown in Figure 1-8. These ports are often called *I/O* (pronounced *eye-oh*) *ports*. A system board groups these I/O ports on the back of the board, so the ports are called *back panel connectors*. Serial ports are used for modems, digitizer tablets, and other devices. Serial ports have fallen into legacy status and may not be installed on new PCs. Almost every peripheral that is connected via serial ports is now available as a USB device. Extra USB ports are often present on the front of the case.

Connectors are identified by gender. When copper pins are exposed in the connector, its gender is male. In Figure 1-8, the serial connector is a male connector. The parallel connector is female because holes are present.

These I/O ports are discussed in the following sections.

Serial Ports A serial port transfers data in or out one bit at a time. Throughout most of the history of PCs, this transfer was accomplished using **RS-232** (short for *recommended standard-232*), a standard interface approved by the Electronic Industries Alliance (EIA) for transferring data over simple cables that connect the computer to a device. Serial ports are legacy hardware but are used for connecting to other devices, such as switches or routers for maintenance.

You can identify the serial ports on the back of a PC by checking for male connectors. If you check your BIOS settings, you may see that your PC has allocated the serial ports as COM1, COM2, and so on.

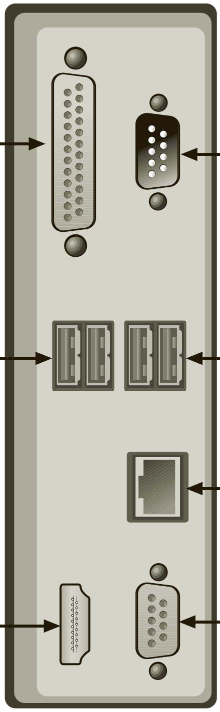

Figure 1-8 Back of computer showing I/O ports

Universal Serial Bus The **Universal Serial Bus** (**USB**) was developed to simplify the connection of peripheral devices to the PC. Almost every peripheral that once could be connected via a serial or parallel port is now available with a USB connector. The major goals of USB were to make it inexpensive to add peripherals to a PC and as easy to connect as a telephone to a wall jack. USB originally featured a minimum bandwidth of 1.5 Mbps (megabits per second) for low-speed devices such as mice and keyboards, and a maximum bandwidth of 12 Mbps for higher-speed devices such as Web cameras, printers, scanners, and external CD-RW drives. You can connect up to 127 USB peripherals with five levels of hubs to a single USB host controller.

In a quest for additional speed, USB 2.0 and then USB 3.0 were introduced. The maximum speed of the connection jumped from 12 Mbps on USB 1.1 to 480 Mbps on USB 2.0 to SuperSpeed (5 Gbps) on USB 3.0. USB 2.0 is both forward and backward compatible with USB 1.1, but USB 3.0 is not. The USB connectors and cables are identical for USB 2.0 and 1.1, but USB 3.0 ports are noted by a blue coloring. USB 2.0 is backward compatible to USB 1.1, but USB 3.0 is not. USB 2.0 devices plugged into a legacy USB 1.1 port simply operate at reduced throughput. Both Hi-Speed USB 2.0 and original USB 1.1 peripherals can operate on a PC at the same time. The new USB 2.0 expansion-hub design manages the transition of data rates between the high-speed host and lower-speed USB peripherals while maintaining full bandwidth utilization. If you have a digital camera, you can take advantage of this increased speed to transfer larger pictures with higher densities.

USB 3.0 devices featured the "SuperSpeed" bus, which provided a fourth transfer mode at 5.0 Gbps (gigabits per second). The raw throughput was 4 Gbps, and the specification considered it reasonable to achieve 3.2 Gbps (0.4 GBps or 400 MBps) or more after protocol overhead. To accommodate the additional pins for SuperSpeed mode, the physical form factors for USB 3.0 plugs and receptacles have been modified from those used in previous versions. USB 3.1 increased the transfer data rate to 10 Gbps and was called *SuperSpeed+*.

FireWire Sometimes called *IEEE 1394*, **FireWire** is a very fast digital input/output system that provides transfer rates of up to 3.2 Gbps. IEEE 1394 FireWire is a standard for a high-performance serial bus (HPSB) and can be used for many of the same applications as USB.

The HDMI (High-Definition Multimedia Interface) port is a newer addition to computers that allows them to be connected to a television, monitor, or projecting device. The HDMI port is used to transfer both audio and video in a digital format that provides a high-definition display. The HDMI port can also transport Ethernet data or remote control signals.

In addition to HDMI, some computers such as tablets may use DisplayPorts. Both HDMI and DisplayPorts can send high-definition digital video and audio from a source device to a display. So what is the difference? HDMI connectors have 19 pins and are most commonly seen in three sizes: Type A (standard), Type C (mini), and Type D (micro). Of these, Type A is by far the most common. DisplayPort connectors have 20 pins and are available in two sizes: DisplayPort and Mini DisplayPort (the latter is the port of choice for Microsoft's Surface Pro tablet). On the other hand, DisplayPort cannot carry Ethernet data, and the standard does not have an audio return channel.

Expansion Cards

An **expansion card** is a printed circuit board that you can insert into a system board to add functionality to a PC. One edge of the expansion card holds the contacts that fit into the expansion slot on the system board, establishing contact between the card's electronics (mostly integrated circuits) and the system board.

An expansion card could add more USB ports to a desktop computer. Laptop designs do not allow for expansion cards because of the compact placement of internal components.

You might refer to an expansion card as an adapter card that allows one system component to connect to and work with another. An adapter is often a simple circuit that converts one set of signals to another; however, the term often refers to devices that are more accurately called *controllers*. For example, display adapters (video cards) and SCSI (small computer system interface) adapters perform extensive processing, but they are still called *adapters*.

These adapters are plugged into slots that vary according to the slot type. Most system boards provide a conventional **PCI slot** (32-bit legacy PCI) to support older adapter cards. The newer **PCI Express** specification allows slots to have different physical sizes depending on the number of lanes connected to the slot. The specification provides for x1, x4, x8, and x16 lanes, which reduces the amount of space needed on the system board. For example, if a slot with an x1 connection is required, the system board can use a smaller slot to save space. PCI Express x16 slots are used mostly for graphics cards, although they can be used with any PCI Express card. Sound cards, for example, are typically PCI Express x1 devices.

Video Adapters You would plug a **video adapter** board, as shown in Figure 1-9, into a PC to give it display capabilities. These capabilities, however, depend on both the logical

Figure 1-9 Video adapter

circuitry and the display monitor. Each adapter offers several video resolutions (pixel densities).

Modern video adapters contain memory so that the computer's RAM is not used for storing displays. With larger amounts of memory, you can display greater resolutions with a larger number of colors. To save money, the manufacturer of your PC may use the system memory for text and graphics. While using part of the main system memory may save costs, it may also result in poor performance.

In addition, most adapters have their own graphics processing unit (GPU) for performing graphics calculations. Your computer will render graphics faster if it uses a graphics card with a fast GPU and enough video RAM.

Sound Adapters A **sound adapter**, which is also called a *sound board* or *sound card*, is an adapter card that records and plays back sound, as shown in Figure 1-10. Sound adapters support both digital audio and Musical Instrument Digital Interface (MIDI) formats. Sound cards provide an input port for a microphone or other sound source and output ports for speakers and amplifiers.

As an alternative to a sound adapter, your PC may have integrated sound circuits provided by a chipset on the system board. If you need to install a separate sound card, the integrated sound circuits can be disabled. An example of integrated audio is AC' 97, which was introduced in 1996 by Intel, or the updated Intel High Definition Audio specification. AC' 97 provides audio with six channels, which is comparable to the sound on a home theater system. Intel HD Audio provides up to eight channels.

Disk Drive Controllers

A disk drive controller manages the transfer of data from a system board to a disk drive and vice versa. In PCs, the controllers are often single chips. When you purchase a computer, it comes with all the necessary controllers for standard components, such as disk drives.

Figure 1-10 Sound adapter

However, if you add disk drives, you may need to insert new controllers that come on expansion boards.

Controllers must be designed to communicate with a computer's expansion bus. There are three standard controller architectures for PCs—the ATA, SATA, and SCSI. Therefore, when you purchase a disk drive, you must ensure that it conforms to your computer's controller architecture.

ATA Controllers (Parallel) **ATA**, or Advanced Technology Attachment, is a disk drive implementation that integrates the controller on the disk drive itself. An enhanced version of the ATA interface transfers data at rates up to 133 MBps; these enhancements are called *ATA/133*.

ATA is also called **PATA**, or Parallel ATA. Parallel controllers transfer data bits over multiple data lines in parallel. (Contrast Parallel ATA with Serial ATA, or SATA, in the next section.) In PATA, which is also known as Integrated Drive Electronics or IDE, each system board controller supports one or two devices, which could be hard drives or CD-ROM drives. Your computer system most likely has two IDE controllers—a primary and secondary controller. Each controller supports two drives—a master and a slave. Using ATA technology, you can attach up to four drives.

SATA Controllers (Serial) **SATA**, or Serial Advanced Technology Attachment, is an evolution of the Parallel ATA physical storage interface. Serial ATA is a serial link—a single cable with a minimum of four wires that creates a single connection between the controller and the drive. Transfer rates for SATA range from 1.5 Gbps (187.5 MBps) to 16 Gbps (2 GBps); the latter rate is much faster than PATA. Besides faster transfer rates, the SATA interface has several advantages over the PATA interface. For example, SATA drives each have their own independent bus, so there is no competition for bandwidth, as there is with PATA. SATA cables are more flexible, thinner, and less massive than the ribbon cables required for PATA hard drives, resulting in less air flow restrictions. **eSATA** allows a SATA device to be connected externally. Newer laptops and desktop computers may have eSATA connectors that allow you to attach a drive that performs at the speed of internal drives.

SCSI Controllers **SCSI** (pronounced *skuzzy*), or small computer system interface, is a parallel interface standard used for attaching peripheral devices to PCs. If your PC does not have a SCSI controller, you can add a SCSI adapter card and attach disk drives. The speeds for SCSI adapters meet and may exceed the speeds of SATA controllers, but they tend to be more expensive. Although you are limited in the number of devices you can attach to a SATA controller, SCSI allows you to connect up to 15 peripheral devices to a single SCSI controller. Note, however, that the lack of a single SCSI standard means that some devices may not work with some SCSI boards. Although SCSI is a standard of the American National Standards Institute (ANSI), it has many variations, so two SCSI interfaces may be incompatible. For example, SCSI supports several types of connectors. Ultra SCSI and Serial Attached SCSI (SAS) are only two examples of modern variations on SCSI.

Storage Devices

Storage devices refer to various devices for storing large amounts of data. Modern mass storage devices include all types of disk drives and tape drives. Mass storage is distinct from RAM, which refers to temporary storage areas within the computer. Unlike RAM, mass storage devices retain data even when the computer is turned off.

The main types of storage devices are:

- Hard drives—These disks are very fast and have large capacities. Some hard drive systems are portable (with removable cartridges), but most are not.
- Optical drives—Unlike hard drives, which use electromagnetism to encode data, optical disc systems use a laser to read and write data. Optical drives have very large storage capacity, but they are not as fast as hard drives.
- Tape drives—These drives are relatively inexpensive and often have very large storage capacities, but they do not permit random access of data.
- USB drives—These small, portable drives use flash memory or external hard drives to store data for backup or transfer between PCs.

Hard Drives A **hard drive** uses rigid rotating platters to read and write on magnetic media. A typical hard drive design, as shown in Figure 1-11, consists of a spindle on which the platters spin at a constant speed. Moving along and between the platters on a common armature are the read/write heads, with one head for each platter face. The armature moves the heads radially across the platters as they spin, allowing each head access to the entirety of the platter. Some hard drives known as solid-state drives (SSDs) use electronic circuits for

Figure 1-11 Hard drive

storage and do not have moving parts, which allows faster access to data. SSDs have several advantages, including lower power consumption, which can improve battery life in portable computers.

Hard drives are cabled to a disk drive controller. Depending on the configuration of the PC you purchase, these hard drives might be connected to SATA or SCSI hard drive controllers. It is also possible to connect external hard drives to USB ports.

Optical Drives Figure 1-12 shows an **optical drive** storage device that uses light produced by lasers instead of magnetism to store data on optical discs. These discs include CDs (COMPACT discs), DVDs (digital versatile disks), and BRDs (Blu-ray disks), which

Figure 1-12 Optical drive

are made up of millions of small bumps and dips. Lasers read these bumps and dips as ones and zeroes, which the computer can understand.

Common types of optical drives include CD-ROM, CD-RW, DVD-ROM, DVD-RW, BR-ROM, and BD-RE drives. CD, DVD, and Blu-ray writers or burners use lasers both to read and write data on the discs. The laser used for writing data is much more powerful than the other laser because it must “burn” the bumps and dips into the disc. Although optical drives can spin discs at very high speeds, they are still significantly slower than hard drives, which store data magnetically. However, because optical media are inexpensive and removable, they are a common format used for distributing computer software.

Tape Drives A **tape drive** is a device that stores computer data on magnetic tape, especially for backups (see Figure 1-13). Like an ordinary tape recorder, a tape drive records data on a loop of flexible celluloid-like material that can be read and erased. Tapes have a large capacity for storing data and are less expensive than hard drive storage. A disadvantage is that tape drives store data sequentially rather than randomly (as hard drives do), and the user can only access specific data by starting at the beginning and rolling through the tape until the desired data is located. The most common use of tape drives is to make backup copies of data for offline archival storage.

USB Drives A **USB drive** is a small, portable flash memory device (see Figure 1-14) that plugs into any computer with a USB port and functions as a portable drive with up to 1 TB

Figure 1-13 Tape drive

Figure 1-14 USB drive

of storage capacity. USB flash drives are easy to use and can be carried in a pocket. USB flash drives are also called jump drives, thumb drives, pen drives, key drives, or simply USB drives. These drives have less storage capacity than an external hard drive, but they are smaller and more durable because they have no internal moving parts.

A USB drive may also refer to a portable hard drive or optical drive that plugs into a computer's USB port. A portable hard drive is a disk drive that is plugged into an external port on a computer, normally a USB port. Typically used for backup, but also as secondary storage, such units rival internal drives in capacity. You can use a USB drive to transport data files between computers in the office.

Communications Devices

Communications devices support transmission of data from one PC to another, or from one device to another. For example, modems, network interface cards, and wireless adapters are all communications devices.

Modems **Modem** is short for *modulator-demodulator*. With the proliferation of cable TV, broadband communications became readily available for the transmission of digital data. A **cable modem**, as shown in Figure 1-15, is designed to operate over cable TV lines. Because the coaxial cable used by cable TV provides much greater bandwidth than telephone lines, your cable modem enables extremely fast access to the World Wide Web.

Network Interface Cards A **network interface card** (**NIC**), as shown in Figure 1-16, is an expansion board that you insert into a computer so that it can be connected to a local area network (LAN). A network card can be either an expansion card that plugs into a computer's bus or an interface on the system board. You use a LAN to interconnect desktop computers in a workgroup and share files within an office.

Wireless Adapters A **wireless adapter**, as shown in Figure 1-17, permits a mobile user to connect to a LAN through a wireless (radio) connection. Access is similar to NIC access, but a wireless adapter allows more freedom of movement. Many newer laptop computers have wireless adapters built into the system board. Traveling sales personnel can use a wireless connection to access their office Web site and determine product specifications and prices.

Figure 1-15 Cable modem

Figure 1-16 Network interface card

Figure 1-17 Wireless adapter

Peripheral Devices

Peripheral devices are external to the PC. For example, keyboards, pointing devices, printers, and external disk drives are common peripheral devices that are not part of the PC but are used in conjunction with it.

In the sections that follow, you will learn about input and output devices.

Input Devices

Input devices feed data into the PC. Examples include keyboards, pointing devices, biometric devices, and digital/video cameras. Although storage devices can provide input, this section is restricted to devices that you use to enter data yourself.

Keyboards Computer keyboards are similar to electric-typewriter keyboards, but they contain additional keys. Keyboards are designed for text entry and to control the operation of the computer. The standard U.S. keyboard has 105 keys. In addition to the 26 letters and 10 digits, special character keys extend the character set. Additional keys are used to control the computer.

Pointing Devices You use a pointing device to move the pointer on the screen, choose commands, click buttons, select text, create drawings, and so on. Examples of pointing devices include mice, trackballs, and touch pads.

A **mouse** consists of a metal or plastic housing, a sensor on the bottom of the housing that is moved across a flat surface, and one or more buttons on top of the housing. As the mouse is moved over the surface in any direction, the sensor (which could be LED or laser based) sends impulses to the computer, causing a mouse-responsive program to reposition a visible indicator (called a *cursor* or *pointer*) on the display screen. The positioning is relative to a variable starting place. By viewing the cursor's present position, the user can readjust the position by moving the mouse. The mouse buttons are used to select text or options on the screen.

Essentially, a **trackball** is a mouse lying on its back. To move the pointer, you rotate the ball with your thumb, your fingers, or the palm of your hand. A trackball usually has one to three buttons next to the ball; you use them just like mouse buttons. You may prefer a trackball to a mouse because the trackball is stationary and does not require much space to use.

A **touch pad** is a small, touch-sensitive pad used as a pointing device on some laptop computers. By moving your finger along the pad, you can move the pointer on the display screen. You click by tapping the pad or pressing the button below the touch pad. A **touch screen** is incorporated into a display device; it allows you to provide input by touching the screen with a finger or stylus.

Biometric Devices **Biometrics** is the science and technology of measuring and statistically analyzing biological data. In information technology, biometrics usually refers to technologies for measuring and analyzing human body characteristics—such as fingerprints—for authentication purposes.

A **fingerprint scanner** (see Figure 1-18) has two basic jobs—recording an image of your finger and determining whether the pattern of ridges and valleys in the image matches the pattern in a previously scanned image. When the image matches, you are permitted to access the PC. Fingerprint scanners are included with a number of high-end laptop computers.

In addition to scanning fingerprints, biometric devices control access by measuring the retina and iris of the eye, voice patterns, and facial characteristics.

Digital/Video Cameras A **digital camera** stores images digitally rather than recording them on film. Typically, the image is stored on a flash card. After a picture is taken, it can be downloaded to a PC and then manipulated with a graphics program and printed. Unlike photographs on film, which have extremely high resolution, digital photos are limited by the amount of memory in the camera.

A **digital video camera** stores frames on digital tape or a digital card. After you record or shoot a video movie, you can download it to a PC and then manipulate it with a video-editing program.

Figure 1-18 Fingerprint scanner

Output Devices

Output devices such as monitors and printers provide output from a PC. Although storage devices can also provide output, this section is restricted to devices that you use to view information yourself.

The most important aspect of a monitor is its screen size. Like televisions, monitor screen sizes are measured in diagonal inches—the distance from one corner to the opposite corner diagonally. Typical sizes run from 17 to 20 inches, but monitors are available in larger sizes. The resolution of a monitor indicates how densely packed the pixels are. In general, more pixels produce a sharper image. Most modern monitors can display 1366 by 768 pixels. Some high-end models can display 2560 by 1440 pixels, or even higher.

LCD Panels LCD is short for *liquid crystal display*, a type of display used on laptop computers. LCD displays use two sheets of polarizing material with a liquid crystal solution between them. An electric current passed through the liquid causes the crystals to align so that light cannot pass through them. Each crystal, therefore, is like a shutter, either allowing light to pass through or blocking the light. Multiple monitors may be used for a single computer.

CRT Monitors CRT is an abbreviation for *cathode ray tube*, the technology used in older televisions and computer display screens.

Printers A printer is a device that prints text or illustrations on paper. Many different types of printers are available. In terms of the technology used, printers fall into the following categories:

- Dot matrix—Creates characters by striking pins against an ink ribbon. Each pin makes a dot, and combinations of dots form characters and illustrations.
- Inkjet—Sprays ink at a sheet of paper. Inkjet printers produce high-quality text and graphics.
- Laser—Uses the same technology as copy machines. Laser printers produce high-quality text and graphics.

An inkjet printer may be your best choice when color printing is required. You should consider a shared laser printer when you need high volumes of black-and-white output in an office environment.

Virtual Machines and Virtualized Devices

In this text, you will work with two virtual machines. The virtualization software provides devices for use by the operating system running within the virtual machine.

You can see which hardware is provided to the virtual machine by reviewing its settings in the management program for the virtualization software. Figure 1-19 shows the settings for a Windows 10 virtual machine running in the Microsoft Hyper-V virtualization software.

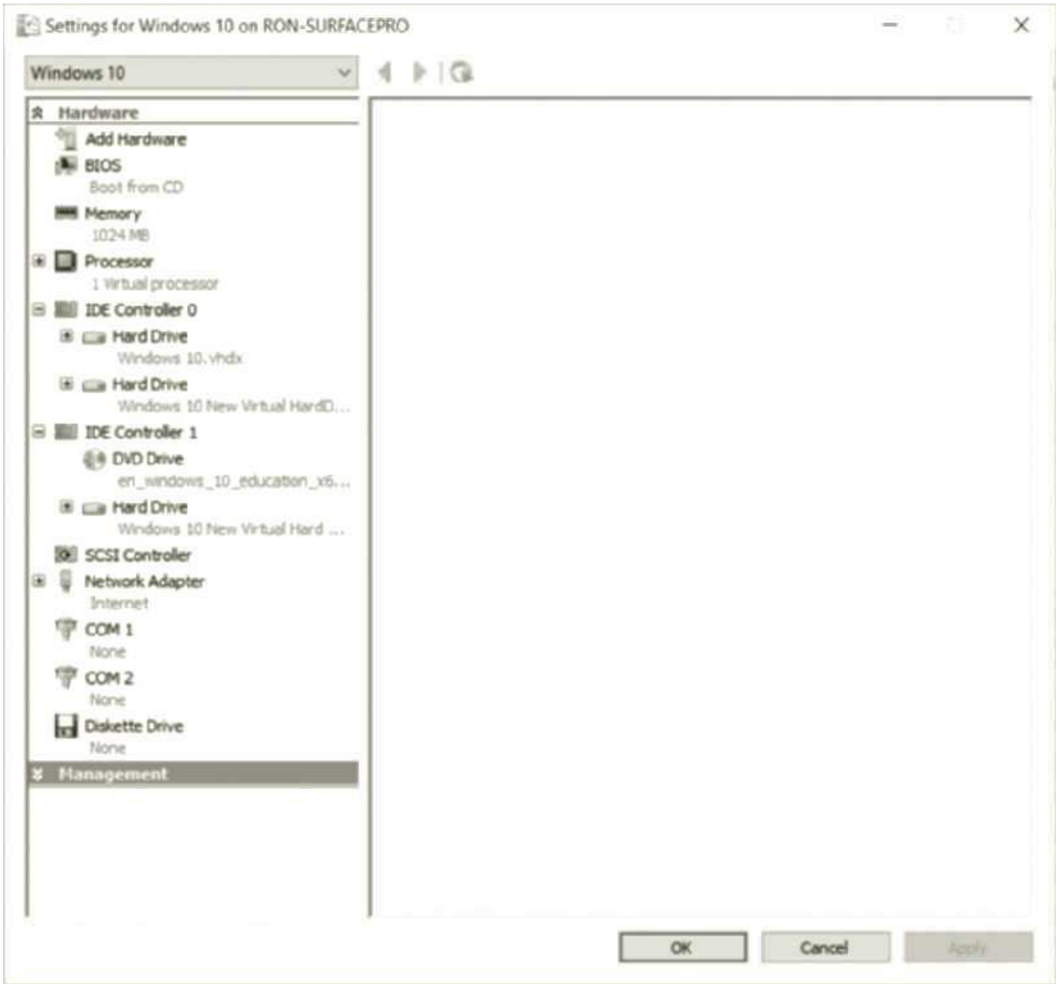

Figure 1-19 Settings window in Microsoft Hyper-V

Source: Microsoft Windows 10

The configuration for this virtual machine consists of the following settings, from top to bottom:

- BIOS—The boot sequence for the virtual machine; in this case, the .iso image is booted from a virtual DVD.
- Memory—The amount of physical memory, 1,024 MB, reserved for the virtual machine. Additional memory improves the performance of the virtual machine.
- Processor—One virtual processor. The addition of more virtual processors improves the performance of processor-bound applications running in virtual machines.
- **IDE controller** 0—An ATA controller with two virtual hard drives: the drive for the Windows 10 OS and an additional drive for data storage.
- IDE controller 1—An ATA controller with two virtual hard drives: the DVD drive for the Windows 10 ISO and an additional drive for data storage.
- SCSI controller—No SCSI drives are used by the virtual machine.
- Network adapter—A virtualized network adapter provides Internet access.
- COM 1—The first virtualized communications port.
- COM 2—The second virtualized communications port.
- Diskette drive—A diskette drive is not used by the virtual machine.

Activity 1-2: Reviewing System Information for Windows 10

Time Required: 10 minutes

Objective: Use the System Information program to review which components are available on the Windows 10 virtual machine.

Description: In this activity, you open the System Information window and review the available components on your PC.

1. If necessary, start your virtual machines using the appropriate instructions in Activity 1-1.
2. To open the System Information window, type **msinfo32** over "Search the web and Windows" in the search box, and then click **System Information**.
3. To review component information, expand the **Components** folder.
4. To review the input components, expand the **Input** folder.
5. To review information about the pointing device, click **Pointing Device**.
6. To review information about the network adapter, expand **Network** and then click **Adapter**.
7. To review information about drives, expand **Storage** and then click **Drives**.
8. To review information about disks, click **Disks**.
9. Close the System Information window.
10. Leave the virtual machine logged on for future activities.

Activity 1-3: Reviewing System Information for CentOS 7

Time Required: 10 minutes

Objective: Use the System Information program to review which components are available on the CentOS 7 virtual machine.

Description: In this activity, you open the System Information window and review the available components on your CentOS 7 virtual machine.

1. If necessary, start your virtual machines using the appropriate instructions in Activity 1-1.
2. To open the terminal console, right-click on the desktop and select **Open in Terminal**.
3. To open the System Information window, type **hardinfo** and press **Enter**.

If you see a "Command not found" message, contact your instructor.

4. To review component information, click **Summary**.
5. To review operating system information, click **Operating System**.
6. To review processor information, click **Processor**.
7. To review the input components, click **Input Devices**.
8. To review storage information, click **Storage**.
9. Close the System Information window.
10. Leave the virtual machine logged on for future activities.

Activity 1-4: Reviewing the Devices on your Windows 10 Virtual Machine

Time Required: 10 minutes

Objective: Use the Device Manager program to review which devices are available on your Windows 10 virtual machine.

Description: In this activity, you open the Device Manager and review the available devices on your PC.

1. If necessary, start your virtual machines using the appropriate instructions in Activity 1-1.
2. To open the System applet, click **Start** and type **Device Manager**.
3. To open the Device Manager, click **Device Manager**.
4. If a Device Manager warning appears, read it and then click **OK**.
5. To review information on the disk drive, double-click the **Disk drives** folder to expand it.

6. Repeat Step 5 for the remaining folders.
7. Close the Device Manager window.
8. Leave the virtual machine logged on for the next activity.

Activity 1-5: Closing the Virtual Machines

Time Required: 3 minutes

Objective: Properly close the virtual machines.

Description: In this activity, you will log off and shut down the two virtual machines. The virtual machines must be properly shut down; otherwise, damage may occur to the virtual hard disks that support the virtual machines.

1. If the screen saver was activated on the Windows 10 virtual machine, log on to the Windows 10 virtual machine, type **Pa$$w0rd**, and then press **Enter**.
2. To shut down the Windows 10 virtual machine, click **Start**, click **Power**, and then click **Shut Down**.
3. If the screen saver was activated on the CentOS 7 virtual machine, move the mouse up on the screen to return to the login screen, type a password of **Pa$$w0rd**, and then click **Unlock**.
4. To shut down the CentOS 7 virtual machine, click **User01** in the upper-right corner. Select **Power Off**, and then click **Power Off** again.
5. Ask your instructor if the host machine should be left on or shut down at the end of the lab.

Preventive Maintenance

When you own or use a PC, you may be responsible for its maintenance. For example, you might need to regularly clean the unit, which can extend its life. You also need to know that a number of potential hazards, including static electricity, can damage the PC. And what will you do with your PC when you no longer need it? This section addresses all of these topics.

Cleaning

Your PC's mortal enemy is excessive heat, which accelerates the deterioration of its delicate circuits. The most common causes of overheating are dust and dirt: Clogged vents and CPU cooling fans can keep heat-dissipating air from moving through the case, and even a thin coating of dust or dirt can raise the temperature of PC components.

In most locations, such as dusty offices, your system may need a cleaning every few months. Most cleaning requires only a can of compressed air, lint-free wipes, cotton swabs, and a few drops of a mild cleaning solution in a bowl of water.

Always turn off and unplug the system before you clean any of its components. Never apply liquid directly to a component. Spray or pour the liquid on a lint-free cloth, and wipe the PC with the cloth.

Cleaning the Outside Start by cleaning the outside of the case and attached peripherals. Wipe the case with a mild cleaning solution. Clear the ventilation openings of any obstructions. Use compressed air, but do not blow dust into the PC or its optical drives.

Turn the keyboard upside down and shake it to clear any crumbs from between the keys. If that does not suffice, blast it briefly with compressed air.

Wipe the monitor case and clear its vents of obstructions without pushing dust into the unit.

Be careful when cleaning LCD panels. These surfaces should only be cleaned with a nonabrasive, lint-free cloth and water. Avoid using glass cleaner and any cleaning solution that contains ammonia, as it will damage the plastic surface of the screen.

Dirty optical discs should be cleaned carefully using a soft, dry, lint-free cloth. Hold the disc by its outer edges or center hole, and then gently wipe outward from the center hub toward the outside edge. Stubborn fingerprints or stains can be removed using a soft, dry, lint-free cloth lightly moistened with water. Never wipe a disc in a circular motion.

Cleaning the Inside Continue your cleaning with the inside of the case. Before cleaning the components in the case, take precautions to ground the static electricity before you touch any of the internal components. You should ground the static electricity by touching the internal metal frame of the computer's case while the computer is plugged into an electrical socket. The static electricity will be discharged and grounded because the electrical circuit is grounded via the AC outlet. Be sure to unplug the power cord before you clean the inside of the case.

Use antistatic wipes to remove dust from inside the case. Avoid touching any circuit board surfaces. Pay close attention to the various fans. Spray these components with a blast of compressed air to loosen dust. To remove the dust rather than rearrange it, you should use a small vacuum.

If your PC is more than four years old, or if the expansion cards plugged into its system board are exceptionally dirty, remove each card, clean its contacts with isopropyl alcohol, and reseat it. If your system is less than two years old, just make sure each card is firmly seated by pressing gently downward on its top edge without touching its face. Likewise, check your power connectors and other internal cables for a snug fit.

Electrostatic Discharge

Electrostatic discharge (ESD) is the rapid discharge of static electricity from one conductor to another conductor of a different potential. An electrostatic discharge can damage integrated circuits in the PC. Whenever the PC case is opened and its internal workings are exposed (for example, to add an adapter card), you could damage the computer with the buildup of static electricity that your body holds.

The internal workings of a computer, and especially the hard drive, are extremely susceptible to static electricity. Human beings are not able to perceive static electricity until it has reached about 1,500 volts. (Walking across a rug can produce up to 12,000 volts of static electricity.) Although it is not life-threatening to people, even a very low voltage of static electricity can seriously damage a hard drive or a system board.

To avoid zapping internal computer components, be sure to ground the static electricity before you touch them, as described in the previous section.

To be on the safe side, always handle electronic circuitry on its insulated areas; avoid touching the circuits themselves. This advice applies to handling the system board, video card, modem, sound card, and hard drive, as well as any other internal components.

Hazards

While electrical problems can damage your PC, many hazards can injure you, including high-voltage shocks. You need to be aware of these hazards and know how to prevent them.

High Voltages in Capacitors The interiors of PC power supplies, monitors, and laser printers contain capacitors that may retain a charge long after power is removed from a circuit; this charge can cause damage to connected equipment and shocks (even electrocution). You should not attempt to service equipment that contains large or high-voltage capacitors.

Power Supplies Whenever you repair or perform maintenance on your PC, you must unplug it after discharging any static electricity. Modern PC system boards have a small voltage running when the PC is plugged in.

You should not attempt to repair a power supply. The safest choice is to replace it.

CRT Monitors While CRTs are becoming a rarity, it is important to know that the voltages inside a CRT monitor can kill you! Recall that capacitors can retain a charge long after power is removed from a circuit; this charge can cause shocks and even electrocution. Another dangerous part of the monitor is the **flyback transformer**, which generates up to 20,000 volts.

Fires You may never have a PC fire, but an electrical fire can strike your office or home. The smoke can harm you as well as your PC. You should use a type C or type ABC fire extinguisher on an electrical fire. Never spray or throw water on an electrical fire; the electrical current could travel up the water stream into you!

Disposal

Many PC components contain harmful ingredients and toxins, including lead, mercury, arsenic, cadmium, selenium, and hexavalent chromium. About 70 percent of the heavy metals (mercury and cadmium) in landfills come from electronic waste. These toxins can cause allergic reactions, brain damage, and cancer.

You must make prudent decisions when disposing of PCs and peripherals.

- Batteries contain toxic chemicals (lithium, mercury, nickel cadmium) and should not be thrown in the trash. You can take batteries to a recycling depot. In some cases, you can send the batteries back to the manufacturer.
- CRTs contain lead. If you toss them in the trash, the lead will end up in a landfill. For this reason, CRTs must be recycled or turned over to a hazardous waste program.
- Significant amounts of gold, silver, copper, steel, aluminum, wire, cable, and other resources can be extracted from computers. Many of these materials are recyclable.

You can drop off used computer equipment at participating Goodwill donation centers. It is free, and you will be given a receipt for tax purposes. At the same time, you will help protect the environment and benefit your community.

Identifying and Connecting PC Components

You should know how to "cable up" a PC. In this section, you will learn to identify the cables and connectors of a typical desktop or laptop system.

USB Cables

You can use USB cables to connect many devices to your computer, including flash memory devices, portable media players, and digital cameras. You can also connect accessories such as mice, keyboards, portable hard drives, BRD-DVD-CD drives, and microphones. Web cameras, printers, scanners, and speakers can also be connected to the computer through the USB ports.

The Standard USB connector, called a *USB-A*, is a rectangular connector found on every USB cable; it connects to your computer. The other end of the USB cable may have a variety of connectors, including the USB-B, a square connector used with printers, portable drives, and larger peripheral devices. USB-C has a 12-pin reversible plug design. Smaller connectors such as the Mini-USB and Micro-USB are commonly used with smaller portable devices, including media players and cameras. Figure 1-20 shows a variety of USB cables with their connectors.

Video Cables

One of the most common video connectors for computer monitors is the 15-pin VGA cable. For example, you can use this cable to connect a PC to a projector. Figure 1-21 shows some common video cables.

If you recently purchased a PC, you may have a Digital Visual Interface (DVI). Newer, thinner laptops use smaller versions of the DVI, such as the Mini-DVI and Micro-DVI. A DVI

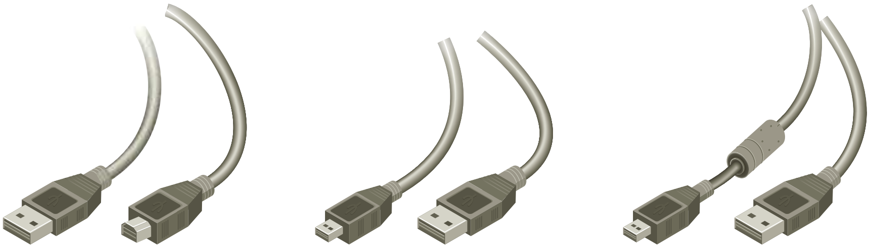

Figure 1-20 USB cables with common connectors

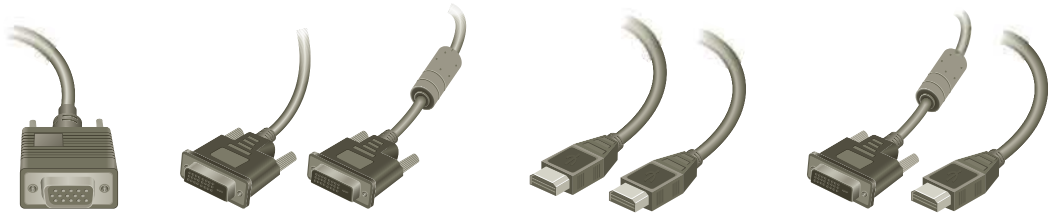

Figure 1-21 Video cables

cable has 29 pins, although some connectors may have fewer pins. DVI's signal is compatible with HDMI; cables can convert between the two formats.

Sound Cables

The most common sound cable is the standard headphone jack. While it is available in several sizes, the 1/8-inch mini-audio cable (shown in Figure 1-22) is used with computers.

Data Cables

Figure 1-23 shows the most common data cables: FireWire and eSATA. FireWire, also known as IEEE 1394, is commonly used for connecting digital camcorders and portable drives. FireWire cables typically have six pins, although a four-pin variety is common as well.

While SATA cables are used internally to connect SATA drives to disk controllers, eSATA cables are designed for portable hard drives. The eSATA connector is larger than the internal SATA cable and has more shielding.

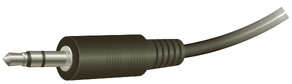

Figure 1-22 Sound cable

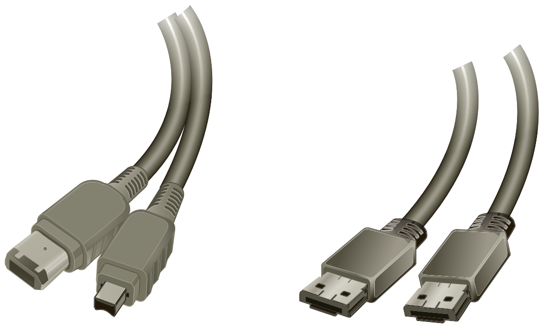

Figure 1-23 Data cables

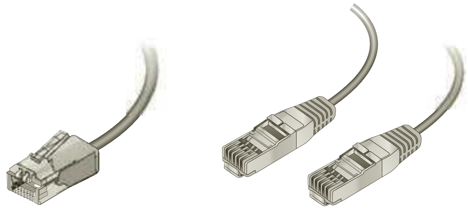

Figure 1-24 Networking cables

Networking Cables

The phone cable, known as the RJ-11, is still used to connect modems to phone jacks for Internet connectivity. The connector has four pins and a retaining clip (see Figure 1-24).

Ethernet is the standard for wired networking. The Ethernet connector, otherwise known as the RJ-45, is attached to an eight-wire twisted pair cable. It looks like a phone plug but is thicker and wider. It has a retaining clip to maintain a tight connector.

Chapter Summary

- Virtual machine technology allows multiple operating systems to run concurrently on a single PC. With virtual machine technology, you can run various Windows operating systems as well as Linux within a host operating system.
- Many hardware components make up a PC. The case houses and protects the main electronic components. The power supply is a sealed metal box that contains power conversion hardware. The system board, or main circuit board, contains the microprocessor, bus, memory, and expansion slots. The BIOS is firmware that supports the PC during start-up. VGA, USB, and other ports permit the connection of devices. Video and sound expansion cards permit graphical and audio communication with the user. Disk drive controllers (such as PATA, SATA, and SCSI) allow the connection of hard drives and optical drives. Communication with other devices is permitted by modems, network interface cards, and wireless adapters.

- Peripherals include input devices such as keyboards, mice, trackballs, touch pads, fingerprint scanners, and digital cameras, which permit input and communication from the user. Output devices include monitors, speakers, and printers.
- Preventive maintenance is the responsibility of the PC's owner. To avoid heat damage, keep the PC clean. Clean the inside and outside of the case and the attached peripherals.
- Many hazards can injure a PC user or damage the PC. For example, electrostatic discharge can damage a PC's internal components. Capacitors in power supplies and CRT monitors retain high voltages. Use a type ABC or type C fire extinguisher on electrical fires.
- Some PC components are not internal but are connected to the PC. Common connectors such as USB simplify the connection of these components. Connect components starting with the connector that is farthest from the power supply connector.

Key Terms

ATA An acronym for *Advanced Technology Attachment*; the disk drive standard commonly known as Integrated Drive Electronics (IDE).

biometrics The science and technology of authenticating a person's identity by measuring physiological features.

BIOS An acronym for *basic input/output system*; the set of essential software routines that test a PC at start-up and start the OS.

bus The set of hardware lines used to transfer data among the components of a PC.

cable modem A device that sends and receives data through coaxial cables.

CRT An acronym for *cathode ray tube*; the basis for the standard PC display screen.

digital camera A type of camera that stores photographic images electronically rather than on film.

digital video camera A camera that captures and stores images on a digital medium. Also known as a camcorder.

EEPROM An acronym for *electrically erasable programmable read-only memory*; a type of EPROM that can be erased with an electrical signal.

electrostatic discharge (ESD) The discharge of static electricity from an outside source—such as human hands—into an integrated circuit, often damaging the circuit.

EPROM An acronym for *erasable programmable read-only memory*; a type of memory chip that can be reprogrammed after manufacture.

eSATA An external connector that provides fast data transfer for external SATA hard drives.

expansion card A circuit card that is plugged into a PC's bus to add extra functions.

fingerprint scanner A scanner that reads human fingerprints for comparison to a database of stored fingerprint images.

FireWire A PC and digital video serial bus interface standard offering high-speed communications. FireWire is also known as IEEE 1394.

firmware Software routines stored in read-only memory (ROM).

flyback transformer A transformer in a CRT monitor that generates up to 20,000 volts.

form factor The physical size and shape of a device. The term is often used to describe the size of PC cases.

guest operating system The operating system running within a virtual machine.

hard drive A device that reads data from and writes data to one or more inflexible platters.

heat sink A device that absorbs and dissipates heat created by an electronic device, such as a microprocessor.

host operating system An operating system running on a physical machine that executes virtualization software.

IDE controller See *ATA*.

LCD An acronym for *liquid crystal display*; a type of display that uses a liquid compound with a polar molecular structure sandwiched between two transparent electrodes.

memory An area where data can be stored and retrieved.

microprocessor A central processing unit (CPU) on a single chip.

modem Short for *modulator/demodulator*; a communications device that enables a PC to transmit data over a standard telephone line.

mouse A common pointing device.

network interface card (NIC) An expansion card used to connect a computer to a local area network.

optical drive A disk drive that reads and may write data to optical (compact) discs.

PATA An acronym for *Parallel Advanced Technology Attachment*. PATA is the same as ATA, which was renamed when SATA was introduced.

PCI Express A connector on a system board that provides 1 to 16 interface lanes. This slot saves space on the system board.

PCI slot A connector on a system board used to insert an adapter card.

PROM An acronym for *programmable read-only memory*.

RAM An acronym for *random access memory*; semiconductor memory that can be read or written by the microprocessor or other devices.

register A small amount of high-speed memory.

ROM An acronym for *read-only memory*; a semiconductor circuit in which data is permanently installed by the manufacturer.

RS-232 An industry-accepted standard for serial communications.

SATA An acronym for *Serial Advanced Technology Attachment*, which transfers data serially to and from the hard drive.

SCSI An acronym for *small computer system interface*. It is used to connect SCSI devices to PCs.

sound adapter An expansion card that supports the recording and playback of sound.

system board The main circuit board that contains a PC's primary components.

tape drive A device for reading and writing data on magnetic tapes.

touch pad A pointing device that responds to movement of a finger on a surface.

touch screen A screen that allows you to provide input by touching it with a finger or stylus.

trackball A pointing device with a stationary housing that contains a ball you roll with your hand.

Universal Serial Bus (USB) A serial bus that connects devices to a PC. USB supports hot plugging.

USB drive A small, portable flash memory card that plugs into a PC's USB port and functions as a portable hard drive with smaller capacity.

video adapter Electronic components that generate the video signal sent to a video display.

virtual machine A software implementation of a machine (that is, a computer) that executes programs like a physical machine.

virtualization A technology that permits one or more guest operating systems to run on an operating system.

virtualized systems Systems that appear to be real but are actually simulations.

wireless adapter A device that supports a wireless connection through a radio connection to a wireless LAN.

Review Questions

1. With virtual machine technology, you move from one OS to another by ________________.
   a. restarting the system
   b. pressing the F2 key
   c. clicking the other OS window
   d. logging off the system
2. Which of the following operating systems can be used with virtual machine technology? (Choose all that apply.)
   a. Windows 10
   b. CentOS 7
   c. Macintosh
   d. physical
   e. logical
   f. emulated
   g. free
3. Microsoft Hyper-V mimics physical PCs so closely that the applications you install in them do not distinguish the virtual machine from a(n) ________________ computer.
   a. supported
   b. emulated
   c. guest
   d. physical