Computer Structure and Logic

SECOND EDITION

Pearson Certification Team

PEARSON

Computer Structure and Logic

Second Edition

Pearson Certification Team

PEARSON IT CERTIFICATION

800 East 96th Street

Indianapolis, Indiana 46240 USA

Computer Structure and Logic

Second Edition

ISBN-13: 978-0-7897-5184-3

ISBN-10: 0-7897-5184-4

Library of Congress Control Number: 2013957444

Printed in the United States of America

First Printing: February, 2014

Trademarks

Warning and Disclaimer

Special Sales

For information about buying this title in bulk quantities, or for special sales opportunities (which may include electronic versions; custom cover designs; and content particular to your business, training goals, marketing focus, or branding interests), please contact our corporate sales department at corpsales@pearsoned.com or (800) 382-3419.

For government sales inquiries, please contact governmentsales@pearsoned.com.

For questions about sales outside the U.S., please contact international@pearsoned.com.

Associate Publisher
Dave Dusthimer

Acquisitions Editor
Betsy Brown

Development Editor
Andrew Cupp

Managing Editor
Sandra Schroeder

Senior Project Editor
Tonya Simpson

Copy Editor
Cheri Clark

Indexer
Larry Sweazy

Proofreader
Sarah Kearns

Technical Editors
Chris Crayton
Aubrey Adams

Publishing Coordinator
Vanessa Evans

Interior Designer
Gary Adair

Cover Designer
Mark Shirar

Compositor
Studio Galou

Contents at a Glance

Table of Contents

About the Technical Reviewers

Aubrey Adams is an electronics and computer systems engineering lecturer, and Cisco Networking Academy instructor, at Central Institute of Technology, Perth, Western Australia. With a background in telecommunications design, Aubrey has qualifications in electronic engineering and management, and graduate diplomas in computing and education. He teaches across a broad range of related vocational and education training areas. Since 2007, Aubrey has technically reviewed a number of Pearson Education and Cisco Press publications, including video, simulation, and online projects.

Chris Crayton is an author, a technical consultant, a trainer, and a SkillsUSA technology competition judge. Formerly, he has worked as a computer technology and networking instructor, network administrator, and PC specialist. Chris has authored several print and online books on PC repair, CompTIA A+, CompTIA Security+, and Microsoft Windows. He has also served as technical editor and content contributor on numerous technical titles for several of the leading publishing companies. He holds MCSE, A+, and Network+ certifications.

We Want to Hear from You!

As the reader of this book, *you* are our most important critic and commentator. We value your opinion and want to know what we're doing right, what we could do better, what areas you'd like to see us publish in, and any other words of wisdom you're willing to pass our way.

We welcome your comments. You can email or write to let us know what you did or didn't like about this book—as well as what we can do to make our books better.

Please note that we cannot help you with technical problems related to the topic of this book.

When you write, please be sure to include this book's title and author as well as your name, email address, and phone number. I will carefully review your comments and share them with the author and editors who worked on the book.

Email: feedback@pearsonitcertification.com

Mail: Pearson IT Certification
ATTN: Reader Feedback
800 East 96th Street
Indianapolis, IN 46240 USA

Reader Services

Visit our website and register this book at www.pearsonitcertification.com/register for convenient access to any updates, downloads, or errata that might be available for this book.

Introduction

Welcome to *Computer Structure and Logic*, Second Edition. This text is designed for those who want to learn about computers from the ground up. The book is planned so that each topic you learn builds on the preceding topic. From desktop computers to mobile devices, hardware to operating systems, basic security and networking, this book gives its readers a solid foundation from which to start their IT career.

This book also acts as a stepping stone to certifications from organizations such as CompTIA, Microsoft, and Cisco. Although further study is necessary to attain those certifications, this book creates a basis from which you can begin that process.

It's a pleasure for us to bring this text to you, and we wish you the best of success in your information technology (IT) endeavors.

Goals and Methods

The number-one goal of this book is to establish a groundwork of computer knowledge and hands-on skills for the reader. To aid you in mastering an extensive list of computer concepts, each chapter first lists the topics to be discussed, thoroughly defines and describes each topic, and finally concludes with chapter review questions and case study problems that test your recall of the concepts.

In this book, we generally use a subsystem approach. Most of the chapters are devoted to a particular component of the computer. Each component discussed builds on the preceding one. Be sure to read the book in order, and don't skip any parts!

Who Should Read This Book?

This book is for entry-level IT students. The ordinary reader should have a basic understanding of how to navigate through Windows and how to use the Internet. Readers will range from people who are very new to the IT field to people attempting to attain a position in the IT field.

This book is also aimed at the reader who ultimately wants to acquire certifications such as the CompTIA A+ and Network+, or certifications from organizations such as Microsoft or Cisco. The book is designed in such a way to offer easy transition to future certification studies. Each chapter of the book aligns to particular CompTIA A+ exam objectives. These objective numbers are mentioned at the beginning of each chapter as a courtesy so that the reader can begin to see how the topics covered relate to the A+ exams.

How This Book Is Organized

This book is designed to be read in order, and in its entirety. As previously mentioned, the book's chapters and concepts build on each other as you progress throughout. There are 13 chapters in total, and they cover the following topics:

- History of Computers
- The von Neumann Computer Model
- Modern Computers
- History of the PC
- What Is a PC?
- What Is a Mobile Computer?
- Numbering Systems Used in Computers
- Basic Boolean Operations
- Measuring Data Transfer and Frequency
- How Computers Process Information
- The Evolution of Motherboards
- Motherboard Components
- Installing Motherboards
- Installing Adapter Cards
- The Evolution of the CPU
- How the CPU Operates
- CPU Technology
- Intel and AMD Processors
- Mobile Processors
- Choosing the Best Processor for the Job
- Installing and Upgrading Processors
- RAM Basics
- RAM Types
- RAM Technologies
- The Synergy Between Memory and Programs
- Installing DIMMs
- Hard Drives
- Optical Drives
- Solid-State Media
- Understanding I/O Ports
- Understanding Input Devices
- Display Types
- Video Connector Types
- Video Settings
- Printing Fundamentals

- Understanding Multimedia Devices
- Understanding the BIOS, CMOS, and Firmware
- Configuring and Updating the BIOS
- Power, the POST, and Error Reporting
- Booting and Resetting Mobile Devices
- The Fundamentals of Computer Operation
- Types of Desktop Operating Systems
- Differences in Windows Versions
- Types of Linux Distributions
- Types of Mobile Operating Systems
- Operating System Architectures
- Disk Partitions, Folders, and Files
- Introduction to Working in the Command Line
- System Management Tools
- Types of Computer Networks
- Network Devices
- Wired and Wireless Network Connections
- Connecting Computers to the Network
- Understanding and Configuring TCP/IP
- Using Networking Command-Line Tools
- TCP/IP Suite of Protocols
- Internet Connectivity Technologies
- Understanding Virtualization
- Cloud Computing Fundamentals
- Security Fundamentals
- Data and Physical Security
- Access Control Purposes and Principles
- Configuring Security Features
- Mobile Security
- Wireless Security
- Virtual Computing and Cloud Computing Security
- PC Tools
- Preventing Electrostatic Discharge
- Using a Troubleshooting Process
- Determining the Type of Problem
- Troubleshooting Hardware
- Troubleshooting Operating Systems
- Troubleshooting Mobile Devices
- Where to Go for More Information

Key Pedagogical Features

To begin the chapter:

Each chapter begins with a few features that help direct you as to what the chapter discusses, before getting into the core topics of the chapter:

- **Chapter Introduction** describes the big ideas in the chapter, with perspective on how it fits with the other chapters.
- **Chapter Outline** lists the titles of the (usually three or four) major sections in each chapter, with a short description.
- **Chapter Objectives** list the most important core topics covered within the chapter.
- **CompTIA A+ Objectives Covered** lists the CompTIA A+ objective numbers for each of the 220-801 and 220-802 exams that correspond to the chapter topics.

In the core of the chapter:

The majority of each chapter, following the chapter introduction, uses text, tables, lists, and figures to explain various computing topics. Along with those descriptions, the core topics also use the following features:

- **Key Terms:** Inside the chapter, the key terms are noted in a **bold font** so that they can be more easily found.
- **Notes:** These notes list topics that the author wants to draw particular attention to, but that you can skip when reading if you want to maintain the flow. Notes typically list some deeper fact about the current topic or some fact that may be a little off-topic. Read these notes at some point, whether during your first read of the chapter or when reviewing and studying.

At the end of each chapter:

The end of each chapter closes with tools and activities that you can use to review the topics from inside the chapter:

- **Chapter Summary:** This gives a brief summary of the big points made inside the chapter.
- **Define the Key Terms:** This section lists the key terms indicated in **bold** throughout the chapter. It reminds you of the terms, and suggests an activity in which you write the definitions for these terms in your own words. You can then compare your definitions with the definitions in the glossary.
- **Answer These Questions and Case Studies:** This section offers multiple-choice questions that can be used to review the topics in the chapter, as well as real-world case studies that help to solidify the reader's knowledge from a more hands-on perspective.

Computer Structure and Logic Lab Manual:

Available as a separate title, the *Computer Structure and Logic Lab Manual* offers lab exercises that can be used with each of the chapters in this book.

Conclusion

Computers are a part of almost everyone's daily lives. They come in all shapes and sizes, and have varying purposes. To understand computers better, you need to study their hardware and software attributes, their design and architecture, how they are networked with each other, how they are secured, and how they can be repaired when necessary. This book lays the foundation of computer knowledge that you can build on and refer to when necessary. The world of computing can be very exciting—hopefully this book will serve to satisfy your quest for knowledge, while being enjoyable as well.

This page intentionally left blank

Chapter 3

Motherboards and Buses

In this chapter, we discuss the **motherboard**—which is the printed circuit board enabling connectivity between all other devices within the computer. We'll also cover chipsets, the various bus technologies, and the range of interfaces that you might encounter within a motherboard. We discuss the evolution of the motherboard, from its early beginnings to today's powerful and robust motherboards.

Deciding on a motherboard should be among your first tasks when building a computer. Adapter cards are also vital because they allow video, audio, and network capabilities. It is important to know how many and what type of adapter card slots are available on your motherboard before selecting specific adapter cards.

So within these pages, you'll learn some of the considerations to take into account when building the core of a PC, but more important, you will learn about the inner workings of the foundation of the computer—the motherboard.

Chapter Outline

- The Evolution of Motherboards
- Motherboard Components
- Installing Motherboards
- Installing Adapter Cards
- Chapter Summary
- Chapter Review Activities

Objectives

- Explain how motherboards have evolved over the past 40 years and how core motherboard technologies have become more sophisticated over time.
- Discuss what we term the “foundation” of the computer, plus form factors, integrated ports and interfaces, memory slots, and expansion slots.
- Demonstrate how to install motherboards.
- Instruct on how to install video and sound cards.

CompTIA A+ Objectives Covered

This chapter covers a portion of the following CompTIA A+ Examination Objectives:

220-801: 1.2, 1.4, 1.11, 3.1, 5.1

220-802: none

The Evolution of Motherboards

In Chapter 1, "Introduction to Computers," we discussed the first computers. These were very complex machines with many components, some of which used 8-bit CPUs. These early CPUs could calculate only 1 byte of data per cycle. But in the early 1980s, IBM released the first of the more popular computers known as PCs. The architecture, or form factor, of these computers and motherboards was known simply as PC. This form factor included a basic motherboard that supported the original 16-bit 8086 processors (also known as 186), which could calculate 2 bytes of data per cycle. This was followed up by the XT form factor, but both of these were used only until 1984 when IBM released the Advanced Technology (AT) form factor for the 286 computer, which became the landmark form factor for a long time. Let's discuss this 286 system as our 16-bit example, and other milestones in computing now.

The 286 PC—Last of the 16-Bit Computers

The AT form factor was designed for the 80286 computer, and remained the form factor standard for 15 years. At the time, this made the 80286 (286 for short) a staple in computing and PC sales were rising quickly. Take a look at Figure 3-1 for an illustration of a 286 motherboard.

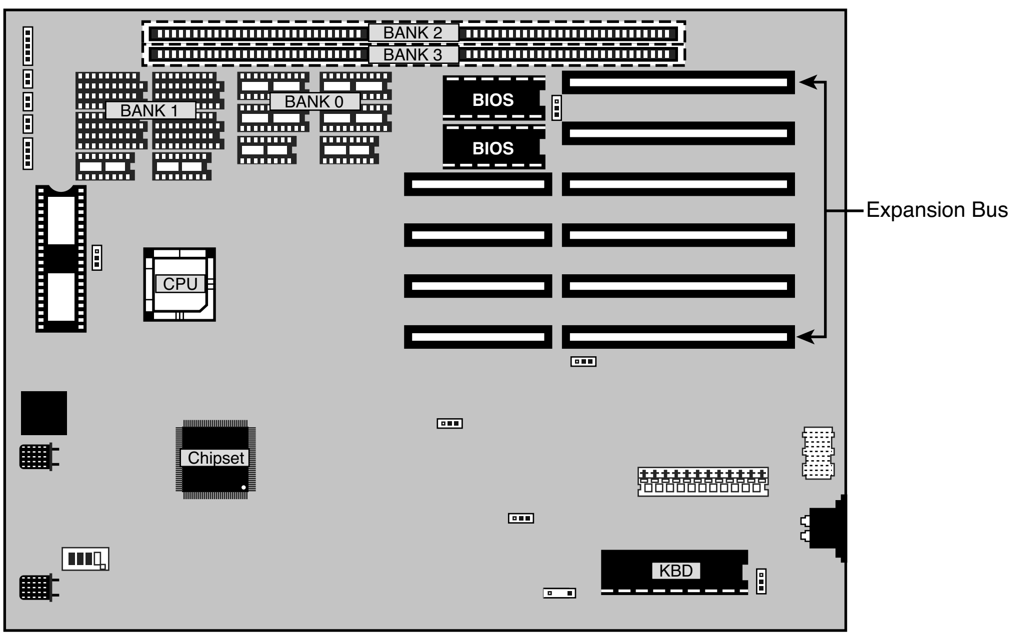


FIGURE 3-1

A 286 motherboard.

Note the very small CPU. This motherboard supported the 16-bit 80286 CPU, which ran at 6 to 12 MHz (depending on the model). That's right—*megahertz*. So it was much slower than today's CPUs. Also, the CPU was 16-bit, which meant that the CPU could process only 2 bytes of data per cycle. This would equate to approximately 10 to 20 MB/s of data in total. Although this doesn't seem like much compared to today's computers, you have to remember that not much was needed at the time. Most displays were monochrome, meaning one color with a black background (also known as 1-bit color). There usually was no mouse or other peripherals. The applications were not very powerful. At this time, most people used the computer as an extravagant word processor. So the speed and power of the CPU was proportionate with what was needed at the time.

The chipset was a very basic device that helped the CPU to communicate with other devices in the computer. But there were a lot fewer devices than in today's computers, so the chipset was also very basic. We'll speak more about chipsets later in this chapter. Memory modules were soldered onto the motherboard. These are shown as Bank 0 and Bank 1 in the figure, and they would often contain 640 KB or 1024 KB of RAM. But on some 286 motherboards, memory could be increased by adding sticks of RAM into slots. In the figure, these would be added to Banks 2 and 3. Back then, 4 MB or so of RAM would be considered a large amount.

NOTE: Memory modules and other slots on a motherboard are usually numbered starting with 0.

You can see that there are two BIOS chips. In a 16-bit system such as this, each chip would be 8-bit, divided up as even/odd, or high and low. In addition, these were often basic read-only memory (ROM) chips that couldn't be modified. Today's computers use a single BIOS chip. In addition, it is known as an EEPROM chip, or electrically erasable, programmable ROM chip. This means that today's BIOS chips can be written to, and completely erased if necessary. We'll talk more about the BIOS in Chapter 7, "Computer Operation."

To the right and below the BIOS chips we see some more slots—these are for adapter cards such as modems and sound, and are known as expansion slots. At the time, these slots used the Industry Standard Architecture (ISA) bus to transmit data between the adapter cards and the CPU. ISA was the standard for many years but is rarely seen today. We'll discuss more about adapter card buses later in this chapter.

On the lower-right side of the figure, you see "KBD," short for keyboard. This is the controller that accepts input from the keyboard, and sends it to the CPU for processing. During the time when we used AT keyboards and PS/2 keyboards, this chip was essential. If it failed, it would have to be replaced (by soldering) or the user would not be able to interface with the computer. Today, most computer keyboards are connected by way of USB. So the USB controller is in charge of interpreting keyboard commands and sending them to the CPU. However, some specialty computers still use a keyboard controller chip that works with a special keyboard.

The power connector is just above the keyboard controller. It is known as an AT 20-pin power connector, and as part of the form factor for AT, it survived for more than 15 years.

The 16-bit 286 systems were fine as far as they went, but the next system would bring about a new paradigm in technology.

The 386 PC—and the 32-Bit Age

The advent of the 80386 PC (386 for short) in the mid- to late 1980s brought with it the 32-bit CPU. This was a quantum leap in processing. The 386 CPUs generally ran between 12 and 33 MHz—much faster than the 286. But the fact that quickly eclipsed the 286 CPU was that the 386 was 32-bit and could therefore process 4 bytes of data per cycle instead of just two. Now, a CPU could process as much as 133 MB/s (theoretically). CPUs at this time also started to be measured in MIPS, or millions of instructions per second. A 33 MHz 32-bit CPU could process in the neighborhood of 11 MIPS.

NOTE: Arguably, this could be considered the most important technology jump in computers to date.

Regardless of how you measure it, it was a huge jump in processing power. This was the gateway to the usage of peripherals such as the mouse, 256-color (8-bit) monitors, and graphical user interfaces such as Windows, as well as powerful applications that were point-and-click. Some of the more formidable 286 computers could do some of these things, so there was some overlap; but they couldn't do them nearly as well as the 386. The 386-based games also grabbed people's attention. Of course, there was an exponential rise in PC sales.

Although the 386 was far advanced compared to its predecessors, the motherboard for it looks fairly similar. Take a look at Figure 3-2.

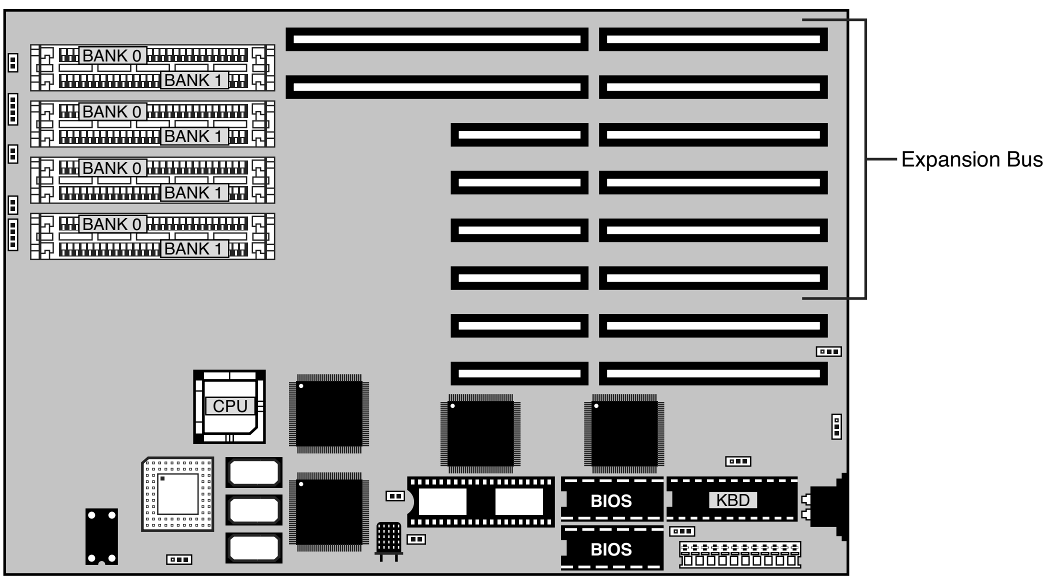


FIGURE 3-2

A 386 motherboard.

CPUs really weren't that much bigger physically. In fact, they had only doubled and tripled in speed. But the underlying technology of having a 32-bit processor, and a correspondingly bigger system bus connecting everything together on the motherboard, leads to the real gains with this system. You will notice more RAM slots. Some 386 computers had as much as 16 MB of RAM, quite a lot at the time. In fact, 4 MB was usually quite enough. For example, Windows 3.1, a common graphical user interface loaded on top of DOS, required only 1 MB of RAM minimum.

You will also notice more expansion slots in the figure, allowing for more adapter cards such as video cards, sound, modems, and network cards. Take heed of the way in which the expansion card slots and memory slots line up, or are parallel, with each other. This is a characteristic of the AT form factor, and one easy way to differentiate it from newer form factors such as ATX.

This 386 CPU was the CPU used during IBM's release of the Personal System 2 (PS/2). The PS/2 saw many improvements to the architecture of the system, most notably the PS/2 connector for keyboard and mouse.

At this point, 32-bit computing became the standard for PCs and remained so for many years, throughout faster versions such as the 486, and Pentiums—that is, until 64-bit computing arrived on the mainstream around 2006.

Today's 64-Bit Computing

Today's PCs are 64-bit computers. That means the CPU can calculate 64 bits (8 bytes) per cycle, doubling that of 32-bit CPUs. But the real advances over the past decade have come in the speed department. As of the writing of this book, one of the fastest CPUs, the Intel Core i7 Extreme, can run as fast as 3.5 *GHz* (not to mention frequencies obtained by overclocking), and can perform as many as 175,000 MIPS. That's 18,000 times the calculating power of the 386 CPU. This holds with Moore's Law (described in Chapter 1), which says that CPU calculation power essentially doubles every two years or so.

But let's not get too excited. Let's break it down and take a look, in Figure 3-3, at a typical illustration of a motherboard that houses a 64-bit CPU.

> **NOTE:** Imagine the future. It's 2030, and an ordinary CPU can perhaps calculate 10 million MIPS (10 trillion instructions per second). Some analysts predict that this breakthrough point will herald a whole new age of technology—one that is, for most people, unimaginable.

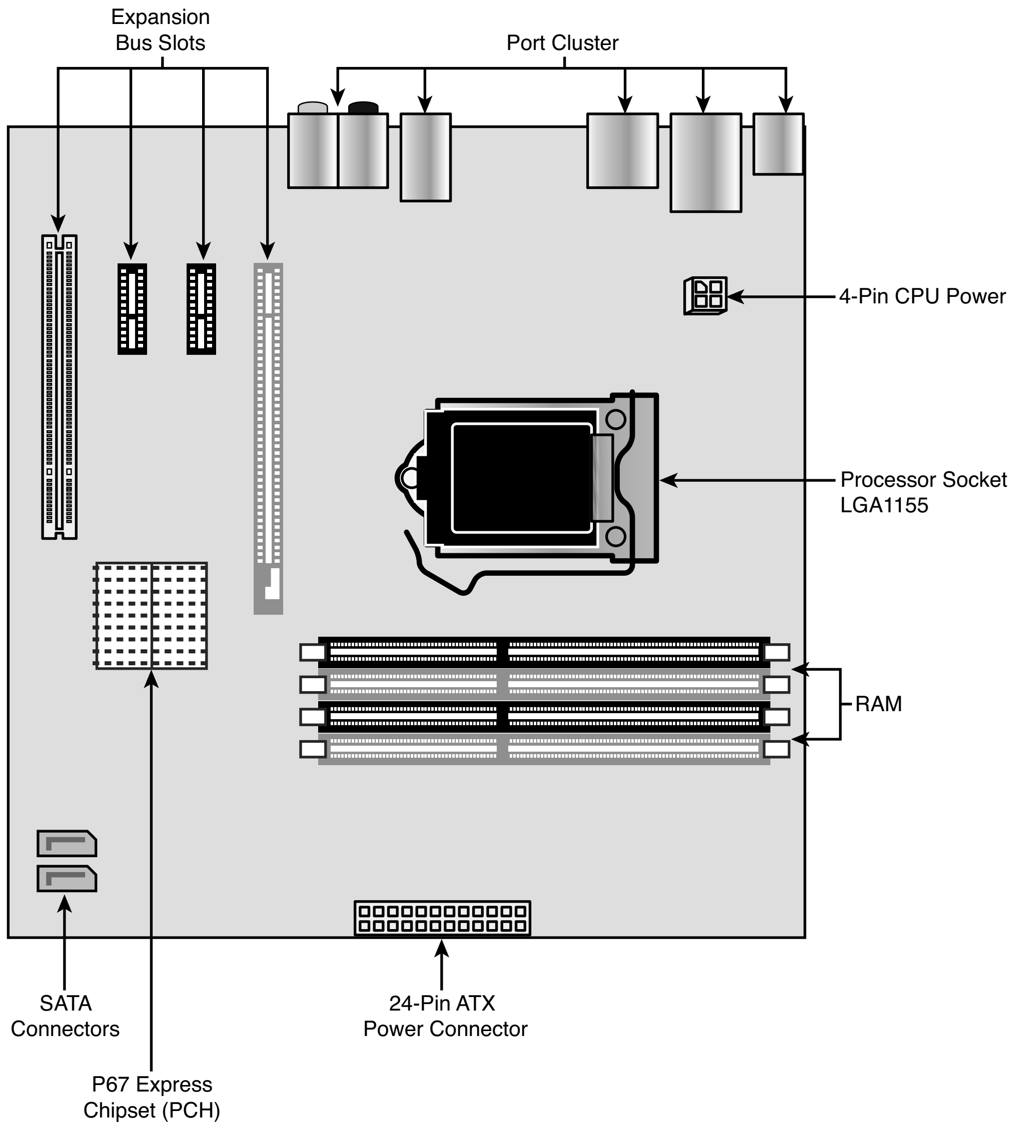


FIGURE 3-3

A current motherboard.

As you can see, there's a lot that is different here compared to the preceding figure we viewed. First of all, the processor area is larger. It is much faster, which in turn requires more power, which in turn makes it run hotter. Power is passed to the CPU via a special four-pin power connector, and a large heat sink and fan combination (not shown) cools the CPU.

The chipset shown, which helps pass data from devices to the CPU, is actually more powerful than some of the 32-bit CPUs from 25 years ago. The increase in RAM speed is commensurate with the increase in CPU speed—this type of RAM is known as double data rate RAM (DDR-RAM).

The entire form factor is different. This motherboard uses the newer ATX form factor. It utilizes a 24-pin power connector, and you will also note that the RAM and the expansion bus slots are perpendicular to each other, or at a 90-degree angle, one of the differentiating characteristics of an ATX board. The expansion bus slots are no longer ISA, but instead we see the newer PCI, in white, and the newest version, PCI Express (PCIe), in blue and in black.

When it comes to permanent storage, older computers used Integrated Drive Electronics (IDE) connections for hard drives, which send data in parallel, but newer systems of today utilize Serial ATA (SATA) connections. Even though they send data in a serial bit stream, today's SATA drives have gone far beyond IDE drives in terms of data transfer rates. In fact, you'll observe a paradigm shift from parallel technologies to serial technologies when you compare PCs from 20 years ago to PCs of today. Another example of this is the aforementioned PCIe, a serial technology that took the place of the parallel PCI.

Finally, we see a port cluster that has all kinds of new connectors that were not available on most 32-bit PCs, including USB, FireWire, Thunderbolt, and more. We'll discuss ports in more depth later in this chapter as well as in Chapter 6, "I/O Devices and Ports."

So this motherboard is far more advanced than what we saw 25 years ago, but will quickly be overshadowed by new technologies (smaller and more powerful) over and over again, during the next 25 years.

Some of the Apple computers during this time saw a change as well. For many years, the Apple Macintosh computer (known as the Mac) used the PowerPC architecture, a RISC-based system designed by IBM. The CPU and motherboard were based on this architecture. However, in 2005, Apple decided to start making the change to Intel-based hardware. It total, this turned out to be a four-year process. In 2009, Apple released Mac OS v10.6 (also code-named Snow Leopard), which removed support for the PowerPC architecture altogether. Now, as far as hardware goes, there is little that differentiates the Mac from the PC. Software, of course, is another story—one that we will delve into more later in the book.

NOTE: Laptops (which we have previously termed "portable computers") have motherboards that lie somewhere between a PC and a mobile computer, but leaning closer to the PC—with some differences in comparison to the PC. The motherboard might or might not have a removable CPU, more devices are soldered directly onto the board, and the board is more difficult to remove and work on.

Other Examples of Modern Motherboards

Of course, PCs aren't the only computers that have motherboards. Just about any computer has a motherboard—the place where everything connects. This might also be known as a mainboard, or main printed circuit board (PCB). Let's broaden the topic and show illustrations of server and mobile computer motherboards and describe the differences compared to PCs.

Server Motherboard

A server is a powerful computer that is used as a central location for data and resources. It might store files for an organization, or run a database. It might control e-mail or serve websites. It could be the place everyone on the network logs in to. Regardless of the server's function, it usually needs more powerful hardware (and software) than your typical PC. Take a look at Figure 3-4. This illustrates a server motherboard.

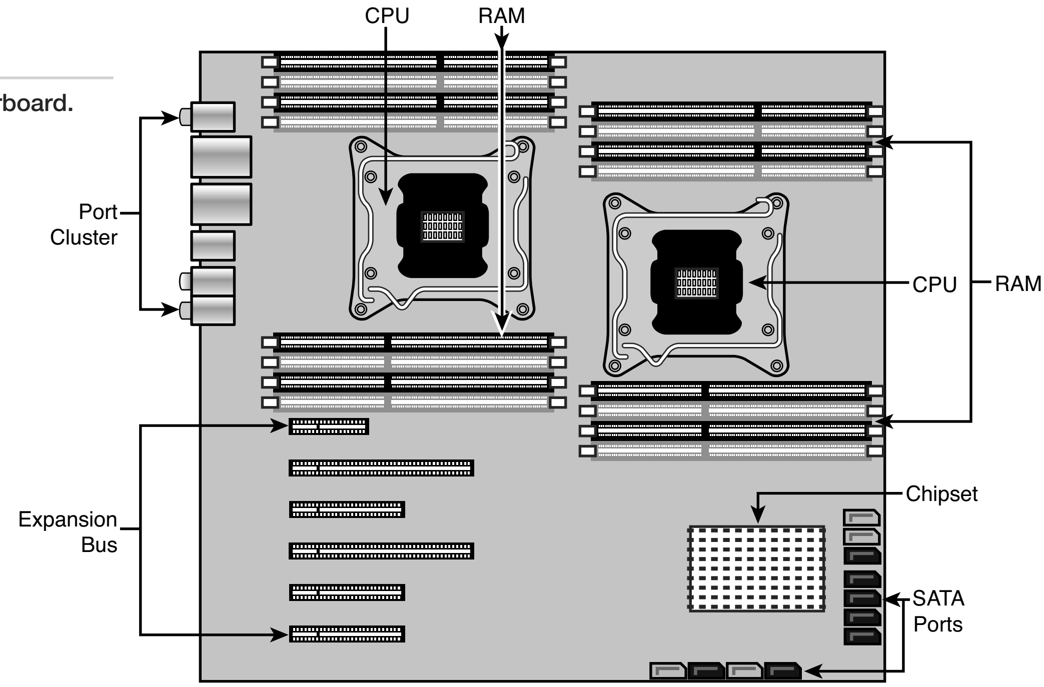


FIGURE 3-4

A server motherboard.

The first thing you will notice in the figure is that there are two CPU sockets! *True* multiprocessing can be accomplished only with two or more physical processors. These processors, working together, create a very powerful collective core for the server. A motherboard such as this might make use of dual Intel Xeon E5 CPUs. Xeon CPUs are quite powerful (and quite expensive) processors designed specifically for the server market. They are intended to work best with a server's processes that run in the background, and are not meant for foreground applications such as Microsoft Word or games. Of course, for every CPU, we should have an additional set of RAM slots, and that's exactly what we have in the illustration—eight slots per CPU to be exact.

You'll also note a large chipset. A powerful chipset is required in this motherboard to aid in transferring data from the CPU(s) to other components. For example, note how many SATA ports there are for hard drives. This is far more than a typical PC motherboard would have. This allows the server to store *lots* of data, perhaps in special redundant arrays.

Server motherboards get much more advanced than this. You might see a server motherboard that has as many as eight CPUs or more. This of course requires a lot more real estate, and necessitates a larger, more powerful form factor. Servers can inhabit the same cases as typical PCs, but more often they occupy a thin chassis, which slides into a server rack, and saves space. To make a superpowerful server, *blades* might be used. Each of these is essentially the guts of a motherboard—CPU and RAM—and they are used collectively to create that superserver. Whether you use a typical computer case, a chassis, or a blade environment, you will need to make sure you acquire a motherboard with the correct form factor.

Mobile Computer Motherboard

Let's discuss the much smaller motherboards you might find in a mobile computer. Remember, mobile devices are computers too, and can be applied to the von Neumann computer model in much the same way as PCs, but on a more simplified and close-knit level.

The motherboards used within many smartphones and some tablet computers have all of the components soldered directly onto them. Figure 3-5 shows an example of a typical smartphone motherboard.

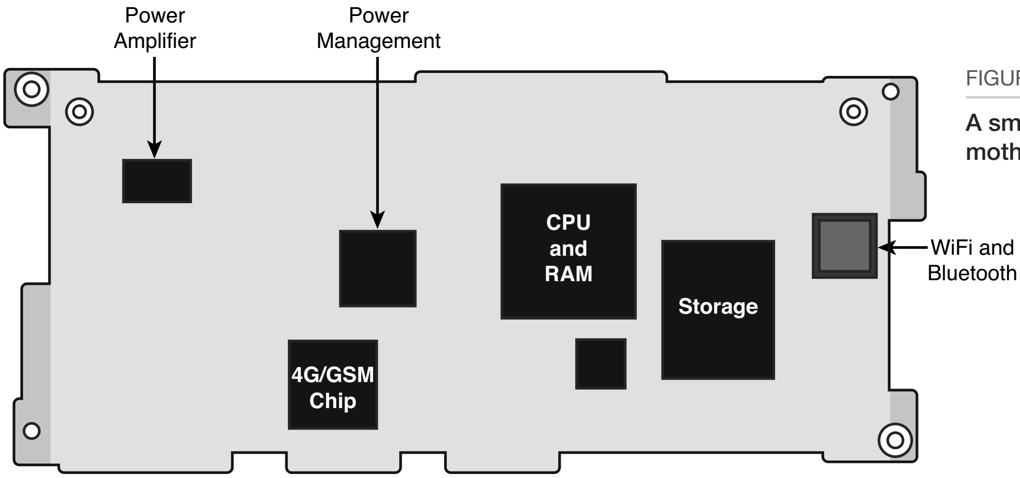


FIGURE 3-5
A smartphone motherboard.

A motherboard such as this might be only six inches in length, perhaps less depending on the smartphone. Because of the space limitations, there is a need for simplicity. Also, we lose out in computing power in comparison to PCs. For example, a typical smartphone CPU is 32-bit instead of 64-bit, and a typical speed might be 1.7 GHz, and it is soldered directly to the board. Also, the RAM often is embedded with the CPU chip; for this phone, 2 GB worth. Long-term storage in the form of flash memory is usually adjacent to the CPU. It is common to have 32 GB of storage.

A device like this often has several other integrated circuits (or chips). For instance, in the figure we see we have a dedicated chip for Wi-Fi and Bluetooth communications, and a separate chip for GSM voice communications and 4G. Another chip (to the upper left) takes care of amplifying the signal for these wireless communications. Finally, a power management chip is in charge of conserving and controlling power to the core devices (CPU, RAM, and storage), the wireless devices, the display, and the operating system. All of these devices are usually soldered directly onto the motherboard. This can make repairs difficult, even for authorized repair centers. In some cases, when damage is severe, or if an integrated circuit cannot be removed, the entire motherboard is replaced.

At this point, you get the idea. We said before that a computer is a computer. It really doesn't matter whether you are dealing with a server, a PC, a handheld computer, a gaming console, or an automobile's computer. They all use a motherboard of sorts, and they all adhere to the same basic principles, regardless of the size or the design of the motherboard.

Motherboard Components

I have found that if a student is going to lack knowledge in one area, it's often the motherboard. However, this is one of the key elements in a computer system, so we can't discount it. It's the starting point for a quick and efficient computer. Because the motherboard connects to everything in the computer system, you need to know many concepts concerning it. This section concentrates on PC motherboards, and goes into more depth about concepts such as buses, the chipset, and other components within the motherboard. Take a look at Figure 3-6, and refer to this often as you continue reading through the chapter.

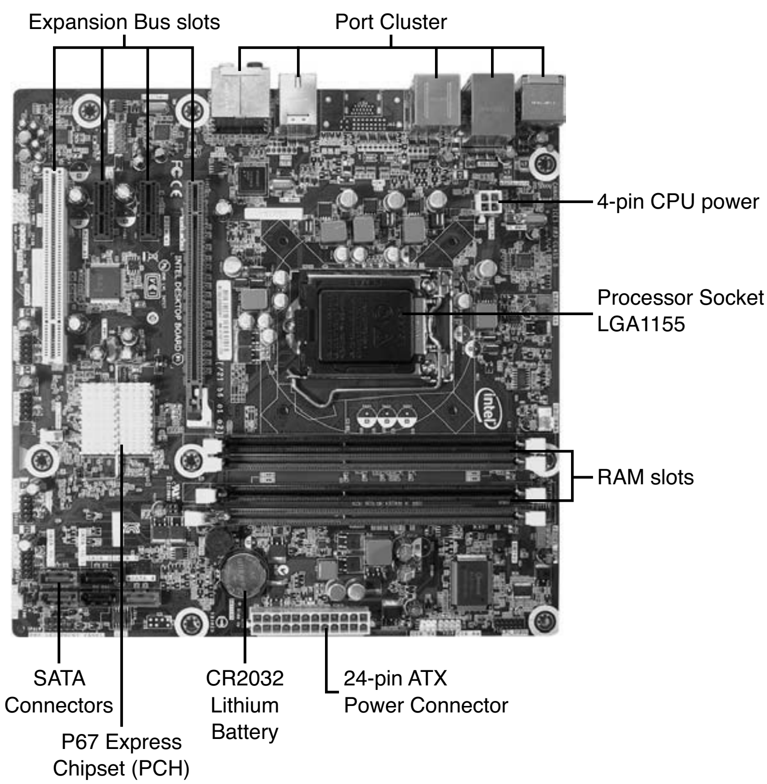


FIGURE 3-6

A typical modern PC motherboard.

The Core Components

The core of the computer is the CPU and RAM. One does the “thinking” and the other does the “remembering.” These are almost always housed within or on the motherboard.

In the computers of the preceding century, everything was connected together by way of the system bus. A bus is simply a pathway or group of pathways that transmit electrical signals. It could be a single copper circuit (serial technology), or a group of copper circuits (parallel technology), often in multiples of 8. The wider the bus, the more circuits, and subsequently the more bits that can be transmitted simultaneously. For example, a 32-bit bus is 32 copper circuits, each able to transmit 1 bit of information at the same time, allowing for 4 bytes of information per cycle. Collectively, this concept is known as **bus width**.

Today, we are not as concerned with the system bus as we are with other terms more specific to the connection type, for example, the connection between the CPU and the chipset, and the connection from the chipset to the RAM. Different CPU manufacturers have their own proprietary names for connections between various devices.

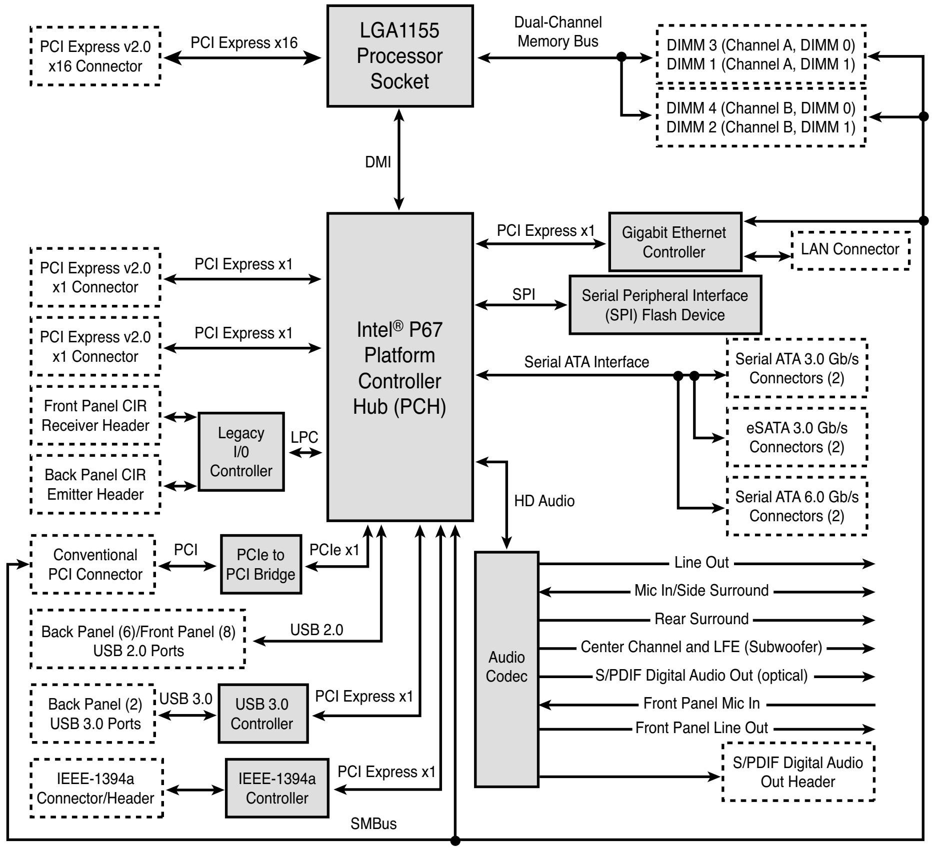
Possibly the most important concept of motherboards is the chipset. If you can understand the chipset, you can master motherboards. Let’s discuss that now.

The Chipset and Connecting Buses

In a general sense, the **chipset** is the motherboard, incorporating all the controllers on the motherboard; many technicians refer to it in this way. But in the more specific sense, the chipset is one or two specific chips. How many depends on the design and the manufacturer of the board. If you refer to Figure 3-6, you see that the chipset is the P67 Express Chipset (PCH). PCH stands for Platform Controller Hub, a name Intel uses. This chipset is composed of a single chip. Figure 3-7 illustrates the connections between the P67 chipset and the rest of the motherboard.

FIGURE 3-7

Intel P67 chipset connections.



NOTE: DMI makes use of *lanes*. A lane is two serial wires that enable the sending and receiving of data simultaneously.

The chipset connects to just about everything directly. Starting clockwise from about two o'clock, you can see the Ethernet controller, Serial Peripheral Interface, Serial ATA interface, HD audio controller, IEEE 1394 controller, USB controllers, PCI controller, and PCI Express x1 connectors. You've probably heard of most of these, but each one is covered in depth as you continue through this book. The point for now is that the chipset is the central meeting point for many devices. It also has a high-speed point-to-point interconnection to the processor called the **Direct Media Interface (DMI) link**, also known as the DMI bus—an Intel-specific name.

The DMI carries all the traffic from the previous list of controllers to the processor. You can imagine that the DMI needs to be powerful. The original DMI provided a data transfer rate of 10 gigabits per second (10 Gb/s) in each direction. (Note the lowercase ”b” indicating bits.) The chipset in the figure makes use of a DMI 2.0 connection and can handle 20 Gb/s in each direction. This is equal to approximately 2.5 gigabytes per second (2.5 GB/s; note the uppercase ”B” for bytes.) The only things the chipset does not connect to directly are the PCI Express x16 slot and the RAM. These are controlled directly by the processor.

This Intel design differs from previous Intel designs and some Advanced Micro Devices (AMD) designs in that there is only one chip in the chipset instead of two chips. Historically, however, the motherboard chipset consisted of two chips: the **northbridge** and the **southbridge**.

- **Northbridge:** In charge of the connection to high data transfer devices such as PCI Express video cards and the RAM.
- **Southbridge:** In charge of the connection to all the secondary controllers: USB, SATA, FireWire, and so on.

In our sample motherboard in Figures 3.6 and 3.7, the northbridge functionality is built directly into the processor; some refer to this as an on-die northbridge. The southbridge functionality is all within the P67 chipset. However, newer AMD designs such as the AMD 990 FX chipset still make use of a northbridge and southbridge. In this scenario, the northbridge controls the PCI Express connections and connects directly to the processor, and the southbridge connects to just about everything else. But the RAM is still controlled directly by the processor, a technique started by AMD.

The AMD connection between the northbridge and the processor is called **HyperTransport**, similar to Intel’s DMI. Version 3.1 of the HyperTransport has a transfer rate of 25.6 GB/s. You might note that this is a lot more than Intel’s DMI. The reason is that the HyperTransport also moves all the PCI Express video data, which accounts for a large chunk.

There is a more powerful version of Intel’s DMI called **Quick Path Interconnect (QPI)**, which can also transfer 25.6 GB/s, similar to HyperTransport. It is used by more powerful workstation and server motherboards.

Older Intel motherboard designs used the northbridge/southbridge concept, but during that time, Intel gave names to each chip. The northbridge was known as the Memory Controller Hub (MCH) and the southbridge was known as the I/O Controller Hub (ICH).

Figure 3-8 shows an example of a P35 chipset, and gives a rough idea of the connections between these and the rest of the motherboard.

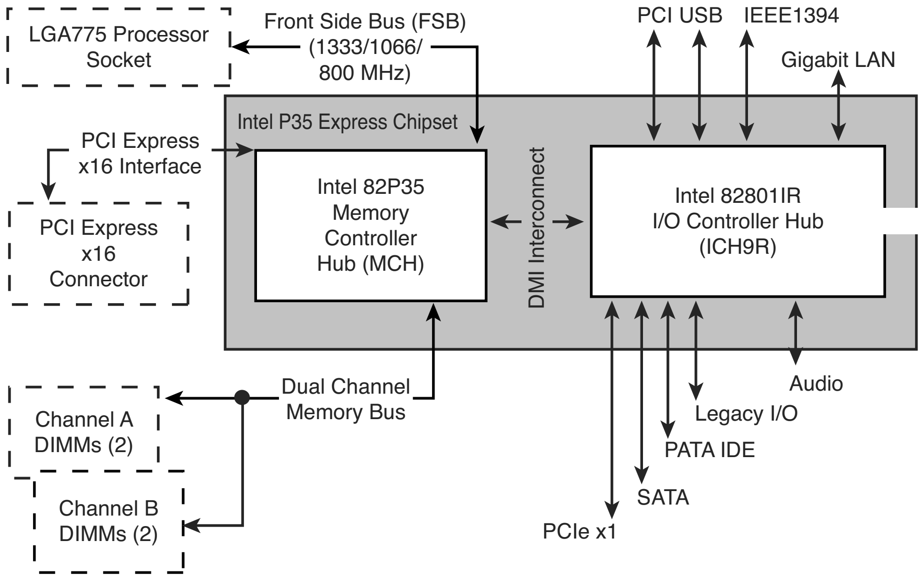


FIGURE 3-8

Intel P35 chipset connections.

In Figure 3-8, you can see that there are three major buses (you can think of them as highways) that lead to and from the MCH: **front-side bus**, **memory bus**, and **PCI Express x16**.

- **Front-side bus (FSB):** This connects the MCH to the processor (CPU) socket. A common speed for this type of motherboard would be between 800 and 1300 MHz, which depends on what type of processor is used. When deciding on a processor, make sure that it can run at one of the FSB speeds prescribed by the motherboard. It also needs to be compatible with, and adhere to, the wattage maximum of the motherboard's socket.
- **Memory bus:** This set of wires connects the MCH to the RAM slots. It has also been referred to as the address bus.
- **PCI Express x16 interface:** This connects the MCH to the PCIe x16 slot used for video; usually there is only one of these slots on a motherboard.

The FSB and memory bus are parallel; however, PCI Express works in groups of serial buses called lanes, similar to the DMI bus mentioned previously.

The ICH provides connectivity to all the secondary buses, some of which are parallel buses (IDE and Audio) and some of which are serial buses (USB, SATA, IEEE 1394, and lesser PCIe slots).

Let's sum up the types of chipsets starting with the oldest:

- **Older Intel motherboards:** These utilize a northbridge and southbridge, which Intel called the MCH and ICH. The northbridge controls the connections to RAM and PCI Express x16 devices such as video cards. The southbridge connects to controllers such as SATA, IDE, USB, and PCI.

- **Today's AMD-based motherboards:** These also have a northbridge/southbridge chipset design. The main difference is that the northbridge controls only the connection to PCIe x16 devices; RAM is controlled by the processor.
- **Newer Intel designs:** These basically do away with the northbridge altogether, incorporating its functionality into the processor. The main chipset takes care of all secondary functions such as SATA and USB.

A last word about chipsets: Certain applications prefer or even require specific chipsets, usually applications on the high-end side. Graphics, music, engineering, and even gaming applications recommend specific chipsets. So before designing your computer, think about which applications you will use and whether they prefer certain chipsets. This will in turn suggest to you what type of motherboard will be best.

NOTE: That was a lot of technical information but core information that we will build on. Consider reviewing the section before moving on.

Form Factors

A computer form factor specifies the physical dimensions of some of the components of a computer system. It pertains mainly to the motherboard but also identifies compatibility with the computer case and power supply. The form factor defines the size and layout of components on the motherboard. It also specifies the power outputs from the power supply to the motherboard. Some of the most common form factors are ATX, microATX, ITX, and BTX. Let's discuss these a little further now.

ATX

Advanced Technology Extended (ATX) was originally designed by Intel in the mid-1990s to overcome the limitations of the now-deprecated AT form factor. It has been one of the most popular standards for PCs ever since. Figure 3-9 shows a typical example of an ATX motherboard.

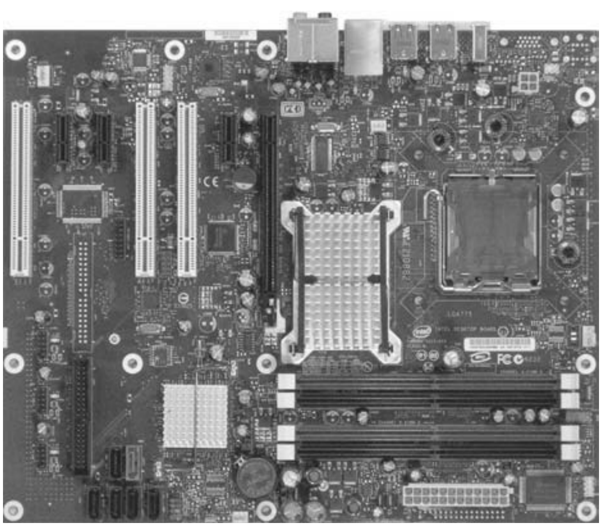


FIGURE 3-9

Example of an ATX form factor motherboard.

The motherboard in Figure 3-9 is a full-size ATX board. Full-size ATX motherboards measure 12 inches × 9.6 inches (305 mm × 244 mm). ATX motherboards have an integrated port cluster on the back and normally ship with an I/O plate that snaps into the back of the case, which fills the gaps between ports and keeps airflow to a minimum. One identifying characteristic of ATX is that the RAM slots and expansion bus slots are perpendicular to each other. Generally, ATX has seven expansion slots. For example, the motherboard in the figure has four PCIe slots and three PCI slots. The ATX specification calls for the power supply to produce +3.3 V, +5 V, +12 V, and –12 V outputs and a 5 V standby output. The original ATX specification calls for a 20-pin power connector (often referred to as P1), and the newer ATX12 Version 2.x specification calls for a 24-pin power connector. The additional four pins are rated at +12 V, +3.3 V, +5 V, and ground, as shown in Table 3-1. Those pins are numbered 11, 12, 23, and 24.

TABLE 3-1

ATX Pin Specification of the Main Power Connector

Pin	Color	Signal	Pin	Color	Signal
1	Orange	+3.3 V	13	Orange	+3.3 V
2	Orange	+3.3 V	14	Blue	–12 V
3	Black	Ground	15	Black	Ground
4	Red	+5 V	16	Green	Power on
5	Black	Ground	17	Black	Ground
6	Red	+5 V	18	Black	Ground
7	Black	Ground	19	Black	Ground
8	Grey	Power good	20	White	–5 V (optional)
9	Purple	+5 V standby	21	Red	+5 V
10	Yellow	+12 V	22	Red	+5 V
11	Yellow	+12 V	23	Red	+5 V
12	Orange	+3.3 V	24	Black	Ground

It's important to know these voltages, or at least keep a table of them handy, when testing a computer's power supply and main power connection on the motherboard. In that vein, always keep a good digital multimeter nearby.

microATX

microATX (or mATX) was introduced as a smaller version of ATX; these motherboards can be a maximum size of 9.6 inches × 9.6 inches (244 mm × 244 mm) but can be as small as 6.75 inches by 6.75 inches (171.45 mm × 171.45 mm). In comparison, microATX boards are usually square, whereas full-size ATX boards are rectangular. microATX is backward compatible with ATX, meaning that most microATX boards can be installed within an ATX form factor case, and they use the same power connectors as ATX. Often, they have the same chipsets as ATX as well. The motherboard shown in Figure 3-6 is microATX. One reason to use this is that this smaller form factor is common for multimedia PCs and home theater PCs (HTPCs).

ITX

ITX is a group of form factors developed by VIA Technologies, Inc., between 2001 and now for use in small, low-power motherboards. The ITX group includes the following:

- **Mini-ITX:** Designed in 2001, this 6.7-inch × 6.7-inch (17 × 17 cm) motherboard is a bit smaller than microATX and is screw-compatible with it, enabling it to be used in microATX and ATX cases if so desired. It uses passive cooling to keep it quiet and conserve power, making it ideal for HTPCs. The first version of these boards came with one expansion slot: PCI. The second version comes with a single PCIe x16 slot.
- **Nano-ITX:** Released in 2005, this measures 4.7 × 4.7 inches (120 mm × 120 mm). It boasts low-power consumption and is used in media centers, automotive PCs, set-top boxes (STBs), and personal video recorders (PVR).
- **Pico-ITX:** Designed and released in 2007, this is half the area of Nano-ITX, measuring 3.9 × 2.8 inches (10 × 7.2 cm). It uses powerful processors and RAM, and thus requires active cooling. It is used in extremely small PCs and ultra-mobile PCs (UMPCs).
- **Mobile-ITX:** Released in 2010, this is the smallest of the four ITX form factors, measuring 60 mm × 60 mm. There are no ports, and it requires a secondary I/O board. It is intended for military, surveying, transportation, and medical markets and is used in UMPCs and smartphones.

BTX

Balanced Technology Extended (BTX) was designed by Intel in 2004 to combat some of the issues common to ATX. More powerful processors require more power and therefore release more heat. BTX was designed with a more efficient thermal layout. There is a lower profile, and the graphics card is oriented differently than ATX, so heat is generally directed out of the case in a more efficient manner. BTX did not receive mainstream attention because Intel and AMD processors, and most video cards' processors, are designed to use less power (and therefore generate less heat). BTX devices are not compatible with ATX devices. One of the ways to identify a BTX motherboard is that the RAM slots and expansion buses are parallel to each other. Also, the port cluster is situated differently on a BTX board. In addition, BTX boards are slightly wider than ATX boards; they measure 12.8 inches × 10.5 inches (325 mm × 267 mm). BTX is less common today, but you will probably still see these motherboards in existence in the field, so you should at least know the basic differences between the ATX and BTX form factors.

Table 3-2 compares the ATX, microATX, ITX, and BTX form factors, supplying the sizes of these motherboards and some of the characteristics that set them apart.

TABLE 3-2

Comparison of Motherboard Form Factors

Form Factor	Width	Depth	Identifying Characteristic
ATX	12 inches	9.6 inches	RAM slots and expansion slots are perpendicular to each other (90-degree angle).
microATX	9.6 inches	9.6 inches	Smaller than ATX but backward compatible to it.
ITX	From 60 mm to 6.7 inches depending on the type	From 60 mm to 6.7 inches depending on the type	Designed for HTPCs, UMPCs, and smartphones.
BTX	12.8 inches	10.5 inches	RAM slots and expansion slots are parallel to each other.

Riser Cards and Daughterboards

Riser cards and daughterboards provide two different methods for providing access to motherboard-based resources. In current slim-line or rack-mounted systems based on ATX technologies, riser cards are used to make expansion slots usable that would otherwise not be available because of limited space inside the case. Riser card designs can include one or more expansion slots, and are available in PCI Express and PCI designs. Figure 3-10 shows two typical implementations of riser card designs.

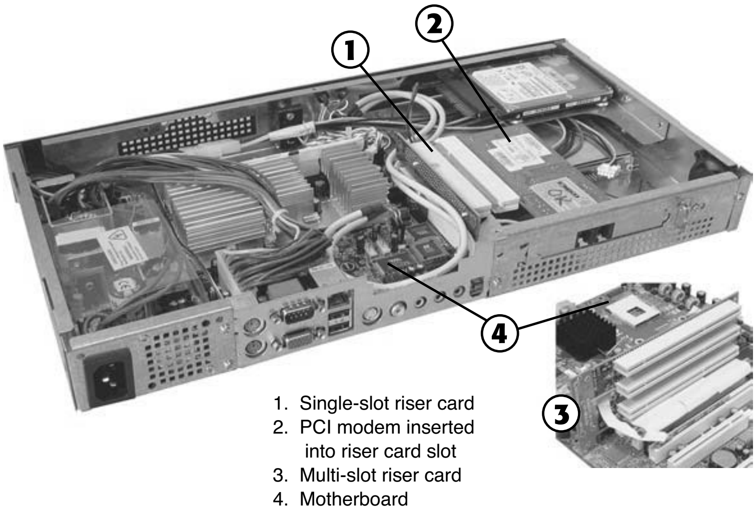


FIGURE 3-10

Examples of riser cards.

The term *daughterboard* is sometimes used to refer to riser cards, but *daughterboard* can also refer to a circuit board that plugs into another board to provide extra functionality. For example, some small form factor motherboards support daughterboards that add additional serial or Ethernet ports, and some standard-size motherboards use daughterboards for their voltage regulators. Daughterboards might be used for other purposes by proprietary PC manufacturers. The use of riser cards and daughterboards can help to create an efficient design and increase airflow throughout the computer.

I/O Ports and Front Panel Connectors

Without input and output ports, you could not communicate with the computer. These ports also take care of displaying information, printing it, and communicating with other computers. Ports can be found on individual adapter cards, or as integrated connection on the motherboard. Figure 3-11 shows some typical integrated ports as found on an ATX motherboard.

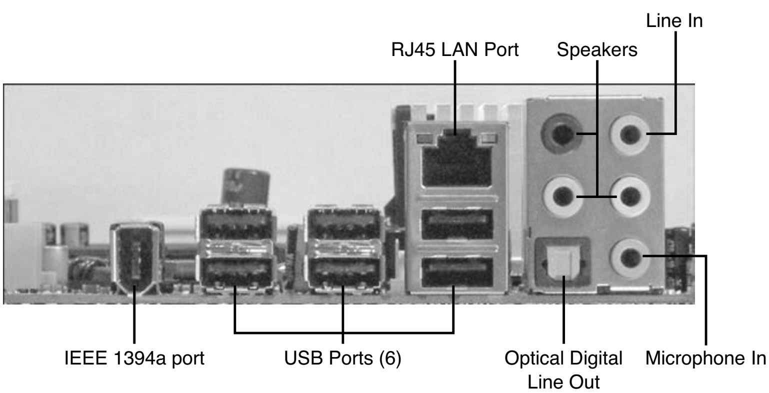


FIGURE 3-11

I/O port cluster on the back panel of an ATX motherboard.

Starting at the left and continuing counterclockwise, you see the following in the figure:

- **IEEE 1394a:** Also known as a FireWire or i.Link, this port is used for devices that demand the low-latency transfer of data, usually concerning music or video.
- **USB:** Universal Serial Bus ports are used by many devices, including keyboards, mice, printers, cameras, and much more. Most of today's motherboards come with a couple of USB 3.0 ports that have a maximum data transfer rate of 5 Gbps but also come with several USB 2.0 ports that have a maximum data rate of 480 Mbps.
- **Audio cluster:** There are six ports in this audio cluster, including an optical digital output, microphone in, line in, and speaker outs.
- **RJ45 LAN port:** This is the wired network connection. On this particular motherboard, it is a Gigabit Ethernet LAN controller and is rated for 10/100/1000 Mbps. This means that it can connect to any of those speed networks and function properly.

NOTE: We'll discuss these ports in more depth in Chapter 6.

Quite often, cases come with front panel ports that are usually wired to the motherboard. These include USB ports, audio ports, memory card readers, external SATA ports, and more. The front panel also has connections for the power button, reset button, power LED light, and hard drive activity LED light. On the motherboard, these are referred to as case connectors. These ports, buttons, and lights are of utmost importance when it comes to HTPCs and gaming computers.

Some integrated motherboard ports use header cables to provide output. Figure 3-12 shows an example of 5.1 surround audio ports on a header cable. The header cable plugs into the motherboard and occupies an empty expansion slot.

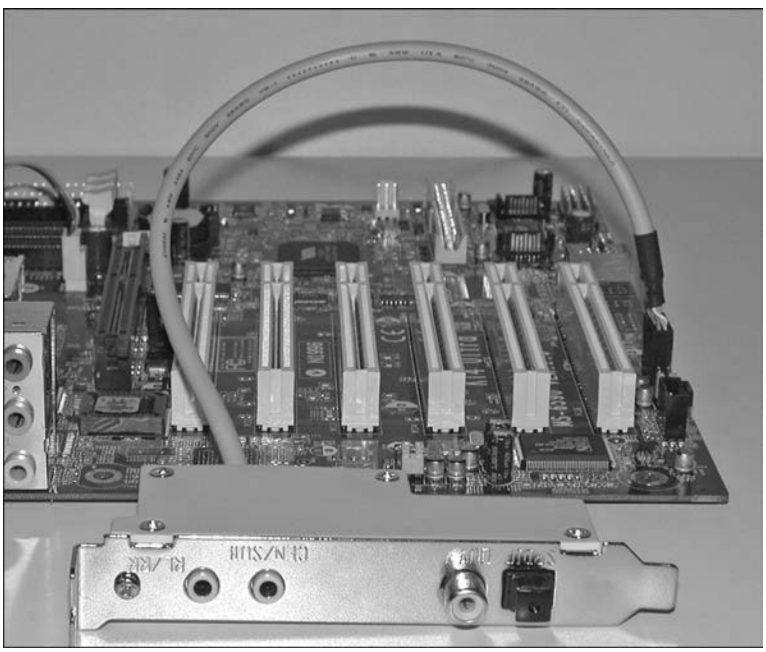


FIGURE 3-12

Example of a header cable.

Remember that integrated ports on a motherboard are very common and extremely convenient. However, to achieve the best performance possible, separate adapter cards (and therefore separate ports) will be necessary. The most important of these is the video card, followed up by audio and network cards, and possibly USB or FireWire cards.

Expansion Buses

There are five expansion buses and their corresponding adapter card slots/connections used in PCs that you should know. They include the following:

- **PCI:** The **Peripheral Component Interconnect (PCI)** bus was developed in the 1990s by Intel as a faster, more compatible alternative to the deprecated ISA bus. It allows for connections to modems and to video, sound, and network adapters; however, PCI connects exclusively to the southbridge, or the main chipset if there is only one chip involved. Because of this, other high-speed video alternatives were developed that could connect directly to the northbridge, or directly to the processor. The PCI bus is used not only by devices that fit into the PCI slot, but also by devices that take the form of an integrated circuit on the motherboard. Originally rated at 33 MHz, today's PCI version 2.1 cards are rated at 66 MHz, and their corresponding PCI bus is 32 bits wide, allowing for a maximum data transfer rate of 266 MB/s. Derivates of PCI include PCI-X, which was designed for servers, using a 64-bit bus and rated for 133 MHz/266 MHz, and Mini-PCI used by laptops. PCI slots are still found on a few of today's motherboards (as shown in Figure 3-13) but for the most part have been overtaken by PCIe technology. A comparison of PCI, AGP, and AMR is shown in Figure 3-14. A comparison of PCI and other expansion buses is shown in Table 3-3 at the end of this list of expansion buses.

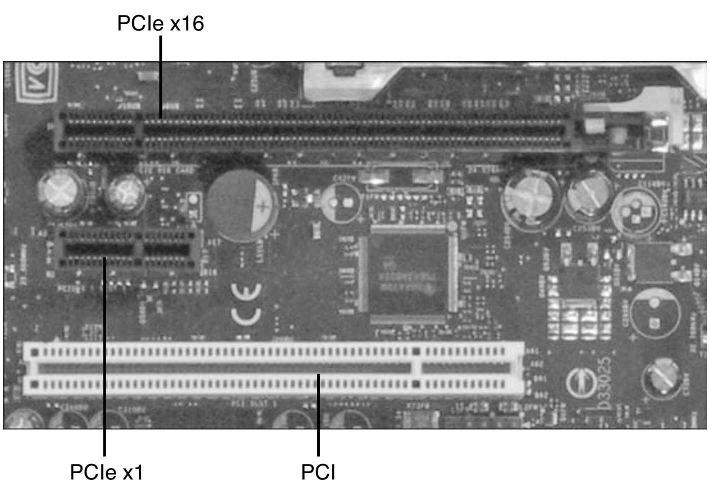
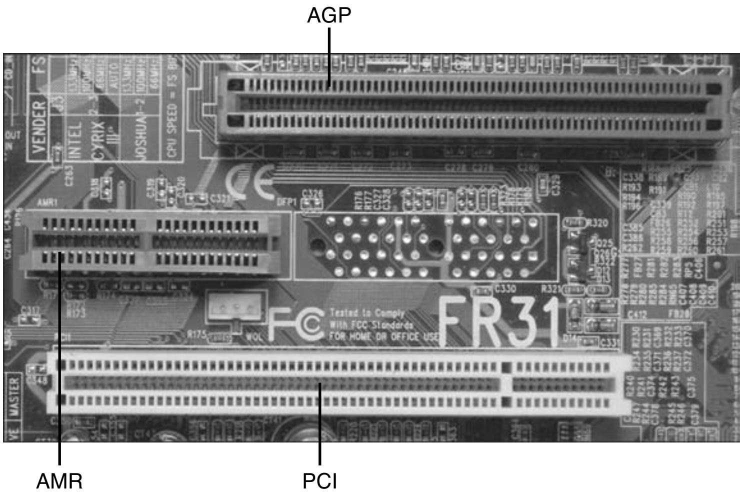


FIGURE 3-13

PCIe x16, PCIe x1, and PCI expansion buses.

FIGURE 3-14

AGP, AMR, and PCI expansion buses.



- **AGP:** The **Accelerated Graphics Port (AGP)** was developed for the use of 3D accelerated video cards and alleviated the disadvantages of PCI for video. Originally designed as a 32-bit 66 MHz bus (known as 1x), it had a maximum data transfer rate of 266 MB/s. Additional versions were delivered, for example, 2x, with a data rate of 533 MB/s, effectively doubling the fastest PCI output. (To do this, the 66 MHz bus was double-pumped to an effective 133 MHz.) Two more versions included 4x (quad-pumped) offering 1 GB/s, and 8x with a maximum data rate of 2 GB/s. The AGP bus connects directly to the northbridge, addressing one of the limitations of PCI. Although there is some compatibility between cards, different slots (1x, 4x, and 8x) use different voltages. You should verify that the AGP card is compatible with the stated voltage in the motherboard documentation. An example of an AGP slot is shown in Figure 3-14. AGP has been virtually eliminated in new computers by PCI Express.
- **PCIe:** Currently the king of expansion buses, **PCI Express (PCIe)** is the high-speed serial replacement of the older parallel PCI standard. The most powerful PCIe slots with the highest data transfer rates connect directly to the northbridge, or directly to the processor; the lesser PCIe slots connect to the southbridge, or, for newer Intel boards, the main chipset. This expansion bus sends and receives data within lanes. These lanes are considered full-duplex, meaning they can send and receive data simultaneously. PCIe version 1 has a data rate of 250 MB/s per lane, version 2 is 500 MB/s, and version 3 is 1 GB/s. Remember, those numbers are for each direction, so PCIe version 3 can send 1 GB/s and receive 1 GB/s at the same time. The number of lanes a PCIe bus uses is indicated with an x and a number; for example, x1 (pronounced "by one") or one lane. Commonly, PCIe video cards are x16 (16 lanes). They have taken the place of AGP video cards due to their improved data transfer rate. For example, a Version 2 PCIe x16 video card can transfer 8 GB of data per second (500 MB × 16 = 8 GB), which is far greater than AGP could hope to accomplish. And Version 3 PCIe x16 video cards take it even further, doubling that to 16 GB/s. Most other PCIe adapter cards are x1, although you might find some x4 cards as well. Of course, compatibility is key. A x1 card can go in a x1 slot or larger, but a x16 card currently fits

only in a x16 slot. So, for example, a PCIe x4 card doesn't fit in a x1 slot, but it does fit in a x4 slot. It also fits in a x16 slot but with no increase in performance. Figure 3-13 displays a x16 slot and a x1 slot. Keep in mind that x4 and x16 slots are controlled by the northbridge, or by the processor, whereas x1 slots are controlled by the southbridge (refer to Figures 3-7 and 3-8). Table 3-3 shows a comparison of PCIe and other expansion buses.

- **AMR and CNR:** Intel's audio/modem riser expansion slot was designed to offer a slot with a small footprint that had the capability to accept sound cards or modems. The idea behind this was to attain Federal Communications Commission (FCC) certification (which is a time-consuming and detailed endeavor) for the adapter card once, instead of having to attain FCC certifications for integrated components on motherboards over and over again with each new motherboard released. This way, the card could be transferred from system to system. The idea was flawed from the start, because adapter cards so quickly progress. This technology and its successor CNR are not used in today's motherboards, but you still could see them in use in the field. Figure 3-14 shows an example of AMR. Quite often, expansion buses are labeled on the motherboard just above the slot. You can see the letters "AMR1" just above the AMR slot toward the left in Figure 3-14. The Communications and Networking Riser (CNR) was Intel's adaptation of AMR and was meant for specialized networking, audio, and modem technologies. It was superior to AMR because it could be software or hardware controlled but had the same result as AMR and has been obsolete since about 2007. Though these are the least important of the expansion buses mentioned so far, you should still be able to identify them in case you work on computers that are a few years older.

3

TABLE 3-3

Comparison of PCI, AGP, and PCIe

Expansion Bus	Bus Width	Frequency	Max. Data Rate
PCI	32-bit	33 MHz	133 MB/s
		66 MHz	266 MB/s
AGP	32-bit	1x = 66 MHz	266 MB/s
		2x = 66 MHz (double-pumped to 133 MHz)	533 MB/s
		4x = 66 MHz (quad-pumped to 266 MHz)	1 GB/s
		8x = 66 MHz (octo-pumped to 533 MHz)	2 GB/s
PCIe	Serial, consists of between 1 and 16 full-duplex lanes	Version 1 = 2.5 GHz*	250 MB/s per lane
		Version 2 = 5 GHz	500 MB/s per lane
		Version 3 = 8 GHz	1 GB/s per lane

*This is also measured in transfers per second, referring to the number of operations that send and receive data per second. It is often closely related to frequency. For example, PCIe v1 is 2.5 gigatransfers per second (2.5 GT/s).

In addition, there are three expansion buses used by laptops that are also important. The most common types of external expansion buses are called PC Card, CardBus, and ExpressCard; I'm talking about those 2-inch-wide slots on the side of the laptop. These expansion buses accept credit card–size devices that can be added to a laptop to increase memory, or add functionality in the form of networking, hard disks, and more. They are hot-swappable, meaning they support hot plugging into the expansion slot while the computer is powered on. Let's talk about them in a little more depth.

- **PC Card (PCMCIA):** The **Personal Computer Memory Card International Association (PCMCIA)** originally developed the PC Card technology used in laptops; it is not an expansion bus, though you might see it referred to that way. PC Cards (originally called PCMCIA cards) were first designed for additional storage and later for modems, network cards, combo cards, and hard drives. You have probably seen these credit card–sized devices in the past; however, they are superseded by another technology known as ExpressCard. PC Cards have a 16-bit bus width and can be used in PC Card slots and CardBus slots.
- **CardBus:** These have a 32-bit bus width (essentially they are PCI); they look similar to PC Cards but cannot be used in a PC Card slot.
- **ExpressCard: ExpressCard** (also known as PCI ExpressCard), a faster expansion bus for laptops, is a separate technology altogether and not compatible with PC Card or CardBus (without an adapter). There are two form factors of ExpressCard: /34, which is 34 mm wide, and /54, which is 54 mm wide and can be identified by a cutout in one corner of the card. Also, PC Cards and CardBus cards have a 68-pin connector, whereas ExpressCard has a 26-pin connector. PC Card and CardBus were the most-used expansion cards in laptops for many years but since 2006 have lost ground to ExpressCard, especially in higher-end laptops. This is yet another example of a technology that is moving from parallel to serial data transfer. A manufacturer of ExpressCard devices can elect to design them using the PCI Express technology or USB 3.0/2.0 technology depending on what type of card they make. For example, an ExpressCard soundcard wouldn't need the speed of PCI Express, so it would probably be designed from a USB 3.0/2.0 standpoint.

Table 3-4 breaks down the characteristics of PC Card, CardBus, and ExpressCard expansion buses.

TABLE 3-4

PC Card, CardBus, and ExpressCard Details

Technology	Type	Data Transfer Rate	Typical Usage
PC Card	Type I (3.3 mm thick)	20 MB/s	RAM, flash memory
PC Card/CardBus	Type II (5 mm thick)	PC Card = 20 MB/s CardBus = 133 MB/s	Network adapters, modems
PC Card/CardBus	Type III (10.5 mm thick)	PC Card = 20 MB/s CardBus = 133 MB/s	Hard drives

Technology	Type	Data Transfer Rate	Typical Usage
ExpressCard	PCI Express mode USB mode	2.5 Gbps (250 MB/s) 480 Mbps (60 MB/s)	External SATA drives, soundcards, Ethernet devices, and so on

NOTE: Remember that maximum data transfer rates are never attained, even in a lab environment. You can expect actual throughput to be substantially lower, but professionals use the maximum data rate as a point of reference and as a way of comparison.

Drive Technologies

Remember the von Neumann model. Long-term storage is imperative. Usually, data is stored over the long term to one or more hard drives. The two most common types of drive technologies that have ports on motherboards are SATA and IDE. These always connect to the southbridge, or simply the chipset if there is only one chip. SATA and IDE support the connection of not only hard drives, but also optical drives such as CD-ROMs, DVD-ROMs, and Blu-ray drives.

- **SATA:** Serial ATA has eclipsed IDE as the most common type of mass storage technology. As you can see in Figure 3-9, there is only one IDE port, but there are six seven-pin SATA ports (one of which is for external connections). And the newer motherboard in Figure 3-6 has no IDE ports whatsoever. The reason for this is speed. Even though SATA sends data in a serial fashion, or one bit at a time, it is faster than IDE. The first generation of SATA is rated at 1.5 Gb/s (once again, note the lowercase "b" indicating bits), equal to roughly 150 MB/s. Second-generation SATA offers a 3.0 Gb/s data rate. Third-generation SATA runs at 6 Gb/s. Most of today's motherboards are compatible with second- and third-generation SATA. Again, hard drives, CD-ROMs, DVDs, and Blu-ray drives can be connected to a SATA port.
- **IDE:** Integrated Drive Electronics interfaces (refer to Figure 3-9) have 40 pins. They utilize the Parallel ATA (PATA) standard that currently specifies a maximum data transfer rate of 133 MB/s. These bytes of information are transferred in parallel; for example, 8 bits at a time. Hard drives, CD-ROM drives, and DVD drives can connect to IDE ports. The IDE connector is 40 pins, but depending on the version, the cables used can have 40 or 80 conductors.

NOTE: Another mass storage interface used often is the Small Computer System Interface (SCSI) standard. We'll discuss this more in Chapter 5, "Memory and Storage."

Installing Motherboards

As an IT person, you might find that you need to build a computer, or perhaps replace or upgrade the motherboard in a current computer. So knowing how to install motherboards is an important skill. Motherboard installation works in a similar fashion whether you are dealing with PCs, laptops, or servers. However, mobile devices require a bit more finesse. For the bulk of this section, we will be referring to the PC. We'll discuss a bit about mobile computers toward the end of the section.

If you look at an unmounted motherboard from the top, you can see that motherboards have several holes around the edges and one or two holes toward the middle of the motherboard. Most ATX-family motherboards are held in place by screws that are fastened to brass spacers which are threaded into holes in the case or a removable motherboard tray. Before you start working with motherboards or other static-sensitive parts, be sure to implement antistatic measures. This usually means an antistatic strap and mat. See Chapter 13, "Computer Troubleshooting," for more about antistatic measures and other precautions you should follow.

Step-by-Step Motherboard Removal

This section shows how to properly remove a motherboard step-by-step. To remove ATX family motherboards from standard cases, follow these steps:

Step 1. Turn off the power switch and disconnect the AC power cable from the power supply. (If your computer is equipped with a kill switch on the power supply, you can turn that off instead of removing the power cable.)

Step 2. Disconnect all external and internal cables attached to add-on cards and label them as you go for easy reconnection later.

Step 3. Disconnect all ribbon cables attached to built-in ports on the motherboard: I/O, storage, and so on.

Step 4. Disconnect all cables leading to internal speakers, key locks, case connectors, speed switches, and other front-panel cables. Most recent systems use clearly marked cables, as shown in Figure 3-15, but if the cables are not marked, mark them before you disconnect them so you can easily reconnect them later.

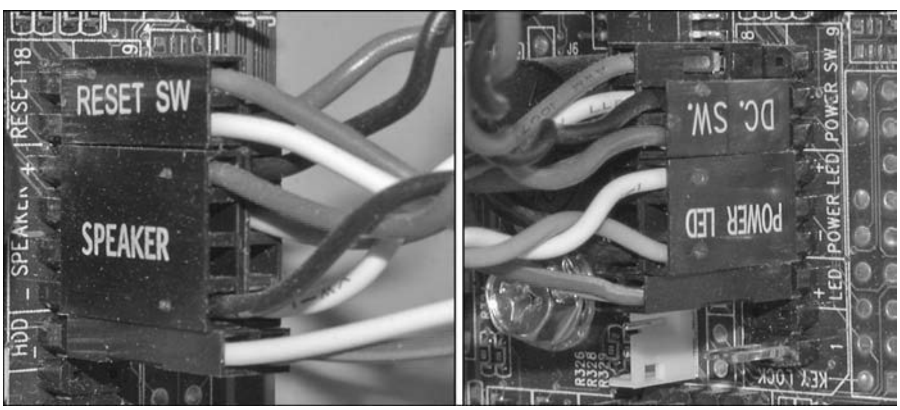


FIGURE 3-15

Case connectors attached to a typical motherboard.

Step 5. Remove all add-on cards and place them in antistatic bags.

Step 6. Disconnect header cables from front- or rear-mounted ports and remove them from the system (see Figure 3-16).

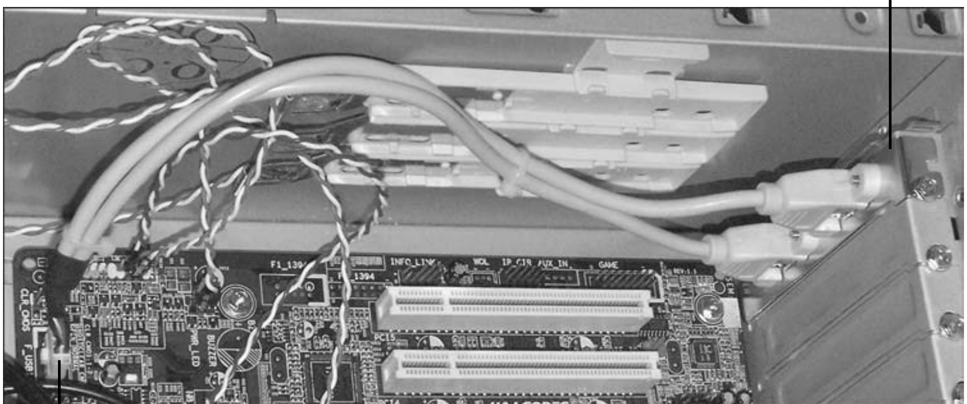


FIGURE 3-16

A typical dual-USB header cable using an expansion slot.

3

Step 7. Disconnect the power-supply leads from the motherboard. The new motherboard must use the same power-supply connections as the current motherboard.

Step 8. Remove the heat sink and the processor before you remove the motherboard and place them on an antistatic mat. Removing these items before you remove the motherboard helps prevent excessive flexing of the motherboard and makes it easier to slip the motherboard out of the case. However, skip this step if the heat sink requires a lot of downward pressure to remove and if the motherboard is not well supported around the heat sink/processor area.

NOTE: You can remove the memory if you wish, but it can be done after the motherboard has been taken out of the computer.

Step 9. Unscrew the motherboard mounting screws and store for reuse; verify that all screws have been removed. Consider using a tub to store the screws. Another option is to use a pillbox. Each day of the week in the pillbox can store a different type of screw.

Step 10. Lift the motherboard and plastic standoff spacers out of the case and place them on an antistatic mat. Remove the I/O shield (the metal plate on the rear of the system that has cutouts for the built-in ports; refer to Figure 3-17) and store it with the old motherboard.

NOTE: Use non-powered screwdrivers to avoid ESD and/or damage to the motherboard.

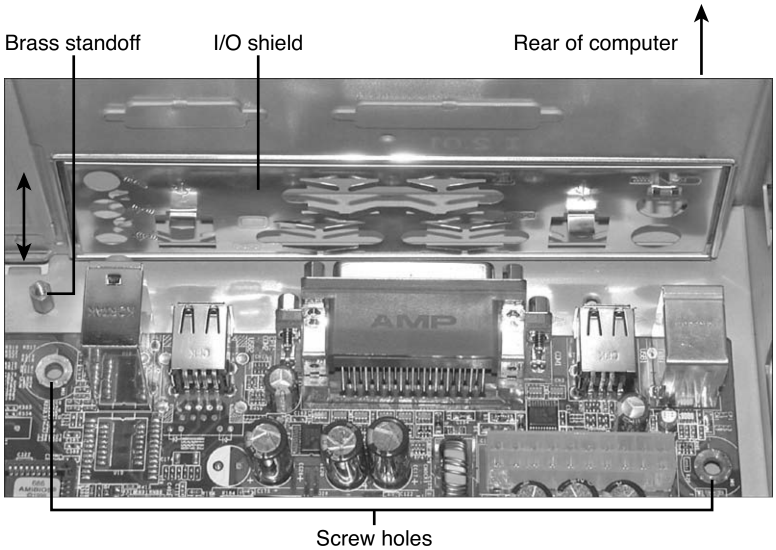


FIGURE 3-17

ATX I/O shield.

Preparing the Motherboard for Installation (ATX)

Before you install the new motherboard into the computer, perform the following steps:

NOTE: Some technicians prefer to install the CPU and RAM after the motherboard has been installed into the case. Choose whatever method works best for you.

Step 1. Review the manual supplied with the new motherboard to determine correct sizes of memory supported, processor types supported, and configuration information.

Step 2. Install the desired amount of memory. See Chapter 5 for details.

Step 3. Install the processor (CPU) and heat sink as described in Chapter 4.

Step 4. Configure CPU speed, multiplier, type, and voltage settings on the motherboard if the motherboard uses jumpers or DIP (Dual Inline Pin) switches. Note that most recent motherboards use BIOS configuration options instead.

Step-by-Step Motherboard Installation

After you have prepared the motherboard for installation, follow these steps to install the motherboard:

Step 1. Place the new motherboard over the old motherboard to determine which mounting holes should be used for standoffs (if needed) and which should be used for brass spacers. Matching the motherboards helps you determine that the new motherboard fits correctly in the system.

Step 2. Move brass spacers as needed to accommodate the mounting holes in the motherboard.

Step 3. Place the I/O shield near the motherboard and identify which port cutouts are required. The I/O shield is marked to help you determine the port types on the rear of the motherboard. If the port cutouts on some I/O shields are not completely removed, remove them. Then install the shield.

Step 4. Determine which holes in the motherboard have brass standoff spacers beneath them, and secure the motherboard using the screws removed from the old motherboard (refer to Figure 3-17).

Step 5. Reattach the wires to the speaker, reset switch, power button, and power lights.

Step 6. Reattach cables from the SATA drives to the SATA ports on the motherboard.

Step 7. Reattach the power supply connectors to the motherboard.

Step 8. Insert the add-on cards you removed from the old motherboard; make sure your existing cards don't duplicate any features found on the new motherboard (sound, video, and so on). If they do, and you want to continue to use the card, you must disable the corresponding feature on the motherboard.

Step 9. Mount header cables that use expansion card slot brackets into empty slots and connect the header cables to the appropriate ports on the motherboard.

Step 10. Attach any cables used by front-mounted ports such as USB or IEEE 1394 ports to the motherboard and case.

Installing Adapter Cards

Although most desktop systems are equipped with a variety of I/O ports and integrated adapters, it is still often necessary to install **adapter cards** to enable the system to perform specialized tasks or to achieve higher performance. The following sections show you how to perform typical installations.

General Installation

Before installing an adapter card, you should determine the following:

- Does the adapter card perform the same task as an integrated adapter on the motherboard? For example, if you are installing a display adapter (also called a graphics card or video card), does the system already have an integrated adapter? If you are installing a sound card, does the system already have a sound card? Depending on the type of card you are installing, it might be necessary to disable the comparable onboard feature first to avoid hardware resource conflicts.

- What type(s) of expansion slots are available for expansion cards? A typical system might have two or three types of expansion slots, such as PCI Express x16, PCI Express x4 (less common), PCI Express x1, and perhaps a legacy PCI slot (for backward compatibility). You can use PCI Express x1 and PCI slots for a variety of adapter cards, but PCI Express x16 slots are designed for display adapters only. The adapter card you select must fit into an available slot.
- When PCI and PCI Express x1 slots are available, which slot should be used? PCI Express x1 slots provide higher performance than PCI slots, and you should use them whenever possible.

The general process of installing an adapter card works like this:

Step 1. Shut down the system.

Step 2. Disconnect it from AC power, either by unplugging the system or by turning off the power supply with its own on/off (kill) switch.

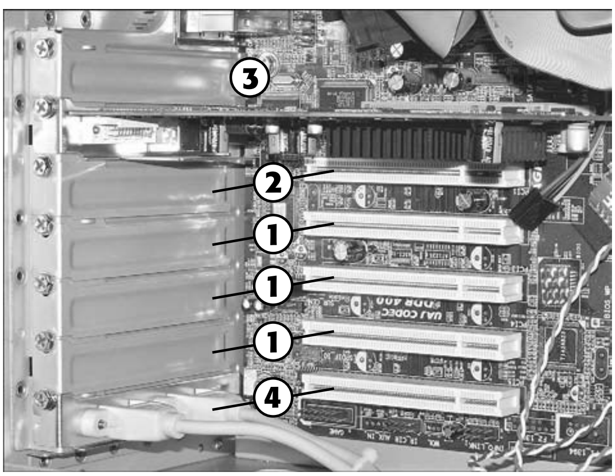
Step 3. Remove the system cover.

Step 4. Locate the expansion slot you want to use. If the slot has a header cable installed in the slot cover, you need to move the header cable to a different slot. Refer to Figures 3-13 and 3-14 for examples of expansion bus slots.

Step 5. Remove the slot cover corresponding to the slot you want to use for the adapter card. Most slot covers are held in place by set screws that fasten the slot cover to the rear of the case, as shown in Figure 3-18. However, some systems use different methods.

FIGURE 3-18

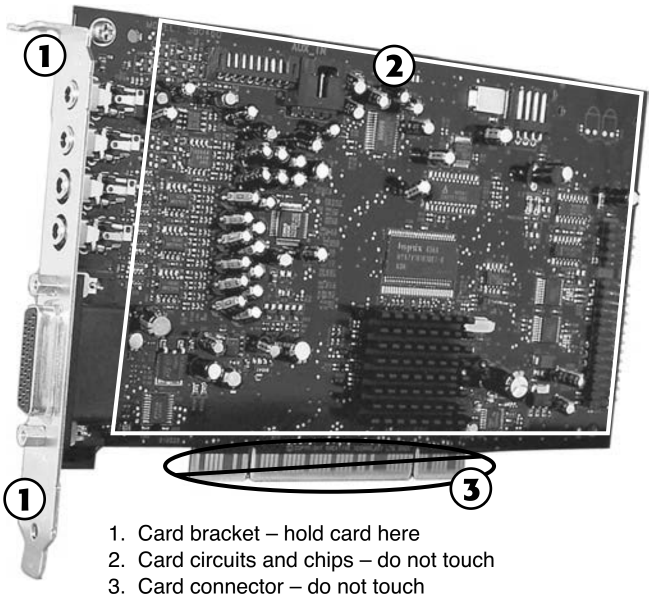
Expansion bus slots, covers, and screws.



1. Available slots and slot covers
2. Not available; too close to neighboring card
3. Available for header cable only; no matching slot
4. Not available; header cable blocks slot

NOTE: If you are unable to remove the slot cover after removing the set screw, loosen the set screw on the adjacent slot cover. Sometimes the screw head overlaps the adjacent slot cover.

Step 6. Remove the card from its antistatic packaging. Hold the card by the bracket, not by the circuit board, chips, or card connector. Figure 3-19 illustrates a typical card and where to hold it safely.



1. Card bracket – hold card here
2. Card circuits and chips – do not touch
3. Card connector – do not touch

FIGURE 3-19

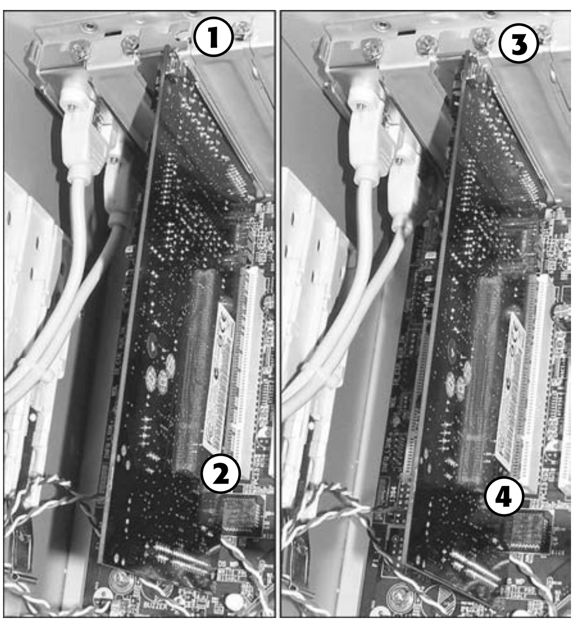
Typical adapter card.

Step 7. Insert the card into the expansion slot, lining up the connector on the bottom.

Step 8. Push the card connector firmly into the slot.

Step 9. Secure the card bracket; on most systems, you secure the card bracket by replacing the set screw. See Figure 3-20.

A Incorrect installation B Correct installation



1. Bracket not secured to rear of system
2. Card connector not completely inserted
3. Bracket secured
4. Card connector completely inserted

FIGURE 3-20

Incorrect and correct adapter card installation.

3

Step 10. Connect any cables required for the card.

Step 11. Reconnect AC power and restart the system.

Step 12. When the system restarts, provide drivers as prompted.

The following sections discuss some special installation considerations that apply to some types of adapter cards.

Display Adapters

More powerful computers require better video cards—most likely PCIe x16. When you install a video card into a slot, make sure the card-locking mechanism on the front of the slot is open before you install the card. Locking mechanisms sometimes use a lever that is moved to one side, flips up and down, or has a locking tab that is pulled to one side.

After installing the display adapter, install the drivers provided by the graphics card vendor. If possible, use updated drivers downloaded from the vendor's website rather than the ones provided on disc.

When connecting the monitor(s) to the display adapter, keep in mind that DVI is a very common connector, but sometimes you might need to make use of DisplayPort, HDMI, or even VGA. If your monitor and video card for some reason don't have the same connectors, you can find video adapters that convert from one standard to the next.

Video Capture Cards and TV Tuners

Video capture cards are used to capture video from analog or digital video sources. Video capture card types include the following:

- **IEEE 1394 (FireWire) cards:** These capture video from DV camcorders. You can also use these cards for other types of 1394 devices, such as hard disks and scanners. You can use an onboard IEEE 1394 port for video capture.
- **Analog video capture cards:** These capture video from analog sources, such as cable or broadcast TV, composite video, or S-video. Many of these cards also include TV tuners. Examples include the Hauppauge WinTV PVR series and the ATI Theater Pro series.
- **Digital video capture card:** These capture digital video from HDMI sources, such as HDTV.
- **TV tuners:** These cards allow your computer to tune into TV stations, either over the air or by way of cable, display to a monitor, and store TV content the way a DVR would.

After installing any type of video capture card or TV tuner, you need to install the drivers provided with the card, connect the card to video sources, and set up the TV tuner feature.

Sound Cards

After installing a sound card, your speakers and microphones require 1/8-inch mini-jack connections. Most sound cards use the same PC99 color-coding standards for audio hardware that are used by onboard audio solutions, as described in Table 3-5.

TABLE 3-5
PC99 Color Coding for Audio Jacks

Usage	Color	Jack Type
Microphone input (mono)	Pink	Mini-jack
Line in (stereo)	Light blue	Mini-jack
Speaker or headphone (front/stereo)	Lime green	Mini-jack
Speaker out/subwoofer	Orange	Mini-jack
Game port/MIDI out	Gold	15-pin DIN

After installing the sound card, you are prompted to install drivers when you restart the system. The driver set might also include a customized mixer program that is used to select speaker types and speaker arrangement (stereo, 5.1, and so on), and provides speaker testing and diagnostics. Be sure to test the speakers to ensure they are plugged into the correct jack(s) and are working properly.

We'll discuss audio and video more as we progress through this book, especially in Chapter 6.

Chapter Summary

Chapter 3 was chock-full of important information. We learned that the motherboard is the foundation of the computer—everything connects to it. In addition, we learned that the motherboard has internal connections, known as buses, that connect the various components within the motherboard such as the CPU, RAM, and expansion slots.

Motherboards have been at the core of computers since their inception. From the 16-bit computers of the 1970s and 1980s to 32-bit systems starting in the mid-1980s, to today's 64-bit systems, the motherboard has played a vital role in transferring information between all components.

We discussed how different motherboards are similar, regardless of what type of computer they are a part of—PCs, servers, mobile computers, gaming consoles, and so on. Remember that the motherboard's most important function is to interconnect and relay power to those core components: the CPU and RAM. But it also interconnects permanent storage (hard drives and optical drives), input devices (keyboard and mouse), and output devices (monitors and printers), and relays power to some of those devices as well.

The core components of a computer are the CPU and RAM, which are connected by a variety of buses (depending on the manufacturer), and are aided by the chipset—which incorporates all of the other controllers on the motherboard. The chipset is the most important component of the motherboard itself. The chipset might be a single chip, or might be broken down into two parts: the northbridge and the southbridge. This depends on the manufacturer of the motherboard, the type of CPU used, and the age of the system.

Motherboards must comply with a form factor standard. This architecture dictates power requirements, size, and connector types. Although AT was the standard for PCs for many years, today's PCs often use ATX. However, servers, mobile computers, and other computing devices use different form factors. Some of the other common form factors include microATX, ITX, and BTX. The form factor also often determines what kind of ports are in the integrated port cluster. These can include USB, FireWire, video and audio, and of course networking ports. USB is the connection of choice for many devices today, including keyboards, mice, microphones, printers, web cameras, and much more.

If a motherboard's integrated components are not satisfactory to a user, the computer can be upgraded with expansion cards. These adapter cards are plugged into one of several buses, with PCI Express (PCIe) being the most prevalent. You might also see legacy devices that use older expansion buses such as PCI, AGP, AMR, and CNR. Because PCIe is much faster and easier to work with, and in general a superior technology, the changes of this grow less and less over time. Laptops cannot incorporate the same expansion buses that are used in PCs. To facilitate the use of adapter cards on laptops, smaller expansion buses were developed, including PC Card, CardBus, and today's most common, ExpressCard. These allow a person to insert special adapter cards directly into the side or back of the laptop.

The installation of motherboards varies from system to system, but you should remember a few basic rules whenever installing a new motherboard, or upgrading a motherboard. Remember to employ antistatic measures, verify that any motherboard purchased is compatible with the rest of the system, and verify whether onboard peripherals are required, or whether separate adapter cards should be used.

The installation of adapter cards is usually pretty easy. However, you should plan beforehand, and make sure that there is an open adapter card slot on the motherboard for the device you plan to install. Also, make sure that the adapter card is of the correct type; for example, PCIe x1, x4, or x16. As always, employ antistatic measures such as an antistatic strap and antistatic mat, and always keep adapter cards inside an antistatic bag until they are ready to be installed.

There are all kinds of specialized peripherals and adapter cards such as video capture cards, TV tuners, and sound cards. Depending on the computer's purpose, you might need to install one or more of these devices. Be sure to plan the customization of the computer before purchase and installation.

Chapter Review Activities

Use the features in this section to study and review the topics in this chapter.

Define the Key Terms for Chapter 3

The following key terms cover the most important concepts in this chapter. To review, without looking at the book or your notes, write a definition for each term, focusing on the meaning, not the wording. Then review your definition compared to your notes, this chapter, and the glossary.

- motherboard
- bus width
- chipset
- Direct Media Interface (DMI) link
- northbridge
- southbridge
- HyperTransport
- Quick Path Interconnect (QPI)
- front-side bus (FSB)
- memory bus
- PCI Express x16
- Advanced Technology Extended (ATX)
- microATX
- ITX
- Balanced Technology Extended (BTX)
- Peripheral Component Interconnect (PCI)
- Accelerated Graphics Port (AGP)
- PCI Express (PCIe)
- Personal Computer Memory Card International Association (PCMCIA)
- ExpressCard
- adapter cards

Answer These Questions and Case Studies

1. Which computer system uses a 64-bit CPU?

- **A.** 286
- **B.** 386
- **C.** 486
- **D.** Core i7

2. Which of the following are considered expansion slots? (Choose all that apply.)

- **A.** PCI
- **B.** FireWire
- **C.** AGP
- **D.** USB

3. Which of the following can you use with SATA connections? (Choose all that apply.)

A. Hard drives
B. Scanners
C. Laser printers
D. DVD-ROMs
E. Dot-matrix printers

4. Which of the following are examples of motherboards that might be used in an HTPC? (Choose all that apply.)

A. ATX
B. micro-ATX
C. Mini-ITX
D. BTX
E. Pico-ATX

5. Which of the following are considered integrated I/O ports?

A. Serial port
B. Parallel port
C. USB port
D. PS/2 mouse and keyboard
E. Audio port
F. Ethernet port
G. All of these options

6. To connect speakers to the sound card, which of the following must you use?

A. 1/2-inch jack
B. 1 1/4-inch jack cable
C. 2/3-inch jack cable
D. 1/8-inch mini-jack cable
E. None of these options

7. How many instructions per second is common for an Intel Core i7 CPU?

A. 11 MIPS
B. 133 MB/s
C. 100,000 MIPS
D. 3.5 GHz

8. Which of the following is a common speed for PCI?
   - **A.** 33 MHz
   - **B.** 133 MHz
   - **C.** 266 MHz
   - **D.** 1066 MHz

9. Which of the following expansion bus technologies would be described as x16 (spoken as "by sixteen")?
   - **A.** PCI
   - **B.** AGP
   - **C.** PCIe
   - **D.** PCI-X

10. Which of the following expansion buses has the fastest data transfer rate?
    - **A.** PCIe x1
    - **B.** AGP 4x
    - **C.** PCIe x16
    - **D.** PS/2

11. What is the most important job of the chipset on Intel motherboards?
    - **A.** Transfer data to the CPU
    - **B.** Transfer data to the RAM
    - **C.** Transfer data to the PCIe
    - **D.** Transfer data to the secondary devices

12. Which of the following should you do first before disconnecting all ribbon cables that are attached to built-in ports on the motherboard? (Select the two best answers.)
    - **A.** Turn off the power switch and disconnect the AC power cable from the power supply
    - **B.** Disconnect all cables leading to internal speakers, key locks, speed switches, and other front-panel cables
    - **C.** Disconnect all external and internal cables attached to add-on cards after labeling them for easy reconnection
    - **D.** Remove all add-on cards and place them on an antistatic mat or in (not on top of) antistatic bags

13. What type of CPU might a server use?

- **A.** Intel Core i7
- **B.** Intel Xeon
- **C.** ARM 32-bit CPU
- **D.** DDR

14. If the sound ports are color-coded, what color should the headphone connection be?

- **A.** Pink
- **B.** Lime green
- **C.** Light blue
- **D.** Gold

15. When installing an adapter card, what should you do just prior to reconnecting power?

- **A.** Restart the system
- **B.** Push the card firmly into the slot
- **C.** Connect any cables required for the card
- **D.** Secure the card bracket

16. What is a common speed for a 386 computer's CPU?

- **A.** 10 MHz
- **B.** 33 MHz
- **C.** 33 GHz
- **D.** 133 MB/s

17. What is the older type of hard drive connector, replaced by SATA?

- **A.** PCIe
- **B.** SCSI
- **C.** IDE
- **D.** AGP

18. Where will the network adapter usually be on a smartphone?

- **A.** In the PCIe slot
- **B.** Connected to USB
- **C.** Soldered onto the motherboard
- **D.** Embedded within the CPU

19. What bus connects the chipset to the CPU on newer Intel-based motherboards?

- **A.** Northbridge
- **B.** DMI
- **C.** HyperTransport
- **D.** Southbridge

20. What is the data transfer rate of a QPI connection?

- **A.** 1 GB/s
- **B.** 25.6 GB/s
- **C.** 20 Gb/s
- **D.** 266 MB/s

Case Study 1

As discussed earlier in this chapter, a motherboard can have many different connections. They can include connections for power, hard drives, optical drives, and much more.

Examine your home computer, and identify the various ports and connections of your motherboard. Diagram what you see on the motherboard and list each of the connections and their distinguishing characteristics.

For example, your motherboard probably has a main power connection with 24 wires (pins) bundled together, as well as PCIe expansion slots.

Case Study 2

Different adapter cards use different expansion buses. Define which expansion buses today's adapter cards would normally utilize, including video cards, sound cards, and network adapters.

Use the Internet to help define which expansion buses would most often be used. Manufacturers' websites and online computer pricing guides can be helpful in finding out what is commonly used in the field.

Case Study 3

Examine your mobile device. Find out the manufacturer name and the model name. If you do not have one, examine another student's mobile device, or select a new one that is easily available online.

Now, access the Internet and research that model in an attempt to find a picture or illustration of its motherboard. Try going to the manufacturer's website and locating the specifications for the device. Or you could try using Google (or your favorite search engine) and searching for the term "*xxx* smartphone motherboard" or "*xxx* tablet motherboard diagram" where *xxx* is the mobile computer's manufacturer/model name. Define where the CPU, RAM, and long-term storage are located on the motherboard.

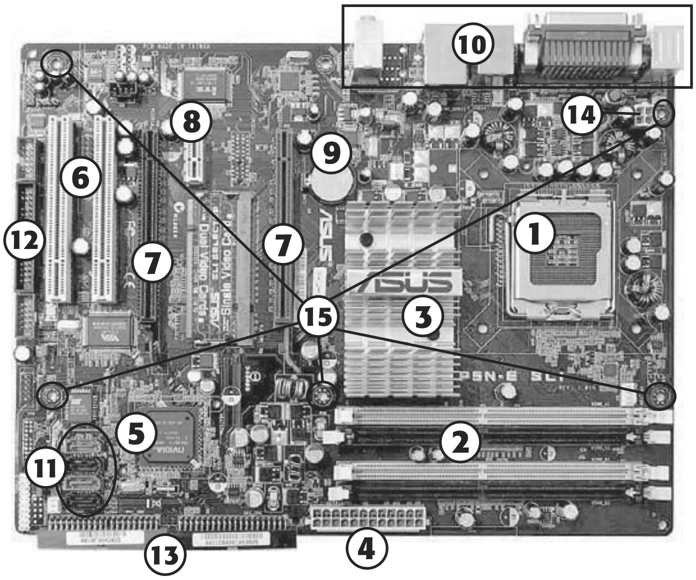
Answers, Explanations, and Solutions

1. D. The only CPU listed that is available in a 64-bit version is the Intel Core i7. The 286 (for the most part) was a 16-bit CPU. The 386 and 486 were 32-bit CPUs.
2. A and C. Motherboards use expansion slots to provide support for additional I/O devices and high-speed video/graphics cards. Expansion slots include PCI, AGP, and PCI-Express (also known as PCIe). Some systems also feature AMR or CNR slots for specific purposes.
3. A and D. Serial ATA (SATA) allows for connections to hard drives and optical drives. Scanners and printers usually connect locally to the PC by way of USB. However, they might also connect directly to the network.
4. B and C. Home theater PCs (HTPCs) often use the micro-ATX or Mini-ATX form factors due to their small size. ATX and BTX are too big for a typical HTPC. Pico-ATX is too small and is used for smaller mobile computers.
5. G. Motherboards in both the ATX and the BTX families feature a variety of integrated I/O ports, including serial, parallel, USB, PS/2, audio, and Ethernet. These are found in as many as three locations. All motherboards feature a rear port cluster, and many motherboards also have additional ports on the top of the motherboard that are routed to header cables that are accessible from the front and rear of the system.
6. D. After installing a sound card, you must connect 1/8-inch mini-jack cables from speakers and the microphone to the sound card. Most sound cards use the same PC99 color-coding standards for audio hardware that are used by onboard audio solutions.
7. C. An Intel Core i7 CPU can typically calculate 100,000 MIPS (millions of instructions per second) or more. The rate of 11 MIPS was common for a 386 computer, as was the separate measurement 133 MB/s. The speed or frequency of a CPU such as the Intel Core i7 is 3.5 GHz.
8. A. A common speed for PCI is 33 MHz. PCI might also operate at 66 MHz depending on several factors. Other faster expansion buses can operate at speeds of 133 MHz and beyond.
9. C. PCIe (PCI Express) has four main types: x1, x4, x8, and x16. PCI (and its derivative PCI-X) and AGP are not described in this manner. AGP shows the x after the number.
10. C. PCIe x16 (version 3) has the fastest data transfer rate at 1 GB/s per lane for a total of 16 GB/s. AGP 4x can transmit 1 GB/s, whereas PCIe x1 transmits only 1 GB/s total, because there is only one lane. PS/2 sends a very small amount of information, only what is needed to input information from a keyboard or mouse.
11. A. The most important job of the chipset on Intel motherboards is to transfer data to the CPU. Although it does do the rest of the jobs listed in the answers, they are all secondary compared to the CPU. However, to make the computer work properly, the chipset should efficiently transfer data to all components: CPU, RAM, the PCIe expansion bus, secondary devices, and everything else.
12. A and C. Before disconnecting the ribbon cables, you should turn off the power switch and disconnect the AC power cable from the power supply (or turn off the kill switch on the power supply if so equipped), and disconnect all external and internal cables attached to add-on cards after labeling them for easy reconnection.

13. B. A server most often uses an Intel Xeon CPU. These are designed specifically for the intense workload a server will encounter. The Intel Core i7 definitely works for servers, but is not as common, and is used more for PCs. ARM 32-bit CPUs are used in mobile computers. DDR (double data rate) is a type of RAM used in PCs and many other types of computers.
14. B. The headphone connection should be lime green according to the PC99 color-coding standard. Pink is the microphone input, light blue is the line in, and gold is the game port.
15. C. Just prior to reconnecting the AC power, you should connect any cables required for the card. Previous to this, the card should be inserted and pushed firmly into the slot, and any card brackets should be secured. Restarting (or starting) the system should be the last thing you do.
16. B. A common speed for a 386 computer's CPU is 33 MHz. A speed of 10 MHz was common for 286 computers, and 33 GHz hasn't been obtained in the PC market as of yet. The final option, 133 MB/s, is a typical example of the amount of data that a 386 CPU can calculate.
17. C. Integrated Drive Electronics (IDE) is the older type of hard drive connector that was replaced by SATA. PCIe is a current expansion bus, often used by video cards, as is AGP. The Small Computer System Interface (SCSI) standard is also used by hard drives, but it has been around since during the IDE era, and is still used today.
18. C. The network adapter, or adapters such as Wi-Fi and GSM, are soldered onto the motherboard of a mobile device. This is true for most mobile computers. Smartphones don't have PCIe slots. Though it is possible to connect a variety of things to a smartphone's USB port, the network adapter more often is integrated into the mainboard. RAM is embedded into the CPU in some smartphone designs.
19. B. The Direct Media Interface (DMI) bus connects the chipset to the CPU on Intel-based motherboards. The northbridge and southbridge are components of AMD and older Intel chipsets. Newer Intel chipsets have a single chip. HyperTransport is the CPU to chipset connection on AMD-based boards.
20. B. A Quick Path Interconnect (QPI) bus can handle a maximum of 25.6 GB/s. This is the same amount as AMD's HyperTransport. The rate of 1 GB/s is the maximum data transfer rate of PCIe (version 3), 20 Gb/s is the maximum for DMI, and 266 MB/s is the maximum for the PCI expansion bus.

Case Study 1 Solution

Refer to Figure 3-21. This shows a typical ATX form factor motherboard. All of the components are labeled. If you haven't already, memorize the components you see in the figure. Then compare them to your motherboard components.



1. Socket 775 processor socket
2. Dual-channel DDR2 memory slots
3. Heat sink over northbridge
4. 24-pin ATX v2.0 power connector
5. Southbridge chip
6. PCI slot (2)
7. PCI Express x16 slot (2)
8. PCI Express x1 slot
9. CMOS battery
10. Port cluster
11. SATA host adapter (4)
12. Floppy drive controller
13. PATA host adapter (2)
14. 4-pin ATX12 power connector
15. Mounting holes

FIGURE 3-21

A typical ATX motherboard.

Case Study 2 Solution

Although there are lots of different scenarios when it comes to adapter cards, the following shows some common expansion buses used by adapter cards. Keep in mind that these technologies are constantly being updated!

- **Video cards:** PCIe x16
- **Sound cards:** PCIe x1 or PCI (could also be integrated into the motherboard)
- **Network cards:** PCIe x1 or PCI (could also be integrated into the motherboard)

Some websites that can offer some more information include these manufacturers' websites:

- www.intel.com
- http://us.creative.com
- www.nvidia.com

Online computer pricing guides that can be of assistance include the following:

- www.pricewatch.com
- www.cyberguys.com
- www.amazon.com

Case Study 3 Solution

A mobile computer's diagram should be available at the manufacturer's website. However, if it is not, you can most likely find an image within a popular search engine.

For example, the HTC One smartphone specifications can be found at this link:

www.htc.com/www/smartphones/htc-one/#specs

Or you can try searching for the phrase "HTC One specifications" within a search engine. An example of a typical smartphone's motherboard layout is shown in Figure 3-22.

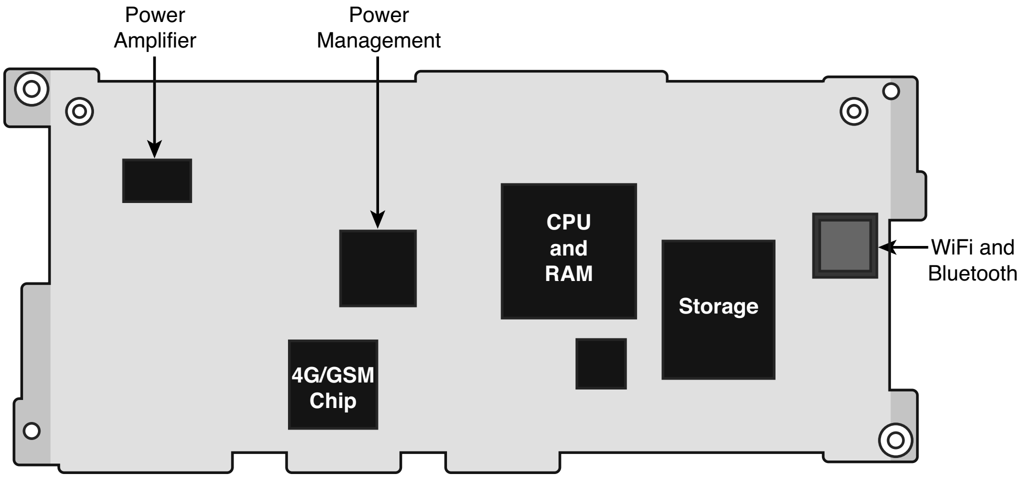


FIGURE 3-22

A typical smartphone motherboard diagram.

In the figure, you can see that the CPU, RAM, and permanent storage are clearly marked. Verify that you have found these components for your mobile computer.

Index

NUMERICS

SYMBOLS

A

B

C

D

E

F

G

H

J

K

L

N

Q

R

S

T

U

V

W

X