CHAPTER 2

Understanding Motherboards and BIOS

In this chapter, you learn about motherboards, including the different types and how to identify different motherboard components. The motherboard includes a significant amount of supporting hardware for a system and is a primary component that determines the overall capabilities and speed of a system. The motherboard also includes firmware, commonly called Basic Input/Output System (BIOS), which is used to start the computer. The BIOS includes a program that you can use to view and configure hardware settings. This chapter shows how to start BIOS, view and manipulate the settings, and update the BIOS program through a process called flashing. You also learn about some basic troubleshooting related to the motherboard and BIOS.

Exam 220-801 objectives in this chapter:

- 1.1 Configure and apply BIOS settings.
  - Install firmware upgrades—flash BIOS
  - BIOS component information
    - RAM
    - Hard drive
    - Optical drive
    - CPU
  - BIOS configurations
    - Boot sequence
    - Enabling and disabling devices
    - Date/time
    - Clock speeds
    - Virtualization support
    - BIOS security (passwords, drive encryption: TPM, lo-jack)
  - Use built-in diagnostics
  - Monitoring

    - Temperature monitoring
    - Fan speeds
    - Intrusion detection/notification
    - Voltage
    - Clock
    - Bus speed
- 1.2 Differentiate between motherboard components, their purposes, and properties.
  - Sizes
    - ATX
    - Micro-ATX
    - ITX
  - Expansion slots
    - PCI
    - PCI-X
    - PCIe
    - miniPCI
    - CNR
    - AGP2x, 4x, 8x
  - RAM slots
  - CPU sockets
  - Chipsets
    - North Bridge
    - South Bridge
    - CMOS battery
  - Jumpers
  - Front panel connectors
    - USB
    - Audio
    - Power button
    - Power light
    - Drive activity lights
    - Reset button
  - Bus speeds

Exam 220-802 objectives in this chapter:

- 4.2 Given a scenario, troubleshoot common problems related to motherboards, RAM, CPU and power with appropriate tools.
  - Common symptoms
    - Unexpected shutdowns
    - System lockups
    - POST code beeps
    - Blank screen on bootup
    - BIOS time and settings resets
    - Attempts to boot to incorrect device
    - Continuous reboots
    - Fans spin—no power to other devices
    - Indicator lights
    - BSOD
  - Tools
    - POST card

REAL WORLD **UNDERSTANDING THE BIOS BOOT ORDER**

I remember teaching a Windows class to several students at a corporate site where basic knowledge about BIOS turned out to be important. Early in the class, we discussed the installation of Windows, and then the students had an opportunity to install it on their system.

Each of the students had an installation DVD, and they needed to put the DVD into the drive, boot to the DVD, and begin the installation. About half the student computers were configured to boot to the DVD first, and these didn't give the students any trouble.

However, many of the computers in the company's training room were configured to boot to the hard drive instead of the DVD. Most of the students using these computers quickly recognized that they needed to reconfigure the BIOS to boot to the DVD, and they quietly did so.

Unfortunately, one of the students didn't understand why his system wouldn't boot to the DVD. He first thought his installation DVD was faulty, so he got another one and tried again and then became convinced his computer was faulty. We ended up working together to reconfigure the BIOS on his system. He remarked that this was the first time he had ever accessed this program. Lacking this basic knowledge didn't stop him from learning, but it did slow him down.

By the end of this chapter, you'll have an opportunity to access the BIOS and see exactly how to manipulate these settings. It is important knowledge, and you never know when you'll need it as a PC technician.

Motherboards

The motherboard is the primary circuit board within a computer, and it holds several key components, including the processor, random access memory (RAM), expansion slots, and more.

Motherboards are created by using form factors that define their size and the components on the motherboard. Similarly, cases are built to support one or more motherboard form factors. In Chapter 1, "Introduction to Computers," Figure 1-2 showed the inside of a computer with the motherboard highlighted. In this chapter, you'll learn more about the types of motherboards available and the individual components on a typical motherboard.

Identifying Motherboard Components

All of the relevant components of a motherboard are presented within this chapter. Figure 2-1 shows the outline of a motherboard with several key components identified. You won't find all of these components on every motherboard or in exactly the same location. However, the figure gives you an idea of common components and how to identify them.

EXAM TIP

When taking the exam, you should be able to identify different components on the motherboard based on their shape. You should also be able to identify their purposes and properties.

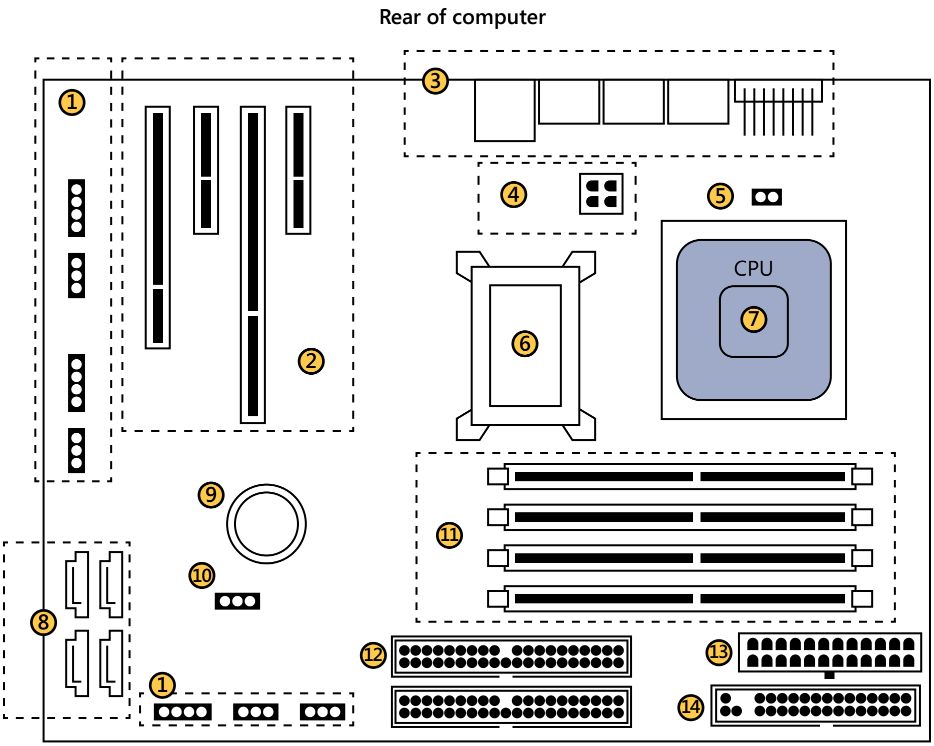

FIGURE 2-1 Motherboard outline.

1. **Miscellaneous connectors and jumpers.** Connectors are available to connect to a speaker, to fans, and to the front of the case for power and displays. They can be located in different places on the motherboard.

2. **Expansion slots.** Expansion slots allow you to add additional cards to a motherboard for additional capabilities. Several different types of expansion slots are available, including Peripheral Component Interconnect (PCI), Accelerated Graphics Port (AGP), and more.

3. **Rear connectors.** Several connectors are attached to the motherboard and are accessible via the rear of the computer. These include connectors for audio and video Universal Serial Bus (USB) devices and more. Chapter 5, "Exploring Peripherals and Expansion Cards," discusses common connectors.

4. **CPU 12-V power.** A 4-pin plug from the power supply plugs into here to provide power to the Central Processing Unit (CPU). On systems with multiple CPUs, this can be two 4-pin plugs or an 8-pin plug.

5. **CPU Fan.** CPUs generate a lot of heat, so it's common to attach a fan on top of them. A connection on the motherboard provides power for the fan. CPU fans are often variable speed so that they can spin faster when the CPU gets hotter.

6. **Chipset.** This consists of one or more integrated circuits (ICs) that connect the CPU with other components and devices on the system. Chipsets are designed to work with specific CPUs and are soldered into the motherboard. They can get hot and often have heat sinks on top of them designed to dissipate heat. Heat sinks are discussed in Chapter 3, “Understanding RAM and CPUs.”
7. **CPU.** The majority of work done by a computer occurs within the processor. The motherboard includes a CPU socket into which a CPU is plugged, and the CPU is normally covered with a heat sink and a cooling fan. CPUs are covered in Chapter 3.
8. **SATA connectors.** Most computers support Serial Advanced Technology Attachment (SATA) drives. SATA connectors have a distinctive *L* shape. SATA connectors come in different versions, and these different versions are identified with different colors. However, there isn’t a standard with the colors between motherboard manufacturers. Chapter 4, “Comparing Storage Devices,” covers hard disk drives.
9. **Battery.** The battery provides power to the Basic Input/Output System (BIOS) so that certain settings are retained. The battery is often circular but can have a barrel shape.
10. **BIOS jumper.** There is often a jumper close to the battery. Shorting the two pins on this jumper will reset the BIOS password or return the BIOS settings to the factory defaults.
11. **RAM.** Motherboards usually have at least two RAM slots, and many have four or six. RAM slots are very specific and will accept only certain types of RAM based on the specifications of the motherboard. Chapter 3 covers RAM.
12. **IDE connectors.** Extended Integrated Drive Electronics (EIDE) connectors are used for EIDE devices such as hard drives and optical drives. Many systems have replaced EIDE drives with SATA drives, but you still might see the connectors. When the board includes them, you’ll see two connectors labeled IDE1 and IDE2, or sometimes IDE0 and IDE1.
13. **P1 power connector.** The primary power connection from the power supply is either a 20-pin connector or a 24-pin connector.
14. **Floppy drive connector.** This is for 3.5-inch floppy drives. They are rare today, but if the system has a floppy connector, it is usually by the IDE connectors.

Sizes

While computer cases come in a wide variety of sizes, you’ll find that most motherboards follow a form factor standard and conform to specific sizes. The following are some of the common motherboard form factors in use today:

- **Advanced Technology Extended (*ATX*).** This has been the standard used in many systems since 1995 and is still used today. It added capabilities and improved on the original AT motherboard design.

- **Micro-ATX (mATX or μATX).** This is a smaller version of the ATX and is very popular with desktop computers. It is designed to be backward-compatible with the ATX form factor so that it can fit in any ATX case and has the same power connectors. Because it is smaller, it has fewer expansion slots.
- **ITX.** ITX motherboards originated with VIA technologies and come in several different *small form factor* (*SFF*) designs, including mini-ITX, nano-ITX, and pico-ITX. They are referred to as embedded boards and consume very little power compared to ATX-based boards. They don't need to be cooled with fans.
  - **Mini-ITX.** These are envisioned for use in home theater systems. They can fit into any case by using standard ATX mount points.
  - **Nano-ITX.** These small boards are designed for smaller devices such as digital video recorders (DVRs) and set-top boxes.
  - **Pico-ITX.** These extremely small boards can be embedded in different types of mobile devices. The Pico-ITX has been adopted as an open standard by the Small Form Factor Special Interest Group, or SFF-SIG.

EXAM TIP

Although there are additional types of motherboards, the preceding list provides an idea of the types you might see on the exam. The ATX motherboard and ATX variants are still the most popular. Additionally, all the ATX variants are smaller than the ATX, and many will fit into a case designed for an ATX motherboard.

Table 2-1 shows the sizes of common motherboard standards, organized from the largest form factors to the smallest.

TABLE 2-1 Form Factor Sizes

Form Factor	Size in Inches	Metric Size
ATX	12 x 9.6	305 mm x 244 mm
Micro-ATX	9.6 x 9.6 largest 6.75 x 6.75 smallest	244 mm x 244 mm 171.45 mm x 171.45 mm
Mini-ITX (VIA)	6.7 x 6.7	17 cm x 17 cm
Nano-ITX (VIA)	4.7 x 4.7	120 mm x 120 mm
Pico-ITX	3.9 x 2.8	10 mm x 7.2 mm

NOTE **THE MICRO-ATX FORM FACTOR**

The Micro-ATX form factor is the only one that comes in different sizes. However, it is designed so that it will fit into any case that supports an ATX motherboard.

Quick Check

1. What type of motherboard is the most common in desktop PCs?
2. How can you identify a SATA data connection?

Quick Check Answers

1. ATX.
2. The connector is shaped like an *L*.

Busses

A *bus* within a computer refers to the connection between two or more components, and it is used to transfer data between these components. A computer has multiple busses that often work independently of each other. However, some busses work together.

As an example, computers have a data bus and an address bus, as shown in Figure 2-2. Data bytes are stored in RAM in separate memory locations, and each location is identified by an address. You can think of these locations as 1, 2, 3, and so on. A typical computer has billions of locations.

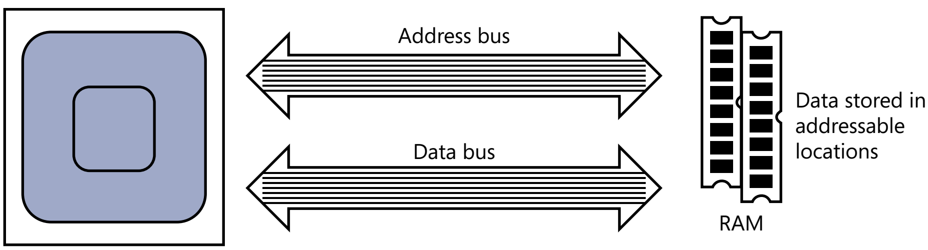

FIGURE 2-2 Address and data bus used to read and write memory data.

When a system wants to retrieve data from a specific location, it places the desired address on the address bus. The data in that memory location is then placed on the data bus for the system. Similarly, when a system wants to write data into a memory location, it simultaneously places the data on the data bus and the address on the address bus. These busses also have other signals that synchronize the activity and control whether data is read or written.

The size of the address bus determines how much memory can be addressed. A 32-bit address bus is limited to 2^{32} addressable locations, or 4 GB of RAM. A 64-bit bus can address 2^{64} addressable locations, or over 17 exabytes (EB) of RAM.

> ***NOTE*** **EXABYTES**
>
> **The order of bytes is kilobyte (KB), megabyte (MB), gigabyte (GB), terabyte (TB), petabyte (PB), and exabyte (EB). Even though 64-bit hardware can address 17 exabytes of RAM, you won't see systems with that much RAM any time soon. A 64-bit version of Windows 7 can have as much as 192 GB of RAM, but 16 GB is usually enough for even the most active power users on a desktop computer.**

Similarly, the size of the data bus determines how much data can be transferred at a time. A 32-bit data bus can transfer 32 bits of data at a time (which equals 4 bytes). A 64-bit data bus can transfer 64 bits of data a time.

Some of the other types of busses you'll come across include the following:

- **Back side bus.** The *back side bus* is the connection between the CPU and its internal cache memory.
- **Front side bus (FSB).** The *front side bus* refers to the connection between the CPU and the supporting chipset on the motherboard. The speed of this is frequently used to identify the speed of the CPU. Newer systems have replaced the front side bus with a *Direct Media Interface (DMI)*.
- **Direct Media Interface (DMI) bus.** This connects the CPU and newer chipsets in place of the front side bus.
- **Expansion slot bus.** Expansion slots have their own dedicated busses, and these are implemented differently depending on the expansion slots included in the system.
- **Universal Serial Bus (USB).** This is used to transfer data between the computer and external USB devices such as USB flash drives.

Bus Speeds

Motherboards include one or more oscillator crystals, which vibrate at specific frequencies when a voltage is applied. The output is a sine wave that alternates at a specific frequency such as 66 MHz or 100 MHz.

> ***NOTE*** **HERTZ, MHz, AND GHz**
>
> **A *hertz* (*Hz*) is a cycle and refers to how many times a signal can go up, down, and return to the starting point in one second. Alternating current (AC) power in North America runs at 60 Hz, meaning that it can finish 60 cycles a second. A 100-*MHz* signal completes 100 million cycles in a second, and a 1-*GHz* signal completes 1 billion cycles in a second.**

A computer uses these cycles as a clock to transfer data. For example, when the cycle is rising (rising edge), the system interprets this as a clock tick and takes an action such as reading or writing data to RAM. Many systems use the rising edge as one clock tick and use the falling edge as another clock tick. Therefore, a system will commonly have two clock ticks for each cycle.

Computers can process data more quickly than the base frequencies of these crystals, and they use additional multiplier circuitry to increase the frequency. For example, if a crystal generates a 100-MHz signal and the motherboard uses a two-times (2X) multiplier, the output is 200 MHz, as shown in Figure 2-3.

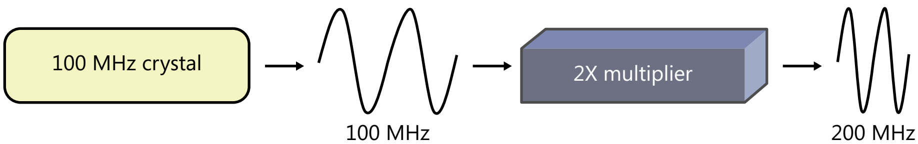

FIGURE 2-3 Crystal and multiplier.

An important point to remember is that the frequency of the bus directly impacts how much data a bus can transfer—the faster the frequency, the more data the bus can transfer.

Additionally, the amount of data a bus can transfer is dependent on how many bits can be transferred at a time. Two common data bus widths in use today are 32 bits and 64 bits. That is, for each clock cycle on a 32-bit bus, the system will send 32 bits of data. If it's a 64-bit bus, it can send 64 bits of data at a time.

NOTE **DATA THROUGHPUT**

Data throughput is commonly expressed as megabytes per second (MB/s) or gigabytes per second (GB/s). For example, some expansion boards can reach speeds of 16 GB/s.

Expansion Slots

Motherboards include expansion slots so that you can add expansion cards. For example, your motherboard can have basic video capabilities built into it, but you might want video that is faster and crisper. You can purchase a top-of-the-line video card with onboard RAM, install it in an expansion slot, and enjoy some awesome graphics.

Before you buy any expansion card, you should know what expansion slots are available in your computer. You don't want to buy a card only to find that it isn't supported by your computer or that the slot is already occupied by another expansion board.

The following sections cover the common types of expansion slots you should know about for the A+ exams. The standards are as follows:

- **Peripheral Component Interconnect (PCI).** This comes in 32-bit and 64-bit versions and reaches speeds up to 533 MB/s. Newer motherboards might still include a PCI slot.
- **Accelerated Graphics Port (AGP).** AGP was introduced as a dedicated slot for a graphics card. It allowed high-end graphics to transfer data at speeds up to 2,133 MB/s without competing with other PCI device data transfers.

- **PCI-Extended (PCI-X).** This was an improvement over PCI and could reach up to 1,064 Mb/s. It is primarily used in servers.
- **PCI Express (PCIe).** This is the primary standard in use today and replaces PCI, AGP, and PCI-X on many motherboards. It can reach speeds up to 2 GB/s on multiple lanes simultaneously.

PCI

The *Peripheral Component Interconnect (PCI)* standard was a replacement for earlier *industry standard architecture (ISA)* and extended ISA expansion cards. It originally used a 32-bit data bus but was later improved to use a 64-bit bus. Table 2-2 shows the data rates and frequencies available with 32-bit and 64-bit versions of PCI.

TABLE 2-2 PCI Data Rates and Frequencies

Standard	Data Rate	Frequency
PCI (32-bit)	133 MB/s	33 MHz
PCI (32-bit)	266 MB/s	66 MHz
PCI (64-bit)	266 MB/s	33 MHz
PCI (64-bit)	533 MB/s	66 MHz

Another difference in PCI cards is that early versions used 5 volts but newer versions used 3.3 volts. Lower voltages decrease the heat generated by the cards. They also increase the speed of the devices because it takes less time for a signal to reach 3.3 V than it does to reach 5 V. Each of these types is keyed differently, as shown in Figure 2-4, to prevent plugging a board into the wrong slot.

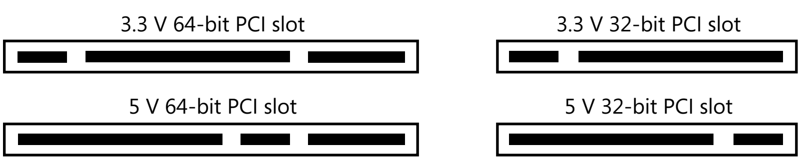

FIGURE 2-4 PCI slots.

> ***TIP*** **PCI CARDS**
>
> **Some PCI cards are created as universal cards with keying that can fit into either a 3.3-V or a 5-V slot. However, only 32-bit PCI cards can plug into 32-bit PCI slots and only 64-bit PCI cards can plug into 64-bit PCI slots.**

Even though PCI has been largely replaced by PCIe, you will likely still see some PCI expansion slots on motherboards. The two versions have different slots, so it is easy to tell the difference between PCI and PCIe expansion slots and cards.

AGP

Accelerated Graphics Port (AGP) is a dedicated expansion slot used for graphics. A huge benefit of AGP over PCI was that it used a separate bus for graphics data so it wasn't competing with data from other expansion cards. Before AGP, graphics cards were plugged into a PCI slot and all PCI devices shared the same data bus. Graphics-intensive applications such as computer-aided design (CAD) applications and some games were extremely slow without AGP.

AGP came in four versions, with each successive version doubling the data rate. Table 2-3 shows the data rates available with the different versions. Notice that AGP always uses a 66-MHz bus.

TABLE 2-3 AGP Data Rates and Frequencies

Standard	Data Rate	Frequency
AGP	266 MB/s	66 MHz
AGP 2X	533 MB/s	66 MHz
AGP 4X	1,066 MB/s	66 MHz
AGP 8X	2,133 MB/s	66 MHz

PCI-X

PCI-Extended (PCI-X) was developed as an enhancement over PCI. It came in 64-bit versions and was primarily used on servers. A benefit was that PCI-X was backward-compatible with PCI so the PCI-X expansion cards could plug into PCI expansion slots.

The most common frequency used with PCI-X is 133 MHz, giving a data throughput rate of 1,064 MB/s. PCI-X also came in versions with different frequencies and data rates, as shown in Table 2-4, but 133 MHz remained the most common.

TABLE 2-4 PCI-X Data Rates

Standard	Data Rate	Frequency
PCI-X	532 MB/s	66 MHz
PCI-X	1,064 MB/s	133 MHz
PCI-X	2.15 GB/s	266 MHz
PCI-X	4.3 GB/s	533 MHz

EXAM TIP

PCI-X and PCIe are sometimes confused and referred to as the same thing, but they are very different. PCI-X is an upgrade to PCI, is backward-compatible with PCI, and is primarily used on servers. PCIe is a newer standard that is designed to replace PCI, PCI-X, and AGP, but it is not backward-compatible with these other versions.

PCIe

PCI Express (PCIe) is the primary standard you'll see in use today in place of PCI, PCI-X, and AGP. Engineers designed this significantly differently from other busses. Three important differences are as follows:

- **Data sent in byte streams.** Previous expansion busses used 32 bit or 64-bit connections and would transfer these bits in parallel, as 32 bits at a time or 64 bits at a time. PCIe instead sends the data as a continuous stream of data bytes and achieves higher data throughputs. The stream is sent as serial data (one bit at a time) instead of parallel.
- **No external clock signal.** Because the data is sent as a stream of bytes, PCIe isn't tied to an external clock signal. This effectively allows it to transfer data much more quickly.
- **Multiple two-way lanes.** A PCIe expansion card includes one or more lanes used to transfer serial data streams. Because the lanes are two-way, a device can send data at the same time it is receiving data. These multiple lanes allow a PCIe card to send and receive more data at the same time. A PCIe can have 1, 2, 4, 8, 16, or 32 lanes (designated as x1, x2, x4, x8, x16, and x32).

Figure 2-5 shows a comparison of different PCIe slots related to a 32-bit PCI slot. There are two important points about these slots:

1. PCIe slots almost always have a plastic extension used to provide additional support for the card. This extension doesn't include any pins but does help the card fit snugly and prevent it from wiggling loose. Smaller cards have one extension, and larger cards often have two extensions.
2. The keying for each of the PCIe cards is the same. If you have a PCIe x1 card, you can plug it into the PCIe x1 slot, the PCI x4 slot, or the PCIx16 slot, as shown in Figure 2-5.

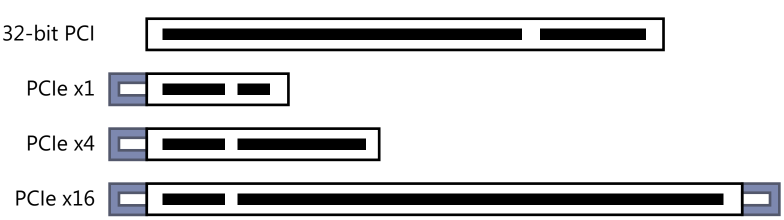

FIGURE 2-5 PCI and PCIe expansion slot comparison.

If you plug a smaller card into the larger slot, some of the pins aren't used, but these additional pins are used for additional lanes that aren't supported by the smaller PCIe x1 card. You can plug any smaller PCIe card into a larger PCIe slot. For example, you can plug a PCIe x4 card into a PCIe x8, PCIe x16, or PCIe x32 slot. However, you can't put a larger card into a smaller slot any more than you can put a round peg into a square hole. It just won't fit.

EXAM TIP

You can plug smaller PCIe expansion cards into larger PCIe expansion slots. However, you cannot mix and match PCI and PCIe expansion cards. PCIe is not backward-compatible with PCI.

PCIe has been steadily improving over the years, and there are currently three versions of PCI. The slots are the same, but each version supports faster speeds. Table 2-5 shows the different data rates you can get out of different PCIe versions. Because PCIe isn't using an external clock, the speed is measured in transfers per second, and all the PCIe versions achieve speeds in the gigatransfers per second (GT/s) range.

TABLE 2-5 PCIe Data Rates

Standard	Data Rate per Lane	Transfers per Second
PCIe v1	250 MB/s	2.5 GT/s
PCIe v2	500 MB/s	5 GT/s
PCIe v3	1 GB/s	8 GT/s
PCIe v4	2 GB/s	16 GT/s

Table 2-5 shows only the data rate per lane. If you have a PCIe x2 card, you'll get the same data rate in each of the two lanes, doubling the overall data rate. Similarly, x4, x8, x16, and x32 cards multiply the overall data rate.

MiniPCI

MiniPCI slots were developed for use in laptop computers. They are smaller and use a 32-bit, 33-MHz bus. They are commonly used to install a wireless network interface card into the slot so the laptop can connect to wireless networks.

MiniPCI Express (MiniPCIe) is an upgrade to MiniPCI similar to the way PCIe is an upgrade to PCI. The MiniPCIe slots and cards are smaller than the MiniPCI slots and cards, but they can carry larger amounts of data. Chapter 8, "Working with Laptops," covers laptops in more depth.

CNR

Some motherboards have a *Communications and Networking Riser (CNR)* expansion slot. It is about the size of a PCIe x1 slot, although it is not compatible with PCIe. The CNR slot is specifically designed to accept audio, modem, and network interface cards. These types of expansion cards have to be certified by the United States Federal Communications Commission (FCC), and by creating the cards separately from the motherboard, manufacturers can certify the motherboards separately from the CNR expansion cards. This allows motherboard manufacturers to create new motherboards more quickly and then just plug in the precertified CNR card. In contrast, when these FCC-governed devices are built into the motherboard, each new motherboard has to be certified separately.

End users rarely insert cards into the CNR slot. Instead, *original equipment manufacturers (OEMs)* would put the appropriate card into the motherboard as they are building a computer.

> ***NOTE*** **WHAT IS AN OEM?**
>
> **An OEM is any company that resells another company's product using their own name and branding. For example, Dell uses motherboards it has purchased from Intel to build computers that it sells. These are marketed as Dell computers, and Dell is the OEM.**

CNR slots aren't common in computers today. Instead, motherboards commonly integrate these capabilities within the motherboard. However, you might see them on smaller form factor motherboards, such as micro-ATX systems.

CPU Chipsets

A CPU *chipset* is one or more ICs that provide the primary interface between the CPU and the rest of the system. The two primary manufacturers of CPUs are Intel and Advanced Micro Devices (AMD). The two primary manufacturers of chipsets that work with these CPUs are also Intel and AMD. Older chipsets divided their functions into *north bridge* and *south bridge*. Newer CPUs take over the functions of the north bridge.

North Bridge and South Bridge

Recent versions of chipsets have used two chips called the north bridge and the south bridge. Figure 2-6 shows how a north bridge (NB) and south bridge (SB) chipset interact.

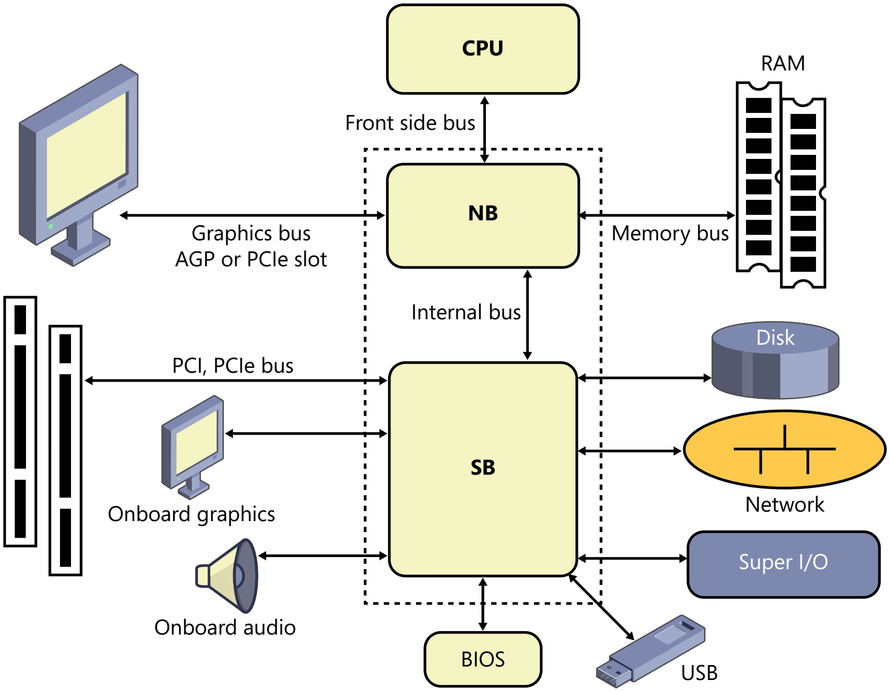

FIGURE 2-6 North bridge and south bridge chipset.

- **North bridge.** The north bridge, also called the *memory controller hub* (*MCH*), is the primary interface for high-speed devices such as the CPU, RAM, and, if it exists, a dedicated graphics slot. On newer processors, the north bridge functions have been taken over by the CPU, as you can see in Figure 2-7.
- **South bridge.** The south bridge provides an interface to low-speed devices, which is essentially everything else in the system. It is also called the I/O Controller Hub (ICH).

EXAM TIP

Features included on a motherboard are dependent on support from the chipset. When the feature is included, it is referred to as *onboard* or *built-in*. For example, the south bridge includes onboard graphics. Alternately, you can add a dedicated graphics card and not use the onboard graphics.

The Super I/O is a separate chip that provides connections to different types of legacy, or older, I/O devices via a serial port, a parallel port, the keyboard, or the mouse. It includes a *universal asynchronous receiver transmitter (UART)* chip needed to translate data between serial and parallel connections. Most new devices use USB, so the Super I/O chip isn't needed or included on many current systems.

Combining North Bridge onto the CPU

Understanding how the north bridge is used for high-speed devices and how the south bridge is used for lower-speed devices is useful background information. However, many newer motherboards using both Intel and AMD CPUs use a single chipset and have moved the functionality of the north bridge to the CPU.

Figure 2-7 shows the configuration for the Intel X79 Express Chipset. If you compare this to Figure 2-6, you can see the differences. Instead of using a single front side bus for graphics, RAM, and the chipset, the CPU has three separate busses: a PCIe bus for graphics, a data bus for RAM, and a Direct Media Interface (DMI) bus for the chipset. The chipset takes care of the rest.

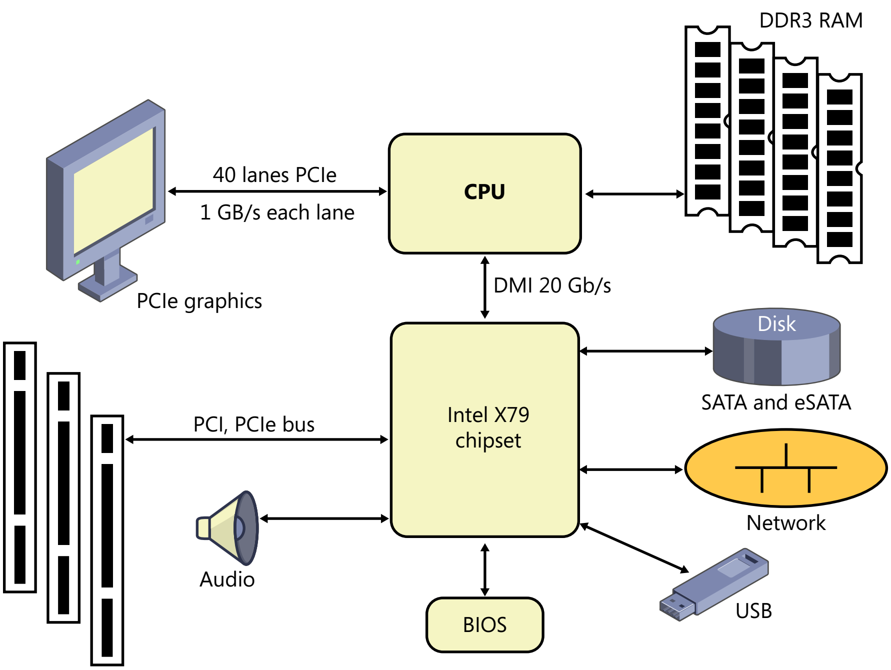

FIGURE 2-7 Newer chipset without north bridge and south bridge.

> ***NOTE*** **POPULAR CHIPSET MODELS**
>
> **Two popular models of current chipsets that have moved the north bridge functions to the CPU are Intel's Sandy Bridge model and AMD's Fusion model.**

Jumpers

Motherboards have a variety of different pins that can be connected with jumpers for different purposes. The most common reason to access a jumper is to reset the BIOS password. It's possible for a user to set the password for the BIOS so that only that user can access the BIOS settings. If the user forgets the password, you can clear it with a jumper so that you are able to manage the BIOS.

Figure 2-8 shows the connections to clear the password, with the jumper removed and lying to the left of the pins. The directions are printed directly on the motherboard (on the bottom left), and for clarity, the pins are labeled. If you want to clear the password, you connect the jumper to pins 1 and 2. By default, this jumper is connected to pins 2 and 3.

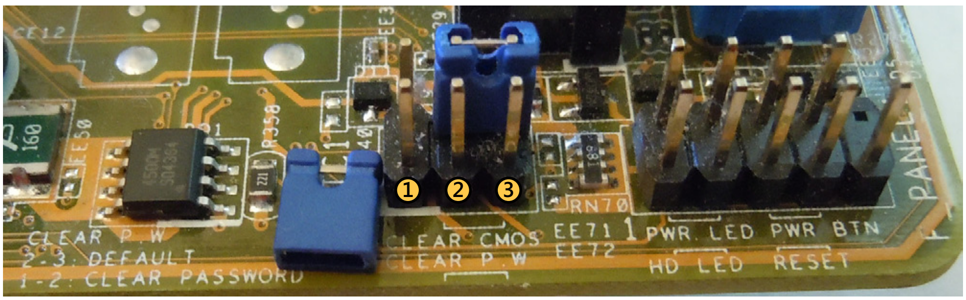

FIGURE 2-8 Motherboard outline.

> ***NOTE*** **JUMPERS**
>
> **This motherboard also has a jumper labeled as CLEAR CMOS. This will reset all of the BIOS settings to the factory default. In Figure 2-8, this jumper is connected to pins 2 and 3, but moving the jumper to pins 1 and 2 will reset the BIOS settings.**

Some motherboards include jumpers that affect the clock speed. By manipulating the jumpers, hobbyists can cause the CPU to run with a faster clock. This is commonly called overclocking and is mentioned in the "Clock Speeds" section later in this chapter.

Front Panel Connectors

Motherboards commonly have connectors that are used to run wires to the front panel. If you look again at Figure 2-8, you can see several front panel connectors on the motherboard (to the right of the password jumper). Wires are plugged into these connectors with the other ends going to the appropriate connection on the front panel. Some common connectors include the following:

- **Power light.** This indicates when the system is turned on from the front panel power button. In the figure it's labeled as PWR LED for *power light emitting diode (LED).*

- **Power button.** This turns the power on for the computer and is labeled as PWR BTN in the figure. This is different from a power switch on the back of the computer. If there is a power switch on the back of the computer, it turns on the power supply but not the computer.

EXAM TIP

ATX motherboards introduced soft power allowing the power to be controlled from the front panel. Plugging in and turning on the power supply provides power to the motherboard, but the computer isn't fully turned on until the front panel button is set to on. If you suspect this power button is faulty, you can remove the connection and connect the two pins on the motherboard connector by using a flat-blade screwdriver. This simulates pressing the button. If the system then turns on, you've verified the power button is faulty. If it doesn't turn on, the problem is elsewhere.

- **Drive activity lights.** When the disk drive is actively reading or writing data, these lights will blink. They are typically red LEDs. Figure 2-8 shows this labeled as HD LED for hard disk drive LED.
- **Reset button.** Many systems include a reset button that will force the computer to restart. Whenever possible, it's better to logically shut down and restart a computer, but if the computer isn't responsive to any keyboard or mouse commands, you can force a restart by pressing the reset button.
- **USB.** On the rear panel, motherboards commonly include USB connections that are connected directly to the motherboard. However, USB devices are very popular with users and users often want access to USB ports on the front panel. Wires run from the USB ports on the front panel to connectors on the motherboard.
- **Audio.** Many systems include one or more audio outputs on the front panel that are connected from the motherboard. A headphone or speaker jack is usually a lime green color and includes a headphones icon. Some systems also have a microphone jack, commonly a pink color, with a microphone icon.

Quick Check

1. **Is it possible to plug a PCIe x4 card into a PCIe x1 slot?**
2. **How can you reset the BIOS password?**

Quick Check Answers

1. **No. You can plug smaller PCIe cards into larger PCIe slots, however.**
2. **Connect the clear password jumper on the motherboard.**

Viewing an Actual Motherboard

Earlier in this chapter, in Figure 2-1, you saw a line drawing of a motherboard with an explanation of many of the components. Figure 2-9 shows a picture of an Intel DX 79SI Extreme series motherboard with the individual components identified. It's a newer motherboard, so it doesn't have some of the older components, such as AGP slots or IDE connectors.

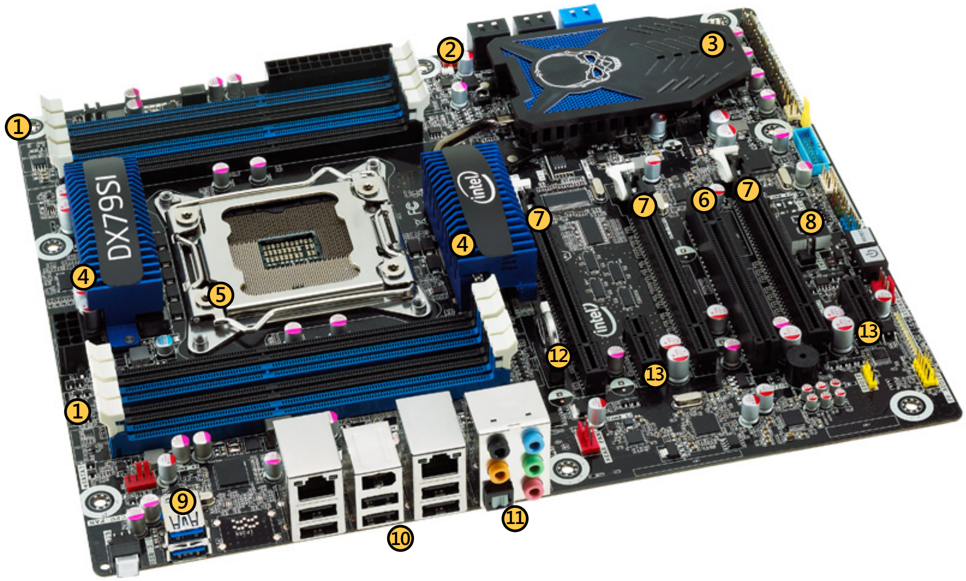

FIGURE 2-9 Intel motherboard. Photo provided by Intel. [Copyright © Intel Corporation. All rights reserved. Used by permission.]

1. **RAM slots.** This motherboard includes eight dual in-line memory module (DIMM) slots for double data rate type 3 (DDR3) memory.
2. **SATA ports.** Four SATA 3 GB/s ports and two SATA 6.0 GB/s ports are included. It's not apparent in the figure, but the 3 GB/s ports are black and the 6 GB/s ports are blue, so that they can be distinguished from each other.
3. **Intel X79 Express Chipset.** This chipset uses the Direct Media Interface (DMI) as an interface to the CPU.
4. **Voltage regulators covered by heat sinks.** The heat sinks keep the voltage regulators cool. One is providing power for the CPU, and one is providing power to the chipset.
5. **CPU socket.** This socket is for an Intel Core i7 processor with either four or six cores.
6. **One PCI expansion slot.** This is for earlier-version PCI cards.

7. **Three PCIe 3.0 x 16 expansion slots.** These are for newer PCIe boards.
8. **Power-on self test (POST) decoder.** This displays different numbers as the system progresses through the startup cycle. It can be used for troubleshooting the motherboard in place of a PCI or PCIe card used for providing the same information.
9. **USB ports 3.0 ports.** These are accessible via the back panel. Other connectors on the board can be routed to USB connectors on the front panel.
10. **Back panel ports.** This group includes two RJ-45 network interface connections, one IEEE 1394 firewall connection, and six USB 2.0 connections.
11. **Audio back panel ports.** This group includes multiple connections for different types of audio, including 7.1 systems.
12. **CMOS battery.** This motherboard is using a circular battery, but the battery is inserted sideways into a battery slot.
13. **PCIe x1 expansion slots.** These are for smaller x1 cards.

BIOS

The *Basic Input/Output System (BIOS)* includes software code that provides a computer with basic instructions so that it can start. When a computer is turned on, it runs the program within BIOS to do some basic system checks, locate the operating system on a disk, and start.

For example, most computers have the operating system on a hard disk, and BIOS provides the initial instructions on how to locate the hard disk and start the operating system. The programming provided by BIOS is referred to as the *bootstrap programming*, and starting a computer is commonly called *booting* a computer. The BIOS allows the computer to start without any user intervention other than turning it on.

The program within BIOS is stored in a chip on the computer that can be rewritten. Older computers used an *electrically erasable programmable read-only memory chip (EEPROM)* for the BIOS. *Read-only memory (ROM)* has gone through several iterations over the years, from *programmable read-only memory (PROM)*, to *erasable read-only memory (EPROM)*, and then to *EEPROM*. New computers use a type of flash memory similar to what is used with USB thumb drives.

NOTE **WHAT IS FIRMWARE?**

The BIOS is often referred to as *firmware*. It is a hardware chip that you can physically see and touch, and it includes software that runs code on the computer. The combination of hardware and software is firmware.

BIOS also includes a BIOS setup application you can use to configure different settings for your computer. For example, you can set the time of the computer, identify which drive to boot to, configure the CPU to support virtualization technologies, and more. These settings are explored later in this chapter.

BIOS vs. CMOS

As you study computers, you're likely to come across the term *complementary metal oxide semiconductor (CMOS)*. When referring to BIOS and CMOS, there are differences.

- **BIOS.** This is the firmware. It stores the instructions for starting the computer and includes a program that can be used to change some settings. The firmware can be updated in a procedure referred to as *flashing the BIOS* (covered later in this chapter).
- **CMOS.** This holds only the user-configurable BIOS settings, such as the current time. Users can change these settings by accessing the BIOS application. CMOS is volatile, meaning that the data is lost if the system is turned off. Motherboards include a CMOS battery to retain the CMOS data even if the system is turned off.

That's probably clear to you: BIOS is the application, CMOS is the data, and a CMOS battery keeps CMOS powered to retain the settings. Unfortunately, it's misleading.

Technically, CMOS is a specific type of chip that you'll rarely find on any motherboard, but there is still a need to store the user-configurable settings. Instead of CMOS, the data can be stored on battery-powered static RAM. Sometimes, it's stored in the same chip as the *real-time clock* that is keeping time. Just like CMOS, these chips are powered by a battery when the system is turned off to ensure the system keeps these settings.

When the BIOS is using newer flash memory, the user-configurable data is often stored on the same chip as the BIOS application. Due to how flash memory stores data, it doesn't even need a battery. However, the real-time clock still needs a battery to keep time when the system is turned off.

Even though systems no longer have CMOS, and this battery isn't powering CMOS, it is still commonly called the *CMOS battery*. Even the CompTIA objectives refer specifically to CMOS and the CMOS battery.

BIOS Vendors

Just as you can purchase software developed by different vendors, motherboard manufacturers can use BIOS developed by different vendors. Two of the most popular BIOS vendors are American Megatrends (AMI) and Phoenix Technologies. Each vendor develops different versions of BIOS to meet the needs of different motherboard manufacturers.

The motherboard vendor chooses the BIOS to include with the motherboard, so you don't have to worry about which one to use. However, there are differences between versions, so it's important to realize that one system will look different from another.

Accessing the BIOS Application

When you first turn on a computer, you'll see one or more screens flash onto the screen, providing bits of information. One of these screens gives you a message to press a specific key to access the setup options or the setup utility.

> ***NOTE*** **BIOS CAN MEAN DIFFERENT THINGS IN DIFFERENT CONTEXTS**
>
> **Primarily, BIOS refers to the bootstrap code used to start the computer without user intervention. However, technicians commonly use the term BIOS to refer to the setup application or setup utility. If you're asked to access the BIOS, you're being asked to get into the setup application or setup utility.**

The only sure way of knowing what key to press is by reading the screen. For example, if the screen says to press the <F2> key to enter the setup utility, you'll need to press the F2 function key. Other common keys or key combinations are: F1, F10, Del (delete key), Ctrl+Alt+Esc keys (pressed at the same time), and Ctrl+Alt+Enter keys. On some laptops, you press the Fn+Esc or FN+F1 keys.

Admittedly, that's a lot of combinations. Just remember that what you really need to do is read the messages on the screen as the system starts.

I strongly encourage you to start up the BIOS on a computer and go through these settings. Your BIOS might not use the same words, but you'll be able to see the settings. You can change settings in the BIOS, and as long as you don't save your changes, they won't apply.

After the BIOS starts, it will look similar to Figure 2-10. The mouse cannot be used in most BIOS utilities; instead, you have to use the keyboard and arrows to navigate. Somewhere on the screen, each BIOS utility will have directions about how to navigate through the program, how to select individual settings, and how to change them. In the figure, these instructions are in the right pane.

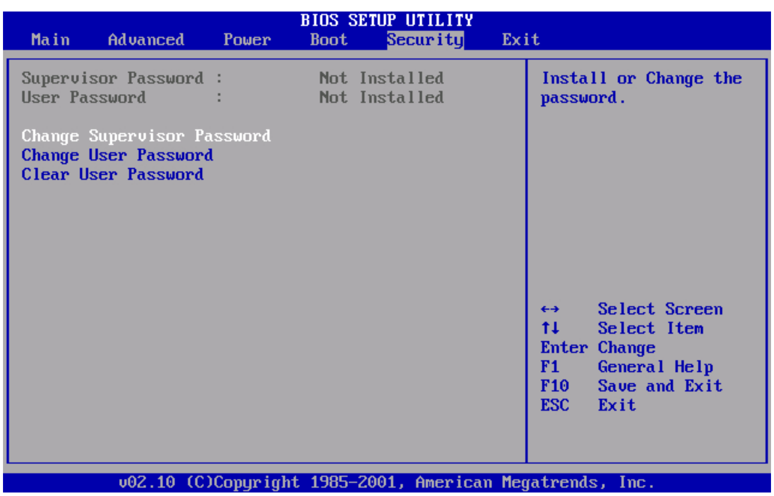

FIGURE 2-10 BIOS setup utility.

BIOS Component Information

You can use the BIOS to verify the different components that are installed on a system. This can be useful to ensure that the system is recognizing newly installed hardware. For example, if you install new RAM but it's not recognized, the BIOS can sometimes give you insight into the problem.

Figure 2-11 shows a screen from a different BIOS version with the system information page selected.

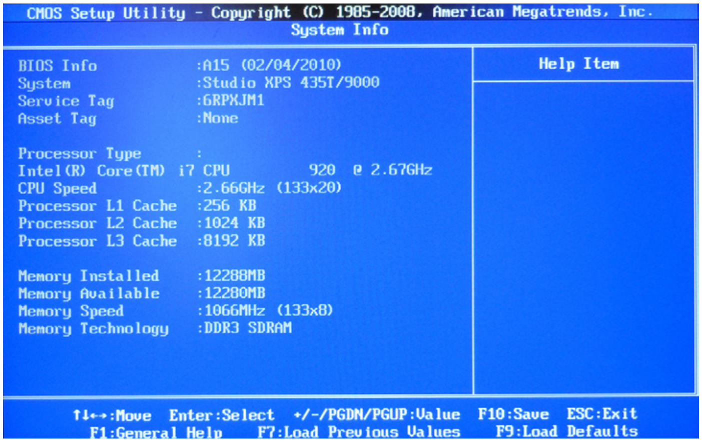

FIGURE 2-11 BIOS setup utility.

This page shows information about the processor type, processor cache, and memory. You can see that the processor is an Intel Core i7, with a 133-MHz clock multiplied by 20, giving a CPU speed of 2.66 GHz.

You can also see that the system has 12 GB (12,288 MB) of RAM installed. The RAM has a speed of 1,066 MHz (using a 133-MHz clock multiplied by 8) and is DDR3 SDRAM.

Additionally, most BIOS systems will automatically detect the presence of different drives and report their presence within BIOS. This includes hard disk drives and different types of optical drives, such as DVD drives. Sometimes these settings are reported in the Standard CMOS Features page, if it exists, and other times the settings are on a dedicated page for the drives.

Drives might be reported as SATA1, SATA2, and so on if the system is using a SATA interface. If the system is using an EIDE interface, they might be reported as IDE, EIDE, or as hard disk drives.

This can be useful if you've installed a new drive but find that it's not recognized after starting. Go into BIOS, find the drive settings, and ensure that the new drive is recognized by BIOS. If it's not recognized, you need to check the hardware such as the cables or configuration.

EXAM TIP

If you've installed any type of hardware but find that it's not recognized after you boot into an operating system, check the BIOS. It might not be recognized by BIOS, indicating that it's not connected correctly or has a fault. It could be disabled in BIOS, and all you'll need to do is enable it. If a drive is recognized by BIOS but not by the operating system, the problem is probably related to a software driver. Drivers are covered in more depth in Chapter 15, "Configuring Windows Operating Systems."

BIOS Configuration

There are a few configuration settings that are important to understand. Changes you make in the configuration will remain in the system even after the system has been powered off.

Time and Date

A very basic setting for the BIOS is the time and date. You'll often see these settings on the very first page of BIOS, which is sometimes called the Main page or the Standard CMOS Features page.

The computer keeps time with a real-time clock, and the CMOS battery keeps the clock ticking even when the system is turned off. You rarely need to change this except when the CMOS battery is failing. If the battery is failing, the real-time clock is slow and needs to be reset often.

EXAM TIP

Common symptoms of a failing CMOS battery are a slow clock or errors related to CMOS settings. If you find you have to reset a clock more than once, you should consider replacing the battery. After unplugging the power to the system, you can remove the battery with a small screwdriver and replace it. After replacing the battery, you'll need to set the date and time, and you might need to reconfigure other BIOS settings.

When replacing the battery, make sure that you replace it with the correct type. Motherboard manufacturers warn that the wrong battery could explode. Also, always follow local regulations when disposing of the original battery.

Boot Sequence

One of the most important BIOS settings for a PC technician to understand is the boot sequence. The boot sequence setting tells the computer the device from which it should try to boot first.

Figure 2-12 shows the boot sequence screen in BIOS. Currently, it's set to boot to the hard drive. If the hard drive doesn't have a bootable operating system, it will look for a bootable operating system on the CDROM, then on a floppy drive, and then by using PXE. As configured, it will never boot using the CDROM drive unless the hard drive failed. If you want to boot using a bootable CDROM drive, you need to change the configuration.

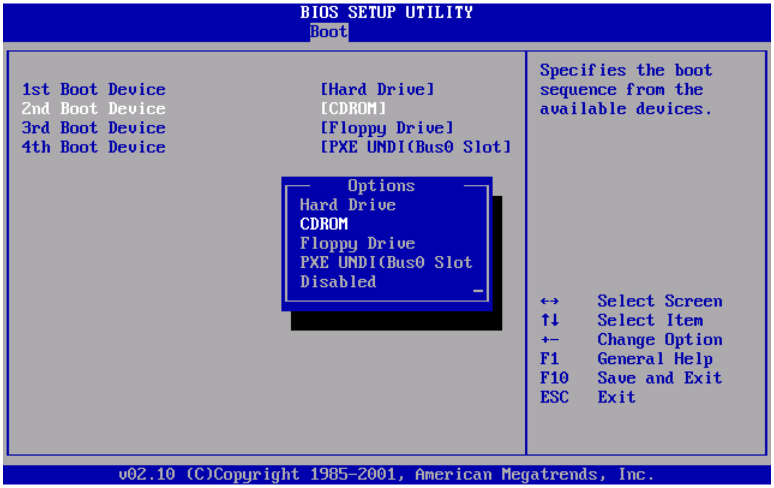

FIGURE 2-12 Configuring the boot sequence.

EXAM TIP

The BIOS on most systems is configured to boot to the hard drive first and will look at other drives only if there's a problem with the hard drive. To boot from a CD or DVD drive, you often have to modify the BIOS.

In Figure 2-12, I selected CDROM in the 2nd Boot Device row and pressed Enter. The Options box has appeared, and I can now use the arrows to change the order. For example, if I press the Up Arrow so that Hard Drive is highlighted and then press Enter, the CDROM and Hard Drive selections will change positions. The system will then attempt to boot to the CDROM first.

The BIOS uses the CDROM setting for any type of optical drive. These include CD drives and DVD drives.

The PXE (Preboot Execution Environment) selection shown in Figure 2-12 allows a system to boot by using a network interface card. A PXE-enabled system contacts a server on the network and can then download an operating system over the network. Chapter 12, "Installing and Updating Windows Operating Systems," discusses network installations using PXE.

Enabling and Disabling Devices

You can often enable and disable devices in BIOS. For example, in Figure 2-12, one of the selections in the Options menu is Disabled. If you want to disable any of the devices, you can select Disabled.

Different types of BIOS allow you to enable and disable devices from different menus. Other devices that can sometimes be enabled or disabled from a BIOS menu include the following:

- **USB controller.** Disabling this prevents USB devices from working.
- **Onboard 1394 (Firewire) controller.** Disabling this prevents Firewire devices from working.
- **Onboard graphics.** This disables graphics capabilities from the chipset. You would disable this on systems that have a dedicated graphics card.
- **Onboard audio.** This disables audio capabilities from the chipset. You would disable this on systems that have audio cards installed in an expansion slot.
- **Onboard network card.** This disables network capabilities from the chipset. You would disable this on systems that have a network interface card installed in an expansion slot.

EXAM TIP

Chipsets include a wide variety of onboard features and capabilities, but these are often basic. It's common to upgrade some features by adding an expansion card. If an expansion card is added, the related onboard feature should be disabled to prevent conflicts. For example, if a powerful graphics card is added, the onboard graphics should be disabled.

Virtualization Support

Virtualization allows you to run one or more operating systems in virtual machines (VMs) instead of physical systems. The VM runs as an application within the physical computer, often called the *host*.

For example, imagine that you wanted to master the details of how Windows 8 and Windows Server 2012 work, but you still want to use Windows 7 for your day-to-day work. Purchasing two additional physical computers and installing Windows 8 on one and Windows Server 2012 on the other would be expensive.

Instead, you can use virtualization software on your Windows 7 computer. You can then install Windows 8 as one VM and Windows Server 2012 as another VM. Figure 2-13 shows how the two VMs would run within Windows 7.

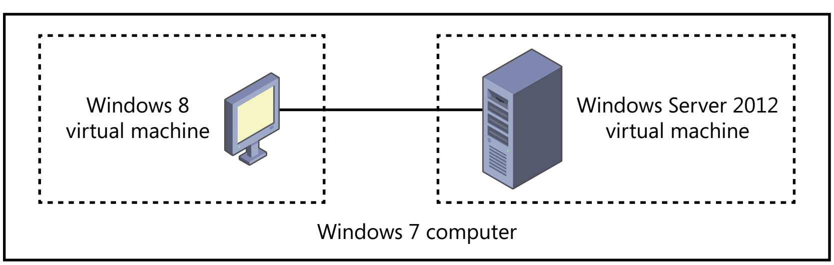

FIGURE 2-13 Running two VMs within Windows 7.

You can configure the VMs so that they can communicate with each other and share Internet access with the host machine. Any time you wanted to play around with a VM, you would start it by using your virtualization software.

EXAM TIP

Virtualization is popular technology frequently used by many IT professionals. It's important to understand the basics, the relevant BIOS settings, and the requirements. This section provides some basics and lists BIOS settings. Chapter 10, "Working with Customers," lists the requirements in a virtualization workstation and mentions virtualization software.

One of the core requirements for virtualization applications to run is CPU support. Most current CPUs include hardware-assisted virtualization (HAV) features, but they are identified differently depending on the CPU vendor:

- **VT-x.** Intel refers to its HAV features as VT-x.
- **AMD-V.** AMD refers to its HAV features as AMD-V, or AMD Virtualization.

Some Intel-based motherboards require you to enable virtualization in the BIOS before it's used. It's referred to differently depending on the BIOS vendor. However, two common names and locations are as follows:

- **Virtualization.** Locate the setting in the Virtualization Support menu and enable the Intel Virtualization Technology setting.
- **Virtualization Technology.** Locate the setting in the System Configuration menu.

Clock Speeds

Motherboards typically include a *serial presence detect* (*SPD*) chip that detects and stores the speed of the CPU and the RAM. The BIOS either reads the data from the SPD chip or automatically detects the clock speeds and reports them. For example, if you look again at Figure 2-11, you can see the CPU and memory speeds. These were detected from the SPD chip.

Some BIOS utilities allow you to manipulate these clock speeds by altering the frequency, the multiplier, or the voltage. For example, if a system has a 133-MHz clock and a 20x multiplier, the speed is 2.66 GHz. If you change the clock from 133 MHz to 148 MHz, you have a speed of 2.96 GHz. If you also change the multiplier from 20x to 24x, you have a speed of 3.55 GHz.

Manufacturers commonly warn that modifying these settings can cause additional heat or other damage, cause the CPU or other components to fail, and reduce system performance. However, for the promise of a quicker PC, many hobbyists are willing to take the risk.

NOTE OVERCLOCKING

Even though motherboard and CPU manufacturers strongly discourage the practice of overclocking, they also realize that hobbyists do so and have created tools to make it easier. For example, if you go to Intel's download center (*http://downloadcenter.intel.com/*) and search "extreme tuning utility," you'll find a tool that you can use to monitor the clocks. If the CPU includes Intel's Turbo Boost Technology, you can use this tool to overclock a system without going into the BIOS.

The biggest danger of overclocking is heat. The more quickly a system runs, the hotter it gets. If it gets too hot, it can destroy components. Chapter 3 talks about some advanced methods of keeping systems cool, including liquid-cooled systems.

Security

Many BIOS utilities include security settings, and the most common security setting is related to BIOS passwords. Other possible settings are related to a *Trusted Platform Module (TPM)* and *LoJack*.

Looking again at Figure 2-10, you can see the settings for a supervisor password and a user password. When set, the supervisor password provides full control over any BIOS settings and is sometimes set by administrators to ensure that they can override any changes made by a user.

Depending on the BIOS, the user password provides varied access. It might allow the user to do anything except change the supervisor password, or it might allow the user to change only limited settings such as the date and time. In some systems, it requires a user to enter the password every time the system is started.

EXAM TIP

It might seem that setting a BIOS password provides a lot of security for the system. However, anyone with a little bit of IT education (or who has read this chapter) knows that most motherboards include a jumper that can reset the BIOS password and override the security.

The TPM is a chip on the motherboard that is used with software applications for security. For example, many Windows-based systems include BitLocker Drive Encryption that can work with a TPM. Combined, they provide full-disk encryption and monitoring of the system. Encryption applies a cipher to the data so that it cannot be read.

If someone steals a drive from an unprotected PC, the thief might be able to install it as a secondary drive in another computer and read the data. However, if the drive is protected with a TPM and BitLocker, the thief will not be able to read data from the drive.

Many automobiles include a LoJack unit. It includes a small transceiver, and if the auto is stolen, it can send out signals used to locate it. Similarly, many laptops include a feature from

Computrace known as LoJack for Laptops, from Computrace. It is disabled by default in the BIOS but can be enabled after purchasing a license from Computrace.

POST and Other Diagnostics

When a computer boots, it will run some basic tests commonly known as *power-on self test* (*POST*). POST performs only rudimentary checks on a few core devices. It ensures that the CPU and system timer are both running, that the RAM and graphics are accessible, that the keyboard is working, and that BIOS is not corrupt.

If the computer passes these tests, it will continue to boot. If it fails one of these tests, it stops and gives you an indication of the failure. You'll usually see an error on the display, but POST can't rely on the display, so it uses different types of beep codes.

The POST routine is in the BIOS, and as you now know, there are many different types of BIOS. Similarly, there are just about as many versions of beep codes. The BIOS manufacturer or the motherboard manufacturer has documentation on each of their beep codes, but it is not feasible to list what every POST beep code means. The following are a few examples of what you might hear:

- **No beep.** This often indicates that a system has no power or has a problem with the power supply. However, some systems do not beep at all, and this is normal.
- **One short beep.** This usually indicates that the system has passed the POST. In some systems, it indicates that the RAM might have a problem.
- **Continuous beep or repeating beeps.** This often indicates a problem with the power supply, the motherboard, or the keyboard.
- **Buzz or quickly repeating beeps.** This often indicates a problem with RAM.

EXAM TIP

When the system gives a different indication than normal, look for what has recently changed. For example, if RAM was recently upgraded and it's now giving a different beep code than normal, check RAM. If nothing has recently changed, you should check the power supply voltages.

Many newer systems will display a message on the screen associated with the beeps. For example, if a key is stuck on the keyboard, you'll hear a different beep code and you'll see a message on the monitor indicating a problem with the keyboard.

Older systems displayed cryptic codes on the screen, such as Error 301 to indicate a stuck key on the keyboard. You had to look up the error code in a manual to determine the error. You'll rarely see messages with just an error code today. Instead, if a key is stuck, you'll see a display indicating that a key is stuck.

Some BIOS programs include other built-in diagnostics. For example, I have a laptop that has a Diagnostic menu that includes selections to run tests on memory and the hard drive. However, these tests are often very basic, and you can find better tools. For example, Chapter 3 covers the Windows Memory Diagnostic, which can be used to check for memory problems. Chapter 16, "Understanding Disks and File Systems," covers many tools, such as chkdsk, that can be used to check and repair disk problems.

POST Cards

Looking again at Figure 2-9, you can see that this motherboard has a POST decoder built into it. As the system boots, this LED display changes as POST enters various stages. By watching this LED as the system boots, you can identify what phases are succeeding and the point at which the system fails. The motherboard manual lists codes from 00 through F9 hexadecimal.

For systems that don't have this built into the motherboard, you can use a *POST card*. POST cards that you can plug into a PCI or PCIe expansion card are available, and they have an LED display that displays the POST code as the system is starting.

Monitoring

Some BIOS applications include the ability to monitor the system and provide feedback when issues are detected. The BIOS records the information, and when the system is restarted, it displays a message on the monitor describing the issue. Some common examples include the following:

- **Temperature monitoring.** Systems with temperature monitors will often shut down when the CPU gets too hot to protect them. When the system restarts, you'll see a message indicating that the system was previously shut down due to a thermal event. This is a clear indication to check all the fans.
- **Intrusion detection/notification.** If the case has a biased switch, as described in Chapter 1, opening the case causes the BIOS setting to change. Each time the system is restarted afterward, the CPU will indicate the detected intrusion.
- **Fan speeds.** The BIOS can monitor the speed of some variable-speed fans and report when the speed exceeds predefined thresholds.
- **Voltage.** Some voltages can be monitored. A variance of more than 5 percent of the specified voltage indicates a problem that can be reported by the BIOS.

Flashing the BIOS

As mentioned earlier, the BIOS is firmware, meaning that it includes software code installed on a hardware chip. This firmware can be upgraded through a process commonly known as *flashing the BIOS*. When you flash the BIOS, you're erasing the original firmware and writing new firmware onto the system.

A common reason to flash the BIOS is to add a capability to your system. For example, you might try to run a virtualization program on your system but get an error indicating that virtualization isn't enabled in the BIOS. When you look in the BIOS, you realize it doesn't have a setting to enable virtualization. However, a newer version of BIOS supports virtualization, so you first need to upgrade the BIOS.

If you need to flash the BIOS, go to the computer manufacturer's website. If the manufacturer doesn't maintain one, you'll need to go to the website of the motherboard manufacturer. One of these sites will provide free downloads of programs you can use to flash the BIOS. First you'll need to see what version of BIOS you have and compare it to available versions.

You can check the version of BIOS you have in your system with the System Information tool in Windows systems. You can access this on Windows 7 systems by clicking Start, typing **msinfo32** in the Search Programs And Files text box, and pressing Enter. It's also available via the Start, All Programs, Accessories, System Tools menu. Figure 2-14 shows the System Information dialog box with the BIOS data shown.

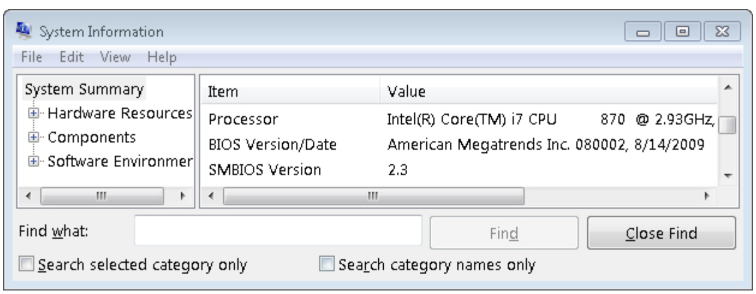

FIGURE 2-14 Viewing the BIOS version in System Information dialog box.

If your version is older than a version available from the manufacturer, you can update it.

Years ago, this was a tedious process. You had to download the program, copy it to a drive that could boot to a basic disk operating system (DOS), restart the computer, boot to this drive, and run the program. The bootable drive was often a floppy or a USB drive, so even creating this bootable drive was a challenge for some people.

The process is much easier today. Most manufacturers provide the update in an application you run from Windows. For example, I recently updated the BIOS on an HP laptop. I located the update on the HP website, downloaded it, and ran it from Windows 7. Figure 2-15 shows what it looks like.

It shows that the version of the current BIOS is slightly older than the new BIOS version (hexadecimal F.26 instead of hexadecimal F.2D). A dialog box appeared asking if I wanted to update the BIOS, and after I clicked Yes, it ran. It took a moment to update the firmware, and when it completed, the system shut down. That was it. The next time I started this computer, it started using the new BIOS.

FIGURE 2-15 Flashing the BIOS with a program from the manufacturer.

> ***IMPORTANT*** **DO NOT TURN OFF COMPUTER DURING UPDATE PROCESS**
>
> **If the system loses power before completing the update, the program in BIOS might be only partially written or corrupt. You will no longer be able to start the system, and usually the only option is to return the computer or motherboard to the manufacturer. Ideally, you should plug the computer into an uninterruptible power supply (UPS).**

UEFI

BIOS is being replaced by Unified Extensible Firmware Interface (UEFI) on many systems. The functionality is largely the same as BIOS—it provides an interface between the hardware and the software so that the computer can start. However, the UEFI provides some enhancements.

One of the primary advantages of UEFI is the ability to boot from disks over 2 TB in size. Additionally, it is designed to be CPU-independent. That is, the same UEFI could potentially work with both Intel and AMD CPUs. Although the CompTIA objectives don't mention UEFI, you might see it, especially when working with larger disks.

Quick Check

1. What would you modify to force your system to start from a CD?
2. What would you call the process of upgrading the BIOS?

Quick Check Answers

1. BIOS
2. Flashing

Troubleshooting

Throughout this chapter, many potential problems and their solutions were addressed. This section reminds you of some common symptoms you might encounter, along with some details about what to check.

- **Invalid boot disk or attempts to boot to incorrect device.** This indicates that the system is trying to boot to a device that doesn't have a bootable operating system. The system might have a non-bootable CD in the drive and is trying to boot from the CD. Remove the CD and try again. You can also modify the BIOS boot sequence to boot to the hard drive first.
- **Fans spin, no POST beep, no power to other devices.** The most likely culprit here is that the CPU is not getting power. This is provided from a 4-pin or 8-pin power connector to the motherboard. It then goes through a regulator to the CPU. Measure the voltages with a multimeter. If the voltages to the motherboard are good, the problem is probably the regulator on the motherboard. It could also be the CPU, but this is less likely unless it was just replaced. The fans spin because the power supply doesn't need the CPU to power them.

> ***NOTE*** **SPINNING FANS, NO POWER**
>
> **Spinning fans and no power to other devices can be a challenging problem. The most likely source is the power supply or the voltage regulator on the motherboard. However, if this symptom started soon after you replaced a component, check that component.**

- **BIOS time and settings reset.** If the BIOS time or settings reset, it indicates that the battery has failed or is failing. You might also see an error from the BIOS on startup, such as CMOS Battery Error, CMOS Checksum Error, or CMOS Timer Error. The solution is to replace the battery.
- **Blank screen on startup.** If you don't see any display on the screen, make sure that everything is plugged in and turned on. Also, make sure that the system is plugged

into the correct connection. Many systems have add-on graphics expansion cards and onboard graphics. The onboard graphics is disabled so that the screen will be blank if the display connection is plugged in here. Instead, plug the monitor into the expansion card.

- **No power.** Make sure that the power supply is plugged in and turned on and that the front panel power button is depressed. Then check the voltages from the power supply as mentioned in Chapter 1. If the voltages are out of tolerance, replace the power supply. If the voltages are good, the motherboard or an expansion board might be faulty.
- **Stop error.** This is commonly called a *blue screen of death* (*BSOD*). If hardware prevents the system from starting, this stop error screen gives an indication of the problem, which could be a faulty motherboard, faulty RAM, or a problem accessing the hard drives.

If you suspect a motherboard is faulty, there usually isn't much you can do. Motherboards themselves can't be repaired by technicians in the field. You can replace the CMOS battery, manipulate jumpers, and replace the CPU, RAM, and expansion cards. However, if the motherboard itself is faulty, you can either send it back to the manufacturer if it is under warranty or you can replace it with another motherboard.

Chapter Summary

- The most popular motherboard form factor is ATX. Smaller motherboard form factors are micro-ATX and different versions of ITX.
- The speed of the computer is determined by bus speeds, and a computer will have multiple busses for transferring information. Bus speeds are based on the speed of a crystal oscillator and a multiplier.
- Expansion slots are used to add expansion cards. Expansion cards expand the capabilities of the computer. Older AGP, PCI, and PCI-X expansion slots are replaced by PCIe in most current computers. PCIe cards cannot be plugged into an AGP, PCI, or PCI-X slot.
- AGP was used for dedicated graphics cards and came in 2x, 4x, and 8x versions. Each version doubled the data rate of the earlier version. AGP had a data rate of 266 MB/s at 66 MHz, and AGP 8x had a data rate of 2133 MB/s.
- PCIe supports multiple two-way lanes and can have 1, 2, 4, 8, 16, or 32 lanes, designated as x1, x2, x4, x8, x16, and x32. More lanes require larger slots. You can plug in smaller PCIe expansion cards (such as x2) into larger PCIe expansion slots (such as x8).
- Motherboards include a chipset to support the CPU and to provide additional features. The north bridge provides an interface for high-speed devices such as the CPU, RAM, and a dedicated graphics card when it's used. The south bridge provides an interface for everything else.

- Newer CPUs have taken over the function of the north bridge and directly access RAM and the PCIe graphics cards. The chipset provides an interface for everything else that is similar to the older south bridge.
- Motherboards include jumpers for different purposes, and almost all motherboards include jumpers that are used to clear the BIOS password and to clear all of the BIOS settings.
- Motherboards include connectors that are used to run wires to the front panel of a computer. These are used for LED indicators, a power button, audio, and USB connections.
- The BIOS includes software embedded on a motherboard chip (commonly called firmware). It includes the code accessed when a computer first starts and helps the computer start.
- BIOS also includes a program that can be used to view and modify configuration of a system. When the system starts, it shows a message indicating what key to press to access this program. Common keys are F2, F10, or Del.
- Common BIOS configuration settings that you can manipulate are the boot sequence, enabling and disabling devices, and the date and time. If the BIOS loses time, if time needs to be reset frequently, or if the system generates CMOS errors, replace the battery.
- BIOS includes power-on self test (POST), which performs basic checks on core hardware components. If it fails POST, it will display an error on the display and give a series of beeps to indicate the problem. These beep codes are different for different systems, so you'll need to consult a manual.
- POST cards are available as PCI or PCIe expansion cards to watch the progress of a system as it starts. It displays codes in an LED display for different phases of the startup.
- BIOS monitors, records, and reports abnormal events related to high temperatures, intrusion detection, fan speeds, and some voltages. These errors are reported when the system restarts.
- Flashing the BIOS is the process of updating it. You can obtain a program to flash the BIOS from the computer manufacturer or the motherboard manufacturer. Before running the program, plug the computer into an UPS to ensure that it doesn't lose power during the update.

Chapter Review

Use the following questions to test your knowledge of the information in this chapter. The answers to these questions, and the explanations of why each answer choice is correct or incorrect, are located in the "Answers" section at the end of this chapter.

1. Which of the following choices lists common motherboard form factors from the smallest to the largest?
   - **A.** Pico-ITX, mini-ITX, micro-ATX, ATX
   - **B.** Pico-ITX, micro-ATX, mini-ITX, ATX
   - **C.** ATX, pico-ITX, mini-ITX, micro-ATX
   - **D.** Mini-ITX, micro-ATX, pico-ITX, ATX
2. Of the following choices, what two components determine the speed of a bus?
   - **A.** Bit size and multiplier
   - **B.** Crystal frequency and bit size
   - **C.** Crystal frequency and multiplier
   - **D.** CPU capability and cache size
3. You have PCIe x2 card that you want to install into a computer. Of the following choices, where could you install it?
   - **A.** PCIe x1 expansion slot
   - **B.** PCIe X4 expansion slot
   - **C.** PCI expansion slot
   - **D.** PCI-X expansion slot
4. You are trying to start a system from a bootable DVD, but the system always boots to the hard drive instead. What should you do?
   - **A.** Replace the DVD.
   - **B.** Replace the DVD drive.
   - **C.** Manipulate the start sequence in the BIOS.
   - **D.** Flash the BIOS.
5. When starting a computer, you see a message indicating a CMOS error. What is the most likely solution?
   - **A.** Flash the CMOS.
   - **B.** Flash the BIOS.
   - **C.** Replace the battery.
   - **D.** Replace the CMOS.

6. After trying to run virtualization software, you realize that the BIOS doesn't support virtualization. What should you do?
   - **A.** Upgrade the CPU.
   - **B.** Upgrade the motherboard.
   - **C.** Replace the CMOS battery.
   - **D.** Flash the BIOS.

Answers

This section contains the answers to the chapter review questions in this chapter.

1. **Correct Answer:** A
   - **A. Correct:** Pico-ITX form factors are 3.9 x 2.8 inches, Mini-ITX are 6.7 x 6.7 inches, micro-ATX are between 6.75 x 6.75 inches and 9.6 x 9.6 inches, and ATX form factors are 12 x 9.6 inches.
   - **B. Incorrect:** Micro-ATX is smaller than mini-ITX.
   - **C. Incorrect:** ATX is the largest, not the smallest.
   - **D. Incorrect:** Pico-ITX is the smallest.
2. **Correct Answer:** C
   - **A. Incorrect:** The bit size (such as 32-bit or 64-bit) determines the data throughput, not the speed.
   - **B. Incorrect:** The bit size determines the data throughput.
   - **C. Correct:** The frequency of the oscillator crystal and the multiplier combine to determine a bus speed.
   - **D. Incorrect:** The CPU uses the clock speed, but it doesn't determine the speed.
3. **Correct Answer:** B
   - **A. Incorrect:** A larger PCIe card will not fit in a smaller PCIe slot.
   - **B. Correct:** You can plug smaller PCIe cards into larger PCIe slots, so a PCIe x2 card will fit in a PCIe x4 slot.
   - **C. Incorrect:** PCIe cards are not compatible with PCI slots.
   - **D. Incorrect:** PCIe cards are not compatible with PCI-X slots.
4. **Correct Answer:** C
   - **A. Incorrect:** Replacing the DVD might be necessary, but you should check the BIOS first.
   - **B. Incorrect:** Replacing the DVD drive might be necessary, but you should check the BIOS first.
   - **C. Correct:** You can change the boot order in the BIOS so that the system tries to boot to the DVD first.
   - **D. Incorrect:** You would flash the BIOS only if it needed to be upgraded. You should try to change the settings first.

5. **Correct Answer:** C

   A. **Incorrect:** The CMOS isn't flashed. Settings in the CMOS are configured by the user and retained by battery power.

   B. **Incorrect:** You'd flash the BIOS to upgrade it, but an upgrade wouldn't solve this problem.

   C. **Correct:** This error indicates that the settings in CMOS aren't being retained by the current battery.

   D. **Incorrect:** The BIOS is normally soldered into the motherboard, and it's rare to replace it.

6. **Correct Answer:** D

   A. **Incorrect:** The current CPU might support virtualization, but it must be enabled in BIOS.

   B. **Incorrect:** Upgrading the motherboard might not be necessary. The BIOS should be upgraded first.

   C. **Incorrect:** The battery doesn't determine whether virtualization is supported.

   D. **Correct:** If the BIOS doesn't support an option, you can often upgrade it by flashing the BIOS to get the new feature.