CHAPTER

3

All About Motherboards

After completing this chapter, you will be able to:

- Describe and contrast various types and features of motherboards
- Configure a motherboard using BIOS or UEFI firmware
- Maintain a motherboard, including updating drivers, flashing UEFI/BIOS, and replacing the CMOS battery
- Select, install, and replace a motherboard
- Replace a laptop system board

In previous chapters, you learned how to work inside a computer and began the process of learning about each major component or subsystem in a computer case. In this chapter, we build on all that knowledge to learn about motherboards, which techies sometimes call the mobo. You'll learn about the many different features of a motherboard, including motherboard sockets, chipsets, buses, expansion slots, and onboard ports and connectors. Then you'll learn how to support a motherboard, and that includes configuring, maintaining, installing, and replacing it. A motherboard is considered a field replaceable unit, so it's important to know how to replace one, but the good news is you don't need to know how to repair one that is broken. Troubleshooting a motherboard works hand in hand with troubleshooting the processor and other components that must work to boot up a computer, so we'll leave troubleshooting the motherboard until later chapters.

MOTHERBOARD TYPES AND FEATURES

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A motherboard is the most complicated component in a computer. When you put together a computer from parts, generally you start with deciding which processor and motherboard you will use. Everything else follows these two decisions. Take a look at the details of Figure 3-1, which shows a microATX motherboard by Intel that can hold an Intel Core i7, Core i5, or Core i3 processor in the LGA1155 processor socket. When selecting a motherboard, generally you'd need to pay attention to the form factor, processor socket, chipset, buses and number of bus slots, and other connectors, slots, and ports. In this part of the chapter, we'll look at the details of each of these features so that you can read a technical motherboard ad with the knowledge of a pro and know how to select the right motherboard when replacing an existing one or when building a new system.

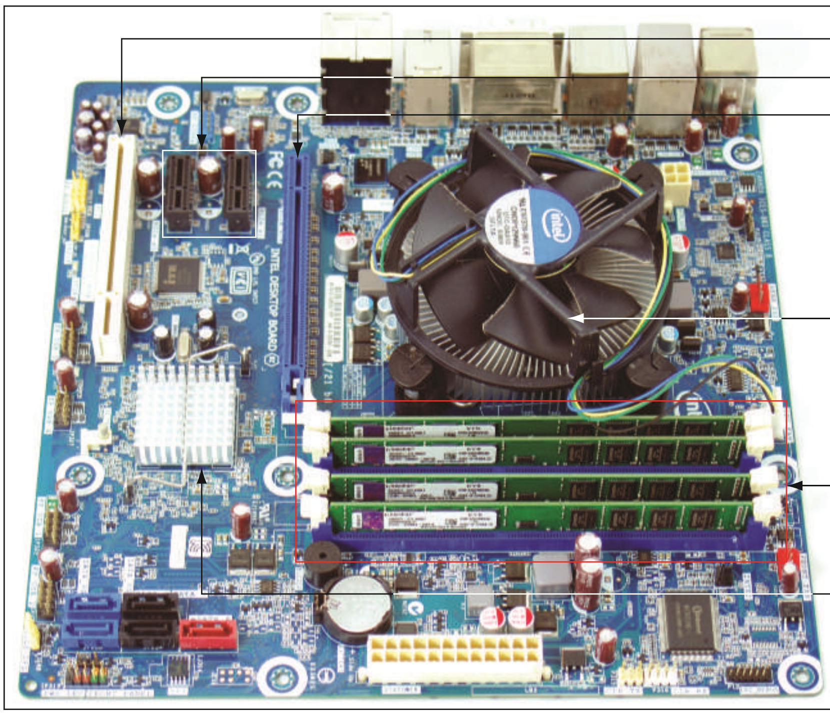

Figure 3-1 The Intel desktop motherboard DH67GD uses the microATX form factor and has the processor, cooler, and memory modules installed

MOTHERBOARD FORM FACTORS

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Recall from the chapter, "First Look at Computer Parts and Tools," that a motherboard form factor determines the size of the board and its features that make it compatible with power supplies and cases. The most popular motherboard form factors are ATX, microATX (a smaller version of ATX), and **Mini-ITX** (a smaller version of microATX). You saw a microATX motherboard in Figure 3-1. Figure 3-2 shows an ATX board, and a Mini-ITX board is shown in Figure 3-3. The Mini-ITX board is also commonly referred to as an **ITX** board.

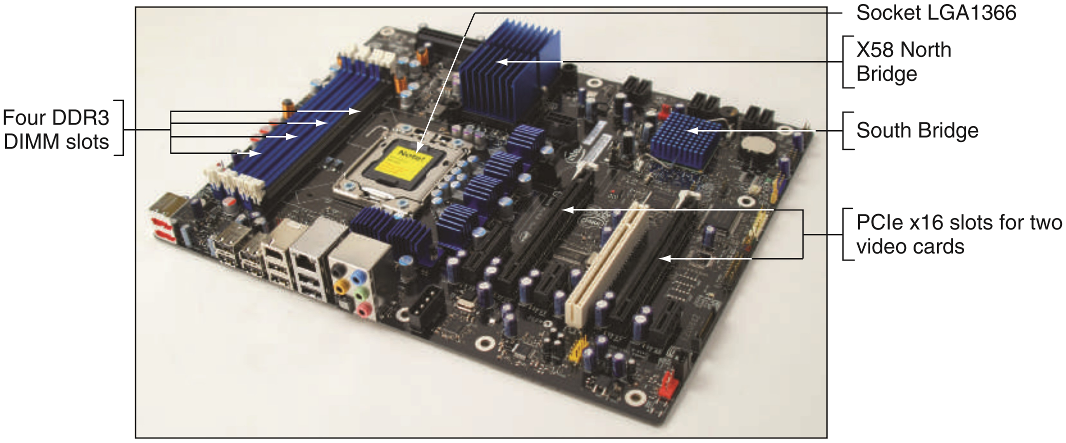
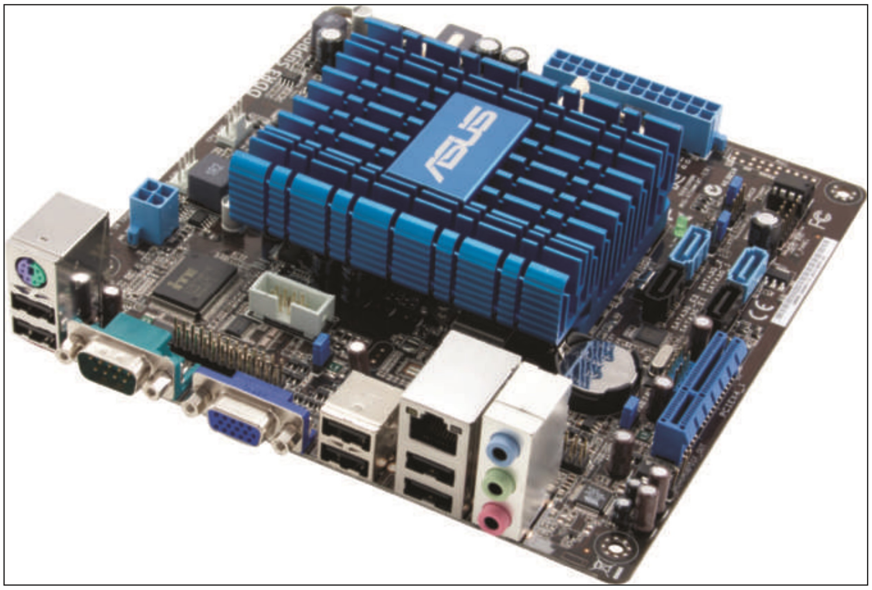


Figure 3-2 The Intel DX58SO motherboard uses the ATX form factor and is designed with the gamer in mind



Courtesy of ASUSTeK Computer, Inc.

Figure 3-3 A Mini-ITX motherboard

Table 3-1 lists the popular and not-so-popular form factors used by motherboards, and Figure 3-4 shows a comparison of the sizes and hole positions of the ATX, microATX, and Mini-ITX boards. Each of these three boards can fit into an ATX computer case and use an ATX power supply.

Form Factor	Motherboard Size	Description
ATX, full size	Up to 12" × 9.6" (305mm × 244mm)	A popular form factor that has had many revisions and variations.
MicroATX	Up to 9.6" × 9.6" (244mm × 244mm)	A smaller version of ATX.
Mini-ITX (aka ITX)	Up to 6.7" × 6.7" (170mm × 170mm)	A small form factor (SFF) board used in low-end computers and home theater systems. The boards are often used with an Intel Atom processor and are sometimes purchased as a motherboard-processor combo unit.
NLX	Up to 9" × 13.6" (229mm × 345mm)	A low profile form factor used in low-end systems with a riser card.

Table 3-1 Motherboard form factors

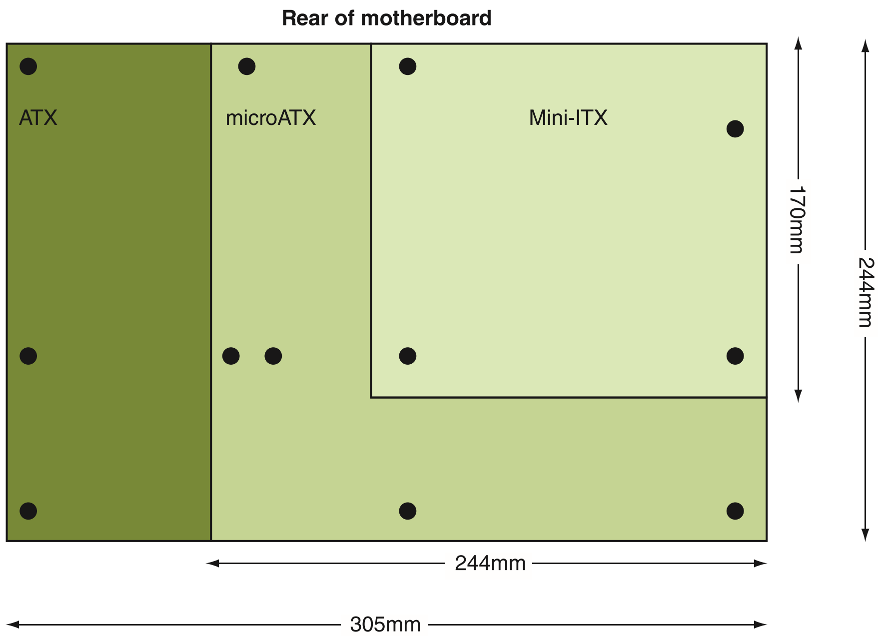


Figure 3-4 Sizes and hole positions for the ATX, microATX, and Mini-ITX motherboards

A+ Exam Tip The A+ 220-901 exam expects you to know about the ATX, microATX, Mini-ITX, and ITX motherboard form factors.

PROCESSOR SOCKETS

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Another important feature of a motherboard is the processor socket. This socket and the chipset determine which processors a board can support. A socket for a desktop or laptop computer is designed to hold either an Intel processor or an AMD processor. Some older processors were installed on the motherboard in a long narrow slot, but all processors sold today use sockets. Now let's look at sockets for Intel and AMD processors.

SOCKETS FOR INTEL PROCESSORS

Table 3-2 lists the sockets used by Intel processors for desktop systems. The first two sockets are currently used by new Intel processors. The last six sockets in the table have been discontinued by Intel, but you still need to be able to support them because you might be called on to replace a processor or motherboard that uses one of these legacy sockets. The types of memory listed in the table that are used with these sockets are explained in detail in the chapter, "Supporting the Power System and Troubleshooting Computers." Intel also makes several Itanium and Xeon processors designed for servers. These server processors might use different sockets than those listed in the table. Mobile processor sockets are also not included in the table.

Intel Socket Name	Used by Processor Family	Description
LGA1150 (aka Socket H3)	Fourth Generation (Haswell) Core i7, Core i5, Core i3, Pentium, and Celeron	◢ 1150 pins in the socket touch 1150 lands on the processor. ◢ LGA1150 (see Figure 3-5) supports DDR3 memory.

Table 3-2 Sockets for Intel processors used for desktop computers (continues)

Intel Socket Name	Used by Processor Family	Description
LGA1155 and FCLGA1155 (aka Socket H2)	Third Generation (Ivy Bridge) Core i7 Extreme, Core i7, Core i5, Core i3, Pentium, and Celeron	◢ 1155 pins in the socket touch 1155 lands on the processor. ◢ The LGA1155 (see Figure 3-6) works with DDR3 memory and was designed to replace the LGA1156 socket.
LGA2011 (aka Socket R)	Second Generation (Sandy Bridge) Core i7 Extreme, Core i7, Core i5, Core i3, Pentium, and Celeron	◢ 2011 pins in the socket touch 2011 lands on the processor, which uses a flip-chip land grid array (FCLGA). ◢ Supports DDR3 and DDR4 memory. ◢ Designed to replace LGA1366, used in high-end gaming and server computers and may require a liquid cooling system.
LGA1156 (aka Socket H or H1)	Core i7, Core i5, Core i3, Pentium, and Celeron	◢ 1156 pins in the socket touch 1156 lands on the processor, which uses a flip-chip land grid array (FCLGA). ◢ Works with DDR3 memory.
LGA1366 (aka Socket B)	Core i7, Core i7 Extreme	◢ 1366 pins in the socket touch 1366 lands on the processor. ◢ Works with DDR3 memory.
LGA771 (aka Socket J)	Core 2 Extreme	◢ 771 pins in the socket touch 771 lands on the processor. ◢ Used on high-end workstations and low-end servers. ◢ Works with DDR2 memory on boards that have two processor sockets.
LGA775 (aka Socket T)	Core 2 Extreme, Core 2 Quad, Core 2 Duo, Pentium Dual-Core, Pentium Extreme Edition, Pentium D, Pentium Pentium 4, Pentium 4 Extreme Edition, and Celeron	◢ 775 pins in the socket touch 775 lands on the processor. ◢ Works with DDR3 and DDR2 memory.

Table 3-2 Sockets for Intel processors used for desktop computers (continued)

★ A+ Exam Tip The A+ 220-901 exam expects you to know about Intel LGA sockets, including the 775, 1155, 1156, 1366, 1150, and 2011 LGA sockets.

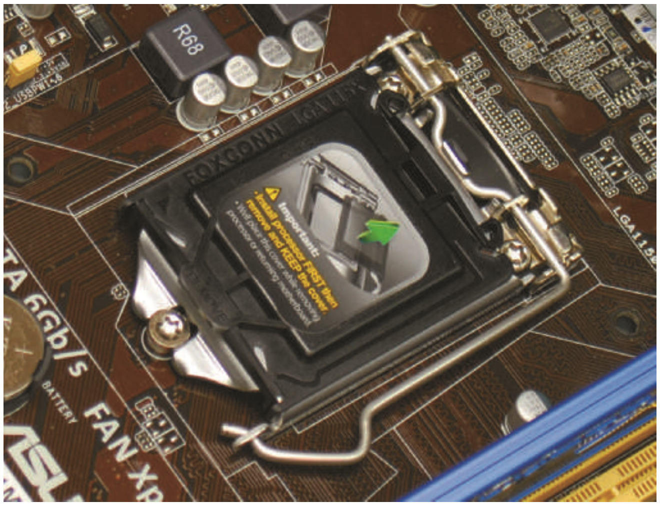

Figure 3-5 Socket LGA1150 with protective cover installed

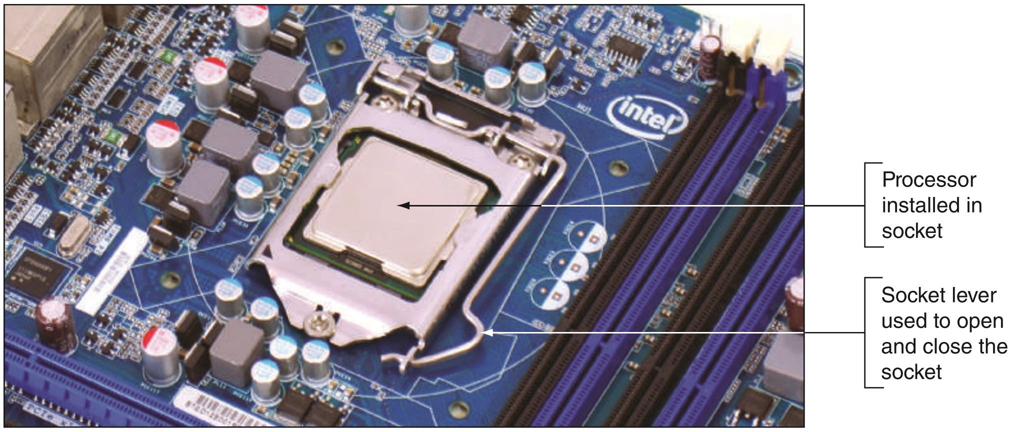

Figure 3-6 The LGA1155 socket is used by a variety of Intel processors

Sockets and processors use different methods to make the contacts between them. Here is a list of the more important methods:

- A **pin grid array (PGA)** socket has holes aligned in uniform rows around the socket to receive the pins on the bottom of the processor. Early Intel processors used PGA sockets, but they caused problems because the small delicate pins on the processor were easily bent as the processor was installed in the socket. Some newer Intel mobile processors, including the Second Generation Core i3, Core i5, and Core i7 processors, use the PGA988 socket or the FCPGA988 socket in laptops.
- A **land grid array (LGA)** socket has blunt protruding pins on the socket that connect with lands or pads on the bottom of the processor. The first LGA socket was the LGA775 socket. It has 775 pins and is shown with the socket lever and top open in Figure 3-7. Another LGA socket is the LGA1366 shown in Figure 3-8. LGA sockets generally give better contacts than PGA sockets, and the processor doesn't have the delicate pins so easily damaged during an installation. You learn how to use both sockets in the chapter, "Supporting the Power System and Troubleshooting Computers."

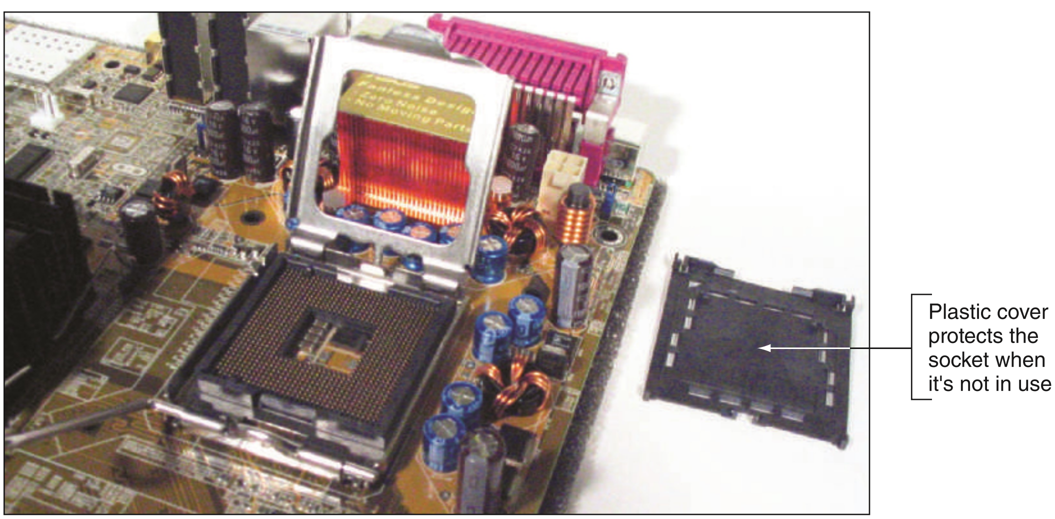

Figure 3-7 Socket LGA775 is the first Intel socket to use lands rather than pins

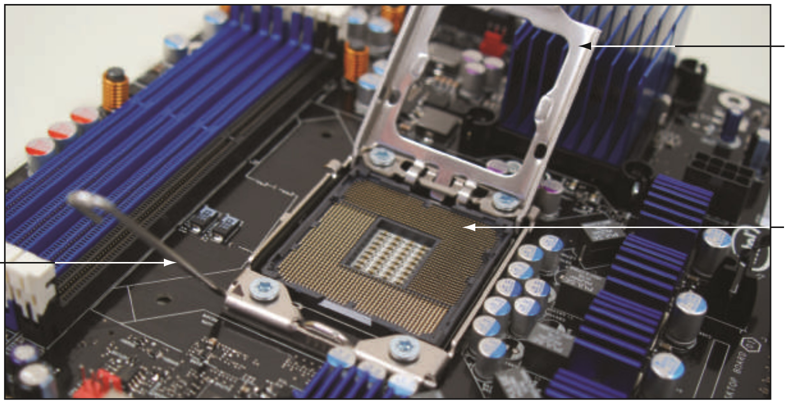

Figure 3-8 The LGA1366 socket with socket cover removed and load level lifted ready to receive a processor

> **Notes** Figure 3-9 shows a close-up photo of the LGA775 socket and the bottom of a Pentium processor. Can you make out the pads or lands on the processor and the pins in the socket?

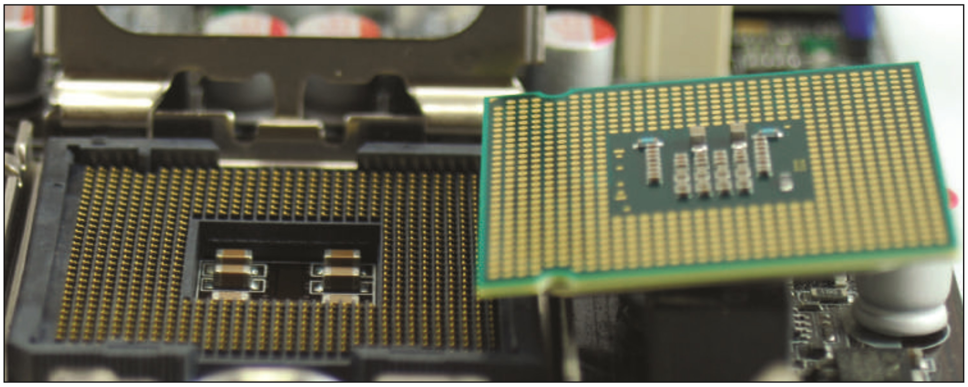

Figure 3-9 Socket LGA775 and the bottom of a Pentium processor

- Some sockets can handle a processor using a **flip-chip land grid array (FCLGA)** processor package or a **flip-chip pin grid array (FCPGA)** package. The chip is flipped over so that the top of the chip is on the bottom and makes contact with the socket. The LGA1155 socket has a flip-chip version, which is called the FCLGA1155 socket. The two sockets are not compatible.
- A **staggered pin grid array (SPGA)** socket has pins staggered over the socket to squeeze more pins into a small space.
- A **ball grid array (BGA)** connection is not really a socket. The processor is soldered to the motherboard, and the two are always purchased as a unit. For example, the little Atom processors often use this technology with a Mini-ITX motherboard in low-end computers or home theater systems.

> **Caution** When a processor is installed in a socket, extreme care must be taken to protect the socket and the processor against ESD and from damage caused by bending the pins or scratching the socket holes during the installation. Take care to not touch the bottom of the processor or the pins or holes of the socket, which can leave finger oil on the gold plating of the contact surfaces. This oil can later cause tarnishing and lead to a poor contact.

So that even force is applied when inserting the processor in the socket, all current processor sockets have one or two levers on the sides of the socket. These sockets are called **zero insertion force (ZIF) sockets**, and this lever is used to lift the processor up and out of the socket. Push the levers down and the processor moves into its pin or hole connectors with equal force over the entire housing. Because the socket and processor are so delicate, processors generally should not be removed or replaced repeatedly.

SOCKETS FOR AMD PROCESSORS

Table 3-3 lists the AMD sockets for desktop systems. AMD has chosen to use the PGA socket architecture for its desktop processors. (Some of AMD's server processors use Socket F, which is an LGA socket.) Figure 3-10 shows the AM2+ socket. The lever on the side of the socket is lifted, and an Athlon 64 processor is about to be inserted. If you look closely near the lower edge of the processor, you can see the small delicate pins that will seat into the holes of the socket.

AMD Socket	Used by Processor Family	Description
FM2+	Used with the A10-, A8-, and A6-Series of processors	◢ 906 holes for pins (PGA) ◢ Uses AMD Steamroller architecture with integrated graphics controller in the processor ◢ Works with DDR3 memory
FM2	Used with the Trinity line of processors	◢ 904 holes for pins (PGA) ◢ Uses AMD Piledriver architecture with integrated graphics controller in the processor ◢ Works with DDR3 memory
FM1	AMD A4, A6, A8, E2, Athlon II	◢ 905 holes for pins (PGA) ◢ Works with DDR3 memory
AM3+	AMD FX	◢ 942 holes for pins (PGA) ◢ Uses Bulldozer architecture and is compatible with AM3 processors ◢ Works with DDR3 memory
AM3 or AMD3	Phenom II	◢ 941 holes for pins (PGA) ◢ Works with DDR3 or DDR2 memory

Table 3-3 Sockets for AMD processors used for desktop computers

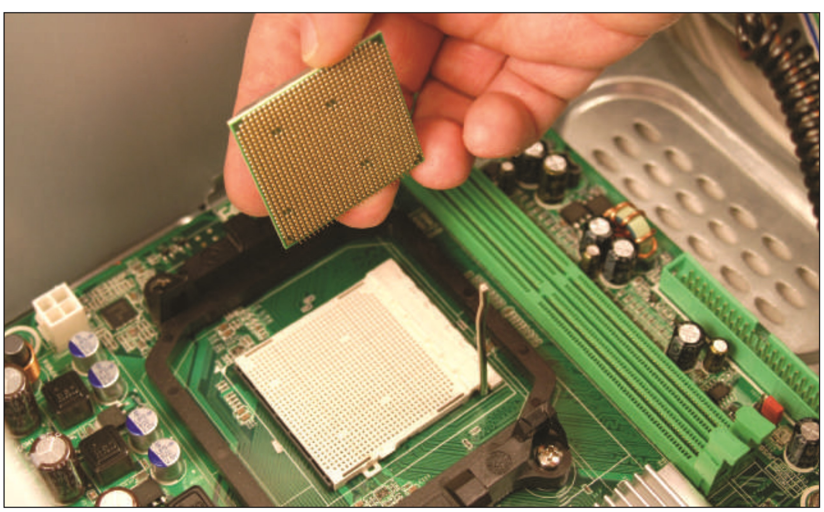

Figure 3-10 AMD Athlon 64 processor to be inserted into an AM2+ socket

A+ Exam Tip The A+ 220-901 exam expects you to know about these AMD sockets: AM3, AM3+, FM1, FM2, and FM2+.

MATCH A PROCESSOR TO THE SOCKET AND MOTHERBOARD

As you glance over Tables 3-2 and 3-3, you'll notice the same processor family listed under several different sockets. For example, the AMD Athlon family of processors offers many versions of the Athlon. Among these are the Athlon X2 Dual-Core, the Athlon Neo, and the Athlon 64 X2 Dual-Core. Because these various processors within the same processor family use different sockets, you must be careful when matching a processor to a motherboard. To be certain you have a good match, search the Intel (*www.intel.com*) or AMD (*www.amd.com*) website for the exact processor you are buying and make sure the socket it uses is the same as the socket on the motherboard you plan to use.

Also, look at the motherboard manufacturer's website or user guide for a list of processors that the motherboard supports. It's not likely to support every processor that uses its socket because the motherboard chipset is designed to work only with certain processors.

A+ Exam Tip The A+ 220-901 exam does not expect you to be familiar with the processor sockets used by laptop computers. For laptops, generally, it is more cost effective to replace a laptop that has a damaged processor than to replace the processor. If you are called on to replace a laptop processor, however, always use a processor the laptop manufacturer recommends for the particular laptop model and system board CPU socket.

THE CHIPSET

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A **chipset** is a set of chips on the motherboard that works closely with the processor to collectively control the memory, buses on the motherboard, and some peripherals. The chipset must be compatible with the processor it serves. The two major chipset manufacturers are Intel (*www.intel.com*) and AMD (*www.amd.com*).

Intel dominates the chipset market for several reasons: It knows more about its own Intel processors than other manufacturers do, and it produces the chipsets most compatible with the Intel family of processors.

INTEL CHIPSETS

Intel has produced far too many chipsets to list them here. To see a complete comparison chart of all Intel chipsets, start at the Intel link *ark.intel.com*.

Here is a list of the more significant chipset families by Intel:

- ***North Bridge and South Bridge use a hub architecture.*** Beginning with the release in 2006 of the Intel i800 series of chipsets, a hub using the Accelerated Hub Architecture is used to connect buses (see Figure 3-11). This hub has a fast and slow end, and each end is a separate chip on the motherboard. The fast end of the hub, called the **North Bridge**, contains the graphics and memory controller, and connects directly to the processor by way of a 64-bit bus, called the **Front Side Bus (FSB)**, **system bus**, or host bus. The slower end of the hub, called the **South Bridge**, contains the I/O controller hub (ICH). All I/O (input/output) devices, except video, connect to the hub by using the slower South Bridge. Notice that in Figure 3-11, the primary PCI Express slot, the slot designated for the video card, has direct access to the North Bridge, but other PCI Express slots must access the processor by way of the slower South Bridge. On a motherboard, when you see two major chip housings for the chipset, one is controlling the North Bridge and the other is controlling the South Bridge (refer to Figure 3-2). Other chipset manufacturers besides Intel also use the North Bridge and South Bridge architecture for their chipsets.

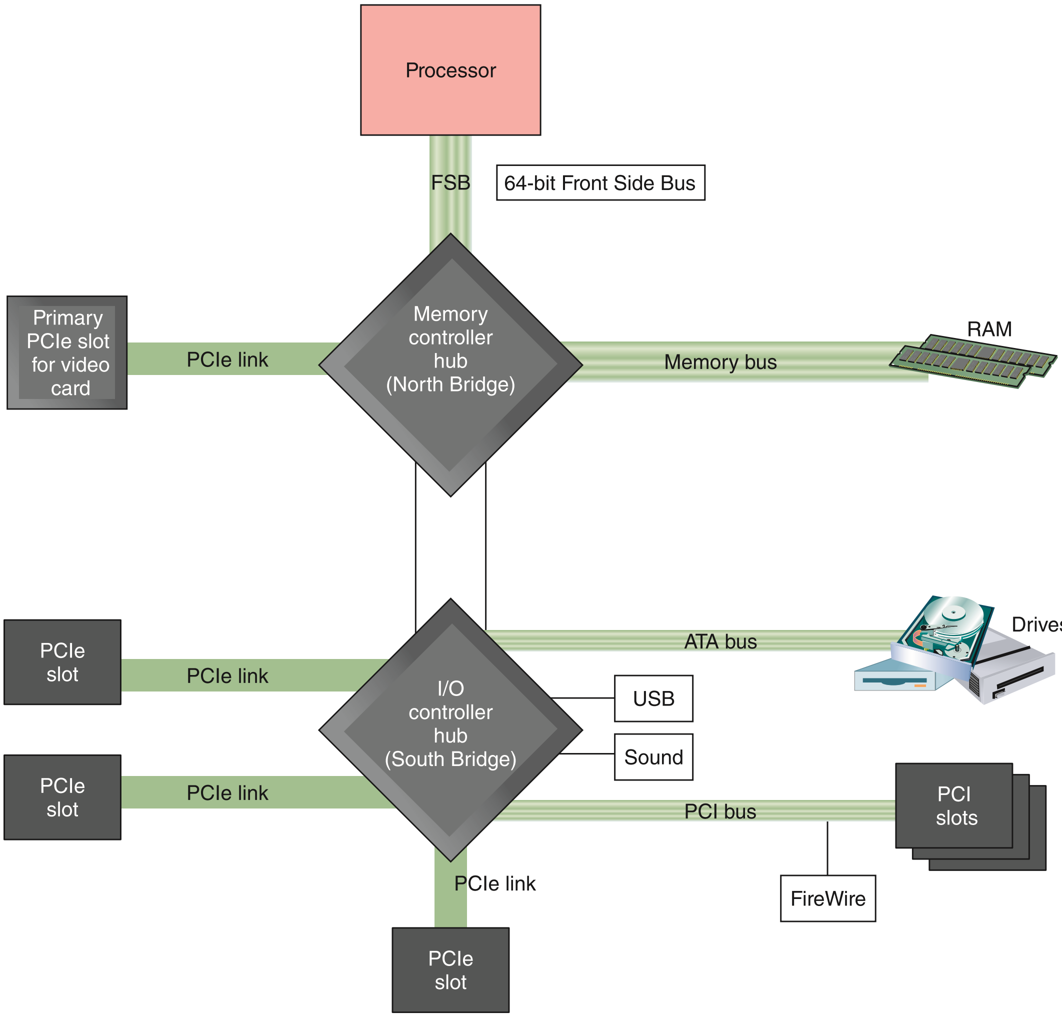

Figure 3-11 The chipset's North Bridge and South Bridge control access to the processor for all components

- ***Nehalem chipsets with the memory controller in the processor.*** The release of the X58 chipset in 2008 was significant because, with previous chipsets, the memory controller was part of the North Bridge. But beginning with the X58, the memory controller was contained in the processor housing. For example, in Figure 3-12, the Core i7 processor contains the memory controller. Notice that memory connects directly to the processor rather than to the North Bridge. Another significant change is the 64-bit Front Side Bus was replaced with a technology called the **QuickPath Interconnect (QPI)**. The QPI has 16 lanes for data packets and works similar to how PCI Express works. All Intel chipsets since the X58 use QuickPath Interconnects. A motherboard using the X58 chipset is shown in Figure 3-13. The board comes with a fan that can be clipped to the top of the North Bridge to help keep the chipset cool.

  Nehalem chipsets, which Intel has begun to call the previous generation of chipsets, support the Intel LGA1366 socket, the Core i7 processors, and PCI Express Version 2. They can also support either SLI or CrossFire technologies. (SLI and CrossFire are two competing technologies that allow for multiple video cards installed in one system.)

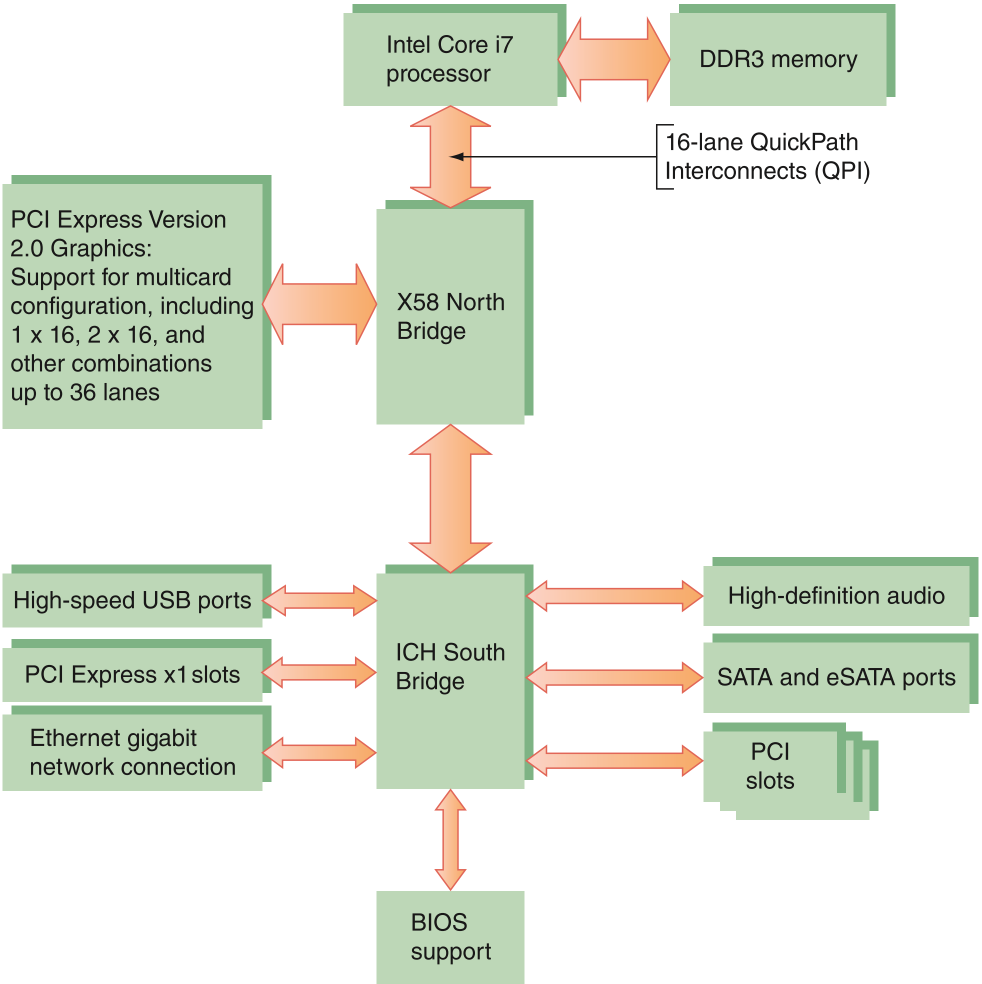

Figure 3-12 X58 chipset architecture

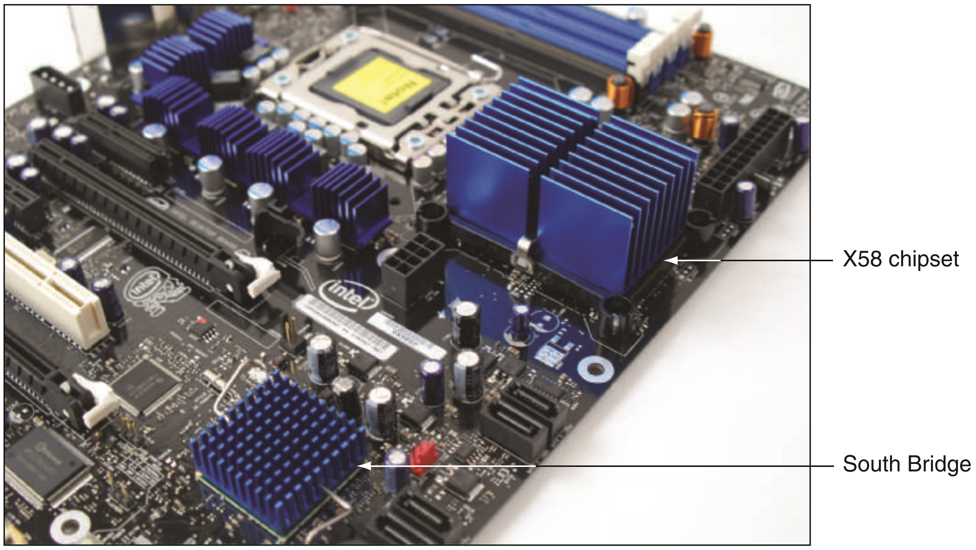

Figure 3-13 The X58 chipset uses heat sinks to stay cool

Notes For an interesting white paper by Intel on QuickPath Interconnect, including a brief history of processor interfaces, go to *www.intel.com* and search on "An Introduction to the Intel QuickPath Interconnect."

- ***Sandy Bridge chipsets with the memory and graphics controller in the processor.*** In 2011, Intel introduced its second-generation chipsets and sockets, which it code-named Sandy Bridge technologies. Rather than using the traditional North Bridge and South Bridge, only one chipset housing is needed, which houses the Platform Controller Hub. The processor interfaces directly with the faster graphics PCI Express 2.0 bus as well as with memory (see Figure 3-14). Therefore, both the memory controller and graphics controller are contained within all Sandy Bridge processors. Sandy Bridge processors, such as the Second Generation Core i7, use the LGA1155 or the LGA2011 socket, and Sandy Bridge motherboards use DDR3 memory. The Sandy Bridge H67 chipset on an Intel motherboard is shown in Figure 3-15 and earlier in Figure 3-1.

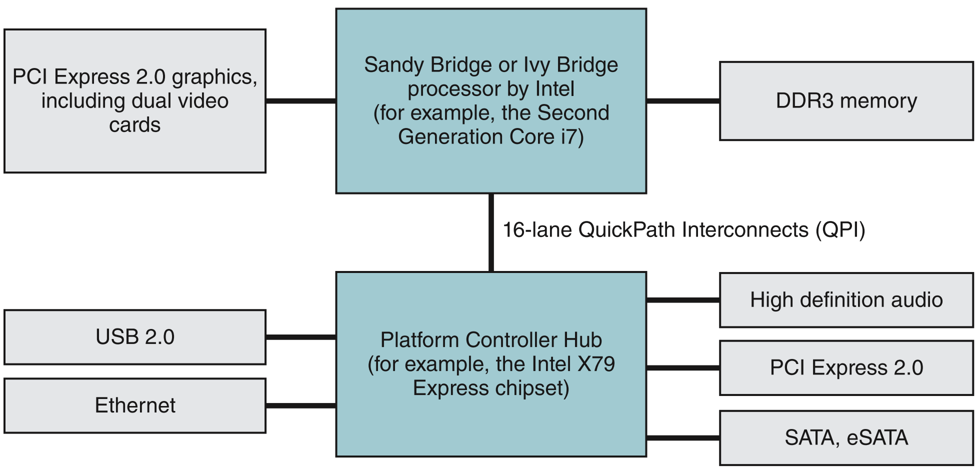

Figure 3-14 The Sandy Bridge architecture uses a single chipset hub, called the Platform Controller Hub

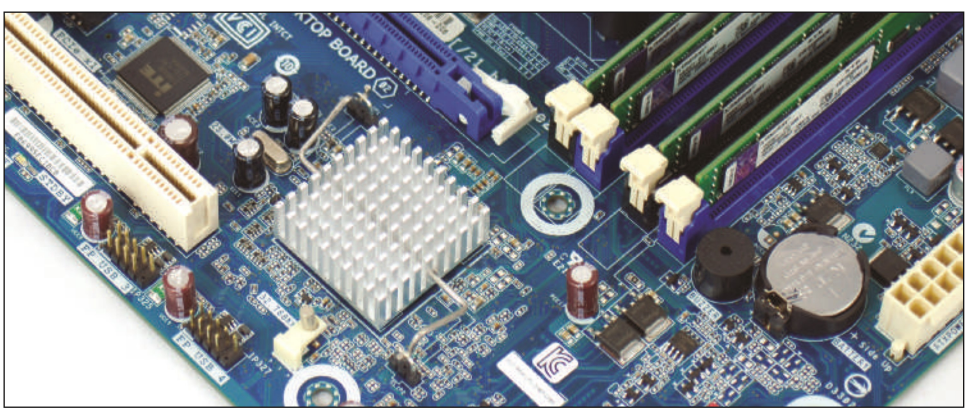

Figure 3-15 The Sandy Bridge H67 chipset on the Intel DH67GD motherboard sits under a heat sink to keep it cool

- ***Ivy Bridge chipsets.*** Third-generation processors and chipsets by Intel, released in 2012 and code-named Ivy Bridge, use less power, squeeze more transistors into a smaller space, and perform better than earlier products. Ivy Bridge chipsets include B75, Q75, Q77, H77, Z75, and Z77. Several Ivy Bridge processors use the LGA1155 socket for backward compatibility with earlier motherboards. The Ivy Bridge chipset uses a single Platform Controller Hub.

- ***Haswell and Broadwell chipsets.*** In 2013, Intel introduced the Haswell chipsets, which work with the LGA1150 and LGA2011 sockets in desktops and servers and also work with low-power processors in laptops and ultrabooks (very thin laptops). The chipsets work with DDR3 and DDR4 memory and use less power than previous chipset architectures. Broadwell chipsets, released in 2015, are a little faster than the Haswell chipsets and can also use the LGA1150 socket.

> **Notes** The Skylake chipset architecture is expected to be released by the time this text is published. The chipset will use the new LGA1151 socket and will support DDR3 and DDR4 memory.

AMD CHIPSETS

AMD specializes in chipsets and graphics processors (called a graphics processor unit or GPU) that target the gaming and hobbyist markets. The two current chipset families by AMD are:

- ***A-Series chipsets.*** These chipsets are designed to support the AMD Accelerated Processing Unit (APU). An APU is a combination of a CPU and a graphics processor unit (GPU) in the same processor housing. In traditional desktops with high graphics needs, the CPU is installed on the motherboard and a GPU is embedded on a video card, also called a graphics adapter, installed in the system. The A-Series chipsets also support AMD CrossFire technology, which uses dual video cards in the same system.
- ***9-Series chipsets.*** These chipsets are designed to support AMD processors that can have up to eight cores. You'll learn more about processor cores in the chapter, "Supporting Processors and Upgrading Memory."

Hands-On | Project 3-1 Identify the Intel Chipset and Processor on Your Computer

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Intel offers two utilities you can download and run to identify an installed Intel processor or chipset. Do the following to use the utilities:

- If you are using a computer with an Intel processor, download and run the Processor Identification Utility available at: *www.intel.com/p/en_US/support/highlights/processors/toolspiu*
- If you are using a computer with an Intel processor and your operating system is a 32-bit OS, download and run the Chipset Identification Utility available at: *www.intel.com/support/chipsets/sb/CS-009266.htm*

Websites change often, so if these links don't work, try searching the Intel website for each utility. What information does each utility provide about your processor and chipset?

Hands-On | Project 3-2 Research the Intel ARK Database

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Intel provides an extensive database of all its processors, chipsets, motherboards, and other products at *ark.intel.com*. Research the database and answer these questions:

1. List three Fourth Generation Core i7 processors. For each processor, list the Processor Number (model), the maximum memory it supports, the PCI Express version it supports (version 1.1, 2.0, 3.0, or 4.0), and the socket it uses.
2. List three Intel motherboards for desktops: An ATX board, a microATX board, and a Mini-ITX board. For each motherboard, list the processor socket it provides, the chipset it uses, the maximum memory it supports, and the number of PCIe slots it has.

(continues)

3. The X99 chipset is designed for gaming computers using the Core i7 processor. What is the launch date for theX99 chipsets?

Find the block diagram for the X99 chipset and answer the following:

4. Which processor socket does the X99 chipset support?
5. Do PCI Express 3.0 graphics adapters connect directly to the processor or to the X99 chipset?
6. Do High-Speed USB ports connect directly to the processor or to the X99 chipset?

BUSES AND EXPANSION SLOTS

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When you look carefully at a motherboard, you see many fine lines on both the top and the bottom of the board's surface (see Figure 3-16). These lines, sometimes called **traces**, are circuits or paths that enable data, instructions, and power to move from component to component on the board. This system of pathways used for communication and the protocol and methods used for transmission are collectively called the **bus**. (A **protocol** is a set of rules and standards that any two entities use for communication.) The parts of the bus that we are most familiar with are the lines of the bus that are used for data; these lines are called the **data bus**. A bus can also carry electrical power (to power components on the motherboard), control signals (to coordinate activity), and memory addresses (for one program to tell another program where to find data or instructions).

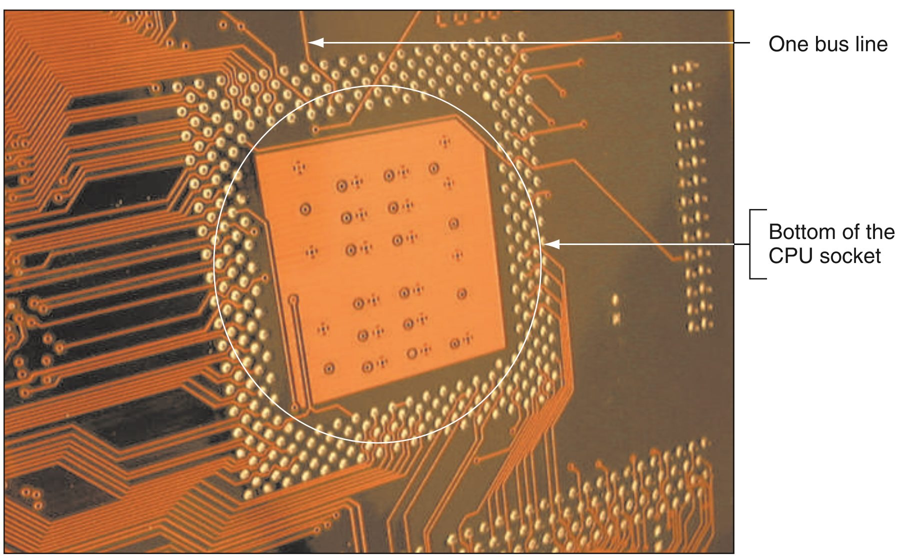


Figure 3-16 On the bottom of the motherboard, you can see bus lines terminating at the CPU socket

All data and instructions inside a computer exist in binary, which means there are only two states: on and off. Binary data is put on a line of a bus by placing voltage on that line. We can visualize that bits are "traveling" down the bus in parallel, but in reality, the voltage placed on each line is not "traveling"; rather, it is all over the line. When one component at one end of the line wants to write data to another component, the two components get in sync for the write operation. Then, the first component places voltage on several lines of the bus, and the other component immediately reads the voltage on these lines. The CPU or other devices interpret the voltage, or lack of voltage, on each line on the bus as binary digits (0s or 1s).

The width of a data bus is called the **data path size**. Some buses have data paths that are 8, 16, 32, 64, 128, or more bits wide. For example, a bus that has eight wires, or lines, to transmit data is called an 8-bit bus. Figure 3-17 shows an 8-bit bus between the CPU and memory that is transmitting the letter A (binary 0100 0001). All bits of a byte are placed on their lines of the bus at the same time: no voltage for binary zero and voltage for binary one. For every eight bits of a bus, a bus might use a ninth bit for error checking. Adding a check bit for each byte allows the component reading the data to verify that it is the same data written to the bus.

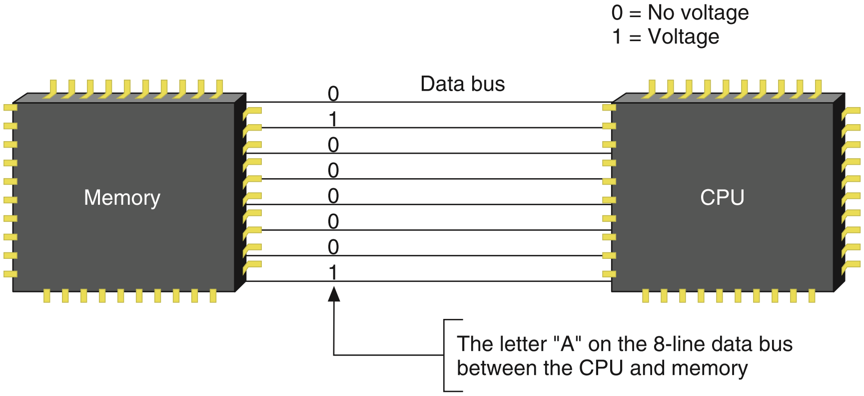


Figure 3-17 A data bus has traces or lines that carry voltage interpreted by the CPU and other devices as bits

One of the most interesting lines, or circuits, on a bus is the **system clock** or system timer, which is dedicated to timing the activities on the motherboard much like a metronome helps a musician with timing. The chipset sends out a continuous pulsating electrical signal on one line of the system bus. This one system clock line, dedicated to carrying the pulse, is read by other components on the motherboard (including the processor, bus slots, memory slots, and so forth) and ensures that all activities are synchronized. Remember that everything in a computer is binary, and this includes the activities themselves. Instead of continuously working to perform commands or move data, the CPU, bus, and other devices work in a binary fashion—do something, stop, do something, stop, and so forth. Each device works on a clock cycle or beat of the clock. Some devices, such as the CPU, do two or more operations on one beat of the clock, and others do one operation for each beat. Some devices might even do something on every other beat, but most components inside the system work according to these beats or cycles.

You can think of this as similar to children jumping rope. The system clock (child turning the rope) provides the beats or cycles, while devices (children jumping) work in a binary fashion (jump, don't jump). In the analogy, some children jump two or more times for each rope pass.

> **Notes** If the processor requests something from a slow device and the device is not ready, the device issues a **wait state**, which is a command to the processor to wait for slower devices to catch up.

The speed of memory, Front Side Bus, processor, or other component is measured in **hertz (Hz)**, which is one cycle per second; **megahertz (MHz)**, which is one million cycles per second; and **gigahertz (GHz)**, which is one billion cycles per second. Common ratings for memory are 1333 MHz and 1866 MHz. Common ratings for Front Side Buses are 2600 MHz, 2000 MHz, 1600 MHz, 1333 MHz, 1066 MHz, 800 MHz, 533 MHz, or 400 MHz. A CPU operates from 166 MHz to almost 4 GHz. The CPU can put data or instructions on its internal bus at a much higher rate than does the motherboard. Although we often refer to the speed of the CPU and memory, talking about the frequency of these devices is more accurate, because the term *speed* implies a continuous flow, while the term *frequency* implies a digital or binary flow: on and off, on and off.

Notes Rather than measuring the frequency of a system bus, sometimes you see a system bus measured in performance such as the GA-990FXA-UD3 motherboard by GIGABYTE (see *www.gigabyte.us*). This system bus is rated at 5.2 GT/s or 5200 MT/s. One GT/s is one billion transfers per second, and one MT/s is one million transfers per second.

A motherboard can have more than one bus, each using a different protocol, speed, data path size, and so on. Table 3-4 lists the various buses used on motherboards today, in order of throughput speed from fastest to slowest. (Throughput is sometimes called bandwidth.) Looking at the second column of Table 3-4, you can see that a bus is called an expansion bus, local bus, local I/O bus, or local video bus. A bus that does not run in sync with the system clock is called an expansion bus. For chipsets that use a South Bridge, expansion buses always connect here. Most buses today are local buses, meaning they run in sync with the system clock. If a local bus connects to the slower I/O controller hub or South Bridge of the chipset, it is called a local I/O bus. Because the video card needs to run at a faster rate than other adapter cards, this one slot always connects to the faster end of the chipset, the North Bridge, or directly to the processor when using Sandy Bridge or later technologies. Today's boards use PCI Express x16 slots for video cards. These video buses that connect to the older North Bridge or directly to the processor are called local video buses.

Bus	Bus Type	Data Path in Bits	Address Lines	Throughput(Bandwidth)
PCI Express Version 4.0 (not yet released)	Local video and local I/O	Serial with up to 32 lanes	Up to 32 lanes	Up to 64 GB/sec for 16 lanes
PCI Express Version 3.0	Local video and local I/O	Serial with up to 32 lanes	Up to 32 lanes	Up to 32 GB/sec for 16 lanes
PCI Express Version 2.0	Local video and local I/O	Serial with up to 32 lanes	Up to 32 lanes	Up to 16 GB/sec for 16 lanes
PCI Express Version 1.1	Local video and local I/O	Serial with up to 16 lanes	Up to 16 lanes	Up to 8 GB/sec for 16 lanes
PCI-X	Local I/O	64	32	Up to 8.5 GB/sec
PCI	Local I/O	32 or 64	32 or 64	133, 266, or 532 MB/sec
FireWire 400 and 800	Local I/O or expansion	1	Serial	Up to 3.2 Gbps (gigabits per second)
USB 1.1, 2.0, and 3.0	Expansion	1	Serial	12 or 480 Mbps (megabits per second) or 5.0 Gbps (gigabits per second)

Table 3-4 Buses listed by throughput

A+ Exam Tip The 220-901 exam expects you to know about the PCI, PCI-X, PCIe, and MiniPCI expansion slots.

So now let's look at the details of the PCI, PCI-X, and PCIe expansion slots used in desktops. We'll also discuss the MiniPCI expansion slots used in laptops. The FireWire and USB buses are discussed in the chapter, "Supporting I/O Devices."

CONVENTIONAL PCI

The first PCI bus had a 32-bit data path, supplied 5 V of power to an adapter card, and operated at 33 MHz. It was the first bus that allowed adapter cards to run in sync with the CPU. PCI Version 2.x introduced the 64-bit, 3.3-V PCI slot, doubling data throughput of the bus. Because a card can be damaged if installed in the wrong voltage slot, a notch in a PCI slot distinguishes between a 5-V slot and a 3.3-V slot. A Universal PCI card can use either a 3.3-V or 5-V slot and contains both notches (see Figure 3-18). Conventional PCI is no longer evolving and ended up with four types of slots and six possible PCI card configurations to use these slots. These slots and cards include 32-bit PCI and 64-bit PCI-X, all shown in Figure 3-19.

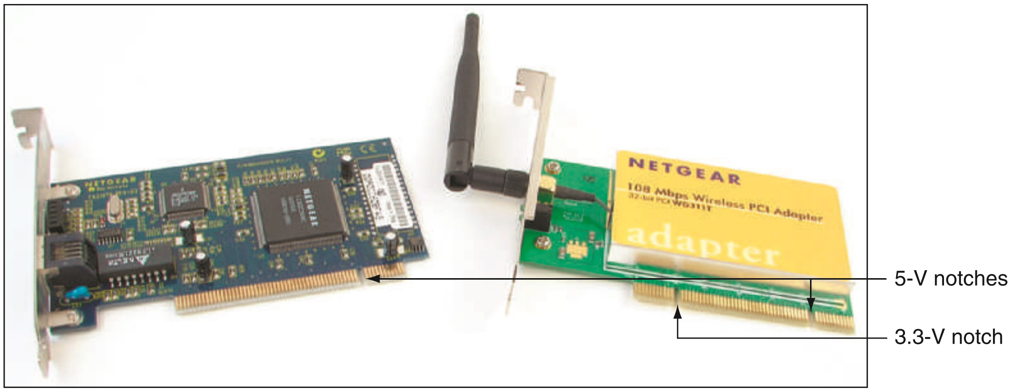


Figure 3-18 A 32-bit, 5-V PCI network card and a 32-bit, universal PCI wireless card show the difference in PCI notches set to distinguish voltages in a PCI slot

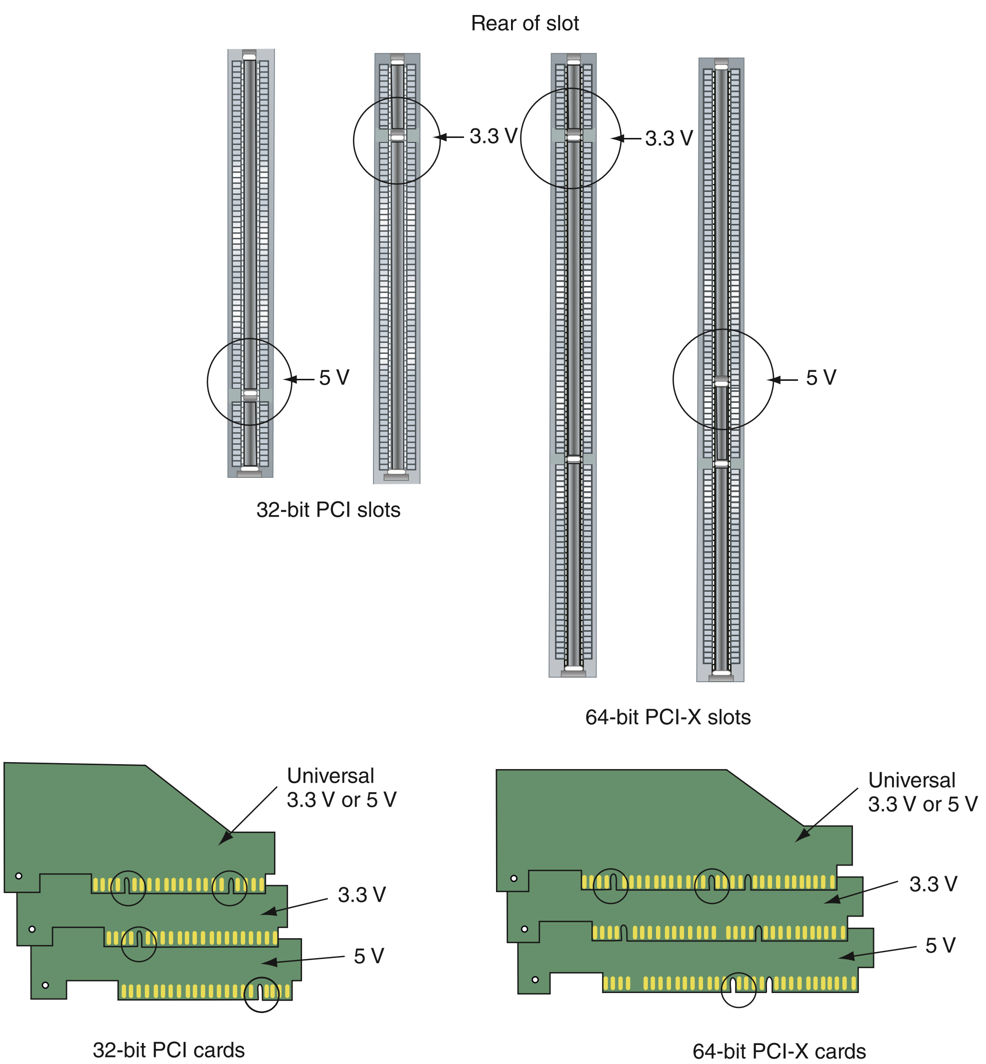
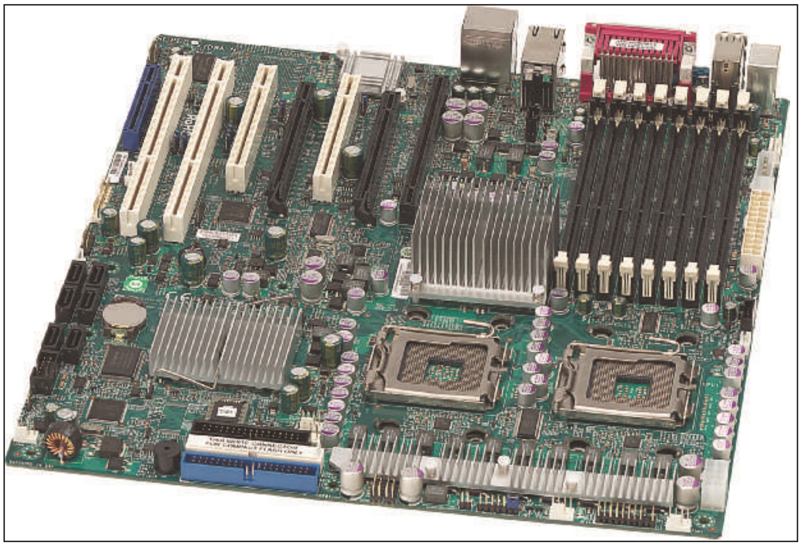


Figure 3-19 With PCI Version 2.x, there are four possible types of expansion slots and six differently configured PCI expansion cards to use these slots

PCI-X

The next evolution of PCI is **PCI-X**, which uses a 64-bit data path and had three major revisions; the last and final revision is PCI-X 3.0. All PCI-X revisions are backward compatible with conventional PCI cards and slots, except 5-V PCI cards are not supported. PCI-X focused on the server market; therefore, it's unlikely you'll see PCI-X slots in desktop computers. Motherboards that use PCI-X tend to have several different PCI slots with some 32-bit or 64-bit slots running at different speeds. For example, Figure 3-20 shows a server motherboard with three types of slots. The two long white slots are PCI-X; the two shorter white slots are PCI, and the two black slots are PCIe. The two PCI-X slots can use most 32-bit and 64-bit PCI or PCI-X cards.



Courtesy of Super Micro Computer, Inc.

Figure 3-20 The two long white PCI-X slots can support PCI cards

PCI EXPRESS

PCI Express (PCIe) uses an altogether different architectural design than conventional PCI and PCI-X and is not backward compatible with either. PCI Express will ultimately replace both these buses, although it is expected PCI Express will coexist with conventional PCI for some time to come (see Figure 3-21). Whereas PCI uses a 32-bit or 64-bit parallel bus, PCI Express uses a serial bus, which is faster than a parallel bus because it transmits data in packets similar to how Ethernet, USB, and FireWire transmit data. A PCIe expansion slot can provide one or more of these serial lanes.

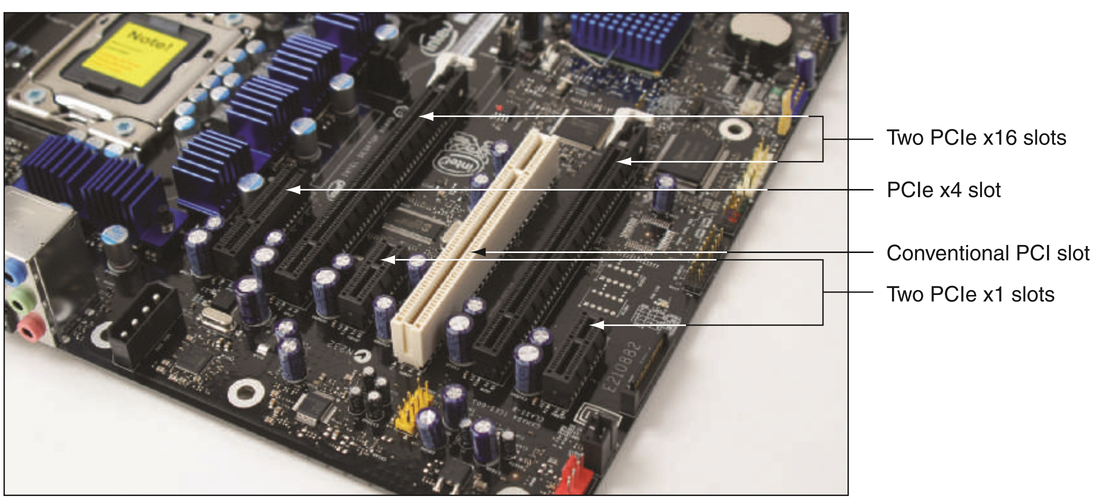


Figure 3-21 Three types of PCIe slots and one conventional PCI slot

Another difference in PCI Express is how it connects to the processor. One or more PCI Express slots used for video cards have a direct link to the North Bridge or to the processor (using Sandy Bridge or later architecture). Refer back to Figures 3-10, 3-11, and 3-13.

PCI Express currently comes in four different slot sizes called PCI Express ×1 (pronounced "by one"), ×4, ×8, and ×16. Figure 3-21 shows three of these slots. Notice in the photo how the PCIe slots are not as tall and the pins are closer together than the conventional PCI slot. A PCI Express ×1 slot contains a single lane for data; this lane is actually four wires. One pair of wires is used to send data and the other pair receives data, one bit at a time. The ×16 slot contains 16 lanes, with each lane timed independently of other lanes. The more lanes you have, the more data gets transmitted in a given time. Therefore, a ×16 slot is faster than a ×4 slot, which is faster than a ×1 slot. A shorter PCI Express card (such as a ×1 card) can be installed in a longer PCI Express slot (such as a ×4 slot).

Revisions of PCIe include PCIe version 1.1, PCIe version 2.0 and 2.1, PCIe version 3.0, and PCIe version 4.0. Here are important facts about each PCIe version:

- ***PCIe version 1.0.*** The original PCIe version 1.0 allowed for 150 W to PCIe cards. Pins on the expansion card provide 75 W, and a new 6-pin PCIe connector from the power supply provides an additional 75 W.
- ***PCIe version 1.1.*** PCIe version 1.1 allowed for more wattage to PCIe cards, up to 225 W. The standard allows for two 6-pin PCIe connectors from the power supply to the card. Therefore, the total 225 W comes as 75 W from the slot and 150 W from the two connectors.
- ***PCIe version 2.0.*** PCIe version 2.0 doubled the frequency of the PCIe bus and allows for up to 32 lanes on one slot (though few motherboards or cards actually use 32 lane slots). The allowed wattage to one PCIe 2.0 card was increased to a total of 300 W by using a new 8-pin PCIe power connector that provides 150 W (see Figure 3-22). The 300 W to the card come from the slot (75 W), from the 8-pin connector (150 W), and an additional 75 W come from a second auxiliary connector on the motherboard. This second connector can be a 6-pin PCIe connector, a Molex-style connector, or a SATA-style connector. You'll see an example of these connectors later in this chapter.

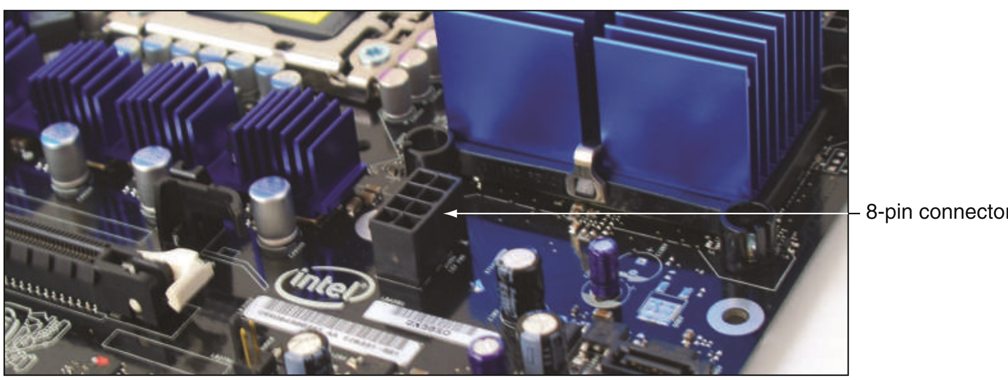


Figure 3-22 8-pin PCIe Version 2.0 power connector

- ***PCIe versions 3.0 and 4.0.*** PCIe version 3.0 roughly doubles the speed of PCIe version 2.0 and is backward compatible with PCIe version 2.0 components. PCIe version 4.0 doubles the speed of PCIe version 3.0 and is also backward compatible with earlier PCIe standards; PCIe version 4.0 devices are not yet available on the market.

MINI PCI AND MINI PCIe IN LAPTOP COMPUTERS

Smaller versions of the PCI and PCIe slots are used in laptops, all-in-one computers, and with small form factor motherboards such as the Mini-ITX board. The **Mini PCI** slot follows the PCI standards and the **Mini PCI Express** slot follows the PCI Express standards. To save space, the slots lay flat on the motherboard and hold an expansion card parallel to the board.

Mini PCIe slots have 52 or 54 pins on the edge connector and have one notch offset from the center of the slot (see Figure 3-23). One screw holds the card securely in the slot. The Mini PCI slot is wider and has 100 or 124 pins and a notch slightly offset from the end of the slot (see Figure 3-24).

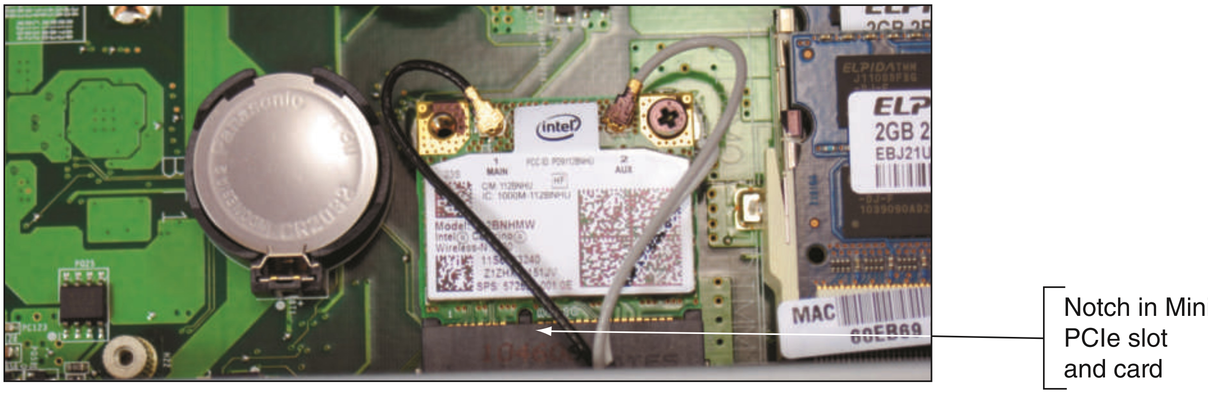


Figure 3-23 Mini PCIe slot with a Wireless Mini PCIe card installed

Figure 3-24 A Mini PCI card has a notch near the side of the edge connector

PCI RISER CARDS USED TO EXTEND THE SLOTS

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Suppose you are installing a Mini-ITX or microATX motherboard into a low-profile or slimline case that does not give you enough room to install a PCI card standing up in an expansion slot. In this situation, a PCI riser card can solve the problem. The riser card installs in the slot and provides another slot at a right angle (see Figure 3-25). When you install an expansion card in this riser card slot, the card sits parallel to the motherboard, taking up less space. These riser cards come for all types of PCI slots, including PCIe, PCI-X, and conventional PCI.

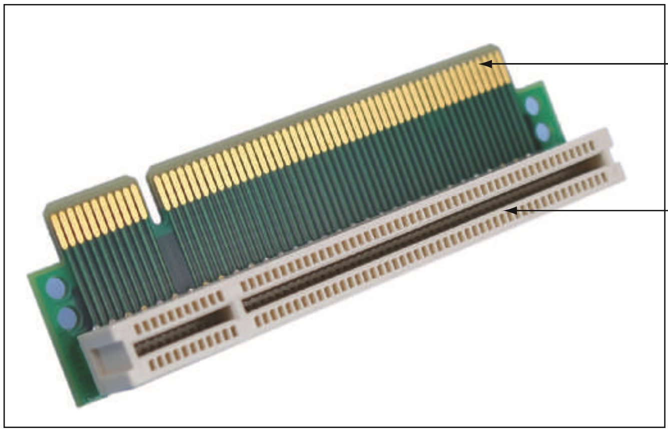

Figure 3-25 PCI riser card provides a 3.3-V slot or 5-V slot depending on which direction the card is inserted in the PCI slot

ONBOARD PORTS AND CONNECTORS

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In addition to expansion slots, a motherboard might also have several ports and internal connectors. Ports coming directly off the motherboard are called **onboard ports** or integrated components. Almost all motherboards have two or more USB ports and sound ports. Boards might also offer a network port, FireWire (IEEE 1394) port, one or more video ports, one or more eSATA ports (for external SATA hard drives), parallel port, serial port, a port for a wireless antenna, and PS/2 ports for a mouse and keyboard. Older motherboards might have a modem port. Figure 3-26 shows ports on an entry-level desktop motherboard.

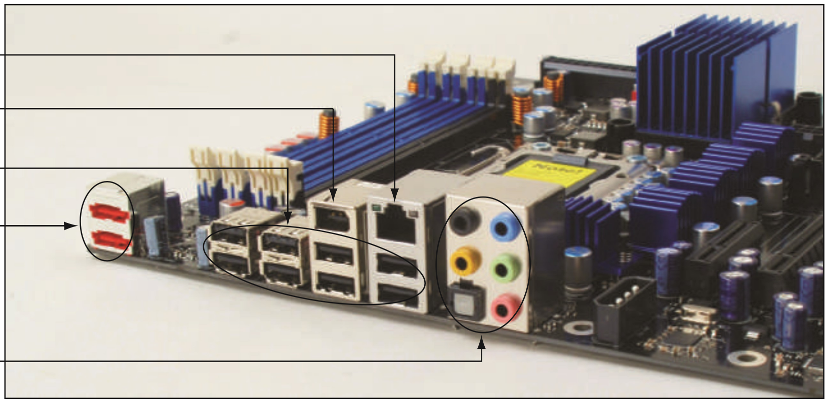

Figure 3-26 A motherboard provides ports for common I/O devices

When you purchase a motherboard, the package includes an **I/O shield**, which is the plate that you install in the computer case that provides holes for these I/O ports. The I/O shield is the size designed for the case's form factor, and the holes in the shield are positioned for the motherboard ports (see Figure 3-27). When you first install a motherboard, you might need to install the drivers that come on the DVD or CD bundled with the board before some of the motherboard ports will work. How to install the motherboard drivers is covered later in this chapter.

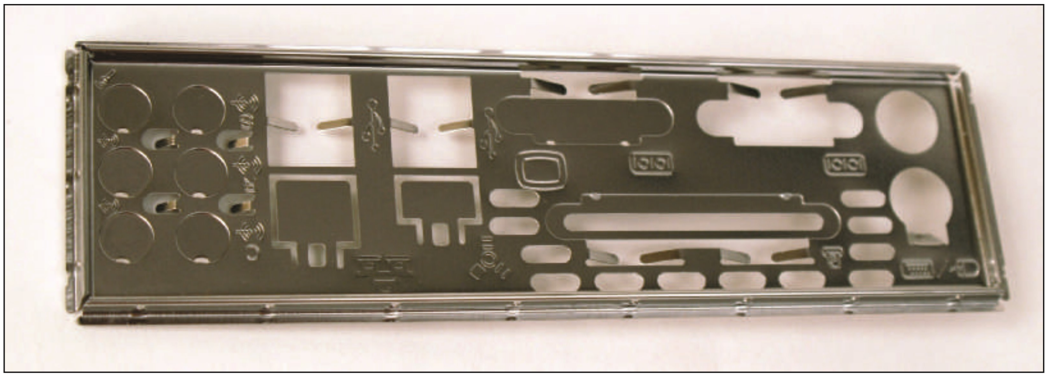

Figure 3-27 The I/O shield fits the motherboard ports to the computer case

A motherboard might have several internal connectors, including SATA, USB, and FireWire (IEEE 1394) connectors. When you purchase a motherboard, look in the package for the motherboard manual either printed or on DVD or CD. It will show a diagram of the board with a description of each connector. For example, the connectors for the motherboard in Figure 3-28 are labeled as the manual describes them. If a connector is a group of pins sticking up on the board, the connector is called a header. You will learn to use most of these connectors in later chapters.

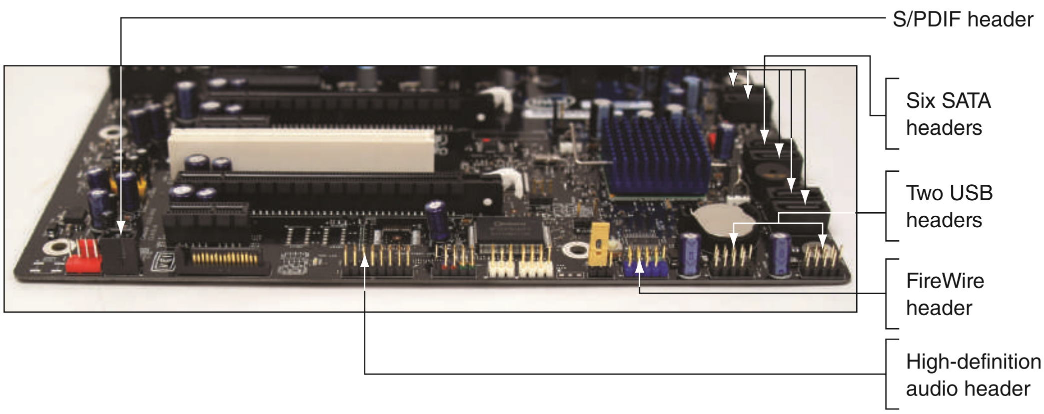

Figure 3-28 Internal connectors on a motherboard for drives and ports on the front of the case

APPLYING | CONCEPTS FIND THE MOTHERBOARD DOCUMENTATION

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The motherboard user guide is essential to identifying components on a board and knowing how to support the board. This guide can be a PDF file stored on the CD or DVD that came bundled with the motherboard. If you don't have the CD, you can download the user guide from the motherboard manufacturer's website.

To find the correct user guide online, you need to know the board manufacturer and model. If a motherboard is already installed in a computer, you can use the Windows System Information utility (msinfo32.exe) to report the brand and model of the board. To access the utility, for Windows 8.x, from the desktop, right-click **Start**, click **Run**, and type **msinfo32.exe** in the Run box. (For Windows 7/Vista, click **Start**, type **msinfo32.exe** in the Search box, and press **Enter**.) In the System Information window, click **System Summary**. In the System Summary information in the right pane, look for the motherboard information labeled as the System Manufacturer and System Model (see Figure 3-29).

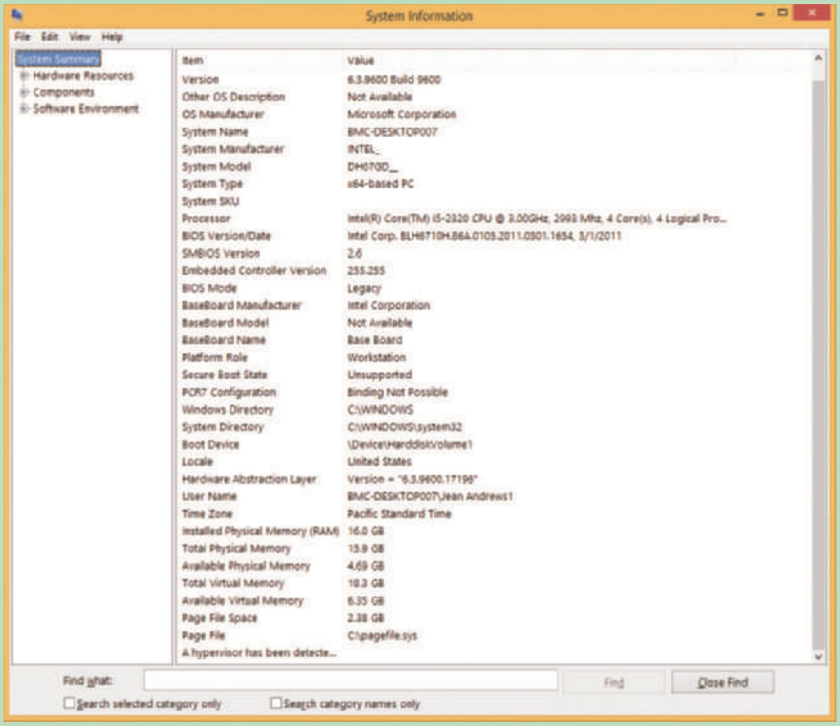

Figure 3-29 Use the System Information window to identify the motherboard brand and model

If the motherboard is not installed or the system is not working, look for the brand and model imprinted somewhere on the motherboard (see Figure 3-30). Next, go to the website of the motherboard manufacturer and download the user guide. Websites for several motherboard manufacturers are listed in Table 3-5. The diagrams, pictures, charts, and explanations of settings and components in the user guide will be invaluable to you when supporting this board.

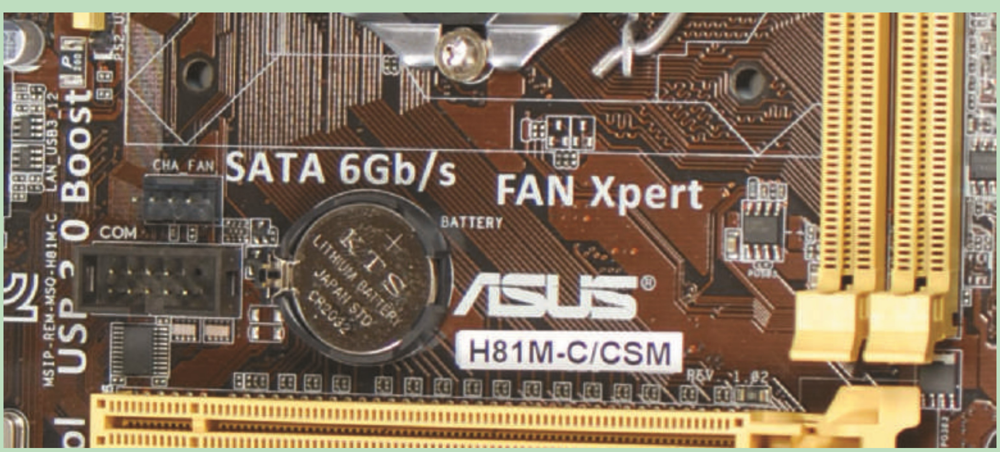

Figure 3-30 The motherboard brand and model are imprinted somewhere on the board

(continues)

Manufacturer	Web Address
ASUS	*www.asus.com*
Evga	*www.evga.com*
ASRock	*www.asrock.com*
Gigabyte Technology Co., Ltd.	*www.gigabyte.com*
Intel Corporation	*www.intel.com*
Micro-Star International (MSI)	*www.msicomputer.com*
Super Micro Computer, Inc.	*www.supermicro.com*

Table 3-5 Major manufacturers of motherboards

Hands-On Project 3-3 Examine a Motherboard in Detail

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1. Look at the back of a desktop computer. Without opening the case, list the ports that you believe come directly from the motherboard.
2. Remove the cover of the case, which you learned to do in the chapter, "Working Inside Desktop Computers and Laptops." List the different expansion cards in the expansion slots. Was your guess correct about which ports come from the motherboard?
3. To expose the motherboard so you can identify its parts, remove all the expansion cards.
4. Draw a diagram of the motherboard and label these parts:
   - Processor socket
   - Chipset
   - RAM (each DIMM slot)
   - CMOS battery
   - Expansion slots (Identify the slots as PCI, PCIe x1, PCIe x4, or PCIe x16.)
   - Each port coming directly from the motherboard
   - Power supply connections
   - SATA drive connectors
5. What is the brand and model of the motherboard?
6. Locate the manufacturer's website. If you can find the motherboard manual on the site, download it. Find the diagram of the motherboard in the manual and compare it with your diagram. Did you label components correctly?
7. Reassemble the computer, as you learned to do in the chapter, "Working Inside Desktop Computers and Laptops."

Hands-On | Project 3-4 Examine Motherboard Documentation

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Using the motherboard brand and model installed in your computer, or another motherboard brand and model assigned by your instructor, download the user guide from the motherboard manufacturer and answer these questions:

1. What processors does the board support?
2. What type of RAM does the board support?
3. What is the maximum RAM the board can hold?
4. If the board has a PCIe slot, what version of PCIe does the board use?
5. What chipset does the board use?

Now that you know what to expect when examining or selecting a motherboard, let's see how to configure a board.

CONFIGURING A MOTHERBOARD

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Firmware on the motherboard is used to enable or disable a connector, port, or component; control the frequency of the CPU, security features, and what happens when the PC first boots; and monitor various activities of the board. Today's motherboards may use these types of firmware:

- ***BIOS***. BIOS is used on older motherboards.
- ***UEFI***. Unified Extensible Firmware Interface (UEFI) is replacing BIOS and is used on most motherboards made after 2012. Microsoft requires UEFI in order for the system to be certified for Windows 8 and later. UEFI is also required for hard drives larger than 2 TB. (One terabyte or TB equals 1000 gigabytes or GB.)
- ***UEFI with BIOS.*** Most personal computer motherboards contain UEFI firmware with BIOS also provided for backward compatibility with older devices.

As an IT support technician, you need to know how to configure the BIOS or UEFI firmware settings. We first look at how to configure BIOS settings and then we'll see how to configure UEFI settings.

USING BIOS SETUP TO CONFIGURE A MOTHERBOARD

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The motherboard settings don't normally need to be changed except, for example, when there is a problem with hardware, or a power-saving feature or security feature (such as a power-on password) needs to be disabled or enabled.

A+ Exam Tip The A+ 220-901 exam expects you to know about BIOS settings regarding RAM, the hard drive, optical drive, CPU, boot sequence, enabling and disabling devices, system date and time, virtualization support, passwords, drive encryption, and monitoring temperature, fan speeds, intrusion detection, voltage, and clock and bus speeds. All these settings are covered in this part of the chapter.

ACCESS THE BIOS SETUP PROGRAM

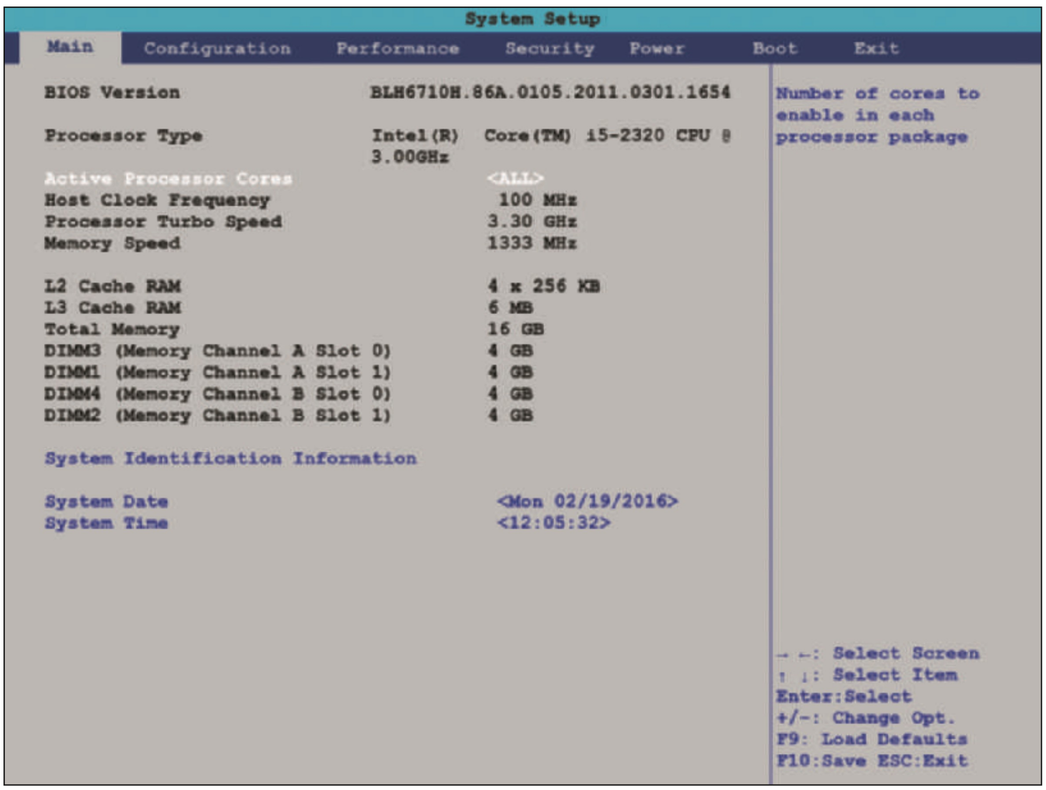
You access the BIOS setup program by pressing a key or combination of keys during the boot process. For most motherboards, you press F2 or Del during the boot. For a few older motherboards, you press Ctrl+Alt+Esc. See the motherboard documentation to know for sure which keys to press. A message such as the following usually appears on the screen near the beginning of the boot:

```
Press DEL to change Setup
```

or

```
Press F2 for Setup
```

When you press the appropriate key or keys, a setup screen appears with menus and Help features that are often very user-friendly. Although the exact menus depend on the BIOS maker, the sample screens that follow will help you become familiar with the general contents of BIOS setup screens. Figure 3-31 shows a main menu for setup. On this menu, you can view information about the BIOS version, processor model and speed, memory speed, total memory, and the amount of memory in each memory slot. You can also change the system date and time.



Source: Intel

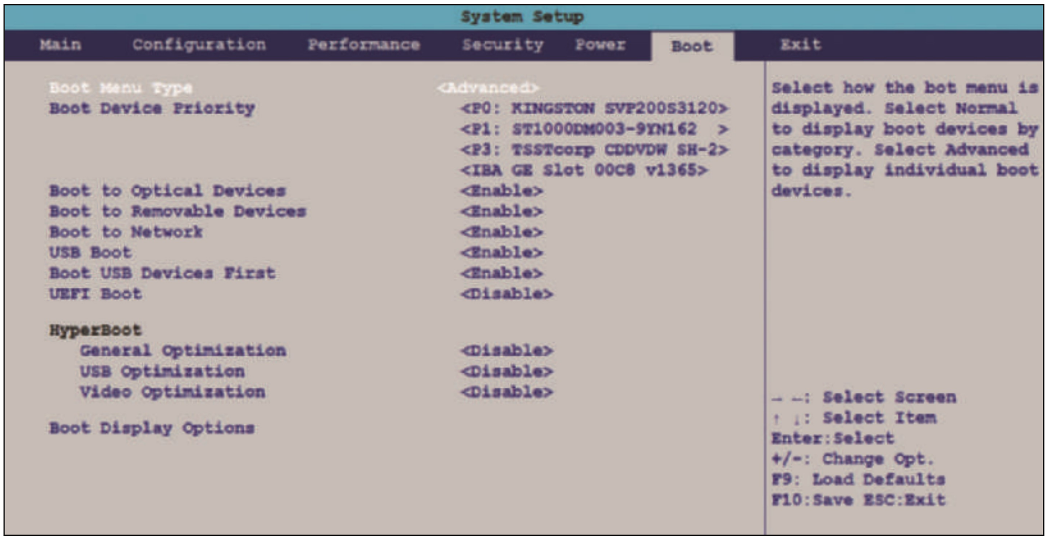
Figure 3-31 BIOS setup main menu

Notes For a comprehensive list of BIOS manufacturers and links to their websites, visit *support.microsoft.com/en-us/kb/243909*.

Now let's examine setup screens that apply to the boot sequence, virtualization, built-in diagnostics, monitoring the system, and security.

CHANGE THE BOOT SEQUENCE

Figure 3-32 shows an example of a boot menu in BIOS setup. Here, you can set the order in which the system tries to boot from certain devices (called the boot sequence or boot priority). Most likely when you first install a hard drive or an operating system, you will want to have the BIOS attempt to first boot from a DVD so that you can install Windows from the setup DVD. After the OS is installed, to prevent accidental boots from a DVD or other media, change setup BIOS to boot first from the hard drive. Notice in Figure 3-32 the option to perform a UEFI Boot. This particular motherboard holds both BIOS and UEFI firmware.



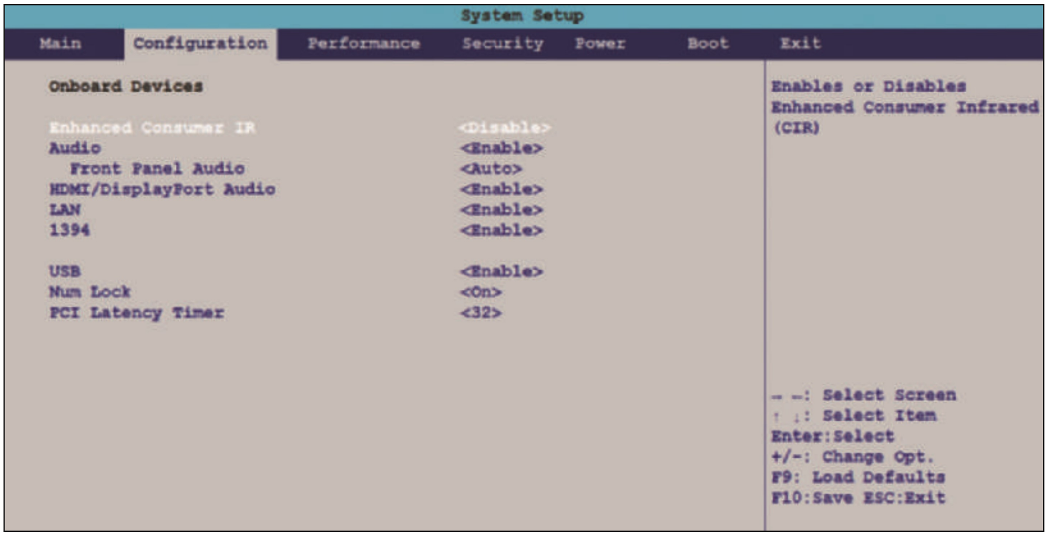
Source: Intel

Figure 3-32 Set the boot priority order in BIOS setup

Also, the BIOS setup boot screens might give you options regarding built-in diagnostics that occur at the boot. Recall from the chapter, "First Look at Computer Parts and Tools," that these tests are called the POST (power-on self test). You can configure some motherboards to perform a quick boot and bypass the extensive POST. For these systems, if you are troubleshooting a boot problem, be sure to set BIOS to perform the full POST.

CONFIGURE ONBOARD DEVICES

You can enable or disable some onboard devices (for example, a network port, FireWire port, USB ports, or video ports) using setup BIOS. For one system, the Configuration screen shown in Figure 3-33 does the job. On this screen, you can enable or disable a port or group of ports, and you can configure the Front Panel Audio ports for Auto, High Definition audio, and Legacy audio, or you can disable these audio ports. What you can configure on your system depends on the onboard devices the motherboard offers.



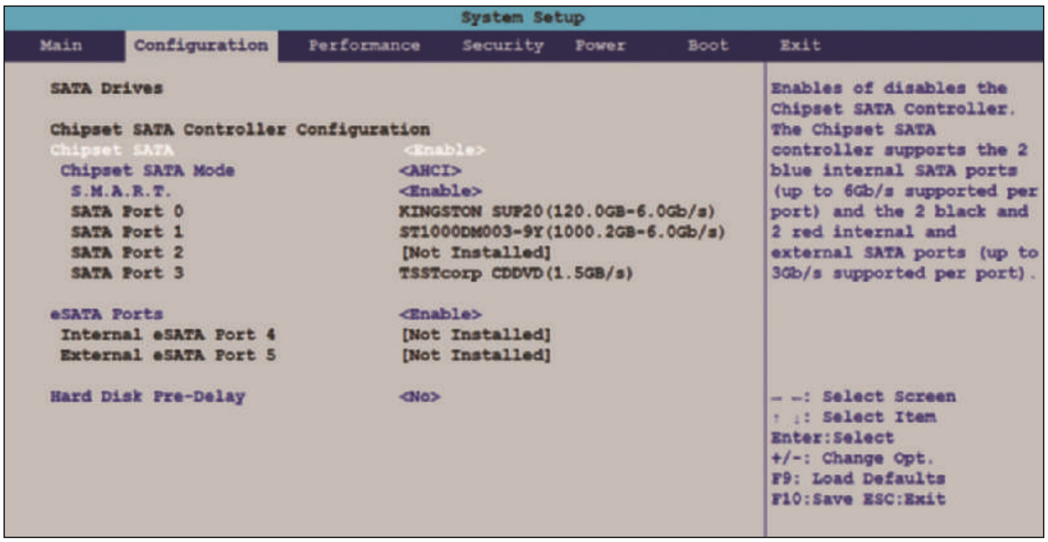
Source: Intel

Figure 3-33 Enable and disable onboard devices

Notes You don't have to replace an entire motherboard if one port fails. For example, if the network port fails, use BIOS setup to disable the port. Then use an expansion card for the port instead.

VIEW HARD DRIVE AND OPTICAL DRIVE INFORMATION

Using setup BIOS, you can view information about installed hard drives and optical drives. For example, in Figure 3-34, one system shows five internal SATA and eSATA ports and one external eSATA port. One 120-GB hard drive is installed on SATA port 0, and another 1000-GB hard drive is installed on SATA port 1. Both ports are internal SATA connectors on the motherboard. Notice the optical drive is installed on SATA port 3, also an internal connector on the motherboard.

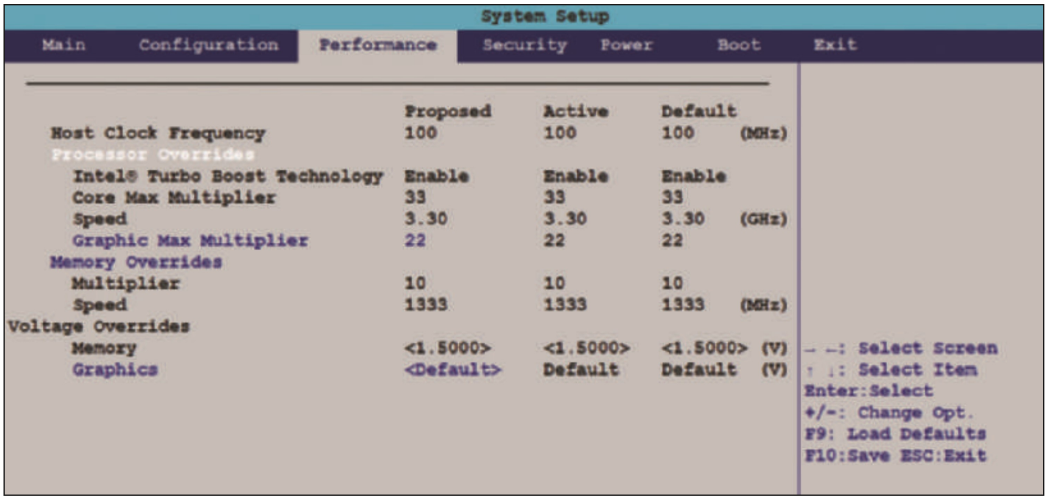


Source: Intel

Figure 3-34 A BIOS setup screen showing a list of drives installed on the system

PROCESSOR AND CLOCK SPEEDS

Overclocking is running a processor, memory, motherboard, or video card at a higher speed than the manufacturer recommends. Some motherboards allow overclocking. If you decide to overclock a system, pay careful attention to the temperature of the processor so it does not overheat; overheating can damage the processor. Figure 3-35 shows one BIOS setup screen for adjusting performance. Notice on the screen the Host Clock Frequency. This is the basic system clock provided by the chipset, by which all other components synchronize activities. The Core Max Multiplier on this screen is 33. (This value is sometimes called the bus/core ratio.) When you multiply 100 MHz by 33, you get 3.30 GHz, which is the frequency of the processor. This board uses the QuickPath Interconnect. For older boards that use a Front Side Bus, you can change the speed of the FSB to overclock the system, which affects the processor and memory speeds. On some boards, you can change the processor multiplier to change the processor speed and/or change the memory multiplier to affect memory speed.

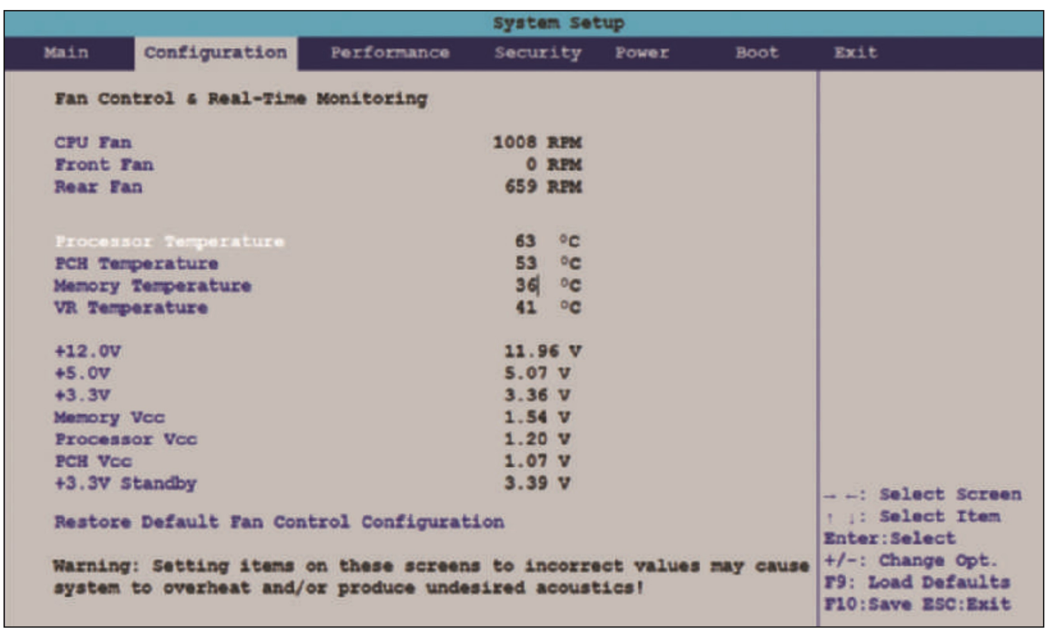


Source: Intel

Figure 3-35 A motherboard might give options for changing the clock speed or multipliers for the processor and memory

MONITOR TEMPERATURES, FAN SPEEDS, AND VOLTAGES

Using BIOS setup screens, you can monitor temperatures inside the case, fan speeds, and voltages. One BIOS screen that allows you to monitor these values and also control fan speeds is shown in Figure 3-36. Case and CPU fans on modern computers adjust their speeds based on the temperatures of the CPU, memory, and motherboard. You can also install software (for example, SpeedFan by Alfredo Comparetti at *www.almico.com/speedfan.php*) in Windows to monitor temperatures and control fan speeds. To use the software, you might need to change a BIOS setting to allow software to control the speeds. For this system, when you select Processor Temperature, you can set the threshold temperatures that software uses to create an alert.



Source: Intel

Figure 3-36 Monitor temperatures, fan speeds, and voltages in a system

INTRUSION DETECTION

BIOS settings might offer several security features, and one of these is an intrusion-detection alert. For example, for the BIOS setup screen shown in Figure 3-37, you can enable event logging, which logs when the case is opened. To use the feature, you must use a cable to connect a switch on the case to a header on the motherboard.

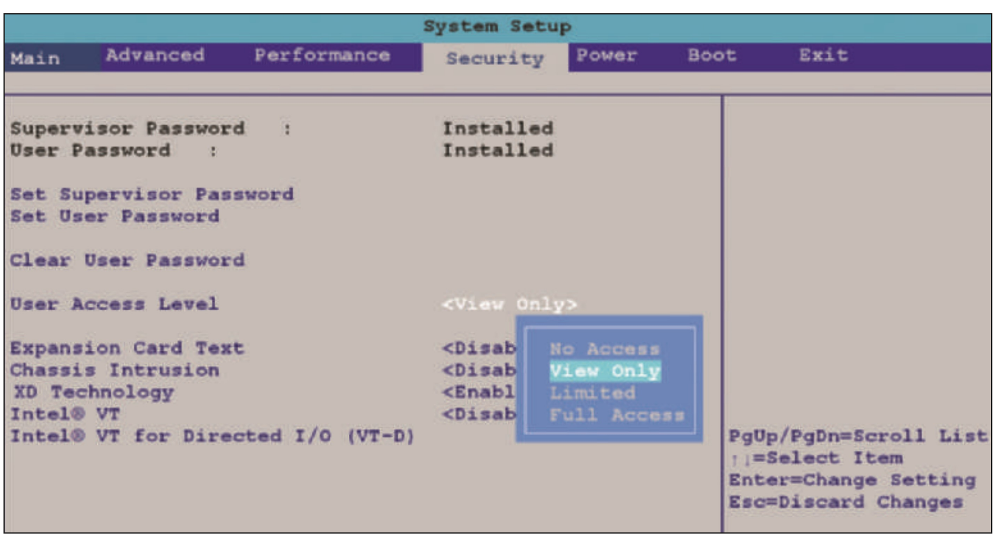
Source: Intel

Figure 3-37 BIOS is enabled to log a chassis intrusion

When the security measure is in place and the case is opened, BIOS displays an alert the next time the system is powered up. For example, the alert message at startup might be "Chassis Intruded! System has halted." If you see this message, know that the case has been opened. Reboot the system and the system should start up as usual. To make sure the alert was not tripped by accident, verify that the case cover is securely in place. Also, sometimes a failed CMOS battery can trip the alert. Intrusion-detection devices are not a recommended best practice for security. False alerts are annoying, and criminals generally know how to get inside a case without tripping the alert.

POWER-ON PASSWORDS

Another security feature is power-on passwords assigned in BIOS setup to prevent unauthorized access to the computer and/or the BIOS setup utility. For one motherboard, this security screen looks like the one shown in Figure 3-38, where you can set a supervisor password and a user password. In addition, you can configure how the user password works.



Source: Intel

Figure 3-38 Set supervisor and user passwords in BIOS setup to lock down a computer

The choices under User Access Level are **No Access** (the user cannot access the BIOS setup utility), **View Only** (the user can access BIOS setup, but cannot make changes), **Limited** (the user can access BIOS setup and make a few changes such as date and time), and **Full Access** (the user can access the BIOS setup utility and make any changes). When supervisor and user passwords are both set and you boot the system, a box to enter a password is displayed. What access you have depends on which password you enter. Also, if both passwords are set, you must enter a valid password to boot the system. By setting both passwords, you can totally lock down the computer from unauthorized access.

A+ Exam Tip The A+ 220-901 exam expects you to know how to use BIOS setup to secure a workstation from unauthorized use.

Notes For added protection, configure the BIOS setup utility so that a user cannot boot from a removable device such as a CD, USB device, or floppy disk.

Caution In the event that passwords are forgotten, know that supervisor and user passwords to the computer can be reset by setting a jumper (group of pins) on the motherboard to clear all BIOS customized settings and return BIOS setup to its default settings. To keep someone from using this technique to access the computer, you can use a computer case with a lockable side panel and install a lock on the case. How to use jumpers is covered later in this chapter.

BIOS SUPPORT FOR VIRTUALIZATION

Virtualization is when one physical machine hosts multiple activities that are normally done on multiple machines. One type of virtualization is the use of virtual machines. A virtual computer or **virtual machine (VM)** is software that simulates the hardware of a physical computer. Each VM running on a computer works like a physical computer and is assigned virtual devices such as a virtual motherboard and virtual hard drive. Examples of VM software are Windows Virtual PC, Microsoft Hyper-V, and Oracle VirtualBox. For most VM software to work, virtualization must be enabled in BIOS setup. Looking back at Figure 3-38, you can see the option to enable Intel VT. Intel VT is the name that Intel gives to its virtualization technology.

LOJACK FOR LAPTOPS TECHNOLOGY

LoJack is a technology embedded in the BIOS of many laptops to protect a system against theft. When you subscribe to the LoJack for Laptops service by Absolute (*www.absolute.com*), the Computrace Agent software is installed. The software and BIOS work together to protect the system. The company can locate your laptop whenever it connects to the Internet, and you can give commands through the Internet to lock the laptop or delete all data on it.

DRIVE ENCRYPTION AND DRIVE PASSWORD PROTECTION

Some motherboards and hard drives allow you to set a password that must be entered before someone can access the hard drive. This password is kept on the drive and works even if the drive is moved to another computer. Some manufacturers of storage media offer similar products. For example, Seagate (*www.seagate.com*) offers Maxtor BlackArmor, a technology that encrypts an entire external storage device that is password protected.

Notes Drive lock password protection might be too secure at times. I know of a situation where a hard drive with password protection became corrupted. Normally, you might be able to move the drive to another computer and recover some data. However, this drive asked for the password, but then could not confirm it. Therefore, the entire drive, including all the data, was inaccessible.

THE TPM CHIP AND HARD DRIVE ENCRYPTION

Many high-end computers have a chip on the motherboard called the **TPM (Trusted Platform Module) chip**. The **BitLocker Encryption** tool in Windows 8/7/Vista is designed to work with this chip; the chip holds the BitLocker encryption key (also called the startup key). The TPM chip can also be used with other encryption software that may be installed on the hard drive other than BitLocker. If the hard drive is stolen from the computer and installed in another computer, the data would be safe because BitLocker has encrypted all contents on the drive and would not allow access without the startup key stored on the TPM chip. Therefore, this method assures that the drive cannot be used in another computer. However, if the motherboard fails and is replaced, you'll need a backup copy of the startup key to access data on the hard drive.

A+ Exam Tip The A+ 220-901 exam expects you to know about drive encryption and the TPM chip.

When you use Windows to install BitLocker Encryption, the initialization process also initializes the TPM chip. Initializing the TPM chip configures it and turns it on. After BitLocker is installed, you can temporarily turn off BitLocker, which also turns off the TPM chip. For example, you might want to turn off BitLocker to test the BitLocker recovery process. Normally, BitLocker will manage the TPM chip for you, and there is no need for you to manually change TPM chip settings. However, if you are having problems installing BitLocker, one thing you can do is clear the TPM chip. *Be careful!* If the TPM chip is being used to hold an encryption key to protect data on the hard drive and you clear the chip, the encryption key will be lost. That means all the data will be lost, too. Therefore, don't clear the TPM chip unless you are certain it is not being used to encrypt data.

APPLYING CONCEPTS MANAGE THE TPM CHIP

A+
220-901
1.1

To manage the TPM chip, follow these steps:

1. Log on to Windows using an administrator account.
2. In the Windows 8 Run box or the Windows 7/Vista Search box, enter the **tpm.msc** command and respond to the User Account Control box. The TPM Management console opens.
3. If no TPM chip is present, the console reports that. If your system has a TPM chip that is not yet initialized, the console will have the option under the Actions pane to Initialize TPM. If the TPM chip is already initialized and ready for use, the console looks similar to the one shown in Figure 3-39.

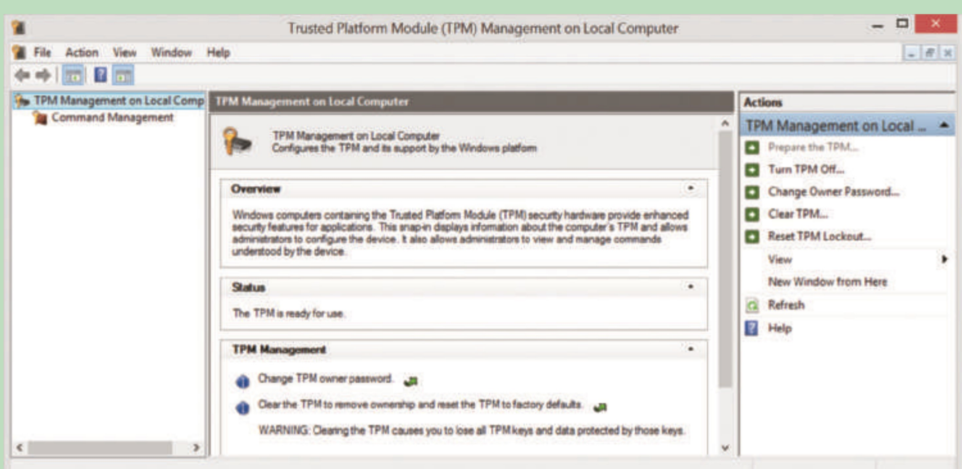
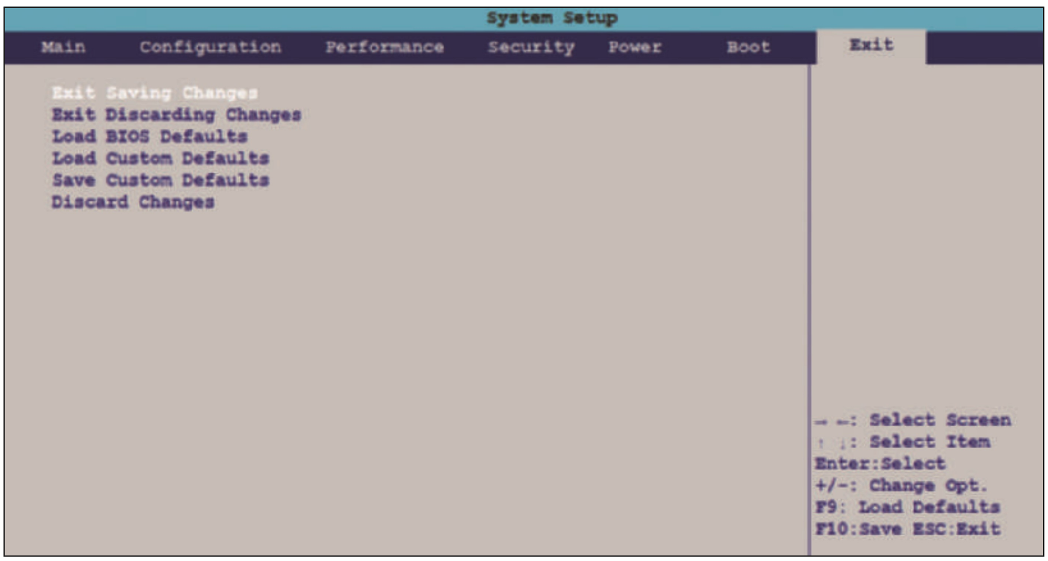


Figure 3-39 Use the TPM Management console to manage the TPM chip in Windows

4. Using the console, you can change the TPM owner password, turn TPM on or off, reset the TPM when it has locked access to the hard drive, and clear the TPM, which resets it to factory defaults. After you have made changes to the TPM chip, you will most likely be asked to restart the computer for the changes to take effect.

EXITING THE BIOS SETUP MENUS

When you finish with BIOS setup, an exit screen such as the one shown in Figure 3-40 gives you various options, such as exit and save your changes or exit and discard your changes. Notice in the figure that you also have the option to load BIOS default settings. This option can sometimes solve a problem when a user has made several inappropriate changes to the BIOS settings.



Source: Intel

Figure 3-40 BIOS setup Exit menu

Hands-On | Project 3-5 Examine BIOS Settings

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1.1

Access the BIOS setup program on your computer and answer the following questions:

1. What key(s) did you press to access BIOS setup?
2. What brand and version of BIOS are you using?
3. What is the frequency of your processor?
4. What is the boot sequence order of devices?
5. Do you have an optical drive installed? What are the details of the installed drive?
6. What are the details of the installed hard drive(s)?
7. Does the BIOS offer the option to set a supervisor or power-on password? What is the name of the screen where these passwords are set?
8. Does the BIOS offer the option to overclock the processor? If so, list the settings that apply to overclocking.
9. Can you disable the onboard ports on the computer? If so, which ports can you disable, and what is the name of the screen(s) where this is done?
10. List three BIOS settings that control how power is managed on the computer.

USING UEFI SETUP TO CONFIGURE A MOTHERBOARD

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1.1

Extensible Firmware Interface (EFI), the original version of UEFI, was first developed by Intel. Today, Unified EFI (UEFI) is managed by several manufacturers and developers under the Unified EFI Forum (see *www.uefi.org*). UEFI firmware on the motherboard working with an operating system that supports UEFI improves on legacy BIOS in these ways:

- ***Faster and better booting.*** UEFI does a faster and better job of booting the system, handing over the boot to the OS, and loading device drivers and applications before the OS loads.
- ***Mouse-enabled interface.*** The mouse-enabled UEFI interface is more user friendly to get information about system components; configure the boot sequence, clock speed, virtualization, and power-on passwords; and monitor temperature, fan speeds, voltage, and bus speeds.
- ***Secure boot.*** UEFI version 2.3 and higher offers a **secure boot**, which prevents a system from booting up with drivers or an OS that are not digitally signed and trusted by the motherboard or computer manufacturer. For secure boot to work, the OS, such as Windows 8 or Linux Ubuntu version 14, must support UEFI.
- ***Support for hard drives larger than 2 TB.*** UEFI allows booting from hard drives larger than 2 TB. A hard drive uses one of two methods for partitioning the drive: The **Master Boot Record (MBR)** method is older, allows for four partitions and is limited to 2-TB drives. The **GUID Partition Table (GPT)** method is newer, allows for any size hard drive, and, for Windows, can have up to 128 partitions on the drive. GPT is required for drives larger than 2 TB or for systems that boot using UEFI firmware.

UEFI allows for backward compatibility. It can boot from a MBR hard drive and provides a BIOS boot through its **Compatibility Support Module (CSM)** feature. CSM is backward compatible with devices and drivers that use BIOS.

APPLYING | CONCEPTS EXPLORE UEFI SETUP

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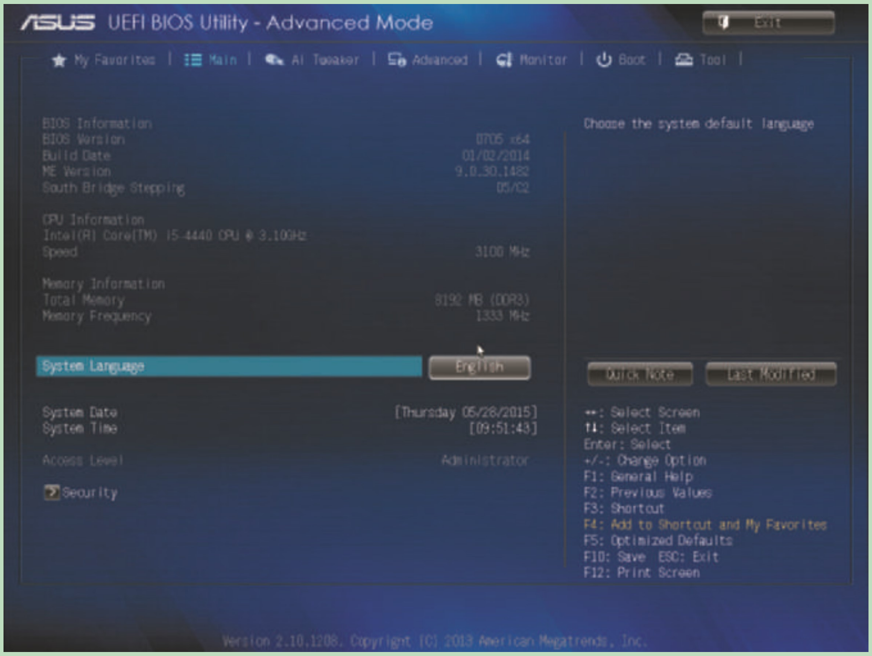
1.1

Let's explore a few important UEFI setup screens that you need to be aware of. If you need help using UEFI setup, refer to the documentation for the motherboard manufacturer. Here are the steps for one system, but your UEFI screens might be different:

1. As with BIOS setup, to access the UEFI firmware, press a key, such as F12, F2, or Del, during the boot. A UEFI main screen appears. Figure 3-41 shows the main screen for one system, but yours might be different. On this screen, you can view information about the CPU and memory and change the language, date, or time. You can use your mouse or arrow keys to navigate through menus at the top of the screen to view and change information. Use the Ai Tweaker screen to overclock the CPU, the Advanced screen to configure the CPU, SATA, USB, onboard devices, power, and network settings, and the Monitor screen to monitor temperature, fans, and voltages. On the Boot screen, you can change the boot sequence and other boot settings. The Tool screen is used to flash UEFI and BIOS.

3



Source: American Megatrends, Inc.

Figure 3-41 UEFI main screen in Advanced Mode by Asus

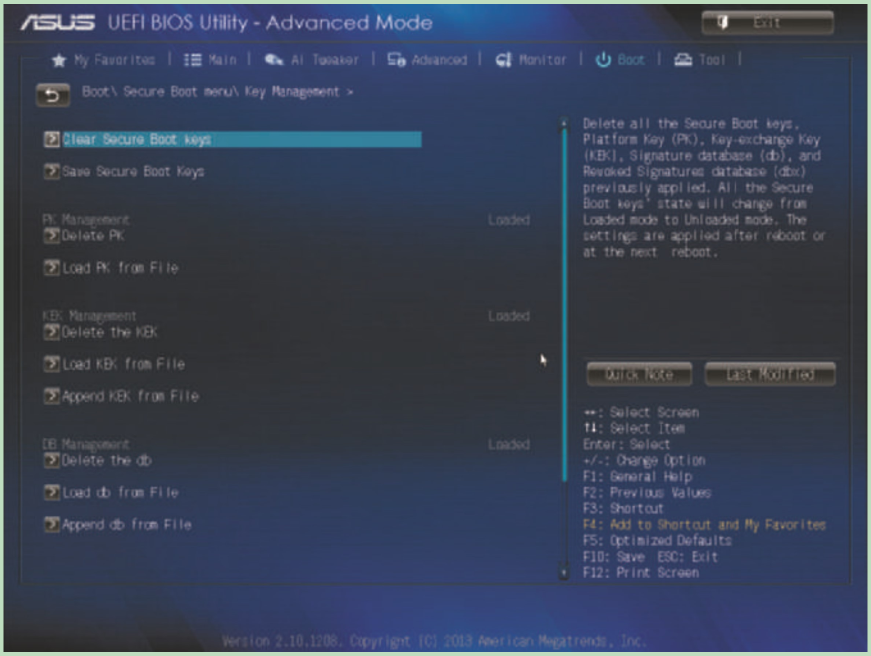
2. To manage the CSM and Secure boot, click the **Boot** menu. On the Boot menu, first make sure Fast Boot is disabled (see Figure 3-42). Notice the two setup modes that are listed in the figure. Select CSM for backward compatibility with older BIOS devices and drivers and MBR hard drives. Select Secure Boot to boot using UEFI secure boot. For secure boot to work, CSM must be disabled, Windows 8 or another UEFI-aware OS must be installed, and the hard drive used for the boot must be partitioned using GPT.

Source: American Megatrends, Inc.

Figure 3-42 Use CSM to boot a legacy BIOS system or disable it to implement UEFI secure boot

(continues)

3. To manage Secure boot, click **Secure Boot**. On the next screen, you can select the operating system that will be loaded when you have more than one OS installed on the system. To manage the keys used for a Secure boot, click **Key Management**. The screen in Figure 3-43 appears.



Source: American Megatrends, Inc.

Figure 3-43 Manage the UEFI secure boot keys and databases

4. A Secure boot uses the following keys, databases, and drivers, which are stored in flash memory on the motherboard and/or on the hard drive and can be managed using commands shown in Figure 3-43:

- The **signature database (db)** holds a list of digital signatures of approved operating systems, applications, and drivers that can be loaded by UEFI. Notice in Figure 3-43, the option to delete the db, load it from a file, or append to it.
- The **revoked signature database (dbx)** is a blacklist of signatures for software that has been revoked and is no longer trusted.
- The **Key-exchange Key (KEK)**, also called the **Key-enrollment Key (KEK)**, database is another database that holds digital signatures provided by OS manufacturers, such as Microsoft and Red Hat (a Linux manufacturer). The OS manufacturer or vendor that owns the keys can update them, which will in turn update the db or dbx. For example, an update may occur when a new OS is released or to revoke a bad release of an OS.
- The **Platform Key (PK)** is a digital signature belonging to the motherboard or computer manufacturer. The PK authorizes turning on or off Secure boot and updating the KEK database.
- **Option ROMs** are UEFI drivers, for example, video, keyboard, and mouse drivers required as the computer first boots, that are digitally signed and identified in the signature database.

Just as with BIOS, UEFI loads an OS and drivers at the beginning of the boot and then turns the control of the computer over to the OS. When UEFI secure boot is active, it checks the OS and each UEFI driver or application before it is loaded to verify it is signed and identified in the secure boot databases. The OS, drivers, and applications that are loaded by UEFI are stored in a system partition on the hard drive named efi. After the OS is launched, it can load additional drivers and applications that UEFI secure boot does not verify.

For normal operation, you would not be required to change secure boot settings unless you want to install hardware that is not certified by the OS or computer manufacturer. In this situation, you could disable secure boot, assuming the PK allows you to do so. When you disable secure boot, the system is no longer protected from rogue drivers or OS installing at the boot. Before you make any changes to the secure boot screen, be sure to use the option to Save Secure Boot Keys, which saves all the databases to a USB flash drive so that you can backtrack your changes later if need be.

Notes On laptops and other computers that carry the Windows 8 logo imprinted on the computer, the computer manufacturer is required to configure secure boot so that it cannot be disabled, which assures that only certified OS and drivers can be loaded by UEFI.

Now let's see what other tasks you might need to do when you are responsible for maintaining a motherboard.

MAINTAINING A MOTHERBOARD

A+ 220-901 1.1

To maintain a motherboard, you need to know how to update the motherboard drivers, flash BIOS or UEFI, and replace the CMOS battery. All these skills are covered in this part of the chapter.

A+ Exam Tip The A+ 220-901 exam expects you to know how to update drivers and firmware and replace the CMOS battery.

UPDATING MOTHERBOARD DRIVERS

A+ 220-901 1.1, 1.2

Device drivers are small programs stored on the hard drive that an operating system, such as Windows or Linux, uses to communicate with a specific hardware device, for example, a printer, network port on the motherboard, or scanner. The CD or DVD that comes bundled with the motherboard contains a user guide and drivers for its onboard components (for example, chipset, graphics, audio, network, and USB drivers), and these drivers need to be installed in the OS. For a motherboard, after installing the board, you can install the drivers from CD or DVD and later update drivers by downloading updates from the motherboard manufacturer's website. Updates are sometimes included in updates to Windows.

Notes The motherboard CD or DVD or the manufacturer's website might contain useful utilities, for example, a utility to monitor the CPU temperature and alert you if overheating occurs or a diagnostics utility for troubleshooting.

If a motherboard or one of its components is giving problems, try downloading and installing updated drivers from the motherboard manufacturer website. Figure 3-44 shows the download page for one Asus motherboard where you can download drivers and BIOS updates. When you download the drivers using the system with the motherboard installed, Asus selects the correct OS, as shown in the figure.

Source: ASUSTek Computer, Inc.

Figure 3-44 Download drivers, BIOS updates, documentation, utilities, and other help software from the motherboard manufacturer's website

If you must download the drivers from a computer that does not have the motherboard installed, be sure to select the correct OS (for example, Windows 7) and the correct type (32 bit or 64 bit). Always use 32-bit drivers with a 32-bit OS and 64-bit drivers with a 64-bit OS. The bit number is the number of bits the driver or OS can process at one time, and you want that to match up. To know what edition and type of Windows you are using, on the Windows 8 desktop, right-click **Start** and click **System**. For Windows 7/Vista, click **Start**, right-click **Computer**, and select **Properties**. The System window appears, giving you details about the Windows installation (see Figure 3-45).

Figure 3-45 The System window reports the edition and type of OS installed

FLASHING BIOS

A+
220-901
1.1

Recall that BIOS includes the BIOS setup program, the startup BIOS that manages the startup process, and the system BIOS that manages basic I/O functions of the system. All these programs are stored on a firmware chip. The process of upgrading or refreshing the programming stored on the firmware chip is called updating the BIOS or **flashing BIOS**. Here are some good reasons you might want to flash the BIOS:

- The system hangs at odd times or during the boot.
- Some motherboard functions have stopped working or are giving problems. For example, the onboard video port is not working.
- You want to incorporate some new features or component on the board. For example, a BIOS upgrade might be required before you upgrade the processor.

Caution Be sure you use the correct motherboard brand and model when selecting the BIOS update on the manufacturer's website. Trying to use the wrong update can cause problems.

The BIOS updates are downloaded from the motherboard manufacturer's website. To flash BIOS, always follow the directions that you can find in the user guide for your motherboard. Here are four methods that most motherboards can use:

- ***Express BIOS update.*** Some motherboards allow for an express BIOS update, which is done from Windows. Download the update file to your hard drive. Close all open applications. Double-click the file, which runs the update program, and follow the directions on screen. The system will reboot to apply the update.
- ***Update from a USB flash drive using BIOS setup.*** Copy the downloaded update file to a USB flash drive. Then restart the system and press a key at startup that launches the BIOS update process. (For some motherboard brands, you press F7.) A screen appears where you can select the USB flash drive. BIOS finds the update file on the flash drive, completes the update, and restarts the system.
- ***Update using a bootable CD.*** You can download an ISO file from the motherboard manufacturer's website that contains the BIOS update. An ISO file has an .iso file extension and contains an **ISO image** of a CD. You can use an ISO image to create a bootable CD with software and data on it. After you have created the bootable CD, boot from it and follow the directions on screen to flash the BIOS.

Notes To use Windows to burn a CD from an ISO file, first insert a blank CD in the optical drive. Then right-click the .iso file, select **Burn disc image**, and follow the directions on screen.

If the BIOS update is interrupted or the update gives errors, you are in an unfortunate situation. You might be able to revert to the earlier version. To do this, generally, you download the recovery file from the website and copy the file to a USB flash drive. Then set the jumper on the motherboard to recover from a failed BIOS update. Reboot the system and the BIOS automatically reads from the device and performs the recovery. Then reset the jumper to the normal setting and boot the system.

Notes To identify the BIOS version installed, look for the BIOS version number displayed on the main menu of BIOS setup. Alternately, you can use the System Information utility (msinfo32.exe) in Windows to display the BIOS version.

Makers of BIOS code are likely to change BIOS frequently because providing the upgrade on the Internet is so easy for them. Generally, however, follow the principle that "if it's not broke, don't fix it." Update your BIOS only if you're having a problem with your motherboard or there's a new BIOS feature you want to use. Also, don't update the BIOS unless the update is a later version than the one installed. One last word of caution: It's very important the update not be interrupted while it is in progress. A failed update can make your motherboard totally unusable. Be sure you don't interrupt the update, and make sure there are no power interruptions. For laptops, make sure the AC adapter is plugged in and powering the system.

Caution Be very careful that you upgrade BIOS with the correct upgrade and that you follow the manufacturer's instructions correctly. Upgrading with the wrong file could make your system BIOS useless. If you're not sure that you're using the correct upgrade, *don't guess*. Check with the technical support for your BIOS before moving forward. Before you call technical support, have the information that identifies your BIOS and motherboard available.

FLASHING UEFI

A+
220-901
1.1

UEFI updates are more secure than BIOS updates because they require digital signatures for the update to be verified. UEFI firmware, drivers, and databases can be updated by way of a USB flash drive or from within Windows. The process using a USB flash drive works like this:

1. Follow the motherboard manufacturer's directions to make the USB drive bootable and download the UEFI update files to the drive.
2. If secure boot is enabled, enter UEFI setup and disable secure boot. Also make sure the USB device is listed in the boot priority order before the hard drive.
3. For a laptop, plug the AC adapter into an external power source so that the power won't fail during the update.
4. Reboot the system, this time from the USB flash drive. Follow the manufacturer's directions to flash UEFI. For one manufacturer, you enter the **flash** command at a command prompt.
5. When prompted, reboot the system. For a secure boot system, go back to UEFI setup and enable secure boot.

Windows updates sometimes include UEFI updates that are handled similarly to driver updates published by hardware manufacturers. When Windows receives an update that it recognizes to be a UEFI update, it hands off the update to UEFI. On the next reboot, the Windows loader verifies the update against the UEFI signature database. If the signature is validated, the update passes to the UEFI firmware. The firmware is then responsible for applying the update and displays a screen letting the user know to not disturb the system while the update is in progress. After the update is completed, the Windows loader continues loading the OS.

Notes If a UEFI update fails to complete, UEFI may reboot and try again up to three times. After the third attempt, the update will be discarded and UEFI will roll back a partial update.

USING JUMPERS TO CLEAR BIOS SETTINGS

A+
220-901
1.1

A motherboard may have jumpers that you can use to clear BIOS/UEFI settings, which returns BIOS/UEFI setup to factory default settings. You might want to clear settings when flashing BIOS didn't work or failed to complete correctly or a power-on password is forgotten and you cannot boot the system.

A **jumper** is two small posts or metal pins that stick up on the motherboard, used to hold configuration information. An open jumper has no cover, and a closed jumper has a cover on the two pins (see Figure 3-46). Look at the jumper cover in Figure 3-46(b) that is "parked," meaning it is hanging on a single pin for safekeeping, but is not being used to turn a jumper setting on.

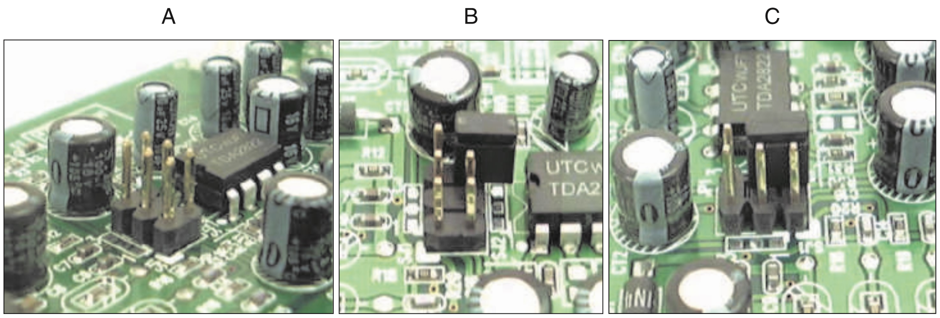


Figure 3-46 A 6-pin jumper group on a circuit board: (a) has no jumpers set to on, (b) has a cover parked on one pin, and (c) is configured with one jumper setting turned on

Most motherboards today allow you to set a supervisor password (to make changes in BIOS setup) or a power-on password (to get access to the system). Know that these passwords are not the same password that can be required by a Windows OS at startup. If both passwords are forgotten, you cannot use the computer. However, jumpers can be set to clear both passwords. Also, if flashing BIOS fails, a jumper can be set to undo the update.

For example, Figure 3-47 shows a group of three jumpers on one board. (The tan jumper cap is positioned on the first two jumper pins on the left side of the group.) Figure 3-48 shows the motherboard documentation on how to use these jumpers. When jumpers 1 and 2 are closed, which they are in the figure, normal booting happens. When jumpers 2 and 3 are closed, passwords to BIOS setup can be cleared on the next boot. When no jumpers are closed, on the next boot, the BIOS will recover itself from a failed update. Once set for normal booting, the jumpers should be changed only if you are trying to recover when a power-up password is lost or flashing BIOS has failed. To know how to set jumpers, see the motherboard documentation.

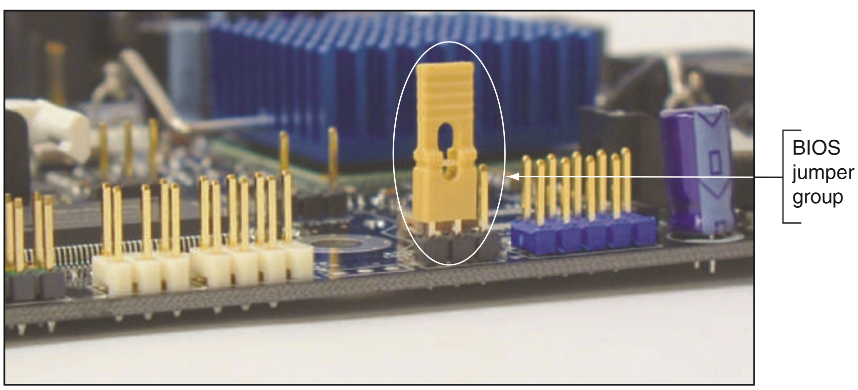


Figure 3-47 This group of three jumpers controls the BIOS configuration

Jumper Position	Mode	Description
1 3	Normal (default)	The current BIOS configuration is used for booting.
1 3	Configure	After POST, the BIOS displays a menu in CMOS setup that can be used to clear the user and supervisor power-on passwords.
1 3	Recovery	Recovery is used to recover from a failed BIOS update. Details can be found on the motherboard CD.

Figure 3-48 BIOS configuration jumper settings

REPLACING THE CMOS BATTERY

A+
220-901
1.2

Motherboard settings may be stored in flash memory in the firmware or in CMOS RAM. **CMOS (complementary metal-oxide semiconductor)** is a method of manufacturing microchips, and **CMOS RAM** is a small amount of memory stored on the motherboard that retains the data even when the computer is turned off because it is charged by a nearby lithium coin-cell battery (see Figure 3-49). If the **CMOS battery** is disconnected or fails, setup information is lost. An indication that the battery is getting weak is that the system date and time are incorrect after power has been disconnected to the PC. A message about a low battery can also appear at startup.

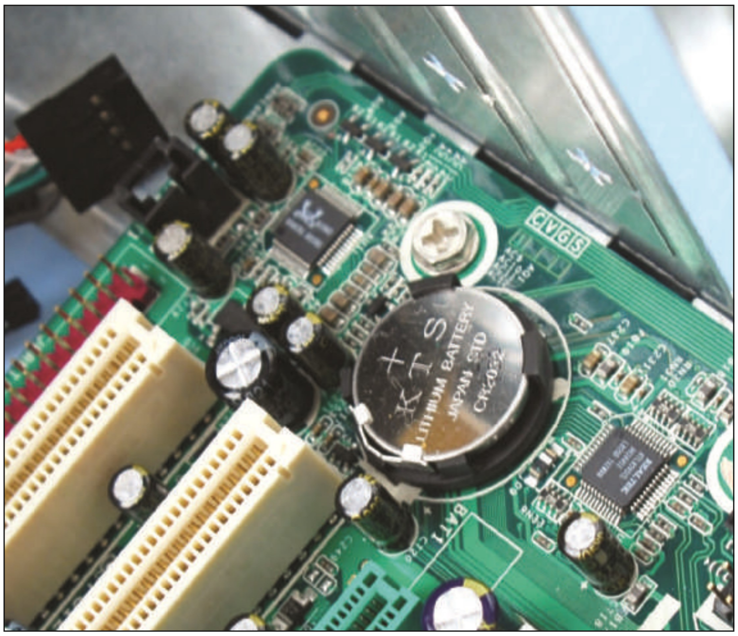


Figure 3-49 The coin-cell battery powers CMOS RAM when the system is turned off and unplugged

A+ Exam Tip The A+ 220-901 exam expects you to know about the CMOS battery.

The CMOS battery on the motherboard is considered a field replaceable unit. The battery is designed to last for years and recharges when the motherboard has power. However, on rare occasions, you might need to replace one if the system loses BIOS settings when it is unplugged. Make sure the replacement battery is an exact match to the original or is one the motherboard manufacturer recommends for the board. Power down the system, unplug it, press the power button to drain the power, and remove the case cover. Use your ESD strap to protect the system against ESD. The old battery can be removed with a little prying using a flathead screwdriver. The new battery pops into place. For more specific directions, see the motherboard documentation.

Hands-On Project 3-6 Examine How to Clear BIOS Settings

A+
220-901
1.1

You can complete the following activity only if you have the documentation for a motherboard: Locate the jumper on the board that returns BIOS setup to default settings and label this jumper on your diagram. It is often found near the CMOS battery. Some boards might have more than one, and some have none.

Now let's turn our attention to installing or replacing a motherboard.

INSTALLING OR REPLACING A MOTHERBOARD

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A motherboard is considered a field replaceable unit, so you need to know how to replace one when it goes bad. In this part of the chapter, you learn how to select a motherboard and then how to install or replace one in a desktop or laptop computer.

HOW TO SELECT A DESKTOP MOTHERBOARD

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Because the motherboard determines so many of your computer's features, selecting the motherboard is, in most cases, your most important decision when you purchase a desktop computer or assemble one from parts. Depending on which applications and peripheral devices you plan to use with the computer, you can take one of three approaches to selecting a motherboard. The first approach is to select the board that provides the most room for expansion, so you can upgrade and exchange components and add devices easily. A second approach is to select the board that best suits the needs of the computer's current configuration, knowing that when you need to upgrade, you will likely switch to new technology and a new motherboard. The third approach is to select a motherboard that meets your present needs with moderate room for expansion.

Ask the following questions when selecting a motherboard:

1. What form factor does the motherboard use?
2. Which brand (Intel or AMD) and model processors does the board support? Which chipset does it use? How much memory can it hold? What memory speeds does the board support?
3. What type and how many expansion slots are on the board (for example, PCI Express 3.0 or PCI)?
4. How many and what hard drive controllers and connectors are on the board (for example, SATA or eSATA)?
5. What are the embedded devices on the board, and what internal slots or connections does the board have? (For example, the board might provide a network port, wireless antenna port, FireWire port, two or more USB ports, video port, and so forth.)
6. Does the board fit the case you plan to use?
7. What are the price and the warranty on the board? Does the board get good reviews?
8. How extensive and user friendly is the documentation?
9. How much support does the manufacturer supply for the board?

Sometimes a motherboard contains an onboard component more commonly offered as a separate device. One example is support for video. The video port might be on the motherboard or might require a video card. The cost of a motherboard with an embedded component is usually less than the combined cost of a motherboard with no embedded component and an expansion card. If you plan to expand, be cautious about choosing a proprietary board that has many embedded components. Often such boards do not easily accept add-on devices from other manufacturers. For example, if you plan to add a more powerful video card, you might not want to choose a motherboard that contains an onboard video port. Even though you can likely disable the video port in UEFI/BIOS setup, there is little advantage to paying the extra money for it.

Notes If you have an embedded component, make sure you can disable it so you can use another external component if needed. Components are disabled in UEFI/BIOS setup.

Table 3-5 shown earlier in the chapter lists some manufacturers of motherboards and their web addresses. For motherboard reviews, check out *www.motherboards.org* and *www.pcmag.com*, or do a general search of the web.

HOW TO INSTALL OR REPLACE A MOTHERBOARD

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When you purchase a motherboard, the package comes with the board, I/O shield, documentation, drivers, and various screws, cables, and connectors. When you replace a motherboard, you pretty much have to disassemble an entire computer, install the new motherboard, and reassemble the system, which you learned to do earlier. The following list is meant to be a general overview of the process and is not meant to include the details of all possible installation scenarios, which can vary according to the components and case you are using. The best place to go for detailed instructions on installing a motherboard is the motherboard user guide.

Caution As with any installation, remember the importance of using an ESD strap to ground yourself when working inside a computer case to protect components against ESD.

The general process for replacing a motherboard is as follows:

1. ***Verify that you have selected the right motherboard to install in the system.*** The new motherboard should have the same form factor as the case, support the RAM modules and processor you want to install on it, and have other internal and external connectors you need for your system.
2. ***Get familiar with the motherboard documentation, features, and settings.*** Especially important are any connectors and jumpers on the motherboard. It's a great idea to read the motherboard user guide from cover to cover. At the least, get familiar with what it has to offer and study the diagrams in it that label all the components on the board. Learn how each connector and jumper is used. You can also check the manufacturer's website for answers to any questions you might have.
3. ***Remove components so you can reach the old motherboard.*** Use an ESD strap. Turn off the system and disconnect all cables and cords. Press the power button to dissipate the power. Open the case cover and remove all expansion cards. Disconnect all internal cables and cords connected to the old motherboard. To safely remove the old motherboard, you might have to remove drives. If the processor cooler is heavy and bulky, you might remove it from the old motherboard before you remove the motherboard from the case.
4. ***Install the I/O shield.*** The I/O shield is a metal plate that comes with the motherboard and fits over the ports to create a well-fitting enclosure for them. A case might come with a standard I/O shield already in place. Hold the motherboard up to the shield and make sure the ports on the board will fit the holes in the shield (see Figure 3-50). If the holes in the shield don't match up with the ports on the board, punch out the shield and replace it with the one that came bundled with the motherboard.

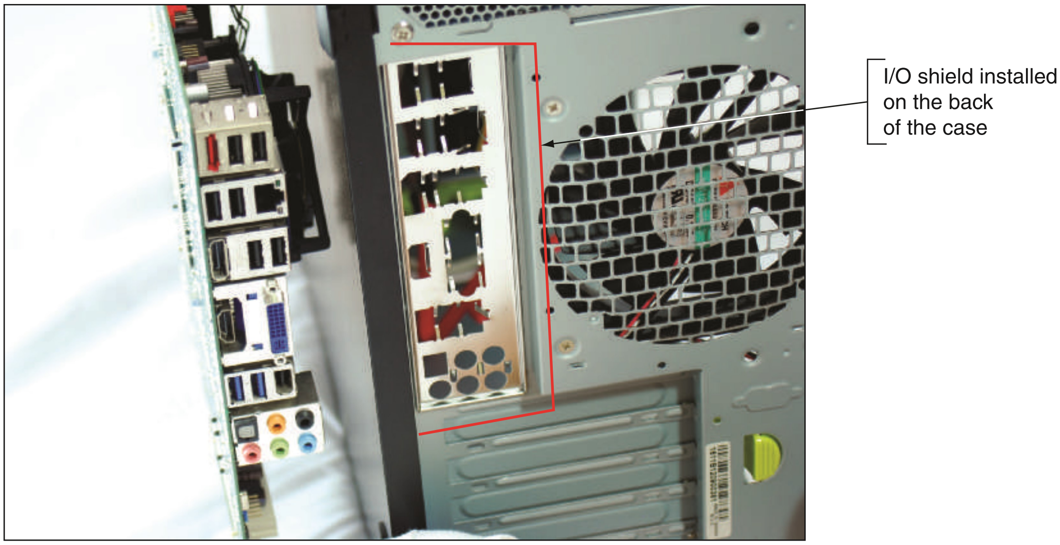

Figure 3-50 Make sure the holes in the I/O shield match up with the ports on the motherboard

5. ***Install the motherboard.*** Place the motherboard into the case and, using spacers or screws, securely fasten the board to the case. Because coolers are heavy, most processor instructions say to install the motherboard before installing the processor and cooler to better protect the board or processor from being damaged. On the other hand, some motherboard manufacturers say to install the processor and cooler and then install the motherboard. Follow the order given in the motherboard user guide. The easiest approach is to install the processor, cooler, and memory modules on the board and then place the board in the case (see Figure 3-51).

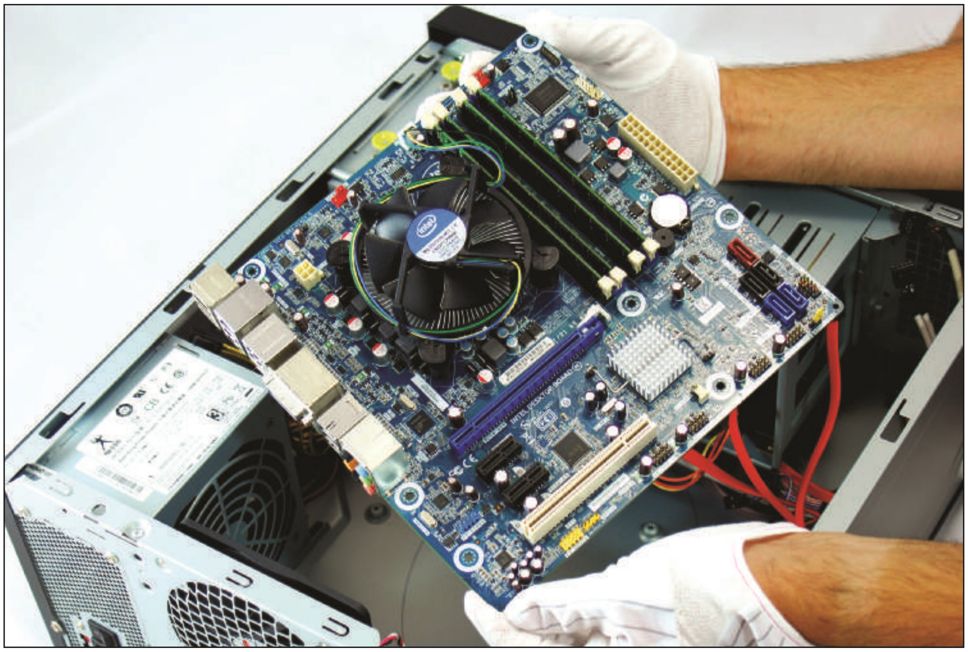

Figure 3-51 Motherboard with processor, cooler, and memory modules installed is ready to go in the case

6. ***Install the processor and processor cooler.*** The processor comes already installed on some motherboards, in which case you just need to install the cooler. How to install a processor and cooler is covered in the chapter, "Supporting Processors and Upgrading Memory."
7. ***Install RAM into the appropriate slots on the motherboard.*** How to install RAM is covered in the chapter, "Supporting Processors and Upgrading Memory."
8. ***Attach cabling that goes from the case switches to the motherboard, and from the power supply and drives to the motherboard.*** Pay attention to how cables are labeled and to any information in the documentation about where to attach them. The chapter, "First Look at Computer Parts and Tools," can help you identify the types of power connectors. You'll need to connect the P1 connector, the fan connectors, and the processor auxiliary power connector. Position and tie cables neatly together to make sure they don't obstruct the fans and the airflow.
9. ***Install the video card on the motherboard.*** This card should go into the primary PCI Express ×16 slot. If you plan to install multiple video cards, install only one now and check out how the system functions before installing the second one.
10. ***Plug the computer into a power source, and attach the monitor, keyboard, and mouse.*** Initially install only the devices you absolutely need.
11. ***Boot the system and enter UEFI/BIOS setup.*** Make sure settings are set to the default. If the motherboard comes new from the manufacturer, it will already be at default settings. If you are salvaging a motherboard from another system, you might need to reset settings to the default. You will need to do the following while you are in UEFI/BIOS setup:
    - Check the time and date.
    - Make sure fast boot (also called abbreviated POST) is disabled. While you're installing a motherboard, you generally want it to do as many diagnostic tests as possible. After you know the system is working, you can choose fast boot.
    - Set the boot order to the hard drive, and then the optical drive, if you will be booting the OS from the hard drive.
    - Leave everything else at their defaults unless you know that particular settings should be otherwise.
    - Save and exit.
12. ***Observe POST and verify that no errors occur.***
13. ***Verify Windows starts with no errors.*** If Windows is already installed on the hard drive, boot to the Windows desktop. Use Device Manager to verify that the OS recognizes all devices and that no conflicts are reported.
14. ***Install the motherboard drivers.*** If your motherboard comes with a CD that contains some motherboard drivers, install them now. You will probably need Internet access so that the setup process can download the latest drivers from the motherboard manufacturer's website. Reboot the system one more time, checking for errors.
15. ***Install any other expansion cards and drivers.*** Install each device and its drivers, one device at a time, rebooting and checking for conflicts after each installation.
16. ***Verify that everything is operating properly, and make any final OS and UEFI/BIOS adjustments, such as setting power-on passwords.***

Notes Whenever you install or uninstall software or hardware, keep a notebook with details about the components you are working on, configuration settings, manufacturer specifications, and other relevant information. This helps if you need to backtrack later and can also help you document and troubleshoot your computer system. Keep all hardware documentation for this system together with the notebook in an envelope in a safe place.

3

Hands-On | Project 3-7 Insert and Remove Motherboards

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Using old or defective expansion cards and motherboards, practice inserting and removing expansion cards and motherboards. In a lab or classroom setting, the instructor can provide extra cards and motherboards for exchange.

REPLACING A LAPTOP SYSTEM BOARD

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Replacing the system board (motherboard) on a laptop probably means you'll need to fully disassemble the entire laptop except the LCD assembly in the lid. Therefore, before you tackle the job, consider alternatives. If available, use diagnostic software from the laptop manufacturer to verify that the problem is a failed system board. If a port or component on the system board has failed, consider installing an external device rather than replacing the entire board. Replacing the system board is a big deal, so consider that the cost of repair, including parts and labor, might be more than the laptop is worth. A new laptop might be your best solution.

If you do decide to replace a system board, use a replacement purchased from the laptop manufacturer. Here is the general procedure for replacing the system board in one laptop:

1. Remove the keyboard, optical drive, and mini PCIe card.
2. The next step is to remove the laptop lid and keyboard bezel assembly. To do this, first remove two screws on the back of the laptop (see Figure 3-52) and the screws on the bottom of the laptop. You can then crack the case by lifting the laptop lid and keyboard bezel from the case (see Figure 3-53).

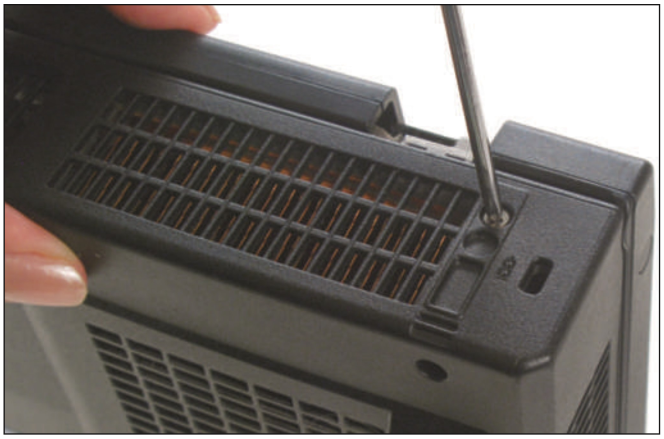

Figure 3-52 Remove two screws on the back of the notebook

Figure 3-53 Cracking the notebook case

3. Lift up the assembly and look underneath to see two cables connecting the assembly to the motherboard (see Figure 3-54). Disconnect these two cables and set the assembly aside.

Figure 3-54 Lift the assembly to locate the two cable connections

4. To remove the CPU fan assembly, remove screws (see Figure 3-55) and then lift the fan assembly up. Then open the CPU socket and remove the CPU.

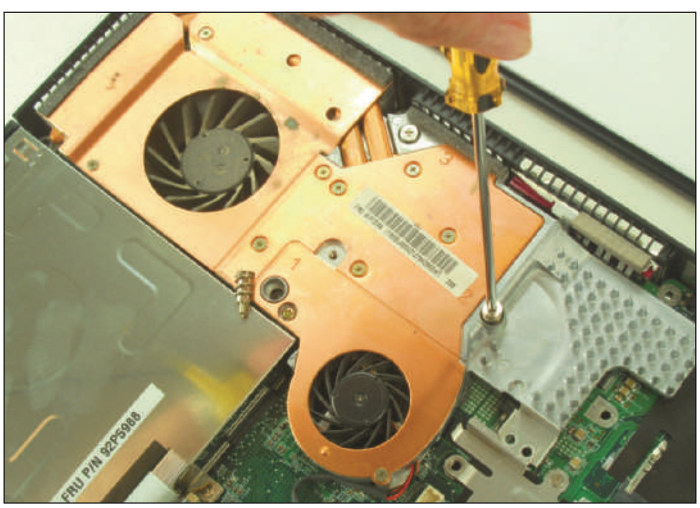

Figure 3-55 Remove the screws holding the CPU fan assembly in place

5. The DVD drive can now be removed, and the motherboard is fully exposed.
6. Remove a single screw that holds the motherboard in place (see Figure 3-56) and lift the board out of the case. Figure 3-57 shows the bottom of the board. Both top and bottom are packed with components. When reassembling the system, all steps are done in reverse.

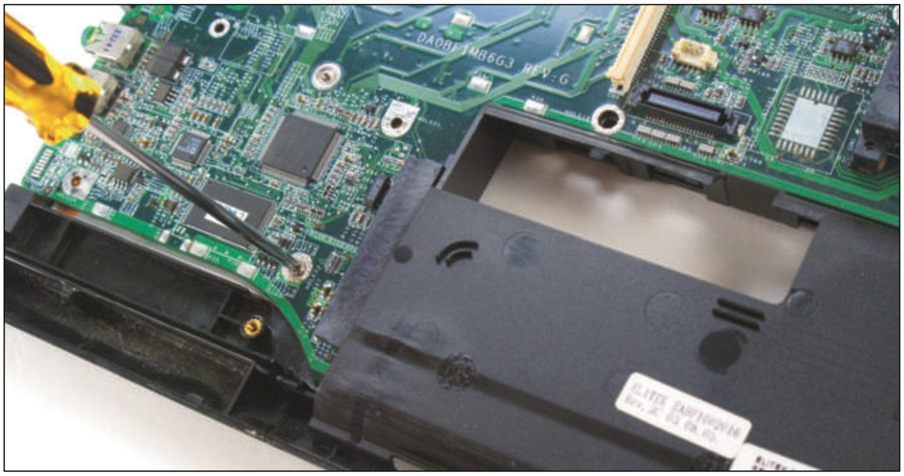

Figure 3-56 Remove the single screw attaching the system board to the case

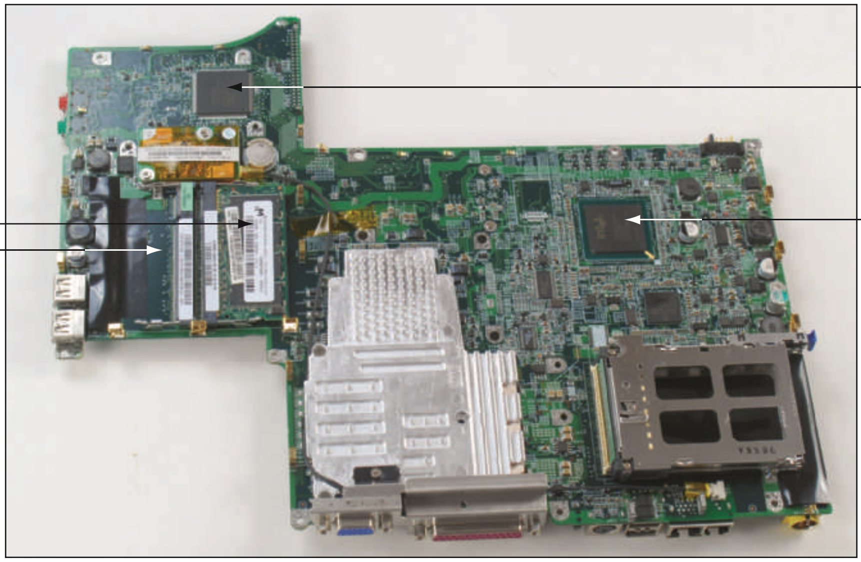

Figure 3-57 Bottom of the system board

>> CHAPTER SUMMARY

Motherboard Types and Features

- The motherboard is the most complicated of all components inside the computer. It contains the processor socket and accompanying chipset, firmware holding the UEFI/BIOS, memory slots, expansion slots, jumpers, ports, and power supply connections. The motherboard you select determines both the capabilities and limitations of your system.
- The most popular motherboard form factors are ATX, microATX, and Mini-ITX.

- A motherboard will have one or more Intel sockets for an Intel processor or one or more AMD sockets for an AMD processor.
- The chipset embedded on the motherboard determines what kind of processor and memory the board can support.
- Major advancements in past Intel chipsets included the Accelerated Hub Architecture (using the North Bridge and South Bridge), Nehalem chipsets (using the memory controller on the processor), and Sandy Bridge chipsets (using the memory and graphics controller on the processor). All later chipsets use the memory and graphics controller in the processor package.
- Buses used on motherboards include conventional PCI, PCI-X, and PCI Express. PCI Express is replacing all the other bus types.
- Some components can be built into the motherboard, in which case they are called onboard components. Other components can be attached to the system in some other way, such as on an expansion card.

Configuring a Motherboard

- The firmware that controls a motherboard and the boot is the older BIOS or the newer UEFI. Most UEFI firmware provides for backward compatibility with BIOS devices.
- Motherboard settings that can be configured using UEFI/BIOS setup include changing the boot priority order, enabling or disabling onboard devices, support for virtualization, and security settings (for example, power-on passwords and intrusion detection). You can also view information about the installed processor, memory, and storage devices and temperatures, fan speeds, and voltages.

Maintaining a Motherboard

- Motherboard drivers might need updating to fix a problem with a board component or to use a new feature provided by the motherboard manufacturer.
- To flash BIOS, use a utility program in Windows, a USB flash drive, or a bootable CD.
- To update UEFI, you can boot from a USB flash drive that holds the updates, or Windows can receive an update during the normal Windows update process and then pass it on to the UEFI firmware, which applies the update.
- Jumpers on the motherboard may be used to clear UEFI/BIOS settings, restoring them to factory default. The CMOS battery that powers CMOS RAM might need replacing.

Installing or Replacing a Motherboard

- When selecting a motherboard, pay attention to the form factor, chipset, expansion slots, and memory slots used and the processors supported. Also notice the internal and external connectors and ports the board provides.
- When installing a motherboard, first study the motherboard and its manual, and set jumpers on the board. Sometimes the processor and cooler are best installed before installing the motherboard in the case. When the cooling assembly is heavy and bulky, it is best to install it after the motherboard is securely seated in the case.

Replacing a Laptop System Board

- For laptops, it's usually more cost effective to replace the laptop than to replace a failed system board.

3

>> KEY TERMS

For explanations of key terms, see the Glossary for this text.

Accelerated Processing Unit (APU)
ball grid array (BGA)
BitLocker Encryption
bus
chipset
CMOS (complementary metal-oxide semiconductor)
CMOS battery
CMOS RAM
Compatibility Support Module (CSM)
data bus
data path size
device driver
EFI (Extensible Firmware Interface)
flashing BIOS
flip-chip land grid array (FCLGA)
flip-chip pin grid array (FCPGA)
Front Side Bus (FSB)
gigahertz (GHz)
GUID Partition Table (GPT)
hertz (Hz)
I/O shield
ISO image
ITX
jumper
Key-enrollment Key (KEK)
Key-exchange Key (KEK)
land grid array (LGA)
LoJack
Master Boot Record (MBR)
megahertz (MHz)
Mini-ITX
PCI
PCI Express
North Bridge
onboard port
option ROM
overclocking
PCI Express (PCIe)
PCI-X
pin grid array (PGA)
Platform Key (PK)
protocol
QuickPath Interconnect (QPI)
revoked signature database (dbx)
riser card
secure boot
signature database (db)
small form factor (SFF)
South Bridge
staggered pin grid array (SPGA)
system bus
system clock
TPM (Trusted Platform Module) chip
trace
Unified Extensible Firmware Interface (UEFI)
virtual machine (VM)
virtualization
wait state
zero insertion force (ZIF) socket

>> REVIEWING THE BASICS

1. What are the three most popular form factors used for motherboards?
2. Which type of Intel chipsets was the first to support the graphics controller to be part of the processor?
3. How many pins does the Intel Socket B have? What is another name for this socket?
4. What type of memory does the LGA1155 socket work with? Which socket was it designed to replace?
5. Does the Sandy Bridge chipset family use two chipset housings on the motherboard or a single chipset housing? The Nehalem chipset?
6. How many pins does the AMD socket AM3 have?
7. Which part of a Nehalem chipset connects directly to the processor, the North Bridge or the South Bridge?
8. How does the throughput of PCI Express Version 3.0 compare to PCIe Version 2.0?
9. What is the maximum wattage that a PCIe Version 2.0 expansion card can draw?
10. What type of power connector on the motherboard was introduced with PCIe Version 1.0? How much power does this connector provide?
11. What type of power connector was introduced with PCIe Version 2.0? How much power does this connector provide?
12. If you are installing an expansion card into a case that does not have enough clearance above the motherboard for the card, what device can you use to solve the problem?
13. Which chip on the motherboard does Windows BitLocker Encryption use to secure the hard drive?
14. How can you find out how many memory slots are populated on a motherboard without opening the computer case?

15. What are two reasons you might decide to flash BIOS?
16. What is the easiest way to obtain the latest software to upgrade BIOS?
17. What can you do if the power-on password and the supervisor password to a system have been forgotten?
18. How is CMOS RAM powered when the system is unplugged?
19. Describe how you can access the BIOS setup program.
20. Does Windows 7 support a secure boot in UEFI? Windows 8? Linux Ubuntu version 14?
21. Which partitioning method must be used for partitioning a 4-TB hard drive?
22. If a USB port on the motherboard is failing, what is one task you can do that might fix the problem?
23. What might the purpose be for a SATA-style power connector on a motherboard?
24. What is the purpose of installing standoffs or spacers between the motherboard and the case?
25. When installing a motherboard, suppose you forget to connect the wires from the case to the front panel header. Will you be able to power up the system? Why or why not?

>> THINKING CRITICALLY

1. Why don't all buses on a motherboard operate at the same speed?
2. When you turn off the power to a computer and unplug it at night, it loses the date, and you must reenter it each morning. What is the problem and how do you solve it?
3. Why do you think the trend is to put more control such as the graphics controller and the memory controller in the processor rather than in the chipset?
4. When troubleshooting a desktop motherboard, you discover the network port no longer works. What is the best and least expensive solution to this problem? If this solution does not work, which solution should you try next?
   a. Replace the motherboard.
   b. Disable the network port and install a network card in an expansion slot.
   c. Use a wireless network device in a USB port to connect to a wireless network.
   d. Return the motherboard to the factory for repair.
   e. Update the motherboard drivers.
5. A computer freezes at odd times. At first you suspect the power supply or overheating, but you have eliminated overheating and replaced the power supply without solving the problem. What do you do next?
   a. Replace the processor.
   b. Replace the motherboard.
   c. Reinstall Windows.
   d. Replace the memory modules.
   e. Flash BIOS.

>> REAL PROBLEMS, REAL SOLUTIONS

REAL PROBLEM 3-1 Labeling the Motherboard

Figure 3-58 shows a blank diagram of an ATX motherboard. Using what you learned in this chapter and in the chapter, "First Look at Computer Parts and Tools," label as many components as you can. If you would like to print the diagram, look for "Figure 3-58" in the online content that accompanies this text at *www.cengagebrain.com*. For more information on accessing this content, see the Preface.

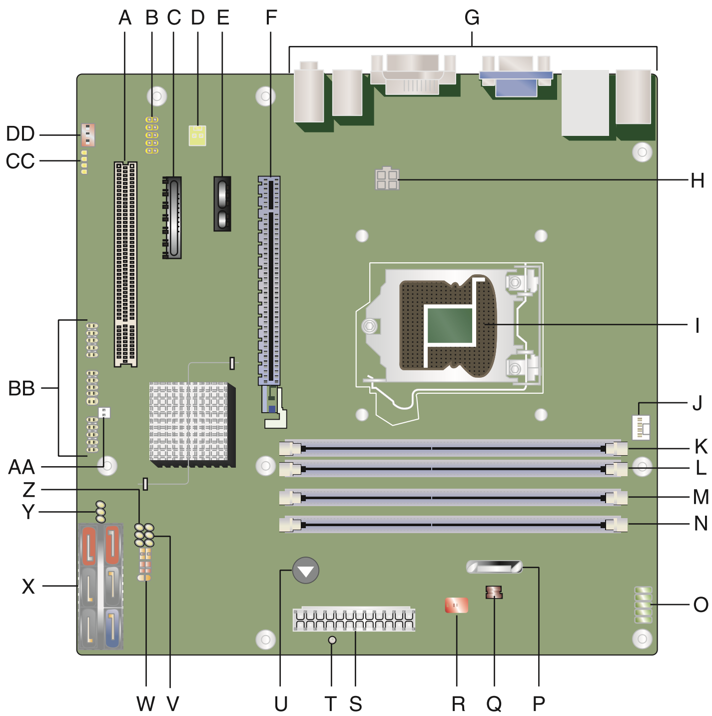

Figure 3-58 Label the motherboard

REAL PROBLEM 3-2 Selecting a Replacement Motherboard

When a motherboard fails, you can select and buy a new board to replace it. Suppose the motherboard in your computer has failed and you want to buy a replacement and keep your repair costs to a mum. Try to find a replacement motherboard on the web that can use the same case, power supply, processor, memory, and expansion cards as your current system. If you cannot find a good match, what other components might have to be replaced (for example, the processor or memory)? What is the total cost of the replacement parts? Save or print webpages showing what you need to purchase.

REAL PROBLEM 3-3 Researching Maintaining a Motherboard

Using the motherboard user guide that you downloaded in Hands-On Project 3-4, answer the following questions:

1. How many methods can be used to flash UEFI/BIOS on the motherboard? Describe each method. If your system uses BIOS rather than UEFI, what can you do to recover the system if flashing BIOS fails?
2. Locate the CMOS battery on the diagram of the motherboard. What are the steps to replace this battery?

Using a computer in your school lab, do the following to practice replacing the CMOS battery:

1. Locate the CMOS battery on your motherboard. What is written on top of the battery? Using the web, find a replacement for this battery. Print the webpage showing the battery. How much does the new battery cost?
2. Enter BIOS setup on your computer. Write down any BIOS settings that are not default settings. You'll need these settings later when you reinstall the battery.
3. Turn off and unplug the computer, press the power button to drain the system of power, open the case, remove the battery, and boot the PC. What error messages appear? What is the system date and time?
4. Power down the computer, unplug it, press the power button to drain the power, replace the battery, and boot the PC. Close up the case and return BIOS settings to the way you found them. Make sure the system is working normally.

CHAPTER 4

Supporting Processors and Upgrading Memory

After completing this chapter, you will be able to:

- Compare characteristics and purposes of Intel and AMD processors used for personal computers
- Install and upgrade a processor
- Compare the different kinds of physical memory and how they work
- Upgrade memory

Previously, you learned about motherboards. In this chapter, you learn about the two most important components on the motherboard, which are the processor and memory. You learn how a processor works, about the many different types and brands of processors, and how to match a processor to the motherboard.

Memory technologies have evolved over the years. When you support an assortment of desktop and laptop computers, you'll be amazed at all the different variations of memory modules used not only in newer computers, but also in older computers still in use. A simple problem of replacing a bad memory module can become a complex research project if you don't have a good grasp of current and past memory technologies.

The processor and memory modules are considered field replaceable units (FRUs), so you'll learn how to install and upgrade a processor and memory modules. Upgrading the processor or adding more memory to a system can sometimes greatly improve performance. How to troubleshoot problems with the processor or memory is covered in the chapter, "Supporting the Power System and Troubleshooting Computers."