

# 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

**P**reviously, 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.

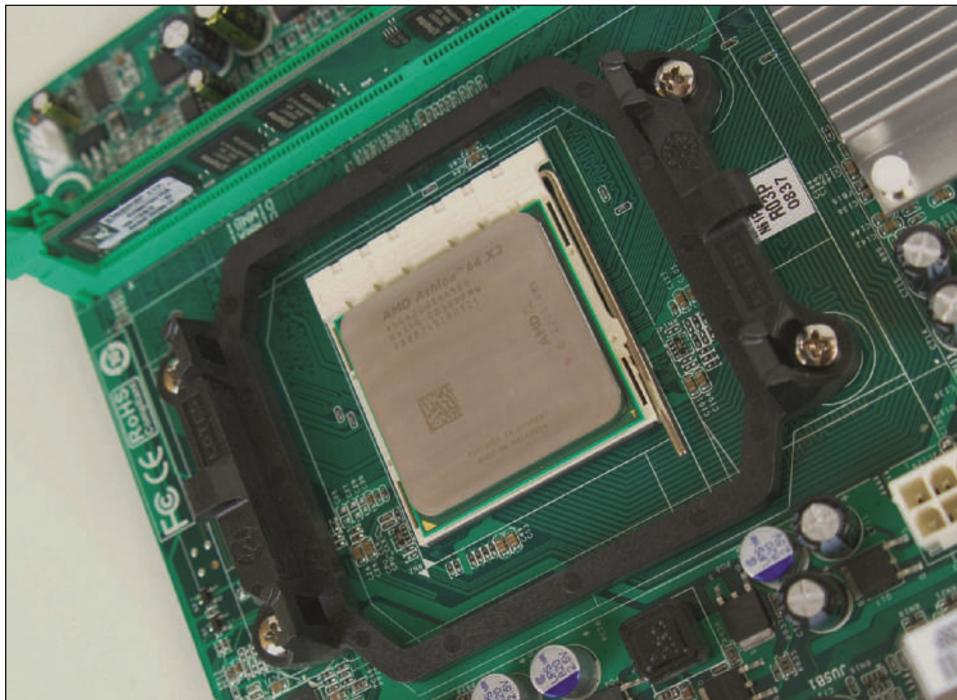
Memory technologies have evolved over the years. When you support an assortment of desktop and laptop computers, you'll be amazed at all the different variations of memory modules used not only in newer computers, but also in older computers still in use. A simple problem of replacing a bad memory module 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."

## TYPES AND CHARACTERISTICS OF PROCESSORS

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The processor installed on a motherboard is the primary component that determines the computing power of the system (see Figure 4-1). Recall that the two major manufacturers of processors are Intel ([www.intel.com](http://www.intel.com)) and AMD ([www.amd.com](http://www.amd.com)).



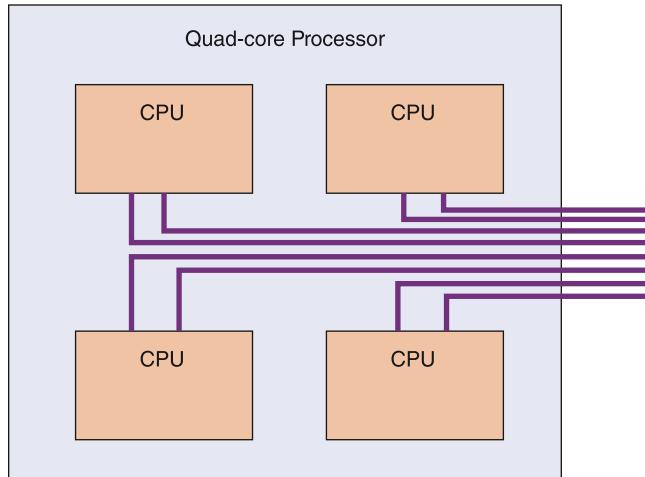
**Figure 4-1** An AMD Athlon 64 X2 installed in socket AM2+ with cooler not yet installed

In this chapter, you learn a lot of details about processors. As you do, try to keep these nine features of processors at the forefront. These features affect performance and compatibility with motherboards:

- ▲ **Feature 1: Processor speed.** The **processor frequency** is the speed at which the processor operates internally and is measured in gigahertz, such as 3.3 GHz. Current Intel and AMD processors run at 1.8 GHz up to more than 4.4 GHz.
- ▲ **Feature 2: Socket and chipset the processor can use.** Recall that important Intel sockets for desktop systems are the LGA1150, LGA1155, LGA1156, LGA2011, LGA1366, and LGA775. AMD's important desktop sockets are AM3+, AM3, AM2+, AM2, FM1, FM2+, and FM2 sockets.
- ▲ **Feature 3: Processor architecture (32 bits or 64 bits).** All desktop and laptop processors sold today from either Intel or AMD are hybrid processors, which can process 64 bits or 32 bits at a time. A hybrid processor can use a 32-bit operating system (OS) or a 64-bit OS. Windows 8 and most editions of Windows 7 come in either type.
- ▲ **Feature 4: Multiprocessing abilities.** The ability of a system to do more than one thing at a time is accomplished by several means:
  - ▲ **Multiprocessing.** Two processing units (called arithmetic logic units or ALUs) installed within a single processor is called **multiprocessing**. The Pentium was the first processor that contained two ALUs, which means the processor can execute two instructions at the same time.
  - ▲ **Multithreading.** Each processor or core processes two threads at the same time. When Windows hands off a task to the CPU, it is called a **thread** and might involve several instructions. To handle two threads, the processor requires extra registers, or holding areas, within the processor

housing that it uses to switch between threads. In effect, you have two logical processors for each physical processor or core. Intel calls this technology **Hyper-Threading** and AMD calls it **HyperTransport**. The feature must be enabled in UEFI/BIOS setup and the operating system must support the technology.

- ▲ **Multicore processing.** Multiple processors can be installed in the same processor housing (called **multicore processing**). A processor package might contain up to eight cores (dual-core, triple-core, quad-core, and so forth). In Figure 4-2, this quad-core processor contains four cores or CPUs. Using multithreading, each core can handle two threads. Therefore, the processor appears to have up to eight logical processors as it can handle eight threads from the operating system.

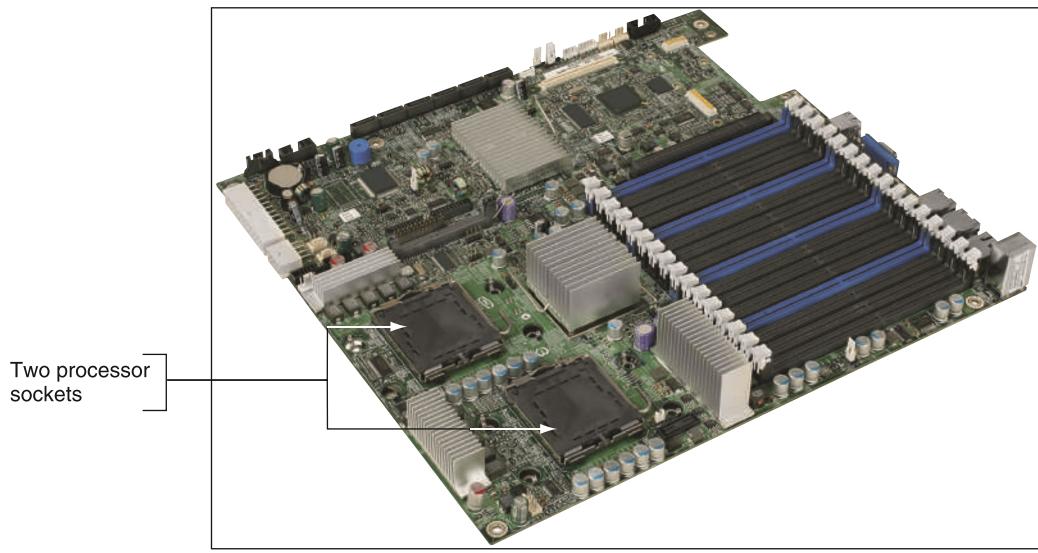


**Figure 4-2** This quad-core processor has four cores and each core can handle two threads

▲ **Dual processors.** A server motherboard might have two processor sockets, called **dual processors** or a **multiprocessor platform** (see Figure 4-3). A processor (for example, the Xeon processor for servers) must support this feature.

▲ **Feature 5: Memory cache, which is the amount of memory included within the processor package.** Today's processors all have some memory on the processor chip (called a die). Memory on the processor die is called **Level 1 cache (L1 cache)**. Memory in the processor package, but not on the processor die, is called **Level 2 cache (L2 cache)**. Some processors use a third cache farther from the processor core, but still in the processor package, which is called **Level 3 cache (L3 cache)**.

**3 cache (L3 cache).** Memory used in a memory cache is **static RAM (SRAM**; pronounced “S-Ram”). Memory used on the motherboard loses data rapidly and must be refreshed often. It is, therefore, called volatile memory or **dynamic RAM (DRAM**; pronounced “D-Ram”). SRAM is faster than DRAM because it doesn't need refreshing; it can hold its data as long as power is available.



**Figure 4-3** This motherboard for a server has two processor sockets, which allow for a multiprocessor platform

▲ **Feature 6: Security. Execute Disable Bit (EDB)** (also called eXecute Disable [XD] by Intel, Enhanced Virus Protection by AMD, and disable execute bit by CompTIA) is security built into a processor so that it can work with the operating system to designate an area of memory for holding data or instructions. When an area is designated for data, instructions stored in this area are not executed, thus preventing a **buffer overflow attack** by malicious software, which attempts to run its code from an area of memory assigned to another program for its data. EDB requires a compatible OS. You can enable EDB using the BIOS or UEFI setup screen (see Figure 4-4). It is important to remember that even though EDB can stop malware from executing, it cannot remove it. You still need to use anti-malware software to remove the malware.



Source: American Megatrends, Inc.

**Figure 4-4** The Execute Disable Bit is enabled using the UEFI setup screen

- ▲ **Feature 7: The memory features on the motherboard that the processor can support.** DRAM memory modules that might be used on a motherboard include DDR, DDR2, DDR3, or DDR4. Besides the type of memory, a processor can support certain amounts of memory, memory speeds, and number of memory channels (single, dual, triple, or quad channels). All these characteristics of memory are discussed later in the chapter.
- ▲ **Feature 8: Support for virtualization.** A computer can use software to create and manage multiple virtual machines and their virtual devices. Most processors sold today support virtualization, and the feature must be enabled in UEFI/BIOS setup.
- ▲ **Feature 9: Integrated graphics.** A processor might include an integrated GPU. A **graphics processing unit (GPU)** is a processor that manipulates graphic data to form the images on a monitor screen. The GPU might be on a video card, on the motherboard, or embedded in the CPU package. When inside the CPU package, it is called integrated graphics. Many AMD processors and all the Intel second generation and higher processors have integrated graphics.

**★ A+ Exam Tip** The A+ 220-901 exam expects you to be familiar with the characteristics of processors. Know the purposes and characteristics of Hyper-Threading, core processing, types of cache, virtualization, integrated GPU, disable execute bit (CompTIA's name for EDB), and 32-bit versus 64-bit processing.

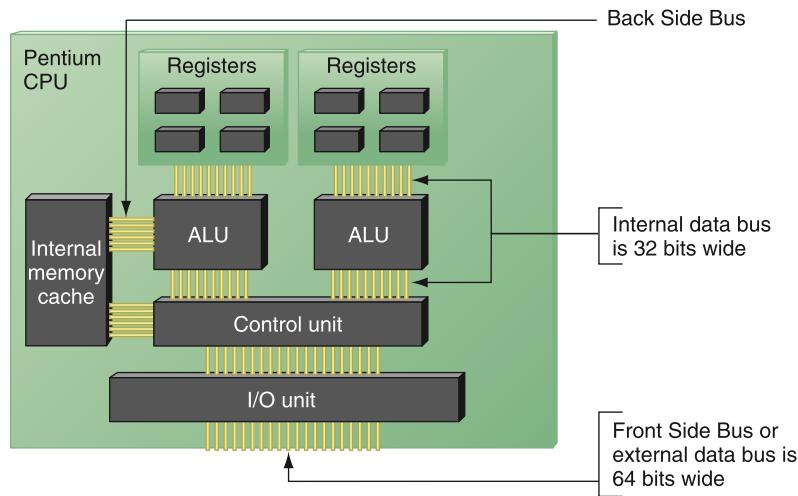
Let's now turn our attention to a discussion of how a processor works, including several of the processor features just listed. Then you'll learn about the families of Intel and AMD processors.

## HOW A PROCESSOR WORKS

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Although processors continue to evolve, they all have some common elements. These elements are diagrammed in Figure 4-5 for the Pentium processor. The Pentium made several major advances in processor technologies when it was first introduced. Because of its historical significance and the foundation it created for today's processors, it's a great place to start when learning how a processor works.

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**Figure 4-5** Since the Pentium processor was first released in 1993, the standard has been for a processor core to have two arithmetic logic units so that it can process two instructions at once

A processor contains these basic components diagrammed in Figure 4-5 for the Pentium processor:

- ▲ An input/output (I/O) unit manages data and instructions entering and leaving the processor.
- ▲ A control unit manages all activities inside the processor itself.
- ▲ One or more arithmetic logic units (ALUs) do all logical comparisons and calculations inside the processor. All desktop and laptop processors sold today contain two ALUs in each processor core within the processor package.
- ▲ Registers, which are small holding areas on the processor chip, work much like RAM does outside the processor to hold counters, data, instructions, and addresses that the ALU is currently processing.
- ▲ Internal memory caches (L1, L2, and possibly L3 or L4) hold data and instructions waiting to be processed by the ALU.
- ▲ Buses inside the processor connect components within the processor housing. These buses run at a much higher frequency than the motherboard buses that connect the processor to the chipset and memory on the motherboard.

If the processor operates at 3.2 GHz internally and the Front Side Bus is operating at 800 MHz, the processor operates at four times the FSB speed. This factor is called the **multiplier**. As you learned in the chapter, “All About Motherboards,” you can view the actual processor frequency and the clock speed using the UEFI/BIOS setup screens. You can also change the multiplier or the clock speed in order to overclock or throttle the processor.

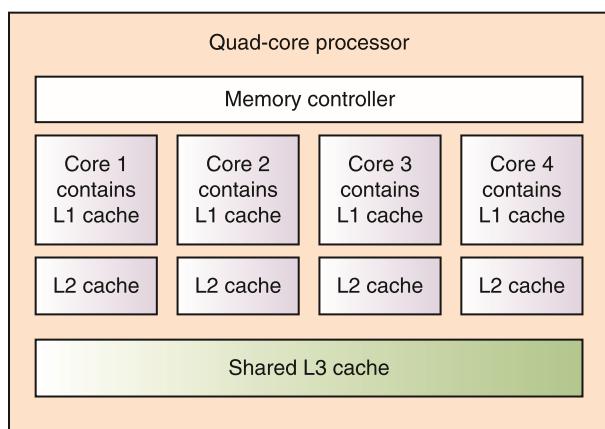
In Figure 4-5, you can see the internal data bus for the Pentium was only 32 bits wide. More important, however, than the width of the internal bus is the fact that each ALU and register in the early Pentiums could process only 32 bits at a time. All desktop and laptop processors sold today from either Intel or AMD contain ALUs and registers that can process 32 bits or 64 bits at a time. To know which type of operating

system to install, you need to be aware of three categories of processors currently used on desktop and laptop computers:

- ▲ **32-bit processors.** These older processors are known as **x86 processors** because Intel used the number 86 in the model number of these processors. If you are ever called on to install Windows on one of these old Pentium computers, you must use a 32-bit version of Windows. These processors can handle only 32-bit instructions from the OS.
- ▲ **Processors that can process 32 bits or 64 bits.** These hybrid processors are known as **x86-64 bit processors**. AMD was the first to produce one (the Athlon 64) and called the technology AMD64. Intel followed with a version of its Pentium 4 processors and called the technology Extended Memory 64 Technology (EM64T). Because of their hybrid nature, these processors can handle a 32-bit OS or a 64-bit OS. All desktop or laptop processors made after 2007 are of this type.
- ▲ **64-bit processors.** Intel makes several 64-bit processors for workstations or servers that use fully implemented 64-bit processing, including the Itanium and Xeon processors. Intel calls the technology IA64, but they are also called x64 processors. They require a 64-bit operating system and can handle 32-bit applications only by simulating 32-bit processing.

 **Notes** To know which type of operating system is installed (32-bit or 64-bit) and other information about the Windows installation, recall from the chapter, "All About Motherboards," that you can use the System window. To open the System window in Windows 8, press **Win+X** and click **System**. In Windows 7, click **Start**, right-click **Computer**, and select **Properties**.

Each core in a processor has its own cache and can also share a cache. Figure 4-6 shows how quad-core processing can work if the processor uses an L3 cache and an internal memory controller. Each core within a processor has its own independent internal L1 and L2 caches. The L1 cache is on the die and the L2 cache is off the die. In addition, all the cores might share an L3 cache within the processor package. Recall that prior to the memory controller being in the processor package, it was part of the North Bridge chipset. Putting the controller inside the processor package resulted in a significant increase in system performance.



**Figure 4-6** Quad-core processing with L1, L2, and L3 cache and the memory controller within the processor housing

## INTEL PROCESSORS

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Intel's current families of processors for the desktop include the Core, Atom, Celeron, and Pentium families of processors. In addition, Intel groups its processors into Sixth Generation, Fifth Generation, Fourth Generation, Third Generation, Second Generation, and Previous Generation processors. Each generation improves on how the processor and chipset are integrated in the system. Processors in each family are listed in Table 4-1. Some significant retired processors are also listed. Later in the chapter, you'll learn about the memory technologies mentioned in the table.

Processor	Speed	Description
<b>Fifth-Generation (Broadwell) Processors</b>		
Core i7	Up to 3.8 GHz	6-MB cache, quad core 1333/1600/1866 MHz DDR3 memory Dual-channel memory
Core i5	Up to 3.6 GHz	4-MB cache, quad core 1333/1600/1866 MHz DDR3 memory Dual-channel memory
<b>Fourth-Generation (Haswell) Processors</b>		
Core i7	Up to 4.4 GHz	8-MB cache, quad core 1333/1600 MHz DDR3 memory Dual-channel memory
Core i5	Up to 3.6 GHz	4- to 6-MB cache, quad or dual core 1333/1600 MHz DDR3 memory Dual-channel memory
Core i3	Up to 3.8 GHz	3- to 4-MB cache, dual core 1333/1600 MHz DDR3 memory Dual-channel memory
<b>Third-Generation (Ivy Bridge) Processors</b>		
Core i7	Up to 3.9 GHz	8-MB cache, quad core 1333/1600 MHz DDR3 memory Dual-channel memory
Core i5	Up to 3.8 GHz	6-MB cache, quad core 1333/1600 MHz DDR3 memory Dual-channel memory
Core i3	Up to 3.5 GHz	3-MB cache, dual core 1333/1600 MHz DDR3 memory Dual-channel memory
<b>Second-Generation (Sandy Bridge) Processors</b>		
Core i7 Extreme	Up to 3.9 GHz	15-MB cache, six cores 1066/1333/1600 MHz DDR3 memory Quad-channel memory
Core i7	Up to 3.9 GHz	8- to 12-MB cache, four or six cores 1066/1333/1600 MHz DDR3 memory Dual- or quad-channel memory
Core i5	Up to 3.8 GHz	3- to 6-MB cache, dual or quad core 1066/1333 MHz DDR3 memory Dual-channel memory
Core i3	Up to 3.4 GHz	3-MB cache, dual core 1066/1333 MHz DDR3 memory Dual-channel memory
Pentium	Up to 3.0 GHz	3-MB cache 1066/1333 MHz DDR3 memory Dual-channel memory
<b>Previous-Generation Processors</b>		
Core i7 Extreme	Up to 3.4 GHz	8- or 12-MB cache 1066 MHz DDR3 memory Triple-channel memory
Core i7	Up to 3.3 GHz	8- or 12-MB cache, four or six cores 800/1066/1333 MHz DDR3 memory Dual- or triple-channel memory

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Table 4-1 Current Intel processors (continues)

Processor	Speed	Description
Core i5	Up to 3.3 GHz	4- or 8-MB cache, dual or quad core 1066/1333 MHz DDR3 memory Dual-channel memory
Core i3	Up to 3.3 GHz	Dual core, 4-MB cache 1066/1333 MHz DDR3 memory Dual-channel memory
Atom	Up to 2.1 GHz	Up to 1-MB cache, some dual core 800/1066 MHz DDR3 memory 667/800 MHz DDR2 memory Single-channel memory
Celeron, Celeron Desktop, Celeron D	1.6 to 3.6 GHz 533/667/800 MHzFSB	128-KB to 1-MB cache
Core 2 Extreme, Core 2 Quad, Core 2 Duo	Up to 3.2 GHz 533 to 1600 MHz FSB	2- to 12-MB cache Dual or quad core
Pentium Extreme, Pentium, Pentium 4, Pentium D	Up to 3.7 GHz	Up to 4-MB cache, some dual core

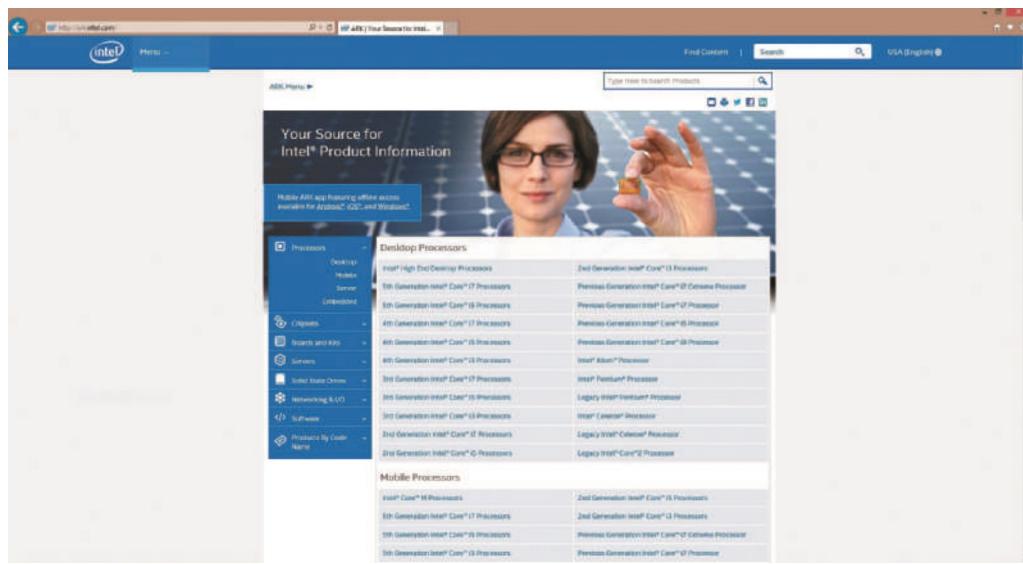
**Table 4-1** Current Intel processors (continued)

An Intel Sandy Bridge Core i5 processor is shown in Figure 4-7. You can purchase a processor with or without the cooler. When it's purchased with a cooler, it's called a boxed processor. The cooler is also shown in the photo. If you purchase the cooler separately, make sure it fits the socket you are using.



**Figure 4-7** The Intel Core i5 processor (processor number i5-2320) with boxed cooler

Each processor listed in Table 4-1 represents several processors that vary in performance and functionality. To help identify a processor, Intel uses a processor number. For example, two Core i7 processors are identified as i7-940 and i7-920. To find details about an Intel processor, search the Intel ARK database at [ark.intel.com](http://ark.intel.com) (see Figure 4-8).



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Source: Intel

**Figure 4-8** The Intel ARK database at *ark.intel.com* lists details about all Intel products

Some of the Intel mobile processors are packaged in the Centrino processor technology. Using the **Centrino** technology, the Intel processor, chipset, and wireless network adapter are all interconnected as a unit, which improves laptop performance. Several Intel mobile processors have been packaged as a Centrino processor. You also need to be aware of the Intel Atom processor, which is Intel's low-powered processor and is used in low-cost desktops, laptops, and netbooks.

## AMD PROCESSORS

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Processors by Advanced Micro Devices, Inc., or AMD ([www.amd.com](http://www.amd.com)) are popular in the game and hobbyist markets, and are generally less expensive than comparable Intel processors. Recall that AMD processors use different sockets than do Intel processors, so the motherboard must be designed for one manufacturer's processor or the other, but not both. Many motherboard manufacturers offer two comparable motherboards—one for an Intel processor and one for an AMD processor.

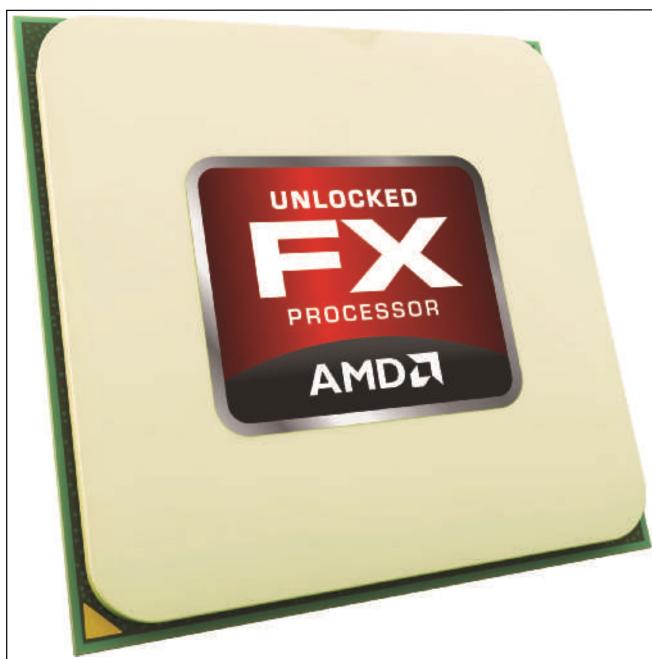
The current AMD processor families are the FX, Phenom, Athlon, Sempron, A Series, and E Series for desktops and the Athlon, Turion, V Series, Phenom, and Sempron for laptops. Table 4-2 lists the current AMD processors for desktops. Figure 4-9 shows an FX processor by AMD.

Processor	Core Speed	Description
<b>FX Black Edition Family</b>		
<b>FX 4-Core Black Edition</b>	<b>Up to 3.6 GHz</b>	<b>Quad-core uses AM3+ socket</b>
<b>FX 6-Core Black Edition</b>	<b>Up to 3.3 GHz</b>	<b>Six-core uses AM3+ socket</b>
<b>FX 8-Core Black Edition</b>	<b>Up to 3.6 GHz</b>	<b>Eight-core uses AM3+ socket</b>
<b>Phenom Family</b>		
<b>Phenom II X6</b>	<b>Up to 3 GHz</b>	<b>Six-core uses AM3 socket</b>
<b>Phenom II X6 Black</b>	<b>Up to 3.2 GHz</b>	<b>Six-core uses AM3 socket</b>
<b>Phenom II X4</b>	<b>Up to 3.2 GHz</b>	<b>Quad-core uses AM3 socket</b>
<b>Phenom II X3</b>	<b>Up to 2.5 GHz</b>	<b>Triple-core uses AM3 socket</b>

**Table 4-2** Current AMD processors (continues)

Processor	Core Speed	Description
Phenom II X2	Up to 3.1 GHz	Dual-core uses AM3 socket
Phenom X4	Up to 2.6 GHz	Quad-core uses AM2+ socket
Phenom X3	Up to 2.4 GHz	Triple-core uses AM2+ socket
<b>Athlon Family</b>		
Athlon II X4	Up to 2.3 GHz	Quad-core uses AM3 socket
Athlon X4	Up to 3.2 GHz	Quad-core uses FM2 socket
Athlon II X3	Up to 3.4 GHz	Triple-core uses AM3 socket
Athlon II X2	Up to 3 GHz	Dual-core uses AM3 socket
Athlon X2	Up to 2.3 GHz	Dual-core uses AM3 socket
Athlon	Up to 2.4 GHz	Single-core uses AM2 socket
<b>Sempron Family</b>		
Sempron	Up to 2.3 GHz	Single-core uses AM2 socket

Table 4-2 Current AMD processors (continued)



Courtesy of Advanced Micro Devices, Inc.

Figure 4-9 The AMD FX processor can have up to eight cores

learn about selecting and installing processors in desktops. Later in the chapter, you learn about selecting and installing processors in laptops.

In the next part of the chapter, you learn the detailed steps to select and install a processor in several of the popular Intel and AMD sockets used by desktop computers.

## SELECTING AND INSTALLING A PROCESSOR

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A hardware technician is sometimes called on to assemble a desktop computer from parts, exchange a processor that is faulty, add a second processor to a dual-processor system, or upgrade an existing processor to improve performance. In each situation, it is necessary to know how to match a processor for the system in which it is installed. And then you need to know how to install the processor on the motherboard for each of the current Intel and AMD sockets used for desktop and laptop systems. In this part of the chapter, you

### SELECT A PROCESSOR TO MATCH SYSTEM NEEDS

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When selecting a processor, the first requirement is to select one that the motherboard is designed to support. Among the processors the board supports, you need to select the best one that meets the general requirements of the system and the user's needs. To get the best performance, use the highest-performing processor the board supports. However, sometimes you need to sacrifice performance for cost.

## APPLYING CONCEPTS SELECT A PROCESSOR

Your friend, Alice, is working toward her A+ certification. She has decided the best way to get the experience she needs before she sits for the exam is to build a system from scratch. She has purchased an Asus motherboard and asked you for some help selecting the right processor. She tells you that the system will later be used for light business needs and she wants to install a processor that is moderate in price to fit her budget. She says she doesn't want to install the most expensive processor the motherboard can support, but neither does she want to sacrifice too much performance or power.

The documentation on the Asus website ([support.asus.com](http://support.asus.com)) for the ASUS H81M-C motherboard gives this information:

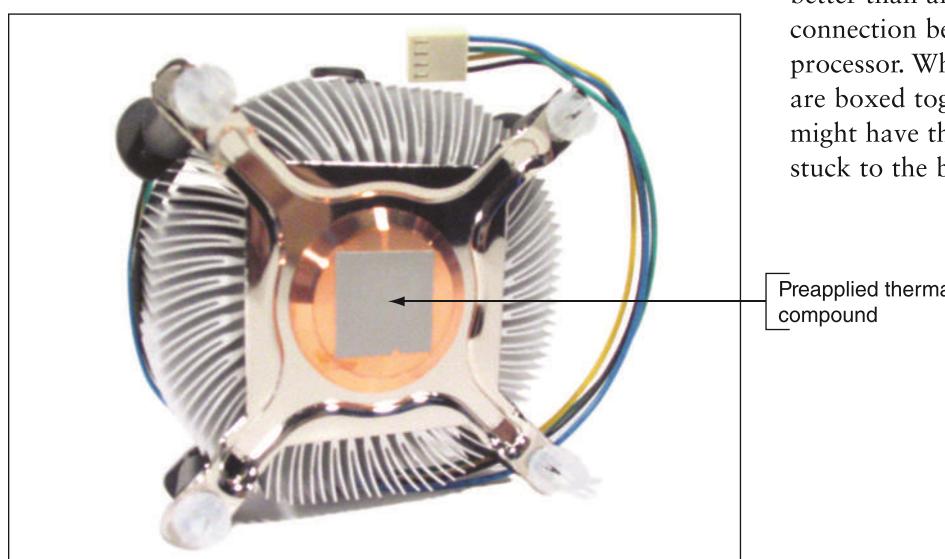
- ▲ The microATX board contains the H81 chipset and socket LGA1150 and uses DDR3 memory.
- ▲ CPUs supported include a long list of Fourth-Generation Core i3, Core i5, and Core i7 processors and Celeron and Pentium processors. Here are five processors found in this list:
  - ▲ Intel Core i7-4790, 3.6 GHz, 8-MB cache
  - ▲ Intel Core i5-4590, 3.3 GHz, 6-MB cache
  - ▲ Intel Core i3-4350, 3.6 GHz, 4-MB cache
  - ▲ Intel Celeron G1850, 2.9 GHz, 2-MB cache
  - ▲ Intel Pentium G3260, 3.3 GHz, 3-MB cache

Based on what Alice has told you, you decide to eliminate the most expensive processors (the Core i7) and the least-performing processors (the Celerons and Pentiums). That decision narrows your choices down to the Core i3 and Core i5. Before you select one of these processors, you need to check the list on the Asus site to make sure the specific Core i3 or Core i5 processor is in the list. Look for the exact processor number, for example, the Core i3-4350. Also double-check and make sure the processor uses the correct socket and is a Fourth-Generation processor.

You will also need a cooler assembly. If your processor doesn't come boxed with a cooler, select a cooler that fits the processor socket and gets good reviews. You'll also need some thermal compound if it is not included with the cooler.

The cooler is bracketed to the motherboard using a wire or plastic clip. A creamlike **thermal compound** is placed between the bottom of the cooler heat sink and the top of the processor. This compound eliminates air pockets, helping to draw heat off the processor. The thermal compound transmits heat

better than air and makes an airtight connection between the fan and the processor. When processors and coolers are boxed together, the cooler heat sink might have thermal compound already stuck to the bottom (see Figure 4-10).



**Figure 4-10** Thermal compound is already stuck to the bottom of this cooler that was purchased boxed with the processor

## INSTALL A PROCESSOR

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Now let's look at the details of installing a processor in Intel LGA1150, LGA1155, LGA1366, LGA775, and AMD AM2+ sockets.

### INSTALLING AN INTEL PROCESSOR IN SOCKET LGA1150

We're installing the Intel Core i5-4440 processor in Socket LGA1150 shown in Figure 4-11. In the photo, the socket has its protective cover in place.

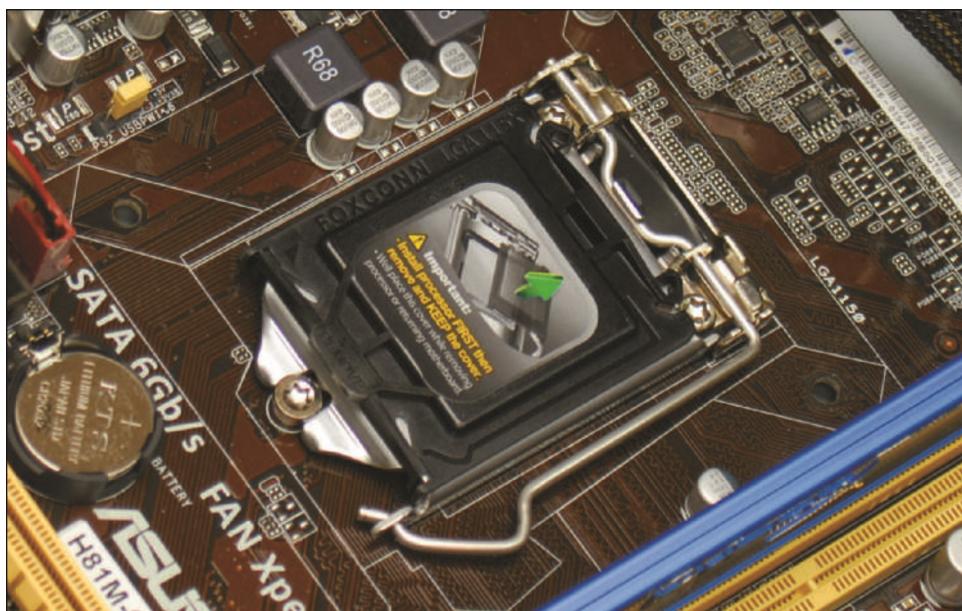


Figure 4-11 Intel socket LGA1150 with protective cover in place

**★ A+ Exam Tip** The A+ 220-901 exam expects you to know how to install a processor in these Intel processor sockets: LGA775, LGA1150, LGA1155, LGA1156, LGA1366, and LGA2011.

When building a new system, if the motherboard is not already installed in the case, follow the directions of the motherboard manufacturer to install the motherboard and then the processor or to install the processor and then the motherboard. The order of installation varies among manufacturers. When replacing a processor in an existing system, power down the system, unplug the power cord, press the power button to drain the system of power, and open the case. Follow these steps to install the processor and cooler using socket LGA1150:

1. Read all directions in the motherboard user guide about installing the processor and carefully follow them in order.
2. Use an ESD strap or antistatic gloves to protect the processor, motherboard, and other components against ESD.
3. Remove the socket protective cover. Keep this cover in a safe place. If you ever remove the processor, put the cover back on the socket to protect the socket. While the socket is exposed as in Figure 4-12, be *very careful* to not touch the pins in the socket.

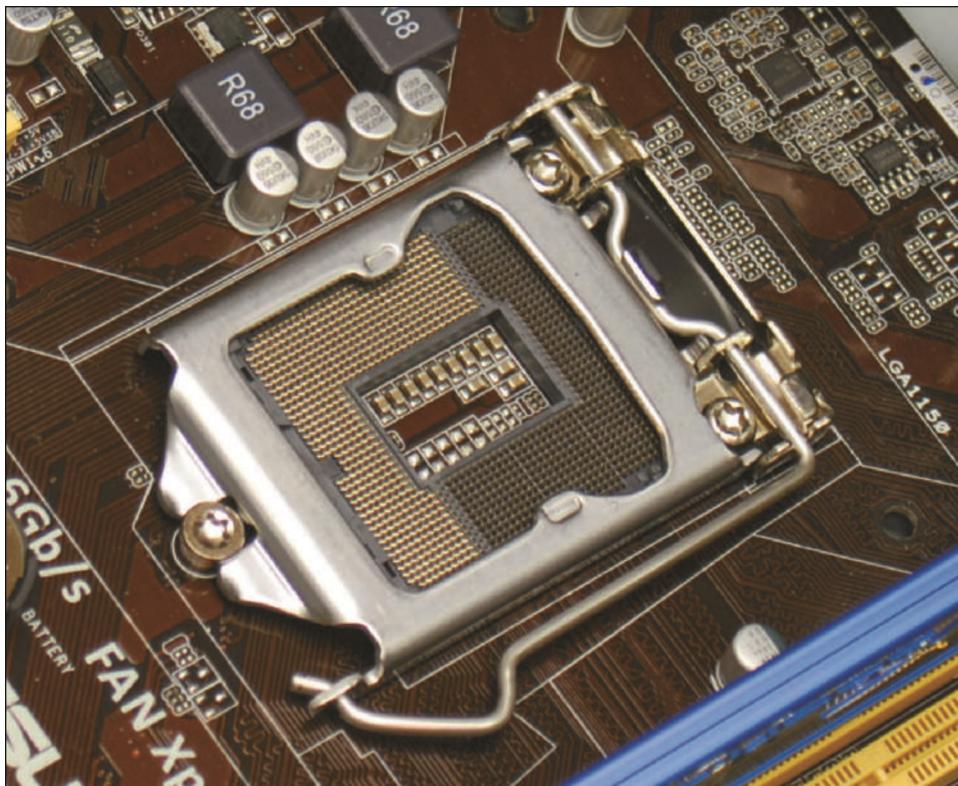


Figure 4-12 The exposed socket is extremely delicate

4. Open the socket by pushing down on the socket lever and gently pushing it away from the socket to lift the lever. As you fully open the socket lever, the socket load plate opens, as shown in Figure 4-13.

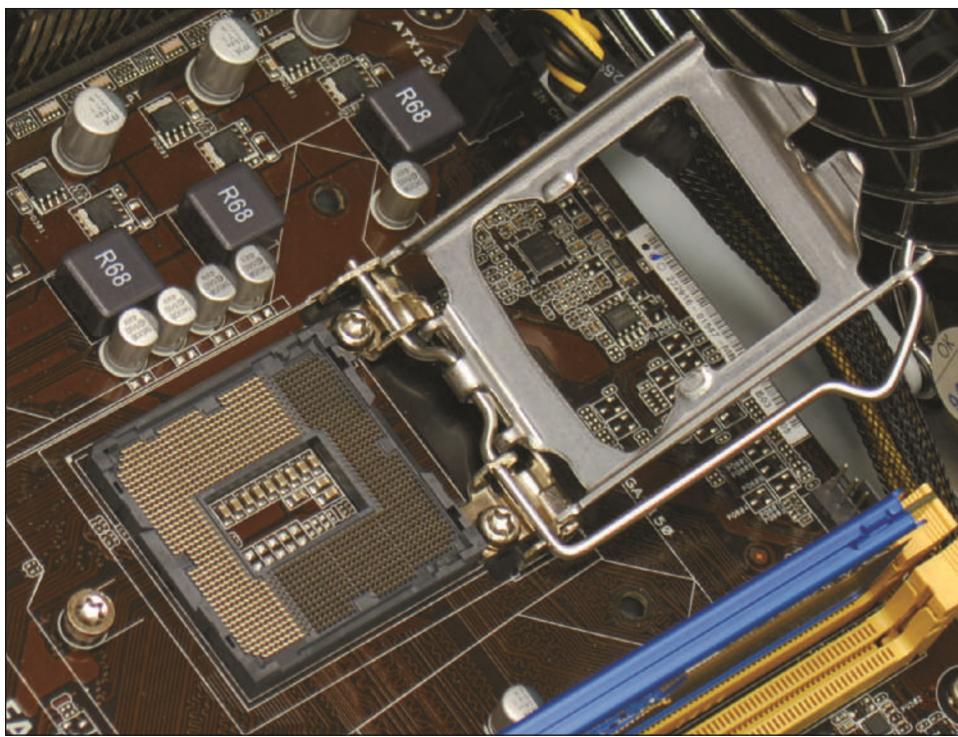
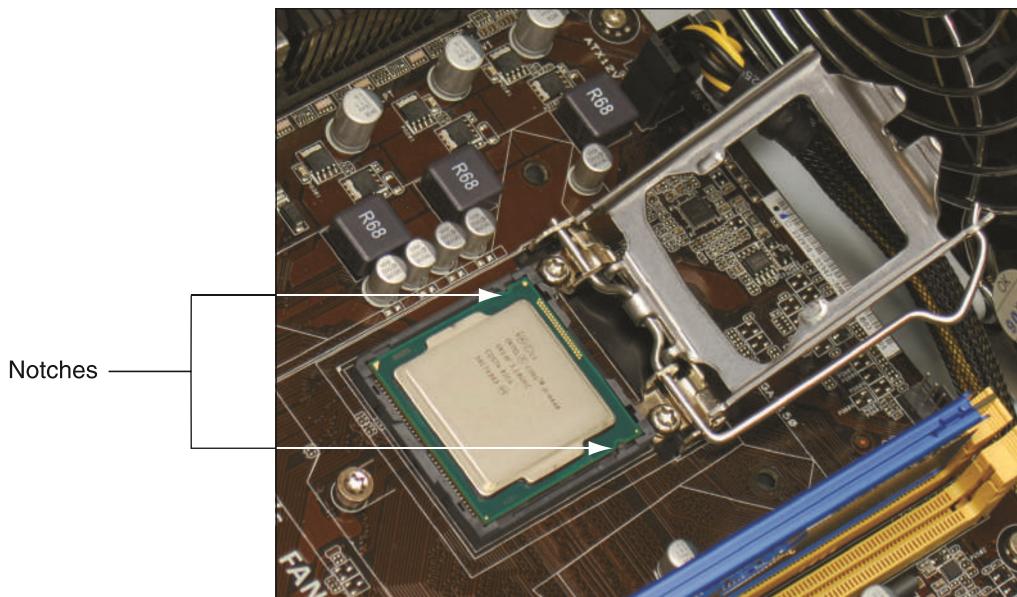


Figure 4-13 The load plate is open, and ready for the processor

5. Remove the clear plastic protective cover from the processor. While the processor contacts are exposed, take extreme care to not touch the bottom of the processor. Hold it only at its edges. (It's best to use antistatic gloves as you work, but the gloves make it difficult to handle the processor.) Put the processor cover in a safe place and use it to protect the processor if you ever remove the processor from the socket.
6. Hold the processor with your index finger and thumb and orient the processor so that the two notches on the edge of the processor line up with the posts embedded on the socket. Gently lower the processor straight down into the socket. Don't allow the processor to tilt, slide, or shift as you put it in the socket. To protect the pads, it needs to go straight down into the socket.
7. Check carefully to make sure the processor is aligned correctly in the socket. Closing the socket without the processor fully seated can destroy the socket. Figure 4-14 shows the processor fully seated in the socket. Close the socket load plate so that it catches under the screw head at the front of the socket.

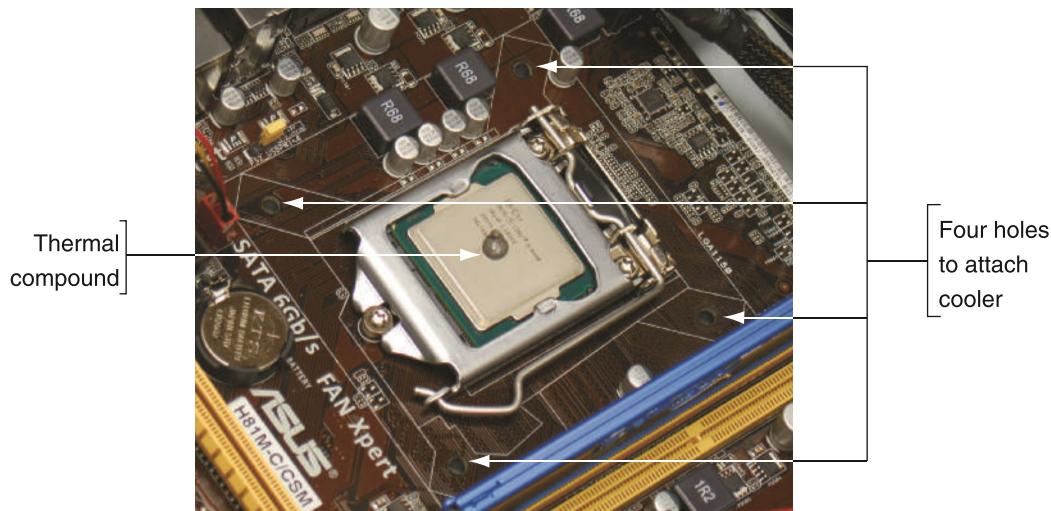


**Figure 4-14** Orient the processor so the notches line up with the posts on the socket

8. Push down on the lever and gently return it to its locked position.

We are now ready to install the cooler. Before installing a cooler, read the directions carefully and make sure you understand them. Clips that hold the fan and heat sink to the processor frame or housing are sometimes difficult to install. The directions might give you important tips. Follow these general steps:

1. The motherboard has four holes to anchor the cooler. You can see them labeled in Figure 4-15. Examine the cooler posts that fit over these holes and the clips, screws, or wires that will hold the cooler firmly in place. Make sure you understand how this mechanism works.
2. If the cooler has thermal compound preapplied, remove the plastic from the compound. If the cooler does not have thermal compound applied, put a small dot of compound (about the size of a small pea) in the center of the processor (see Figure 4-15). When the cooler is attached and the processor



**Figure 4-15** If the cooler does not have preapplied thermal compound, apply it on top of the processor

is running, the compound spreads over the surface. Don't use too much—just enough to later create a thin layer. If you use too much compound, it can slide off the housing and damage the processor or circuits on the motherboard. To get just the right amount, you can buy individual packets that each contain a single application of the thermal compound.



**Notes** When removing and reinstalling a processor, use a soft dry cloth to carefully remove all the old thermal compound from both the processor and the cooler. Don't try to reuse the compound.

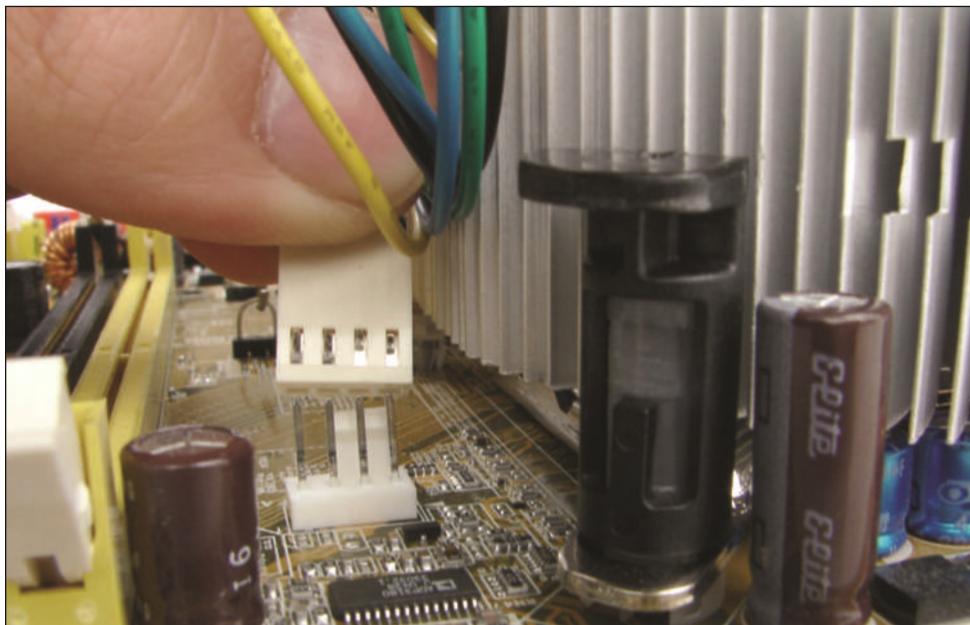
3. Verify the locking pins on the cooler are turned as far as they will go in a counterclockwise direction. (Make sure the pins don't protrude into the hollow plastic posts that go down into the motherboard holes.) Align the cooler over the processor so that all four posts fit into the four holes on the motherboard and the fan power cord can reach the fan header on the motherboard.
4. Push down on each locking pin until you hear it pop into the hole. To help keep the cooler balanced and in position, push down two opposite pins and then push the remaining two pins in place. Using a flathead screwdriver, turn the locking pin clockwise to secure it (see Figure 4-16). (Later, if you need to remove the cooler, turn each locking pin counterclockwise to release it from the hole.)



**Figure 4-16** The pins are turned clockwise to secure the cooler to the motherboard

 **Notes** If you later notice the CPU fan is running far too often, you might need to tighten the connection between the cooler and the processor.

5. Connect the power cord from the cooler fan to the 4-pin CPU fan header on the motherboard near the processor, as shown in Figure 4-17.



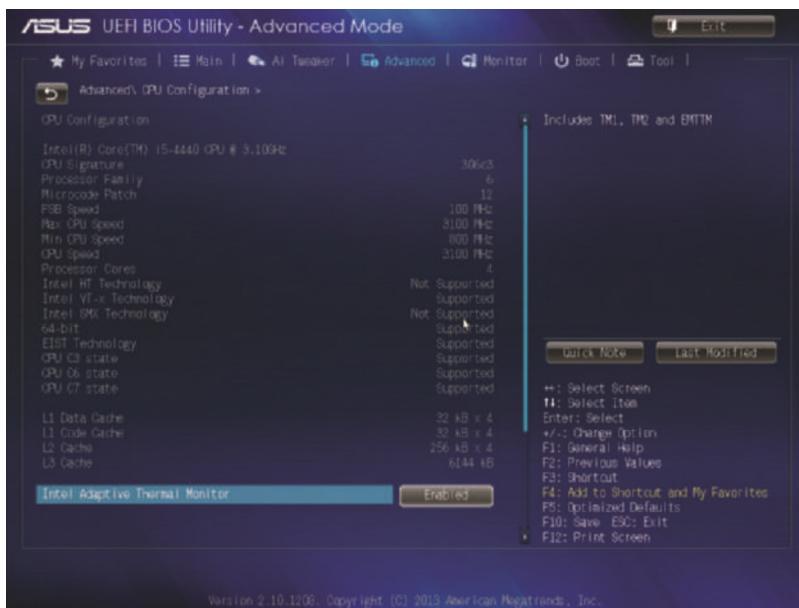
**Figure 4-17** Connect the cooler fan power cord to the motherboard CPU fan header

After the processor and cooler are installed and the motherboard is installed in the case, make sure cables and cords don't obstruct fans or airflow, especially airflow around the processor and video card. Use cable ties to tie cords and cables up and out of the way.

Make one last check to verify that all power connectors are in place and other cords and cables connected to the motherboard are correctly done. You are now ready to plug back up the system, turn it on, and verify all is working. If the power comes on (you hear the fan spinning and see lights), but the system fails to work, most likely the processor is not seated solidly in the socket or some power cord has not yet been connected or is not solidly connected. Turn everything off, unplug the power cord, press the power button to drain power, open the case, and recheck your installation. If the system comes up and begins the boot process, but suddenly turns off before the boot is complete, most likely the processor is overheating because the cooler is not installed correctly. Turn everything off, unplug the power cord, press the power button to drain power, open the case, and verify that the cooler is securely seated and connected.

After the system is up and running, you can check UEFI/BIOS setup to verify that the system recognized the processor correctly. The setup screen for one processor is shown in Figure 4-18.

Also check in UEFI/BIOS setup the CPU and motherboard temperatures to verify the CPU is not overheating. For the UEFI setup in this system, this screen is under the Monitor menu, as shown in Figure 4-19.



4

Source: American Megatrends, Inc.

**Figure 4-18** Verify the CPU is recognized correctly by UEFI setup

Source: American Megatrends, Inc.

**Figure 4-19** Verify the processor temperature is within an acceptable range

The maximum processor temperature varies by processor; to know the maximum, download the datasheet specifications for the processor from the Intel website ([ark.intel.com](http://ark.intel.com)). For the Intel Core i5-4440, the processor will stop execution if the temperature rises above 130 degrees. If you see the temperature rising this high, open the case cover and verify that the processor fan is running. Perhaps a wire is in the way and preventing the fan from turning or the fan wire is not connected. Other troubleshooting tips for processors are covered in the chapter, “Supporting the Power System and Troubleshooting Computers.”

## INSTALLING AN INTEL PROCESSOR IN SOCKET LGA1155

The installations of all processors and sockets in this part of the chapter are similar to that of installing a processor in Socket LGA1150, so we will not repeat many of those steps. Listed next are the differences when installing a processor in the LGA1155 socket. These socket pins are delicate, so work slowly and take care. Here is how to work with this socket:

1. Open the socket by pushing down on the socket lever and gently pushing it away from the socket to lift the lever (see Figure 4-20). You can then lift the socket load plate, as shown in Figure 4-21. Next, remove the socket protective cover.



Figure 4-20 Release the lever from the socket

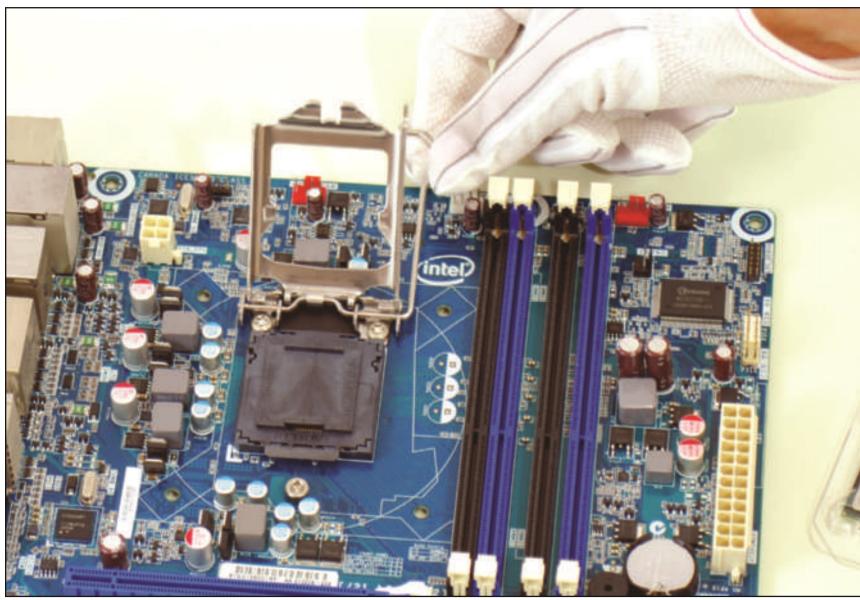


Figure 4-21 Lift the socket load plate to expose the processor socket

2. To install the processor, hold the processor with your index finger and thumb and orient the processor so that the gold triangle on the corner of the processor lines up with the right-angle mark embedded on the motherboard just outside a corner of the socket (see Figure 4-22). Gently lower the processor straight down into the socket. Don't allow the processor to tilt, slide, or shift as you put it in the socket. To protect the pads, it needs to go straight down into the socket.

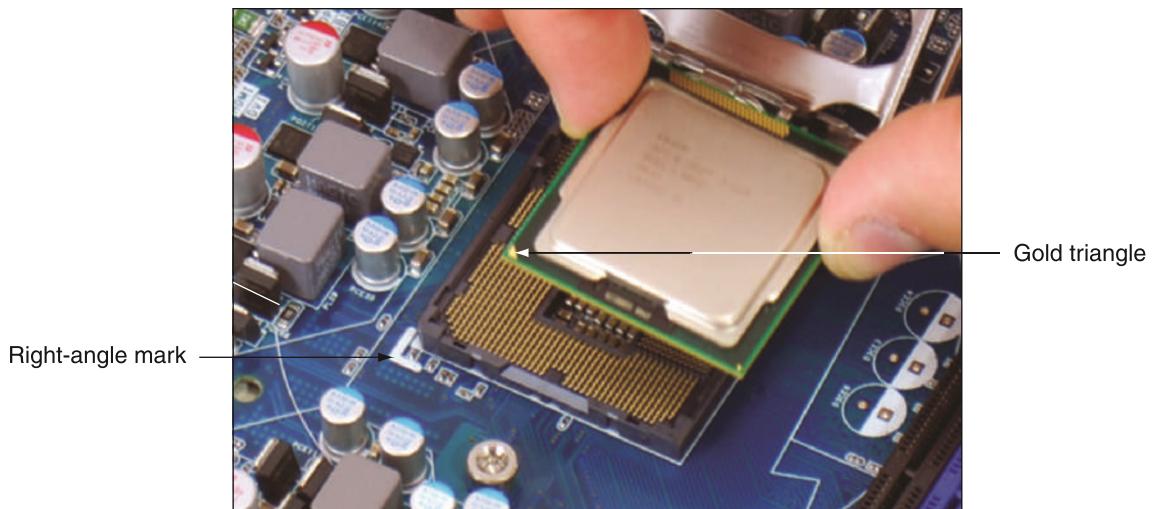


Figure 4-22 Align the processor in the socket using the gold triangle and the right-angle mark

3. You can now lower the socket load plate and return the lever to its locked position (see Figure 4-23).

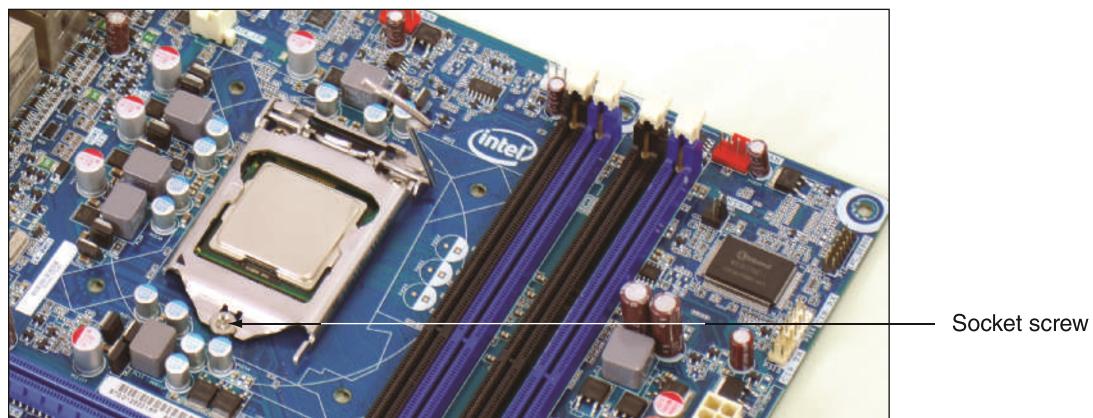


Figure 4-23 The socket screw head secures the socket load plate

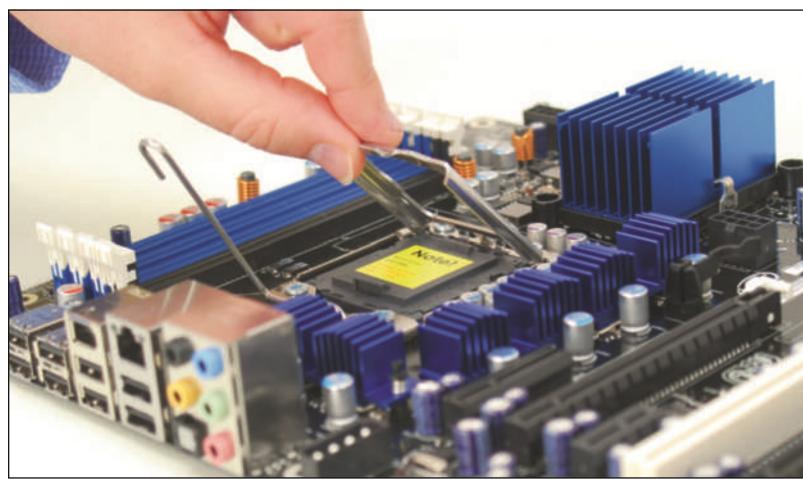


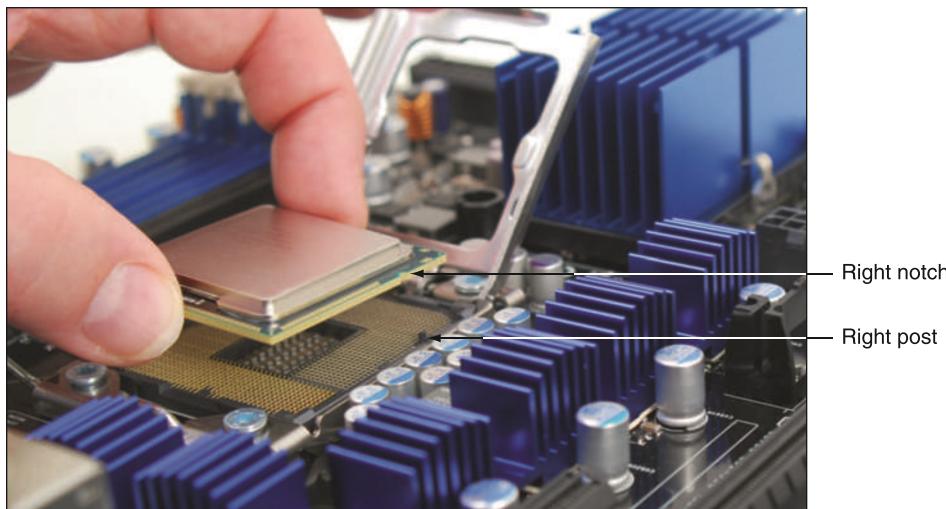
Figure 4-24 Lift the socket load plate

### INSTALLING AN INTEL PROCESSOR IN SOCKET LGA1366

Listed next are the differences when installing a processor in the LGA1366 socket:

1. To open the socket, press down on the socket lever and gently push it away from the socket to lift the lever. You can then lift the socket load plate, as shown in Figure 4-24. Next, remove the socket protective cover.

2. To install the processor, hold the processor with your index finger and thumb and orient the processor so that the notches on the two edges of the processor line up with the two posts on the socket. You can see the notch and post on the right side of the processor and socket in Figure 4-25. Gently lower the processor straight down into the socket. Don't allow the processor to tilt, slide, or shift as you put it in the socket. To protect the pins, it needs to go straight down into the socket.



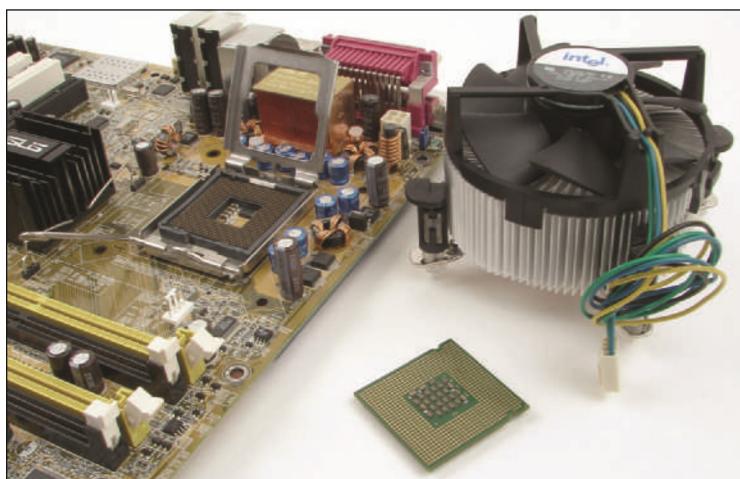
**Figure 4-25** Orient the processor over the socket so that the notches on each side of the processor match the posts on each side of the socket

3. You can now lower the socket load plate and return the lever to its locked position.

### INSTALLING AN INTEL PROCESSOR IN SOCKET LGA775

Socket LGA775 is shown in Figure 4-26 along with a Pentium processor and cooler. In the photo, the socket is open and the protective cover removed. The processor is lying upside down in front of the cooler. When installing a processor in socket LGA775, do the following:

1. Push down on the lever and gently push it away from the socket to lift it. Lift the socket load plate. Remove the socket protective cover.



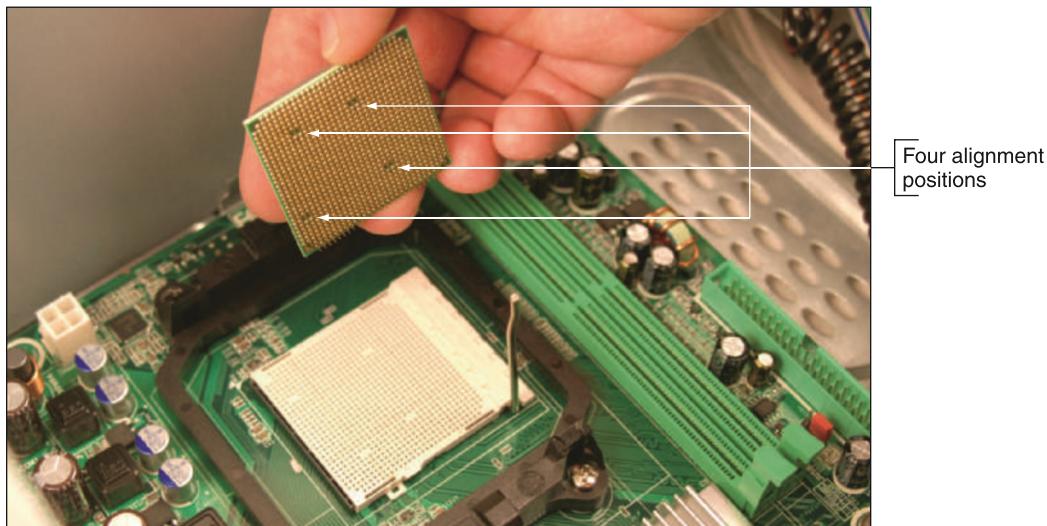
**Figure 4-26** A Pentium, cooler, and open socket 775

2. Orient the processor so that the notches on the two edges of the processor line up with the two notches on the socket. Gently place the processor in the socket. Socket LGA775 doesn't have those delicate pins that Socket LGA1366 has, but you still need to be careful to not touch the top of the socket or the bottom of the processor as you work.
3. Close the socket cover. Push down on the lever and gently return it to its locked position.

## INSTALLING AN AMD PROCESSOR IN SOCKET AM2+

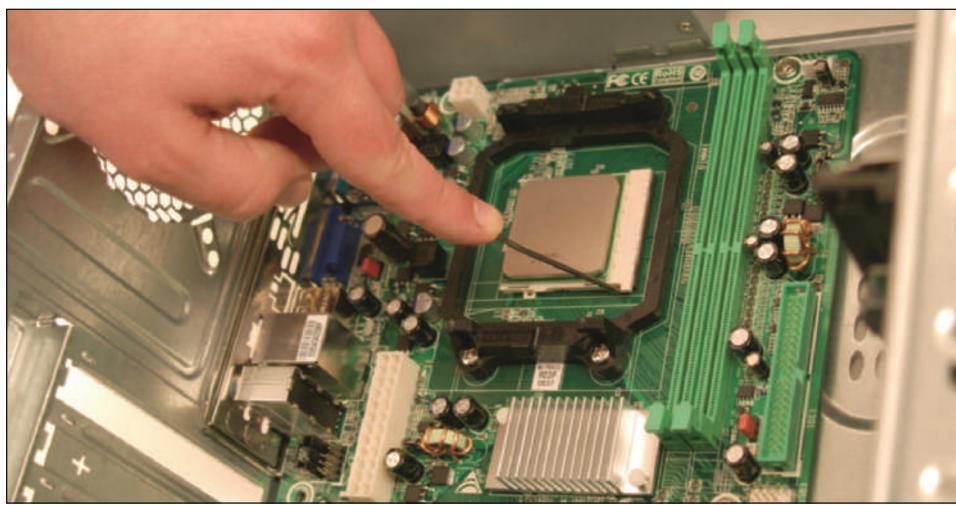
When installing an AMD processor in AMD socket AM2, AM2+, or other AMD sockets, do the following:

1. Open the socket lever. If there's a protective cover over the socket, remove it.
2. Holding the processor very carefully so you don't touch the bottom, orient the four empty positions on the bottom with the four empty positions in the socket (see Figure 4-27). For some AMD sockets, a gold triangle on one corner of the processor matches up with a small triangle on a corner of the socket. Carefully lower the processor into the socket. Don't allow it to tilt or slide as it goes into the socket. The pins on the bottom of the processor are very delicate, so take care as you work.



**Figure 4-27** Orient the four alignment positions on the bottom of the processor with those in the socket

3. Check carefully to make sure the pins in the processor are sitting slightly into the holes. Make sure the pins are not offset from the holes. If you try to use the lever to put pressure on these pins and they are not aligned correctly, you can destroy the processor. You can actually feel the pins settle into place when you're lowering the processor into the socket correctly.
4. Press the lever down and gently into position (see Figure 4-28).



**Figure 4-28** Lower the lever into place, which puts pressure on the processor

5. You are now ready to apply the thermal compound and install the cooler assembly. For one system, the black retention mechanism for the cooler is already installed on the motherboard (see Figure 4-29). Set the cooler on top of the processor, aligning it inside the retention mechanism.



Figure 4-29 Align the cooler over the retention mechanism

6. Next, clip into place the clipping mechanism on one side of the cooler. Then push down firmly on the clip on the opposite side of the cooler assembly; the clip will snap into place. Figure 4-30 shows the clip on one side in place for a system that has a yellow retention mechanism and a black cooler clip. Later, if you need to remove the cooler, use a Phillips screwdriver to remove the screws holding the retention mechanism in place. Then remove the retention mechanism along with the entire cooler assembly.

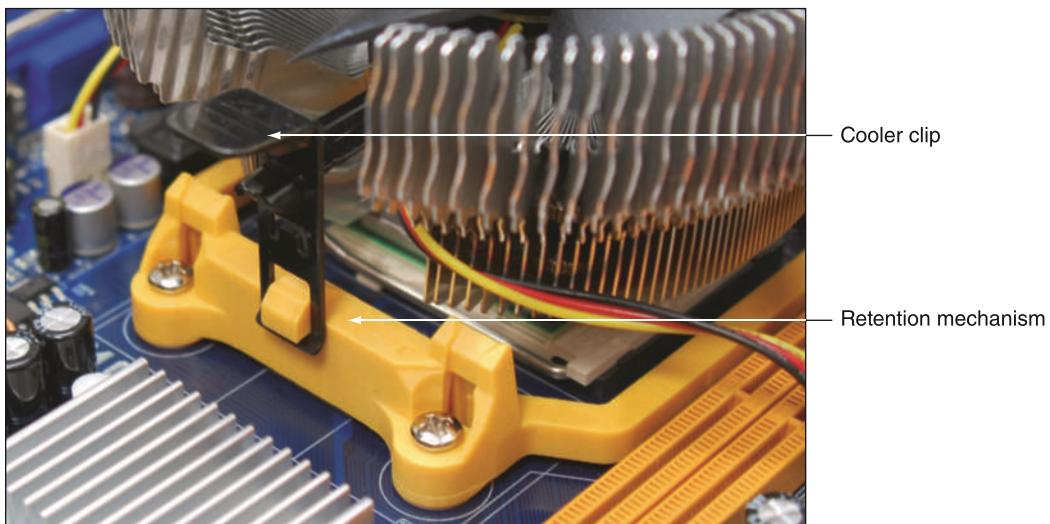


Figure 4-30 The clips on the cooler attach the cooler to the retention mechanism on the motherboard

7. Connect the power cord from the fan to the 4-pin CPU fan header on the motherboard next to the processor.

 **Notes** How to troubleshoot problems with the processor, motherboard, and RAM is covered in the chapter, “Supporting the Power System and Troubleshooting Computers.”

## Hands-On | Project 4-1 Research a Processor Upgrade or Replacement

To identify your motherboard and find out the processor and processor socket a motherboard is currently using, you can use UEFI/BIOS setup, Windows utilities, or third-party software such as Speccy at [www.periform.com/speccy](http://www.periform.com/speccy). To research processors a board can support, you can use the motherboard user guide, the website of the motherboard manufacturer, and for Intel processors, the Intel site at [ark.intel.com](http://ark.intel.com). Research the current processor and processor socket of your computer's motherboard and which processors your board can support, and answer the following questions:

1. What is the brand and model of your motherboard? What processor socket does it use? How did you find your information?
2. Identify the currently installed processor, including its brand, model, speed, and other important characteristics. How did you find your information?
3. List three or more processors the board supports according to the motherboard documentation or website.
4. Search the web for three or more processors that would match this board. Save or print three webpages showing the details and prices of a high-performing, moderately performing, and low-performing processor the board supports.
5. If your current processor fails, which processor would you recommend for this system? Explain your recommendation.

Now assume the Core i7 920 processor that you saw installed in Figure 4-25 has gone bad. The motherboard in which it is installed is the Intel DX58SO desktop board. The owner of the motherboard has requested that you keep the replacement cost as low as possible. What processor would you recommend for the replacement? Save or print a webpage showing the processor and its cost.

## Hands-On | Project 4-2 Insert and Remove a Processor

In this project, you remove and install a processor. As you work, be very careful to not bend pins on the processor or socket, and protect the processor and motherboard against ESD. Do the following:

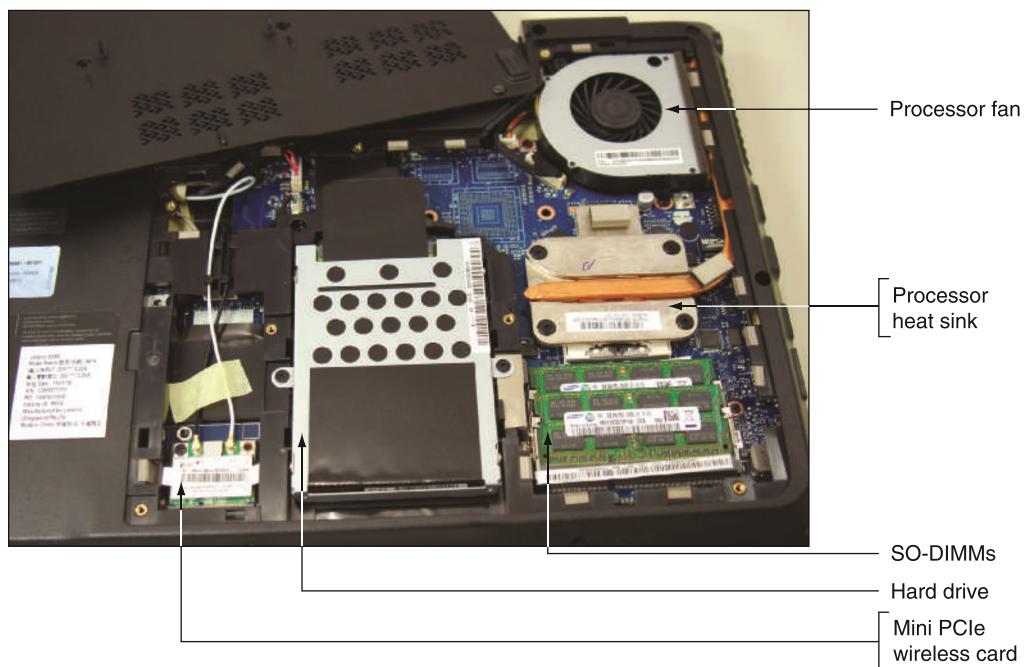
1. Verify the computer is working. Turn off the system, unplug it, press the power button, and open the computer case. Put on your ESD strap. Remove the cooler assembly. Remove all the thermal compound from the cooler and processor.
2. Reinstall the processor and thermal compound. Have your instructor check the thermal compound. Install the cooler.
3. Replace the case cover, power up the system, and verify all is working.

## REPLACING THE PROCESSOR IN A LAPTOP

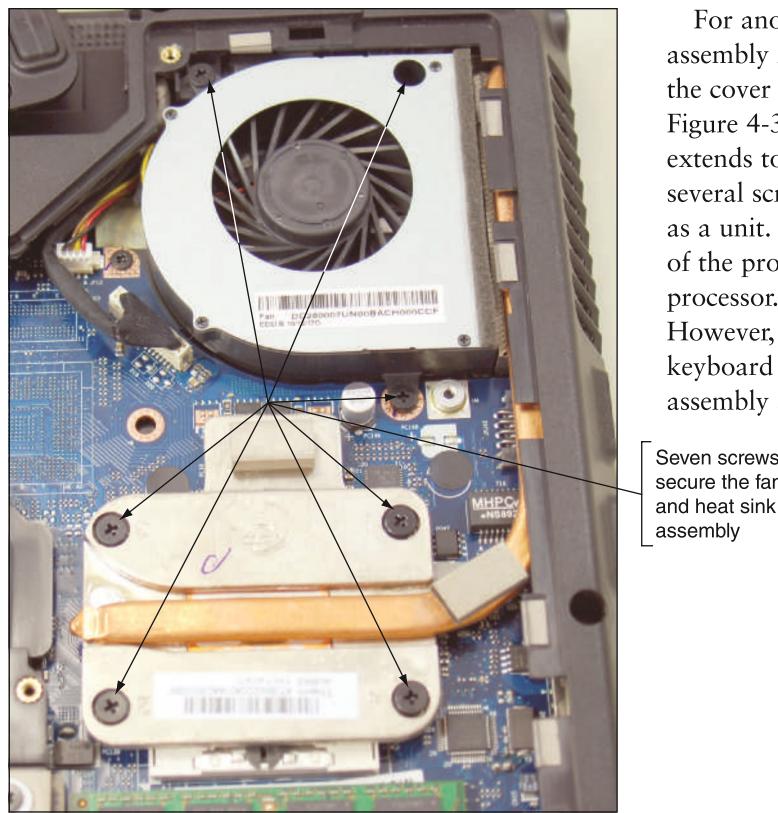
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Before replacing the processor in a laptop, consider the laptop might still be under warranty. Also consider it might be more cost effective to replace the laptop rather than replacing the processor, including the cost of parts and labor. If you do decide to replace a processor in a laptop, be sure to select a processor supported by the laptop manufacturer for the particular model laptop. The range of processors supported by a laptop does not usually include as many options as those supported by a desktop motherboard.

For many laptops, removing the cover on the bottom of a laptop exposes the processor fan and heat sink assembly. When you remove this assembly, you can then open the socket and remove the processor. For example, looking at the laptop shown in Figure 4-31, you can see the processor heat sink and fan assembly exposed. To remove the assembly, remove the seven screws and the fan power connector (see Figure 4-32). Then lift the assembly straight up, being careful not to damage the processor underneath.



**Figure 4-31** The cover is removed from the bottom of a laptop exposing several internal components



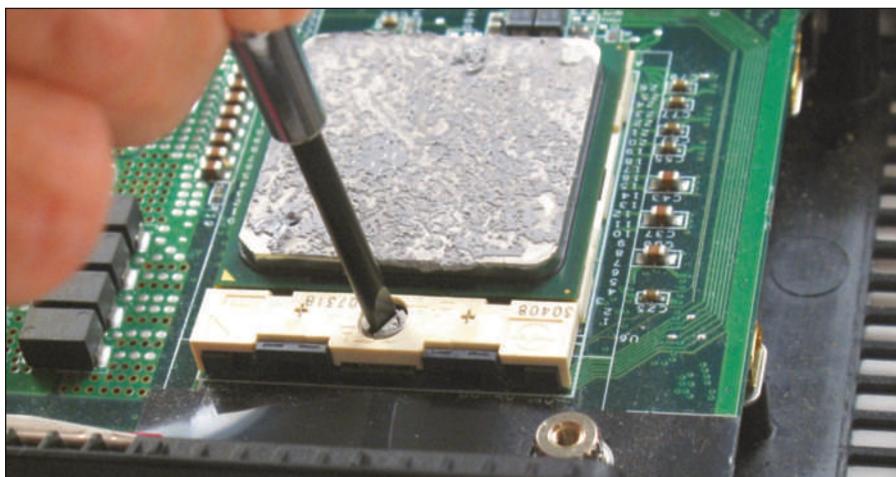
For another laptop, the heat sink and fan assembly is also exposed when you remove the cover on the bottom of the laptop (see Figure 4-33). Notice the heat sink on this laptop extends to the processor and chipset. You remove several screws and then lift the entire assembly out as a unit. For both laptops, the heat sink fits on top of the processor and the fan sits to the side of the processor. This design is typical of many laptops. However, some laptops require you to remove the keyboard and the keyboard bezel to reach the fan assembly and processor under the bezel.

**Figure 4-32** Seven screws hold the processor heat sink and fan assembly in place



**Figure 4-33** Remove the cover from the bottom of the laptop to expose the heat sink and fan assembly and to reach the processor

Figure 4-34 shows the heat sink and fan assembly removed in one laptop, exposing the processor. Notice the thermal compound on the processor. To remove the processor, turn the CPU socket screw 90 degrees to open the socket, as shown in the figure. Most Intel and AMD sockets have this socket screw on the side of the socket, as shown in Figure 4-34, although other sockets have the screw on the corner of the socket.



**Figure 4-34** Open the CPU socket

Lift the CPU from the socket. Be careful to lift straight up without bending the CPU pins. Figure 4-35 shows the processor out of the socket. If you look carefully, you can see the missing pins on one corner of the processor and socket. This corner is used to correctly orient the processor in the socket, which is socket 478B.

Before you place the new processor into the socket, be sure the socket screw is in the open position. Then delicately place the processor into its socket. If it does not drop in completely, consider that the screw might not be in the full open position. Be sure to use thermal compound on top of the processor. Intel recommends

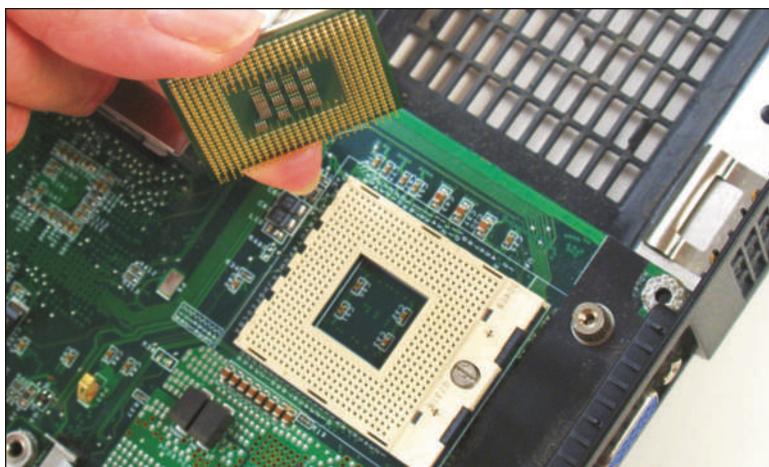


Figure 4-35 The processor removed from socket 478B

0.2 grams of compound, which is about the size of a small pea. To make sure you use just the right amount of compound, consider buying it in individual packets that are measured for a single application.

Now let's turn our attention to the various memory technologies used in personal computers, and how to upgrade memory.

## ***MEMORY TECHNOLOGIES***

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Recall that random access memory (RAM) temporarily holds data and instructions as the CPU processes them and that the memory modules used on a motherboard are made of dynamic RAM or DRAM. DRAM loses its data rapidly, and the memory controller must refresh it several thousand times a second. RAM is stored on memory modules, which are installed in memory slots on the motherboard (see Figure 4-36).

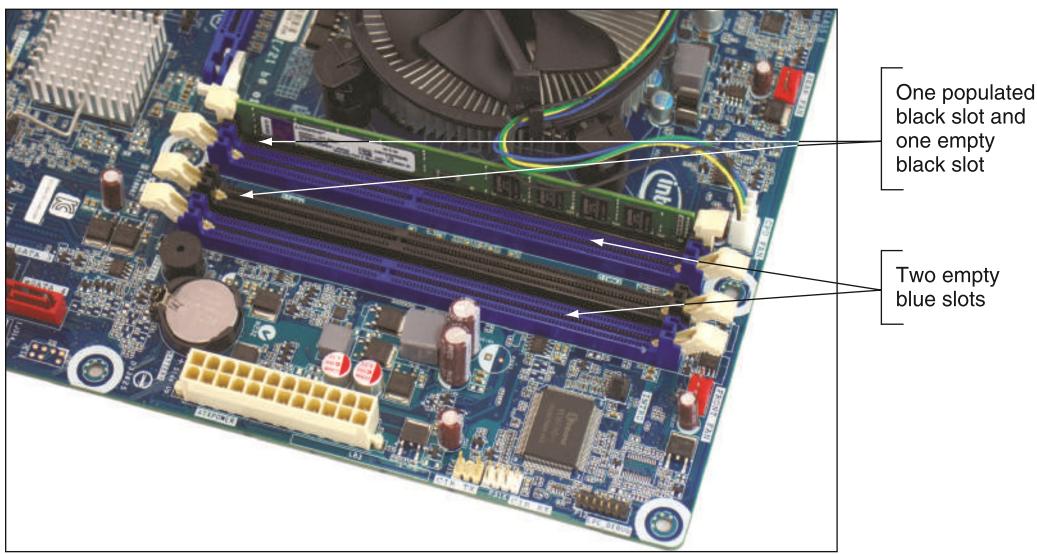


Figure 4-36 RAM on motherboards today is stored in DIMMs

**★ A+ Exam Tip** The A+ 220-901 exam expects you to know the purposes and characteristics of DDR, DDR2, and DDR3 memory technologies.

Several variations of DRAM have evolved over the years. Here are the four major categories of memory modules:

- ▀ All new motherboards for desktops sold today use a type of memory module called a **DIMM (dual inline memory module)**.
- ▀ Laptops use a smaller version of a DIMM called a **SO-DIMM (small outline DIMM)** and pronounced “sew-dim”). MicroDIMMs are used on subnotebook computers and are smaller than SO-DIMMs.
- ▀ An older type of module is a **RIMM**, which is designed by Rambus, Inc.
- ▀ Really old computers used **SIMMs (single inline memory modules)**. You’re unlikely to ever see these modules in working computers.

The major differences among these modules are the width of the data path that each type of module accommodates and the way data moves from the system bus to the module. DIMMs have seen several evolutions. Five versions of DIMMs, one RIMM, and two types of SIMMs are shown in Table 4-3. Notice the notches on the modules, which prevent the wrong type of module from being inserted into a memory slot on the motherboard. The table includes older and current memory technologies.

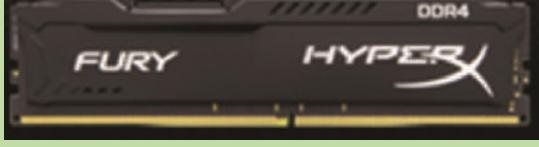
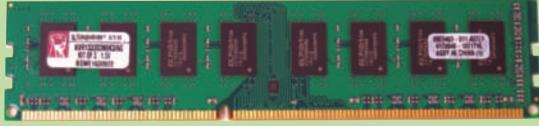
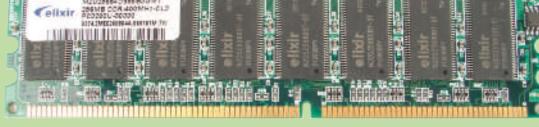
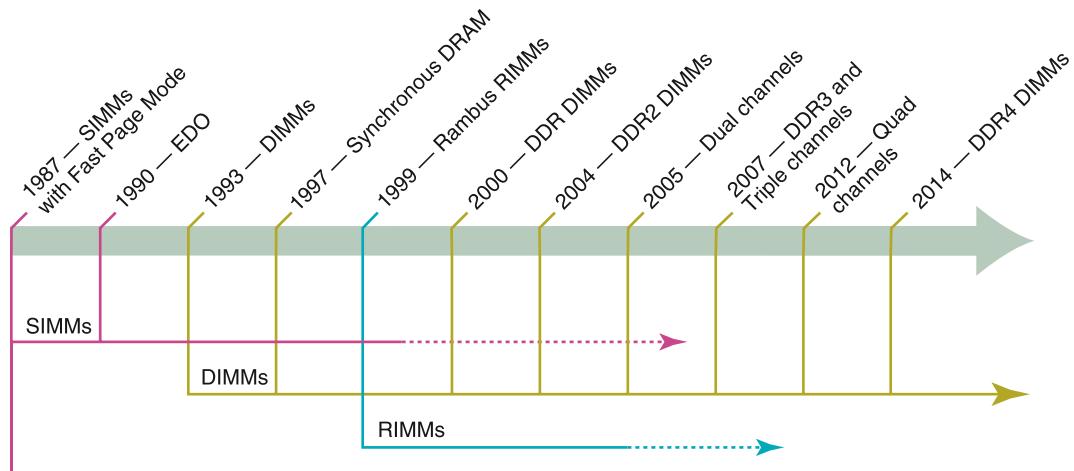
Description of Module	Example
<b>288-pin DDR4 DIMM</b> is currently the fastest memory with lower voltage requirements. It can support quad or dual channels or function as single DIMMs. It has one notch near the center of the edge connector.	 Source: kingston.com
<b>240-pin DDR3 DIMM</b> can support quad, triple, or dual channels or function as single DIMMs. It has an offset notch farther from the center than a DDR2 DIMM.	
<b>240-pin DDR2 DIMM</b> can support dual channels or function as single DIMMs. It has one notch near the center of the edge connector.	
<b>184-pin DDR DIMM</b> can support dual channels or function as a single DIMM. It has one offset notch.	
<b>168-pin SDRAM DIMM</b> has two notches on the module. The positions of these notches depend on the memory features the DIMM uses.	
<b>RIMM</b> has 184 pins and two notches near the center of the edge connector.	
<b>72-pin SIMMs</b> were installed in groups of two modules to each bank of memory.	
<b>30-pin SIMMs</b> were installed in groups of four modules to each bank of memory.	

Table 4-3 Types of memory modules

In this chapter, you see tons of different technologies used by RAM and so many can get a little overwhelming. You need to know about them because each motherboard you might support requires a specific type of RAM. Figure 4-37 is designed to help you keep all these technologies straight. You might find it a useful road map as you study each technology in the chapter. And who keeps up with all these technologies? JEDEC ([www.jedec.org](http://www.jedec.org)) is the organization responsible for standards used by solid-state devices, including RAM technologies. The goal of each new RAM technology approved by JEDEC is to increase speed and performance without greatly increasing the cost.



**Figure 4-37** Timeline of memory technologies

Even though an older RAM technology is no longer used by new motherboards, RAM manufacturers continue to produce the older RAM because older motherboards require these replacement modules. In Figure 4-37, the dotted lines for SIMMs and RIMMs indicate these technologies are now obsolete. All new motherboards today use DIMMs. However, if you check some retail websites, you can see that RIMMs can still be purchased.

 **Notes** For an interesting discussion on how RAM works, complete with animation, see the webpage by HowStuff Works, Inc., at [www.howstuffworks.com/ram.htm](http://www.howstuffworks.com/ram.htm).

We'll now look at each of the types of DIMM and SO-DIMM modules and the technologies they use.

## DIMM TECHNOLOGIES

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DIMMs use a 64-bit data path. (Some early DIMMs had a 128-bit data path, but they're now obsolete.) A DIMM (dual inline memory module) gets its name because it has independent pins on opposite sides of the module.

Early DIMMs did not run in sync with the system clock because they were too slow to keep up. Their speeds are measured in nanoseconds (ns), which is how long it takes for the module to read or write data. The first DIMM to run synchronized with the system clock was **synchronous DRAM (SDRAM)**, which has two notches, and uses 168 pins. (Don't confuse SDRAM with SRAM. SRAM is static RAM used in processor memory caches, and SDRAM is dynamic RAM used on DIMMs.) Synchronized memory runs in step with the processor and system clock, and its speeds are measured just as processor and bus speeds are measured in MHz.

**Double Data Rate SDRAM (DDR SDRAM, or SDRAM II, or simply DDR)** is an improved version of SDRAM. DDR runs twice as fast as regular SDRAM, has one notch, and uses 184 pins. Instead of

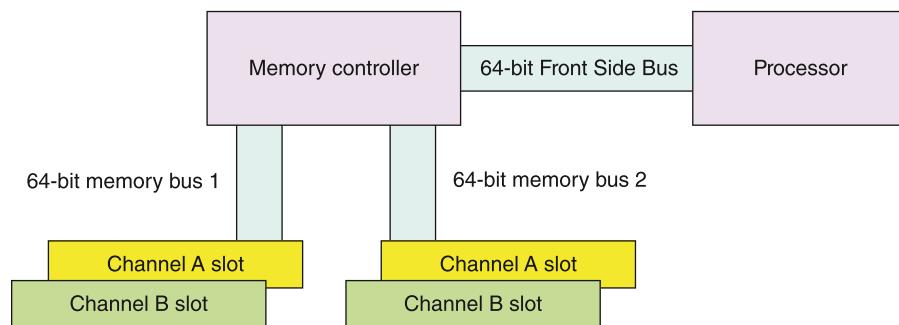
processing data for each beat of the system clock, as regular SDRAM does, it processes data when the beat rises and again when it falls, doubling the data rate of memory. If a motherboard runs at 200 MHz, DDR memory runs at 400 MHz. Three other improvements over DDR are DDR2, DDR3, and DDR4. DDR2 is faster and uses less power than DDR. DDR3 is faster and uses less power than DDR2. The trend continues with DDR4 being faster and using less power than DDR3. Both DDR2 and DDR3 use 240 pins. They are not compatible because their notches are not in the same position, and the different notch positions keep someone from installing a DDR2 or DDR3 DIMM in the wrong memory slot. DDR4 uses 288 pins.

Factors that affect the capacity, features, and performance of DIMMs include the number of channels they use, how much RAM is on one DIMM, the speed, error-checking abilities, and buffering. All these factors are discussed next.

### SINGLE, DUAL, TRIPLE, AND QUAD CHANNELS

When you look at a motherboard, you might notice the DIMM slots are different colors. This color coding is used to identify the channel each slot uses. Channels have to do with how many DIMM slots the memory controller can address at a time. Early DIMMs only used a **single channel**, which means the memory controller can access only one DIMM at a time. To improve overall memory performance, **dual channels** allow the memory controller to communicate with two DIMMs at the same time, effectively doubling the speed of memory access. A motherboard that supports **triple channels** can access three DIMMs at the same time. Sandy Bridge technology introduced **quad channels** where the processor can access four DIMMs at the same time. DDR, DDR2, DDR3, and DDR4 DIMMs can use dual channels. DDR3 DIMMs can also use triple channels. DDR3 and DDR4 DIMMs can use quad channels. For dual, triple, or quad channels to work, the motherboard and the DIMM must support the technology.

Figure 4-38 shows how dual channeling works on a board with four DIMM slots. The board has two memory channels, Channel A and Channel B. With dual channeling, the two DIMMs installed in the two slots labeled Channel A can be addressed at the same time. If two more DIMMs are installed in the Channel B slots, they can be accessed at the same time.



**Figure 4-38** Using dual channels, the memory controller can read from two DIMMs at the same time

When setting up dual channeling, know that the pair of DIMMs in a channel must be equally matched in size, speed, and features, and it is recommended they come from the same manufacturer. A motherboard supporting dual channels was shown in Figure 4-36. The two black DIMM slots make up the first channel, and the two blue slots make up the second channel. To use dual channeling, matching DIMMs must be installed in the black slots and another matching pair in the blue slots, as shown in Figure 4-39. Know that the second pair of DIMMs does not have to match the first pair of DIMMs because the first channel runs independently of the second channel. If the two DIMM slots of a channel are not populated with matching pairs of DIMMs, the motherboard will revert to single channeling.

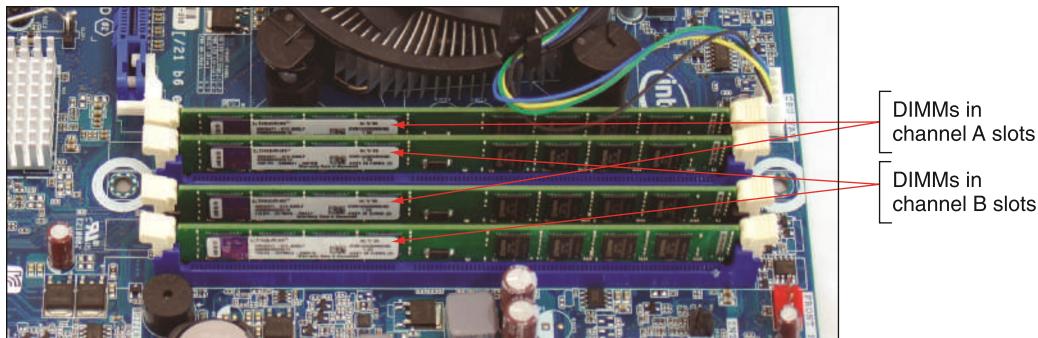


Figure 4-39 Matching pairs of DIMMs installed in four DIMM slots that support dual channeling

**★ A+ Exam Tip** The A+ 220-901 exam expects you to be able to distinguish between single-channel, dual-channel, and triple-channel memory installations.

For a triple-channel installation, three DIMM slots must be populated with three matching DDR3 DIMMs (see Figure 4-40). The three DIMMs are installed in the three blue slots on the board. This motherboard has a fourth black DIMM slot. You can barely see this black slot behind the three filled slots in the photo. If the fourth slot is used, then triple channeling is disabled, which can slow down performance. If a matching pair of DIMMs is installed in the first two slots and another matching pair of DIMMs is installed in the third and fourth slots, then the memory controller will use dual channels. Dual channels are not as fast as triple channels, but certainly better than single channels.

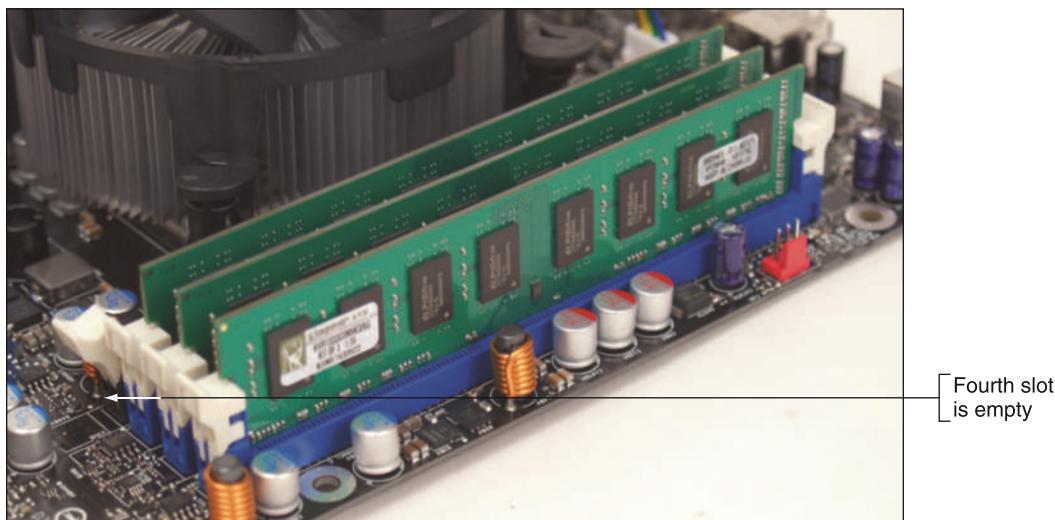


Figure 4-40 Three identical DDR3 DIMMs installed in a triple-channel configuration

The latest memory technology is quad channeling that was introduced with Intel Sandy Bridge chipsets and processors. Figure 4-41 shows an Intel motherboard that has the LGA2011 socket and eight memory slots. The processor can access four slots at the same time. The four black slots can be addressed by the processor on one memory channel and the four blue slots on another channel. Second Generation Sandy Bridge and later processors contain the memory controller within the processor package rather than on the chipset. To get the highest performance, memory slots are placed on either side of the processor in order to shorten the length of the memory bus. Because of the high performance of processors that use the LGA2011 socket, Intel recommends that systems using this socket use liquid cooling methods.



Courtesy of Intel Corporation

**Figure 4-41** The Intel Desktop Board DX79T0 has eight memory slots and supports two quad channels

## DIMM SPEEDS

DIMM speeds are measured either in MHz (such as 1333 MHz or 800 MHz) or PC rating (such as PC6400). A PC rating is a measure of the total bandwidth in MB/second of data moving between the module and the CPU. To calculate the PC rating for a DDR DIMM, multiply the speed by 8 bytes because a DIMM has an 8-byte or 64-bit data path. For example, a DDR DIMM that runs at 800 MHz has a bandwidth or transfer rate of  $800 \times 8$  or 6400 MB/second, which is expressed as a PC rating of PC6400. A DDR2 PC rating is usually labeled PC2, a DDR3 PC rating is labeled PC3, and a DDR4 PC rating is labeled PC4. In Figure 4-42, this memory ad shows the PC rating and lists speed as the DDR rate. Table 4-4 lists some current PC ratings.

Speed	PC Rating	Capacity	Part Number	Price
1333MHz	PC6400	512MB	CT25664BF160B	\$15.99
1600MHz	PC12800	512MB	CT64642335	\$16.99
1866MHz	PC14900	512MB	CT6464240B	\$16.99
2133MHz	PC17000	2GB	CT2G3S1067M	\$16.99

Source: crucial.com

**Figure 4-42** Memory speed is expressed in PC rating and lists speed as DDR rating

**★ A+ Exam Tip** The A+ 220-901 exam expects you to be able to calculate PC ratings, given the transfers per second. To get the PC rating, multiply the transfers per second by eight. To get the speed, divide the PC rating by eight.

## SINGLE-SIDED AND DOUBLE-SIDED DIMMs

A DIMM can have memory chips installed on one side of the module (called **single-sided**) or both sides of the module (called **double-sided**). Most desktop and laptop processors address memory 64 bits at a time. A **memory bank** is the memory a processor addresses at one time and is 64 bits wide, and a DIMM

Type of Memory	Speed	PC Rating
DDR4 DIMM	2666 MHz	PC4-21300
DDR4 DIMM	3000 MHz	PC4-24000
DDR4 DIMM	2133 MHz	PC4-17000
DDR3 DIMM	2000 MHz	PC3-16000
DDR3 DIMM	1800 MHz	PC3-14400
DDR3 DIMM	1333 MHz	PC3-10600
DDR2 DIMM	800 MHz	PC2-6400
DDR2 DIMM	667 MHz	PC2-5400
DDR DIMM	500 MHz	PC4000

Table 4-4 PC ratings for current memory modules

slot provides a 64-bit data path. However, some double-sided DIMMs provide more than one bank, which means the chips on the DIMM are grouped so that the memory controller addresses one group and then addresses another. These DIMMs are said to be **dual ranked**, and don't perform as well as DIMMs where all the memory is addressed at one time. Figure 4-43 shows some examples of DDR dual-ranked memory modules used in servers.

**32GB Kit (16GBx2) DDR4 PC4-17000**  
Registered ECC 1.2V  
part #: CT2K16G4VFD4213  
DDR4 PC4-17000 • CL=15 • Dual Ranked • x4 based •  
Registered • ECC • DDR4-2133 • 1.2V • \$659.99

compare   [add to wish list](#)   QTY  [add to cart](#)

**16GB kit (8GBx2) DDR4 PC4-17000**  
Unbuffered ECC 1.2V  
part #: CT2K8G4WFD8213  
DDR4 PC4-17000 • CL=15 • Dual Ranked • x8 based •  
Unbuffered • ECC • DDR4-2133 • 1.2V • \$223.99

compare   [add to wish list](#)   QTY  [add to cart](#)

**64GB kit (16GBx4) DDR4 PC4-17000**  
Registered ECC 1.2V  
part #: CT4K16G4RFD4213  
DDR4 PC4-17000 • CL=15 • Dual Ranked • x4 based •  
Registered • ECC • DDR4-2133 • 1.2V • \$823.99

compare   [add to wish list](#)   QTY  [add to cart](#)

Source: crucial.com

Figure 4-43 Memory ad lists dual-ranked DDR4 memory

## ERROR CHECKING AND PARITY

Because DIMMs intended to be used in servers must be extremely reliable, error-checking technology called **ECC (error-correcting code)** is sometimes used. The memory modules shown in Figure 4-43 are ECC memory. Some DDR, DDR2, DDR3, and DDR4 memory modules support ECC. A DIMM normally has an even number of chips on the module, but a DIMM that supports ECC has an odd number of chips on

the module. The odd extra chip is the ECC chip. ECC compares bits written to the module to what is later read from the module, and it can detect and correct an error in a single bit of the byte. If there are errors in 2 bits of a byte, ECC can detect the error but cannot correct it. The data path width for DIMMs is normally 64 bits, but with ECC, the data path is 72 bits. The extra 8 bits are used for error checking. ECC memory costs more than non-ECC memory, but it is more reliable. For ECC to work, the motherboard and all installed modules must support it. Also, it's important to know that you cannot install a mix of ECC and non-ECC memory on the motherboard because such a mixture causes the system to not work.

As with most other memory technologies discussed in this chapter, when buying memory to add to a motherboard, match the type of memory to the type the board supports. To see if your motherboard supports ECC memory, look for the ability to enable or disable the feature in UEFI/BIOS setup, or check the motherboard documentation.

Older SIMMs used an error-checking technology called **parity**. Using parity checking, a ninth bit is stored with every 8 bits in a byte. If memory is using odd parity, it makes the ninth or parity bit either a 1 or a 0, to make the number of 1s in the nine bits odd. If it uses even parity, it makes the parity bit a 1 or a 0 to make the number of 1s in the 9 bits even.

**★ A+ Exam Tip** The A+ 220-901 exam expects you to know that parity memory uses 9 bits (8 bits for data and 1 bit for parity). You also need to be familiar with ECC and non-ECC memory technologies.

Later, when the byte is read back, the memory controller checks the odd or even state. If the number of bits is not an odd number for odd parity or an even number for even parity, a **parity error** occurs. A parity error always causes the system to halt. On the screen, you see the error message “Parity Error 1” or “Parity Error 2” or a similar error message about parity. Parity Error 1 is a parity error on the motherboard; Parity Error 2 is a parity error on an expansion card.

Figure 4-44 shows a SIMM for sale. It's pricy because this old technology is hardly ever used. Notice the module is non-parity memory. In the ad, the SIMM is called EDO memory. EDO (extended data out) is a technology used by SIMMs.

Source: crucial.com

Figure 4-44 A SIMM appears in a memory ad as EDO memory

**Notes** RAM chips that have become undependable and cannot hold data reliably can cause errors. Sometimes this happens when chips overheat or power falters.

## BUFFERED AND REGISTERED DIMMs

Buffers and registers hold data and amplify a signal just before the data is written to the module. (Using buffers is an older technology than using registers.) Some DIMMs use buffers, some use registers, and some use neither. If a DIMM doesn't support registers or buffers, it's referred to as an unbuffered DIMM. Looking at the ad in Figure 4-42 for value memory used in desktops, you can see all the modules are unbuffered. However, in Figure 4-43, two of the kits of expensive server memory are registered DIMMs.

## CAS LATENCY AND RAS LATENCY

Two other memory features are **CAS Latency** (CAS stands for “column access strobe”) and **RAS Latency** (RAS stands for “row access strobe”), which are two ways of measuring access timing. Both features refer to the number of clock cycles it takes to write or read a column or row of data off a memory module. CAS Latency is used more than RAS Latency. Lower values are better than higher ones. For example, CL8 is a little faster than CL9.


**Notes**

In memory ads, CAS Latency is sometimes written as CL, and RAS Latency might be written as RL.

Ads for memory modules might give the CAS Latency value within a series of timing numbers, such as 5-5-5-15. The first value is CAS Latency, which means the module is CL5. The second value is RAS Latency. Looking back at Figure 4-42, you can see CL ratings vary from 2.5 to 11.


**Notes**

When selecting memory, use the memory type that the motherboard manufacturer recommends.

## TYPES OF MEMORY USED IN LAPTOPS

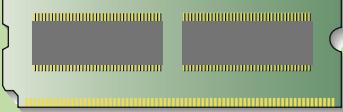
Today's laptops use DDR4, DDR3L, DDR3, or DDR2 SO-DIMM (small outline DIMM) memory. Table 4-5 lists current SO-DIMMs. All of these memory modules are smaller than regular DIMMs.


**A+ Exam Tip**

The A+ 220-901 exam expects you to know that DDR3, DDR2, and DDR memory can be found on SO-DIMMs.

Memory Module Description	Sample Memory Module
<p><b>2.74" 260-pin SO-DIMM contains DDR4 memory. The one notch on the module is offset from the center of the module.</b></p>	 Source: crucial.com
<p><b>2.66" 204-pin SO-DIMM contains DDR3 memory. The one notch on the module is offset from the center of the module. A DDR3L SO-DIMM uses less power than a regular DDR3 SO-DIMM.</b></p>	 Courtesy of Kingston Technology Corporation
<p><b>2.66" 200-pin SO-DIMM contains DDR2 SDRAM. One notch is near the side of the module.</b></p>	 Courtesy of Kingston Technology Corporation
<p><b>2.66" 200-pin SO-DIMM contains DDR SDRAM. One notch near the side of the module is slightly offset from the notch on a DDR2 SDRAM module.</b></p>	 Courtesy of Micron Consumer Products

**Table 4-5** Memory modules used in laptop computers (continues)

Memory Module Description	Sample Memory Module
<b>2.66" 144-pin SO-DIMM</b> contains SDRAM. One notch is slightly offset from the center of the module.	 Courtesy of Micron Consumer Products
<b>2.35" 72-pin SO-DIMM</b> has no notch on the edge connector.	
<b>160-pin SO-RIMM</b> contains Rambus memory and has two notches.	 Courtesy of High Connection Density, Inc.

**Table 4-5** Memory modules used in laptop computers (continued)

4

Just as with memory modules used in desktop computers, you can only use the type of memory the laptop is designed to support. The number of pins and the position of the notches on a SO-DIMM keep you from inserting the wrong module in a memory slot.

Now, onward to upgrading memory.

## HOW TO UPGRADE MEMORY

A+  
220-901  
1.3, 3.1

To upgrade memory means to add more RAM to a computer. Adding more RAM might solve a problem with slow performance, applications refusing to load, or an unstable system. When Windows does not have adequate memory to perform an operation, it gives an “Insufficient memory” error or it slows down to a painful crawl.

When first purchased, many computers have empty slots on the motherboard, allowing you to add DIMMs or SO-DIMMs to increase the amount of RAM. Sometimes a memory module goes bad and must be replaced.

When you add more memory to your computer, you need answers to these questions:

- ▲ How much RAM do I need and how much is currently installed?
- ▲ How many and what kind of memory modules are currently installed on my motherboard?
- ▲ How many and what kind of modules can I fit on my motherboard?
- ▲ How do I select and purchase the right modules for my upgrade?
- ▲ How do I physically install the new modules?

All these questions are answered in the following sections.

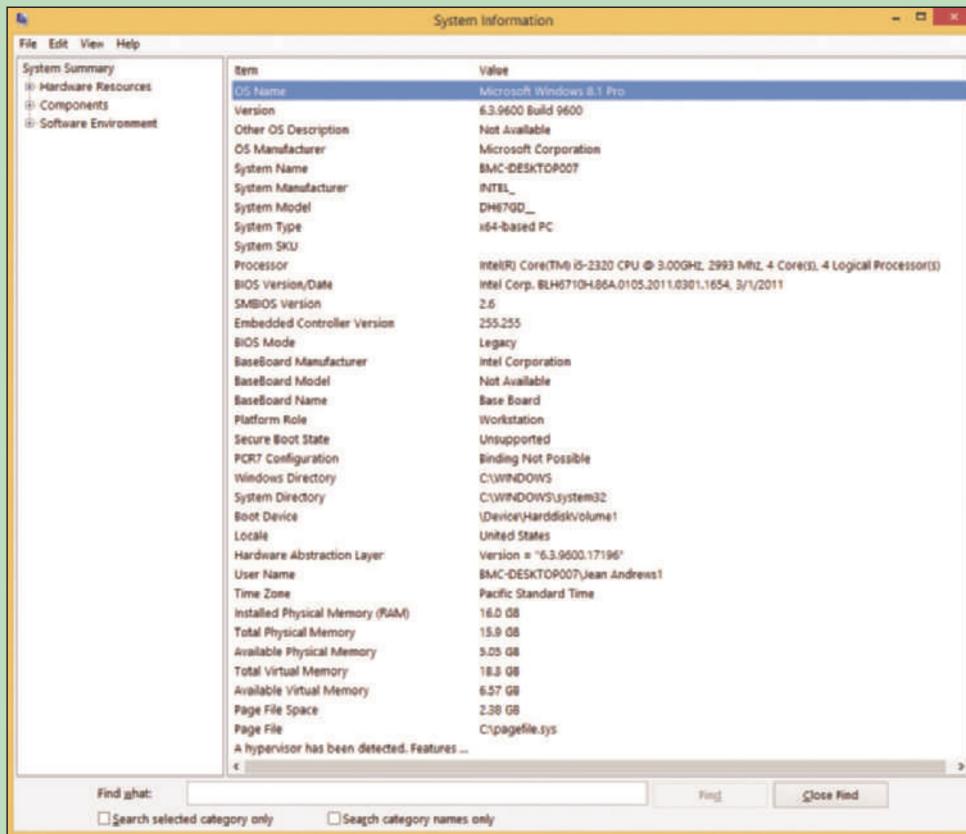
## HOW MUCH MEMORY DO I NEED AND HOW MUCH IS CURRENTLY INSTALLED?

A+  
220-901  
1.3, 3.1

With the demands today’s software places on memory, the answer is probably, “All you can get.” Windows 8 and Windows 7 need at least 2 GB, but more is better. The limit for a 32-bit OS is 4 GB installed RAM. A 64-bit Windows installation can handle more. For example, a 64-bit installation of Windows 8 can use up to 128 GB of RAM, and a 64-bit installation of Windows 7 Home Premium can use up to 16 GB of RAM.

**APPLYING CONCEPTS****HOW MUCH MEMORY IS CURRENTLY INSTALLED?**

In Windows, you can use the System Information window to report the amount of physical memory installed. From the Windows 8 desktop, right-click **Start**, click **Run**, and then type **msinfo32**. For Windows 7, click **Start** and type **msinfo32** in the Search box. The System Information window shown in Figure 4-45 reports the amount of installed physical memory. Notice on the window that 16 GB is installed.



**Figure 4-45** The System Information window reports installed physical memory

The BIOS setup screen shows more information about installed memory than does Windows. Reboot the computer and access BIOS setup (you learned how to do that in the chapter, “All About Motherboards”). The BIOS setup main menu for one system is shown in Figure 4-46. This screen shows the number of memory slots and how much RAM is installed in each slot. Notice the system has two memory channels of two slots each. You can, therefore, conclude this system is using dual channels.

System Setup	
Main	Configuration
BIOS Version	BLH6710H.86A.0105.2011.0301.1654
Processor Type	Intel(R) Core(TM) i5-2320 CPU @ 3.00GHz
Active Processor Cores	<ALL>
Host Clock Frequency	100MHz
Processor Turbo Speed	3.30 GHz
Memory Speed	1333 MHz
L2 Cache RAM	4 x 256 KB
L3 Cache RAM	6 MB
Total Memory	16 GB
DIMM3 (Memory Channel A Slot 0)	4 GB
DIMM1 (Memory Channel A Slot 1)	4 GB
DIMM4 (Memory Channel B Slot 0)	4 GB
DIMM2 (Memory Channel B Slot 1)	4 GB
System Identification Information	
System Date	[Thu 05/01/2012]
System Time	[09:35:49]

Number of cores to  
enabled in each  
processor package

--: Select Screen  
+: Select Item  
Enter:Select  
+/-: Change Opt.  
F9: Load Defaults  
F10:Save ESC:Exit

Figure 4-46 BIOS setup reports memory configuration and amount

Source: Intel

4

## HOW MANY AND WHAT KIND OF MEMORY MODULES ARE CURRENTLY INSTALLED?

A+  
220-901  
1.3, 3.1

The next step to upgrading memory is to determine what type of memory modules the motherboard is currently using. If the board already has memory installed, you want to do your best to match the new modules with whatever is already installed. To learn what type of memory modules are already installed, do the following:

1. Open the case and look at the memory slots. How many slots do you have? How many are filled? Remove each module from its slot and look on it for imprinted type, size, and speed. For example, a module might say “PC2-4200/512MB.” The PC2 tells you the memory is DDR2, the 4200 is the PC rating and tells you the speed, and the 512 MB is the size. This is not enough information to know exactly what modules to purchase, but it’s a start.
2. Examine the module for the physical size and position of the notches. Compare the notch positions to those in Table 4-3.
3. Read your motherboard documentation. If the documentation is not clear (and some are not) or you don’t have the documentation, look on the motherboard for the imprinted manufacturer and model (see Figure 4-47). With this information, you can search a good memory website such as Kingston ([www.kingston.com](http://www.kingston.com)) or Crucial ([www.crucial.com](http://www.crucial.com)), which can tell you what type of modules this board supports.

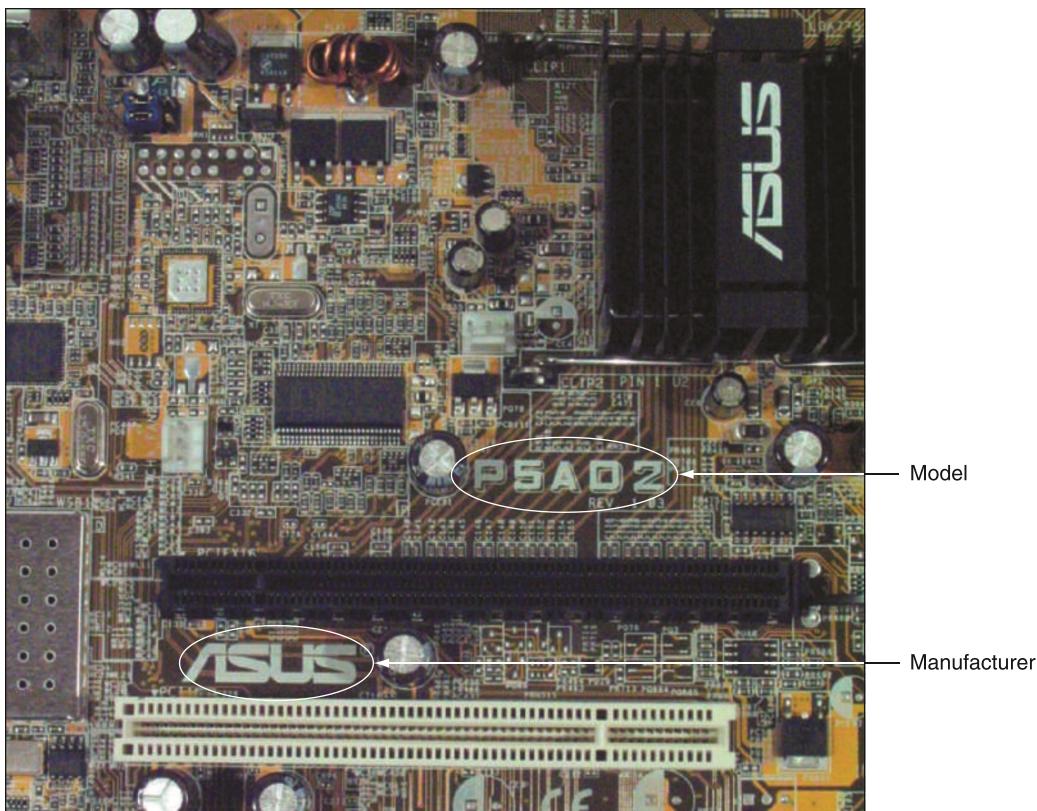


Figure 4-47 Look for the manufacturer and model of a motherboard imprinted somewhere on the board

4. Look in the documentation to see if the board supports dual channel, triple channel, or quad channels. If it does, most likely the memory slots on the board will be color-coded in pairs (for dual channels) or groups of three slots (for triple channels) or four slots (for quad channels). If the board supports multiple channels and modules are already installed, verify that matching DIMMs are installed in each channel.
5. If you still have not identified the module type, you can take the motherboard and the old memory modules to a good computer parts store and they should be able to match it for you.

### Hands-On | Project 4-3 Use an Online Memory Scanner

A great shortcut to research a memory upgrade is an online memory scanner. Go to [www.crucial.com/systemscanner](http://www.crucial.com/systemscanner) by Crucial. Download and run the Crucial System Scanner, which scans your system and reports what type of memory is installed and can be installed. Using the Crucial report, answer these questions:

1. Which motherboard do you have installed? How much memory is installed? How many memory slots does the board have? How many are populated?
2. What is the maximum memory the board supports? What type of memory does the board support? What would be the total cost of the memory upgrade if you were to max out the total memory on the board?

## **HOW MANY AND WHAT KIND OF MODULES CAN FIT ON MY MOTHERBOARD?**

A+  
220-901  
1.3, 3.1

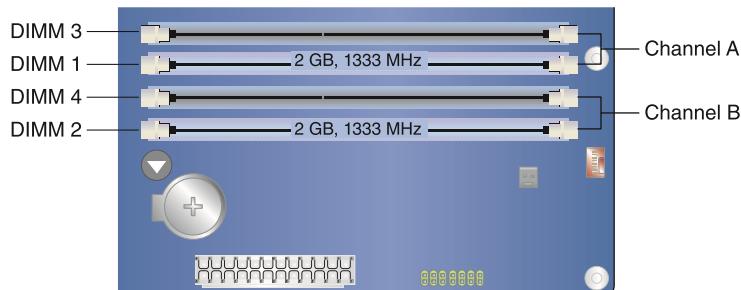
Now that you know what memory modules are already installed, you're ready to decide how much and what kind of modules you can add to the board. Keep in mind that if all memory slots are full, sometimes you can take out small-capacity modules and replace them with larger-capacity modules, but you can only use the type, size, and speed of modules that the board can support. Also, if you must discard existing modules, the price of the upgrade increases.

4

To know how much memory your motherboard can physically hold, read the documentation that comes with the board. You can always install DIMMs as single modules, but you might not get the best performance by doing so. For best performance, install matching DIMMs in all the slots (two, three, or four slots) on one channel. Now let's look at a few examples. The examples are ordered from a more recent motherboard to an older motherboard. As you study these examples, notice that the older the board, the more complicated the configuration can be and the harder it is to understand the documentation. Is life with computers getting simpler or what?

### **MOTHERBOARD USING DDR3 DUAL-CHANNEL DIMMs**

The Intel Desktop Board DH67GD shown earlier in Figure 4-21 has four memory slots that use dual channeling. These slots are numbered in the user guide, as shown in Figure 4-48. The slots can hold Dual Channel DDR3 1333 MHz and 1066 MHz non-ECC, 1.35-V modules for up to 32 GB of RAM on this board. To use four DIMMs and dual channeling, install matching DIMMs in the two blue slots and matching DIMMs in the two black slots.



**Figure 4-48** Documentation shows four DIMM slots that use dual channels

The motherboard user guide says it is possible to use only three DIMMs and dual channeling if you install matching DIMMs in the two blue slots and install a third DIMM in a black slot. This third DIMM must be equal in speed and total size of the DIMMs in the blue slots. For example, you can install two 4-GB DIMMs in the two blue slots and one 8-GB DIMM in a black slot for a total of 16-GB of RAM. If you install only a single DIMM on this board, it must go in the first blue slot, which is the blue slot closest to the processor.

### **MOTHERBOARD USING DDR3 TRIPLE-CHANNEL DIMMs**

The Intel motherboard shown earlier in Figure 4-40 has four DDR3 memory slots that can be configured for single, dual, or triple channeling. The four empty slots are shown in Figure 4-49. If triple channeling is used, three matching DIMMs are used in the three blue slots. If the fourth slot is populated, the board reverts to single channeling. For dual channeling, install two matching DIMMs in the two blue slots farthest from the processor and leave the other two slots empty. If only one DIMM is installed, it goes in the blue slot in the farthest position from the processor.

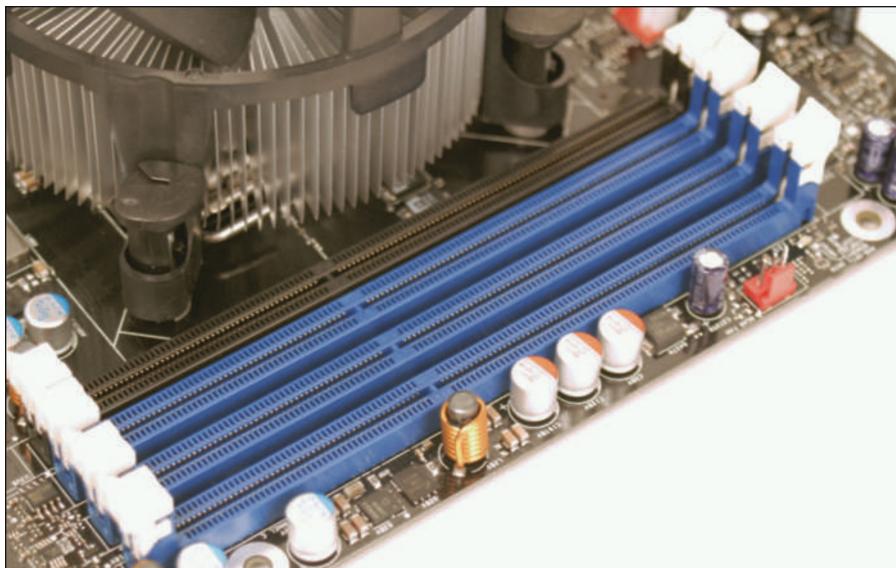


Figure 4-49 Four DDR3 slots on a motherboard

The motherboard documentation says that these types of DIMMs can be used:

- ▲ The DIMM voltage rating no higher than 1.6 V
- ▲ Non-ECC DDR3 memory
- ▲ Serial Presence Detect (SPD) memory only
- ▲ Gold-plated contacts (some modules use tin-plated contacts)
- ▲ 1333 MHz, 1066 MHz, or 800 MHz (best to match the system bus speed)
- ▲ Unbuffered, nonregistered single- or double-sided DIMMs
- ▲ Up to 16 GB total installed RAM

The third item in the list needs an explanation. Serial Presence Detect (SPD) is a DIMM technology that declares to system UEFI/BIOS at startup the module's size, speed, voltage, and data path width. If the DIMM does not support SPD, the system might not boot or boot with errors. Today's memory always supports SPD.

### MOTHERBOARD USING DDR DIMMs WITH DUAL CHANNELING

Let's look at another example of a DIMM installation. The Pentium motherboard allows you to use three different speeds of DDR DIMMs in one to four sockets on the board. The board supports dual channeling and has two blue slots for one channel and two black slots for the other channel. For dual channeling to work, matching DIMMs must be installed in the two blue sockets. If two DIMMs are installed in the two black sockets, they must match each other.

This board supports up to 4 GB of unbuffered, 184-pin, non-ECC memory running at PC3200, PC2700, or PC2100. The documentation says the system bus can run at 800 MHz, 533 MHz, or 400 MHz, depending on the speed of the processor installed. Therefore, the speed of the processor determines the system bus speed, which determines the speed of memory modules.

Figure 4-50 outlines the possible configurations of these DIMM modules, showing that you can install one, two, or four DIMMs and which sockets should hold these DIMMs. To take advantage of dual channeling on this motherboard, you must populate the sockets according to Figure 4-50, so that identical DIMM pairs are working together in DIMM\_A1 and DIMM\_B1 sockets (the blue sockets), and another pair can work together in DIMM\_A2 and DIMM\_B2 sockets (the black sockets).

The board has two installed DDR DIMMs. The label on one of these DIMMs is shown in Figure 4-51. The important items on this label are the size (256 MB), the speed (400 MHz or 3200 PC rating), and the CAS Latency (CL3). With this information and knowledge about what the board can support, we are now ready to select and buy the memory for the upgrade. For example, if you decide to upgrade the system to

Mode	Sockets			
	DIMM_A1	DIMM_A2	DIMM_B1	DIMM_B2
Single channel	(1)	Populated	—	—
	(2)	—	Populated	—
	(3)	—	—	Populated
	(4)	—	—	Populated
Dual channel*	(1)	Populated	—	Populated
	(2)	—	Populated	—
	(3)	Populated	Populated	Populated

\*Use only identical DDR DIMM pairs

Figure 4-50 Motherboard documentation shows that one, two, or four DIMMs can be installed



Figure 4-51 Use the label on this DIMM to identify its features

1 GB of memory, you would buy two DDR, 400 MHz, CL3 DIMMs that support dual channeling. For best results, you need to also match the manufacturer and buy Elixir memory.

## HOW DO I SELECT AND PURCHASE THE RIGHT MEMORY MODULES?

A+  
220-901  
1.3, 3.1

You're now ready to make the purchase. As you select your memory, you might find it difficult to find an exact match to DIMMs already installed on the board. If necessary, here are some compromises you cannot or can make:

- ▲ Mixing unbuffered memory with buffered or registered memory won't work.
- ▲ When matching memory, for best results, also match the module manufacturer. But in a pinch, you can try using memory from two different manufacturers.
- ▲ If you mix memory speeds, know that all modules will perform at the slowest speed.

Now let's look at how to use a website or other computer ad to search for the right memory.

## USING A WEBSITE TO RESEARCH YOUR PURCHASE

When purchasing memory from a website such as Crucial Technology's site ([www.crucial.com](http://www.crucial.com)) or Kingston Technology's site ([www.kingston.com](http://www.kingston.com)), look for a search utility that will match memory modules to your motherboard (see Figure 4-52). These utilities are easy to use and help you confirm you have made

the right decisions about type, size, and speed to buy. They can also help if motherboard documentation is inadequate, and you're not exactly sure what memory to buy.

Four items identify the motherboard brand and model

Further refine your search

Source: kingston.com

**Figure 4-52** The Kingston website DIMM recommendations for a particular motherboard

Let's look at one example on the Crucial site where we are looking to install memory in the Intel DH67GD motherboard discussed earlier in the chapter. The search results are shown in Figure 4-53.

Motherboard brand and model

Diagram of selected motherboard

Memory supported by your board

Source: crucial.com

**Figure 4-53** Selecting memory off the Crucial website

Modules faster than the board supports are listed. They will work on the board, running at a slower speed, but it's not necessary to spend the money for speed you won't use. The best buy is the second item listed; these DIMMs are rated at 1333 MHz, which is the maximum speed the board supports.

## Hands-On | Project 4-4 Plan and Price a Memory Upgrade

4

Using the information you gained about your computer in Hands-On Project 4-3, research the web to determine the total cost of the memory upgrade in order to max out the total memory on your computer. You can keep the cost down by using the modules you already have, but don't forget to match the speed of the modules already installed. Print two webpages from two sites other than the Crucial site that show the modules you would purchase. How much will the upgrade cost?

### HOW DO I INSTALL THE NEW MODULES?

A+  
220-901  
1.3, 3.1

When installing RAM modules, be careful to protect the chips against static electricity, as you learned to do in the “Working Inside Desktop Computers and Laptops” chapter. Follow these precautions:

- Always use an ESD strap as you work.
- Turn off the power, unplug the power cord, press the power button, and remove the case cover.
- Handle memory modules with care.
- Don't touch the edge connectors on the memory module or on the memory slot.
- Don't stack cards or modules because you can loosen a chip.
- Usually modules pop into place easily and are secured by spring catches on both ends. Make sure that you look for the notches on one side or in the middle of the module that orient the module in the slot.

Let's now look at the details of installing a DIMM.

### INSTALLING DIMMs

For DIMM modules, small clips latch into place on each side of the slot to hold the module in the slot, as shown in Figure 4-54. Some newer motherboards have only one latch on the slot. To install a DIMM, first pull the supporting arms on the sides of the slot outward. Look on the DIMM edge connector for the notches,

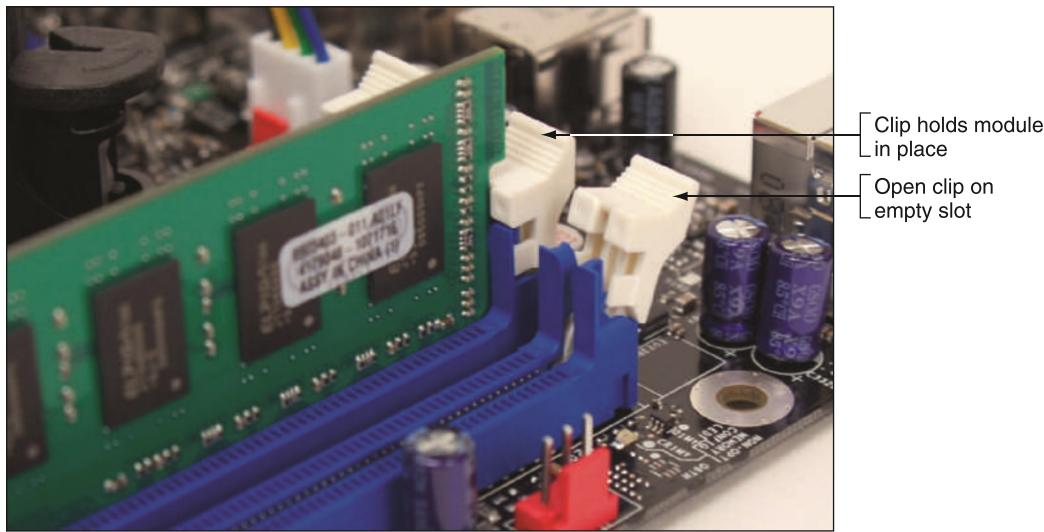
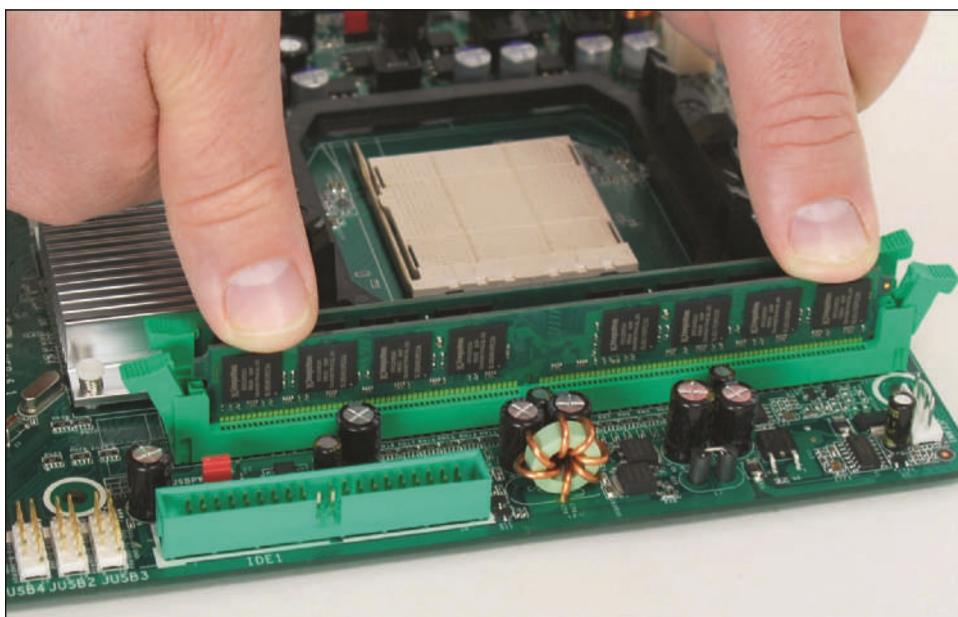


Figure 4-54 Clips on each side of a slot hold a DIMM in place

which help you orient the DIMM correctly over the slot, and insert the DIMM straight down into the slot. When the DIMM is fully inserted, the supporting clips should pop back into place. Figure 4-55 shows a DIMM being inserted into a slot on a motherboard. Apply pressure on both ends of the DIMM at the same time.



**Figure 4-55** Insert the DIMM into the slot by pressing down until the support clips lock into position

Most often, placing memory on the motherboard is all that is necessary for installation. When the computer powers up, it counts the memory present without any further instruction and senses the features that the modules support, such as ECC or buffering. For some really old computers, you must tell BIOS setup the amount of memory present. Read the motherboard documentation to determine what yours requires. If the new memory is not recognized, power down the system and reseat the module. Most likely it's not installed solidly in the slot.

### Hands-On | Project 4-5 Examine UEFI/BIOS Settings

On your home or lab computer, use UEFI/BIOS setup to answer these questions:

1. Which processor is installed? What is the processor frequency?
2. What are the UEFI/BIOS settings that apply to the processor and how is the processor configured?
3. What information does UEFI/BIOS report about total memory installed and how each memory slot is populated? Does the board support dual, triple, or quad channeling? How do you know?

### Hands-On | Project 4-6 Upgrade Memory

To practice installing additional memory in a computer in a classroom environment, remove the DIMMs from one computer and place them in another computer. Boot the second computer and check that it counts the additional memory. When finished, return the borrowed modules to the original computer.

## HOW TO UPGRADE MEMORY ON A LAPTOP

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3.1

Before upgrading memory, make sure you are not voiding the laptop's warranty. Search for the best buy, but make sure you use memory modules made by or authorized by your laptop's manufacturer and designed for the exact model of your laptop. Installing generic memory might save money but might also void the laptop's warranty.

Upgrading memory on a laptop works about the same way as with upgrading memory on a desktop: Decide how much memory you can upgrade and what type of memory you need, purchase the memory, and install it. As with a desktop computer, be sure to match the type of memory to the type the laptop supports.

4

### Hands-On | Project 4-7 Upgrade Laptop Memory

A friend has a Lenovo ThinkPad X200 laptop and is looking for ways to improve its performance. He's cleaned up the hard drive and is now considering the possibility of upgrading memory. Windows reports the system has 2 GB of RAM. He opens the cover on the bottom of the case and discovers that both SO-DIMM slots are filled. How much will the upgrade cost to bring total RAM in the system to 4 GB? Print the webpage to support your answer. What type and speed of SO-DIMMs does this laptop use?

### APPLYING | CONCEPTS UPGRADE MEMORY ON A LAPTOP

Most laptops are designed for easy access to memory. Follow these steps to exchange or upgrade memory for one laptop:

1. Back up data and shut down the system. Remove peripherals, including the AC adapter. Remove the battery. Be sure to use a ground bracelet as you work.
2. Many laptops have a RAM door on the bottom of the laptop. For some laptops, this door is in the battery cavity. Turn the laptop over and loosen the screws on the RAM door. (It is not necessary to remove the screws.)
3. Raise the door (see Figure 4-56) and remove the door from its hinges. The two memory slots are exposed.



Figure 4-56 Raise the DIMM door on the bottom of the notebook

(continues)

4. Notice in Figure 4-57 that one slot is filled and one is available for a memory upgrade. Also notice in the figure that when you remove the RAM door, the CMOS battery is exposed. This easy access to the battery makes exchanging it very easy. To remove a SO-DIMM, pull the clips on the side of the memory slot apart slightly (see Figure 4-58). The SO-DIMM will pop up out of the slot and can then be removed. If it does not pop up, you can hold the clips apart as you pull the module up and out of the slot.

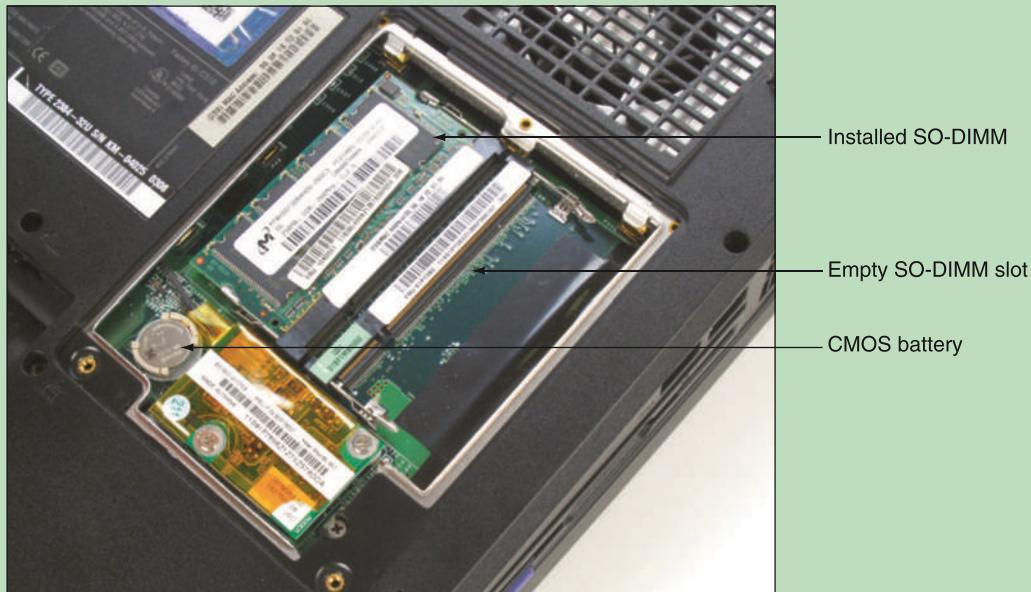


Figure 4-57 SO-DIMM slots, one installed SO-DIMM, and the CMOS battery are exposed



Figure 4-58 Pull apart the clips on the memory slot to release the SO-DIMM

5. To install a new SO-DIMM, insert the module at an angle into the slot (see Figure 4-59) and gently push it down until it snaps into the clips (see Figure 4-60). Replace the RAM door.



**Figure 4-59** Insert a new SO-DIMM into a memory slot



**Figure 4-60** Push down on the SO-DIMM until it pops into the clips

6. Replace the battery, plug in the power adapter, and power up the laptop.

4

## >> CHAPTER SUMMARY

### Types and Characteristics of Processors

- ▲ The most important component on the motherboard is the processor, or central processing unit. The two major manufacturers of processors are Intel and AMD.
- ▲ Processors are rated by the processor speed, the socket and chipset the processor can use, processor architecture (32-bit or 64-bit), multicore rating, how much internal memory cache the processor has, amount and type of RAM the processor can support, and the computing technologies the processor can use.
- ▲ A processor's memory cache inside the processor housing can be an L1 cache (contained on the processor die), L2 cache (off the die), and L3 cache (farther from the core than L2 cache).
- ▲ The core of a processor has two arithmetic logic units (ALUs). Multicore processors have two, three, or more cores (called dual core, triple core, quad core, and so forth). Each core can process two threads at once if the feature is enabled in UEFI/BIOS setup.
- ▲ The current families of Intel processors for desktops include the Core, Atom, Celeron, and Pentium families of processors. Several different processors are within each family.
- ▲ The current AMD desktop processor families are the FX, Phenom, Athlon, and Sempron. Several processors exist within each family.

### Selecting and Installing a Processor

- ▲ Select a processor that the motherboard supports. A board is likely to support several processors that vary in performance and price.
- ▲ When installing a processor, always follow the directions given in the motherboard user guide and be careful to protect the board and processor against ESD. Current Intel sockets LGA1150, LGA1155, LGA1366, and LGA775 use a socket lever and socket load plate. When opening these sockets, lift the socket lever and then the socket load plate, install the processor, and then close the socket. Many AMD sockets have a socket lever, but not a socket load plate.

## Memory Technologies

- ▲ DRAM is stored on DIMMs for desktop computers and SO-DIMMs for laptops.
- ▲ Types of current DIMMs are DDR4 with 288 pins, DDR3 and DDR2 DIMMs that have 240 pins, and DDR DIMMs with 184 pins.
- ▲ DIMMs can be single-sided or double-sided. Some double-sided DIMMs provide more than one memory bank and are called dual ranked or quad ranked. A memory bank has a 64-bit data path and is accessed by the processor independently of other banks.
- ▲ DIMMs can work together in dual channels, triple channels, and quad channels so that the memory controller can access more than one DIMM at a time to improve performance. In a channel, all DIMMs must match in size, speed, and features. DDR3 DIMMs can use dual, triple, or quad channeling, but DDR and DDR2 DIMMs can only use dual channels. DDR4 DIMMs can use dual or quad channels.
- ▲ DIMM speeds are measured in MHz (for example, 1333 MHz) or PC rating (for example, PC3-10600).
- ▲ The memory controller can check memory for errors and possibly correct those errors using ECC (error-correcting code). Using parity, an older technology, the controller could only recognize an error had occurred, but not correct it.
- ▲ Buffers and registers are used to hold data and amplify a data signal. A DIMM is rated as a buffered, registered, or unbuffered DIMM.
- ▲ CAS Latency (CL) and RAS Latency (RL) measure access time to memory. The lower values are faster than the higher values.
- ▲ Today's laptops use DDR4, DDR3L, DDR3, or DDR2 SO-DIMMs.

## How to Upgrade Memory

- ▲ When upgrading memory, use the type, size, and speed the motherboard supports and match new modules to those already installed. Features to match include DDR4, DDR3, DDR2, DDR, size in MB or GB, speed (MHz or PC rating), buffered, registered, unbuffered, single-sided, double-sided, CL rating, tin or gold connectors, support for dual, triple, or quad channeling, ECC, and non-ECC. Using memory made by the same manufacturer is recommended.
- ▲ When upgrading components on a laptop, including memory, use components that are the same brand as the laptop, or use only components recommended by the laptop's manufacturer.

### >> KEY TERMS

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

buffer overflow attack	dual channels	Level 3 cache (L3 cache)	SIMM (single inline memory module)
CAS Latency	dual processors	memory bank	single channel
Centrino	dual ranked	multicore processing	single-sided
DDR	dynamic RAM (DRAM)	multiplier	SO-DIMM (small outline DIMM)
DDR2	ECC (error-correcting code)	multiprocessing	static RAM (SRAM)
DDR3	Execute Disable Bit (EDB)	multiprocessor platform	synchronous DRAM (SDRAM)
DDR3L	graphic processing unit (GPU)	parity	thermal compound
DDR4	Hyper-Threading	parity error	thread
DIMM (dual inline memory module)	Hyper Transport	processor frequency	triple channels
Double Data Rate SDRAM (DDR SDRAM)	Level 1 cache (L1 cache)	quad channels	x86 processor
double-sided	Level 2 cache (L2 cache)	RAS Latency	x86-64 bit processor
		RIMM	
		SDRAM II	

**>> REVIEWING THE BASICS**

1. Who are the two major manufacturers of processors?
2. What is the name of the memory cache that is on the same die as the processor?
3. What is the name of the memory cache that is closest to the processor die but is not housed on the die?
4. What is the name of the Intel technology that allows a processor to handle two threads at the same time? 4
5. How many threads can a quad-core processor handle at once?
6. Which two Intel processor sockets use a screw head to hold down the socket load plate?
7. What is the purpose of the Execute Disable Bit?
8. Which is faster, SRAM or DRAM? Why?
9. How many pins are on a DDR3 DIMM? DDR2 DIMM?
10. How many pins are on a DDR DIMM?
11. How many notches does a DDR3 DIMM have?
12. Which DIMM performs better, a double-sided dual-ranked DIMM or a double-sided single-ranked DIMM?
13. What prevents a DDR DIMM from being installed in a DDR2 DIMM slot on a motherboard?
14. Which module, a DDR3 or DDR2 DIMM, uses lower voltage?
15. In a memory ad for DIMMs, you notice 64Meg ×72 for one DIMM and 64Meg ×64 for another DIMM. What does the 72 tell you about the first DIMM?
16. What type of DIMM supports triple channeling?
17. If 2 bits of a byte are in error when the byte is read from ECC memory, can ECC detect the error? Can it fix the error?
18. A DIMM memory ad displays 5-5-5-15. What is the CAS Latency value of this DIMM?
19. What is the most amount of RAM that can be used by a 32-bit installation of Windows 7 Professional?
20. A motherboard uses dual channeling, but you have four DIMMs available that differ in size. The motherboard supports all four sizes. Can you install these DIMMs on the board? Will dual channeling be enabled?
21. How many pins does a DDR3 SO-DIMM have? A DDR2 SO-DIMM?
22. Which is faster, CL3 memory or CL5 memory?
23. You are looking to purchase two DIMMs running at 400 MHz. You find DIMMs advertised at PC4000 and PC3200. Which do you purchase?
24. You need to find out how much RAM is installed in a system. What command do you execute to launch the System Information utility?
25. Although ECC memory costs more than non-ECC memory, why would you choose to use it? Which type of computer typically requires ECC memory?

**>> THINKING CRITICALLY**

1. You need to upgrade memory in a system but you don't have the motherboard documentation available. You open the case and notice that the board has four DIMM slots; three slots are colored yellow and one slot is black. What type of DIMM does the board likely use? How can you be sure?
2. If your motherboard supports DIMM memory, will RIMM memory still work on the board?
3. If your motherboard supports ECC DDR3 memory, can you substitute non-ECC DDR3 memory?
4. You have just upgraded memory on a computer from 1 GB to 2 GB by adding one DIMM. When you first turn on the PC, the memory count shows only 1 GB. Which of the following is most likely the source of the problem? What can you do to fix it?
  - a. Windows is giving an error because it likely became corrupted while the computer was disassembled.
  - b. The new DIMM you installed is faulty.
  - c. The new DIMM is not properly seated.
  - d. The DIMM is installed in the wrong slot.
5. Your motherboard supports dual channeling and you currently have two slots used in Channel A on the board; each module holds 1 GB. You want to install an additional 1 GB of RAM. Will your system run faster if you install two 512-MB DIMMs or one 1-GB DIMM? Explain your answer.

**>> REAL PROBLEMS, REAL SOLUTIONS****REAL PROBLEM 4-1 Understanding Dual-Processor Motherboards**

Print the webpage of a picture of a motherboard that supports dual processors. Use one of these websites to find the picture:

- ▲ ASUS at [www.asus.com](http://www.asus.com)
- ▲ Intel at [www.intel.com](http://www.intel.com)

Answer these questions about the motherboard:

1. What is the manufacturer and model number of the motherboard?
2. What type of memory and how much memory does the board support?
3. What operating systems does the board support?
4. What processors does the board support?

**REAL PROBLEM 4-2 Troubleshooting Memory**

Follow the rules outlined earlier in the text to protect the computer against ESD as you work. Remove the memory module in the first memory slot on a motherboard, and boot the PC. Did you get an error? Why or why not?

**REAL PROBLEM 4-3** Playing the Memory Research Game

In a group of four players with Internet access and a fifth person who is the scorekeeper, play the Memory Research Game. The scorekeeper asks a question and then gives players one minute to find the best answer. Five points are awarded to the player who has the best answer at the end of each one-minute play. The scorekeeper can use these questions or make up his or her own. If you use these questions, mix up the order:

1. What is the fastest DDR3 DIMM sold today?
2. What is the largest size DDR2 DIMM sold today?
3. What is the largest size fully buffered ECC 240-pin DDR2 DIMM sold today?
4. What is the lowest price for an 8-GB 240-pin ECC DDR3 DIMM?