3 On the Motherboard

In this chapter you will learn:

- To recognize and identify important motherboard parts
- To explain the basics of how a processor works
- Issues to consider when upgrading or replacing the motherboard or processor
- Information regarding GPUs
- How to add cards to computers
- The differences between PCI, PCI-X, AGP, and PCIe adapters and slots
- Motherboard technologies such as HyperTransport, Hyper-Threading, and multi-core
- The benefits of active listening

CompTIA Exam Objectives:

What CompTIA A+ exam objectives are covered in this chapter?

- ✓ 901-1.2 Explain the importance of motherboard components, their purpose, and properties.
- ✓ 901-1.4 Install and configure PC expansion cards.
- ✓ 901-1.6 Install and configure various types of CPUs and apply the appropriate cooling method.
- ✓ 901-4.1 Given a scenario, troubleshoot common problems related to motherboards, RAM, CPU, and power with appropriate tools.
- ✓ 902-5.4 Demonstrate proper communication techniques and professionalism.

On the Motherboard Overview

Chapter 1 introduced you to the motherboard, which holds the majority of the electronics in the computer. Chapter 2 focused on connecting devices to a motherboard port or through an adapter port. Some parts of the motherboard are of specific interest to IT staff and that is what this chapter delves into. Key parts of the motherboard include the processor and processor socket, memory or RAM slots, and the various types of expansion slots. Figure 3.1 points out these key motherboard components.

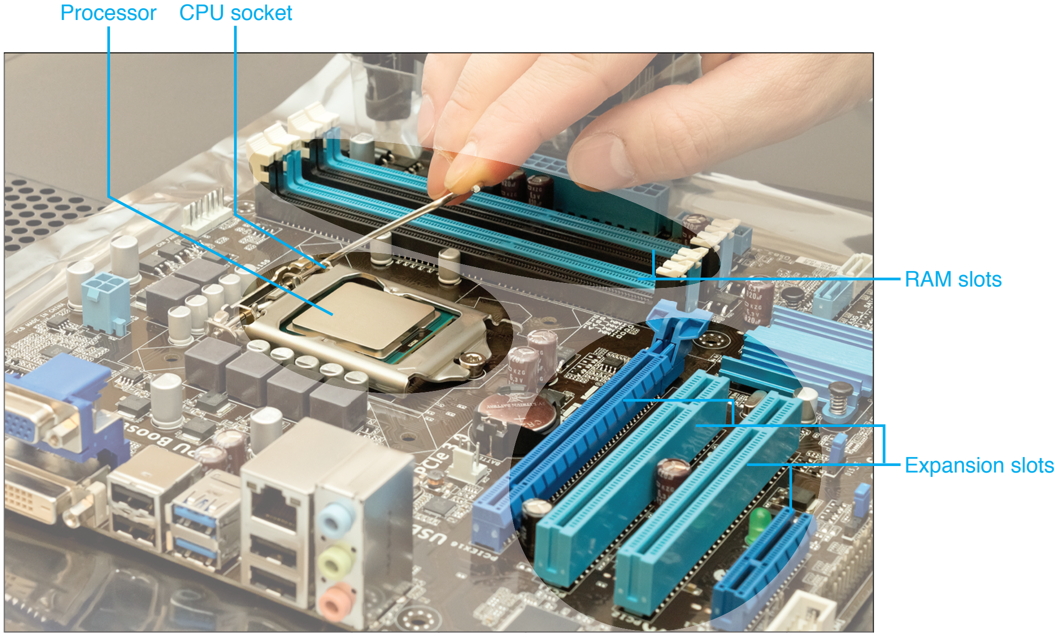

FIGURE 3.1 Key motherboard components

Processor Overview

At the heart of every computer is a special motherboard chip called the **processor**, which determines, to a great extent, the power of the computer. The processor is also called the central processing unit (**CPU**) or microprocessor. The processor executes instructions, performs calculations, and coordinates input/output operations. Each motherboard has electronic chips that work with the CPU and are designed to exact specifications. Whether these other electronic components can keep up with the processor depends on the individual component's specifications. The major processor manufacturers today are Intel, Motorola, VIA, Samsung, NVIDIA, Apple Inc., Qualcomm, and AMD (Advanced Micro Devices, Inc.). Intel and AMD are the predominant manufacturers for desktop and laptop processors, and the other manufacturers target the mobile/smartphone markets. Figure 3.2 shows a processor.

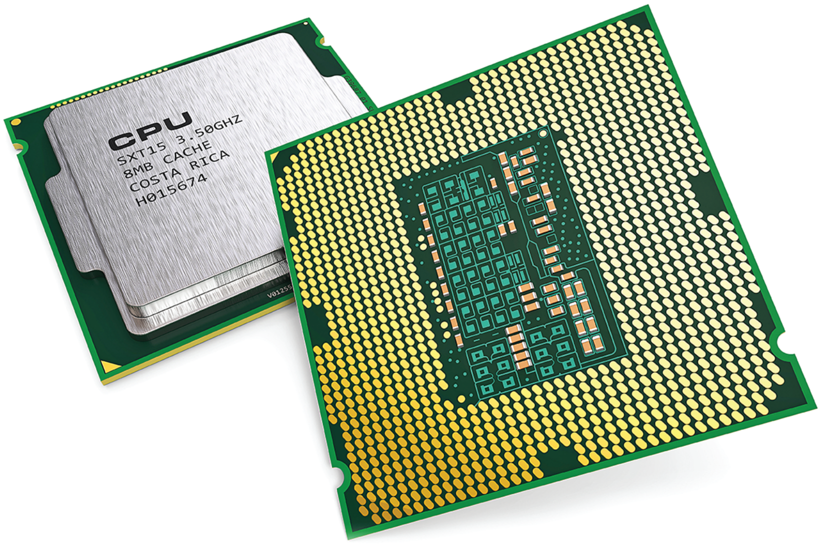

FIGURE 3.2 Intel processor

Processor Basics

Processors come in a variety of speeds, measured in **gigahertz** (GHz). Hertz is a measurement of cycles per second. One hertz equals one cycle per second. One gigahertz is 1 billion cycles per second, or 1GHz. The original PC CPU, the 8088 microprocessor, ran at 4.77MHz. Today's processors run at speeds near 5GHz.

The number of bits processed at one time is the processor's register size (word size). Intel's 8086 processor's register size is 16 bits, or 2 bytes. Today's CPUs have register sizes of 64 or 128 bits.

Buses

Processors operate on 1s and 0s. Processors operate on 1s and 0s. The 1s and 0s must travel from one place to another inside the processor, as well as outside to other chips. To move the 1s and 0s around, electronic lines called a **bus** are used. The electronic lines inside the CPU are known as the **internal data bus** or system bus. In the 8086, the internal data bus comprises 16 separate lines, with each line carrying one 1 or one 0. The word size and the number of lines for the internal data bus are equal. The 8086, for example, has a 16-bit word size, and 16 lines carry 16 bits on the internal data bus. In today's processors, 64 or 128 internal data bus lines operate concurrently.

For a CPU to communicate with devices in the outside world, such as a printer, the 1s and 0s travel on the **external data bus**. The external data bus connects the processor to adapters, the keyboard, the mouse, the hard drive, and other devices. An external data bus is also known as an external data path. You can see the external data lines by looking between the expansion slots on the motherboard. Some solder lines between the expansion slots are used to send data out along the external data bus to the expansion slots. Today's processors have 64- and 128-bit external data paths. Figure 3.3 shows the internal and external data buses.

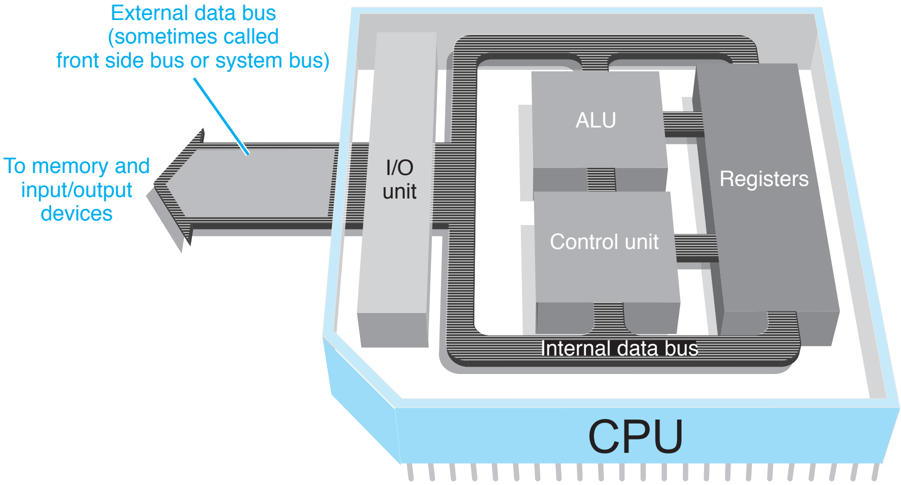

FIGURE 3.3 Internal and external data buses

ALUs

A processor has a special component called the arithmetic logic unit (ALU), which does all the calculations and comparison logic that the computer needs. Figure 3.3 shows the basic concept of how the ALU connects to the registers, control unit, and internal bus. The control unit coordinates activities inside the processor. The I/O unit manages data entering and leaving the processor. The registers in the CPU make up a high-speed storage area for 1s and 0s before the bits are processed.

To make sense of all of this, take a look at a letter typed on a computer that starts out *Dear DEAR MOM*. To the computer, each letter of the alphabet is a different combination of eight 1s and 0s. For example, the letter *D* is 01000100, and the letter *E* is 01000101. Figure 3.4 demonstrates that the size of the bus greatly increases performance on a computer similar to the way that increasing the number of lanes of a highway decreases congestion.

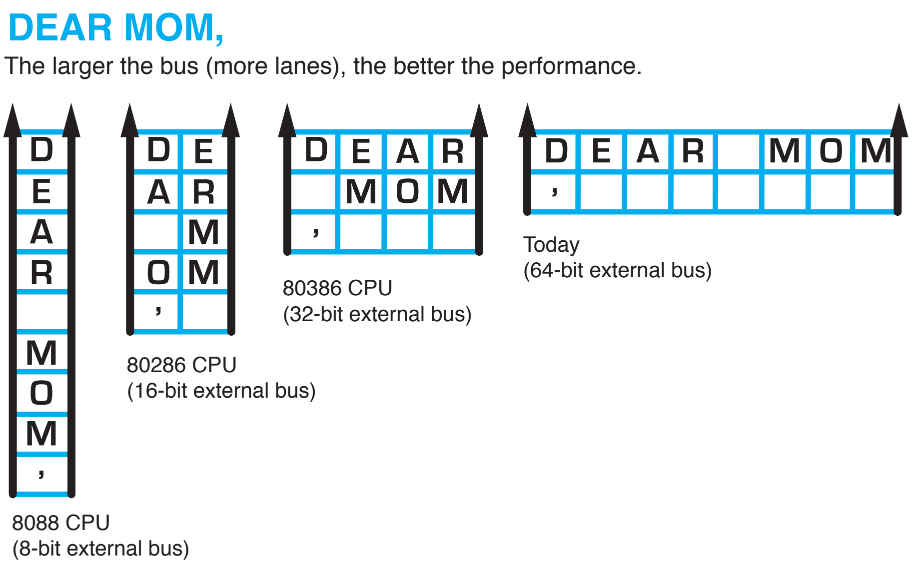

FIGURE 3.4 Bus performance

Pipelines

Processors have multiple pipelines (separate internal buses) that operate simultaneously. To understand pipelining, take the example of a fast-food restaurant. In the restaurant, assume that there are five steps (and one employee per step) involved in making a burger and giving it to the customer. First, (1) take the order and input it into the computer system; (2) brown the buns and cook the burgers; (3) add the condiments to the buns and burgers; (4) wrap the burgers, add fries, and insert them into the bag; and then (5) take the customer's money and give the bag to the customer. Keep in mind that the person taking the customer's order and inputting the order can serve another customer once he or she has completed this task for the first customer. The same is true for each person along the line. To make this burger process go faster, you could (maybe) do one of the things shown in Figure 3.5. (1) Make your employees work faster; (2) break the tasks into smaller tasks (such as seven steps instead of five and have seven people); or, (3) have more lines of people doing exactly the same process tasks.

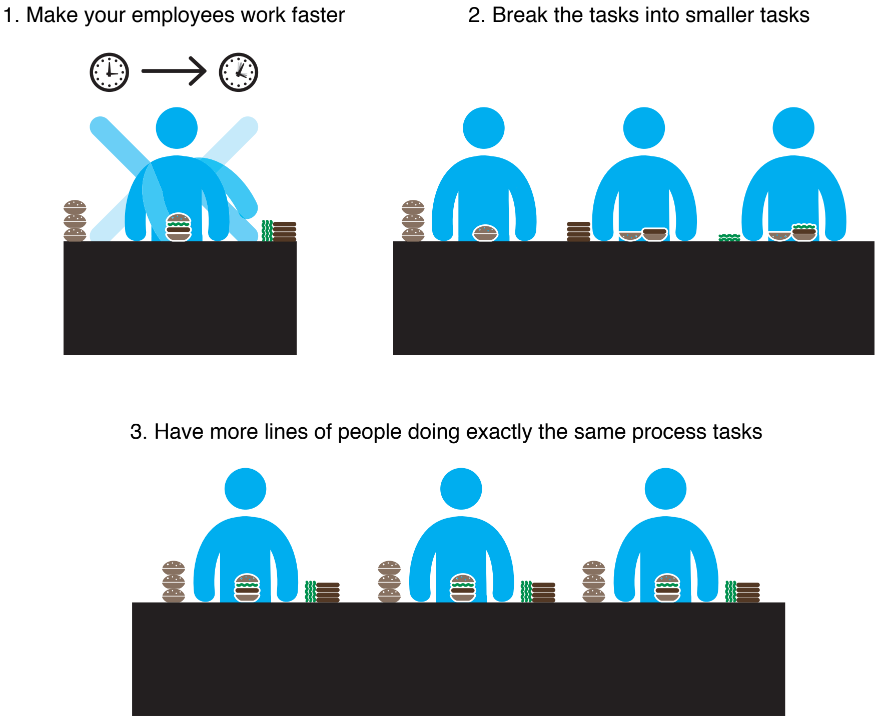

FIGURE 3.5 Ways to get faster processes

To relate this to processors, making the employees work faster is the same as increasing the CPU clock speed. Breaking the tasks into smaller tasks is the same as changing the structure of the CPU pipeline. Instead of performing the standard 5 tasks, the CPU might perform 6, 7, 14, 20, or even more steps. This allows each step to be acted upon more quickly, the task to be smaller, and production to be faster. Having more lines of people doing the same complete process is like having multiple pipelines.

A 32- or 64-bit CPU can have separate paths, each of which handles 32 or 64 bits. For example, if a processor has two pipelines, the Dear Mom letter can be in one pipeline, while a photo upload using a different application can be in the other pipeline.

A processor might have 12 pipelines for integers and 17 pipelines for floating-point numbers. (A floating-point number is a number that can include a decimal point.) Other processors contain anywhere from 20- to 31-stage pipelines. Debate continues about whether a longer pipeline improves performance.

Speeding Up Processor Operations Overview

You can determine the speed of a processor by looking at the model number on the chip, but processors frequently have devices attached to them for cooling, which makes it difficult to see the writing on the chip. A processor commonly does not use its maximum speed all the time in order to save power or stay cool. Also, a processor is not always functioning at its maximum potential for a lot of reasons including coding used within an application, the user switching from application to application, inadequate bus width, or the amount of RAM installed. The processor can also operate beyond its rated specifications. Intel Turbo Boost allows the processor to operate faster than it is rated in order to handle periods of increased workload.

TECH TIP

Locating your processor speed

An easy way to tell processor speed with Windows is to right-click *Computer (Vista/7) or This PC (8/10)* from within Windows Explorer/File Explorer > *Properties*.

We have already taken a look at how increasing the CPU pipeline can, to some extent, improve processor operations, but other technologies also exist. We will start by defining some of the terms that relate to this area and associating those terms with concepts and the various technologies used. Table 3.1 list some terms related to speed.

TABLE 3.1 Motherboard speed terms

Term	Explanation
clock or **clock speed**	The speed of the processor's internal clock, measured in gigahertz.
bus speed	The speed at which data is delivered when a particular bus on the motherboard is being used.
front side bus (FSB)	The speed between the CPU and some of the motherboard components. This is what most people would term the motherboard speed. Sometimes the speed is listed in megatransfers per second, or MT/s. With MT/s, not only is the speed of the FSB considered, but also how many processor transfers occur each clock cycle. A 266MHz FSB that can do four transfers per second could list as 1064MT/s. The FSB is being upgraded with technologies such as AMD's HyperTransport and Intel's QPI (QuickPath Interconnect) and DMI (Direct Media Interface).
back side bus	The speed between the CPU and the L2 cache located outside the main CPU but on the same chip.
PCI bus speed	The speed at which data is delivered when the PCI bus is being used. Common speeds for the PCI bus are 33 and 66MHz, allowing bandwidths up to 533MB/s.
PCIe bus speed	The speed at which data is delivered when the PCIe bus is being used. This bus is the main bus used on the motherboard and is used for PCIe adapters. Common speeds for the PCIe bus v2.x are from 500MB/s (x1) to 8GB/s (x16), v3.x are from 985MB/s (x1) to 15.75GB/s (x16), and 4.x are from 1969 MB/s (x1) to 31.51GB/s (x16).

Term	Explanation
AGP bus speed	The speed at which data is delivered when the AGP bus is being used. The AGP bus is an older standard used for video cards.
CPU speed	The speed at which the CPU operates; it can be changed on some motherboards.
CPU throttling	Reducing the clock frequency to slow the CPU in order to reduce power consumption and heat. This is especially useful in mobile devices.

Cache

An important concept related to processor speed is keeping data flowing into the processor. Registers are a type of high-speed memory storage inside the processor. They are used to temporarily hold calculations, data, or instructions. The data or instruction the CPU needs to operate on is usually found in one of three places: cache memory, the motherboard memory (main memory), or the hard drive.

Cache memory is a very fast type of memory designed to increase the speed of processor operations. CPU efficiency is increased when data continuously flows into the CPU. Cache provides the fastest access. If the information is not in cache, the processor looks for the data in motherboard RAM. If the information is not there, it is retrieved from the hard drive and placed into the motherboard memory or the cache. Hard drive access is the slowest of the three. Table 3.2 lists the types of cache.

TABLE 3.2 Types of cache

Type	Explanation
L1 cache	Cache memory integrated into the processor
L2 cache	Cache in the processor packaging, but not part of the CPU; also called on-die cache
L3 cache	Usually found in the more powerful processors and can be located in the CPU housing (on-die) or on the motherboard

An analogy best explains this. Consider a glass of cold lemonade, a pitcher of lemonade, and a can of frozen lemonade concentrate. If you were thirsty, you would drink from the glass because it is the fastest and most easily accessible. If the glass were empty, you would pour lemonade from the pitcher to refill the glass. If the pitcher were empty, you would go to the freezer to get the frozen concentrate to make more lemonade. Figure 3.6 shows this concept.

Usually, the more cache memory a system has, the better that system performs, but this is not always true. System performance also depends on the efficiency of the cache controller (the chip that manages the cache memory), the system design, the amount of available hard drive space, and the speed of the processor. When determining memory requirements, you must consider the operating system used, applications used, and hardware installed. The Windows XP operating system takes a lot less memory than Windows 10. High-end games and desktop publishing take more RAM than word processing. Free hard drive space and video memory are often as important as RAM in improving a computer's performance. Memory is only one piece of the puzzle. All of the computer's parts must work together to provide efficient system performance. Figure 3.7 shows this hierarchy of data access for the CPU.

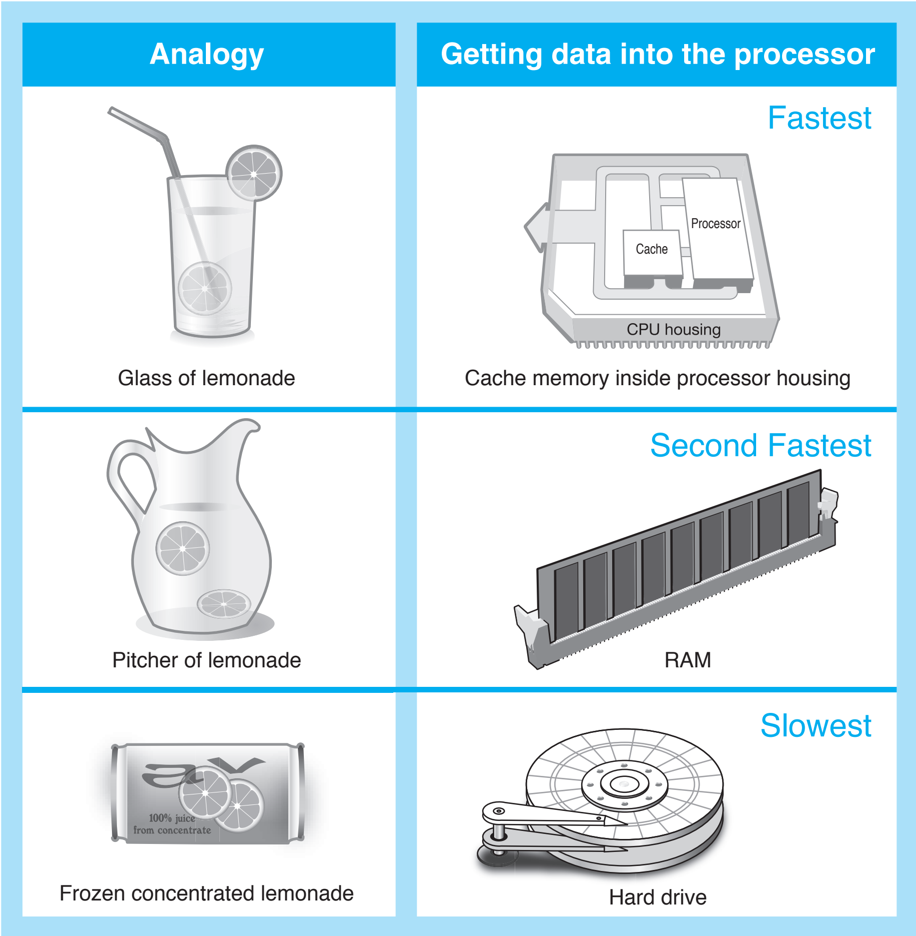

FIGURE 3.6 CPU data sources

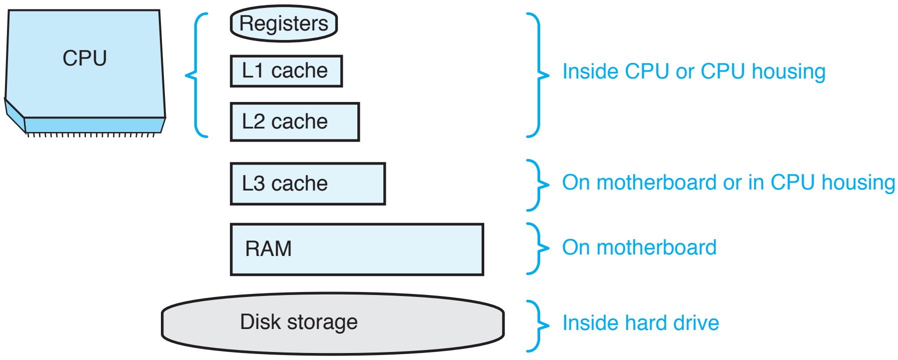

FIGURE 3.7 Data access hierarchy

Clocking

The motherboard generates a clock signal that is used to control the transfer of 1s and 0s to and from the processor. A clock signal can be illustrated as a sine wave. One clock cycle is from one point on the sine wave to the next point that is located on the same point on the sine wave later in time, as shown in Figure 3.8.

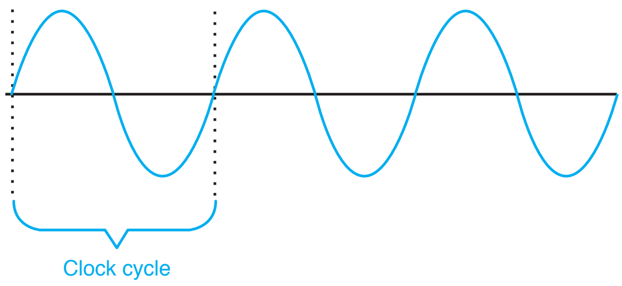

FIGURE 3.8 Clock cycle

In older computers, data was sent to the CPU only once during a clock cycle. Then, newer memory technologies evolved that allow data to be sent twice during every clock cycle. Today, data is sent four times during a single clock cycle, as shown in Figure 3.9.

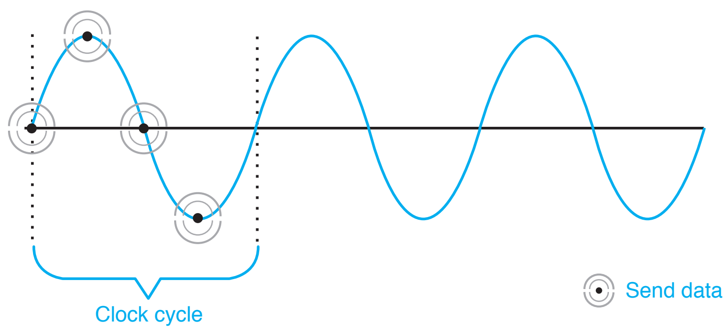

FIGURE 3.9 Clock cycle that clocks data four times per cycle

Threading Technology

Several threading techniques are used to speed up processor efficiency: multithreading and HT (Hyper-Threading Technology). A **thread** is a small piece of an application process that can be handled by an operating system. An operating system such as Windows schedules and assigns resources to a thread. Each thread can share resources (such as the processor or cache memory) with other threads. A thread in the pipeline might have a delay due to waiting on data to be retrieved or access to a port or another hardware component. Multithreading keeps the line moving by letting another thread execute some code. This is like a grocery cashier taking another customer while someone goes for a forgotten loaf of bread. Figure 3.10 shows this concept.

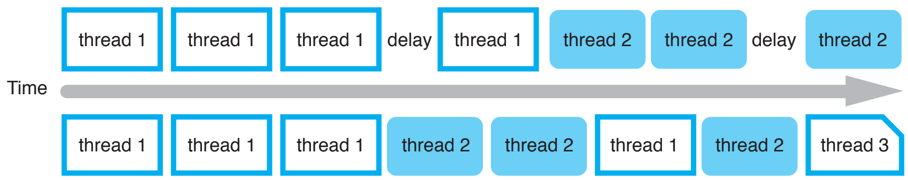

FIGURE 3.10 Multithreading

Intel's HTT (**Hyper-Threading** HT or HT Technology) allows a single processor to handle two separate sets of instructions simultaneously. To the operating system, HT makes the system appear as if it has multiple processors. Intel claims that the system can have up to a 30 percent increase in performance, but studies have shown that the increase is application dependent. If the application being used cannot take advantage of the multithreading, then HT can be disabled in the system BIOS/unified extensible firmware interface (UEFI) (covered in Chapter 4).

Connecting to the Processor

We have considered various ways to speed up processor operations, including having more stages in the processor, increasing the speed of the clock, and sending more data in the same amount of time. Accessing L2 cache and motherboard components was a bottleneck in older systems because the CPU used the same bus to communicate with RAM and other motherboard components as it did with L2 and motherboard cache. The solution is DIB (dual independent bus). With DIB, two buses are used: a back side bus and a front side bus. The back side bus connects the CPU to the L2 cache. The FSB (front side bus) connects the CPU to the motherboard components. The FSB is considered the speed of the motherboard. Figure 3.11 illustrates the concept of a front side bus. Remember that the front side bus is more detailed than what is shown; the figure simply illustrates the difference between the back side bus and the front side bus.

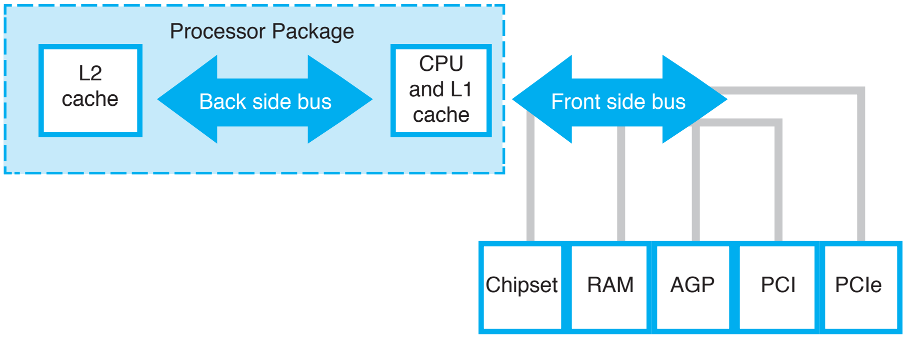

FIGURE 3.11 Front and back side bus

Many people think that the higher the CPU speed, the faster the computer. This is seldom true. Several factors contribute to computer speed. One factor is bus speed. Bus speed describes how fast the CPU can communicate with motherboard components, such as memory, the chipset, or the PCI/PCIe bus. The first Pentium CPUs ran at the same speed as the bus (60MHz); in time, CPUs got faster and buses stayed the same. Advances in technology have not reached the rest of the motherboard components (and it would cost too much to try to have them keep pace).

Intel and AMD have technologies to replace the front side bus in some parts. AMD's solution is Direct Connect. Direct Connect allows each of the processor cores to connect directly to memory, to the other motherboard components such as the expansion slots, and to other processor cores using a high-speed bus called **HyperTransport**. Figure 3.13, later in this chapter, shows HyperTransport connectivity. Intel has QuickPath Interconnect (QPI), Serial Peripheral Interface (SPI), and Direct Media Interface (DMI), which are full-duplex (that is, traffic can flow in both directions simultaneously) point-to-point connections between the processor and one or more motherboard components. This type of connectivity used with Intel-based processors and chipsets is shown later in Figure 3.38.

Multi-Core Processors

In the past, when two processors were installed, software had to be specifically written to support having multiple processors. That is no longer true. A **dual-core** processor combines two CPUs in a single unit. A tri-core processor has three processors in a single unit. Both Intel and AMD have **quad-core** CPU technologies, which is either two dual-core CPUs installed on the same motherboard, two dual-core CPUs installed in a single socket, or today's model of all four cores installed in one unit. Now there are also **hexa-core** (six cores) and **octa-core** (eight cores) processors. IT professionals in the field find it easiest to just say *multi-core* to describe the multiple cores contained in the same processor housing.

Single-core processors and early dual-core processors accessed memory through a memory controller, as shown in Figure 3.12. Today, the processor cores have their own memory controller built into the processor. Figure 3.13 shows how an AMD quad-core processor has an integrated controller and interfaces with the rest of the motherboard using a high-speed bus called HyperTransport. HyperTransport is a feature of AMD's Direct Connect architecture. With Direct Connect, there are no front side buses. Instead, the memory controller and input/output functions directly connect to the CPU.

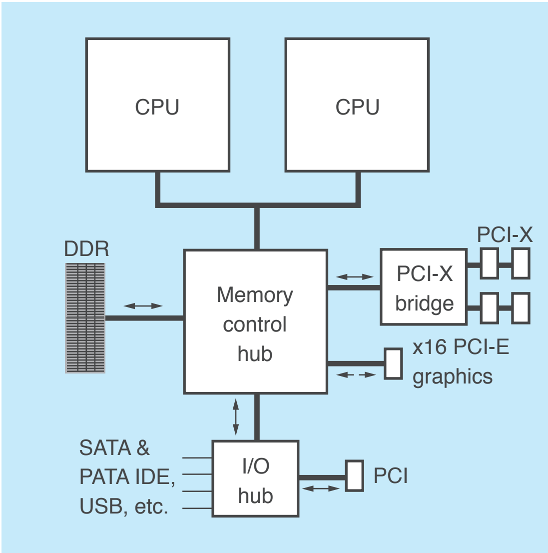

FIGURE 3.12 Older method of processors interfacing with memory

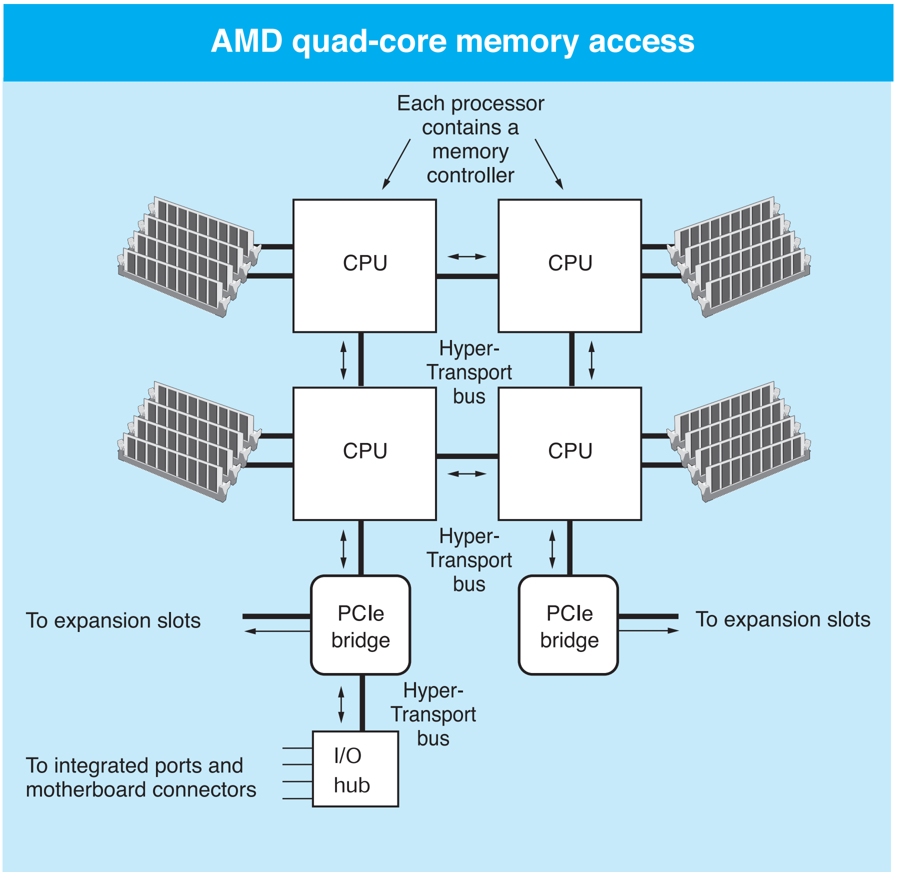

FIGURE 3.13 AMD quad-core memory access

All applications can take advantage of the multi-core technology and the background processes that are associated with the operating system and applications. This improves operations when multitasking or when running powerful applications that require many instructions to be executed, such as drawing applications and games.

Graphics Processing Unit (GPU)

Another bottleneck for computer performance is video. Computer users who want better video performance buy a separate video adapter that contains a GPU. Both Intel and AMD have a graphics processing unit (**GPU**) within the CPU on some of their processor models. With an integrated GPU (**iGPU**), sometimes called an integrated graphics processor (**IGP**), an external video card with a GPU is not required, and graphical data is processed quickly, with reduced power consumption. Today's CPUs contain multiple core processors, whereas GPUs contain hundreds of smaller core processors. GPUs can also be used for other purposes that are not directly related to graphics that increase system performance. These GPUs are sometimes referred to as a general-purpose GPU (GPGPU).

A computer system can also have multiple GPUs. AMD provides information about the number of "compute cores." For example, an AMD system that has four CPUs and two GPUs would have six compute cores. Figure 3.14 shows how an IGP is within the same housing as the CPU cores.

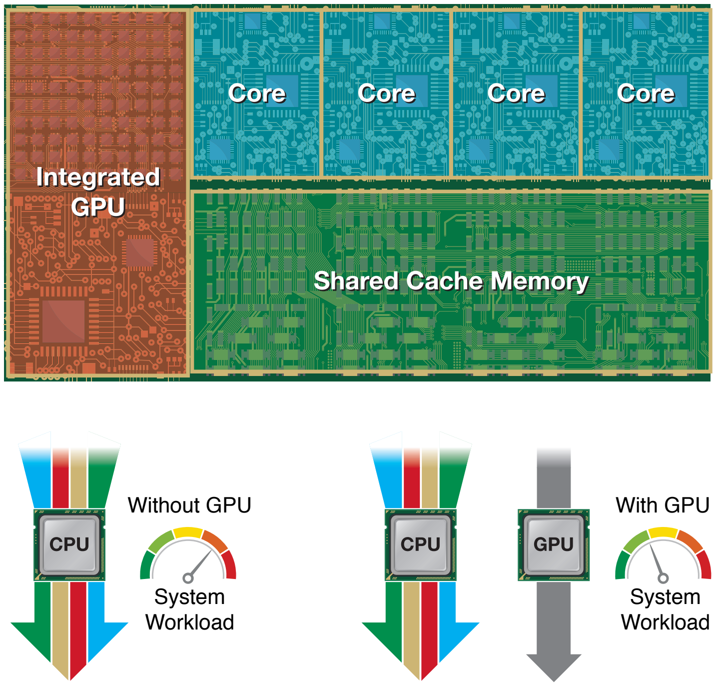

FIGURE 3.14 CPU vs. GPU

Integrated GPUs can either share part of the motherboard RAM with the rest of the system or have a separate block of memory dedicated for video. Integrated GPUs can have their own cache memory or share with the CPU. IGPs can be part of the chipset or be included as part of the CPU housing (on-die). AMD calls its processors that have a GPU integrated with the CPU an accelerated processing unit (**APU**). Intel calls its integrated GPU Intel HD Graphics and Intel Iris Graphics.

Virtualization

One advantage of having multiple processor cores is that home and business computers can take advantage of virtualization. **Virtualization** is having one or two virtual machines on the same computer. Virtualization software, such as VMware Workstation, Oracle VM VirtualBox, or Microsoft Hyper-V, enables one computer to act as if it were two or more computers. The computer can have two or more operating systems installed through the use of the virtualization software. Each operating system would have no knowledge of the other operating system.

Windows 7 has Virtual PC and Windows 8 has Hyper-V, which allow an application to run in a virtual environment as if an older operating system had been installed. The concept of virtualization is of interest to businesses so that legacy software can be put on a newer machine but kept separate from the main operating system or another virtualized machine on the same computer. Reduced costs and physical space are benefits of virtualization. Home computer users can install multiple operating systems in separate VMs (virtual machines) within the same physical box, with each VM being seen as a separate computer. This would be important for those of you taking the CompTIA A+ certification. You could install Windows Visa, Windows 7, Windows 8, and Linux in order to better prepare for the exam.

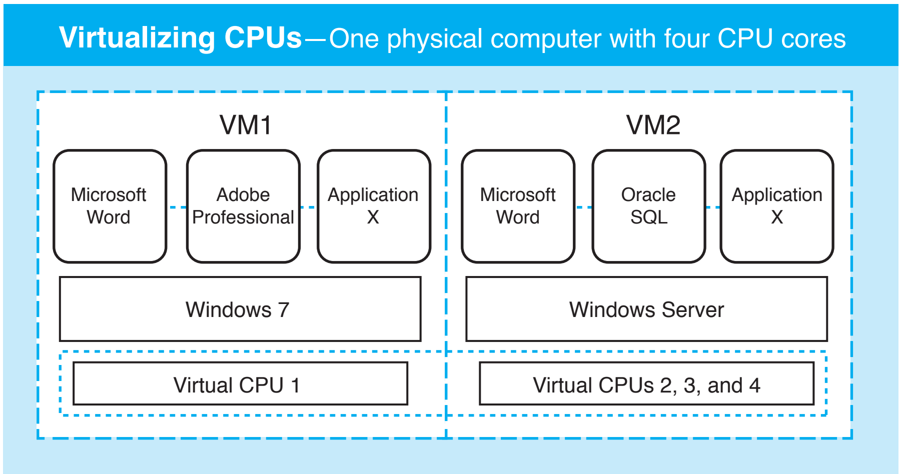

FIGURE 3.15 The concept of virtualization

Selecting a motherboard and processor is important when in a virtual environment. Not all processors were designed for virtualization. Refer to the virtualization software documentation to determine whether the CPU used is allowed to be used in a virtual environment. Another issue regarding processors and virtualization is licensing. For virtualization software that must be purchased (that is, is not freeware), the software manufacturer can charge on a per-processor or per-socket license basis or a per-core basis. If a CPU has four cores, then pricing might play into what virtualization software is purchased.

Intel Processors

Traditionally, Intel has rated its processors by GHz and people have compared processors based on speed alone. Now, Intel arranges its products by family numbers. In a family of processors, you can compare attributes such as speed and the amount of cache memory and other technologies. Table 3.3 shows Intel's processor families. Figure 3.16 shows a close-up of a processor installed into the motherboard.

TABLE 3.3 Intel processor families

Processor family*	Comments
Core i7	Multi-core with cache memory shared between cores and on-board memory controller. Good for virtualization, graphic/multimedia design and creation, and gaming.
Core i5	Midrange dual- and quad-core processor. Used for video, photos, and email, and Internet access.
Core i3	Low-end desktop and mobile processor used for common tasks such as word processing and Internet access.
Pentium	Single- or dual-core desktop/laptop processor for general computing.
Celeron	Entry-level desktop or mobile device processor for general computing.
Atom	Mobile Internet device processor.

*Intel is constantly upgrading processors. For more information, visit www.intel.com.

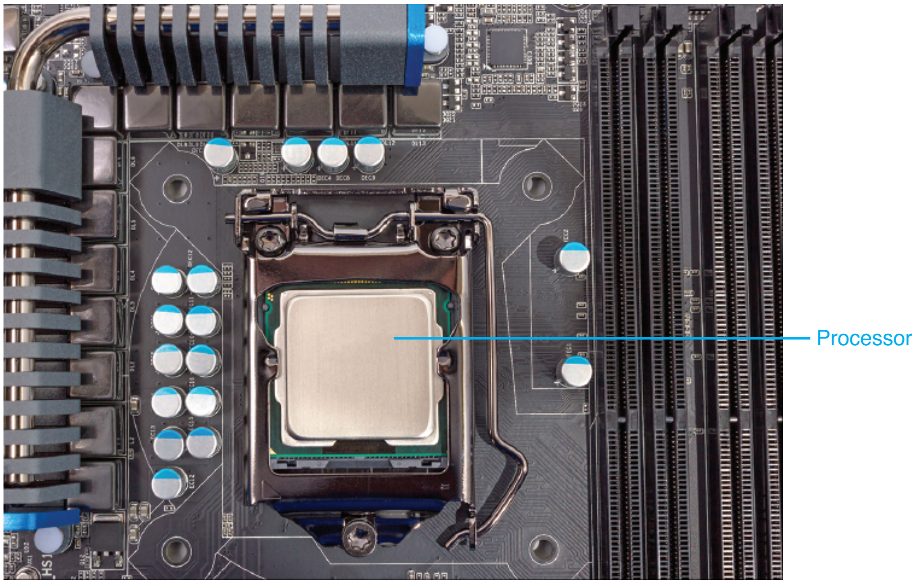

FIGURE 3.16 Installed processor

CPU Sockets

A processor inserts into a socket or slot, depending on the model. Most processors today insert into a socket. There are different types of sockets: pin grid array (PGA), which has even rows of holes around a square socket; staggered pin grid array (SPGA), which has staggered holes so more pins can be inserted; plastic pin grid array (PPGA); micro pin grid array (µPGA); flip chip ball grid array (FCBGA); and land grid array (LGA) are all used with either AMD and/or Intel processors. Figure 3.17 shows a CPU socket.

AMD Processors

AMD is Intel's largest rival in computer processors. Anyone buying a processor should research all models and vendors. Table 3.4 lists the AMD processor families.

TABLE 3.4 AMD processor families

Processor family	Comments
FX	Multi-core (4-, 6-, or 8-core) high-performance desktop processor.
Phenom II	Multi-core (2, 3, 4, or 6 cores in a single package) high-end desktop for HD support, multimedia creation and editing, gaming, and virtualization. Supports 32- and 64-bit computing, 3DNow!, SSE, SSE2, SSE3, SSE4a, HyperTransport, and Direct Connect technologies.
Athlon II/Mobile/ and Athlon APU	Multi-core (2-, 3-, or 4-core) desktop/mobile processor for productivity, photos, and music.
Sempron APU/Mobile	Lower-cost, low noise, low heat desktop/notebook processor for basic productivity, email, and web browsing or in a home theater computer.
A-series APU/Mobile	Multi-core (2-, 3-, or 4-core) high-performance processor with integrated GPU.
Turion II	Single- or dual-core notebook processor.

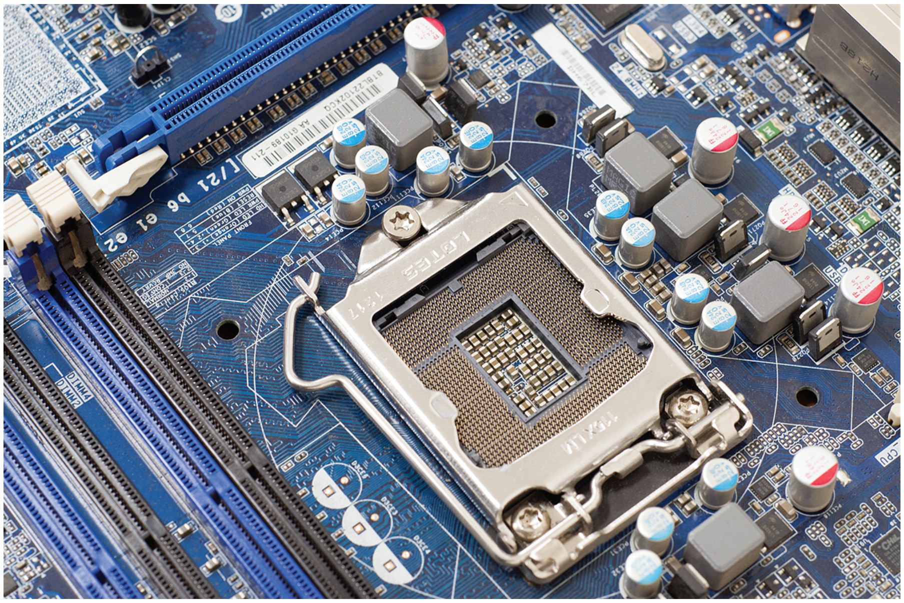

FIGURE 3.17 CPU socket

Processor sockets are also called zero insertion force (**ZIF**) **sockets**; they come in different sizes. A processor socket accepts one or more specific processor models. The socket has a small lever to the side that, when lifted, brings the processor slightly up and out of the socket holes. When installing a processor, the CPU is aligned over the holes and the lever is depressed to bring the processor pins into the slot with equal force on all the pins. In Figure 3.17, notice the lever beside the socket that is used to lift the metal cover so the CPU can be installed into the socket. Table 3.5 lists the commonly used Intel and AMD CPU sockets and is a good study table for the A+ certification.

TECH TIP

Buying the right CPU

If you buy a motherboard and processor separately, it is important to ensure that the motherboard CPU socket is the correct type for the processor.

TABLE 3.5 Desktop CPU sockets

Socket	Description
LGA 775	775-pin for Intel Pentium 4s, Celerons, Core 2 Duo, Core 2 Extreme, and Core 2 Quads
LGA 1150	1150-pin for Intel Core Haswell, Broadwell
LGA 1155	1155-pin for Intel Core i7, i5, i3
LGA 1156	1156-pin for Intel Core i7, i5, i3
LGA 1366	1366-pin for Intel Core i7, Xeon, and Celeron
LGA 2011	2011-pin for Intel Core i7 and Xeon
AM3	940-pin for AMD Phenom II X3, X4, and Athlon II
AM3+	942-pin for AMD FX, Phenom II, Athlon II, Sempron
FM1	905-pin for AMD Athlon II, Llano
FM2	904-pin for AMD APUs, Trinity
FM2+	906-pin for AMD APUs, Kaveri, Godavari, and A8/A10 series

Processor Cooling

Keeping the CPU cool is critical. Both Intel and AMD have technologies that reduce processor energy consumption (and heat) by turning off unused parts of the processor or slowing down the processor when it starts to overheat. But these measures alone are not enough. Today's systems use one or more of the methods listed in Table 3.6. Figure 3.18 shows a heat sink and a fan.

TABLE 3.6 Processor cooling methods

Method	Description
heat sink	A block of metal (usually aluminum or copper), metal bars, or metal fins that attach to the top of the processor or other motherboard components. Heat from the processor is transferred to the heat sink and then blown away by the air flow throughout the computer case.
fan	Fans can be attached to the processor, beside the processor, and in the case.
thermal paste or **thermal pad**	Thermal paste, compound, or grease is applied to the top of the processor before a heat sink is attached. Some heat sinks and fans come pre-applied. A thermal pad provides uniform heat dispersion and lies between the processor and the heat sink.
liquid cooling	Liquid is circulated through the system, including through a heat sink that is mounted on the CPU. Heat from the processor is transferred to the cooler liquid. The now-hot liquid is transported to the back of the system, converted to heat, and released outside the case. CPU temperature remains constant, no matter the usage. Some systems require the liquid to be periodically refilled.
phase-change cooling (vapor cooling)	Expensive option that uses a technique similar to a refrigerator: A gas is converted to a liquid that is converted back to gas.
heat pipe	A metal tube used to transfer heat away from an electronic component.
passive cooling	Passive cooling involves no fans, so a heat sink that does not have a fan attached is known as a passive heat sink.

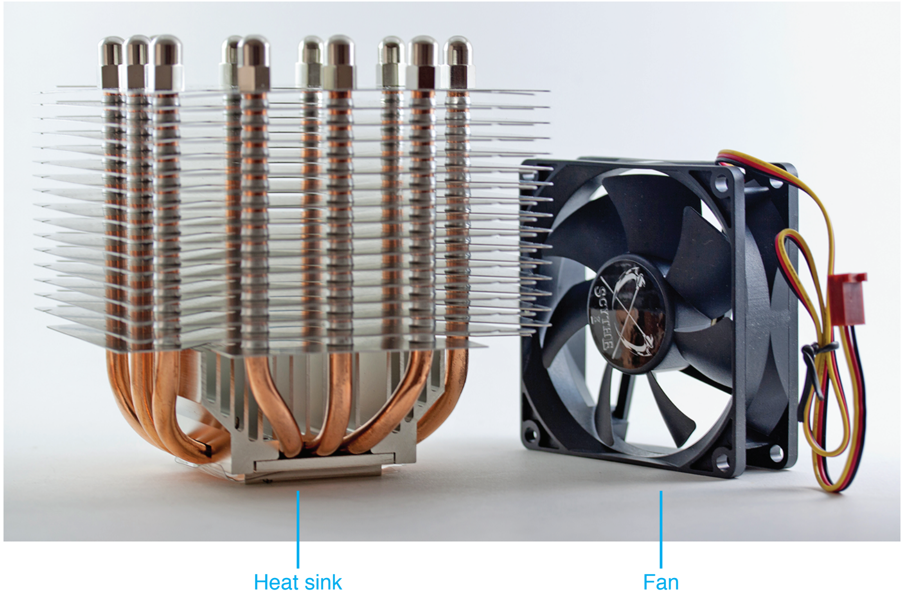

FIGURE 3.18 Heat sink and fan

The largest chip on the motherboard with a fan or a heat sink attached is easily recognized as the processor. Figure 3.19 shows an Intel Core i7 that has a fan and a heat sink installed. Notice the heat pipes that are used as part of the heat sink.

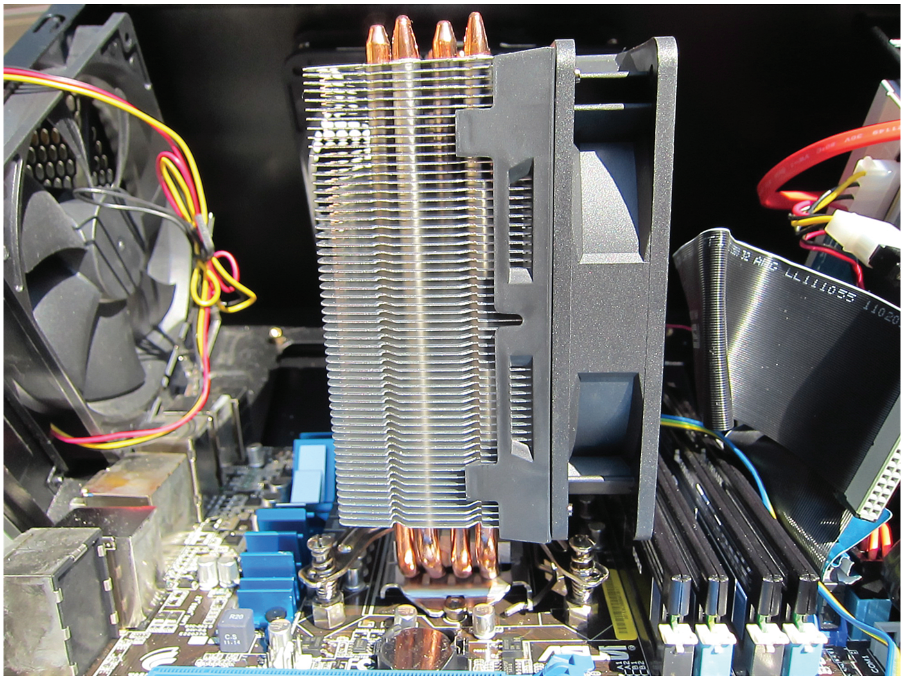

FIGURE 3.19 CPU with heat sink and fan attached

Additional motherboard components can also have heat sinks attached. These are normally the chipset and/or the I/O (input/output) controller chips. Figure 3.20 shows a motherboard with these cooling elements.

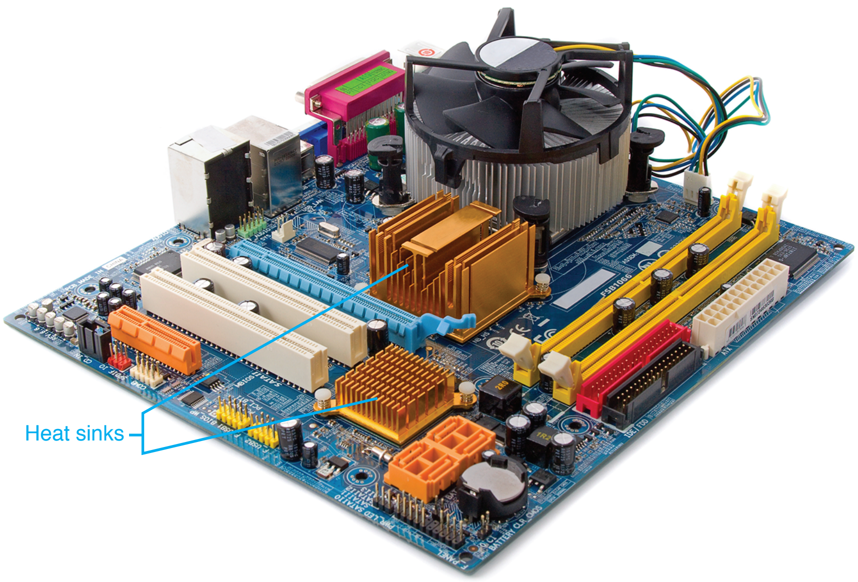

FIGURE 3.20 Motherboard heat sinks

TECH TIP

When thermal paste acts like glue

Over time, thermal paste can act like glue, making the processor hard to separate from the heat sink. You can use a thermal paste cleaner, acetone, or denatured alcohol to separate the two parts. Do not pry!

Installing a Processor

Processors are sold with installation instructions. Also, motherboard manuals (documentation) include the steps to upgrade or install the CPU. The following are the general steps for installing a processor:

Parts: Proper processor for the motherboard (refer to motherboard documentation)
Antistatic materials

Step 1. Ensure that power to the computer is off and the computer is unplugged.

Step 2. Place an antistatic wrist strap around your wrist and attach the other end to a ground or unpainted metal part of the computer. Otherwise, use an antistatic glove.

Step 3. Push the retention lever down and outward to release the CPU retention plate. Move the handle backward until the retention plate is fully open. Do not touch the CPU socket.

Step 4. Remove the processor from packaging, taking care to hold it by the edges and never touch the bottom metal portion of the processor. Remember that a CPU fits only one way into the socket. Look at the processor and the socket before inserting the chip to ensure proper alignment. A socket and CPU normally have a triangle marking or circular dot that indicates pin 1 as shown in Figure 3.21. The processor also has notches on each side that align with the socket. Do not force! Insert the CPU into the socket by aligning it with the socket and lowering it until it is flush with the socket as shown in Figure 3.22.

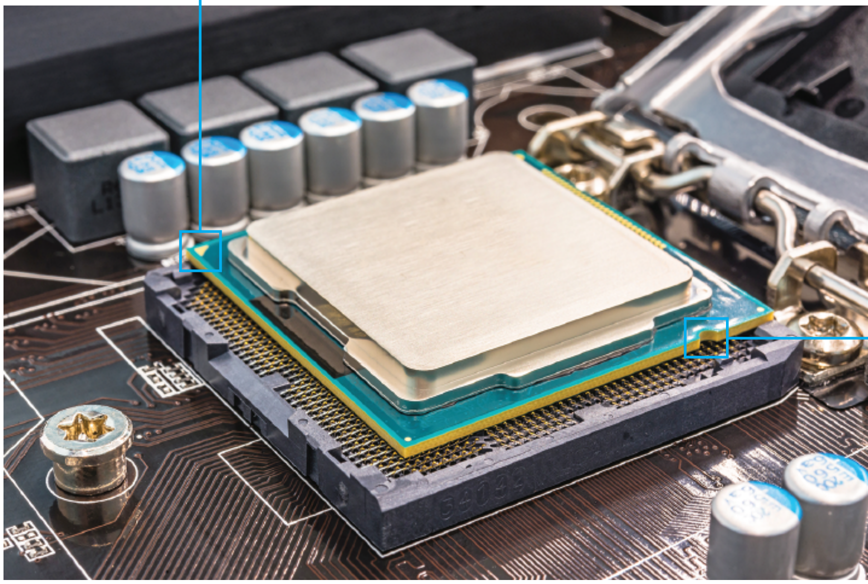

FIGURE 3.21 Pin 1 and notch on a processor

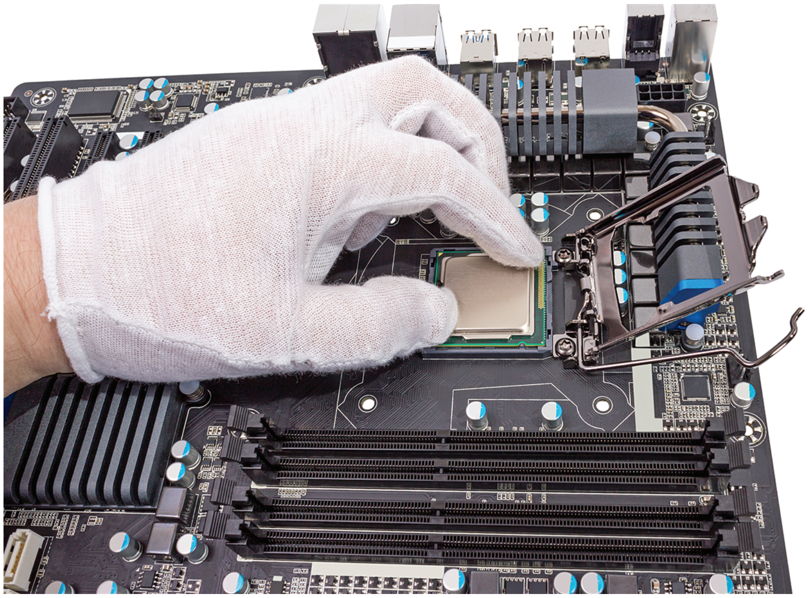

FIGURE 3.22 Installing a CPU

TECH TIP

Handling the CPU

Always hold the CPU by the edges to avoid bending or touching the pins underneath. Do not touch the CPU until it is ready to be installed in the socket.

TECH TIP

Cool the CPU

Do not apply power to the computer until the CPU and the heat sink, fan, and/or cooling unit are installed. Running the CPU without installing appropriate cooling mechanisms will overheat the CPU and destroy or weaken it.

Upgrading Processors

Two common questions asked of technicians are "Can a computer be upgraded to a higher or faster processor?" and "Should a computer be upgraded to a higher or faster processor?" Whether or not a computer can be upgraded to a higher or faster processor depends on the capability of the motherboard. When a customer asks if a processor should be upgraded, the technician should ask, "What operating system and applications are you using?" The newer the operating system, the more advanced a processor should be. Some games and applications that must perform calculations, as well as graphic-oriented applications, require a faster, more advanced processor. The motherboard's documentation is very important when considering a CPU upgrade. Read the documentation to determine whether the motherboard can accept a faster processor.

TECH TIP

Upgrading your CPU

Do not upgrade a processor unless the documentation or manufacturer states that the motherboard supports a newer or faster processor.

Throttle management is the ability to control the CPU speed by slowing it down when it is not being used heavily or when it is hot. Usually this feature is controlled by a system BIOS//UEFI setting and the Windows *Power Options* Control Panel. Some users may not want to use CPU throttling so that performance is at a maximum. Others, such as laptop users, may want to conserve power whenever possible to extend the time the laptop can be used on battery power.

Upgrading components other than the processor can also increase speed in a computer. Installing more memory, a faster hard drive, or a motherboard with a faster front side bus sometimes may improve a computer's performance more than installing a new processor. All devices and electronic components must work together to transfer the 1s and 0s efficiently. The processor is only one piece of the puzzle. Many people do not realize that upgrading only one computer component does not always make a computer faster or better.

Overclocking Processors

Overclocking is changing the front side bus speed and/or multiplier to boost CPU and system speed. Overclocking has some issues:

- CPU speed ratings are conservative.
- The processor, motherboard, memory, and other components can be damaged by overclocking.
- Applications may crash, the operating system may not boot, and/or the system may hang (lock up) when overclocking.
- The warranty may be void on some CPUs if you overclock.

- When you increase the speed of the CPU, the processor's heat increases. Extra cooling, using fans and larger heat sinks, is essential.
- Input/output devices may not react well to overclocking.
- The memory chips may need to be upgraded to be able to keep up with the faster processing.
- You need to know how to reset the system BIOS/UEFI in case the computer will not boot properly after you make changes. This process is covered in Chapter 4.

TECH TIP

Be ready to cool

The primary problem with overclocking is insufficient cooling. Make sure you purchase a larger heat sink and/or extra fans before starting the overclocking process.

Many motherboard manufacturers do not allow changes to the CPU, multiplier, and clock settings. The changes to the motherboard are most often made through BIOS/UEFI Setup. However, CPU manufacturers may provide tuning tools in the form of applications installed on the computer for overclocking configuration. Keep in mind that overclocking is a trial-and-error situation. There are websites geared toward documenting specific motherboards and overclocked CPUs.

Installing CPU Thermal Solutions

Some CPUs come with a thermal solution such as a heat sink and/or fan. The thermal solution commonly comes with a preapplied thermal paste or attached thermal pad. Heat sinks and fans attach to the processor using different methods. The most common methods are screws, thermal compound, and clips. Clips can use retaining screws, pressure release (where you press down on them, and they release), or a retaining slot. Small screwdrivers can be used to release the clips that attach using the retaining slot. Clips for fans or heat sinks can be difficult to install. The type of heat sink and/or fan installed must fit the processor and case. Additional hardware may have to be installed on the motherboard to be able to attach the CPU thermal solution. Figure 3.23 shows a CPU cooler being installed.

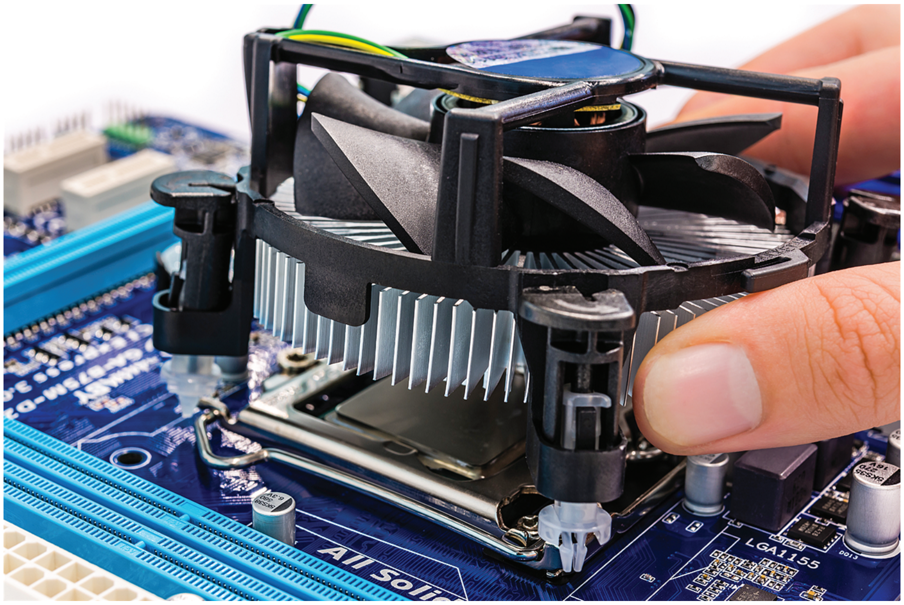

FIGURE 3.23 CPU heat sink/fan installation

TECH TIP

Take a pic of the CPU

Before attaching a heat sink and/or fan to the CPU, take a picture of the markings on top. These could be used if you ever need technical support and need the exact specifications. Techs often take pictures to document motherboard replacements and wiring.

If a used thermal solution is being installed, then the thermal pad or old thermal paste should be removed and new thermal paste applied. Do not scratch the surface of the heat sink. Use a plastic scribe or tool to remove a thermal pad or old paste. A thermal paste cleaner, acetone, or denatured alcohol with a lint-free cloth can be used to remove residual paste.

When installing thermal paste, you should apply the prescribed amount in the center of the processor. Spread the compound evenly in a fine layer over the portion of the center of the CPU that comes in contact with the heat sink. When the heat sink is attached to the processor, the thermal compound will spread (hopefully not over the edges). Always follow the heat sink installation directions.

CPU fans frequently have a 3- or 4-pin cable that attaches to the motherboard. The motherboard might have a 3- or 4-pin connector. A 3-pin fan can be attached to a 4-pin motherboard connector, and a 4-pin fan cable can be connected to a 3-pin motherboard connector, as shown in Figure 3.24. Note that when a 3-pin cable attaches to 4-pin connector, the fan is always on and cannot be controlled, like a 4-pin cable to 4-pin connector can.

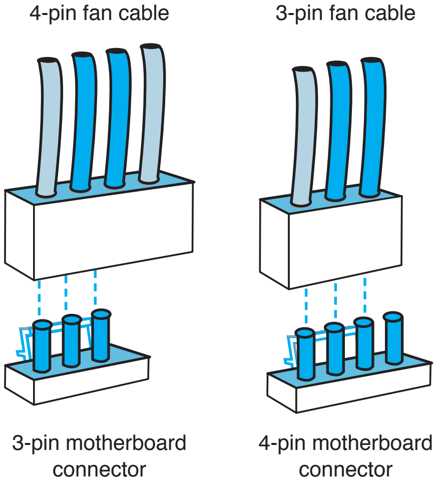

FIGURE 3.24 CPU fan connectivity

Troubleshooting Processor Issues

Processor issues can appear in different ways, as illustrated in Figure 3.25.

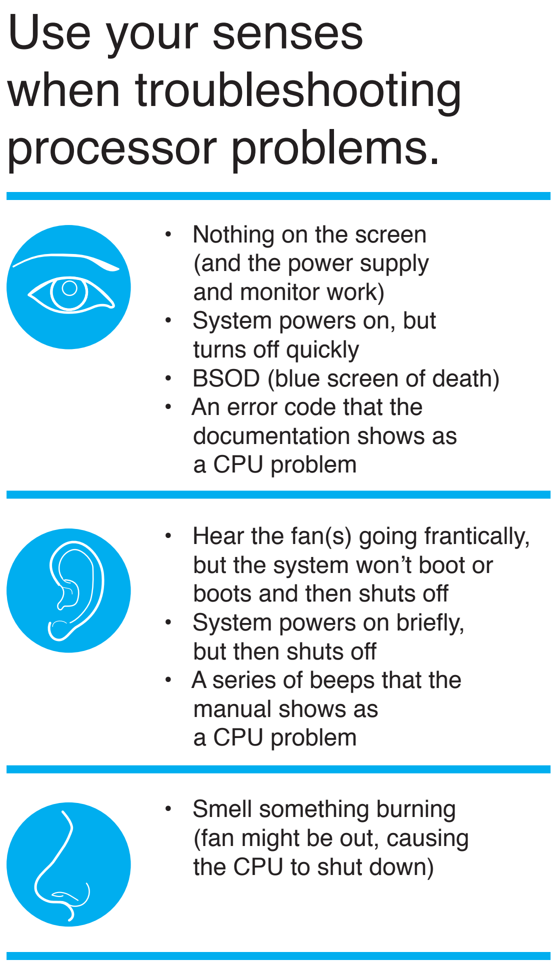

FIGURE 3.25 Detecting processor problems

The following measures can help you solve CPU issues:

> The number-one issue related to processor problems is heat. Ensure that the fans work. Fans are cheap devices compared to replacing a processor or motherboard. Ensure the computer has adequate circulation/cooling. Vacuum any dust from the motherboard/CPU. Cool the room more.

> Many BIOS/UEFI screens show the CPU temperature. (This is covered in more detail in Chapter 4.)

> Research any visual codes shown on the motherboard LEDs or listen for audio beeps as the computer beeps. Refer to the computer or motherboard manufacturer website.

Processor issues and determining whether an issue is a CPU or motherboard issue are some of the hardest things to troubleshoot. When your video port does not work, you can insert another video card to determine the problem. However, diagnosing processor and motherboard issues isn't so simple. If you have power to the system (that is, the power supply has power coming out of it), the hard drive works (try it in a different computer), and the monitor works (try it on a different computer), then the motherboard and/or CPU are prime suspects.

Expansion Slots

If a computer is to be useful, the CPU must communicate with the outside world, including other motherboard components and adapters plugged into the motherboard. An expansion slot is used to add an adapter to the motherboard. It has rules that control how many bits can be transferred at a time to the adapter, what signals are sent over the adapter's gold connectors, and how the adapter is configured. Figure 3.26 shows expansion slots on a motherboard.

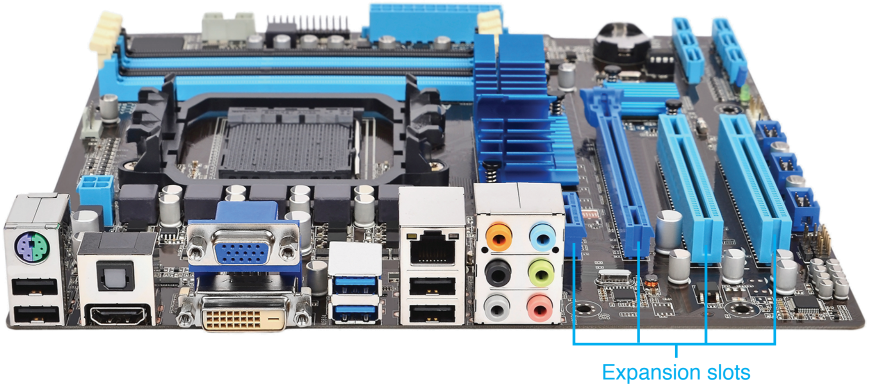

FIGURE 3.26 Motherboard expansion slots

Expansion slots used in PCs are usually some form of PCI (Peripheral Component Interconnect), AGP (Accelerated Graphics Port), or PCIe (PCI Express). Other types of expansion slots that have been included with older PCs are ISA (Industry Standard Architecture), EISA (Extended Industry Standard Architecture), MCA (Micro Channel Architecture), and VL-bus (sometimes called VESA [video electronics standards association] bus). A technician must be able to distinguish among adapters and expansion slots and be able to identify the adapters/devices that use an expansion slot. A technician must also realize the abilities and limitations of each type of expansion slot when installing upgrades, replacing parts, and making recommendations.

An alternative to an adapter plugging directly into the motherboard is the use of a riser board. A riser board plugs into the motherboard and has its own expansion slots. Adapters can plug into these expansion slots instead of directly into the motherboard. Riser boards are used with rack-mounted servers and low-profile desktop computer models. The riser card is commonly inserted into a motherboard slot or attached using screws. Figure 3.27 shows how a riser board attaches to a motherboard.

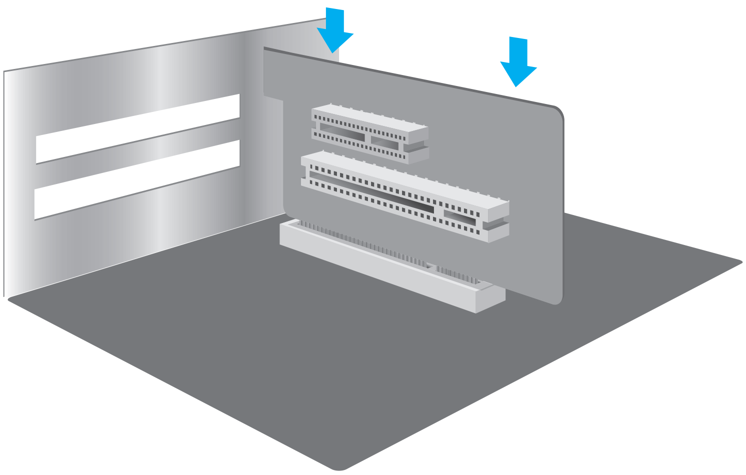

FIGURE 3.27 Installing a riser board

PCI (Peripheral Component Interconnect)

A previously popular expansion slot is Peripheral Component Interconnect (**PCI**). PCI comes in four varieties: 32-bit 33MHz, 32-bit 66MHz, 64-bit 33MHz, and 64-bit 66MHz. Figure 3.28 shows the most common type of PCI expansion slot.

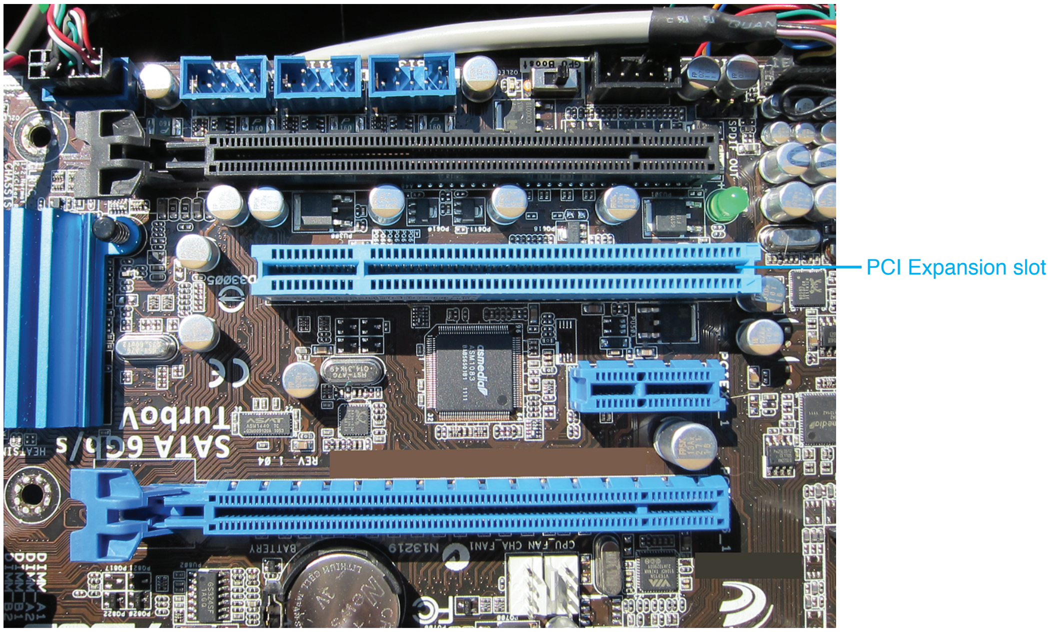

FIGURE 3.28 PCI expansion slot

An upgrade to the PCI bus called **PCI-X** can operate at 66, 133, 266, 533, and 1066MHz. PCI-X allows faster speeds and is backward compatible with the previous versions of the bus. PCI-X expansion slots were commonly found in network servers (powerful computers used in the corporate environment). A chip called the PCI bridge controls the PCI devices and PCI bus. With the PCI-X bus, a separate bridge controller chip is added. Today's motherboards may have a limited number (or none) of PCI or PCI-X expansion slots because of a newer standard called PCI Express (PCIe), which is covered later in this chapter. Figure 3.29 shows how the PCI-X bus integrates into the system board. AGP and the north bridge are covered later in this chapter.

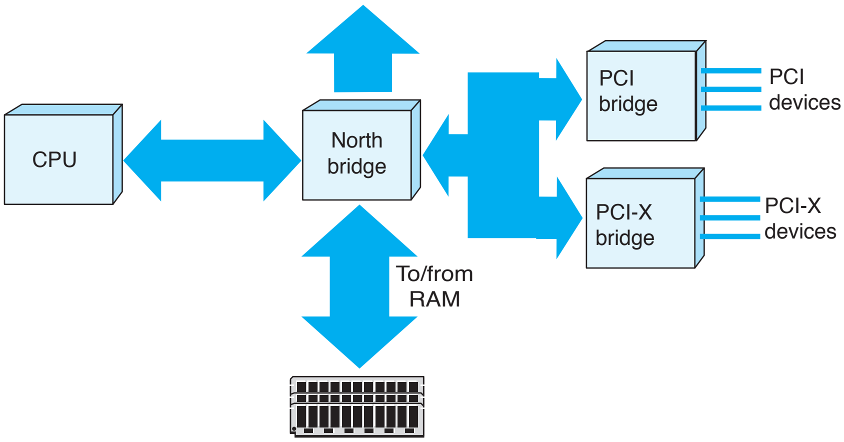

FIGURE 3.29 PCI-X block diagram

TECH TIP

PCI cards in PCI-X slots

Remember that older PCI cards can fit in a PCI-X expansion slot, but a PCI-X adapter requires a PCI-X expansion slot.

AGP (Accelerated Graphics Port)

AGP (Accelerated Graphics Port) is a bus interface for graphics adapters developed from the PCI bus. Intel provided the majority of the development for AGP, and the specification was originally designed around the Pentium II processor. AGP speeds up 3-D graphics, 3-D acceleration, and full-motion playback. Previous video adapters were limited by the bottleneck caused by going through an adapter and a bus shared with other devices. With AGP, the video subsystem is isolated from the rest of the computer. Figure 3.30 shows an illustration of an AGP slot compared with PCI expansion slots. All of these expansion slots have been replaced by PCIe (covered next).

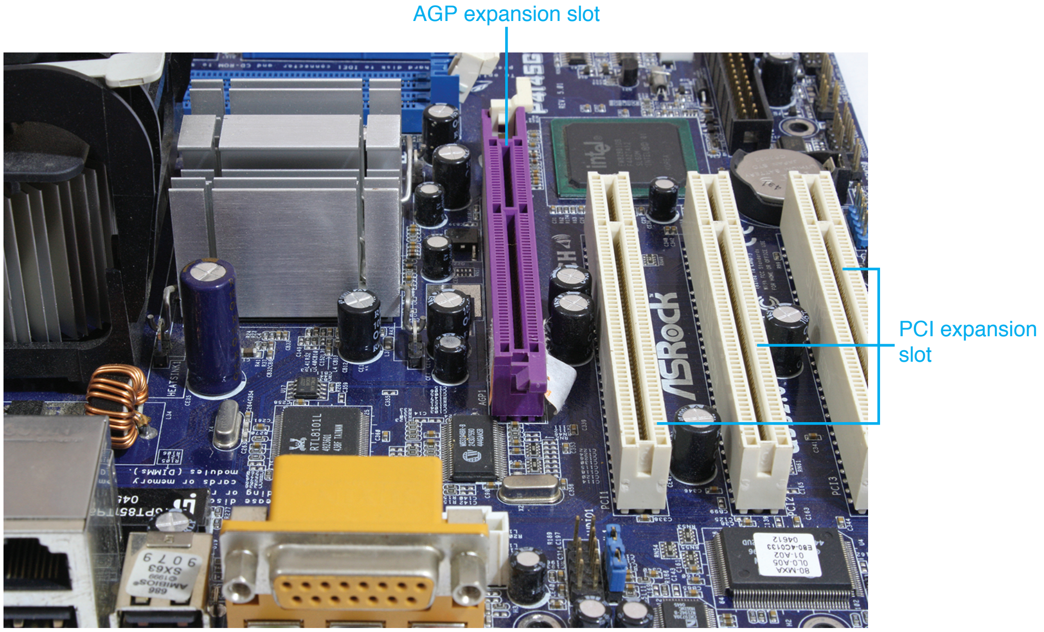

FIGURE 3.30 AGP and PCI expansion slots

PCIe (Peripheral Component Interconnect Express)

PCI, PCI-X, and AGP have been replaced with **PCIe** (PCI Express), which is also seen as PCI-E. PCIe outperforms all other types of PCI expansion slots. Table 3.7 shows different PCIe versions.

The older PCI standard is half-duplex bidirectional, which means that data is sent to and from the PCI or PCI-X card using only one direction at a time. PCIe sends data full-duplex bidirectionally; in other words, it can send and receive at the same time. Figure 3.31 shows this concept.

TABLE 3.7 PCIe versions

PCIe version	Speed (per lane per direction)
1.0	2.5GT/s (gigatransfers per second) or 250MB/s
2.0	5GT/s or 500MB/s
3.0	8GT/s or 1GB/s
4.0	16GT/s or 2GB/s

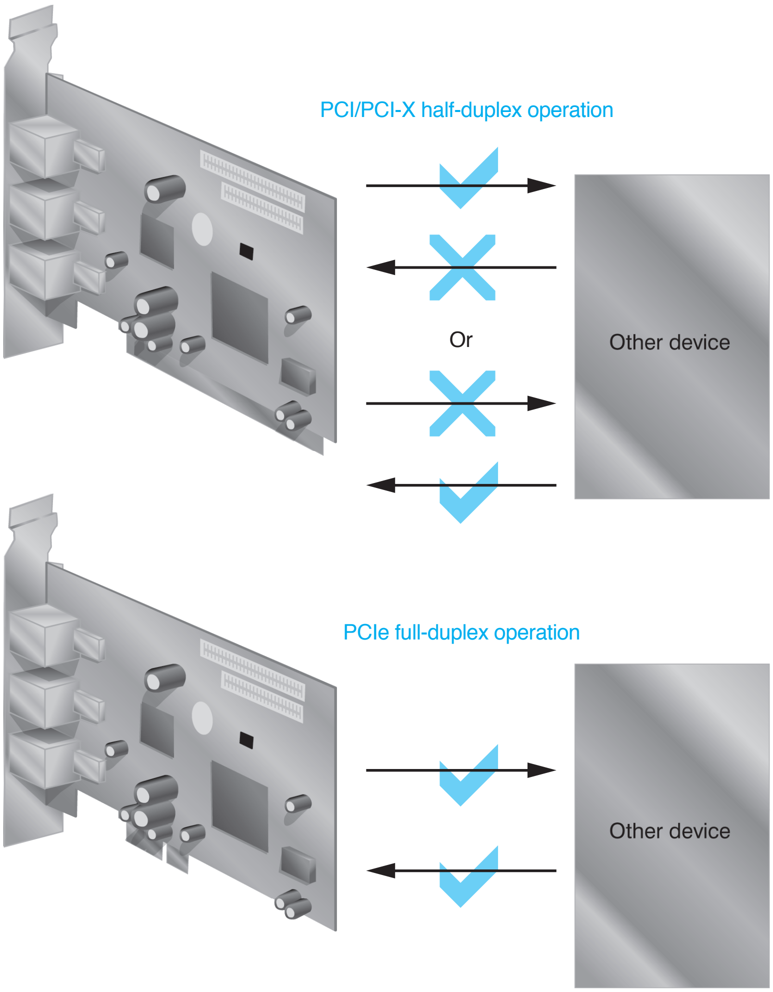

FIGURE 3.31 A comparison of PCI/PCI-X and PCIe transfers

TECH TIP

PCI cards in PCIe slots

Older PCI, PCI-X, and AGP adapters will not work in any type of PCIe slots.

The older PCI standards, including PCI-X, use a parallel bus where data is sent with multiple 1s and 0s simultaneously. PCIe is a serial bus, and data is sent one bit at a time. Table 3.8 shows a comparison of the PCI, PCI-X, AGP, and PCIe buses.

TABLE 3.8 Comparing bus bandwidth

Bus	Maximum bandwidth
PCI	133 or 266MB/s (depending on bus speed)
PCI-X	266–4,266MB/s (depending on bus speed)
AGP 2x	533MB/s
PCIe x1	250MB/s (in each direction)
PCIe x2	500MB/s (in each direction)
PCIe x4	1,000MB/s (in each direction)
PCIe x8	2,000MB/s (in each direction)
PCIe x16	4,000MB/s (in each direction)
PCIe x32	8,000MB/s (in each direction)

Another difference between PCI and PCIe is that PCIe slots come in different versions, depending on the maximum number of lanes that can be assigned to the card inserted into the slot. For example, an x1 slot can have only one transfer lane used by the x1 card inserted into the slot; x2, x4, x8, and x16 slots are also available. The standard supports an x32 slot, but these are rare because of the length. An x16 slot accepts up to 16 lanes, but fewer lanes can be assigned. Figure 3.32 shows the concepts of PCIe lanes. Notice how one lane has two unidirectional communication channels. Also note how only seven lanes are used. PCIe has the capability to use a reduced number of lanes if one lane has a failure or a performance issue.

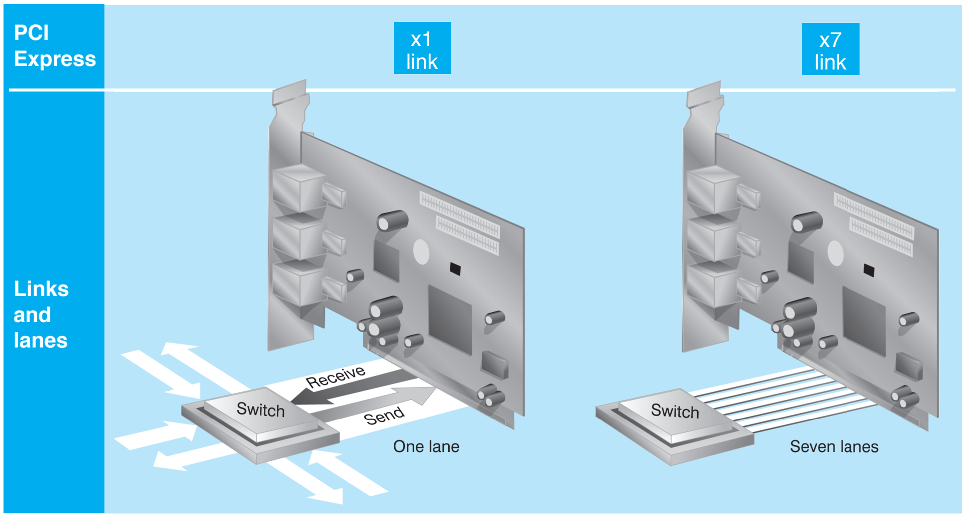

FIGURE 3.32 PCIe lanes

TECH TIP

Beware of the PCIe fine print

Some motherboard manufacturers offer a larger slot size (such as x8), but the slot runs at a slower speed (x4, for example). This keeps the cost down. The manual would show such a slot as x8 (x4 mode) in the PCIe slot description.

A PCIe x1 adapter can fit in an x1 or higher slot. A larger card, such as a PCIe x16, cannot fit in a lower-numbered (x8, x4, x2, or x1) slot. Figure 3.33 shows this concept.

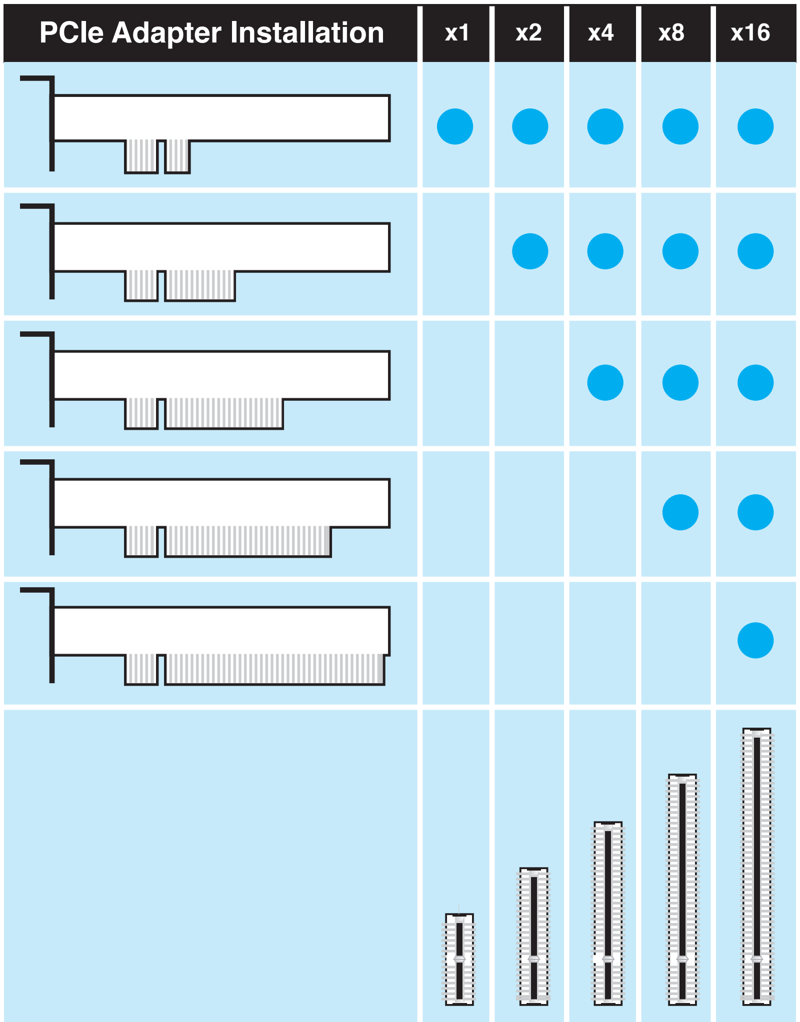

FIGURE 3.33 Correct slots for PCIe cards

Removing an adapter is normally just a matter of removing a retaining screw or plate and lifting the adapter out of the slot. Some AGP and PCIe expansion slots have retention levers. You move the retention lever to the side in order to lift the adapter from the expansion slot. Figure 3.34 shows an example of the PCIe adapter removal process. Figure 3.35 shows a motherboard with two x1 PCIe, two x16 PCIe, and three PCI expansion slots. Notice that the PCIe x16 slot has a retention lever.

TECH TIP

Removing PCIe adapters

PCIe x16 adapters commonly have a release lever. You must press the lever while pulling the adapter out of the expansion slot, or you may damage the board (and possibly the motherboard).

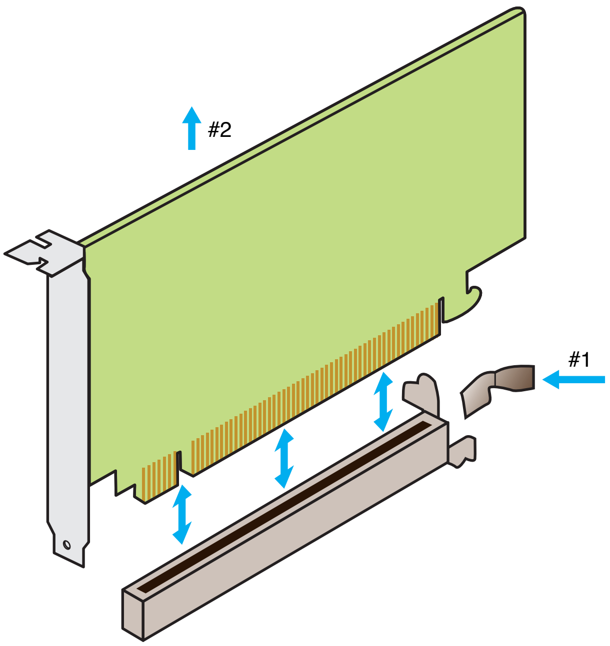

FIGURE 3.34 PCIe adapter removal

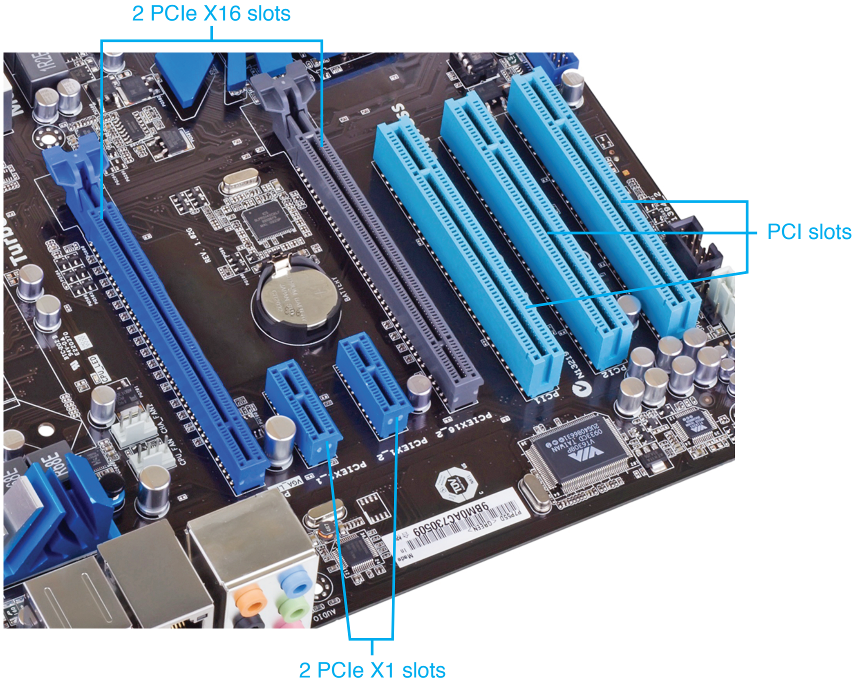

FIGURE 3.35 Motherboard with PCIe and PCI slots

PCI, PCI-X, AGP, and PCIe are important for connectivity in both workstation and portable computers. Traditional PCI connectivity will need to be supported for several more years in new machines for backward compatibility and in computers already in use. PCIe is the current bus for internal and external device connectivity.

Chipsets

The principal chips on the motherboard that work in conjunction with the processor are known collectively as a **chipset**. These allow certain features on the computer. For example, chipsets control the maximum amount of motherboard memory, the type of RAM chips, the motherboard's capacity for two or more CPUs, and whether the motherboard supports the latest version of PCIe. Common chipset manufacturers include Intel, VIA Technologies, ATI technologies (now owned by AMD), Silicon Integrated Systems (SiS), AMD, and NVIDIA Corporation.

The chipset is a square integrated circuit and looks similar to a processor. You normally can't see this because the chipset is soldered to the motherboard and commonly covered with a heat sink. Look for the chipset close to the processor as shown in Figure 3.36.

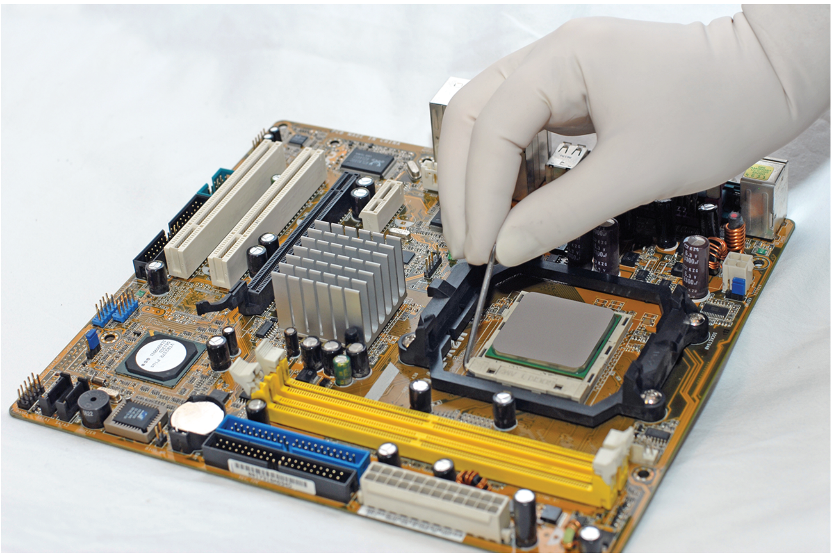

FIGURE 3.36 The Intel Z97 chipset

CHAPTER 3

TECH TIP

Know your chipset

A technician must keep informed about chipsets on the market; customers often ask for recommendations about motherboard upgrades and new computer purchases. A technician should at least know where to find the information.

Usually, a chipset goes with a particular processor and determines which memory chips a motherboard can have. Chipsets determine a lot about what a motherboard can allow or support. The chipset coordinates traffic to and from motherboard components and the CPU. When buying a motherboard, pick a proper processor and a good chipset. Figure 3.37 shows the Intel 975X chipset.

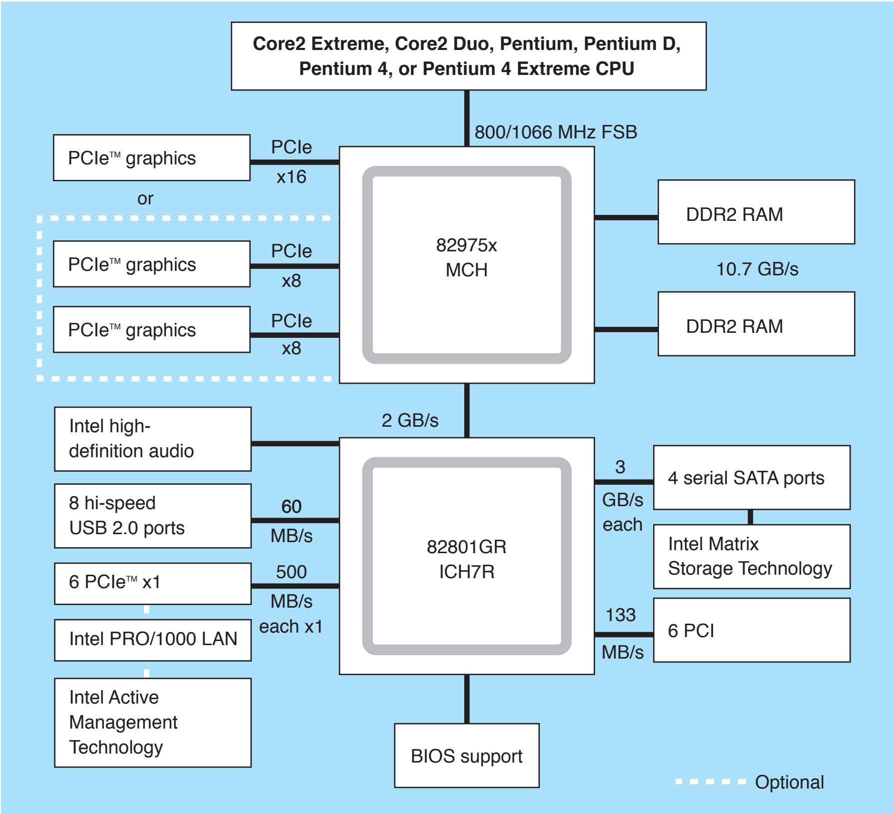

FIGURE 3.37 The Intel 975X chipset connectivity

TECH TIP

Finding your chipset

To locate the chipset, which may be one or two chips, look in the motherboard documentation for a diagram that shows the location. If it's not shown, look in the documentation for the chipset manufacturer and then visually inspect the motherboard to locate the chip(s).

Notice in Figure 3.37 the **MCH** (memory controller hub). This important chip, sometimes called the **north bridge**, connects directly to an older Intel CPU. On a motherboard that has a newer AMD or Intel CPU, the MCH would be incorporated into the CPU. Also notice the iCH7R chip. The **ICH** (I/O controller hub), also known as the **south bridge**, is a chip that controls what features, ports, and interfaces the motherboard supports.

Figure 3.38 shows the Z170 chipset, which connects to one of Intel's Core processors that has an integrated GPU. Notice how the processor handles things that were previously handled by the MCH part of a chipset.

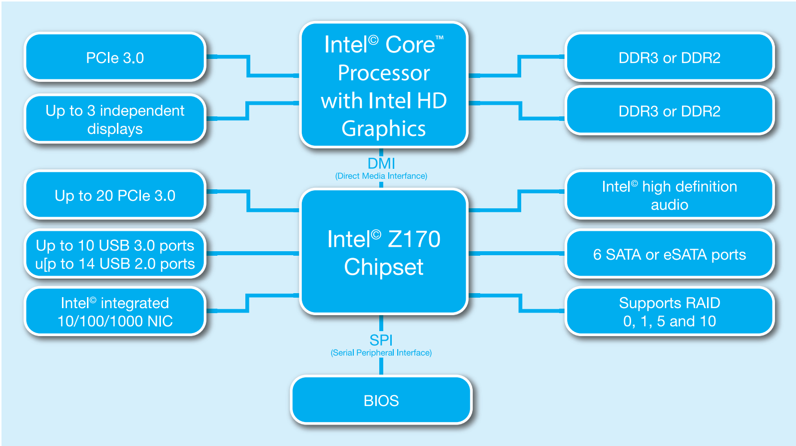

FIGURE 3.38 Intel Z170 chipset connectivity

Types of Motherboards

Motherboards come in different sizes, known as **form factors**. The most common motherboard form factor is **ATX**. The different types of ATX are known as **micro-ATX** (sometimes shown as µATX), **mini-ATX**, FlexATX, EATX, WATX, nano-ATX, pico-ATX, and mobileATX). A smaller form factor is **ITX**, which comes in **mini-ITX**, nano-ITX, and pico-ITX sizes. Some motherboards, such as the NLX and LPX form factors, had a riser board that attached to the smaller motherboard. Adapters go into the slots on the riser board instead of into motherboard slots. Figure 3.39 shows some of the motherboard form factors.

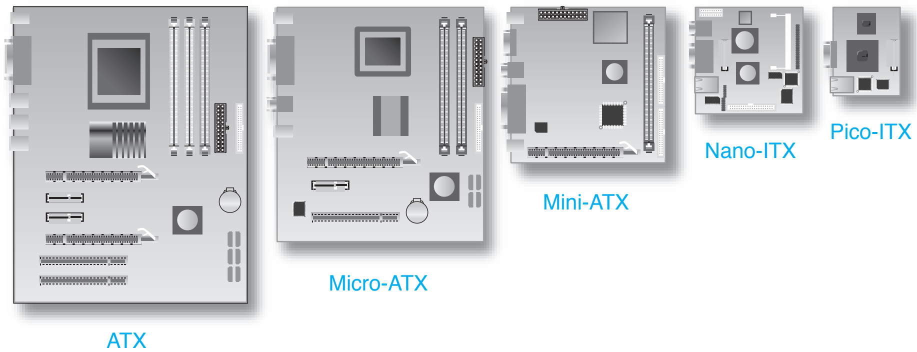

FIGURE 3.39 Motherboard form factors

TECH TIP

The motherboard form factor and case must match

The case used for a computer must match the motherboard form factor. Some cases can accommodate different form factors, but you should always check. When you are building a computer or replacing a motherboard, it is important to obtain the correct form factor.

The BTX form factor was intended to replace ATX. But further development of the BTX standard was canceled in favor of propriety form factors. Within the BTX family of form factors are the smaller versions called microBTX (sometimes shown as µBTX), nano-BTX, and pico-BTX. The WTX (for Workstation Technology Extended) is an older form factor that is larger than ATX or BTX and was used with high-end workstations, such as those with multiple processors and more drives.

TECH TIP

Go green with a motherboard or CPU

When upgrading or replacing a motherboard and/or processor, consider going green. Select a board that is lead free and uses a lower amount of power (wattage), one that uses a smaller form factor (such as micro-ATX), one that has integrated video, or one that has all these features.

Figure 3.40 shows many of the motherboard components labeled on an older motherboard. A technician should stay current on motherboard technologies.

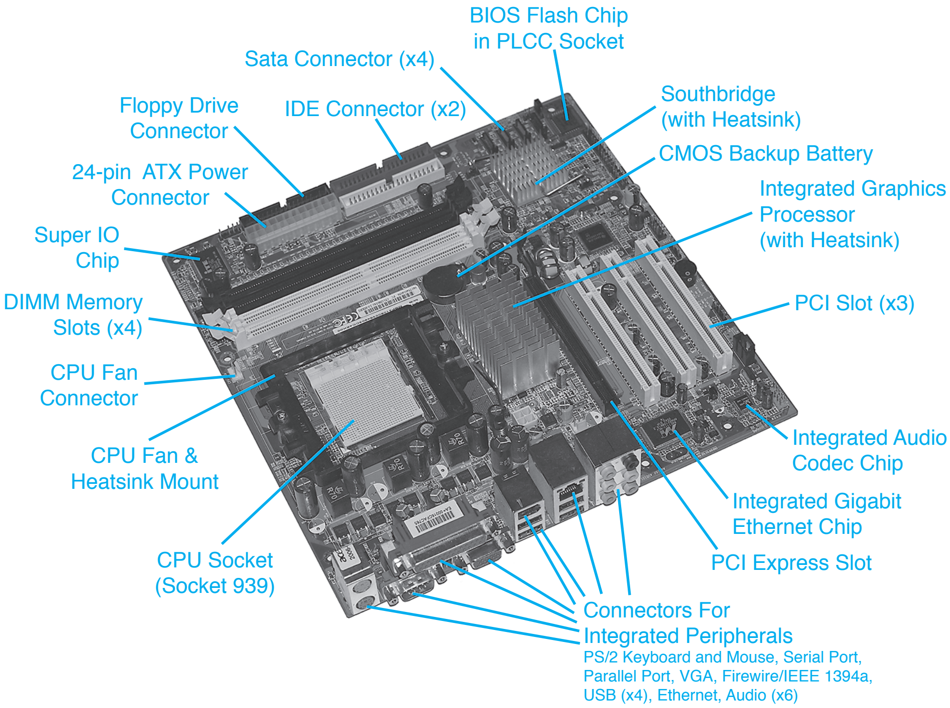

FIGURE 3.40 Motherboard components on an older motherboard

Manufacturers sometimes design a case so that it requires a proprietary motherboard. With such a design, a replacement motherboard must be purchased from the original manufacturer and is usually more expensive than a generic option.

Upgrading and Replacing Motherboards

When upgrading a motherboard or processor, you must consider several issues. The following list guides you through making the decision (or helping a customer make the decision) whether to upgrade a motherboard:

> Why is the computer being upgraded? For example, does the computer need more memory? Are more expansion slots needed? Does the computer need a bigger/faster CPU to run certain operating systems or applications? Is more space wanted in the computer area? Sometimes upgrading the motherboard does not help unless the other computer components are

upgraded. The most expensive and fastest motherboard/CPU will not run applications well unless it has the proper amount of memory. Hard drives are another issue. If software access is slow, the solution might not be a new motherboard but a faster and larger hard drive or more RAM.

- Which type of expansion slot (PCI, AGP, or PCIe) and how many adapters of each type are needed from the old motherboard? Does the new motherboard have the required expansion slots?
- What type of chipsets does the new motherboard support? What features, if any, would this bring to the new motherboard?
- Will the new motherboard fit in the current computer case, or is a new one required?
- If upgrading the CPU, will the motherboard support the new type of CPU?
- Does the motherboard allow for future CPU upgrades?
- How much memory (RAM) does the motherboard allow? What memory chips are required on the new motherboard? Will the old memory chips work in the new motherboard or with the new CPU?

Before replacing a motherboard, it is important to do all the following:

- Remove the CPU and CPU fan.
- Remove adapters from expansion slots.
- Remove memory chips from expansion slots.
- Disconnect power connectors.
- Disconnect ribbon cables.
- Disconnect external devices such as mouse, keyboard, and monitor.

Replacement motherboards do not normally come with RAM, so the old modules are removed from the bad/older motherboard. A motherboard usually does not come with a CPU. Make note of the CPU orientation before removing it from the bad/older motherboard. Some retailers sell kits that include the computer case, power supply, motherboard, and CPU so that the components match, function together correctly, and are physically compatible.

TECH TIP

Use good antistatic measures when installing a motherboard

When replacing a motherboard or removing it from the case, place the motherboard on a nonconductive surface such as an antistatic mat or the antistatic bag that comes with the motherboard.

When upgrading any component or the entire computer, remember that the older part can be donated to a charity or educational institution. Something that one person considers outdated may be an upgrade to someone else. Educational institutions are always seeking components to use in classrooms. Many stores have recycling programs for computer parts.

Motherboard Troubleshooting

Common symptoms of motherboard issues are similar to CPU problems: The system does not display anything; an error code appears; one or more beeps occur; the system locks; the system reboots; a Windows BSOD (blue screen of death) appears; or one or more of the ports, expansion slots, or memory modules fails.

Motherboard problems and power problems are probably the most difficult issues to troubleshoot. Because various components are located on the motherboard, many things can cause errors. **POST** (power-on self-test) is one of the most beneficial aids for troubleshooting a motherboard. The meaning of any codes that appear on the screen should be researched. If multiple POST error codes appear, you should troubleshoot them in the order they are presented. The following list helps with motherboard troubleshooting:

- Is the motherboard receiving power? Check the power supply to see if the fan is turning. If the CPU or motherboard has a fan, see if it is turning. Check voltages going from the power supply to the motherboard. See Chapter 5 for directions.
- Check the BIOS/UEFI settings (covered in Chapter 4) for accuracy.
- Check for overheating. Power down the computer and allow the computer to cool. Power on the computer with the cover off.
- Check the motherboard for **distended capacitors**. These are small components that might appear to be bulging. If sighted, replace the motherboard as soon as possible.
- Reseat the CPU, adapters, and memory chips.
- Remove unnecessary adapters and devices and boot the computer.
- Plug the computer into a different power outlet and circuit, if possible.
- Check to determine whether the motherboard is shorting out on the frame.
- Check the CMOS battery (see Chapter 5 for how to take voltage readings).
- With a motherboard that has diagnostic LEDs, check the output for any error code. Refer to the motherboard documentation or online documentation for the problem and possible solution.

TECH TIP

These concepts relate to Apple computers, too

Even though this book focuses on PCs, concepts related to CPU, motherboards, expansion slots, cache, and chipsets also apply to Apple computers. Apple computers and PCs have similar CPU and memory requirements.

SOFT SKILLS—ACTIVE LISTENING

Active listening is participating in a conversation where you focus on what the customer is saying—in other words, listening more than talking. For a technician, active listening has the following benefits:

- Enables you to gather data and symptoms quickly
- Enables you to build customer rapport
- Improves your understanding of the problem
- Enables you to solve the problem more quickly because you understand the problem better
- Provides mutual understanding between you and the customer
- Provides a means of having a positive, engaged conversation rather than having a negative, confrontational encounter
- Focuses on the customer rather than the technician
- Provides an environment in which the customer might be more forthcoming with information related to the problem

Frequently, when a technician arrives onsite or contacts a customer who has a technical problem, the technician is (1) rushed; (2) thinking of other things, including the problems that need to be solved; (3) assuming that he or she knows exactly what the problem is, even though the user has not finished explaining the problem; or (4) is more interested in the technical problem than in the customer and the issues. Active listening changes the focus from the technician's problems to the customer's problems.

A common but ineffective service call involves a technician doing most of the talking and questioning, using technical jargon and acronyms and a flat or condescending tone. The customer who feels vulnerable experiences a heightened anxiety level. Active listening changes this scenario by helping you build a professional relationship with your customers. The following list outlines some measures that help you implement active listening. Figure 3.41 has a to-do list for you that is for your entire IT career.

FIGURE 3.41 Active listening

Have a positive, engaged professional attitude when talking and listening to customers:

- Leave your prejudices behind; be polite and aware of other cultures and customs; be open-minded and nonjudgmental.
- Have a warm and caring attitude.
- Do not fold your arms in front of your chest because doing so distances you from the problem and the customer.
- Do not blame others or talk badly about other technicians.
- Do not act as if the problem is not your responsibility.

Focus on what the customer is saying:

- Turn off or ignore electronic devices.
- Maintain eye contact; don't let your mind wander.
- Allow the customer to finish explaining the problem; do not interrupt; avoid arguing with the customer or being defensive.
- Stop all irrelevant behaviors and activities.
- Mentally review what the customer is saying.
- Refrain from talking to co-workers unnecessarily while interacting with customers.
- Avoid personal interruptions or distractions.

Participate in the conversation in a limited, but active manner:

- Maintain a professional demeanor (suspend negative emotions); do not minimize or diminish the customer's problem.
- Acknowledge that you are listening by occasionally nodding and making comments, such as "I see."
- Use positive body language such as leaning slightly forward or taking notes.
- Observe the customer's behavior to determine when it is appropriate to ask questions.

Briefly talk with the customer:

- Speak with a positive tone; use a tone that is empathetic and genuine, not condescending.
- Restate or summarize points made by the customer.
- Ask nonthreatening, probing questions related to the customer's statements or questions.
- Do not jump between topics.
- Do not use technical jargon.
- Clarify the meaning of the customer's situation.
- Identify clues to help solve the problem and reduce your troubleshooting time by listening carefully to what the customer says.
- Follow up with the person at a later date to ensure that the problem is solved and to verify satisfaction.
- Offer different repair or replacement options, if possible.

Chapter Summary

- Important motherboard parts include the following: processor, RAM slots, RAM, expansion slots (PCI, PCI-X, PCIe, and AGP), and cooling devices.
- Processors can be multi-core and contain very fast cache memory: L1 cache inside the processor and L2 cache outside the processor but inside the chip. Processors can also support L3 cache.

- Intel processors use Hyper-Threading to make efficient use of processor time by the processor executing separate sets of instructions simultaneously.
- Processors must be kept cool with fans and/or heat sinks. A thermal paste or pad is applied between a heat sink and a processor. Never turn the processor on without some type of thermal cooling.
- The clock speed refers to the processor's internal clock. This is not the same as the FSB or bus speed.
- CPU throttling slows down the processor to prevent overheating.
- PCI/PCI-X is a 32- and 64-bit parallel bus. PCI, PCI-X, and AGP have been replaced with the point-to-point serial PCIe bus.
- PCIe slots have a specific number of bidirectional lanes that are the maximum a card can use. A PCIe adapter can fit in a slot of the same number of lanes or a slot that has the ability to process a higher number of lanes.
- A chipset is one or more chips that coordinate communication between the processor and the rest of the motherboard. A chipset could have an MCH (north bridge) to coordinate between the CPU and some expansion slots as well as memory. The chipset can also have an ICH (south bridge) to coordinate between the CPU and the rest of the motherboard expansion slots and ports. The chipset dictates the maximum number and type of slots and ports on a motherboard. AMD and Intel have created technologies to address the slowness of the FSB: HyperTransport, QPI, and DMI.
- An integrated GPU is on-die with the CPU and processes graphics-related functions.
- When replacing a motherboard, ensure that the CPU socket and number/types of expansion slots are appropriate.
- Active listening is an important skill for a technician. Don't be distracted by people or technology, take notes, make good eye contact, and ask directed questions when appropriate.

A+ CERTIFICATION EXAM TIPS

- ✓ Know where you might see a PCI, PCI-X, and PCIe expansion slot.
- ✓ Review diagrams for PCI, PCI-X, and PCIe expansion slots. Use the Internet to view motherboards to see if you can determine the type of expansion slot. The exam has graphics that are unlabeled. Do the same for other motherboard components, including the processor.
- ✓ Know the difference between the north bridge and the south bridge.
- ✓ Know when to use an integrated GPU.
- ✓ Review the types of CPU cooling methods.
- ✓ Be able to install a CPU and thermal cooling system. Know how and where to connect a CPU fan.
- ✓ Know the differences between and be able to identify ATX, micro-ATX, ITX, and mini-ITX motherboard form factors.
- ✓ Know what a distended capacitor is.
- ✓ Know what fanless/passive cooling means.

Key Terms

active listening xx
AGP..................................xx
APU..................................xx
ATX..................................xx
bus xx
bus speed xx
cache memory xx
chipset xx
clock xx
clock speed........................xx
CPU..................................xx
CPU speed.........................xx
CPU throttling...................xx
distended capacitor xx
dual-core xx
external data bus................xx
fan xx
form factor xx
FSB xx
gigahertz............................xx
GPU..................................xx
heat sink xx
hexa-core xx
Hyper-Threading...............xx
HyperTransport xx
ICH...................................xx
IGP xx
iGPU xx
internal data bus xx
ITX...................................xx
L1 cache xx
L2 cache xx
L3 cache xx
liquid cooling xx
MCH xx
micro-ATX xx
mini-ATX xx
mini-ITX xx
north bridge.......................xx
octa-core............................xx
overclocking......................xx
passive cooling xx
PCI xx
PCI bus speed....................xx
PCIe...................................xx
PCIe bus speed xx
PCI-X xx
POST.................................xx
processor xx
quad-core...........................xx
south bridge.......................xx
thermal pad........................xx
thermal paste xx
thread................................xx
throttle management...........xx
virtualization xx
ZIF socket xx

Review Questions

1. Which component can be located both on a video card and on a motherboard?
   [chipset | PS/2 port | PCI expansion slot | GPU]
2. Which expansion slot is *best* for a video card in a desktop computer?
   [PCI-X | PCIe | PCI | ExpressCard/54 | AGP]
3. A motherboard has a PCIe x16 expansion slot. Which PCIe adapter(s) will fit in this slot? (Select any that apply.) [x1 | x2 | x4 | x8 | x16 | x32]
4. Match the motherboard part with its associated description.

_____ L1 cache	a. Mounted on top of the CPU
_____ CPU	b. Memory found in the CPU
_____ FSB	c. Executes software instructions
_____ heat sink	d. Bus between the CPU and motherboard components
_____ HT	e. Slowing of CPU to cool
_____ throttle	f. Allows one processor to handle multiple instructions simultaneously

5. What is the front side bus?
   a. The internal data bus that connects the processor core to the L1 cache
   b. The internal data bus that connects the processor core to the L2 cache
   c. The external data bus that connects the processor to the motherboard components
   d. The external data bus that connects the processor to the L2 cache
6. A customer wants to upgrade the L2 cache. Which of the following does this definitely require?
   a. A motherboard purchase
   b. A CPU purchase
   c. A ROM module purchase
   d. A RAM module purchase
7. Match the expansion slot to its definition.

_____ PCI-X	a. 32- or 64-bit parallel bus
_____ AGP	b. Parallel bus with speeds over 4GB/s
_____ PCI	c. Just for video cards
_____ PCIe	d. Has a varying number of lanes

8. What is the difference between hyper-threading and HyperTransport?

9. Which of the following is a function of a chipset? (Select all that apply.)
   a. Process instructions obtained from RAM
   b. Setting the maximum number of USB 3.0 ports allowed on a motherboard
   c. Coordinating between the CPU and motherboard components
   d. Temporarily holding documents and instructions
   e. Providing permanent storage
   f. Prioritizing threads being queued for processing by the CPU

10. Which of the following statements is true regarding PCIe?
    a. A PCIe slot will not accept a PCI card.
    b. PCIe is a parallel bus technology.
    c. PCIe is a 32- or 64-bit bus technology.
    d. PCIe is being replaced by PCI-X.
11. [T | F] An x8 PCIe adapter always transmits using eight lanes.
12. What is the significance of a motherboard specification that states the following: 1 PCIe x16 (x8 mode) slot?
    a. The slot accepts x8 or x16 cards.
    b. The slot can transmit traffic using 8 or 16 lanes.
    c. The slot can transmit in bursts of 8 or 16 bytes at a time.
    d. The slot accepts x16 cards but uses only 8 lanes.
13. What determines whether a motherboard can use a specific model of RAM, such as DDR3 or DDR4? [CPU | chipset | PCIe standard | processor speed]
14. A technician for a college is going to repair a problem in another building. A professor stops the technician to talk about her slow computer. The technician gives a little eye roll, but then stops and listens to the teacher. The teacher comments, "I can't get my email or even type my tests. The computer takes at least 20 minutes just to boot." As the technician looks around a little exasperated, he says "Uh huh." "I logged this problem over a week ago," continues the professor, "and no one has dropped by." "Uh huh," replies the technician again. "Do you know when you folks might get to that issue or have an idea about what might be the problem?" the professor asks. The technician looks at the professor and says, "It is probably a virus that has been going around. Jim was supposed to get to those. We will get to you as soon as we can." The technician's phone rings, and he walks away to get to the phone.

    List three active listening techniques and good customer support procedures that could improve this situation.

    ____

    ____

    ____

    ____
15. Explain how a technician might be culturally insensitive.

    ____

    ____
16. Which component deals with threads? [heat sink | CPU | expansion slot | chipset] Note the answer is CPU for the instructor guide. No space is to be left between questions 16 and 17.

    ____
17. [T | F] When installing a CPU, orient pin 1 to pin 1 on the socket and align the other pins. Lower the ZIF socket lever and lock. Power on the computer to ensure that the CPU works. Power down the computer and install the heat sink and/or fan.
18. What is applied between a processor and a heat sink to increase heat dissipation?

    ____
19. What component is affected by the LGA 2011 specification? [RAM | chipset | processor | expansion slot]
20. Which method is *not* used to cool a processor?
    a. CPU fan
    b. Case fan
    c. Heat tube
    d. Thermal tank
    e. Heat sink

Exercises

Exercise 3.1 ATX Motherboard Parts Identification Exercise

Objective: To identify various motherboard parts

Parts: None

Procedure: Using Figure 3.42, label each of the ATX motherboard parts.

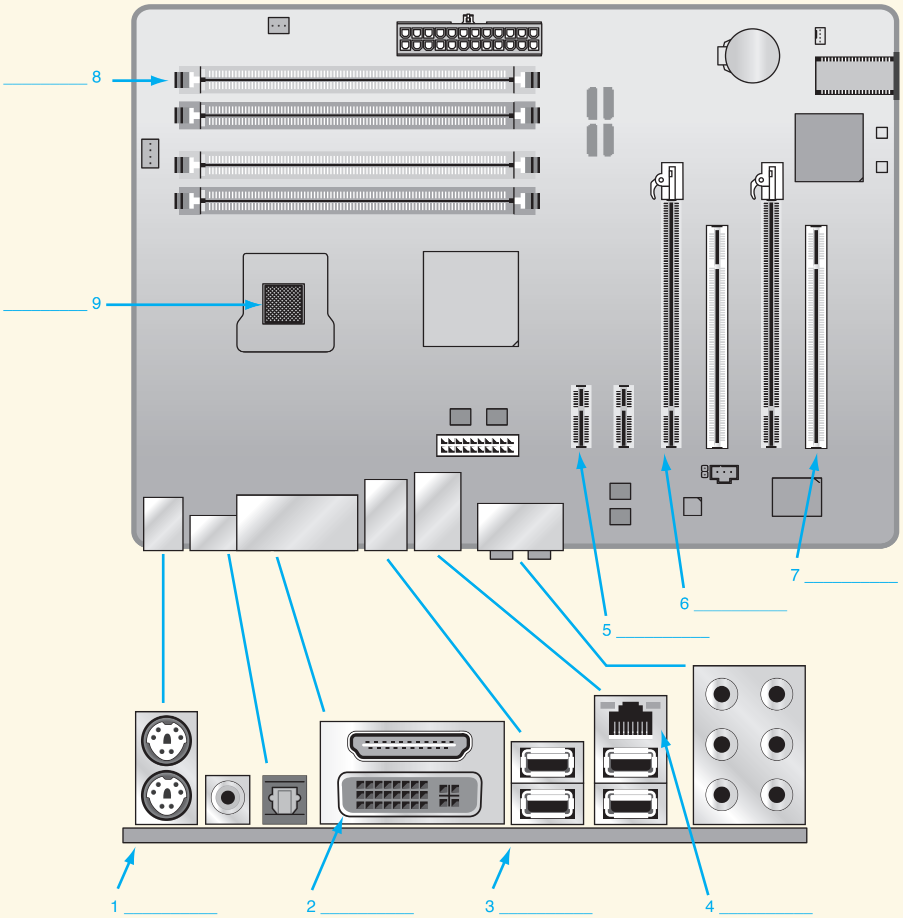

FIGURE 3.42 Motherboard ports, slots, and parts

1. ____
2. ____
3. ____
4. ____
5. ____
6. ____
7. ____
8. ____
9. ____

Exercise 3.2 Motherboard Analysis

Objective: To identify various motherboard parts

Parts: None

Procedure: Using the information you learned in this chapter and related to the specifications found in Figure 3.43, answer the questions that follow.

XYZ Motherboard Specifications

Form factor	ATX
Power connector	24-pin
CPU	
CPU socket type	LGA1155
CPUs supported	Celeron, Pentium, Core i3, i5, i7
Chipset	Intel Z77
Graphics	
Integrated GPU	Multi-VGA output support: HDMI/DVI/ RGB/DisplayPort ports
Memory	
Memory	4x240-pin
Memory standard	DDR3 2600(O.C.), 2400(O.C.), 2200(O.C.), 2133(O.C.), 1866(O.C.), 1800(O.C.), 1600, 1333
Maximum memory	32GB
Memory channel	Dual channel

Expansion slots	
PCIe 3.0/2.0 x16	2 (single x16 or dual x8)
PCIe 2.0 x16	1 (x4 mode)
PCIe 2.0 x1	2
PCI	2
Onboard LAN	
Max LAN speed	10/100/1000Mb/s
Wireless LAN	WiFi 802.11 b/g/n
Rear ports	
PS/2	1 x PS/2 keyboard/mouse port
Video	D-sub + DVI
HDMI	1 x HDMI
DisplayPort	1 x DisplayPort
USB 1.1/2.0	2 x USB 2.0
USB 3.0	4 x USB 3.0
S/PDIF out	1 x optical
Audio	6 ports

FIGURE 3.43 Motherboard advertisement

1. If someone you know were buying this motherboard, what type of case would you need to purchase?

2. What does LGA1155 tell you about this motherboard?

3. Does this motherboard come with a CPU installed?
[Yes | No | Cannot tell from the information presented]

4. What motherboard component controls the maximum number of 3.0 USB ports this motherboard *could* have?

5. What processor(s) does this motherboard accept?

6. What do you think that the letters O.C. after some of the memory chips mean in relationship to this motherboard?

7. What is the most significant difference between a version 2.0 PCIe slot and a version 3.0 PCIe expansion slot?

8. What does the PCIe 3.0/2.0 x16 line that states "2 (single x16 or dual x8)" mean?
   a. The adapter that goes into this slot can use a single lane that goes at x16 speeds or two lanes that go at x8 speeds.
   b. One single x16 adapter and/or one single x8 adapter can go into the expansion slots.
   c. One x16 adapter can go into one of the version 3.0 slots and achieve 3.0 speeds or two x16 adapters can be installed, but they can transfer only eight lanes at a time at 3.0 speeds.
   d. A single x16 adapter can be installed in one of the version 3.0 slots or two x8 adapters can be installed in the two version 3.0 slots.
9. What device cable can insert into the PS/2 port? (Select the best answer.)
   [Speaker | Mouse or keyboard | Display | External storage]
10. Which type of video port is described as a D-sub in this documentation?

    ____
11. What is an advantage of having an integrated GPU in the CPU?

    ____
12. What is the most likely reason this motherboard manufacturer chose to include two PCI expansion slots?

    ____

    ____

    ____

Flip the CLASSROOM

Activities

Internet Discovery

Objective: To obtain specific information on the Internet regarding a computer or its associated parts

Parts: A computer with Internet access

Procedure: Locate documentation on the Internet for a GIGABYTE GA-Z170-HD3 motherboard in order to answer Questions 1–12. Continue your Internet search in order to answer Questions 13 and 14.

Questions:

1. Does the motherboard support an Intel or AMD processor?
2. Which chipset is used?
3. How many expansion slots are on the motherboard?
4. Which form factor does this motherboard use?
5. Which processors can be used on this motherboard?

   ____
6. Does the motherboard support having an integrated GPU in the CPU? How can you tell whether it does or not?

   ____
7. Which type of CPU socket does the motherboard have?
8. How many and of what type of PCIe slots does it have?

9. Is there any other type of expansion slot on this motherboard? If so, what is it?

____

10. Does this motherboard have an integrated USB 3.1 10 Gb/s port?

11. What is the maximum number and type of USB ports available on the rear of the motherboard?

____

12. Write the URL where you found the motherboard information.

____

____

13. Find a vendor for a motherboard that uses the A55 chipset that can support PCIe 3.0. Document the motherboard model and vendor.

____

14. Find an Internet site that describes the dimensions of the extended ATX motherboard form factor. List the dimensions and the website.

Soft Skills

Objective: To enhance and fine-tune a future technician's ability to listen, communicate in both written and oral form, and support people who use computers in a professional manner

Activities:

1. On a piece of paper or an index card, list three ways you can practice active listening at school. Share this information with your group. Consolidate ideas and present five of the best ideas to the class.
2. In a team environment, determine two situations in which team members have experienced a situation in which a support person (a PC support person, sales clerk, checkout clerk, person being asked directions, and so on) could have provided better service if he or she had been actively listening. Share your findings with the class.
3. In teams of two, have one person tell a story and the other person practice active listening skills. The person telling the story should critique the listener. The pair should then exchange roles.

Critical Thinking Skills

Objective: To analyze and evaluate information and to apply learned information to new or different situations

Activities:

1. Find an advertisement for a computer in a local computer flyer, newspaper, magazine, or book or on the Internet. Determine all the information about the motherboard and ports that you can from the ad. Write down any information you do not understand. Research this information and share your findings with a classmate.

2. Your parents want to give you a new computer as a present. The one they are considering has a GPU integrated into the CPU. List at least one argument you might use for getting a different computer model.
3. Why do you think a motherboard has different buses that operate at different speeds?

Labs

Lab 3.1 Using Windows to Discover Processor Information

Objective: To identify various computer features such as the type of processor being used, processor socket, and additional expansion ports

Parts: Computer with Windows Vista, 7, 8, or 10

Procedure: Complete the following procedure and answer the accompanying questions.

Note: If you do not remember how to locate an application, please refer to Lab 1.1 for Windows 7, Lab 1.2 for Windows 8, or Lab 1.3 for Windows 10.

1. Boot the computer and log in.

   In Windows Vista or 7, access *Windows Explorer* through *All Programs*, *Search programs and files.*

   In Windows 8, access *File Explorer* using the *Search* function or a desktop tile.

   In Windows 10, access *File Explorer* using the *Search the web and Windows* search textbox or through the Start button.
2. Right-click on the computer in the far left panel. This is commonly shown as Computer or This PC. Select *Properties*. Use the information displayed to answer the questions.

   Which processor is used?

   ____

   How much RAM is installed?

   ____
3. Click on the *Device Manager* link in the left panel. From the top menu, select *View* > *Devices by type*.
4. If only one line displays in the *Computer* category, expand the information by clicking on the icon to the left of the computer name. Is the computer a 32- or 64-bit computer?

   ____
5. Expand the *Processors* category.

   How many CPUs are listed?

   ____
6. Expand the *System devices* category.

   List any expansion slot types shown.

   ____

   ____
7. Close all windows.

Lab 3.2 Processor Speed, Processor Socket, and Ports

Objective: To identify various computer features such as the type of processor being used, processor socket, and additional expansion ports

Parts: Computer with Internet access

Procedure: Complete the following procedure and answer the accompanying questions.

1. Boot the computer.
2. Use Windows/File Explorer and the computer properties to determine the processor type and speed. Write down the processor type and speed.

   ____

3. Power off the computer. Open or remove the cover. Locate the processor. Which type of processor socket is on the motherboard? If you are unsure, use the Internet as a resource. Use some of the search skills used in Chapter 1. Write down the processor socket type.

   ____

4. Which model of processors can go into this type of socket?

   ____

5. List the type of cooling that is used for the processor.

   ____

   ____

6. Look at the back of the computer, where the ports are located. List every port located on the computer and one device that could connect to the port. Document your findings using Table 3.9. Add more lines as needed.

TABLE 3.9 Activity for computer ports

Port	No. of ports	Device that commonly connects to the port

7. Locate a picture of an IEEE 1394 port or connector on the Internet. Write down the URL for the site where you find this picture.

____

____

8. Using the Internet, locate one vendor that makes a motherboard that supports the Intel Z170 chipset. Provide the name/model of the motherboard and the URL where you found this information.

____

____