Chapter 2: Picking Your Processor

Exam Objectives

- **Understanding CPU characteristics**
- **Identifying popular CPUs**
- **Identifying sockets**
- **Installing a processor**

Although all components of the computer function together as a team, every team needs a leader — someone who gives out instructions and keeps everyone working toward the same goal. If any PC component were to be considered the team leader, it would probably be the *central processing unit (CPU),* also known as the *processor.* The key word here is *central,* which implies "center" or "focus." The CPU can be considered the focus of the computer because it controls a large number of the computer system's capabilities, such as the type of software that can run, the amount of total memory that the computer can recognize, and the speed at which the system will run.

In this chapter, you get a look at some of the features of the CPU that are responsible for regulating the capabilities of the computer system. It will also discuss the importance of the CPU and its role as a PC component, as well as identify some of the main characteristics that make one CPU better than another.

When preparing for the A+ exams, it is important that you're comfortable with terms like *MMX, throttling,* and *cache memory.* You also want to be sure that you're comfortable with the differences between various processors. For example, what makes a Pentium 4 better than a Celeron? Which AMD processor competes with the Celeron? All of these are questions you should know the answer to before you take the A+ Certification exams, and this chapter helps you find out the answers. Good luck!

Understanding Processor Terminology

In this section, you learn some basic terms that describe characteristics of different processors — past and present. The exam might not ask for the specific definition of each term, but understanding the terms will help you answer the related questions in this topic area.

Processor speed

Processor speed is the speed at which the processor executes its instructions or commands. This speed was originally measured in millions of hertz, or *megahertz (MHz),* per second. A *hertz* is also known as a clock *cycle,* and a processor can execute code at every clock cycle. Thus, a processor operating at a measly 1 MHz per second can execute *one million tasks every second.* Processors today now measure their speed in *gigahertz* (*GHz*) per second. A gigahertz is a billion clock cycles per second — so the CPU can execute tasks a billion times per second!

Original CPUs had a speed of 4.77 MHz, while systems at the time of this writing are running around 3.0 GHz. Although processor speed is not the only factor affecting performance, in general, the faster the processor, the faster the system.

Data bus

A city bus is responsible for transferring people from one location to another. In the world of computers, a *bus* is responsible for delivering data from one location on the PC to another. The *data bus* is the term used to define the pathway between the processor and memory. Because the processor accesses information from memory so often, an entire bus — the data bus — is dedicated to this action. The larger the data bus, the more data can be carried from the CPU to memory in one clock cycle.

Here's an illustration. What would happen if 50 people needed to go from one end of the city to the other, but a city bus had only 25 available seats? The answer is simple. The bus would make two trips. But wouldn't it be more efficient to get a larger bus? If you upgraded the bus to 50 seats, the bus would have to make only one trip to transfer the 50 people from one end of the city to the other, which increases the efficiency of the public transit system.

The data bus works the same way, only it transfers data in the form of *bits* (a single bit is either a one or a zero). All data processed by the computer is in the form of bits. The data bus has a "full capacity" point at which it cannot handle any more bits of data, just as the bus system in the city has a "full capacity" point (measured in "seats").

If a processor has a 16-bit data bus, it means that it can deliver at most 16 bits during a single clock cycle. If the same processor needs to deliver 32 bits of information, it will have to take two trips, send 16 bits during the first clock cycle and the remaining 16 bits during the next clock cycle. Taking that same 32 bits of information and processing it on a 32-bit processor means that the information will be delivered in one trip — one clock cycle — as opposed to two, which increases the overall efficiency of the system.

Address bus

Figure 2-1 shows how system memory is organized like a spreadsheet, in rows and columns. These rows and columns make up blocks that can be written to and read from. If you want to store information in one of the blocks, you have to reference the location by address. For example, you may store data in cell B2.

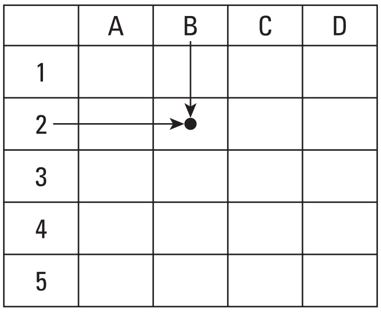


Figure 2-1: How system memory is organized.

To store information into system memory, your processor has to give an address that points to a particular storage location, only the address doesn't look like "B2." It looks something like "10," or maybe "11," which are two completely different memory locations and, as a result, the data would get stored in two different blocks.

Your processor accesses memory locations through the *address bus.* If, for example, the address bus is two-bit, the processor has two address lines from the processor to system memory. The *address lines* carry signals that specify locations in memory, each with an on/off state. A "1" represents an on state, and "0" represents an off state. The combination of the on/off states of both address lines at any given time is how a reference to an area in memory is made. The left side of Figure 2-2 illustrates a processor making a reference, or *call,* to Address 10, while the right side shows a reference to Address 11. These two address calls reference completely different locations in memory.

If you add another address line to the address bus, the processor can access even more possible addresses because the processor has more variations with three bits than with two. A two-bit address bus can make a reference to four possible memory addresses (2×2), while a three-bit address bus can make a reference to eight possible memory addresses ($2 \times 2 \times 2$).

Therefore, the address bus dictates how much physical memory the processor can access. For example, an old 80286 processor has a 24-bit address bus, which means that it can access 16,777,216 (2^{24}) memory addresses, or 16MB of system memory. Newer processors have 36-bit address buses, which allows them to access 68,719,476,736 memory addresses, or 64GB of memory.

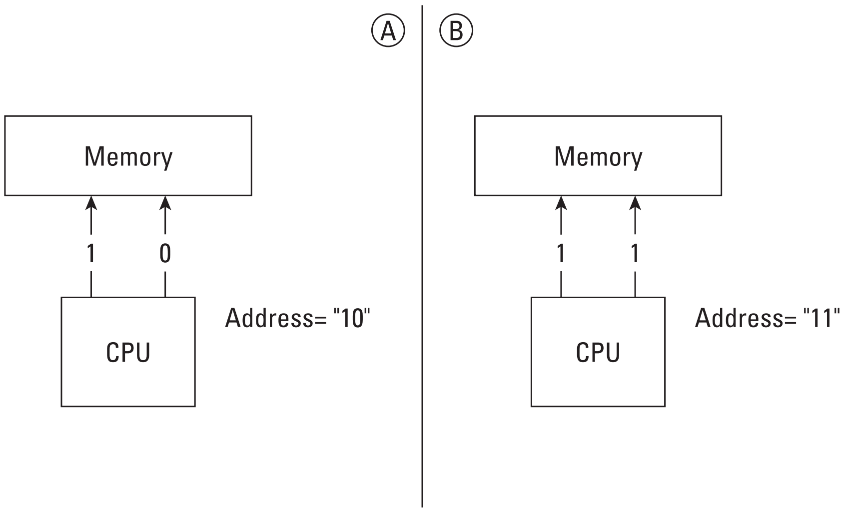


Figure 2-2: Accessing two different memory addresses with the address bus.

Registers

Registers are storage areas within the processor used to store data temporarily for manipulation later. They are used to store and process data and perhaps write back the result of the processed data. The benefit of storing this information in the registers instead of in memory is that the processor contains the information and does not have to retrieve it from memory — which takes time. It is as if information to be processed were in your pocket, rather than across a room, where you would have to walk all the way over and pick it up. Having information in your pocket means it can be accessed much more quickly, saving time and increasing performance. Registers give a processor quicker access to data, and the more registers a processor has, the more data it can store.

Registers are measured in bits. A processor with 16-bit registers has 16 containers into which a programmer can choose to store information, while a processor with 32-bit registers has twice as many containers that it can use to store information.

Cache memory

The processor accesses information that resides in system memory, which is a slower process than if the information is stored in the processor's own special "high-speed memory," known as *cache memory.* When the information is sitting in system memory and the processor sends a request for that information, the request goes to the *memory controller*, which manages data in memory. The memory controller finds the data in memory, retrieves it, and delivers it to the processor. Throughout this entire process, the processor is simply "waiting around" for the information. Thus, many of the newer processors include their own special high-speed memory within the processor's chip.

When the processor retrieves information from slower system memory, it then stores it in the high-speed cache in case the processor wants to access the information a second time. The benefit is that the second time the data is needed, it is sitting in the high-speed memory located on the processor chip. The processor will not need to sit around and wait for the data to come from system memory — again increasing overall performance.

Cache memory is integrated right into the processor's chip and is made up of *static RAM (SRAM).* For more information on SRAM check out Book II, Chapter 3. Cache memory is very expensive because it is much quicker than regular system memory. As a result of this extra memory being integrated into the processor chip, the processor becomes more expensive than a processor that has less or no cache memory.

There are two types of cache memory: *Level 1 (L1) cache* and *Level 2 (L2) cache.* L1 cache is built into the processor, whereas L2 cache resides outside the processor. In the past, L2 cache resided on the motherboard, but newer processors have a bit of L1 and L2 cache in the chip package. If you upgrade the cache memory on your computer, you are adding L2 cache to the motherboard — you wouldn't be able to upgrade the L1 cache on the processor. Because L1 cache is built into the chip, you can't upgrade it without replacing the entire processor.

The integration of cache memory into processor chips didn't come to market until the 80486 chips were developed in 1989. Generally, 80486 chips had 8K of L1 cache, and the Pentium chip increased that amount to 16K. In fact, many of the newer processors have increased the L1 cache to over 16K and have also included some L2 cache. The more cache memory a processor has, the quicker (and more expensive) the system will be.

Math co-processor

The *math co-processor,* also known as the *Numeric Processing Unit (NPU),* is the processor's sidekick. Systems that have math co-processors can well outperform systems that do not have math co-processors because the math co-processor takes some of the workload off the CPU. For example, it performs many of the large calculations that applications may require, such as floating point arithmetic. Overall system performance increases because the CPU can focus on logic functions while the math co-processor executes complicated mathematical functions.

If you have large spreadsheets or use large graphics applications, you may find that applications run very poorly or not at all on systems without a math co-processor. If you are running a system that does not have a math co-processor integrated into the CPU, then you can add one to the motherboard — or perhaps upgrade the main processor.

In earlier computers, the processor was one chip and the math co-processor was a separate chip on the motherboard. For example, years ago, a 386 computer used an 80386 chip on the motherboard as the processor, but you could add an 80387 chip to the board to act as the math co-processor. All processors since the 80486 computer, including Pentium-class systems, have a math co-processor integrated into the processor's chip, so you will not be adding a math coprocessor to the system.

Real-mode versus protected-mode

A *real-mode* processor is a processor that sees memory as a whole unit and deals with it as a single entity. In other words, if you have 512MB of RAM, the real-mode processor sees that as one block of memory. This is limiting because in order to run multiple programs at the same time, each program has to be assigned its own independent block of that 512MB — something that real-mode processors cannot do. As a result, real-mode processors don't have any *multitasking* capabilities — the capabilities to divide memory up into multiple parts and run different applications or tasks in each part.

Protected-mode processors support the segregation of system memory into different parts and assigning a different application to each part of memory. Therefore, protected-mode processors support multitasking and multitasking operating systems, such as Windows 2000 and Windows XP.

Protected-mode processors also support *virtual memory,* which is the process of using hard disk space as emulated memory. This means you could increase your 512MB of RAM by using 768MB of hard disk space as "pretend" RAM. In this case, as far as the applications that are running are concerned, the system has 1280MB of memory — the combination of true memory plus virtual memory.

MMX

After the Pentium was developed, Intel introduced a feature called *MultiMedia eXtensions*, or *MMX*. MMX added 57 new instructions that were built into the processor and told the system how to work with audio, video, and graphics. If these instructions were not built into the processor, the processor would have to retrieve them from somewhere else.

At the time MMX was developed, both the home and business user seemed to be heading toward the world of multimedia, and it made sense to enhance the processor and make it "multimedia-aware." Running any kind of multimedia application on a processor that supports MMX gives you a major performance increase over a processor that doesn't support MMX technology.

Hyperthreading

Hyperthreading is a feature designed by Intel that was placed in the Pentium processors. *Hyperthreading technology,* or *HTT,* allows a processor to logically act as two different processors by being able to execute simultaneous threads. A *thread* is a part of an application that executes at any given time. For example, when running Microsoft Word, one thread accepts keystrokes, and another thread runs the spell checker while you type — two parts of the application run at the same time.

In order for a system to truly be able to take advantage of multithreaded applications, you normally need a system that has multiple processors — one processor to run one thread at a time. With hyperthreading, one processor is able to run more than one thread at a time, increasing performance by 15 to 30 percent.

Dual core processors

A *dual core* processor combines two independent processors and the L1 cache from those processors onto a single processor chip. The benefit of a dual core processor is that it can execute multiple threads at the same time without hyperthreading because you essentially have two processors.

A dual core processor has the benefit of having two processors' core features packaged into one physical processor. The core features include pipelines and cache memory. A dual core processor can benefit from the two processors' combined L1 cache on the same chip, meaning that each of the processors in the dual core each have a block of L1 cache available. The dual core processor also has a block of shared L2 cache between the two processors in the dual core chip.

A huge benefit of being only one chip on the motherboard is that the one dual core chip draws less power than two separate processors would. Figure 2-3 shows the logical view of a dual core processor.

Throttling

Throttling is a feature built into a lot of newer processors today and involves the CPU sensing when it is going to overheat and then reduces its speed to lower the heat to an acceptable range.

Processors that support throttling have a built-in thermal sensor (a high-tech thermometer) that monitors the temperature of the processor. When the processor detects that it is going to overheat, maybe due to a fan failure, the processor drops its speed so the temperature drops to an acceptable range.

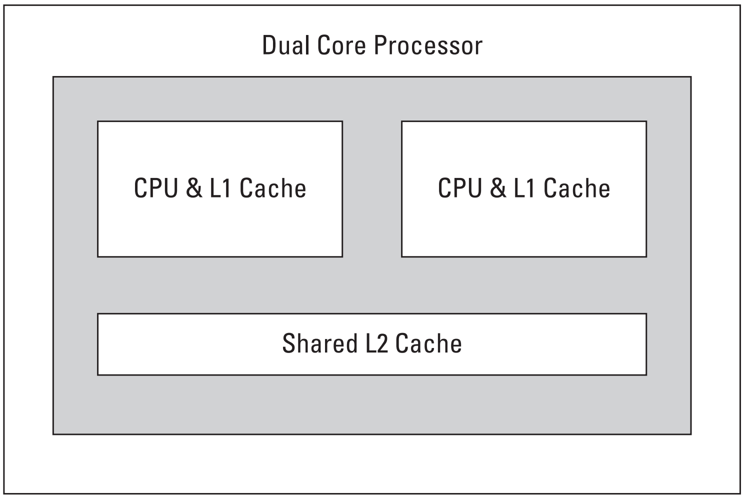


Figure 2-3: Looking at the logical structure of a dual core processor.

Overclocking

Overclocking is a big feature for PC enthusiasts and involves running a piece of hardware faster than the speed at which it is rated. A number of devices can be overclocked, such as video adapters and, of course, processors.

Although you may be able to overclock the processor, it is not recommended because overclocking can result in an unstable system or even hardware failure.

VRM

The *Voltage Regulator Module (VRM)* is responsible for regulating the voltage that is delivered to the processor. The VRM is located on the motherboard or appears as its own device in the system and provides the correct running voltage to the processor.

Some VRMs use a jumper on the motherboard to determine how much voltage is supplied to the processor, while other VRMs sense what the processor needs on startup. Typically, VRMs on the motherboard sense what voltage the processor needs and then supply that voltage.

Chip packaging

The term *chip packaging* refers to how the chip is constructed and delivered to the consumer. The chip package defines the appearance or form factor of the chip. Many chip packages have been used over the years.

The chip packages you should be familiar with for the A+ exam are as follows:

- **Dual Inline Package (DIP) chip:** A rectangular chip with two rows of 20 pins. Pin 1 is located at the end of the chip that has a square notch carved into it. It is important to identify Pin 1 because when you add a DIP chip to the motherboard, you will have to match Pin 1 on the chip with Pin 1 in the chip socket.

  Older processors, such as the 8088 and many math co-processor chips, use the DIP chip style. Although they are no longer used for CPUs, DIP chips are still used for cache memory and BIOS chips on motherboards. They are also found on memory modules. (See Book II, Chapter 3, for a discussion of memory modules.)
- **Pin Grid Array (PGA) chip:** One of the most popular processor chip packages in use today, the PGA chip is a square chip that has an array of pins filling up the shape of the chip. In general, the PGA chip uses hundreds of pins. You can locate Pin 1 on the PGA by identifying the corner of the PGA chip that has the corner cut off — that corner is where Pin 1 is located. Figure 2-4 compares a DIP (right side) with a PGA (left side) chip type.

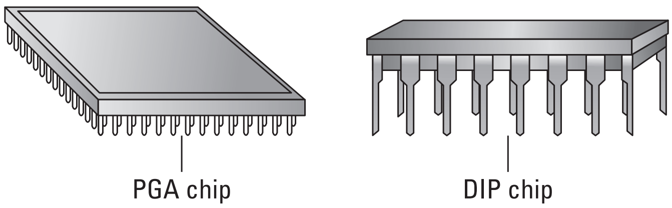


Figure 2-4: Comparing a DIP chip package (right) to a PGA package (left).

Today's implementation of the PGA chip fits into a *Zero Insertion Force (ZIF)* socket. The ZIF socket is ideal for upgrading processors compared to the days before ZIF sockets were used because the ZIF socket has a lever on the side of the socket that you pull up on, which raises the chip out of the socket. Because the chip is automatically raised out of the socket, it allows you to simply remove the chip out of the socket with little effort! Before ZIF sockets were used, you had to pry the chip out of the socket trying to ensure that you did not damage the chip or the pins. With the ZIF socket, after the processor is raised, you can replace the old chip with a new one. In the past, not all boards used ZIF sockets, so you had to get some special extractors to pull the chip out (carefully!). Figure 2-5 shows a ZIF socket.

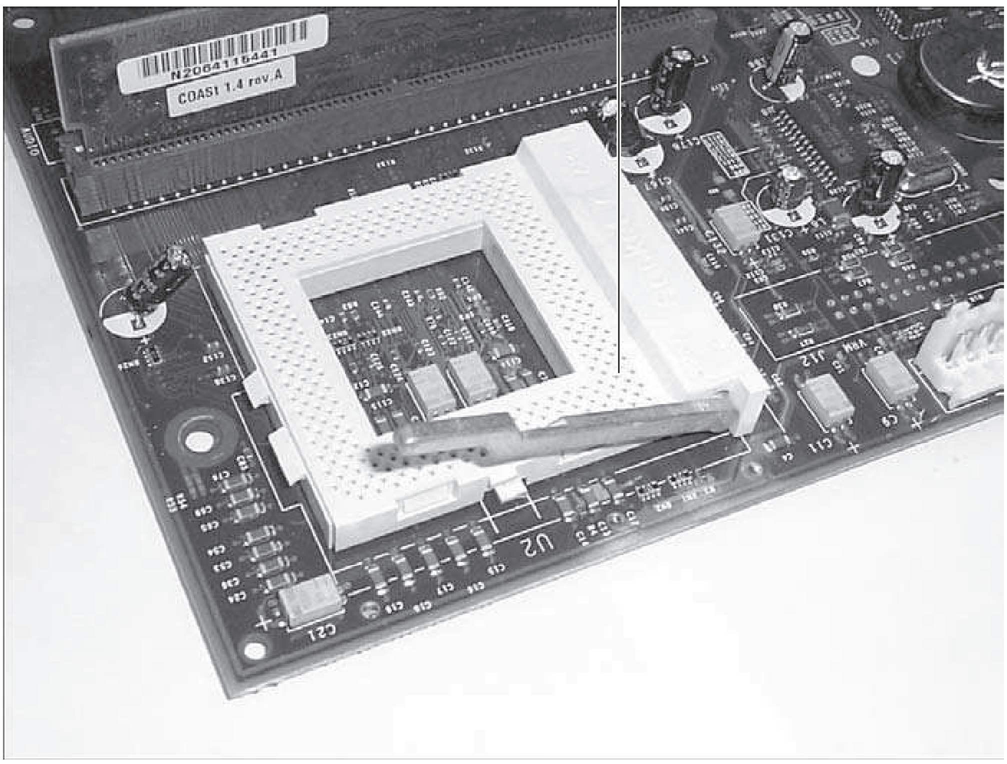
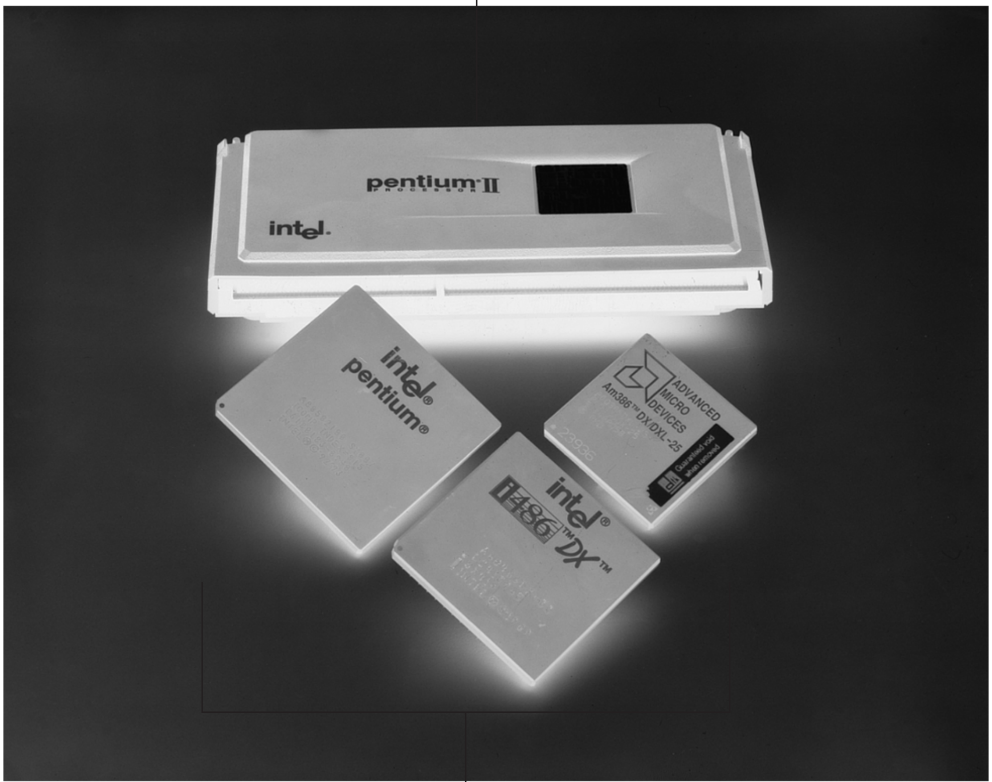


Figure 2-5: A ZIF socket on the motherboard holds a processor.

✦ **Single Edge Contact (SEC) chip:** A chip package type that was popular with the Pentium II processors, the SEC chip is a huge cartridge surrounded by a plastic casing. The newer version, SEC2, is implemented as a card that is inserted into a slot on the motherboard and doesn't have the big plastic casing around it. It is important to stress that the SEC and SEC2 are inserted into a slot and not a socket. For more information on slots and sockets, read the next section. Figure 2-6 shows an SEC chip package along with some PGA chip packages.

Be sure to remember the different chip package types for the A+ exams. The Pentium II processor used the SEC, while the newer processors such as the Pentium 4 are using the PGA.

SEC chip



PGA chips

Figure 2-6: An SEC chip package along with some PGA chip packages.

Identifying Socket Types

Intel decided to develop a new standard for upgrading a processor on motherboards, beginning with the 80486 chips and continuing with the Pentium-class processors. This standard was called processor sockets. A *processor socket* is a socket designed to hold a specific processor chip with the appropriate number of pins. This enabled Intel to develop new chips with compatibility of a particular socket in mind. For example, if a socket is developed with 321 pins, Intel could develop a new processor that has 321 pins and know that the processor will work with any motherboard that has the right socket. This allows the consumer to upgrade a processor much easier than in the past. Intel could design a new chip for an old socket so that customers could update their computers by dropping the new processor in the compatible socket.

Original Pentium processors supported mainly Socket 5 with 320 pins or Socket 7 with 321 pins. Thus, to add a Pentium processor to a motherboard, you would have to find out what socket existed on that board and then purchase a CPU that would fit in that socket. You would also have to remember to match the voltage of the board to the voltage required by the CPU. Figure 2-7 will help you identify a CPU socket in your system.

The sockets are normally labeled with the type of socket it is along the side of the socket. For example, notice in the figure that the socket is labeled as PGA 370, meaning it's Socket 370 and will hold any processor designed for socket 370. Socket 370 is a socket that holds a processor containing 370 pins.

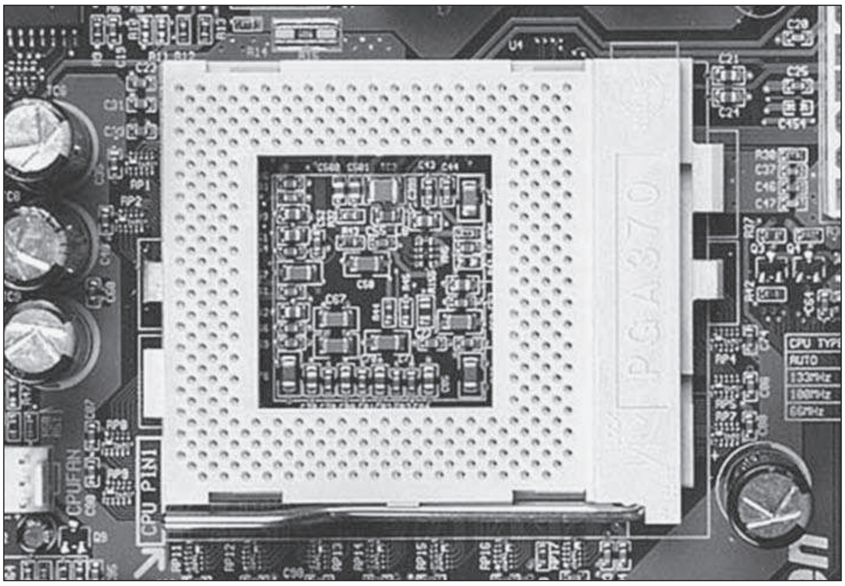


Figure 2-7: Identifying a processor socket.

Table 2-1 lists the different types of sockets and the processors that are placed in the sockets. For more information about the processors, read the sections, "Looking at Popular Intel Processors" and "Don't Forget Non-Intel Chips," later in this chapter. Table 2-1 also shows the number of pins associated with the different types of sockets.

Table 2-1 Processor Socket Types

Socket	*Processor*	*Number of Pins*
Socket A	Later Athlon, Duron, and Athlon XP	462
Socket 1	80486, 80486DX2, 80486DX4	169
Socket 2	80486, 80486DX2, 80486DX4	238
Socket 3	80486, 80486DX2, 80486DX4	237
Socket 4	Pentium 60/66	273
Socket 5	Pentium 75-133	320
Socket 7	Pentium 75-200	321

Socket	Processor	Number of Pins
Socket 8	Pentium Pro	387
Socket 370	Celeron and Pentium III	370
Socket 418	Itanium	418
Socket 423	Pentium 4	423
Socket 478	Later Celerons and Pentium 4	478
Socket 603	Xeon (Pentium 4 version)	603
Socket 611	Itanium	611
Socket 940	Opteron	940
Slot A	Athlon	242
Slot 1	Pentium II and Pentium III	242
Slot 2	Xeon	330

FOR THE EXAM

It is important to know the socket types used to hold the Pentium II, Pentium III, Pentium 4, Celeron, Athlon, Athlon XP, and Duron processors. You will not be expected to memorize the entire chart, but you should be familiar with the sockets used by today's popular processors.

Originally, the sockets were simply called Socket 1, Socket 2, and so on up to Socket 8. To make it easier to understand what processors went into which sockets, Intel started naming the sockets after the number of pins that existed on the processor that the socket would support. For example, Socket 370 holds a processor with 370 pins, while Socket 478 holds a processor with 478 pins. It is much easier now to identify what processors go into which sockets!

Now that you understand some of the characteristics of processors and you understand what a socket is, take a look at some of the popular Intel and AMD chips you are expected to know for the A+ exams.

Looking at Popular Intel Processors

In this section, I provide an overview of the Pentium-class processors and their characteristics, including data bus, address bus, registers, and the amount of cache memory supported on these processors. You will also be introduced to any new or unique processor features that each processor offers.

Pentium

The original Pentium processor was released in 1993 and was developed at speeds of 60 MHz and 66 MHz. The Pentium processor was a PGA chip that was placed in Socket 5 or Socket 7. Soon after its release, Intel marketed

Pentium processors in 75 MHz, 90 MHz, 100 MHz, 120 MHz, 133 MHz, 150 MHz, 166 MHz, and 200 MHz flavors, which were really just clock multipliers of the original 60 MHz or 66 MHz systems.

Clock multiplying is the concept that the processor will run faster than the motherboard that the processor sits in. For example, the original Pentium processor ran on 60 or 66 MHz motherboards. Say that the computer is marketed as being a Pentium 90. Since we know that the motherboard runs at 60 or 66 MHz, we can determine that the 90 comes from 60 * 1.5 — meaning that the processor runs 1.5 times the speed of the motherboard. This is important because, as a consumer, when you purchase a computer, you want to make sure you know what the motherboard speed is, too, not just the advertised speed of the processor.

From a consumer's point of view, clock multipliers become important when you take a look at computers such as the Pentium 133 and the Pentium 150. Which is faster? The obvious answer is the Pentium 150, the system with the higher megahertz speed. But is it really? The Pentium 133 is a clock double of the 66 MHz board, while the Pentium 150 is a clock double and a half of the 60 MHz board. My point being that the overall performance of the system is controlled by more than just the speed of the processor — you need to consider other components such as the speed of the motherboard.

By looking at the motherboard speeds of the Pentium 133 and the Pentium 150, you could assume that the computer running the Pentium 133 may be able to keep up with, if not outperform, the one running the Pentium 150. Table 2-2 compares the speed of the motherboard and processor for the different Pentium systems.

Table 2-2 Pentium Clock Multipliers

Processor	*Motherboard Speed (MHz)*	*Multiplier*	*Processor Speed (MHz)*
Pentium 90	60	1.5	90
Pentium 100	66	1.5	99
Pentium 120	60	2	120
Pentium 133	66	2	132
Pentium 150	60	2.5	150
Pentium 180	60	3	180
Pentium 200	66	3	198
Pentium II	100	4.5	450

The Pentium processor has a 32-bit address bus, 32-bit registers, and a 64-bit data bus. It also has 16K of L1 cache that is divided into two 8K channels. One channel is for data cache and the other for application code cache.

Before the Pentium came along, processors used one *instruction pipeline*. This meant that when an application executed, it would run each stage of the application job one step after the other. For example, if an application has three lines of code, as seen in Figure 2-8, each line of code can only be processed after the previous line of code is fully completed. This creates a delay, or wait time, that slows performance.

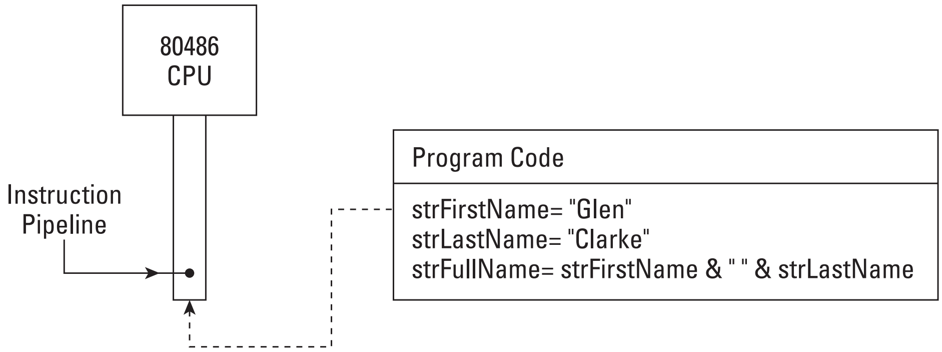


Figure 2-8: Single instruction pipelined processor executing application code.

The Pentium processor introduced a feature called *superscalar design*, which is the fact that the processor has two instruction pipelines, named U and V. Having two instruction pipelines enables the processor to execute two instructions at the same time. Thus, the three lines of program code, shown in Figure 2-9, can be quickly executed on a Pentium processor because Lines 1 and 2 are processed at the same time, causing Line 3 to be processed that much sooner. Notice that Lines 1 and 2 execute parallel to one another; therefore, *parallel processing* is taking place.

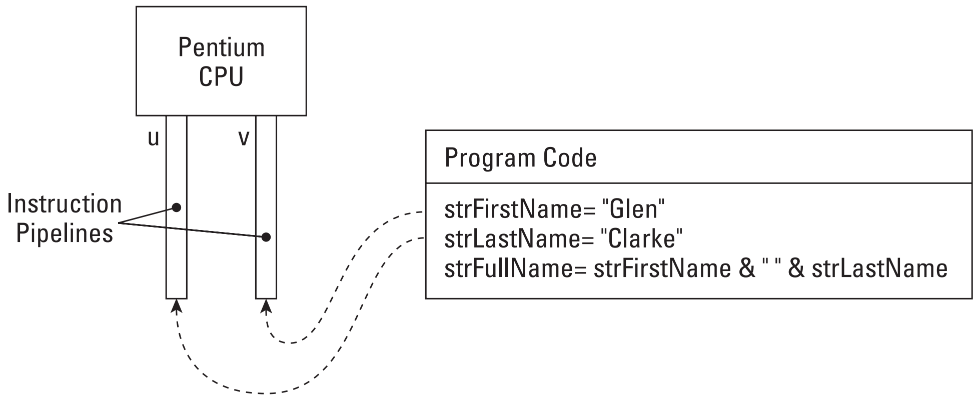


Figure 2-9: Dual instruction pipelined processor processing application code.

An application has to be designed to take advantage of two instruction pipelines. These applications are often labeled something like “Pentium Aware” or “Pentium Ready.”

Pentium Pro

In 1995, Intel released the Pentium Pro chip, which added a new level of performance to the Pentium processor. The Pentium Pro had all the characteristics of the Pentium processor — such as a 64-bit data bus and 32-bit registers — but it increased the address bus to 36 bits, which means that the Pentium Pro can access 64GB of RAM. The speed of the Pentium Pro ranges from 120 MHz to around 200 MHz.

The Pentium Pro includes two additional features on its chip that help it outperform the original Pentium. First, the Pentium Pro chip is really a two-chip team. One chip was the actual processor (with 16K of L1 cache, like the Pentium chip), but the other chip holds an extra 256K of cache memory. Since this cache memory is physically outside of the CPU, it is considered L2 cache.

The second feature that leads to the performance gain of the Pentium Pro is what is known as *dynamic execution.* Dynamic execution has three stages: multiple branch prediction, dataflow analysis, and speculative execution.

- **Multiple branch prediction** is the idea that the processor will look ahead and predict a number of instructions that may be needed in the very near future.
- **Dataflow analysis** occurs when the processor looks at the instructions it has predicted will be needed next and then assigns them a logical order of execution.
- **Speculative execution** is the actual execution of a given instruction based on the prediction and the order of execution assigned.

The Pentium Pro chip, shown in Figure 2-10, was implemented as a PGA chip that was placed in Socket 8.

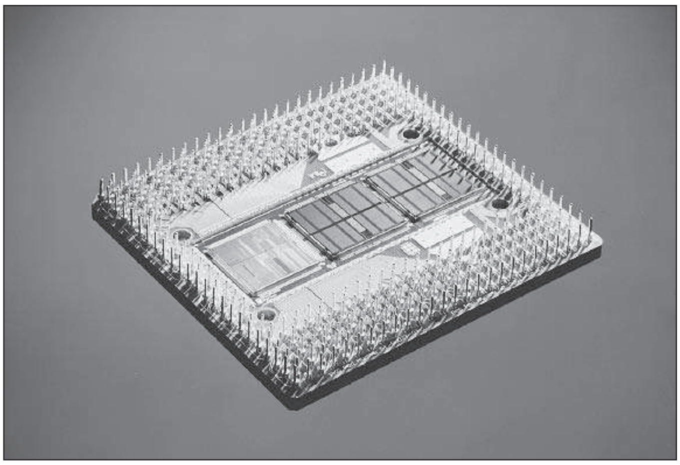


Figure 2-10: The Intel Pentium Pro processor.

Pentium II

In 1997, Intel produced the Pentium II, which was really just an enhanced Pentium Pro with speeds ranging from 233 MHz to 450 MHz. The Pentium II had a 64-bit data bus, a 36-bit address bus (64GB of RAM), and 64-bit registers and supports features such as MMX.

The Pentium II increased the amount of L1 cache that was integrated into the CPU to 32K, as opposed to 16K. The 32K of L1 cache was still divided into two equal channels: one 16K channel for data and one 16K channel for application code.

Intel packaged the Pentium II in the *Single Edge Contact* (SEC), sometimes also referred to as the *Single Edge Contact Connector (SECC),* that fits into Slot 1 on the motherboard. The SEC is a module enclosed in a casing or shell with two chips inside, one chip being the processor and the other chip being the 512K of L2 cache. Refer to Figure 2-9 to see what a Pentium II processor, which uses the SEC, looks like.

Another enhancement that accompanied the Pentium II was *Single Instruction Multiple Data (SIMD).* To visualize how SIMD works, imagine five toddlers in a playroom, and that these toddlers are at the entertaining age of two — the age, of course, when the toddlers are preparing for their teen years by answering "no" to everything you say. You walk into the playroom and see that the five toddlers have found your box of darts and are throwing them at the walls. You are faced with a choice: You can either walk around to each child and explain why throwing darts at your walls is not a good idea (which means you will have to explain the same thing five different times), or you can have a good scream at the top of your lungs, which means that all the children will stop immediately and listen. SIMD works on the same basic principle. With SIMD, the processor gives the instruction to multiple processes at once — instead of having to give the same instruction multiple times. Thus, the processor saves time and creates a much more efficient way to work with information.

Celeron

The Pentium II processor performs very well, and with all that cache memory, it should! Unfortunately, that performance comes with a price. If you are not willing to pay that price, Intel has created a chip for you: the Celeron chip!

The Celeron chip is nothing more than a less-expensive version of the Pentium II processor with the built-in L2 cache either removed entirely or reduced. The first-generation Celeron chip was code-named the Covington; it has no L2 cache memory on it. The second-generation Celeron was code-named the Mendocino, and it contains 128K of L2 cache. Although this version of the Celeron does have L2 cache, it is dramatically reduced from the Pentium II's 512K so that it can be sold at a lower price.

The original Celeron shipped in an SEC package but also had a version that was packaged as a PGA, as shown in Figure 2-11.

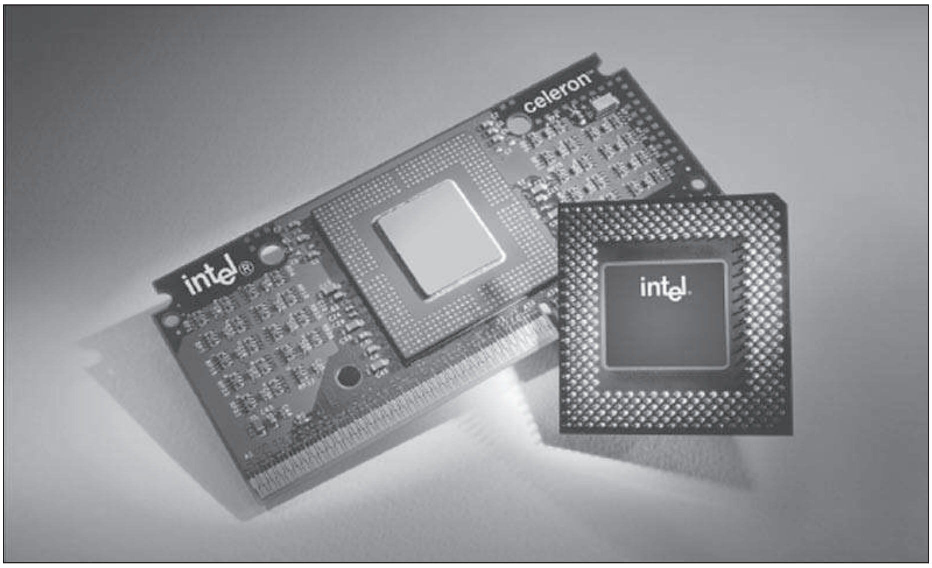


Figure 2-11: Intel's Celeron processor was first implemented as an SEC package, but later had a PGA chip that was placed in Socket 370.

Pentium III

The Pentium III processor shares many of the Pentium II's characteristics. It supports dynamic execution (as the Pentium Pro also did) and MMX technology, has 32K of L1 cache, and has either 256K or 512K of L2 cache. The Pentium III runs at a speed of 450 MHz to 1000 MHz, or 1 GHz.

The Pentium III chip offers 70 additional instructions that are integrated into the chip, enhancing the user's experience with 3-D graphic applications. The Pentium III chip also supports a number of low-power states to help conserve energy when the system is not in use. This processor is designed to run on either 100 MHz or 133 MHz motherboards.

Also note that there is a Pentium III version of the Celeron chip that runs as fast as the Pentium III processor but again has the L2 cache memory reduced. So now there are multiple versions of the Celeron chip — the PII version and the PIII version.

The Pentium III processor shipped in the SEC2 package (shown in Figure 2-12) originally, but was then packaged as a PGA chip. The SEC2 goes in Slot 1, while the PGA chip is inserted into Socket 370.

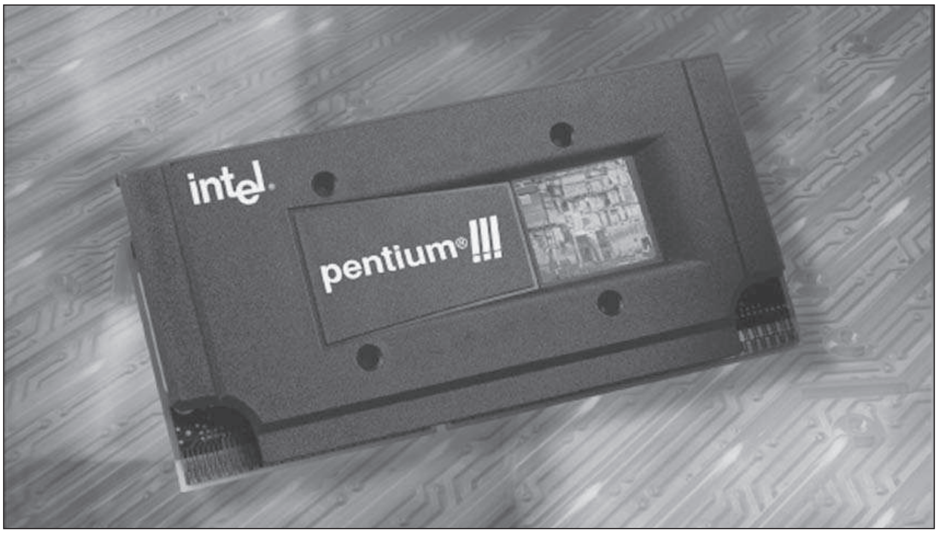


Figure 2-12: The Pentium III processor in the SEC2 package that lives in Slot 1.

Xeon

The Xeon processor is built on the Pentium II and Pentium III architecture — meaning that, like the Celeron, there is a PII version and PIII version of the Xeon. The Xeon chip is designed for higher-end systems, such as server-class systems, and contains more cache memory than the typical PII and PIII. The Xeon comes in flavors of 512K, 1MB, and 2MB of L2 cache.

The Xeon can also address 64GB of RAM and is designed for multiprocessing systems. A *multiprocessing system* is a computer with a motherboard that supports multiple CPUs. The Xeon processor has been designed to coexist with two, four, or eight CPUs.

The Pentium II Xeon and Pentium III Xeon chips were originally packaged as an SEC (shown in Figure 2-13) that was placed in Slot 2, but later versions use the PGA and are placed in Socket 603. The Xeon chip also contains a thermal sensor that shuts the processor down if it starts to overheat.

The Celeron is a scaled-down version of the Pentium II or III processor, and the Xeon is a step up from the Pentium II or III. There are also PIV (Pentium 4) versions of the processors:

- **PIV XEON:** Designed to work with a multiprocessing system that uses one or two processors.
- **PIV XEON MP:** Designed to work with a multiprocessing system that uses four or eight processors.

Figure 2-13: The Pentium II Xeon processor was originally delivered in the SEC package.

Pentium 4

The Pentium 4 processor runs at between 2 GHz and 4 GHz. The Pentium processor has 20K of L1 cache and 512K of L2 cache. The processor is shipped as a 423-pin or 478-pin PGA package, which means that the chip will be placed in Socket 423 or Socket 478 (shown in Figure 2-14).

The Pentium 4 processor gets a huge performance benefit by being able to perform four data transfers in one clock cycle along the *front side bus (FSB).* The FSB is the bus that connects the processor to system memory (see Chapter 1 of this minibook).

Itanium and Itanium II

Intel created its first 64-bit processor in the Itanium and Itanium II processors. Because they were designed as 64-bit processors, you will be able to run 32-bit code on them, such as most copies of Windows and Office applications, but you will not be leveraging the 64-bit architecture by running 32-bit code. Special 64-bit editions of Windows can run on the Itanium processor, which enables you to take advantage of the 64-bit architecture. To learn more about the 64-bit editions of Windows, check out `www.microsoft.com/windowsxp/64bit`.

The original Itanium processor used a special packaging known as the *Pin Array Cartridge (PAC),* which uses 418 pins, while the Itanium II was packaged in *Organic Land Grid Array (OLGA)* — which is a variation of the PGA, but the chip is located on a *processor card* (a circuit board that holds the processor). The OLGA fits into Socket 611.

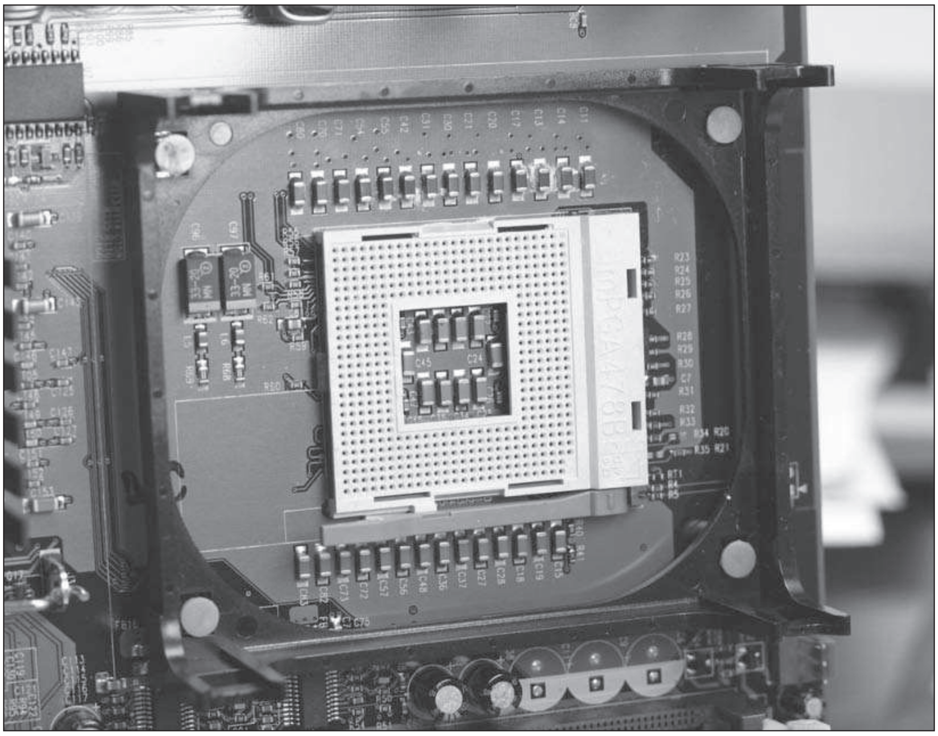


Figure 2-14: Socket 478 can house a Pentium 4 processor.

The Itanium processor runs at around 1 GHz and contains a large block of cache memory: 32K of L1 cache, 96K of L2 cache, and 2MB or 4MB of L3 cache. The L3 cache is an additional block of cache memory located in the chip packaging.

Moving from 32-bit processors and applications to 64-bit versions would truly benefit any user that is using applications that are memory-intensive or calculation-intensive. For example, a user who works a lot with multimedia-type applications would see an improvement in performance.

Pentium "M"

For years, laptop manufacturers have been asking for smaller processors to place in laptop systems, and they finally have their wish. A number of processors have come out with the "M" version, which stands for *mobile.* The mobile version of the processors are smaller than the processors that go in desktop systems, so they will fit better and also use a lot less power. The benefit of using less power also means that they run much cooler.

Because the mobile versions of the processors use less power, they also are going to run a little slower than their desktop counterparts.

Some popular brands of mobile processors are the Intel Pentium III M and the Pentium M. Intel's big competitor, AMD, also has mobile versions of their processors: Athlon XP M and Mobile Duron. (Some manufacturers put the word *mobile* in the name of the processor instead of the letter *M.*) The next sections discuss more about AMD processors.

Don't Forget Non-Intel Chips

One of Intel's major competitors is *Advanced Micro Devices, Inc.* AMD has developed a family of processors that compete with the Pentium-class processors. In this section, I provide an overview of some of the characteristics of the AMD processors.

K6

The AMD K6 processor was designed to compete with the original Intel Pentium. The K6 has 64K of L1 cache, supports MMX technology, and has built-in branch prediction techniques. This processor has 321 pins, which means that it will fit into a Socket 7–supported motherboard.

K6-2

The K6-2 processor was designed to compete with the Pentium II chip. It has 64K of L1 cache and 256K of L2 cache. The K6-2 also supports dynamic execution, MMX technology, and superscalar design.

The K6-2 has added 3DNow! Technology — a number of additional instructions integrated into the chip to improve 3-D graphics applications. The K6-2 chip also uses a 100 MHz motherboard speed, which is a big improvement over the 60/66 MHz motherboard speed that the original Pentiums were using.

The K6-2 has 321 pins, which means that it will fit into a Socket 7–supported motherboard.

K6-III

The K6-III processor is designed to compete with the Pentium III chip. This chip shares many of the features of the K6-2, including a 100 MHz system bus. One of its new features is a Tri-Level cache. Not only can it take advantage of an L1 and L2 cache but also an L3 cache that can be included on the motherboard.

Athlon

The AMD Athlon chip has 128K of L1 cache and 512K of L2 cache. It supports improved dynamic execution, MMX technology, and 3DNow! Technology. The Athlon chip runs at speeds of up to 1.2 GHz and is designed to run on a 200 MHz system bus speed.

Unlike the K6-2 and K6-III, the Athlon is not a PGA-packaged chip that supports Socket 7. It uses its own socket type, called *Slot A,* because the processor is packaged as an SEC. The Slot A socket is not compatible with Intel's Slot 1, which means users have to purchase a motherboard designed for the Athlon chip.

Later versions of the Athlon moved to the PGA package that has 462 pins. These PGA chips are placed in Socket A.

Athlon XP

After the Athlon chip was produced, Intel created the Pentium 4 chip. So AMD wanted to create a competing chip for the Pentium 4, the Athlon XP. The Athlon XP is packaged as a PGA with 462 pins and is placed in Socket A. The Athlon XP runs at 2 GHz or more and contains 128K of L1 cache and 512K of L2 cache.

AMD markets these processors a little differently. Instead of labeling the processor with its speed, AMD labels it with its competitor's speed. For example, the Athlon XP 1800+ is rated at 1.6 GHz but runs as fast as Intel's 1.8 GHz processor.

Duron

AMD wanted to create a processor that competed with each version of the Intel processors. So, if the Athlon XP competes with the Pentium 4, what competes with the Celeron? You guessed it — the Duron.

The Duron has 128K of L1 cache and 64K of L2 cache. This processor is packaged as a PGA with 462 pins, which means it too goes into socket A.

Opteron

Just as the Duron was built to compete with Intel's Celeron, AMD created the Opteron to compete with Intel's 64-bit Itanium processors. The Opteron runs at about 1.8 GHz and contains 128K of L1 cache and 1MB of L2 cache.

The Opteron is packaged with a Micro-PGA, which is made up of 940-pins and is placed in Socket 940. One of the major differences between the Opteron and the Itanium is that the Itanium cannot run 32-bit applications; AMD decided that the Opteron would run in a 32-bit *or* 64-bit mode, thus allowing it to run 32-bit applications.

Installing a Processor

Now that you understand some of the popular processors that exist today, take a look at how to install a processor. This section identifies installation decisions you have to be aware of before actually attempting to install the processor.

Will it fit in the socket?

The first thing you need to verify before you purchase a new processor for your system is what socket type you have on your motherboard. You want to make sure that you purchase a processor that fits in that socket. For example, if you have Socket A on the motherboard, what processors fit in Socket A? If you said Athlon, Athlon XP, and Duron, you are correct.

Also be sure you know how many pins the socket has, because some processors support a few different-size sockets. For example, Intel makes both Socket 423 and Socket 478 versions of the Pentium 4, so you need to make sure you get the correct version of the Pentium 4 for your socket.

CPU voltage and transistor integration

Another important CPU characteristic that you have to watch for when upgrading your processor is the voltage the processor requires. The *voltage* is the power the processor draws from the main motherboard, which the motherboard receives originally from the power supply.

A processor is designed to run at a certain voltage. You need to ensure that the motherboard you are placing the processor into provides that voltage. If a motherboard supports more than one voltage, you can typically change a jumper on the motherboard, which will then control the voltage used by the processor. For more information on jumpers check out Book II, Chapter 1.

Performing the installation

Because most systems today are using ZIF sockets and PGA chips, I will discuss installing a processor into the ZIF socket. After you have verified that your new processor will work with your motherboard, you are ready to install the processor. To install the processor, first remove the existing one by pulling up on the lever on the ZIF socket. When you pull the lever on the ZIF socket, the existing processor should rise out of the socket a bit.

TIP

Be sure to ground yourself before touching the insides of the computer. It is a great idea to get an antistatic wrist strap and clamp it to the computer's chassis so that you have a constant ground. For more information on safety procedures, refer to Book I, Chapter 3.

When the processor has risen a bit out of the socket, you can then gently lift the processor out (as shown in Figure 2-15). Be sure to lift the processor straight up so that you do not bend any of the pins.

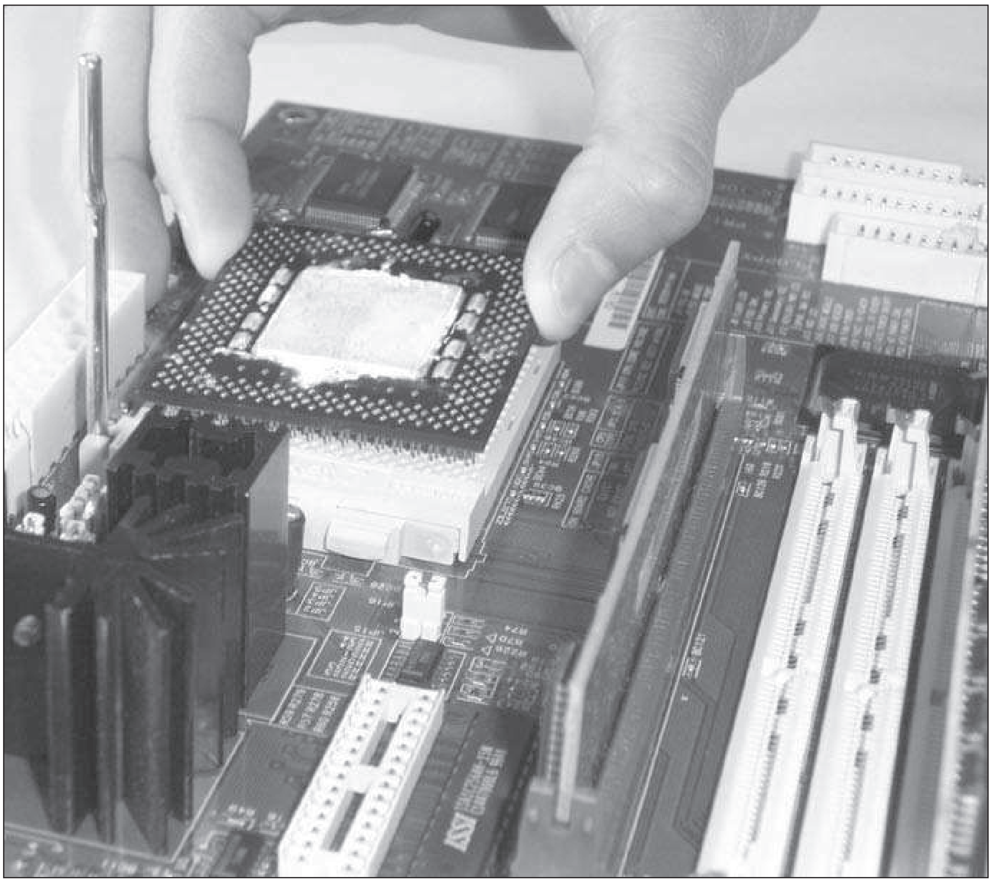


Figure 2-15: Removing the processor from its socket.

After you have the old processor out of the socket, you can install the new processor by first finding out where Pin 1 is on the processor chip. Pin 1 is located in one of the corners of the chip and is usually indicated with a gold line marked on the bottom of the chip that contains the pins. If you don't see a line indicating where Pin 1 is, you will notice that one of corners of the square PGA is cut off (see Figure 2-16) — this corner is Pin 1.

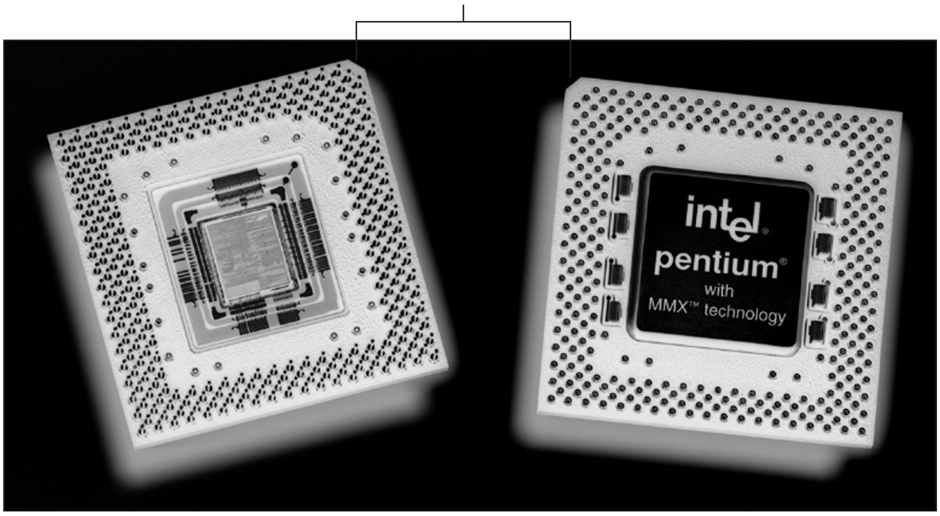


Figure 2-16: The cut-out corner of the processor indicates the location of Pin 1.

After you have located Pin 1 on the PGA chip, you also need to figure out where Pin 1 goes in the socket. Again, you can figure this out by finding the "cut-off" corner of the socket. This corner is where the cut-off corner of the processor goes, as seen in Figure 2-17.

When you have matched up Pin 1 on the PGA chip with Pin 1 on the ZIF socket, carefully place the processor into the socket and then pull the lever down to lock it in place.

WARNING!

Just lay the chip into the socket; don't push it in. The whole point of a *zero insertion force* socket is that you don't have to risk damaging the pins by applying pressure.

Now that you have the processor in the processor socket, you need to install something to keep it cool, such as a heat sink or fan — or maybe even both.

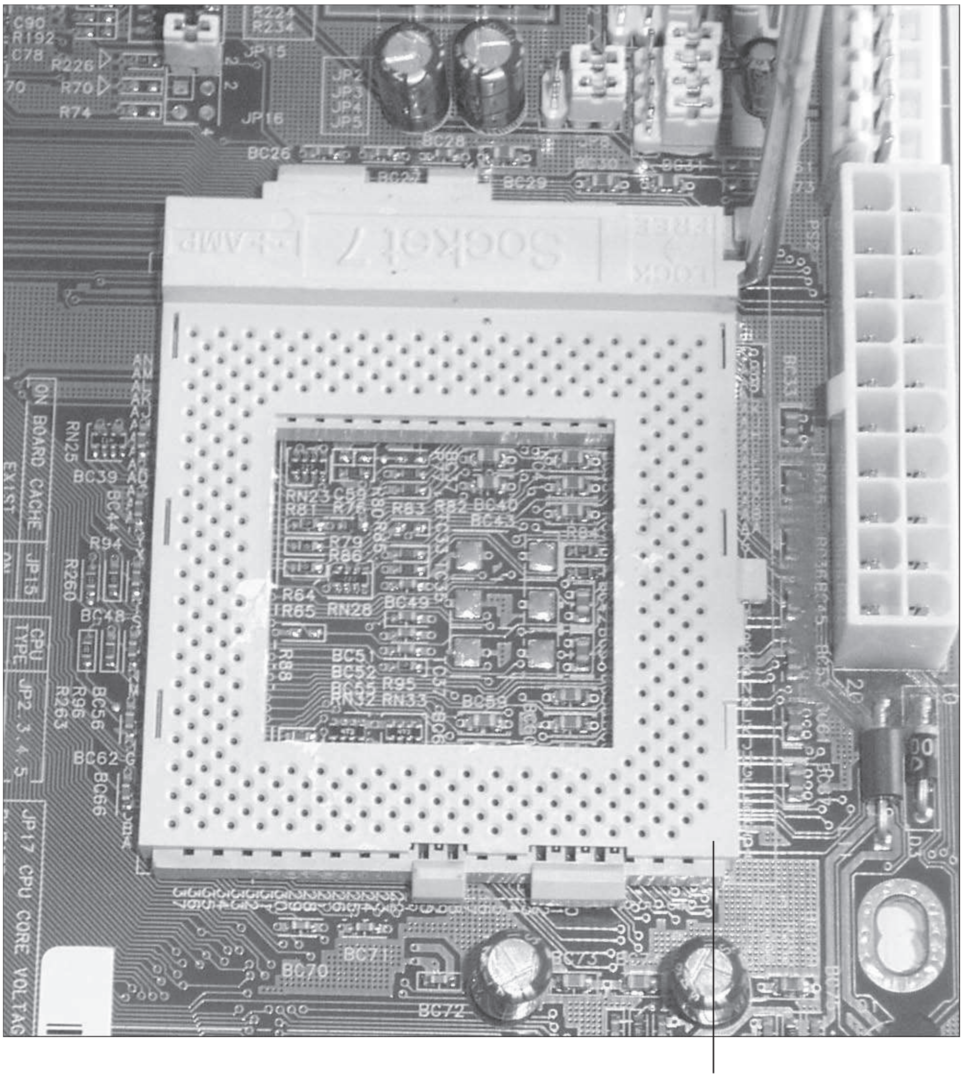


Figure 2-17: Identifying the cut-out corner in the processor socket.

Keeping a Processor Cool

Processors are made up of thousands, even millions, of transistors. A *transistor* acts as a switch, either permitting or prohibiting the flow of electrical current. If current is allowed to flow through the transistor, some result is generated. If the current is not allowed to flow through the transistor, a different result is generated.

A processor contains millions of transistors that each hold an electrical charge, causing the processor to run at very high temperatures. Therefore, it is important that you keep the processor cool. The most common cooling mechanisms today are heat sinks and CPU fans, which are sometimes used in tandem.

A number of other cooling devices are on the market today, and they are a little more expensive than your typical heat sink or CPU fan. The following are other cooling techniques you may find in systems today:

- **Liquid cooling:** A liquid cooling system pumps a cooling liquid throughout the PC by using small hoses. The benefit of a liquid cooling system is the reduced noise, but its big drawback is the amount of space needed in the PC for the components of the cooling system and, of course, the threat of a leak if the cooling system is not installed properly.
- **Temperature sensors:** A number of processors today come with a built-in thermal sensor (a high-tech thermometer). Temperature sensors allow the processor to identify that it is overheating and shut itself down until the temperature drops to normal.
- **Thermal compound:** This is a liquid paste that is placed between the processor and the heat sink to help draw the heat away from the processor and pass it through the heat sink.

Heat sinks and CPU fans

Due to the size of the Pentium processor and the number of transistors passing current, the chip can get so hot that it becomes unstable. Thus, many Pentium processors come with either a cooling fan or heat sinks. A number of processors today have a heat sink with a fan on top of the heat sink.

Heat sinks are a group of metal pins that are placed on the chip to draw heat away from it. A *cooling fan* is a small fan placed on top of the processor to pull the hot air away, helping to keep the processor cool. Figure 2-18 shows a heat sink.

Installing a heat sink and fan

Some processors may get so hot that a heat sink may not be enough of a cooling device; in this case, you may want to place a fan on top of the heat sink. To install the heat sink and fan on your system, simply place the heat sink on the processor and then clamp it in place with the heat sink clamping bar. After you have the heat sink in place, you can secure a fan on top of it by clamping the fan on the heat sink, as shown in Figure 2-19.

FOR THE EXAM

The term passive heat sink is used for a heat sink that does not use a fan on top, while the term *active heat sink* is used for a heat sink with a fan on top.

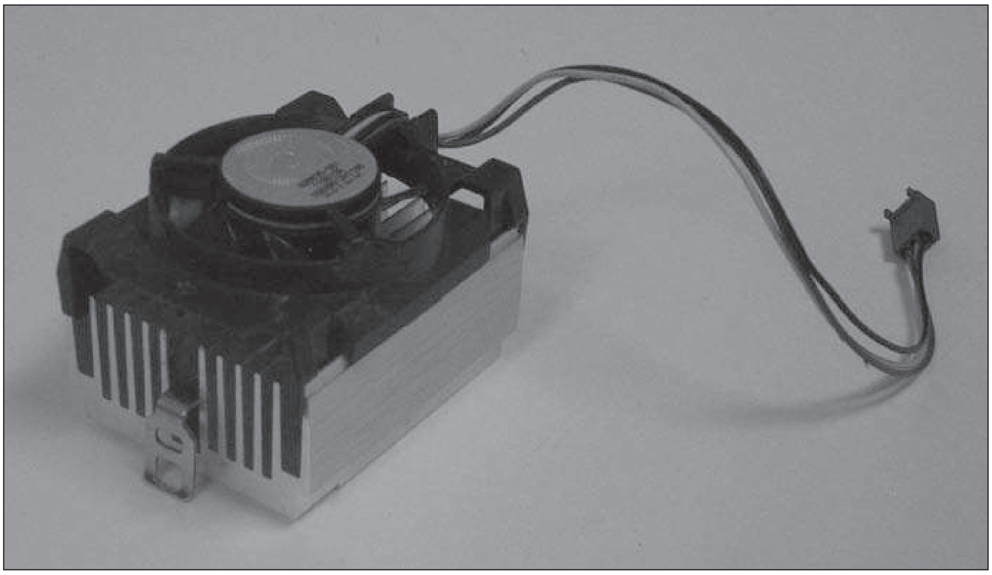


Figure 2-18: Looking at a heat sink.

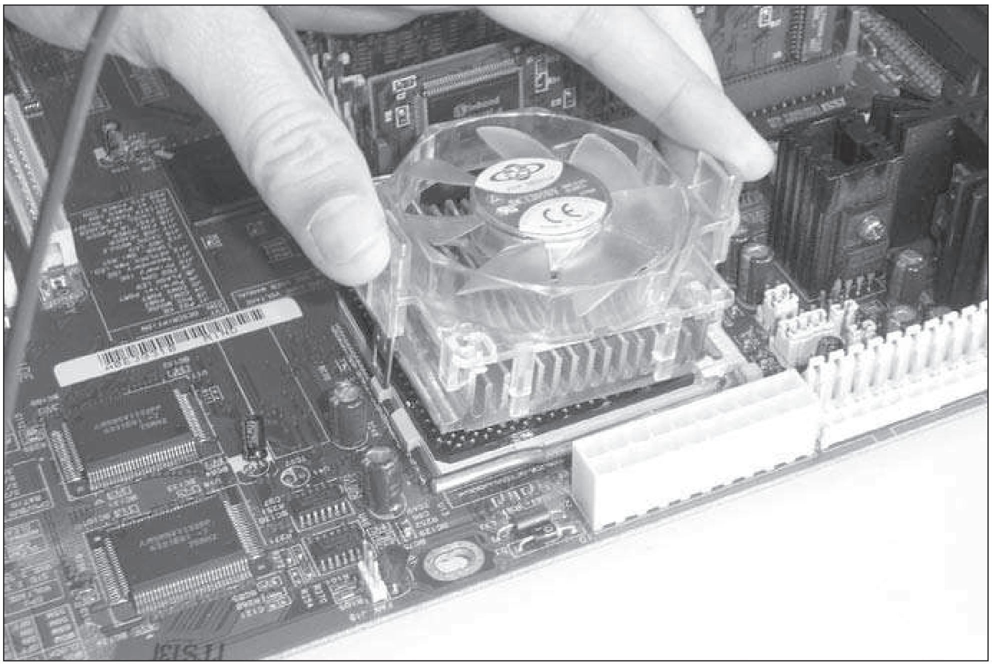


Figure 2-19: Placing the fan on top of the heat sink.

Increasing Performance

When it comes to processors, there are a number of different ways to increase the performance of your system. A first and obvious way is to buy the faster processor when upgrading; for example, upgrade a 1.8 GHz processor to a 3

GHz processor if possible. Also, get a processor that is designed to run on the faster motherboards. For example, back when the Pentium II processors were popular, there were 100 MHz motherboards or 133 MHz motherboards — you get a faster system by having a 133 MHz motherboard.

You will have to look at other features of the processor, such as the L1 cache and L2 cache that resides in the processor packaging. Acquiring a processor with more cache memory can dramatically increase system performance.

Getting an A+

This chapter provides an overview of the key terms that are used to identify the popular processors and their capabilities. Some of the points you need to remember when preparing for the exam are:

- The three major chip packages are DIP, PGA, and SEC. PGA being the popular chip packaging used in today's systems.
- The speed of the processor is measured in Gigahertz (GHz), but has been measured in Megahertz (MHz) in the past.
- L1 cache is cache memory integrated into the processor chip, while L2 cache is found outside the CPU chip.
- A socket is used to hold the processor in place on the motherboard. Be sure to be familiar with the sockets for Intel's Pentium III, Pentium 4, and Celeron chips. Also know about the sockets for AMD's Athlon, Athlon XP, and Duron chips.
- Be sure to review the characteristics of different Intel chips and AMD chips.