EXAM PREP

Your Complete Certification Solution

A+ Essentials

Exam 220-602

Exam 220-603

Exam 220-604

CompTIA® A+

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Charles J. Brooks
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CompTIA® A+ Exam Prep (Exams A+ Essentials, 220-602, 220-603, 220-604)

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Introduction

CompTIA® A+ Exam Prep is designed for those with the goal of certification as an A+ certified technician.

The 2006 version of CompTIA's A+ Certification exams represents the most extensive changes to the certification since its inception. The traditional two-test model featured one exam for Hardware (Core) and a separate exam for Operating System Technologies. That's been changed to a two-test requirement featuring one required exam followed by three options for Advanced exams to complete the certification.

The introductory level exam is called the A+ Essentials exam (220-601). The three options for the Advanced exam are designed to address the three main professional tracks commonly associated with A+ certification—Depot Technician (220-604), Remote Support Technician (220-603), and the all-around IT Technician (220-602).

NOTE

For a complete listing of the latest exam objectives, go to http://certification.comptia.org/a/.

Many of the objectives given for each exam overlap with objectives in the other exams. The main difference between the Essentials exam that everyone must take and any of the Advanced exams is supposed to be the level of knowledge required. CompTIA gives a recommendation of 500 hours of experience for the Essentials exam taker and 1,000 hours for any of the Advanced exams.

These exams measure essential competencies for a microcomputer hardware service technician with six months of on-the-job experience. You must demonstrate knowledge that would enable you to properly install, configure, upgrade, troubleshoot, and repair microcomputer hardware. This includes basic knowledge of desktop and portable systems, basic networking concepts, and printers. You also must demonstrate knowledge of safety and common preventive-maintenance procedures.

Another major change for the 2006 A+ exam is the inclusion of a soft skills domain. This is not exactly a new idea for the A+ exam. Various past versions have required a customer service element as part of the certification. However, the computer repair industry has made it clear that in most computer repair-related job roles, customer service and satisfaction skills are equally as important as technical skills.

For the 2006 version of the A+ exams, CompTIA has continued to use a fixed length, linear format test. They have also continued their practice of injecting new test items into the exam and administering them as nonscored questions. The psychometric evaluation of the questions is derived from these tests. When the new questions have been validated through this method, they will be injected into the live 2006 exams as scored questions.

After validation, the questions will be returned to the question pools as scored items, thus creating a dynamic test pool that is continually being renewed. To cope with this, Educational Technologies Group (ETG) has established our Dynamic Test Tracking system that is available to everyone who purchases this product.

ETG's Dynamic Test Tracking system is an online service that includes dynamic, interactive updates for each chapter and lab procedure in our course. These changes also include Test Tips and Curriculum Notes for any changes encountered in the A+ exams over the life of this exam version. In this way, your courseware will never be out of date or incomplete.

How This Book Helps You

This book is your one-stop answer for the A+ exams. Everything you need to know to pass the exams is in here. You do not have to take a class in addition to buying this book to pass the exam. Depending on your personal study habits or learning style, however, you might benefit from buying this book and taking a class. It can also help advanced users and administrators who are not studying for the exam but are looking for a single-volume technical reference.

Our book provides a self-guided tour of all the areas covered by all four of the A+ exams and identifies the specific skills you need to achieve your A+ certification. You also will find the features that make Que's training guides so successful: clear organization, helpful hints, tips, real-world examples, and step-by-step exercises. Specifically, this book is set up to help you in the following ways:

Organization

This book is organized according to individual exam objectives. It covers every objective that you need to know for all four A+ exams. As much as possible, the objectives are covered in the same order as they are listed by the certifying organization, CompTIA, to make it as easy as possible for you to learn the information. We also have attempted to make the information accessible in the following ways:

- The book includes a full list of exam topics and objectives.
- Each chapter begins with a list of the objectives to be covered.

- Each chapter also begins with an outline that provides an overview of the material and the page numbers indicating where you can find particular topics.
- Information on where the objectives are covered is also conveniently condensed on the tear card at the front of this book.

Instructional Features

This book is designed to provide you with multiple ways to learn and reinforce the exam material. Following are some of the helpful methods:

- *Objective explanations*—As mentioned previously, each chapter begins with a list of the objectives covered in the chapter. In addition, immediately following each objective is an explanation in a context that defines it more meaningfully.
- *Test tips*—Exam tips appear in the margin to provide specific exam-related advice. Such tips might address what material is covered (or not covered) on the exam, how it is covered, mnemonic devices, and particular quirks of that exam.
- *Summaries*—Each chapter ends with a summary.
- *Terms you'll need to understand*—A list of key terms appears at the end of each chapter. The key terms are also italicized the first time they appear in the text of the chapter.
- *Notes*—These paragraphs appear in the margin and contain various kinds of useful information such as tips on technology or administrative practices, historical background on terms and technologies, or side commentary on industry issues.
- *Warnings*—When you are using sophisticated technology improperly, the potential for mistakes or even catastrophes to occur is ever present. Warnings appear in the margin to alert you to such potential problems.
- *Challenges*—These instructional elements require you to analyze a situation and come up with a solution to a technical problem. They are included here in anticipation of the application questions that appear in the A+ exams. Answers appear in the "Challenge Solutions" section.

Extensive Practice Test Options

This book provides numerous opportunities for you to assess your knowledge and to practice for the exam. The practice options include the following:

- *Review questions*—These questions appear in the "Exam Prep Questions" section. They reflect the kinds of multiple-choice questions that appear on the A+ exams. Use them to practice for the exam and to help you determine what you know and what you need to review or study further. Answers and explanations for them are provided.

- *Practice exam*—A practice exam is included in the "Final Review" section for each exam (as discussed later).
- *MeasureUp*—The MeasureUp software included on the CD that accompanies this book provides even more practice questions. You also can purchase more questions at www.measureup.com.

Final Review

This part of the book provides the following three valuable tools that can help you prepare for the exam:

- *Practice Exam*—A full practice test for each of the exams is included. Questions are written in the styles used on the actual exams. Use it to assess your readiness for the real thing.
- This book includes the Glossary and Appendix A, "What's on the CD-ROM."

These and all the other book features mentioned previously will enable you to thoroughly prepare for the exam.

Registering for the Exam

To register for the A+ exam, contact Marcraft at 800-441-6006. Special discounts are available for Que customers.

For more information about the exam or the certification process, contact Educational Technologies Group (ETG) or the CompTIA organization:

CompTIA Headquarters

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Hardware and Software You Will Need

As a self-paced study guide, this book was designed with the expectation that you will use your computer as you follow along through the exercises. You also should use the MeasureUp software on the accompanying CD. Your computer should meet the following criteria:

- 32-bit operating system (Windows 9x/2000/XP or NT 4.0)
- 10MB hard-drive space
- 16MB RAM
- IE 4.01 or later
- 640×480 video resolution with 256 colors or more
- CD-ROM drive

Advice on Taking the Exam

You should keep the following advice in mind as you study:

- *Read all the material.* Make sure that your exam preparation is thorough. Do not just drop into the book and read around. Read through all the material. This book includes additional information not reflected in the objectives in an effort to give you the best possible preparation for the examination—and for on-the-job experiences to come.
- *Complete the steps.* They will provide you with another way of understanding the material as well as more information on how well you comprehend it.
- *Use the questions to assess your knowledge.* Do not just read the chapter content; use the questions to find out what you know and what you do not. Study some more, review, and then assess your knowledge again.

- *Review the exam objectives.* Develop your own questions and examples for each topic listed. If you can develop and answer several questions for each topic, you should not find it difficult to pass the exam.

Remember, the primary objective is not to pass the exam—it is to understand the material. After you understand the material, passing the exam should be simple. Knowledge is a pyramid; to build upward, you need a solid foundation. This book and the CompTIA A+ certification program are designed to ensure that you have that solid foundation.

NOTE

Although this book is designed to prepare you to take and pass the A+ Essentials, Depot Technician, Remote Support Technician, and IT Technician exams, there are no guarantees. Read this book, work through the questions and exercises, and when you feel confident, take the practice exam and additional exams using the MeasureUp test engine. This should tell you whether you are ready for the real thing.

When taking the actual certification exam, make sure that you answer all the questions before your time limit expires. Do not spend too much time on any one question. If you are unsure, answer it as best as you can; then mark it for review after you have finished the rest of the questions.

Good luck!

3

CHAPTER THREE

Microprocessors

Terms you'll need to understand:

- Hyperthreading
- Throttling
- Overclocking
- L1 cache
- L2 cache
- L3 cache
- Voltage Regulator Module
- Single-Edge Contact cartridge
- Pentium processors
- Duron processors
- Opteron processors
- Athlon processors
- Dual-core processors

Exam objectives you'll learn in this chapter:

Essentials 1.1—Identify the fundamental principles of using personal computers.

- Identify the names, purposes, and characteristics of processor/CPUs.
- CPU chips (for example, AMD, Intel)
- CPU technologies
  - Hyperthreading
  - Dual core
  - Throttling
  - Micro code (MMX)
  - Overclocking
  - Cache
  - VRM
  - Speed (real vs. actual)
  - 32 versus 64 bit
- Identify the names, purposes, and characteristics of cooling systems—for example, heat sinks, CPU and case fans, liquid cooling systems, and thermal compound.

Outline

Introduction

This chapter covers the microprocessor areas of the CompTIA A+ Certification—Essentials examination under Objective 1.1. It also covers the cooling systems area of the objective. Computer technicians are often asked to upgrade existing systems with new devices, such as a new microprocessor. Therefore, every technician should be aware of the characteristics of possible CPU upgrades and be able to determine whether a particular upgrade is physically possible and worthwhile.

To be a successful technician, you must be aware of the capabilities of the different microprocessors that are available for use in a system. Technicians must know what impact placing a particular microprocessor in an existing system may have on its operation. They must also be able to identify the type of processor being used and the system settings necessary to maximize its operation.

Intel Microprocessors

There were originally several competitors in the PC-compatible microprocessor market. However, over time the market has narrowed to two major players competing for market domination—Intel and American Micro Devices (AMD). Intel has set the standard for processor performance throughout most of the personal computer era. However, AMD has shown itself a worthy opponent, frequently taking the market lead with speed increases and new innovations.

For the most part, the previous generations of microprocessors have disappeared from the marketplace, leaving the Pentium and its clones as the only processor types that need to be discussed in detail. The following sections first look at the advancements Intel has produced and then focus on the AMD processors that compete with them.

The Pentium Processor

When IBM was designing the first PC, it chose the Intel 8088 microprocessor and its supporting chipset as the standard CPU for its design. This was a natural decision because one of IBM's major competitors (Apple) was using Motorola microprocessors for its designs. The choice to use the Intel microprocessor still impacts the design of PC-compatible systems. In fact, the microprocessors used in the vast majority of all PC-compatible microcomputers include the Intel 8088/86, 80286, 80386, 80486, and Pentium (80586 and 80686) devices.

This original Pentium architecture has appeared in three generations. The first generation, code named the P5, came in a 273-pin PGA package and operated at 60 or 66MHz speeds. It used a single +5V (DC) operating voltage, which caused it to consume a large amount of power and generate a large amount of heat. It generated so much heat during normal operation that an additional CPU cooling fan was required.

The second generation of Pentiums, referred to as P54Cs, came in a 296-pin Staggered Pin Grid Array (SPGA) package and operated at 75, 90, 100, 120, 133, 150, and 166MHz in different versions. For these devices, Intel reduced the power-supply voltage level to +3.3V (DC) to consume less power and provide faster operating speeds. Reducing the power-supply level in effect moved the processor's high- and low-logic levels closer together, which means that less time is required to switch back and forth between them. The SPGA packaging made the second generation of Pentium devices incompatible with the first-generation system boards.

The second-generation devices also employed internal clock multipliers to increase performance. In this scenario, the clock signal introduced to the microprocessor is the same one that drives the system's buses; however, the internal clock multiplier causes the microprocessor to operate internally at some multiple of the external clock speed (for example, a Pentium operating from a 50MHz external clock and using a 2× internal multiplier is actually running internally at 100MHz).

The third generation of Pentium designs, designated as P55C, employed a 296-pin SPGA arrangement. This package adhered to the 321-pin Socket-7 specification designed by Intel. The P55C was produced in versions that operate at 166, 180, 200, and 233MHz. This generation of Pentium devices operated at voltages below the +3.3V level established in the second generation of devices. The P55C was known as the Pentium MMX (Multimedia Extension) processor. Figure 3.1 shows the pin arrangements for PGA and SPGA devices. Notice the uniformity of the PGA rows and columns versus the staggered rows and columns of the SPGA device.

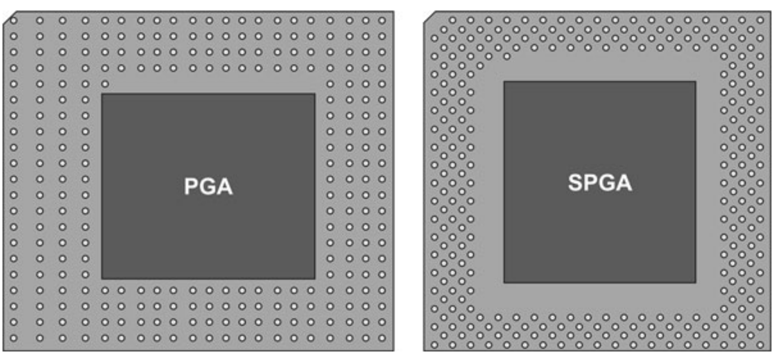

FIGURE 3.1 PGA and SPGA pin arrangements.

Intel Cache Structures

One method of increasing the memory-access speed of a computer is called *caching*. This memory management method assumes that most memory accesses are made within a limited block of addresses. Therefore, if the contents of these addresses are relocated into a special section of high-speed SRAM, the microprocessor could access these locations without requiring any wait states.

The original Intel Pentium had a built-in first-level cache that could be used for both instructions and data. The internal cache was divided into four 2KB blocks containing 128 sets of 16-byte lines each. Control of this cache is handled directly by the microprocessor. The microprocessor's internal first-level cache is also known as an *L1 cache*. Many of the older Pentium system boards extended the caching capability of the microprocessor by adding an external, second-level 256KB/512KB memory cache. The second-level cache became known as an *L2 cache*.

With the Pentium Pro, Intel moved the 256KB or 512KB L2 cache from the system board to the processor package. This design technique continued through the Pentium II and III slot processors so that the 256KB/512KB L2 cache resided in the microprocessor cartridge.

In later CPUs, such as the Celeron, Intel moved the L2 cache (128KB/256KB and 256KB/512KB, respectively) onto the actual microprocessor die. Moving the L2 cache onto the die made the microprocessor directly responsible for managing the L2 cache and enabled it to run at full speed with the microprocessor. In all these systems, no cache existed on the system board.

When Intel designed the Itanium processor, it built in capabilities for managing an additional external level of cache in the microprocessor cartridge. This additional cache level was dubbed *L3 cache*. Later versions of the Itanium microprocessors can support up to 12MB of cache in the cartridge.

The Xeon processor has continued this design concept and improved it by moving a 1MB or 2MB L3 cache onto the microprocessor die. Again, the external cache is able to run at full speed with the microprocessor. The computer industry has taken a more liberal definition of L3 cache; it sometimes refers to L3 cache as cache memory mounted on system boards with processors that possess onboard L1 and L2 cache.

Advanced Pentium Architectures

Intel has continued to improve its Pentium line of microprocessors by introducing additional specifications, including the Pentium MMX, Pentium Pro, Pentium II, Pentium III, and Pentium 4 processors. At the same time, Intel's competitors have developed clone designs that equal or surpass the capabilities of the Intel versions.

Pentium MMX Processors

The Pentium MMX processor extended the multimedia and communications processing capabilities of the original Pentium device by the addition of 57 multimedia-specific instructions to the instruction set. Intel also increased the onboard L1 cache size to 32KB. The cache was divided into two separate 16KB caches: the instruction cache and the data cache. The typical L2 cache used with the MMX is 256KB or 512KB and employs a 66MHz system bus.

The Pentium MMX processor was produced in 166, 200, and 233MHz versions and used a 321-pin SPGA Socket-7 format. It required two separate operating voltages. One source was used to drive the Pentium processor core; the other was used to power the processor's I/O pins.

Pentium Pro Processors

Intel departed from simply increasing the speed of its Pentium processor line by introducing the Pentium Pro processor. Although compatible with all the software previously written for the Intel processor line, the Pentium Pro was optimized to run 32-bit software. However, the Pentium Pro did not remain pin-compatible with the previous Pentium processors. Instead, Intel adopted a 2.46 inch×2.66 inch, 387-pin PGA configuration to house the Pentium Pro processor core, and an onboard 256KB (or 512KB) L2 cache with a 60 or 66MHz system bus.

The L2 cache complements the 16KB L1 cache in the Pentium core. Figure 3.2 illustrates this arrangement. Notice that although the L2 cache and the CPU are on the same PGA device, they are not integrated into the same IC. The unit is covered with a gold-plated copper/tungsten heat spreader.

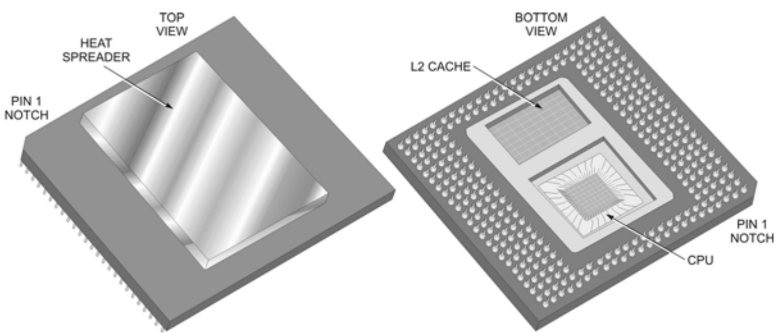

FIGURE 3.2 The Pentium Pro microprocessor.

The L2 onboard cache stores the most frequently used data not found in the processor's internal L1 cache as close to the processor core as it can be without being integrated directly into the IC. A high-bandwidth cache bus (referred to as the backside bus) connects the processor and L2 cache unit.

The Pentium Pro was designed to be used in single-microprocessor applications as well as in multiprocessor environments such as high-speed, high-volume file servers and workstations. Several dual-processor system boards have been designed for twin Pentium Pro processors. These boards, like the one shown in Figure 3.3, are created with two Pentium Pro sockets so that they can operate with either a single processor or with dual processors.

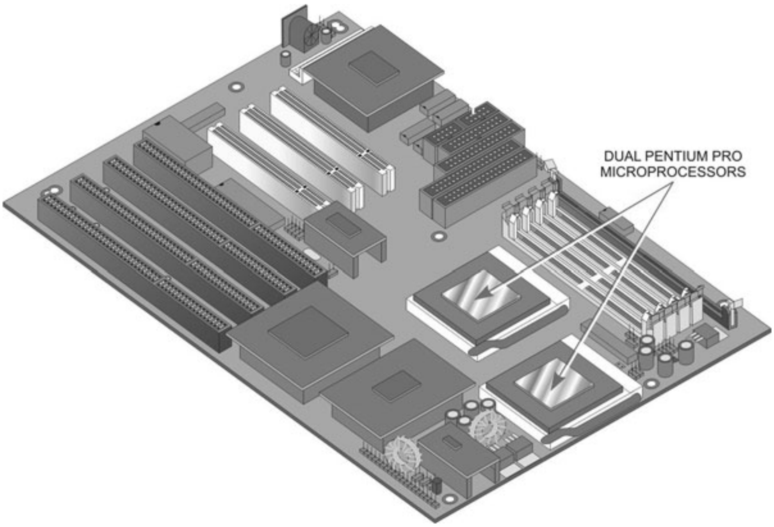

FIGURE 3.3 A multiprocessor system board.

Pentium II Processors

Intel radically changed the form factor of the Pentium processors by housing the Pentium II processor in a new Single-Edge Contact Cartridge (SECC), as shown in Figure 3.4. This cartridge uses a special retention mechanism premounted to the system board to hold the device in place.

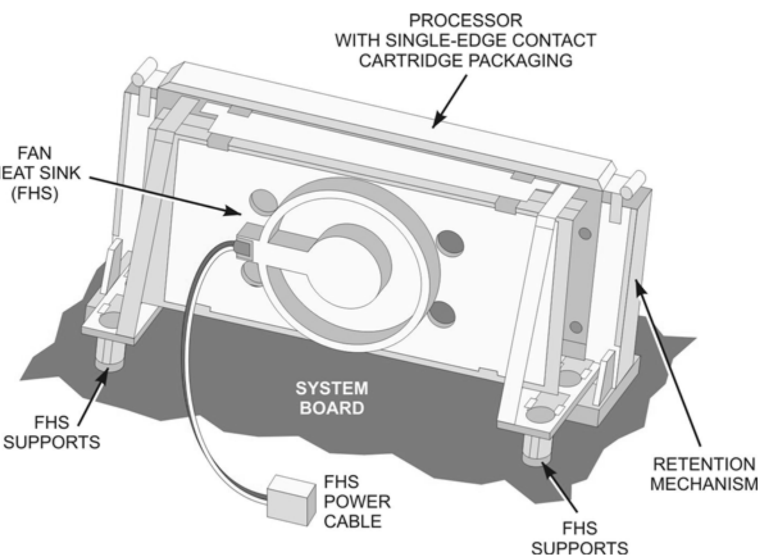

FIGURE 3.4 The Pentium II cartridge.

The proprietary 242-contact socket design is referred to as the Slot 1 specification and was designed to enable the microprocessor to operate at bus speeds in excess of 300MHz.

The cartridge also requires a special Fan Heat Sink (FHS) module. Like the SEC cartridge, the FHS module requires special support mechanisms to hold it in place. The fan draws power from a special power connector on the system board or from one of the system's auxiliary power connectors.

Inside the cartridge is a substrate material on which the processor and related components are mounted. The components consist of the Pentium II processor core, a tag RAM, and an L2 burst SRAM. Tag RAM is used to track the attributes (read, modified, original location in RAM, and so on) of data stored in the cache memory.

The Pentium II includes all the multimedia enhancements from the MMX processor, as well as retaining the power of the Pentium Pro's dynamic execution, and features up to 512KB of L2 cache and employs a 66 or 100MHz system bus. The L1 cache is increased to 32KB, and the L2 cache operates with a half-speed bus. Figure 3.5 shows the content of the Pentium II cartridge.

EXAM ALERT

Remember which components Intel included in the SEC cartridge.

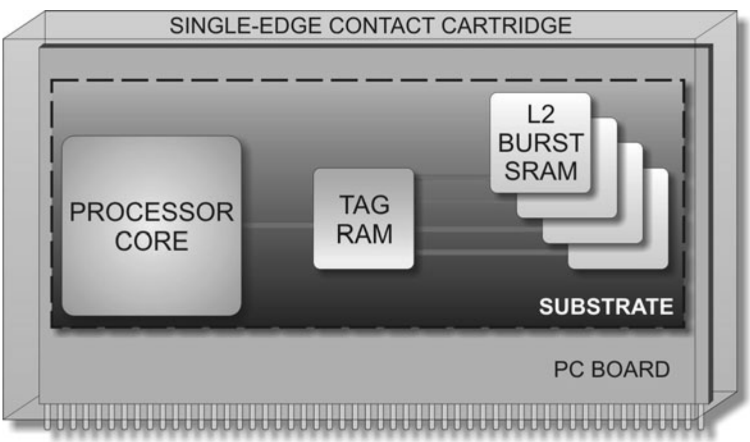

FIGURE 3.5 Inside the Pentium II cartridge.

A second cartridge type, called the Single-Edged Processor Package (SEPP), was developed for use with the Slot 1 design. In this design, the boxed processor is not completely covered by the plastic housing as it is in the SEC design. Instead, the SEPP circuit board is accessible from the backside.

Intel followed the Pentium II processor with an improved low-cost design it called the Pentium Celeron. The first version of this line of processors was built around a Pentium II core without a built-in cache. Later, Celeron versions featured a 66MHz bus speed and only 128KB of L2 cache. Initially, these versions were packaged in the SEC cartridge.

Pentium III Processors

Intel quickly followed the Celeron release with a new Slot 1-compatible design it called the Pentium III. The original Pentium III processor (code named Katmai) was designed around the Pentium II core but increased the L2 cache size to 512KB. It also increased the speed of the processor to 600MHz, including a 100MHz front-side bus (FSB) speed.

Later versions of the Pentium III and Celeron processors were developed for the Intel Socket 370 specification. This design returned to a 370-pin, ZIF socket/SPGA package arrangement, as shown in Figure 3.6.

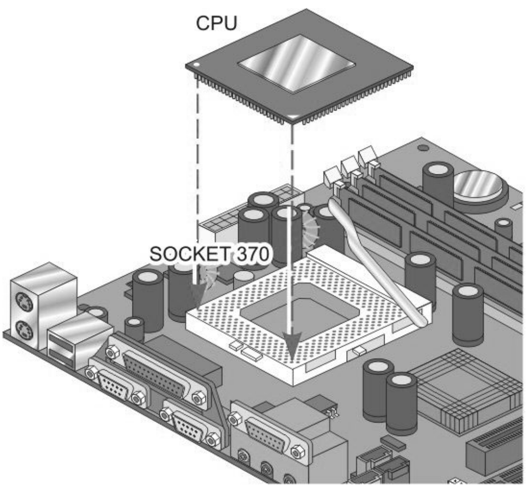

FIGURE 3.6 Socket 370.

The first pin grid array versions of the Pentium III and Celeron processors conformed to a standard called the Plastic Pin Grid Array (PPGA) 370 specification. Intel repackaged its processors into a PGA package to fit this specification. The PPGA design was introduced to produce inexpensive, moderate-performance Pentium systems. The design topped out at 533MHz with a 66MHz bus speed.

Intel upgraded the Socket 370 specification by introducing a variation called the Flip Chip Pin Grid Array (FC-PGA) 370 design. Intel made small modifications to the wiring of the socket to accommodate the Pentium III processor design. In addition, it employed a new 0.18 micron IC manufacturing technology to produce faster processor speeds (up to 1.12GHz) and front-side bus speeds (100MHz and 133MHz). However, the new design provided only 256KB of L2 cache. Further developments of the Pentium III employed 0.13 micron IC technology to achieve 1.4GHz operating speeds with increased cache sizes (256KB or 512KB).

Xeon Processors

Intel has produced three special versions of the Pentium III that they have collectively named the Pentium Xeon, as shown in Figure 3.7. These processors are designed to work with an edge connector-based Slot 2 specification that Intel has produced to extend its Slot 1/boxed-processor scheme to a 330-contact design. Each version features a different level of L2 cache (512KB, 1MB, 2MB).

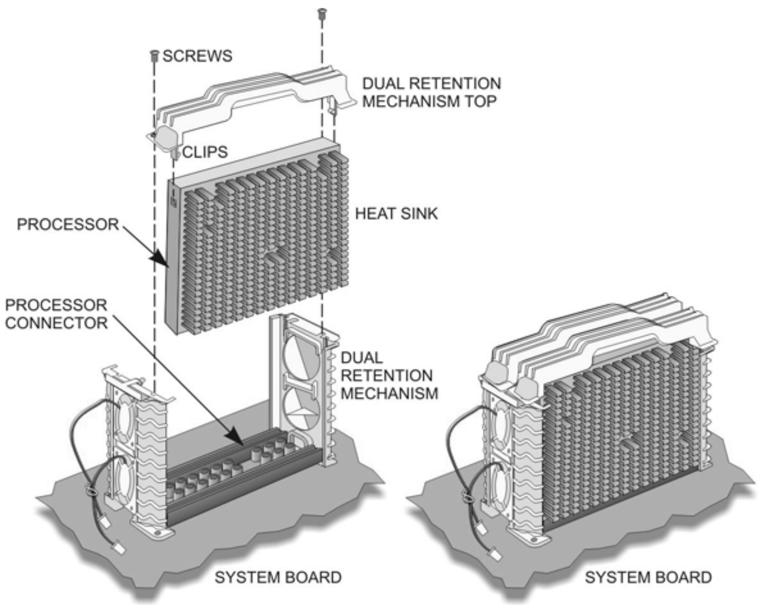

FIGURE 3.7 The Xeon processor.

The Xeon designs were produced to fill different high-end server needs. The Xeon processor functions at speeds up to 866MHz and is built on the 0.18-micron process technology. The processor allows for highly scalable server solutions that support up to 32 processors.

Pentium 4 Processors

Intel then released the Pentium 4 (Williamette 423) microprocessor. The Pentium 4 was a new processor design based on 0.18-micron IC construction technology. It employed a modified Socket 370 PGA design that uses 423 pins and boasts operating speeds up to 2GHz.

The system's FSB was increased from 64 to 128 bits and operates at up to 400MHz. The bus is actually clocked at 100MHz, but data is transferred four times in a single clock cycle (referred to as a *quad-pumped bus*). Therefore, the transfer rate of the bus is considered to be 400MT/s. With a width of 128 bits, this provides the FSB with a theoretical bandwidth of 6400MBps.

In addition to the new front-side bus size, the Pentium 4 features WPNI (Williamette Processor New Instructions) in its instruction set. The L1 cache size has been reduced from 16KB in the Pentium III to 8KB for the Pentium 4. The L2 cache is 256KB and can handle transfers on every clock cycle.

The operating voltage level for the Pentium 4 core is 1.7Vdc. To dissipate the 55 watts of power (heat) that the microprocessor generates at 1.5GHz, the case incorporates a metal cap that acts as a built-in heat sink.

Newer .13-micron versions operate at speeds up to 3.06GHz. This newer Pentium 4 design employs an improved 478-pin version of the chip that increased the L2 cache size to 512KB. This type of Pentium 4 processor has been produced in versions that run at 2.0, 2.2, 2.4, 2.8, and 3.06GHz. The 2.4GHz version increased the speed of the quad pumped bus to 533MHz (133×4). Some variations of the 2.4 to 3.06 processors were produced with support for 800MHz FSB operations.

The evolution of the Pentium 4 processor topped out with the delivery of a 3.2 and 3.4GHz version in 2004. The 3.06MHz version of the Pentium 4 brought hyperthreading technology (HTT) to the Intel line of processors. *Hyperthreading* is an architecture that enables multiple program threads to be run in different sections of the processor simultaneously. Basically, the structure fools the operating system into thinking that two processors are available.

The most advanced versions of the Pentium 4 processor are the Pentium 4 Extreme Editions (P4EE). In its ongoing battle with AMD for microprocessor supremacy, Intel added 2MB of Level 3 (L3) cache to the Xeon core and called them P4EE. Later versions of these processors have been clocked at 3.73GHz and are equipped with 1066MHz front-side buses. They are available in either Socket 603 or LGA 775 versions.

L3 cache is cache memory placed between the L2 cache and main memory. This level of cache typically provides a higher hit rate than L2 cache (because of being larger in size) but requires a longer access time to retrieve data. These memory caches can be implemented on the system board, or as in the case of the PE4EE processors, on the microprocessor die.

Itanium Processors

The Intel Itanium processor, as shown in Figure 3.8, provides a new architecture specifically for servers. It maximizes server performance through special processing techniques Intel refers to as Explicitly Parallel Instruction Computing (EPIC).

The Itanium processor design features a three-level, onboard cache system. The L1 cache size is 32KB operating fully pipelined, the L2 cache size ranges up to 256KB, and the new L3 cache is available in sizes ranging from 2 or 4MB to 12MB. The cartridge's connector specification provides separate voltage levels for the processor and cache devices to improve signal integrity.

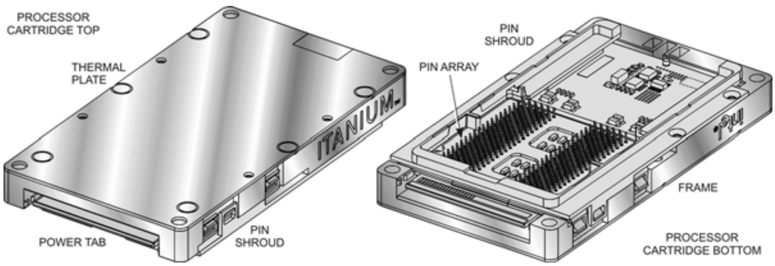

FIGURE 3.8 The Itanium processor.

Itanium processors are designed to be available 100 percent of the time. Therefore, they tend to be very expensive—often more expensive than the complete network operating system that they are running. However, the cost of the processor is nothing compared to the cost of most online businesses going down for just one hour.

Intel Dual-Core Processors

Dual-core processors provide two execution cores in one physical processor package. The two cores are actually produced on the same piece of silicon (on the same die). This enables the system to divide processing tasks between the two cores. Fitting two processors into a single package theoretically doubles the computing power of the device without having to clock it twice as fast. Figure 3.9 shows a dual-core processor arrangement.

FIGURE 3.9 A dual-core processor.

Intel has launched the Pentium D and Pentium Extreme Edition (EE) lines of dual-core processors. The Extreme Edition versions employ Intel's hyperthreading technology that enables a single processor core to simulate the operation of two different logical processors that can be used to work on different program segments simultaneously. Including the hyperthreading technology in a dual-core processor package enables it to process four threads simultaneously (it functions like four single-core processors). Table 3.1 lists the key characteristics of the Intel dual-core processors.

TABLE 3.1 Intel Dual-Core Processors

PROCESSOR	CLOCK FREQUENCY	L2-CACHE	FRONT SIDE BUS SPEED	CLOCK MULTIPLE	CORE VOLTAGE	POWER DISSIPATION
Pentium D 805	2.667GHz	2 × 1MB	533MT/s	20×	1.25/1.4V	95W
Pentium D 820	2.800GHz	2 × 1MB	800MT/s	14×	1.2/1.4V	95W
Pentium D 830	3GHz	2 × 1MB	800MT/s	15×	1.2/1.4V	130W
Pentium D 840	3.2GHz	2 × 1MB	800MT/s	16×	1.2/1.4V	130W
Pentium D 920	2.8GHz	2 × 2MB	800MT/s	14×	1.2/1.337V	130W
Pentium D 930	3GHz	2 × 2MB	800MT/s	15×	1.2/1.337V	130W
Pentium D 940	3.2GHz	2 × 2MB	800MT/s	16×	1.2/1.337V	130W
Pentium D 950	3.4GHz	2 × 2MB	800MT/s	17×	1.2/1.337V	130W
Pentium D 960	3.6GHz	2 × 2MB	800MT/s	18×	1.2/1.337V	130W
Pentium Extreme Edition 840	3.2GHz	2 × 1MB	800MT/s	16×	1.2/1.4V	130W
Pentium Extreme Edition 955	3.466GHz	2 × 2MB	1066MT/s	13×	1.2/1.337V	130W
Pentium Extreme Edition 965	3.733GHz	2 × 2MB	1066MT/s	14×	1.2/1.337V	130W

As Table 3.1 shows, most of the dual-core Intel designs employ an 800MHz FSB to communicate with the rest of the system. So far, the exceptions to this are the Pentium EE 955 and EE 965 processors that use a 1066MHz FSB.

NOTE

Some documentation will specify the front-side bus speed in terms of Mega Transfers per Second (MT/s). This is a realistic measurement of the bus's channel speed instead of its clock speed. For instance, if the bus transfers data on both the rising and falling edges of its clock signal (referred to as *double pumping*), a 400MHz clock would effectively yield a 800MT/s throughput rate.

The two cores communicate with each other through a special bus interface block or through the FSB. Most of the dual-core Intel designs employ an 800MHz or 1066MHz FSB to communicate with the rest of the system. The two cores can also access each other's L2 caches through this interface. However, each core can only use half of the FSB bandwidth frequency when working under heavy load. Some models include 1MB of L2 cache for each core, whereas other models have enlarged the L2 cache to 2MB for each core.

All the current and planned dual-core processors from Intel are designed to use a new type of socket called the Land Grid Array (LGA) 775. Unlike previous socket types, the LGA775, also referred to as Socket-T, places contact pins on the system board and contact pads on the bottom of the microprocessor.

A hinged metal rim folds down over the microprocessor package and holds its contact pads securely against the signal pins on the system board. A locking arm is used to clamp the processor package in place. The heat sink and fan unit are connected directly and securely to the system board on four points. Figure 3.10 shows the LGA775 socket arrangement.

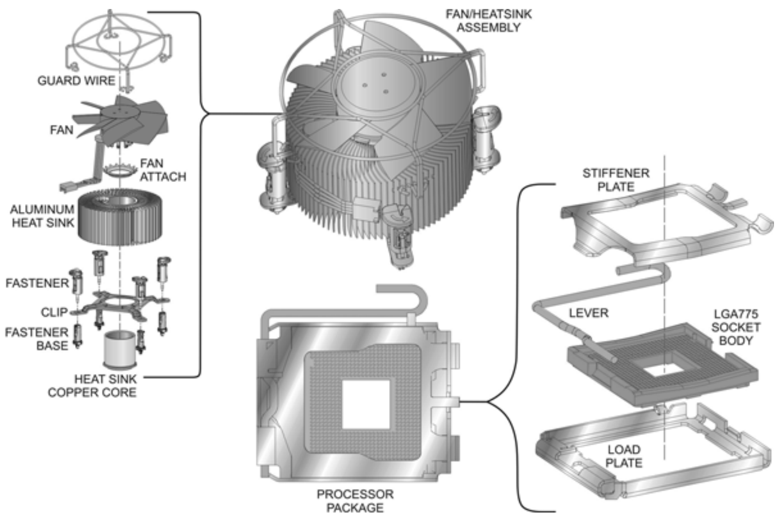

FIGURE 3.10 The LGA775 socket.

Advanced Intel Microprocessor Technologies

All Intel dual-core processor types incorporate advanced technologies into their feature sets. Some of these processors support the Intel Execute Disable Bit virus protection (XD bit), EM64T 64-bit extension, and enhanced SpeedStep technologies. Other designs also include Virtualization Technology (VT), which enables a single machine to run multiple operating systems at once.

XD-bit technology is used to separate areas of memory into regions for distinct uses. For example, a section of memory can be set aside exclusively for storing processor instructions (code), and another section can be marked only for storage of data.

In the case of Intel processors, any section of memory marked with the XD attribute means it's only for storing data. Therefore, processor instructions cannot be stored there. This is a popular technique for preventing malicious software from taking over computers by inserting their code into another program's data storage area and then running that code from within this section. This is known as a *buffer overflow attack*.

EM64T is a 64-bit microprocessor architecture and corresponding instruction set that is an extension of the x86 instruction set used with all Intel processors. Intel has included this technology and extended instruction set in its Pentium 4, Pentium D, Pentium Extreme Edition, Celeron D, and Xeon processors.

Enhanced Intel SpeedStep Technology (EIST) enables the operating system software to dynamically control the clock speed of a processor. Running the processor at higher clock speeds provides better performance. However, running the processor at a lower speed provides for reduced power consumption and heat dissipation. This *throttling* technique is used to conserve battery power in notebooks, extend processor life, and reduce noise from cooling devices.

Each processor type has a range of core operating speeds at which it can work. For example, a Pentium M processor designated as a 1.5GHz processor can actually operate safely at any speed between 600MHz and 1.5GHz. The Intel dual-core designs leave some margin for processor overclocking to satisfy the PC performance enthusiast. *Overclocking* is the practice of manually configuring the microprocessor clock to run at a higher speed than the IC manufacturer suggests, in order to squeeze additional performance out of the system.

The SpeedStep technology enables the user or the operating system to change the speed setting in 200MHz increments. Windows operating systems prior to Windows XP require a special driver and a dashboard application to provide speed control for the processor. However, Windows XP has speed step support built in to its Control Panel's Power Management Console.

Hyperthreading Software Support

The presence of two microprocessors does not automatically double system performance. The controlling operating system software must distribute tasks to all available processor resources. This requires the OS to handle multiple program execution threads that can run independently. The problem is that software has not traditionally been written with multiple threading capabilities. Most existing software applications are single threaded—they are written so only one task is worked on at a time. In these cases, the dual-core processor performs just like its single-core version.

On the other hand, modern operating systems can deliver multitasking operation—operations where the system works on more than one application at a time. The operating system switches from one task to another in a predetermined order. This is done so quickly that the system appears to be working on multiple tasks at the same time. Operating systems can use processors with hyperthreading technology to provide smooth and responsive operations during intensive multitasking operations.

AMD Processors

Advanced Micro Devices (AMD) offers several clone microprocessors: the 5×86 (X5), 5×86 (K5), K6, K6PLUS-3D, and K7 microprocessors. The X5 offers operational and pin compatibility with the 80486DX4. Its performance is equal to that of the Pentium and MMX processors.

The K5 processor is compatible with the Pentium, and the K6 is compatible with the MMX. Both the K5 and K6 models are Socket 7 compatible, enabling them to be used in conventional Pentium and Pentium MMX system board designs (with some small modifications). The K6 employs an extended 64KB L1 cache that doubles the internal cache size of the Pentium II.

The K6PLUS-3D is operationally and performance compatible with the Pentium Pro, and the K7 is operationally and performance compatible with the Pentium II. However, neither of these units has a pin-out compatibility with another processor.

AMD continued to produce clone versions of Pentium processors. In some cases, the functions and performance of the AMD devices went beyond those of the Intel design they are cloning. Two notable AMD Pentium clone processors are the *Athlon* and the *Duron*.

The Athlon is a Pentium III clone processor. It is available in a Slot 1 cartridge clone, called the Slot A specification. Figure 3.11 shows the front and back sides of the cartridge version of the Athlon processor along with a Slot A connector.

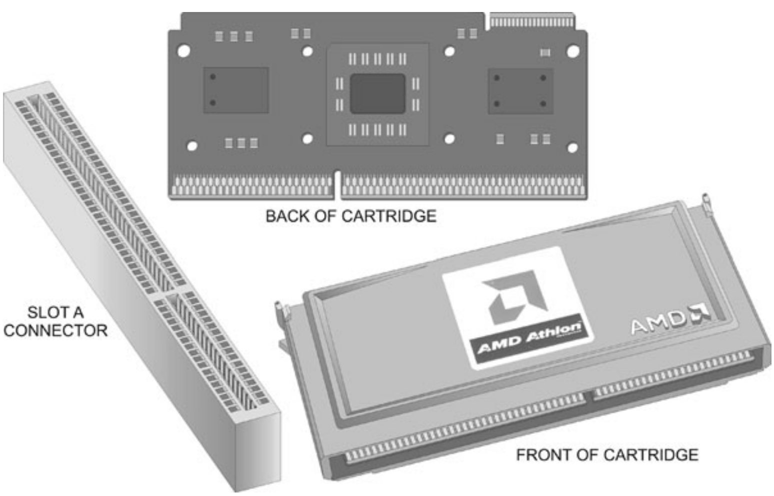

FIGURE 3.11 The Slot A Athlon processor.

The Athlon is also available in a proprietary SPGA Socket A design that mimics the Intel Socket 370 specification. The Socket A specification employs a 462-pin ZIF socket and is supported only by two available chipsets.

The first Athlon version was the K7 version that ran between 500MHz and 700MHz, provided a 128KB L1 cache and a 512KB L2 cache, and employed a 100MHz system bus. Subsequent Athlon versions have included the K75, Thunderbird, Thoroughbred, and Barton versions. These versions are constructed using the improved 0.18-micron manufacturing technology.

The K75 processors operated at speeds between 750MHz and 1GHz, provided a 128KB L1 cache and a 512KB L2 cache, and employed a 100MHz system bus. The Thunderbird version ran between 750MHz and 1.2GHz, provided a 128KB L1 cache and a 256KB L2 cache, and employed a 133MHz system bus. The Thoroughbred version featured 256KB of L2 cache along with the standard 64+64KB L1 cache and operated at speeds up to 2.8GHz.

An even later evolution of the Athlon processor was given the title of Athlon XP. These versions were based on the Thoroughbred and the newer Barton core versions. The Barton versions feature a 512KB L2 cache, a slower clock speed, and a maximum processor speed of 3.0GHz.

Athlon 64 Processors

AMD made several technology changes to the Athlon processor when it unveiled its Athlon 64 line of processors. These processors are built on a new core that includes the AMD64 64-bit architecture. This architecture is an extension of the x86 Instruction Set that was originally created by Intel for its 80x86 line of processors. In addition, the Athlon 64 architecture implemented additional internal registers to support independent floating-point math operations.

A new No-Execute (NE) bit technology was also introduced with the Athlon 64. NE technology marks different areas of memory as being for use with data or as being reserved for instructions. Any attempt to execute code from a memory page that has been tagged as a no-execute page will result in a *memory access violation error*. This feature makes it more difficult for certain types of malware to take control of the system and execute its payload.

The Athlon 64 processor introduced another considerable change to Pentium class PC architecture by moving the memory controller from the supporting system board chipset into the microprocessor package. This effectively removes the front-side bus from the system architecture and improves memory access operations by avoiding external bus access overhead.

Instead of continuing the traditional FSB structure, AMD adopted a special bidirectional, serial/parallel I/O bus and controller technology from the HyperTransport Technology Consortium for its Athlon 64 processors. The *HyperTransport* (*HT*) *technology* handles the I/O functions previously performed across the FSB at speeds much higher than existing FSB clocking. AMD also employs this bus to interconnect multiple processor cores to provide efficient cooperation between the cores.

The Athlon 64 FX is a special designation given to some Athlon 64 versions. These processors are typically clocked faster than the traditional Athlon versions to make them more interesting to gamers and other enthusiasts.

There are two common socket sizes used with Athlon 64 processors: a 754-pin socket for a value/budget version of the Athlon 64 that provides only a 64-bit, single-channel memory interface, and a 939-pin version that is the standard for all other Athlon 64 versions.

Duron Processors

The Duron processor is a Celeron clone processor that conforms to the AMD Socket A specification. The Duron features processor speeds between 600MHz and 800MHz. It includes a 128KB L1 cache and a 64KB L2 cache and employs a 100MHz system bus. Like the newer Celerons, the Duron is constructed using 0.18-micron IC manufacturing technology.

Athlon Dual-Core Processors

AMD took the lead in the processor development races by pushing dual-core processors to the forefront. Unlike the Intel dual-core processors discussed earlier in the chapter, AMD designed its dual-core devices to fit in the same 939-pin socket interface it was already using for its single-core Athlon 64 processor. In addition, the existing Athlon 64 chipset had been designed with this possibility in mind. These features make upgrading to dual-core processors relatively easy and attractive. All that is required is to physically exchange the microprocessor packages and perform a logical upgrade by flashing the system's ROM BIOS with programming to support the new processor.

Figure 3.12 provides a block diagram of the AMD *Athlon 64 X2* Dual-Core processor design. Unlike the Intel processors, the dual processor cores in the 64 X2 can communicate with each other through the System Request Interface. This interface enables communications to take place at the core clock speed of the processors.

The AMD multicore technology also changed the front-side bus arrangement found in existing Pentium/PCI systems. This portion of the system has been redesigned in a Direct Connect Architecture that directly connects the processors, the memory controller, and the HyperTransport (I/O) controller to the CPU through the Crossbar Switch portion of the System Request Interface inside the processor. This gives the processors direct on-chip access to the 128-bit ECC memory controller (in contrast to having to access an external bus to get to the North Bridge).

The complete line of AMD64 devices (single and dual core) offers AMD's advanced HyperTransport bus interface technology for high-speed I/O communication. This interface consists of an integrated HyperTransport controller and a 16-bit, 1GHz bus that interconnects the cores of the multicore AMD processor through its Direct Connect Architecture and provides 8GBps transfer rates. The HyperTransport interface also connects the processor package to the system board's chipset. This connection scheme is shown in Figure 3.13.

The AMD 64 X2 has been built on two different microprocessor core types. Both versions include dual AMD64 microprocessor cores. These cores are rated to operate at core voltages between 1.35V and 1.4V. Likewise, they both contain dual 64+64 (Data/Instructions) L1 cache memory units. They also run identical microprocessor instruction sets and extensions. Finally, they both work with Socket-939 structure and provide 1GHz HyperTransport high-speed I/O interfaces.

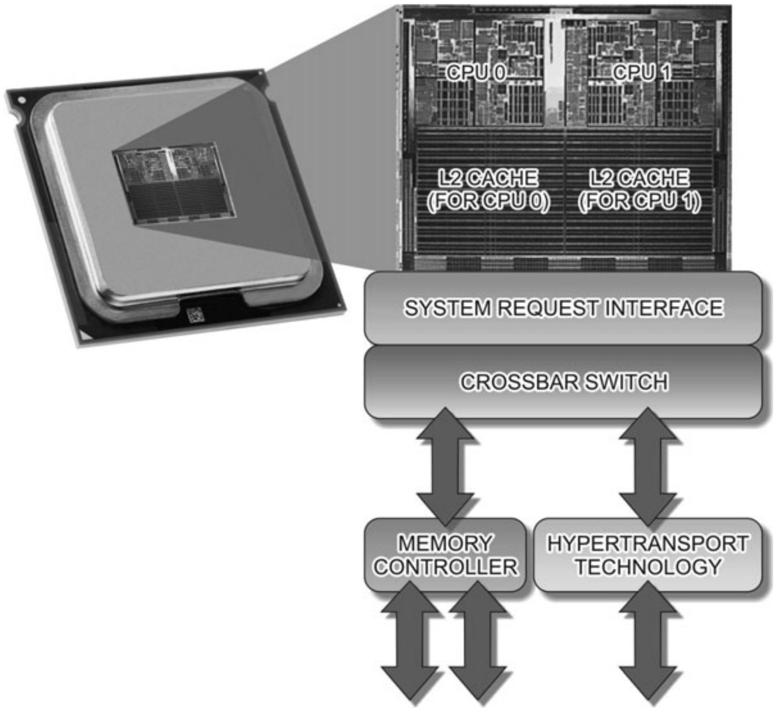

FIGURE 3.12 The AMD dual-core processor's design.

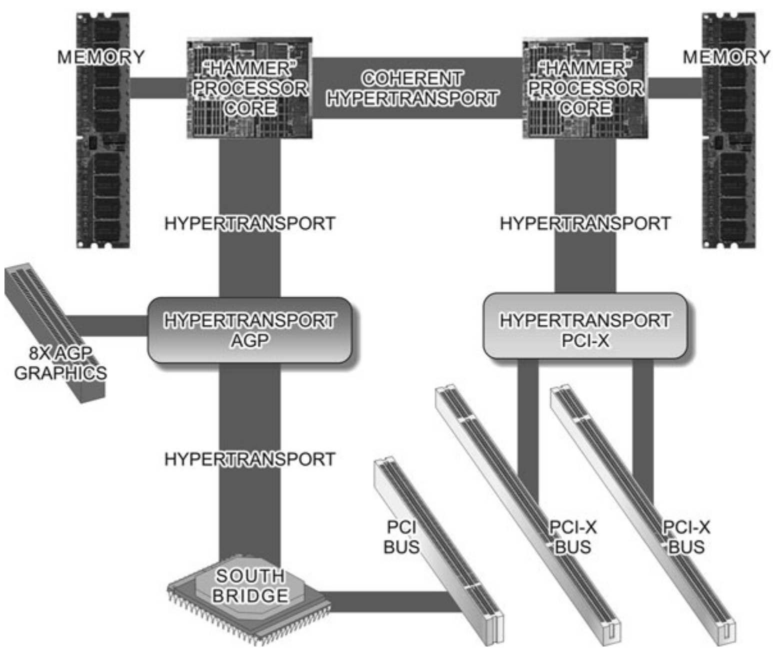

FIGURE 3.13 HyperTransport links.

The 4400+ processor runs on a 2.2GHz clock and the 4800+ uses a 2.4GHz clock. Both versions provide a 1MB full speed L2 cache for each core. They also dissipate 89 or 110 watts of power. On the other hand, the 3800+is designed for a 2.0GHz clock, the 4200+ uses a 2.2GHz clock, and the 4600+ version employs a 2.4GHz clock. In these versions, the L2 cache is limited to 512KB for each core and the power dissipation is limited to 110W max.

The Athlon 64 X2 is supported by a number of chipsets from many manufacturers. These include:

- *NVIDIA*—Nforce4 Series chipsets
- *ATI*—Radeon Xpress 200 Series chipsets
- *VIA*—K8 Series chipsets
- *SiS*—75x Series chipsets or greater

In at least one case (NVIDIA nFORCE Professional), the chipset designed to support the AMD dual-core processor is a single chip, as shown in Figure 3.14. The AMD processors provide direct connection to the system's DDR memory through its Direct Connect Architecture, and the nFORCE chipset handles the PCIe graphics, Ethernet networking, and SATA disk-drive interfaces.

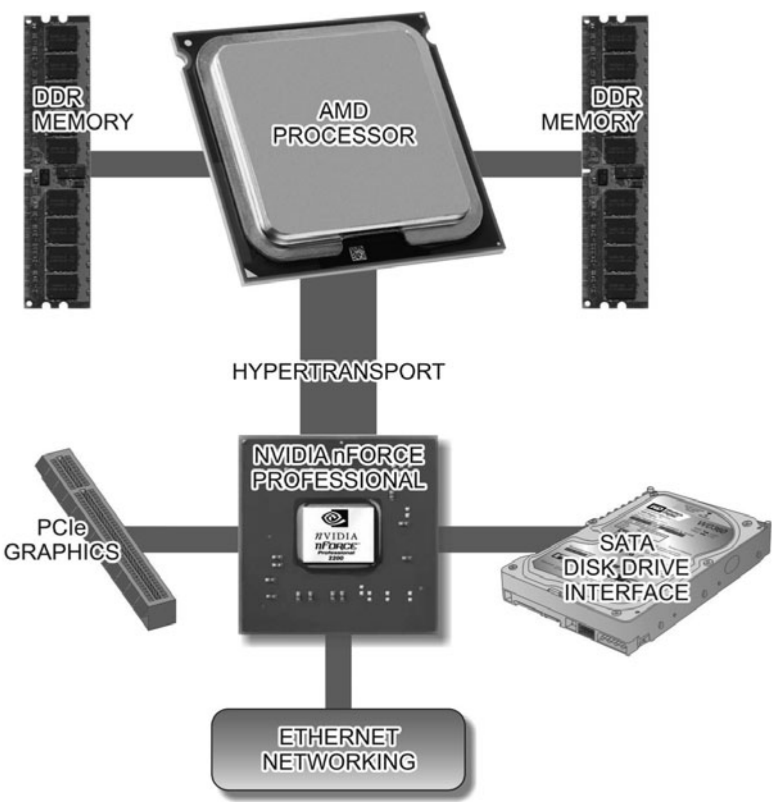

FIGURE 3.14 A single-chip AMD chipset.

Like the dual-core Intel processors, the Athlon 64 X2 supports a 64-bit extension to the x86 Instruction set, enhanced virus protection with supported operating systems, and speed throttling features. In the AMD environment, these features are known as AMD64, NX (no execute bit), and CoolnQuiet. The functions associated with these features are roughly the same as those of the Intel EM64T, XD bit, and SpeedStep features described earlier in this chapter.

Opteron Processors

AMD has also produced a line of dual-core, high-end *Opteron processors* for network server and workstation units. These units are built on AMD's K8 core and are intended to compete with Intel's Xeon line of processors. The original 1XX Opteron versions were built for a 939-pin socket. However, newer 2XX and 8XX 940-pin versions have been introduced for the newer Socket M2 (AM2) specification. As mentioned in Chapter 2, "PC System Boards," several Athlon64, Athlon 64 FX, Athlon64 X2, and Sempron processor versions have been developed to use the Socket M2 specification. Table 3.2 lists the prominent features of the dual-core Opteron processors from AMD.

TABLE 3.2 AMD Dual-Core Opteron Processors

MODEL	CLOCK FREQUENCY	L2-CACHE	MEMORY	MULTIPLIER	VOLTAGE	TDP	SOCKET
165	1.8GHz	2 × 1MB	up to PC-3200	9×	1.35/1.3V	110W	Socket 939
170	2.0GHz	2 × 1MB	up to PC-3200	10×	1.35/1.3V	110W	Socket 939
175	2.2GHz	2 × 1MB	up to PC-3200	11×	1.35/1.3V	110W	Socket 939
180	2.4GHz	2 × 1MB	up to PC-3200	12×	1.35/1.3V	110W	Socket 939
185	2.6GHz	2 × 1MB	up to PC-3200	13×	1.35/1.3V	110W	Socket 939
265/865	1.8GHz	2 × 1MB	up to PC-3200R	9×	1.35/1.3V	95W	Socket 940
270/870	2.0GHz	2 × 1MB	up to PC-3200R	10×	1.35/1.3V	95W	Socket 940
275/875	2.2GHz	2 × 1MB	up to PC-3200R	11×	1.35/1.3V	95W	Socket 940
280/880	2.4GHz	2 × 1MB	up to PC-3200R	12×	1.35/1.3V	95W	Socket 940
285/885	2.6GHz	2 × 1MB	up to PC-3200R	13×	1.35/1.3V	95W	Socket 940

Table 3.3 summarizes the characteristics of common Intel and AMD microprocessors. Both companies add new or upgraded processors to their product lines on a regular basis. Therefore, this list is not intended to be a complete list of all existing processors, just the main ones in existence up to the time when the text was created.

TABLE 3.3 Microprocessor Characteristics

MICRO-PROCESSOR	DIAMETER SIZE (mm)	VRM (VOLTS)	SPEED (MHz)	CACHE ON DIE (KB)	CACHE ON CARTRIDGE	CACHE ON BOARD (KB)	SOCKETS OR SLOT TYPES
Pentium	23.1 × 23.1	2.5-3.6	75-166	L1–8+8	-	L2–256/512	Socket 7
Pentium MMX	25.4 × 25.4	2.0-3.5	166-233	L1–16+16	-	L2–256/512	Socket 7
AMD - K6-2:K6-3	33.5 × 33.5	2.2-3.3	300-550	L1–32+32	-	L2–256/512	Super Socket 7
Pentium Pro	24.2 × 19.6	3.1-3.3	150, 166, 180, 200	L1–8+8	L2–256/ 512/1000	-	Socket 8
Pentium II/III Celeron (.25 micron)	25.4 × 25.4 18 × 62 × 140 Box	1.5-2.6	233.1000	L1–16+16	L2–256/ 512–128KB	- -	Slot 1
Xeon II/III (330) (.25 micron)	27.4 × 27.4 18 × 87 × 125 Box	1.5-2.6	500/550 700/90	L1–16+16	L2–512 KB/ 1 MB/2 M	- -	Slot 2
Pentium III Celeron (.25 micron)	25.4 × 25.4 Slug 27.4 × 27.4 Opening	1.1-2.5	300-566	L1–16+16– L2–128/256	- -	- -	Socket 370 PPGA
Pentium III (Coppermine) Celeron (.18 micron)	9.3 × 11.3	1.1-2.5	667-1000	L1–16+16– L2–128/256	- -	- -	Socket 370 FC-PGA
Pentium III (Tualatin) Celeron (.13 micron)	31 × 31	1.1-2.5	800-1500	L1–16+16 L2–128/ 256/512	- -	- -	FC-PGA2
Pentium 4 (.18 micron)	31 × 31	1.75	1300- 2000	L1–12+8– L2–256	- -	- -	Socket 423 FC-PGA
Pentium 4 (.18 micron) (.13 micron)	31 × 31 33 × 33	1.75-1.50	1400- 2000 1800- 3400	L1–12+8 L2–512	- -	- -	FC-PGA2
Pentium Xeon (.18 micron)	31 × 31	1.4-1.8–1.7	1400- 2000	L1–12+8– L2–256	- -	- -	Socket 603 FC-BGA
Pentium Xeon (.13 micron)	35 × 35	1.4-1.8– 1.475	1800- 3400	L1–12+8– L2–512	- -	- -	Socket 603 FC-BGA2

TABLE 3.3 *Continued*

MICRO-PROCESSOR	DIAMETER SIZE (mm)	VRM (VOLTS)	SPEED (MHz)	CACHE ON DIE (KB)	CACHE ON CARTRIDGE	CACHE ON BOARD (KB)	SOCKETS OR SLOT TYPES
Itanium (.18 micron) (266MHz)	71.6 × 127.7	1.7	733/800	1–16+16 L2–512	L3–2MB 4MB	4MB -	PAC-418
Celeron D	125.0 × 90nm × 81mm	1.25-1.4	2133.3333	L1–12+ 16KB/ L2–256KiB	-	-	Socket 478/ LGA775
Pentium 4 Extreme Edition	169.0 × 130nm × 237mm	1.2/1.25-1.337/1.4	3200-3733	L1–12+8/ L2– 2x1024KiB or 2x2048KiB	L3.2MB	-	FC-LGA775
Pentium D	230.0/ 376.0 × 90/ 65nm × 206/ 280mm	1.2/1.25-1.337/1.4	2667-3600	L1–24+ 32KB/L2– 2x1024KiB or 2x2048KiB	-	-	FC-LGA775
Athlon/Duron	9.1 × 13.1	1.75	800-1400	L1–64+64	L2–256KB	-	Slot A /242 CPGA
Athlon/Duron	11.1 × 11.6	1.75	733.1800 1400-3200	L1–64+64	L2–256KB	-	Socket A /462 ORGA
Athlon XP-M	68.5 × 130nm × 144mm	1.5-1.75	1333.2333	L1–64+64	L2–128KiB/ 256KiB/ 512KiB	-	Socket A/462
Athlon 64	105.9/ 68.5/76 × 130/130/ 90nm × 193/144/ 84mm	1.25-1.40, 1.35, 1.4, 1.5	2133.3333	L1–64+64	L2– 1024KiB/ 512KiB	-	Socket 754/939
Athlon 64 FX	233.0 × 90nm × 199mm	1.50-1.55, 1.50, 1.35/1.4	1.3.1.35V, 2200-2800	L1–64+64	L2–1024KiB	-	Socket 754/939/ 940/AM2
Opteron	114.0/105.9 × 90/130nm × 115/193mm	1.50-1.55/ 1.35-1.4	1400-2400/ 1600-3000	L1–64+64	L2–1024KiB	-	Socket 939/940

NOTE

The PC industry has added a new measurement to contend with. This is the kiB (kibibyte or kilo binary byte) as presented in Table 3.3. The kiB is related to the kilobyte (KB) but is intended to remove the inaccuracy that exists between the 1000 units generally attributed to the term kilo and the 1024 units it represents in digital systems. Therefore, when you see a PC quantity specified in kiB, it represents 1024 bytes.

Microprocessor Clock Speeds

In the Pentium processor, two speed settings are established for the microprocessor—one speed for its internal core operations and a second speed for its external bus transfers. These two operational speeds are tied together through an internal clock multiplier system. The Socket 7 specification enabled system boards to be configured for different types of microprocessors using different operating speeds. In older systems, the operating speed of the microprocessor was configured through external settings.

Prior to Pentium II, all Pentium processors used 50, 60, or 66MHz external clock frequencies to generate their internal operating frequencies. The value of the internal multiplier was controlled by external hardware DIP-switch or jumper settings on the system board.

Pentium II processors moved to a 100MHz external clock and front-side bus. The Pentium III and all slot processors up to 1GHz continued to use the 100MHz clock and FSB. However, beginning with the Pentium III, the external clock speed was increased to 133MHz. At the same time, the Celeron processors retained the 66MHz clock and bus speeds up to 800MHz.

The Pentium 4 processors use external clocks of 100MHz and 133MHz. From these clock inputs, the Pentium 4's internal clock multipliers generate a core frequency of up to 3.06GHz and front-side bus frequencies of 400MHz, 533MHz, and 800MHz. They have also used four different special memory buses with different memory types. In Pentium 4 systems, it is possible to set clock speeds for the memory and front-side buses independently. The different memory bus configurations are designed to work with different types of advanced RAM and run at speeds of 400, 533, and 800MHz.

Newer processors, such as Intel's 3.46GHz Pentium 4 Extreme Edition, Pentium D dual core, and the Core 2 Duo, possess a 1066MHz FSB capability that works with 266MHz quad-pumped (that is, multiplied by 4) DDR2 RAM.

As mentioned previously in the chapter, double pumping a bus (also referred to as a dual-pumped, double-transition, or double data rate bus) involves transferring data on both the rising and falling edges of the clock signal's square wave. Similarly, quad pumping a bus (also referred to as a quad data rate or a double data rate 2 bus) transfers data four times during a clock cycle. This technique actually requires two versions of the clock signal that are 90 degrees out of phase. These techniques are used to transfer data between the microprocessor and RAM on the FSB using a lower, more stable clock frequency.

You may encounter some confusion because much of the industry uses the MHz terminology given in the previous paragraph to describe the FSB, when the proper terminology should be that the 266MHz actual bus clock frequency provides 1066MT/s across the bus (instead of 1066MHz).

In the example pointed out previously, the processor's advertised core speed is listed as 3.46GHz (3466MHz). That processor's documentation will show that an internal x13 multiplier is required to achieve this core operating speed. This means that the clock signal the non-core portions of the processor are using (which is also the system clock and the FSB clock) is running at 266MHz (3466/13).The quad-pumped bus-signaling technique used by these processors provides a transfer rate of 1066MT/s.

This discussion becomes even more complex when dealing with memory structures. In these discussions, you may also see the FSB bandwidth specified in terms of MBps. This value is arrived at by multiplying the bus's transfer rate by its width in bytes. Double- and quad-pumped memory operations are covered in detail in Chapter 4, "Random Access Memory (RAM)."

Processor Power Supply Levels

Beginning with the Pentium MMX, Intel adopted dual voltage-supply levels for the overall IC and for its core. This was done for two reasons:

- To make the processor's switching time faster so that it can be clocked faster.
- To reduce the processor's power consumption/dissipation (in the form of heat).

Common Intel external/internal voltage supplies are +5/+5 for older units and +3.3/+3.3, +3.3/+2.8, +3.3/+1.8, and +3.3/1.45 for newer units.

The transistors that make up the microprocessor (and every other digital device) have maximum turn on and turn off rates. When the system clock nears this point, no further performance increase can occur without a change that allows the transistor to be clocked faster. The answer was to move the core's high and low logic voltage levels (that represent 1 and 0) closer to each other (0 and 1.8 vs. 0 and 5) so that it requires less time to switch back and forth between them. At the maximum change rate of the transistors, it doesn't take as long to get from 0 to 1.8V as it does to get from 0 to 5.0V. Therefore, you can turn the devices on and off more often with a smaller voltage separation.

The second reason for using the lower voltage level in the processor core is also electrical—transistors dissipate power in the form of heat. In electronic devices, power dissipation is directly proportional to both voltage and current. Therefore, if the current or the voltage associated with an electronic component like a transistor is lowered, so is the level of power that will be generated. Although the power associated with a single microprocessor is very small, when you multiply that value by millions of transistors, you get a very large number.

Clone processors may use compatible voltages (especially if they are pin compatible) or may use completely different voltage levels. Common voltages for clone microprocessors include +5, +3.3, +2.5, and +2.2. The additional voltage levels are typically generated through special regulator circuits on the system board that you might have to set manually. In each case, the system board user's guide should be consulted anytime the microprocessor is replaced or upgraded.

From the second-generation Pentiums forward, system boards have employed Voltage Regulator Modules (VRMs) to supply special voltage levels associated with different types of microprocessors that might be installed. The VRM module may be designed as a plug-in module so that it can be replaced easily in case of component failure. This is a somewhat common occurrence with voltage regulator devices. It also enables the system board to be upgraded when a new Pentium device is developed that requires a different voltage level or a different voltage pairing.

Configuring Microprocessors and Buses

Most system boards feature autodetection functions as part of the PnP process that automatically detect different field replaceable unit (FRU) components on the board (processors, fans, RAM modules, and adapter cards) and synchronize the different bus speed configurations. For example, the autodetect feature examines the installed microprocessor and the installed RAM modules to configure the front-side bus for optimum microprocessor-memory operations.

Similarly, the chipset may detect an advanced video adapter card in one of the expansion slots and adjust the expansion bus speed to maximize the performance of the video display. Likewise, the system autodetects the installed hard drives and CD/DVD-ROM drives and adjusts the IDE bus speed to provide the best drive-system performance based on what it finds.

Finally, the system evaluates the information it has acquired about its components and buses and configures the North and South Bridges to provide synchronization between their other buses and the PCI bus that connects them. The PCI bus speed (and by default its AGP video slot derivative) does not change to accommodate different installed components. Its speed is established as a derivative of the microprocessor clock speed (not to be confused with the advertised operational speed rating of the microprocessor).

Some BIOS versions actually provide a user-definable clock divider setting for the operation of the PCI bus. In these systems, you can set the PCI clock divider at one-half (for example) and the PCI bus will run at half the speed of the system's FSB clock frequency. This option is generally provided to keep the PCI bus running within specification when the processor is being overclocked. The setting options should be used to keep the PCI bus speed near the specified maximum speed for the standard PCI bus and its adapter cards, which is 37.5MHz.

The BIOS version must support the parameters of the microprocessor so that the PnP process can correctly configure the device and the chipset.

Key microprocessor and bus configuration settings typically included items such as the following:

- *Microprocessor Type*—This setting tells the system what type of processor is installed. If this setting is incorrect, the system will assume that the installed processor is the one specified by the setting and try to interact with it on that basis. Depending on which microprocessor is indicated, the system POST might identify the processor incorrectly and still run, but not properly. In other cases, the processor might lock up during the POST or not run at all. In either case, the processor could be damaged.
- *Core-to-Bus Speed Ratio*—Again, depending on the exact mismatch, the system might overclock the processor and run, but erratically. If the overclocking is less than 20%, the system might run without problems. However, the processor's life expectancy will be decreased over time. If the deviation is greater than 20%, the system might not come up at all, and the processor might be damaged.
- *Bus Frequency Setting*—Configuring this setting incorrectly will cause the processor to run faster or slower. This is a common method employed by users to increase the operating speed of their older systems. If the variation is less than 20%, the system will probably work with a shortened processor life over time. Greater levels of overclocking the bus might cause the system to have random lockups.
- *Core Voltage Level*—This setting establishes the voltage level at which the microprocessor core will operate. The setting is linked to the processor's speed and power dissipation. Normally, the microprocessor will not operate at all if the voltage level is more than 20% too low. Conversely, if you operate a processor at a voltage level that is higher than its specified value, this can cause physical damage to it.

The processor configuration settings must be correct for the type of microprocessor installed in the system. If the core voltage level is set too high, the microprocessor will probably overheat slowly, or burn out, depending on the amount of voltage applied. Conversely, if the voltage level is configured too low for the installed processor, the system will most likely refuse to start. Likewise, setting the speed selection incorrectly can cause the system to think that a different processor is installed in the system.

For example, if an 850MHz Pentium III processor is installed in a system whose BIOS-supported processor speeds only up to 600MHz, the BIOS will report a processor speed of only 600MHz during the POST portion of the startup. The system will be limited to running at 600MHz. For this reason and others, the capabilities of the system BIOS should always be examined when performing microprocessor upgrades.

However, as described earlier in this chapter, newer processors possess speed step capabilities that enable them to reduce their operating speeds in steps depending on their usage levels.

This is a power-saving feature and must be considered before assuming a newer system is incorrectly configured.

EXAM ALERT

Know why a processor would show an incorrect speed rating.

As mentioned earlier, different groups of PC enthusiasts, such as gamers, make a practice of overclocking the processor to squeeze additional performance out of the system.

Because the microprocessor is running faster than designed, both the front-side bus and the PCI bus run faster than their stated values by a factor directly proportional to the amount that the microprocessor is overclocked. The additional speed also generates additional heat from both the processor and its supporting devices. This requires the installation of additional fans and cooling systems to prevent damage from the additional heat generated.

Challenge #1

Your company's board of directors approves your recommendation for upgrading existing systems as outlined in the previous chapter. When you upgrade the first system, you find that it is running at only 450MHz. What should you do to get the system up to the speed you recommended to the board?

Refer to the "Challenge Solution" section at the end of the chapter for the resolution to this challenge.

Fans, Heat Sinks, and Cooling Systems

All Pentium processors require the presence of a heat sink and a microprocessor fan for cooling purposes. As Figure 3.15 illustrates, these devices come in many forms, including simple passive heat sinks and fan-cooled, active heat sinks.

Passive heat sinks are finned metal slabs that can be clipped or glued with a heat-transmitting adhesive (referred to as *thermal compound* or *paste*) onto the top of the microprocessor. The fins increase the surface area of the heat sink, enabling it to dissipate heat more rapidly. *Active heat sinks* add a fan unit to move air across or through the heat sink. The fan moves the heat away from the heat sink and the microprocessor more rapidly.

The original ATX power-supply specification called for these systems to employ power supplies that use a reverse-flow fan that brings in cool air from the back of the unit and blows it directly onto the microprocessor. For this to work properly, the system board must adhere to the ATX form factor guidelines and place the microprocessor in the correct position on the system board. However, this portion of the ATX design specification has almost completely been ignored in favor of exhaust fan designs, which pull air through the system unit, across the system board and processor, and then push it out through the power supply unit.

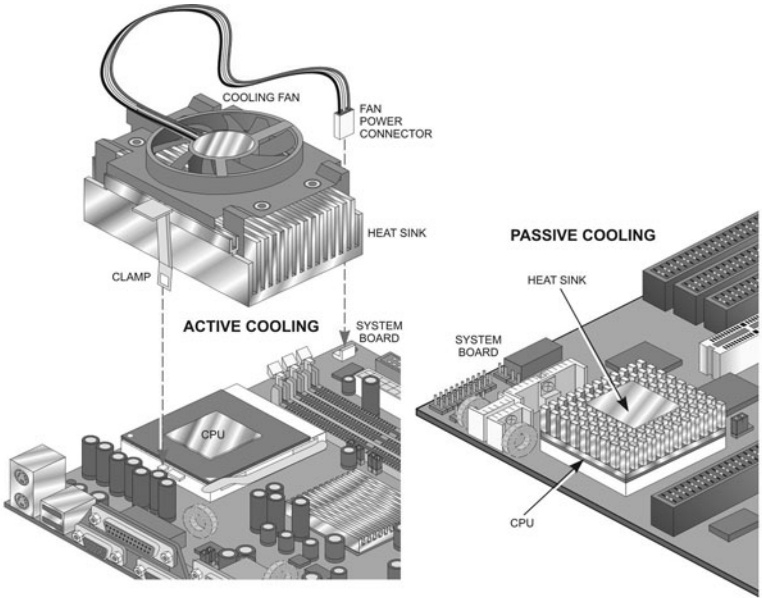

FIGURE 3.15 Typical microprocessor cooling systems.

Slot-based cartridge processors (Pentium II and III processors) also require special heat sink and fan support structures that work with the cartridge package. These units mount vertically on the system board beside the processor cartridge and provide support for the heat sink as well as the fan unit.

The support mechanism is designed so that it plugs into standard predrilled holes in the system board. For repair or upgrading purposes, the fan unit can be removed from the support mechanism and replaced.

In newer Pentium systems, the BIOS interrogates the processor during startup and configures it appropriately. This prevents the user from subjecting the processor to potentially destructive conditions, such as overclocking. In addition, these systems can monitor the *health* of the processor while it is in operation and take steps to compensate for problems such as overheating. This normally involves speeding up or slowing down the processor fan to maintain a given operating temperature.

The fan module must be one supported by the installed BIOS. If a fan unit is installed that does not have proper stepping in the BIOS routines, the system will not be able to correctly control the fan speed. Therefore, it may not be able to keep the processor cool enough for proper operation. Also, some fans are built better than others. For instance, fans that use ball bearings instead of slip ring bearings tend to run smoother and make less noise. However, they are usually more expensive than the slip ring versions.

BTX Thermal Module

The BTX form factor design is based on creating specific airflow zones within the case. The component responsible for generating the airflow is the BTX Thermal Module. The thermal module combines a heat sink and fan into a special duct that channels the air across the system board's main components. The duct fits tightly against large air vents in the front center portion of the case. The fan draws air in from the front and pushes it directly over the microprocessor mounted under the assembly in a linear flow pattern. The air continues toward the back of the case, passing over the graphics card and major chipset components. A fan in the power-supply unit draws some of the air across the memory devices before exhausting it out through the rear of the unit. Figure 3.16 shows the flow of air through the BTX case.

Advanced Cooling Systems

As system designers continue to push microprocessors for more speed, they also increase the amount of power that they dissipate. The latest microprocessor design techniques have created processors that generate more than 80 watts of power that must be dissipated as heat. This is more heat than a 60-watt light bulb generates. It is beyond the capabilities of most processor fans and heat sinks to effectively dissipate this much heat.

Simple air-cooling systems cannot create a large enough temperature differential to cool the processor. Therefore, system designers have begun to equip very high-speed systems with refrigerated cooling systems. Originally, the designers adopted water-based cooling systems that cooled and circulated water to carry heat away from the processor. Figure 3.17 shows the components of a sample water-based cooling system typically used to cool processors that have been configured to run in overclocking conditions.

The water cooler system consists of the following:

- A water reservoir tank
- A water pump that circulates water throughout the cooling system
- A condenser coil radiator with fans that cool the water and exhaust heat into the outside atmosphere
- A CPU cooling block that connects directly to the microprocessor and extracts heat from it

The water pump operates from inside the reservoir tank and forces cooling water through the system. Most of the pumps for these systems are adaptations of home aquarium pumps and are designed for 120Vac operation; therefore, they must have an external power cord.

The CPU cooling block consists of a copper-finned heat sink that mounts to a bracket installed around the microprocessor. Pentium 4 system boards have standard hole patterns already supplied to permit such devices to be attached to them. The heat sink is enclosed in a water jacket that circulates cooling water around the fins. This water jacket removes more heat from the processor faster than an air-cooled heat sink.

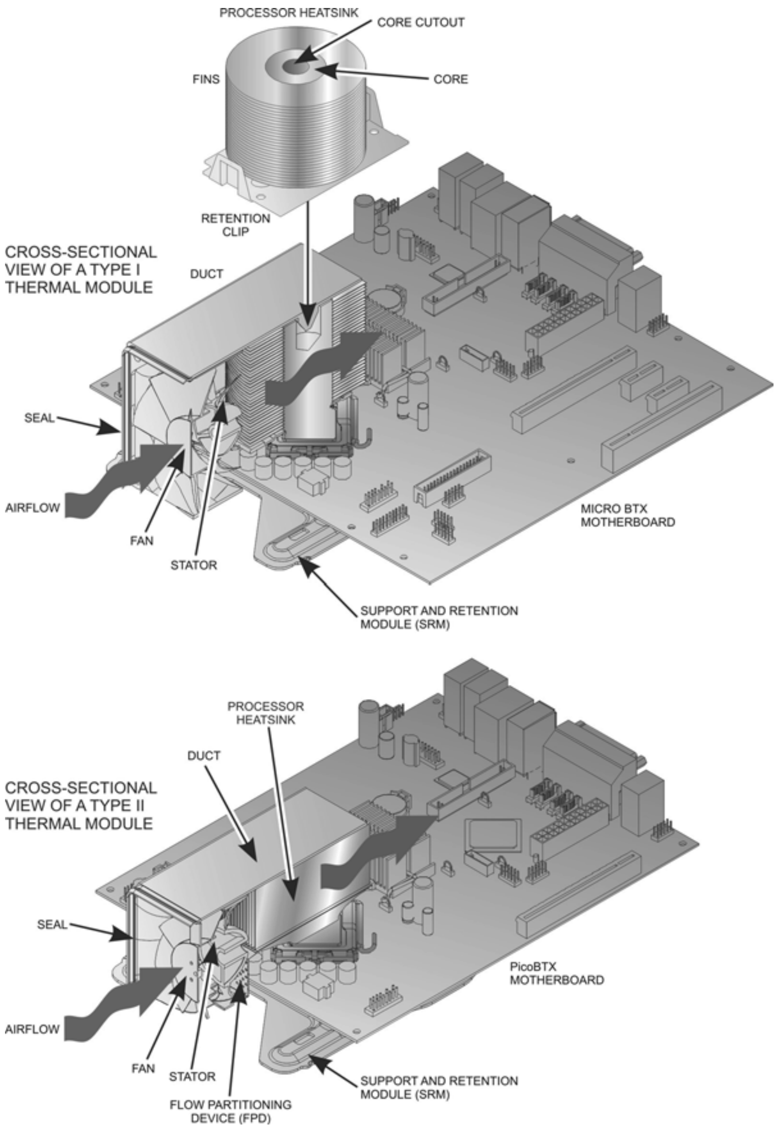

FIGURE 3.16 Airflow in a BTX system.

Heated water from the CPU cooler is pumped through the radiator. The radiator is composed of several coils of tubing to maximize the surface area that is used to dissipate heat. The additional fans push air across the coils and speed up the radiation process in the same manner as conventional CPU fans do for air-cooled heat sinks. The cooled water returns to the reservoir for recirculation.

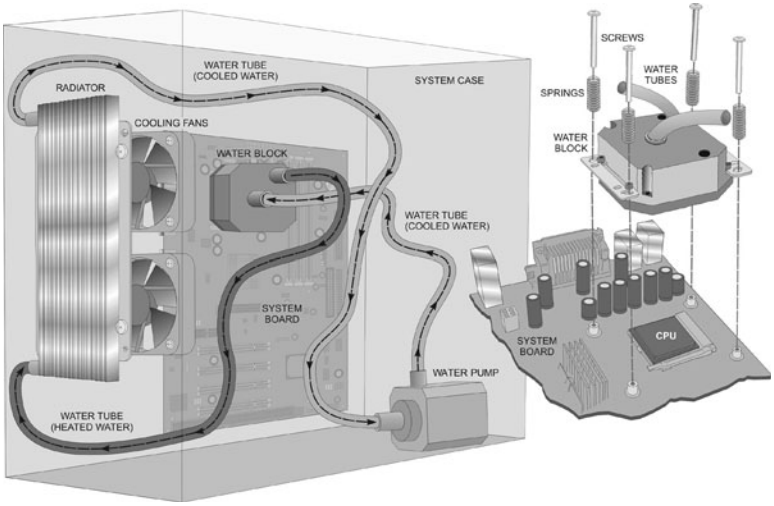

FIGURE 3.17 Water-based microprocessor coolers.

More advanced liquid-based cooling systems have migrated to nonwater coolants like those used in residential refrigerators or automobile air conditioners. The components associated with a refrigerated cooling system used with a PC system include the following:

- An evaporator that mounts on top of the microprocessor.
- A condenser with cooling fan that mounts to the case so that air can be exhausted to the outside of the case.
- A compressor that places the cooling liquid under pressure so that it can perform refrigeration.
- A flow control/expansion device that acts as a restriction in the lines of the system that causes the refrigerant to lose pressure and partially vaporize.
- Insulated tubing that connects the four major components in a closed-loop cooling circuit.

As Figure 3.18 illustrates, the components of the PC cooling system do not fit inside a typical desktop or tower unit. Instead, they must be used in cases that have been modified for them, or in cases that have been designed specifically for them.

The four major components of the system are interconnected by a sealed piping system that holds a refrigerant liquid. The compressor is used to compress the refrigerant and pump it through the system. The high-pressure, high-temperature refrigerant first passes through the condenser unit where it exchanges heat with the surrounding air and cools somewhat.

Next, the refrigerant is forced through the flow control/expansion device, which restricts its flow and causes it to lose pressure as it passes through the device. The loss in pressure causes some of the refrigerant to change into a gas. In the process, the gaseous portion of the refrigerant extracts heat from the remaining liquid and thereby cools it.

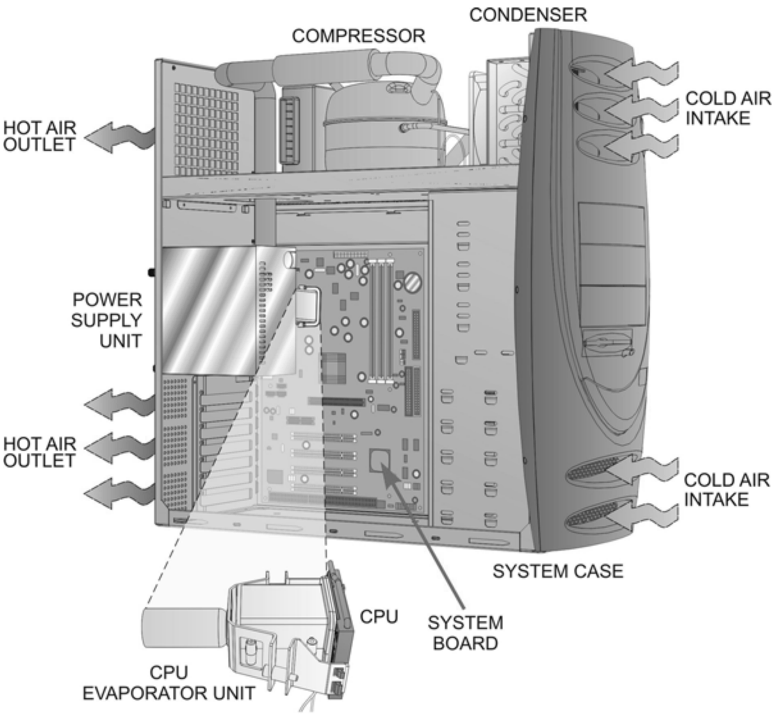

FIGURE 3.18 PC refrigerant coolers.

The refrigerant is then passed through the evaporator on the microprocessor in the form of a warm liquid. As air passes over the evaporator, heat is extracted from the processor body and is passed to the cooler refrigerant. The remainder of the liquid refrigerant becomes a cool gas as it gathers heat from the evaporator and is drawn back to the compressor where the process begins again.

As the air passes over the evaporator and cools, moisture can condense around the processor in the form of condensate. To protect the processor and printed circuit board around it, special insulating foam pads must be mounted around the microprocessor socket. In addition, special heating elements are typically mounted on the backside of the system board under the microprocessor socket position and on top of the processor (as shown in Figure 3.19).

The BIOS controls the refrigerant cooling system through its Health Management system. This includes monitoring the actual temperature of the microprocessor and manipulating the cooling system to maintain a designated temperature level. It also controls the temperature of the heating element under the printed circuit board.

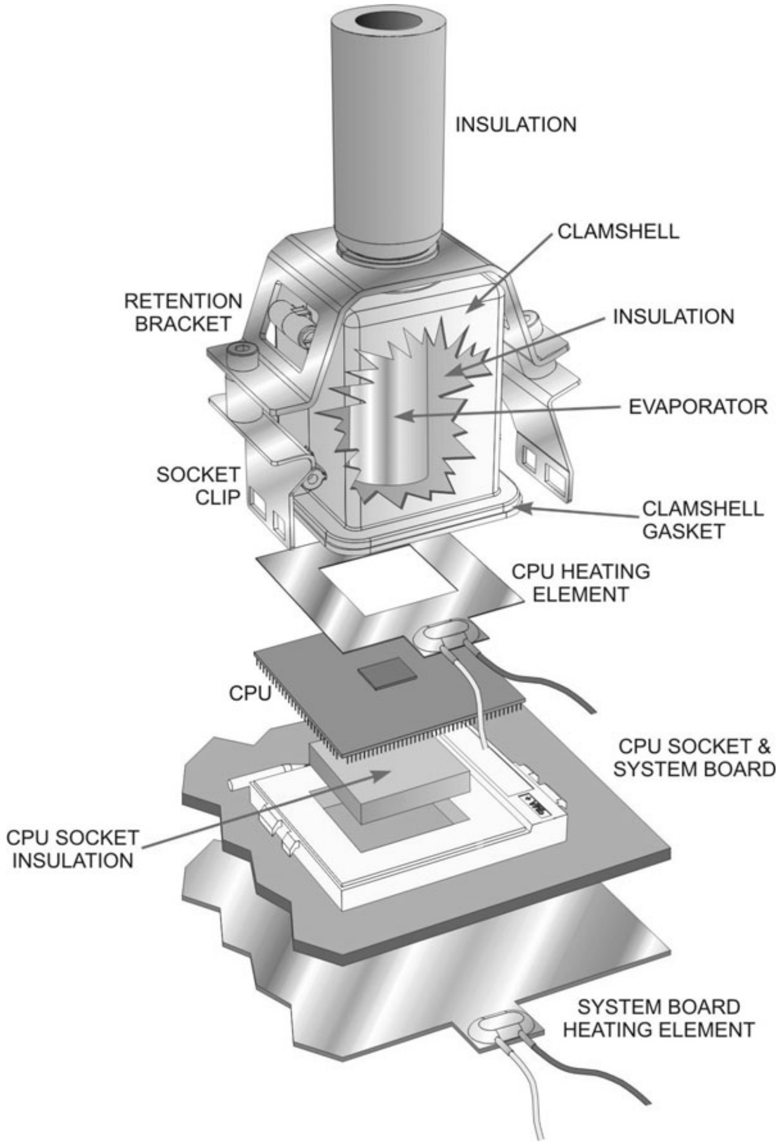

FIGURE 3.19 Condensation prevention.

This technology is not widely used in PCs. Although the military has been using this type of cooling system for more than five years, it is just beginning to be used with commercial PCs. Because the liquid refrigerants used in these systems are considered hazardous to the environment, you must be aware that only individuals licensed to handle refrigerants can legally work on these units.

Exam Prep Questions

1. To obtain higher performance levels from their systems, gamers typically configure their systems to drive the microprocessors at higher speeds than the manufacturers suggest. What is this practice called?

   ❍ **A.** Hyperthreading

   ❍ **B.** Processor throttling

   ❍ **C.** Overclocking

   ❍ **D.** Speed stepping

2. Which of the following is not a component of a Pentium II SEC cartridge?

   ❍ **A.** Processor core

   ❍ **B.** Tag RAM

   ❍ **C.** 262-contact socket interface

   ❍ **D.** L2 burst SRAM

3. AMD Athlon 64 processors provide HyperTransport technology. How does this make the AMD systems different from comparable Intel Core Duo systems?

   ❍ **A.** The AMD boards use this technology to automatically change the operating speeds of their processors to conserve power.

   ❍ **B.** The AMD boards with HyperTransport do not require a North Bridge in their chipsets.

   ❍ **C.** The HyperTransport feature allows the AMD boards to clock their processors at higher speeds than recommended for standard boards.

   ❍ **D.** The HyperTransport feature allows the AMD boards to run multithreaded applications.

4. Which types of system board sockets can accept a Pentium III microprocessor? (Select all that apply.)

   ❍ **A.** Slot 1

   ❍ **B.** Super Socket 7

   ❍ **C.** Socket 370

   ❍ **D.** Socket A

5. Which processors can be used in a Socket 370 system?

❍ **A.** Pentium MMX, Celeron

❍ **B.** Celeron, Pentium III

❍ **C.** Pentium III, Pentium 4

❍ **D.** Celeron, Duron

6. Which microprocessor can use a Slot 1 connection?

❍ **A.** Athlon K7/550

❍ **B.** Duron/600

❍ **C.** Celeron/266

❍ **D.** Pentium Pro

7. Which advanced microprocessor architecture enables multiple program segments to be run in different sections of the processor simultaneously to fool the operating system into thinking that two processors are available?

❍ **A.** Hyperthreading

❍ **B.** Hypertransport

❍ **C.** Speed stepping

❍ **D.** Dual-core processing

8. What is the appropriate socket for the Pentium II microprocessor?

❍ **A.** Slot 1

❍ **B.** Super Socket 7

❍ **C.** Socket 370

❍ **D.** Slot A

9. You are trying out your new Dual Core Pentium, Windows XP Professional-based notebook computer on a long flight when you notice in System Properties that the system is reporting the wrong processor speed. What should you do?

❍ **A.** Return the notebook to the vendor for one with the correct processor.

❍ **B.** Use Windows Updates to download and install SP2 to correct this common reporting error.

❍ **C.** Nothing, the system has throttled back to save power.

❍ **D.** Run the system's system board drivers disc to update the system board with the correct drivers for the processor.

10. What is the appropriate socket for the Pentium 4 microprocessor?

❍ **A.** Socket A

❍ **B.** Super Socket 7

❍ **C.** Socket 370

❍ **D.** Socket 423

11. What is the appropriate socket for the Duron microprocessor?

❍ **A.** Socket A

❍ **B.** Super Socket 7

❍ **C.** Socket 370

❍ **D.** Socket 423

12. What is the appropriate socket for a new dual-core Intel microprocessor?

❍ **A.** SPGA 973 Socket

❍ **B.** Socket A

❍ **C.** LGA 775Socket

❍ **D.** FCPGA 921 Socket

13. The unofficial overclocking record for a Pentium 4 processor is 8.32GHz. The overclocking team that accomplished this record pushed the processor's internal clock multiplier to 16. At what speed did the FSB run in this machine?

❍ **A.** 133MHz

❍ **B.** 520MHz

❍ **C.** 1.04GHz

❍ **D.** 4.16GHz

14. Which processor can be used in a Slot A system board?

❍ **A.** Athlon K7/550

❍ **B.** Duron/600

❍ **C.** Celeron/266

❍ **D.** Pentium II/233

15. What is the actual clock frequency of a dual core Pentium D 915 with a quad-pumped FSB running at 800MT/s?

❍ **A.** 100MHz

❍ **B.** 200 MHz

❍ **C.** 400 MHz

❍ **D.** 800 MHz

16. Which advanced processor technologies are useful in preventing malicious software programs from taking control of programs and running their own code? (Select all that apply.)

❍ **A.** XD-bit technology

❍ **B.** No-step technology

❍ **C.** MMX technology

❍ **D.** NE-bit technology

Answers and Explanations

1. **C.** Overclocking is the practice of manually configuring the microprocessor clock to run at a higher speed than the IC manufacturer suggests, to squeeze additional performance out of the system.
2. **C.** The Pentium II's proprietary 242-contact socket design is referred to as the Slot 1 specification.
3. **B.** The AMD multicore technology also changed the front-side bus arrangement found in existing Pentium/PCI systems. This portion of the system has been redesigned in a Direct Connect Architecture that directly connects the processors, the memory controller, and the Hypertransport (I/O) controller to the CPU through the Crossbar Switch portion of the System Request Interface inside the processor. This gives the processors direct on-chip access to the 128-bit ECC memory controller (in contrast to having to access an external bus to get to the North Bridge).
4. **A, C.** Intel followed the Pentium II processor with a new Slot 1-compatible design it called the Pentium III. Later versions of the Pentium III and Celeron processors were developed for the Intel Socket 370 specification.
5. **B.** Later versions of the Pentium III and Celeron processors were developed for the Intel Socket 370 specification.
6. **C.** Initially, the Celeron was packaged in the Slot 1 (SECC) cartridge.
7. **A.** Intel's hyperthreading architecture enables multiple program threads to be run in different sections of a single processor simultaneously. Basically, this structure fools the operating system into thinking that two processors are available for use.
8. **A.** The Pentium II used Slot 1. Refer to Table 3.3, "Microprocessor Characteristics."

9. **C.** Both Intel and AMD's newest processors have the capability to dynamically control their clock speeds. Running the processor at higher clock speeds provides better performance. However, running the processor at a lower speed provides for reduced power consumption and heat dissipation. This throttling technique is used to conserve battery power in notebooks, extend processor life, and reduce noise from cooling devices. When you monitor the System Properties of a portable computer, the processor speed that is reported may be lower than the actual processor speed. This behavior can occur because some portable computers reduce the processor speed to conserve power. If you monitor the computer while it is on battery power or in some other power-saving mode, the speed that is reported is lower than the computer's normal operating speed.

10. **D.** The Pentium 4 uses Socket 423 or Socket 478. Refer to Table 3.3, "Microprocessor Characteristics."

11. **A.** The Duron uses Socket A. Refer to Table 3.3, "Microprocessor Characteristics."

12. **C.** All the current and planned dual-core processors from Intel are designed to use a new type of socket called the Land Grid Array (LGA) 775. Unlike previous socket types, the LGA775, also referred to as Socket-T, places contact pins on the system board and contact pads on the bottom of the microprocessor. A hinged metal rim folds down over the microprocessor package and holds its contact pads securely against the signal pins on the system board. A locking arm is used to clamp the processor package in place. The heat sink and fan unit are connected directly and securely to the system board on four points.

13. **B.** The internal $\times 16$ multiplier setting required to achieve a core operating speed of 8.32GHz means that the clock signal the noncore portions of the processor were using (which is also the system clock and the FSB clock) was running at 520MHz (8320/16). The quad-pumped bus signaling technique used by the Pentium 4 provided a maximum theoretical transfer rate of 2080MT/s.

14. **A, B.** The Athlon K7 version runs between 500MHz and 700MHz, provides a 128KB L1 cache and a 512KB L2 cache, employs a 100MHz system bus, and uses Slot A.

15. **B.** Quad pumping a bus (also referred to as a quad data rate or a double data rate 2 bus) transfers data four times during a clock cycle. This means that an FSB featuring an 800MT/s (also commonly referred to as an 800MHz bus) is actually using a bus clock frequency of 200MHz.

16. **A, D.** Intel's XD-bit technology is used to separate areas of memory into regions for distinct uses. Likewise, AMD's No-Execute (NE) bit technology was introduced with the Athlon 64 processor and also marks different areas of memory as being for use with data, or as being reserved for instructions. In both versions, a section of memory can be set aside exclusively for storing processor instructions (code), and another section can be marked only for storage of data. In the case of Intel processors, any section of memory marked with the XD/NE attribute means it's only for storing data. Therefore, processor instructions cannot be stored there. This is a popular technique for preventing malicious software from taking over computers by inserting their code into another program's data storage area and then running that code from within this section.

Challenge Solution

1. The old BIOS supported processor speeds up to only 450MHz. Now, processors are capable of running 1GHz. You must upgrade the system BIOS to support higher operating speeds for the processor. With many Slot 1 system boards, you will not have any problems upgrading to 1GHz, provided that you get the newest BIOS version; however, this is not true for every system board. You should have checked the chipset and BIOS information before purchasing the new microprocessors. There is a chance that you will be able to upgrade only to 600MHz.

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