2

Chapter 2:

On the Motherboard

OBJECTIVES

After completing this chapter you will

1. Understand the major components on a motherboard including the microprocessor, chipset, math coprocessor, and expansion slots.
2. Understand the basic operation of a microprocessor and what must be considered when upgrading it.
3. Recognize and identify the microprocessor.
4. Understand the differences among the various architectures and buses.
5. Recognize different expansion slots.
6. Recognize an adapter's architecture or bus.

KEY TERMS

3DNow!
AGP
bit
bus
bus-mastering
byte
cache memory
CardBay
CardBus
chipset
clone
COAST
CPU
DIB
EISA
exabyte
expansion slot
external data bus
form factor
FSB
gigabyte
gigahertz
HyperTransport
IEEE 1394 (FireWire)
InfiniBand
internal data bus
ISA
jumper
kilobyte
L1 cache
L2 cache
L3 cache
local bus
math coprocessor
MCA
megabyte
megahertz
microprocessor
MMX
multiplier
on-die cache
overclocking
overdrive
PC
PC Car
PCI
petabyte
pipeline
RapidIO
SEC cartridge
SEPP cartridge
Slot A
SmartMedia
Socket A
SSE
Super 7 socket
terabyte
USB
VL-bus
VRM
word size
write-back cache
write-through cache
ZV port

MICROPROCESSOR OVERVIEW

At the heart of every microcomputer is a special motherboard chip called the **microprocessor** (or processor) that determines, to a great extent, how powerful a computer can be. The microprocessor is also called the **CPU** (**Central Processing Unit**). The CPU executes instructions, performs math calculations, and coordinates input/output operations. Each motherboard has electronic chips that work with the CPU and are designed to certain specifications. Whether or not these other components can keep up with the microprocessor depends on the individual component's specifications. The major microprocessor manufacturers today are Intel, Motorola, Cyrix (now Via), and AMD (Advanced Micro Devices, Inc.). The microprocessors designed by Motorola have been used in Apple computers for years. Intel designed the microprocessors IBM used in their first computers.

IBM put microcomputers in the workplace and the home. Those early computers influenced a lot of what happened in the computer industry. The machines sold by companies who copied IBM's first computers were known as **clones** or IBM-compatibles. These two terms are still used in the computer industry today even though companies are not copying IBM at this point. Another name for the computer is **PC** or Personal Computer. This book focuses on compatibles (non-Apple computers) because they are in the majority used in businesses today. Intel and AMD microprocessors are covered extensively because they are the most common in the computer industry.

MICROPROCESSOR BASICS

All microprocessors use 1s and 0s. One *1* or one *0* is a **bit**. Eight bits grouped together are a **byte**. The letter *A* looks like 01000001 to the microprocessor. Each character on a keyboard appears as one byte or eight bits to the microprocessor. Approximately 1,000 bytes are a **kilobyte**. (1,024 bytes to be exact, but the computer industry rounds the number off to the nearest thousand for ease of calculation.) Ten kilobytes are shown as 10K or 10KB. Approximately one million bytes are a **megabyte**. 540 megabytes are shown as 540MB or 540M. A true megabyte is 1,048,576 bytes. Approximately one billion bytes (1,073,741,824 bytes) are a **gigabyte** and are shown as 1GB or 1G. Beyond the gigabyte is a **terabyte** that is approximately one trillion bytes. A **petabyte** is one thousand terabytes (or 2 to the fiftieth power) and finally, an **exabyte** is approximately one billion times one billion bytes or 2 to the sixtieth power.

The number of bits processed at one time is the microprocessor's **word size**. Each word contains eight bytes or eight characters. Another term some industry books and magazines use is *register size*. Intel's 8086 microprocessor's word size was 16 bits or two bytes. Today's microprocessors have word sizes of 32 bits. Future microprocessors will have 64-bit word sizes. The result of this will be the development of 64-bit operating systems and 64-bit applications.

The 1s and 0s must travel from one place to another inside the microprocessor as well as outside to other electronic chips. To move the 1s and 0s around, electronic lines called a **bus** are used. The electronic lines inside the microprocessor are known as the **internal**

data bus. In the 8086, the internal data bus is comprised of 16 separate lines with each line carrying one *1* or one *0*. The word size and the number of lines for the internal data bus are equal. The 8086, for example, had a 16-bit word size and 16 lines carried 16 bits on the internal data bus. In today's microprocessors, several groups of 32 internal data bus lines operate concurrently.

For the microprocessor to communicate with devices in the outside world, the 1s and 0s travel on the **external data bus**. The external data bus connects the microprocessor to adapters, the keyboard, the mouse, the floppy drive, the hard drive, and other devices. The external data bus is also known as the external data path. One can see the external data lines by looking between the expansion slots on the motherboard. Some solder lines between the expansion slots are used to send data out along the external data bus to the expansion slots. The Intel 8088 had an 8-bit external data bus. Today's microprocessors have 64-bit external data paths.

To make sense of all of this, take a look at a letter typed on a computer that starts out: "DEAR MOM." To the microcomputer, the letters of the alphabet are different combinations of eight 1s and 0s. For example, the letter *D* is 01000100; the letter *E* is 01000101. The 8086 microprocessor has a word size of 16-bits and an external data path of 16-bits. Therefore, the letters *D* and *E* travel together down the bus; the letters *A* and *R*, then the letters (*space*) and *M*, and finally the letters *O* and *M* travel as 1s and 0s. Each 1 or 0 travels along a data path line. Intel's 80386DX microprocessor has 32-bit internal and external data buses. In the same "DEAR MOM" letter, the letters *D*, *E*, *A*, and *R* are processed at the same time, followed by (*space*), *M*, *O*, and *M*. You can see that the size of the bus greatly increases performance on a microcomputer. Motherboard Table #1 shows the different models of Intel microprocessors and their internal and external data paths. Many Intel microprocessors are known as the x86 family because of the numbering scheme Intel used in naming the microprocessors.

MOTHERBOARD – TABLE #1

Intel Microprocessors

Microprocessor	Word Size (in bits)	External Data Bus Size (in bits)
8088	16	8
8086	16	16
80286	16	16
80386DX (386)	32	32
80386SX (386SX)	32	16
80486DX (486)	32	32
80486SX (486SX)	32	32
Pentium	32*	64
Pentium Overdrive	32*	32
Pentium Pro	32*	64
Pentium II	32*	64
Celeron	32*	64
Pentium III	32*	64
Pentium 4	32*	64

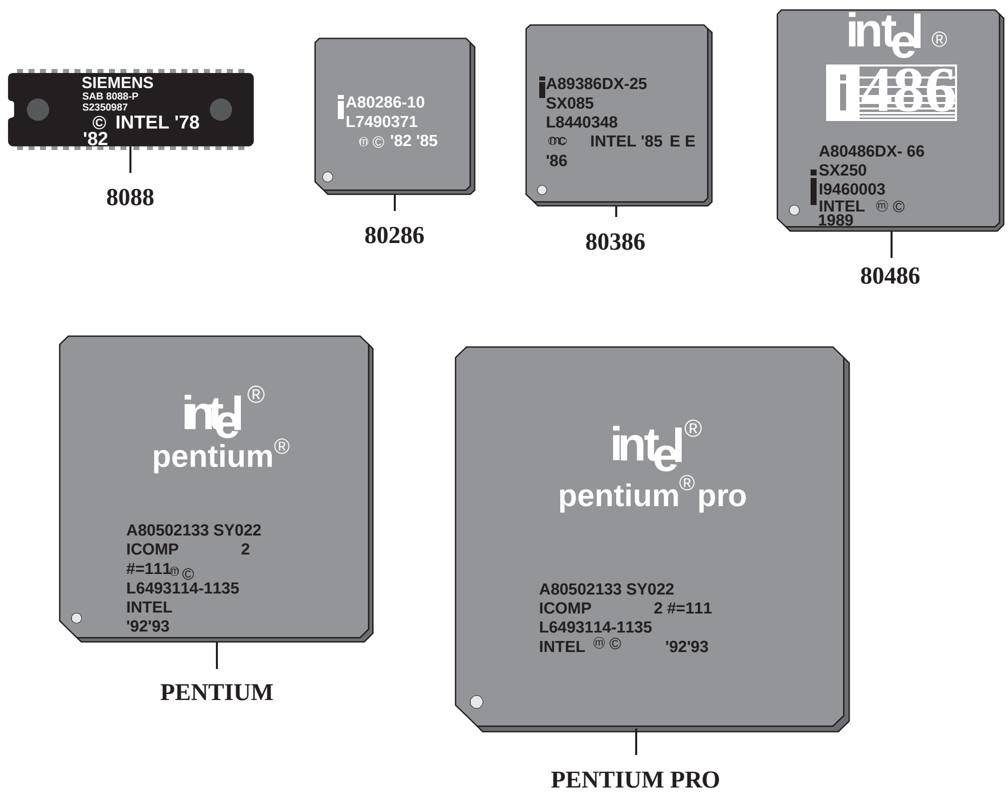
*Multiple 32-bit paths

Notice in Motherboard Table #1 that the 8088 microprocessor has a 16-bit internal data path and an 8-bit external data path. This is bad news. Imagine the "DEAR MOM" letter as it is processed in the computer. The microprocessor handles the letters *D* and *E* simultaneously, but when the letters go outside the microprocessor — to the monitor, for example — the letter *D* goes out the external data bus, followed by the letter *E*. Having an external data path one-half the size of the internal data path slows down a microcomputer considerably. Why would a manufacturer make such a product? The answer is simple æ lower costs. In many issues relating to microcomputers, the bottom line is profit.

Motherboard Table #1 shows Intel's Pentium, Pentium Overdrive, Pentium Pro, Pentium II, Pentium III, and Pentium 4 microprocessors as having 32* bits for the internal data buses. These microprocessors have multiple **pipelines** (separate internal buses) that operate simultaneously. The microprocessor handles 32 bits at a time and has separate paths, each of which handle 32 bits. For example, the Pentium microprocessor has two pipelines. In the "DEAR MOM" scenario, the letters *D*, *E*, *A*, and *R* can be in one pipeline, while (*space*), *M*, *O*, *M* can be in the other pipeline. Motherboard Figure #1 shows some of Intel's microprocessors.

MOTHERBOARD – FIGURE #1

Intel Microprocessors

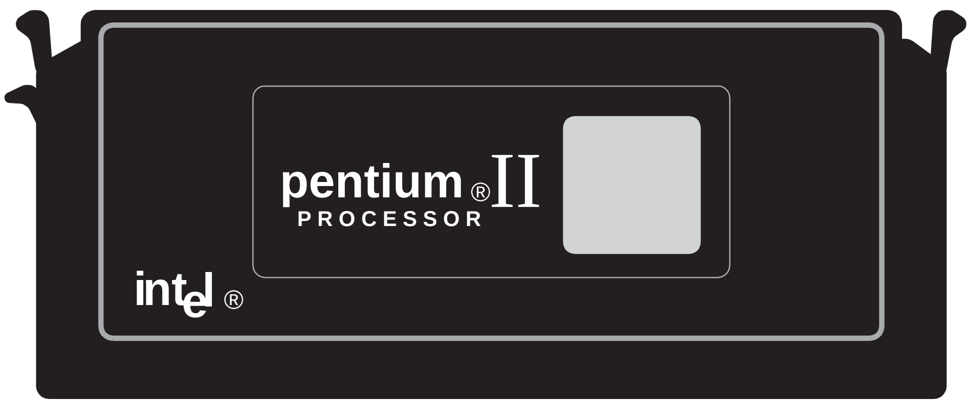


The Pentium II has five execution pipelines, although they only output 64 bits at a time to the external data bus. AMD's K-6 microprocessor has six execution pipelines; the Athlon has nine execution pipelines. Intel has changed the microprocessor pipeline to include more stages. The Pentium III has a 10-stage pipeline and a Pentium 4 has a 20-stage pipeline. Debate continues about whether a longer pipeline improves performance.

The Pentium II microprocessor looks different than the other rectangular and square microprocessors. To achieve speeds up to 300MHz, Intel redesigned the microprocessor casing for the Pentium II. It uses an **SEC** (**Single Edge Contact**) **cartridge** to mount onto the motherboard into an Intel Slot 1 connector. Motherboard Figure #2 shows the Pentium II SEC cartridge.

MOTHERBOARD – FIGURE #2

Pentium II Microprocessor



Intel's Celeron microprocessor was released for low-cost workstations. The CPU uses the P6 architecture similar to the Pentium II, but it is not expandable and does not include as much cache (explained later in the chapter) as the Pentium II. The Celeron uses a **SEPP** (**Single Edge Processor Package**) **cartridge**. This cartridge is similar to the Pentium II's SEC cartridge and it maintains compatibility with the 242-pin slot connector (known as a Slot 1 connector) the Pentium II uses. The Celeron processor is also available in a 370-pin PGA and FCPGA (Flip-Chip Pin Grid Array). The Pentium II Xeon and Pentium III Xeon CPUs insert into a 330-pin Intel Slot 2 connector. This Slot 2 connector allows communication with the microprocessor at the CPU's full speed. The Slot 1 connector supports communication at only one-half CPU speed. Pentium 4 processors use a 423-pin PGA socket and Xeons use a 603-pin PGA socket.

Distinguishing a 486 from a Pentium or Pentium Pro is accomplished by looking at the microprocessor's size. The 486 uses a 169-pin socket; the Pentium uses a 273 or 296-pin socket; the Pentium Pro uses a 387-pin socket. The 486 socket frequently has extra holes for a Pentium upgrade. The Pentium II and Pentium III CPUs are in an SEC cartridge. Pentium 4s and Xeons use large PGAs.

The microprocessor to watch for is a joint venture between Intel and Hewlett-Packard with the code name Merced. The Merced is a 64-bit microprocessor with a new architecture called IA-64. It will still be able to run applications designed for the older X86, Pentium, and Pentium II line. The clock speed of the Merced is expected to be 2GHz and higher. Other Intel processors in the works have the codenames Madison and Deerfield; both of these will use the IA-64 architecture.

AMD PROCESSORS

Advanced Micro Devices, Inc (AMD) makes a product similar to the Pentium known as the K5. The K5 processor fits in the same 296-pin socket as the Pentium. Even though a motherboard might physically accommodate the K5, the BIOS may not recognize it. (The BIOS may have to be upgraded.) Located on the AMD web site is a list of motherboards that accept the K5 CPU without an upgrade.

The different K5 modules are PR75, PR90, PR100, PR120, PR133, and PR166. The numbers after the *PR* are not the CPU speed. Instead, they are what is known as a P-rating, which is the clocked CPU speed when running a specific application as agreed upon by Cyrix, IBM, SGS-Thomson Microelectronics, and AMD. The speeds are actually 75MHz, 90MHz, 100MHz, 90MHz, 100MHz, and 116.7MHz respectively, according to AMD.

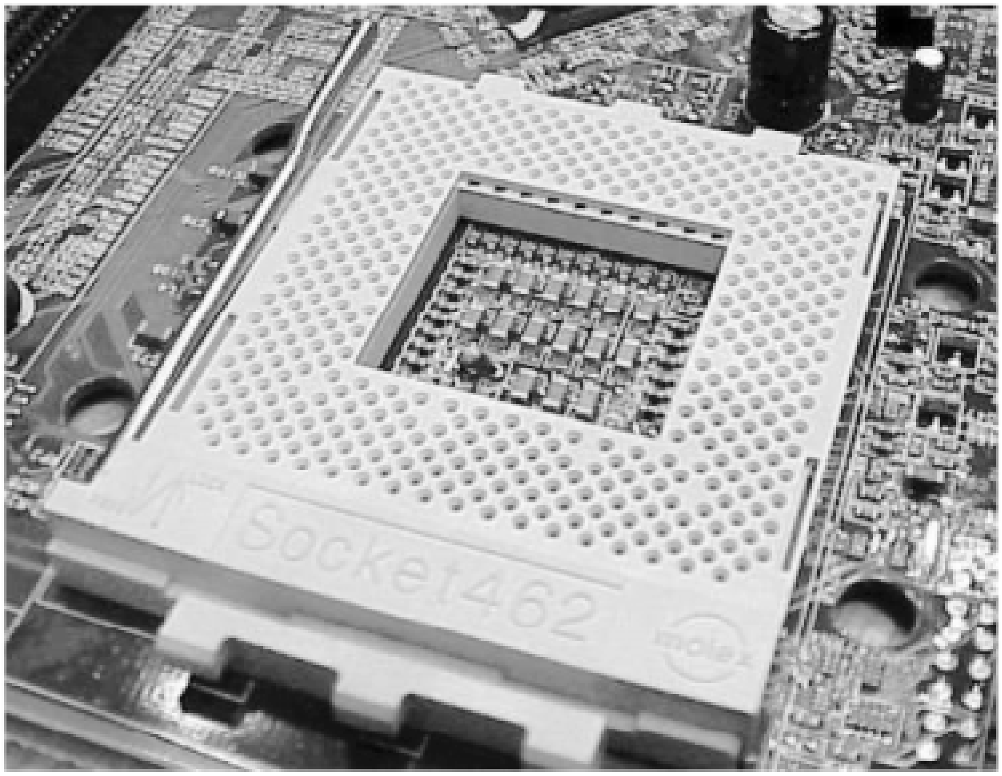
The AMD K6 is a sixth-generation processor to rival Intel's Pentium and Pentium II line. The K6 comes in three flavors—K6, K6-2, and K6-III. Even though the K6 was designed to fit in the same CPU socket as the K5, the K6 uses a higher voltage. The bottom line is that not all motherboards work with K6 processors because of the motherboard voltage and BIOS. Always check AMD's web site at www.amd.com for compatibility.

The K6-2 and K6-III models added speed to the CPU and system bus as well as more support for multimedia applications. Both CPUs fit into something known as a **Super 7 socket**, which is a redesigned Socket 7 that allows for higher bus speeds (from 66MHz to 95 or 100MHz). The Super 7 motherboards allow higher CPU speeds, support for AGP, support for ultra DMA hard drives, and have advanced power management features.

AMD's sixth-generation CPUs are the Athlon and Duron. The Duron is a scaled down version of the Athlon and has more cache memory than Intel's Celeron. The AMD Duron can access the cache through a 200MHz bus not shared by the chipset, RAM, AGP, PCI, and so forth. This CPU targets the home and business user or anyone who executes everyday applications like word processing and spreadsheet applications, e-mail, or Internet access. The Duron and Athlon both use a new socket called **Socket A**. Socket A is a 462-pin PGA socket. Motherboard Figure #3 shows AMD's Socket A.

MOTHERBOARD – FIGURE #3

AMD's Socket A



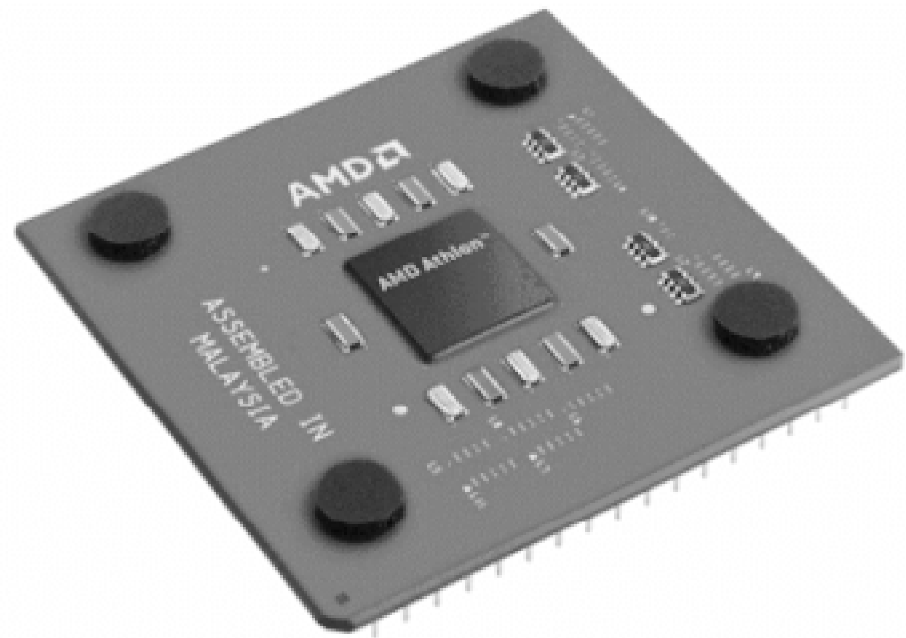
The Duron is available in 600-950+MHz versions.

The Athlon is AMD's powerhouse CPU available in 1 to 1.8+GHz versions. The Athlon can communicate with its L2 cache via a 200 or 266MHz bus. The Athlon is best suited for those who use desktop publishing, CAD, CAE, digital imaging, voice recognition, and scientific applications, or 3D gaming. The Athlon is also used in network servers; it rivals Intel's Pentium 4. The Athlon can execute up to nine instructions simultaneously as well as rearrange up to 72 instructions simultaneously. The Athlon uses either the 462-pin Socket A or the Slot A. The **Slot A** Athlon cartridge is similar to Intel's Pentium III, but they are not interchangeable in CPU slots! The same holds true for the AMD Socket A and Intel's Socket 370—Only Intel CPUs function in the Socket 370.

Both the Athlon and Duron use the E6 design from DEC (Digital Equipment Corp.) compared to Intel's GTL+. The E6 design uses a 100MHz or 133MHz bus and double clocks data yielding a 200MHz or 266MHz bus to the CPU. The E6 design was originally developed for the 21264 Alpha CPU, but was redesigned for AMD. The AMD Athlon is shown in Motherboard Figure #4.

MOTHERBOARD – FIGURE #4

AMD Athlon



The Thunderbird is one of the best of Athlon's CPUs. It uses the 462-pin Socket A and is available in speeds of 750GHz to 1.4+GHz. The AMD Athlon Pro, code named Mustang, has a 12-stage pipeline. The successor to the Athlon is called Sledgehammer and it will have 64-bit instruction registers, but still contain 32-bit instructions for backwards compatibility with today's operating systems and applications. The SledgeHammer will also include 64 bits for memory addressing, which allows up to 18EB (Exabytes) addressing space. Future AMD processors include SledgeHammer, ClawHammer, and Barton. AMD has announced that the Hammer chip family will use a new type of bus called NUMA (Non-Uniform Memory Access) Lightning Data Transport bus. This will probably mean a new CPU socket or slot.

MMX, SSE, AND 3DNOW!

MMX is a microprocessor technology from Intel designed for the X86 microprocessors. Intel placed 57 new commands in the MMX microprocessors that help with multimedia and communications software. Keep in mind almost all software applications now include some pictures, sounds, or movies. If a particular application is not specifically written using the 57 new instructions, the software application's performance can still show a 10 to 20 percent increase in performance. On the flip side, with a particular application written to take advantage of the MMX technology, the software can still operate on non-MMX microprocessors, but the application speed will be slower. All Pentium II and higher microprocessors include the 57 MMX instructions.

MMX technology is not exclusive to Intel microprocessors. AMD and Cyrix processors also use MMX instructions in its command set. For future applications, and faster multimedia applications, the MMX technology is necessary.

MMX2 technology places 70 new instructions beyond MMX. The instructions speed up applications including 2-D games, image editors, speech recognition software, and video encoding. The MMX2 technology is available in Intel's Pentium III microprocessor and is sometimes called KNI (Katmai New Instructions).

Today's applications require intense mathematical calculations because of the emphasis on video and audio integration. Inside the microprocessor is a part called the FPU (Floating Point Unit), which is responsible for handling floating-point numbers. Floating-point numbers are those that use decimals such as 1024.7685 and –581.3724985 compared to integers, which are numbers like 10, 561, and –86. The FPU has registers that hold bits. The more bits the register has, the more accurate a calculation the FPU can perform. Both video and audio applications use floating-point numbers.

Today applications and games use 3-D graphics. A 3-D graphic is made up of small polygons. One 3-D figure could be 500 to 1500 polygons or more. Each time the figure changes, the polygons have to be redrawn and each polygon corner has to be recalculated using floating-point numbers. Four things help speed up calculations: (1) a faster CPU, which also means faster FPU, (2) more CPU pipelines, (3) built-in 3-D instructions that software applications can use, and (4) a good video adapter with a built-in processor and memory installed on the board.

Intel's response to 3-D needs comes through **SSE** (**Streaming SIMD Extensions**). SIMD stands for Single Instruction Multiple data, which means that one instruction can be executed by multiple data items. To put this in English, imagine an instructor with 20 students in a classroom. The instructor could go to each student individually and tell him or her the daily assignment. On the other hand, the instructor *could* stand at the front of the room, stating the assignment to the entire class. The "telling once" scenario is similar to SIMD.

SSE is 50 new instructions that allow floating-point calculations to occur simultaneously. SSE uses 64-bit registers. An upgrade to SSE is known as SSE2 and it uses 128-bit registers. SSE2 contains 144 new instructions and is available in Pentium III and 4 processors. AMD's eighth generation CPUs (the 64-bit processors) may support SSE2, but AMD has its own method of dealing with 3-D.

AMD developed the **3DNow!** Technology, which became available with the K6-2 CPU. 3DNow! has twenty-one specific instructions and support for SIMD. Two 3DNow instructions can be handled simultaneously along with four floating-point calculations. The upgrade to 3DNow! is known as Enhanced 3DNow! and is available in the Athlon microprocessor. AMD will continue to include 3DNow! in future CPUs.

MATH COPROCESSORS

The difference between the 80486SX and the 80486DX microprocessors is in their ability to perform math calculations. The 80486DX microprocessor has the math coprocessor built right into the microprocessor; the 80486SX does not. In prior microprocessors, a separate computer chip called a **math coprocessor,** or a numeric processor, was added to the motherboard to perform some of the number-crunching functions. All microprocessors since Intel's 486DX and AMD's AM486 include the math coprocessor. On older computers, adding a math coprocessor sped up performance, especially with programs such as AutoCAD, spreadsheet applications and graphics-intensive applications. To install a math coprocessor on a machine with an 80486SX microprocessor, add an 80487SX chip to the motherboard. The 80487SX is a microprocessor and math coprocessor combined, similar to the 80486DX. The 80487SX microprocessor takes over for the 80486SX processor. Each microprocessor without math coprocessing abilities has a specific math coprocessor designed to work with it. Motherboard Table #2 shows Intel's microprocessors with their associated math coprocessors, as well as the ones with built-in math coprocessing abilities.

MOTHERBOARD – TABLE #2

Intel Math Coprocressors

Microprocessor	Math Coprocessor
8088	8087
8086	8087
80286	80287
80386DX	80387DX
80386SX	80387SX
80486DX	N/A
80486SX	80487SX
Pentium	N/A
Pentium Overdrive	N/A
Pentium Pro	N/A
Pentium II	N/A
Celeron	N/A
Pentium III	N/A
Pentium 4	N/A

Notice in Motherboard Table #2 how the 80486DX, Pentium, Pentium Overdrive, Pentium Pro, Pentium II, Celeron, Pentium III, and Pentium 4 microprocessors do not have math coprocessors. This is because the math coprocessing ability is built into these microprocessors.

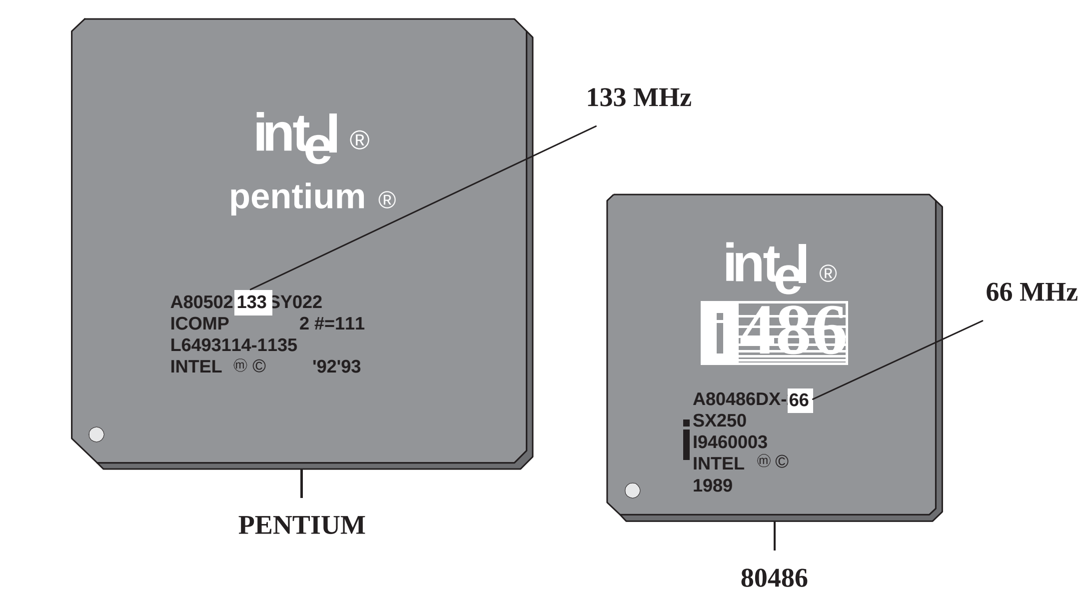
PROCESSOR SPEEDS

Math coprocessors and microprocessors come in a variety of speeds. The speed of a microprocessor and math coprocessor is measured in **megahertz** or **gigahertz**. Hertz is a measurement of cycles per second. One hertz equals one cycle per second. One megahertz is one million cycles per second or 1MHz. One gigahertz is one billion cycles per second or 1GHz. The 8088 microprocessor ran at 4.77MHz. Today's microprocessors run at speeds over 1GHz.

The numbers on top of the chip indicates the speed of a microprocessor and math coprocessor. Look for the number after the hyphen. Examples of chip speeds are in Motherboard Figure #5. The Pentium microprocessor runs at 133MHz. The 80486 microprocessor runs at 66MHz.

MOTHERBOARD – FIGURE #5

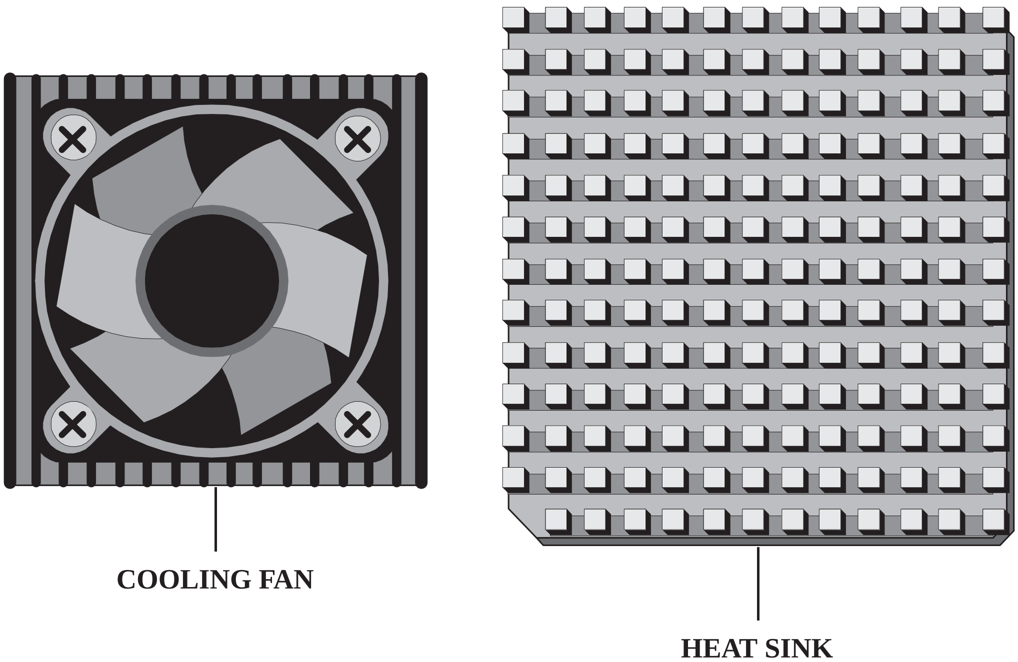
Microprocessor Speeds



The processor speed is easy to determine if you can see the chip, but it is difficult to determine the speed of the 80486 and higher CPUs. These processors frequently have fans or heat sinks attached to them for cooling. A heat sink looks like metal bars protruding from the microprocessor. Any chip on the motherboard with a fan or a heat sink on top is easily recognized as the microprocessor. The fans and heat sinks are very large in today's systems. Some systems have multiple fans to keep the CPU cool. Motherboard Figure #6 shows a microprocessor with a fan and another one with a heat sink.

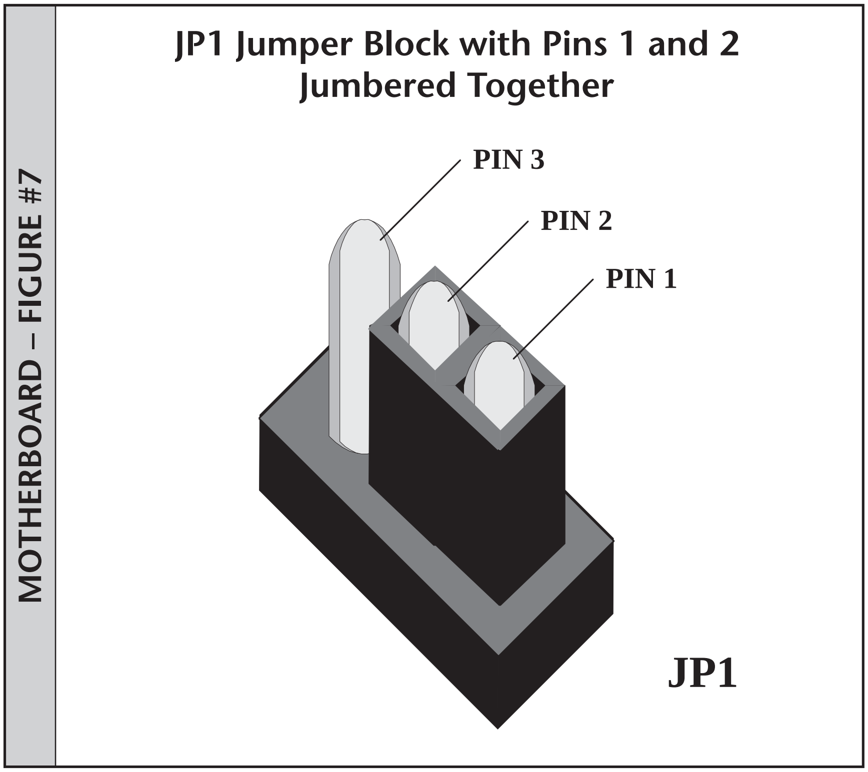
MOTHERBOARD – FIGURE #6

Microprocessor Fan and Heat Sink



The documentation for the motherboard or the computer system is the best source for determining microprocessor speed. Many motherboards accept microprocessors with different speeds. The microprocessor settings can be configured through software or by jumpers. The software is contained in the BIOS and a specific key is pressed during startup to access the software. The processor settings are normally in the Advanced Settings section and this is covered in more detail in the next chapter. A **jumper** is a small metal connector with a plastic cover used to connect two metal pins together. A jumper is normally located on a jumper block. Pins protrude upward from the jumper block. A jumper is enabled when it is placed over two pins. When the jumper is removed, the connection between the pins is disabled. Jumper blocks are normally labeled JP1, JP2, JP3, etc. on the motherboard.

A motherboard manufacturer determines the motherboard configuration, the number of jumpers on the motherboard, the jumper labels, and the use for each jumper. Each jumper can have more than one setting. For example, consider a motherboard with a jumper block and three pins labeled 1, 2, and 3. The jumper can be placed over pins 1 and 2 for one setting or pins 2 and 3 for a different setting. For example, jumper pins 1 and 2 may need to be jumpered together to configure the motherboard for a 166MHz microprocessor. In that case, the jumper is placed over pins 1 and 2; pin 3 is left uncovered. Refer to Motherboard Figure #7 for an illustration of JP1 pins 1 and 2 jumpered together.



Motherboard Figure #7 shows an enlarged jumper; the jumper blocks and jumpers on a motherboard are much smaller. When a jumper is not in use, instead of putting it in a desk drawer, a baggie or in a drawer somewhere, place the jumper over a single pin in the jumper block. Although connecting the jumper over a single pin does not enable anything, it keeps the jumper safe and convenient for when needed later.

When working on a motherboard, look at it to see what jumpers are set. Then refer to the motherboard documentation for the microprocessor speed. Because microprocessors now have math coprocessing functions built in, knowing the CPU's speed is no longer an issue unless you are upgrading the computer to a faster microprocessor or configuring the motherboard.

Many people think that the higher the CPU speed, the faster the computer. This is very seldom true. Several factors contribute to computer speed. One factor is bus speed. Bus speed describes how fast the CPU can communicate with motherboard components, such as memory, chipset, or PCI bus. The first Pentium CPUs ran at a bus speed of 60MHz, however the CPUs got faster and the buses stayed the same. Advances in technology had not reached the rest of the motherboard components.

A **multiplier** is a number that, when multiplied by the bus speed, gives the CPU speed. For example, a 90MHz Pentium is determined by the 60MHz bus speed multiplied by 1.5 (the multiplier) yielding 90MHz. Common multipliers used are 1.5, 2, 2.5, 3, 3.5, 4, 4.5, 5, 5.5, 6, 6.5, 7, 7.5, 8, 8.5, 9, 9.5 and 10. The available multiplier and the bus speed is determined by the motherboard manufacturer. Common motherboard bus speeds include 60, 66, 68, 75, 83, 100, and 133MHz.

When upgrading a microprocessor or installing a new one, there are frequently two sets of motherboard jumpers or motherboard software settings that are very important: CPU bus frequency and bus frequency multiple. The CPU bus frequency setting allows the motherboard to run at a specific speed, such as 66MHz. This speed is the external rate data travels *outside* the microprocessor. The bus frequency multiple enables the motherboard to recognize the *internal* processor speed.

Take for example, a 333MHz Pentium II microprocessor. Its internal clock rate is 333MHz and external clock rate is 66.6MHz. The CPU bus frequency is set on the motherboard to 66MHz. The bus frequency multiple is set to 5. Five times 66MHz equal the internal clock rate of 333MHz. Both settings are configured, either by enabling jumpers on the motherboard or by accessing the BIOS software. An exercise at the end of the chapter helps with this concept.

CACHE MEMORY

The first microprocessor to include math coprocessing abilities was the 80486. It was also the first microprocessor to include cache memory. **Cache memory** is a fast type of memory designed to increase the speed of microprocessor operations. When located inside the microprocessor, it is known as **L1 cache** or as L1 memory. The 80486 has 8K or 16K of L1 write-through cache memory built in. **Write-through cache** uses a technique in which the microprocessor writes 1s and 0s into the cache memory at the same time it writes data to regular memory.

The type of L1 cache used in a Pentium or Pentium Pro microprocessor is different from the type used in the 80486. Instead of using a write-through cache, the Pentium and higher processors use a write-back cache. **Write-back cache** is more efficient than write-through cache. The 1s and 0s are stored and then later written to regular memory when the microprocessor is not busy.

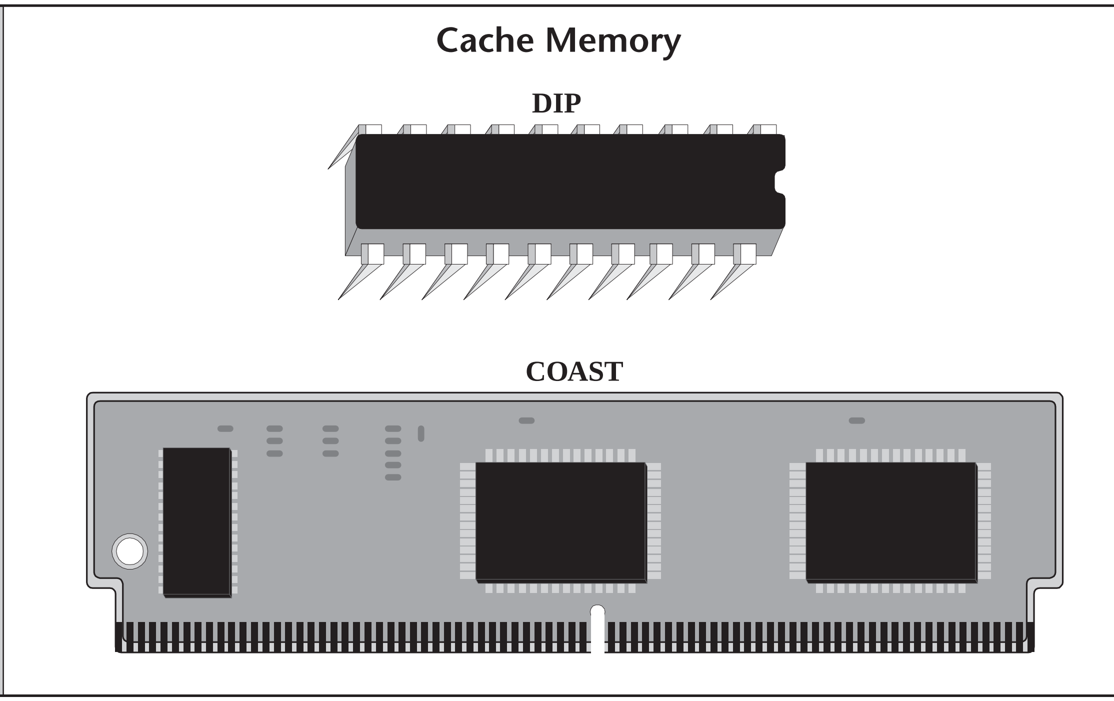
The Pentium and Pentium Pro microprocessors come with 16K of L1 cache divided into two 8K segments. One 8K segment of cache handles microprocessor instructions (commands that tell the microprocessor what to do). The other 8K of cache handles dataæ1s and 0s as in the "DEAR MOM" letter. Two separate caches and two 32-bit internal data paths speed up the microprocessor tremendously. The Pentium II microprocessor has 32K of L1 cache.

L2 cache memory is a special type of memory similar to L1 cache memory. **L2 cache** holds a small amount of data that is "guesstimated" to be the next data the microprocessor will need. It is on the motherboard for Pentium and lower microprocessors, but starting with the Pentium Pro, the L2 cache is inside the microprocessor packaging. Whenever the L2 cache is housed in the microprocessor packaging, it is known as the **on-die cache**. When L2 cache is integrated into the same processor cartridge as the CPU, speed is increased. The cache speed stays the same, but the speed in which the processor accesses the data increases. The microprocessor is not limited by the motherboard routing speed constraints. The Pentium III and 4 have 256KB of L2 cache built into the microprocessor packaging. AMD's Duron has 64KB and the Athlon has 256KB of L2 cache.

When the L1 and L2 cache is included with the processor packaging, any cache installed on the motherboard is called **L3 cache**. Currently, little advantage is gained by more cache on the motherboard when the L1 and L2 cache are included in the microprocessor.

Cache chips on the motherboard can be a DIP (Dual In-line Package) chip, or a **COAST** (**Cache On A STick**) module. COAST memory modules resemble a small SIMM (Single In-line Memory Module). A DIP chip has a row of legs down each side. A COAST memory module is easier to install and holds more information than a DIP chip. Older motherboards use DIP chips. Newer motherboards, such as those used with 80486 and higher microprocessors, use COASTs for the cache. Motherboard Figure #8 shows the two different types of cache memory chips.

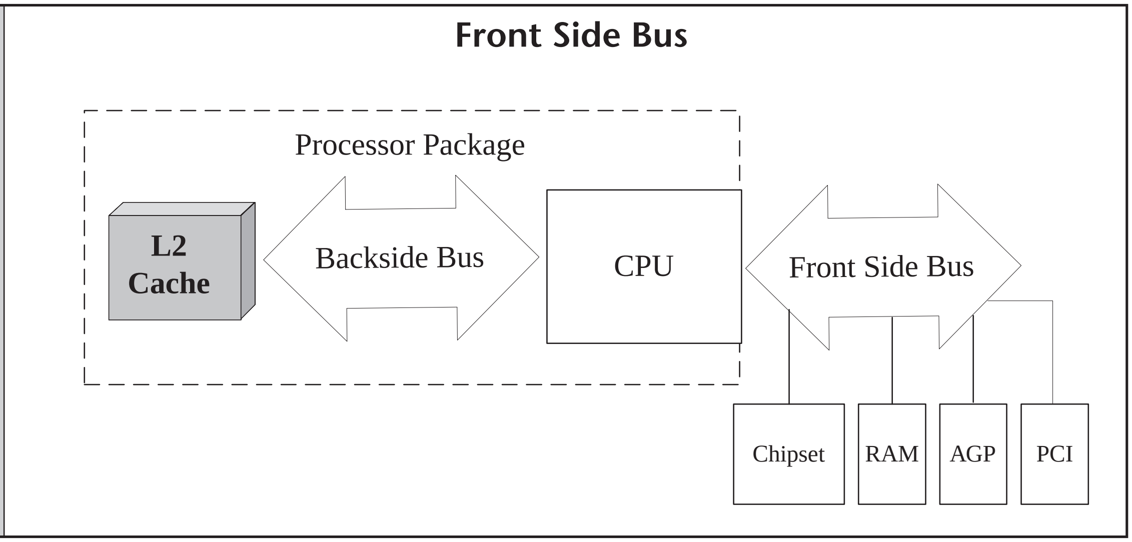
MOTHERBOARD – FIGURE #8



Accessing L2 cache and motherboard components has always been a bottleneck in systems up to the Pentium and K5 processors. This is because with older systems, the CPU must use the same bus to communicate with RAM, L2 cache, the chipset, PCI bus, and other motherboard components. Intel's Pentium Pro and AMD's Athlon/Duron CPUs take a different approach called DIB. With **DIB** (**Dual Independent Bus**), two buses are used: a back side bus and a front side bus. The back side bus connects the CPU to the L2 cache. The **FSB (front side bus)** connects the CPU to the motherboard components. The

Celeron uses a 66MHz FSB; Pentium II, K6-2, and K6-III use a 100MHz FSB; the Pentium III and the K6-3 use a 133MHz FSB; The Duron and some Athlon models use a 200MHz FSB; some Athlon models have a 266MHz FSB; and the Pentium 4 uses a 400MHz FSB. Because the Athlon uses the E6 architecture, each CPU installed in a multiprocessor system has its own 200MHz FSB. Motherboard Figure #9 illustrates the concept of a front side bus.

MOTHERBOARD – FIGURE #9



Keep in mind that the front side bus is more detailed than what is shown; the idea is to illustrate the difference between the back side bus and the front side bus.

OVERDRIVE MICROPROCESSORS

A microprocessor can be upgraded using an **overdrive** chip. Many types of overdrive upgrades are available. When upgrading a microprocessor, be sure to get the correct overdrive. Refer to the motherboard or system documentation to determine which overdrive chip the motherboard allows. For example, when Intel produced the 80486DX2 microprocessor that runs at twice the motherboard speed, many 80486 owners wanted to upgrade their microprocessors. The original overdrive chip had 169 pins and could only be used to upgrade the 80486SX systems. Then Intel released a 168-pin overdrive chip that could be used in 80486DX or 80486SX systems.

Another upgrade chip is the Pentium Overdrive with 32K (16K more than the original Pentium) of L1 cache. However, the Pentium Overdrive chip only has one 32-bit external data path, not two as the Pentium has. The original Pentium Overdrive fit in a 238-pin socket on the motherboard, but the newer 80486 motherboards have an improved 235- or 237-pin socket.

Most 80486 motherboards can be upgraded with an overdrive chip depending on (1) the processor currently installed and (2) the socket(s) available on the motherboard. Documentation for the motherboard or computer system *might* give upgrade details, if not, go to Intel's web site.

MICROPROCESSOR STUDY GUIDES

Motherboard Table #3 shows a consolidated list of Intel microprocessors, word size, external data path, memory address lines (covered in Chapter 7), and common pin configurations.

MOTHERBOARD – TABLE #3

Intel Microprocessor Study Table

CPU	Internal Data Path	External Data Path	Memory Address Lines	Common Pins/Slot
8088	16	8	20 (1MB)	40 (DIP)
80286	16	16	24 (16MB)	68 (PGA)
80386DX	32	32	32 (4GB)	132 (PGA)
80386SX	32	16	32 (4GB)	100 (PGA)
80486DX	32	32	32 (4GB)	168 (PGA)
80486SX	32	32	32 (4GB)	168 (PGA)
Pentium	32*	64	32 (4GB)	296 (PGA) & 320 (PGA)
Pentium Pro	32*	64	36 (64GB)	387 (PGA)
Pentium II	32*	64	36 (64GB)	242 (Slot 1 cartridge)
Celeron	32*	64	36 (64GB)	242 (Slot 1 cartridge) & 370 (PGA)
Pentium III	32*	64	36 (64GB)	370 (PGA) & Slot 1 cartridge
Pentium II/III Xeon	32*	64	36 (64GB)	330 (Slot 2 SEC cartridge)
Pentium 4	32*	64	36 (64GB)	423 (PGA)

*Multiple 32-bit paths

The 320-pin Socket 7 the Pentium uses actually contains 321 pins, but the Pentium only uses 320 of them. AMD's processors, starting with the K5, are listed with their associated pin or slot configurations in Motherboard Table #4.

MOTHERBOARD – TABLE #4

AMD Processors

Processor	Pin/Slot Configuration
K5	320 (PGA—Socket 7)
K6	320 (PGA—Socket 7)
K6-2	320 (PGA—Socket 7 & Super 7)
K6-III	320 (PGA—Super 7)
Duron	462 (PGA—Socket A)
Athlon	462 (PGA—Socket A) & Slot A

MICROPROCESSOR UPGRADE OVERVIEW

Two common questions asked of technicians are "*Can* a computer be upgraded to a higher or faster microprocessor?" and "*Should* a computer be upgraded to a higher or faster microprocessor?" Whether or not a computer *can* be upgraded to a higher or faster microprocessor depends on the capability of the motherboard. When a customer asks if a microprocessor *should* be upgraded, the technician should ask, "What operating system and applications are you using?" If the response is DOS or Windows 95 running mostly DOS and Windows 3.x applications, then the original Pentium is the optimum microprocessor. Even though Windows 95 is a 32-bit operating system, most of the code designed for the operating system is 16 bit and users are still using 16-bit applications designed for Windows 3.1. If the user wants to run Windows 98, Me, NT, or 2000 Professional, then a Pentium II/K6 or higher microprocessor is best.

A quick glance at the motherboard for extra holes around the microprocessor or an extra processor socket/slot is a good place to start in determining if the motherboard can accept a new microprocessor. Also look for the new SEC socket for a Pentium II upgrade. Read the documentation for the motherboard to determine if it can accept a faster microprocessor.

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

Another issue to consider with microprocessor speeds is the voltage level of the microprocessor. All Intel microprocessors used in desktop or tower models up to the 80486DX use 5 volts supplied from the motherboard. The 80486SX, 80487SX, and 80486DX2 microprocessors also run on 5 volts. The 80486DX4 microprocessor runs on 3.3 volts. Members of the Pentium microprocessor family use varying voltages. The lower voltage microprocessors run cooler than the higher voltage ones. Newer microprocessors operate at 2 volts or lower.

Some motherboards can be changed from 5 volts to 3.3 volts needed by the processor, as required by some microprocessor upgrades. If you accidentally insert a 3.3-volt microprocessor into the socket without changing the setting on the motherboard from 5 volts to 3.3 volts, the 5 volts going in the new microprocessor will likely destroy it. Getting the correct microprocessor upgrade and setting configuration jumpers on the motherboard for the correct speed and voltage are critical to a successful microprocessor upgrade. Because the 150MHz and higher Pentiums require a lower voltage, Intel has a socket design (Socket 7 and Socket 8) specifically for these Pentiums. The Socket 7 or Socket 8 can have a **VRM** (**Voltage Regulator Module**) mounted beside the socket, thus providing the appropriate voltage to the new microprocessor.

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

INSTALLING AND OVERCLOCKING MICROPROCESSORS

Whenever a microprocessor is purchased, it includes installation instructions. Also, motherboard manuals (documentation) include the steps to upgrade or install the CPU. Outlined below are general steps for processor installation.

Parts: Proper microprocessor for the motherboard (refer to motherboard documentation)
Microprocessor extractor tool if necessary (normally comes with an upgrade kit)
Anti-static materials

1. Be sure power to the computer is *off*.
2. Place the anti-static wrist strap around your wrist and attach the other end to a ground on the computer.
3. Remove the old processor. During upgrading, some older processors require the use of an extractor tool included with the microprocessor upgrade. If necessary, insert the microprocessor extractor tool under one side of the microprocessor. Pry the chip up slightly. Remove the microprocessor extractor tool. Insert the microprocessor extractor tool under a side of the microprocessor adjacent to the side just lifted. Pry the side up slightly. Repeat for the remaining two sides of the microprocessor until the microprocessor lifts from its socket. If the microprocessor is in a ZIF (Zero Insertion Force) socket, lift the retaining lever outward and upward. The microprocessor will lift gently out of the socket. Gently pull the microprocessor straight upward. Put the old microprocessor into an anti-static bag. To remove a cartridge CPU, push down on the retaining

locks that release the cartridge. Some locks have to be pushed inward before the processor can be removed. List the cartridge out of the slot.

4. Before installing the new CPU, you must configure the motherboard by jumpers or through software configuration. Refer to the motherboard manual for exact steps. If necessary, set any jumpers or switches on the motherboard necessary for proper operation or press the correct key to enter the Setup program that allows you to set the CPU speed and proper multiplier. Some manuals refer to the multiplier as the stepping value. Refer to the motherboard's documentation. Check yourself. A saying that definitely applies to computers and networks is "Think twice, replace once."
5. Insert the new microprocessor into the socket ensuring that pin 1 on the microprocessor (indicated by a dot or a notched corner) aligns with pin 1 of the motherboard socket (indicated by a dot or a notched corner). Newer processors insert only one way into the socket or slot. If the microprocessor is a SEC cartridge, the cartridge has a lock on both sides near the top (away from the connectors). Hold the cartridge over the CPU expansion slot ensuring that the CPU connector aligns in the correct direction with the notch in the expansion slot. Push the locks inward and slide the cartridge into the expansion slot. Some motherboards have a retention mechanism used with microprocessors equipped with mounted heat sinks.

Overclocking is changing the front side bus speed and/or multiplier to boost CPU and system speed. Before describing the steps, we must discuss the overclocking issues.

- Because the CPU is normally covered with a heat sink and/or fan, you cannot easily tell the CPU speed. Some vendors sell a system advertised with a higher rated CPU speed than what is installed.
- CPU speed ratings are conservative.
- The CPU, motherboard, memory, and other components can be damaged by overclocking, especially if it is not performed in a logical, cautious manner.
- Applications may crash, the operating system may not boot, and/or the system may hang when overclocking. If these issues are frustrating to you, do not overclock.
- The warranty is void on the CPU if you overclock.
- When you increase the speed of the CPU, the processor's heat increases. Extra cooling by fans and larger heat sinks are essential.
- PCI and SCSI devices may not react well to the overclocking.
- The hard drive PIO mode may need to be changed because of overclocking.
- The memory chips may need to be upgraded to be able to keep up with the faster CPU.
- You may consider overclocking dishonest. If this is the case, do not do it.

In order to overclock, you must have the motherboard documentation to determine whether the system board supports different CPU speeds and different multipliers. The changes to the motherboard will be made through jumpers or through BIOS Setup. Determine which method is used with your motherboard. A few motherboards do not support speed or multiplier changes. Keep in mind that overclocking is a trial and error situation. There are web sites geared toward documenting specific motherboards and overclocked CPUs.

The first change to make is to increase the bus speed. In the motherboard manual, locate the settings for External Bus Speed, External Frequency, CPU Bus Frequency, External Bus Frequency or something along those lines. The common speeds seen are 50, 55, 60, 66, 75, and 83. Make a note about the current setting (and put it to the side for future reference in case you need to return the setting to the original configuration). Always make changes one step at a time; increase the external bus speed by one setting.

The next change that can be made is to change the multiplier. This setting is frequently marked or documented as Multiplier, Bus Frequency Multiple, CPU to Bus Frequency Ratio, Clock Ratio, or something along those lines. The bus speed times the multiplier equals the CPU speed. Again, only make one change at a time and only increase the multiplier by a .5 increment. For example, if the current setting is 2.0, the next increment would be 2.5. Do not change the setting to 3.0 or 3.5. Do not rush the procedure.

The CPU voltage may need to be increased. Many motherboards allow the CPU voltage to be adjusted. As you can tell, overclocking cannot be accomplished without the motherboard manual. Increase the CPU voltage only in small increments.

The number one problem with overclocking is insufficient cooling. Make sure you purchase the larger heat sink and/or extra fans before starting the overclocking process. When you make a change and start the computer, enter the BIOS Setup program (see Chapter 3). If the Setup program will not load, power off the computer and return the CPU and multiplier settings to the original setting or the setting that previously worked. After each change, enter the Setup program. If that works, load the operating system. If that works, stay with the setting, or continue making incremental changes.

DUAL PROCESSORS

You may ask: "What must I do to install two or more CPUs into a motherboard?"

To install more than one processor into a motherboard, both the operating system and the applications must support SMP (Symmetric Multiprocessing), the motherboard must support multiple CPUs. Most home and business users do not need multiple processors. Give them a power CPU, a good front side bus, lots of memory and hard drive space and they should be fine. Network servers *do* need multiple processors, and network operating systems, such as Novell, NT, 2000 Server, Linux, Microsoft XP, and Unix, support SMP. 2000 Server supports up to four CPUs on a motherboard. Windows 95, 98, and Me do not support multiple CPUs. Motherboard manufacturers have developed system boards that support the Celeron, Pentium II, Pentium III, Pentium Xeon, Pentium 4 Xeon (sometimes called Xeon DP), Athlon MP, and Duron processors.

When installing multiple processors, place the same processor model in each slot and install as much RAM as the customer can afford. If a second processor is added without adding more RAM, both processors have to make do with the same amount of RAM. The general rule of thumb is to double (at least) the amount of RAM when upgrading to two or more CPUs. Because a system has two CPUs installed does not mean that performance will double. A gain of 50 to 70 percent in performance is considered to be excellent. Most applications that support SMP show only a 10 to 15 percent performance gain. Applications that support multiprocessors include Adobe's Photoshop, Discreet's 3D StudioMax, GameSpy Industries, and Quake III.

When installing multiple processors ensure the computer is powered off. Install the processor according to the directions that came with the processor or according to the motherboard documentation. Ensure the system has adequate cooling including a heat sink and/or fan for the new processor. Some motherboards do not come with the second VRM (voltage regulator module) for the second processor slot. The customer may need to purchase one before installing the CPU onto the motherboard. Go into the Advanced Settings portion of BIOS Setup or set the motherboard jumpers according to the documentation. Ensure that the processor speed and multiplier settings are correct. The operating system and/or any applications that support multiple processors may have to be reinstalled before they will recognize new processor(s). The best advice is to install as many processors as needed before loading any applications or operating systems, or to buy the system with multiple processors already installed.

ARCHITECTURES AND BUSES

If the computer is to be useful, the microprocessor must communicate with the outside world including other components on the motherboard and adapters plugged into the motherboard. An architecture or bus is a set of rules that control how many bits can be transferred at one time to an adapter, what signals are sent over the adapter's gold connectors, how the adapter is set up or configured, etc. Three architectures used in PCs are ISA (Industry Standard Architecture), EISA (Extended Industry Standard Architecture), and MCA (MicroChannel Architecture). Note that EISA and MCA are not common in today's computers. ISA is also becoming rare and is only available to handle old adapters. The buses most common today are PCI (Peripheral Component Interconnect), AGP (Accelerated Graphics Port), USB (Universal Serial Bus), IEEE 1394 (FireWire), and PC Card. A technician must be able to distinguish among adapters and ports designed for each bus type and configure the adapters/devices for each bus. The technician must also realize the abilities and limitations of each bus when installing upgrades, replacing parts, or making recommendations to customers.

ISA (INDUSTRY STANDARD ARCHITECTURE)

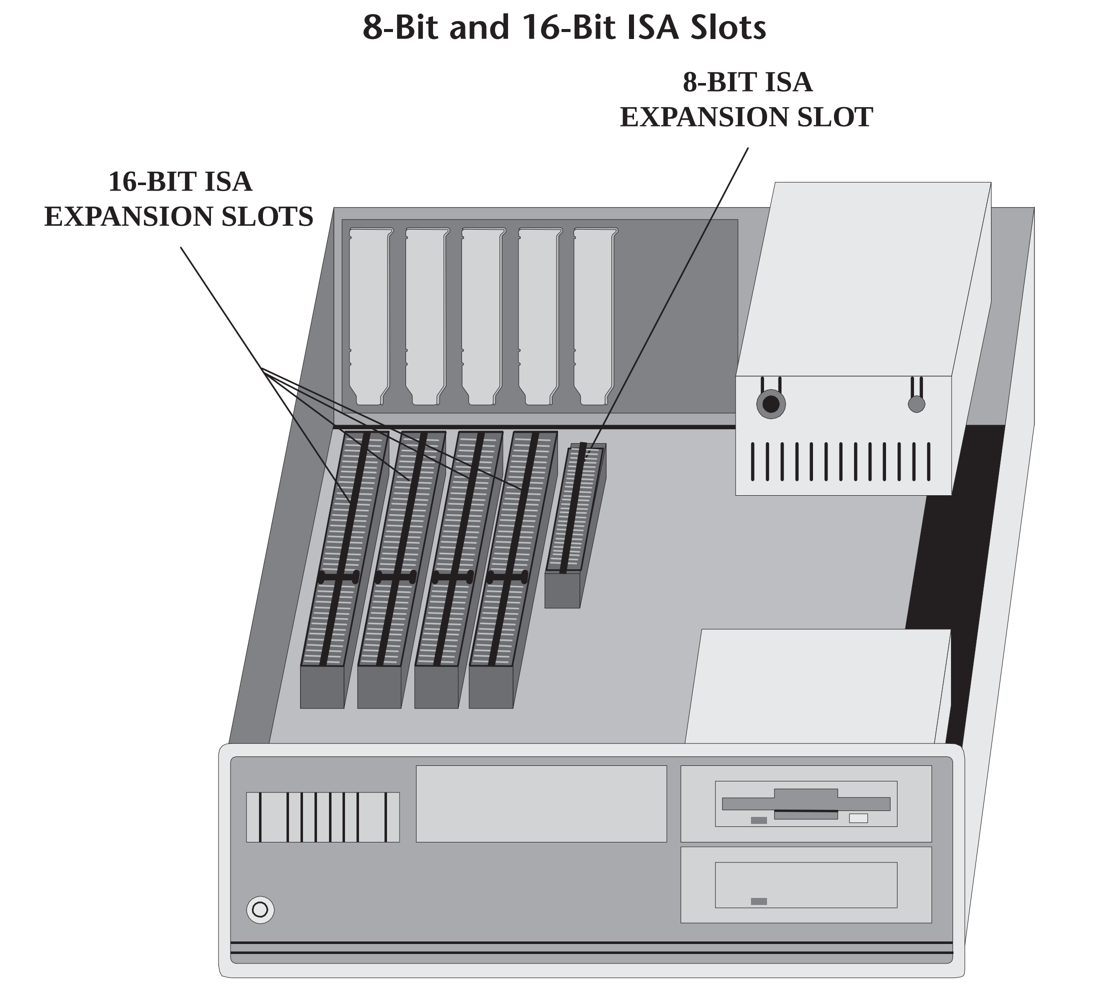
The **Industry Standard Architecture**, better known as **ISA**, is the oldest architecture used with X86 microprocessors and is still has limited use in today's computers. ISA allows 16-bit transfers to adapters installed in ISA slots. A slot or **expansion slot** is the place to plug in an adapter. The number of expansion slots available depends on the manufacturer of the motherboard. ISA is also referred to as the AT Bus. Because computer manufacturers want customers to be able to use their old adapters in an upgraded motherboard or a new computer, ISA is still the architecture with the most adapters available on the market.

ISA operates at 8MHz although some vendors reliably achieve 10MHz throughput. Some vendors have achieved 12MHz, but the industry pronounced 10MHz the maximum speed for ISA. With today's microprocessor speeds in the 400MHz range and greater, it's easy to see how the ISA architecture can be a detriment. Adapters, such as network memory and video, which require high-speed transfers, are hampered by the slowness of the ISA standard. Many people still do not realize how much an ISA adapter handicaps the devices it controls.

> A memory expansion card should *never* be placed in a 386 or higher's ISA expansion slot. All the computer's memory runs at the speed of the ISA expansion slot æ 10MHz. This is true even with 400MHz microprocessors.

ISA was designed to be backwards compatible with IBM's first two computer models, the PC and the XT. The PC and XT had an 8-bit external data bus. The only adapters that worked in the PC and the XT computers were 8-bit adapters. The ISA architecture allows an 8-bit adapter to fit and operate in the 16-bit ISA slot. Reference Motherboard Figure #10 for an example of the difference between an 8-bit ISA adapter and a 16-bit ISA slot.

MOTHERBOARD – FIGURE #10



Motherboards today normally come with only 16-bit ISA slots because an 8-bit ISA adapter fits perfectly in a 16-bit slot. The extension connector on the 16-bit slot remains empty. Many books, advertisements, and vendors call 8-bit adapters ISA cards, but a true ISA adapter is a 16-bit card. The original architecture for computers that used the 8088 microprocessor was the PC Bus. Nevertheless, because some rules from the PC Bus were incorporated into the ISA standard, most people call 8-bit adapters ISA adapters.

ISA adapters are frequently configured through switches and jumpers. This is time-consuming for a technician because most computer owners do not have the documentation for the ISA adapters installed in their systems. This documentation is frequently lost or destroyed. Most companies have adapter documentation on their web sites. However, some adapters do not have identifiers on them so a technician cannot tell which manufacturer produced them. Newer ISA adapters can also be configured through software, which is much easier than setting jumpers or switches.

MCA (MICROCHANNEL ARCHITECTURE)

When IBM computers were cloned and IBM started losing its share of the microcomputer market, IBM decided to develop its own architecture called **MicroChannel Architecture** or **MCA** for short. The MicroChannel Architecture is *incompatible* with ISA. MCA adapters will *not* fit in ISA expansion slots, nor will ISA adapters fit in MCA expansion slots.

The MicroChannel Architecture includes a 32-bit bus, although most MCA adapters are 16-bit adapters. Some MCA cards are able to do 64-bit transfers using a technique called streaming. MicroChannel is a proprietary architecture and any vendor who designs a MCA adapter pays IBM a fee. IBM has maintained strict controls on this architecture, so it has not been cloned.

MCA adapters are much easier to configure than ISA adapters because the adapters are set up through software. When an MCA adapter is sold, a disk ships with the adapter that allows the MCA computer to recognize the adapter and any changes in the adapter's configuration. The drawback to this method is computer users frequently lose the adapter software disk. IBM no longer manufactures computers with only MCA expansion slots.

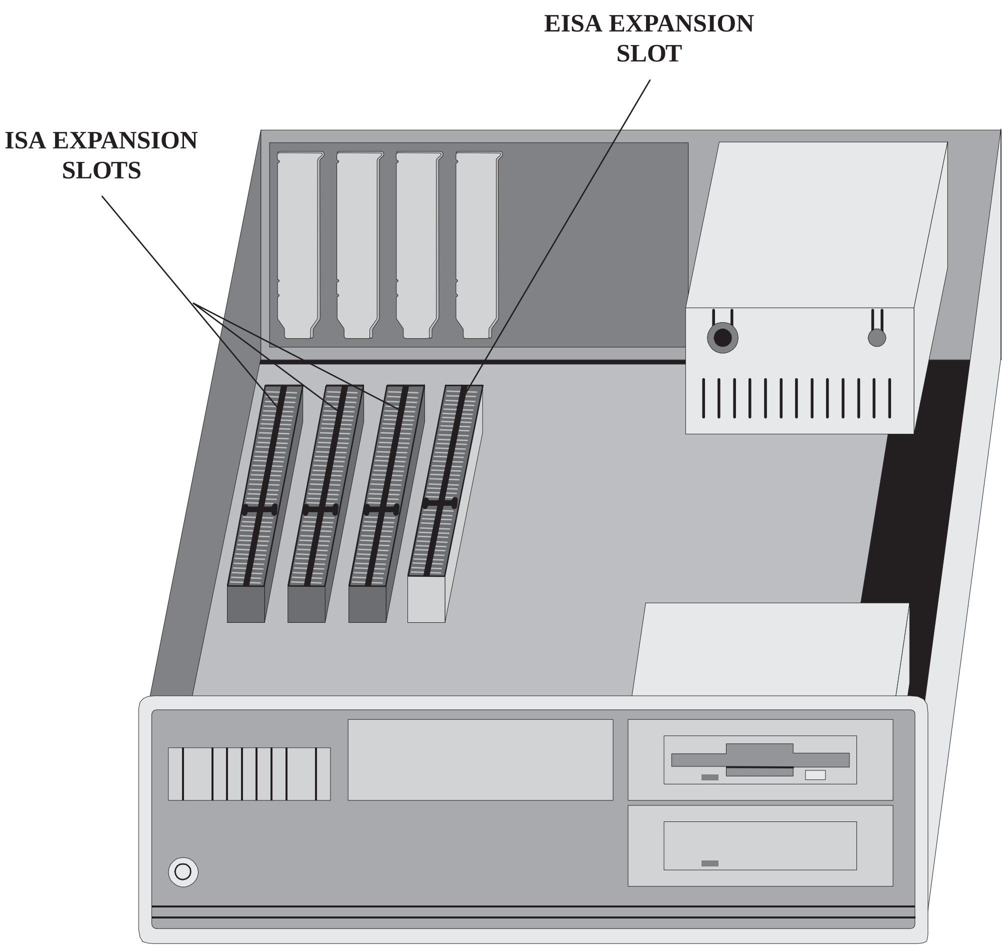
The MicroChannel Architecture introduced a feature called **bus-mastering**. This allows an adapter to take over the external data bus from the microprocessor and execute operations with another bus-mastering adapter without going through the microprocessor. The ISA standard only allowed one bus-master adapter in an ISA machine. However, ISA bus-master adapters are rare. The PCI bus (covered later in the chapter) now supports bus-mastering too. Bus-mastering is important for network and video adapters especially because of their need for speed.

EISA (EXTENDED INDUSTRY STANDARD ARCHITECTURE)

The computer industry was upset by IBM's move to a proprietary architecture. A group of nine vendors: Compaq, Hewlett-Packard, Zenith, Epson, NEC, Wyse, AST, Tandy, and Olivetti got together to develop a new non-proprietary architecture to rival IBM's MicroChannel Architecture. The result was the development of **EISA** (**Enhanced Industry Standard Architecture**). EISA is a 32-bit 10MHz standard that allows ISA adapters to operate in the EISA expansion slots. The ISA adapters do not have access to all the upgraded features the EISA expansion slot offers. Only an EISA adapter is able to take advantage of the upgraded features of the EISA expansion slot. An EISA expansion slot is the same physical length as an ISA expansion slot. The difference between the two is the depth of each expansion slot. The EISA expansion slot is twice as deep as the ISA expansion slot. An EISA adapter has two rows of gold connectors. Reference Motherboard Figure #11 for an example of a motherboard with EISA and ISA expansion slots.

MOTHERBOARD – FIGURE #11

ISA and EISA Expansion Slots

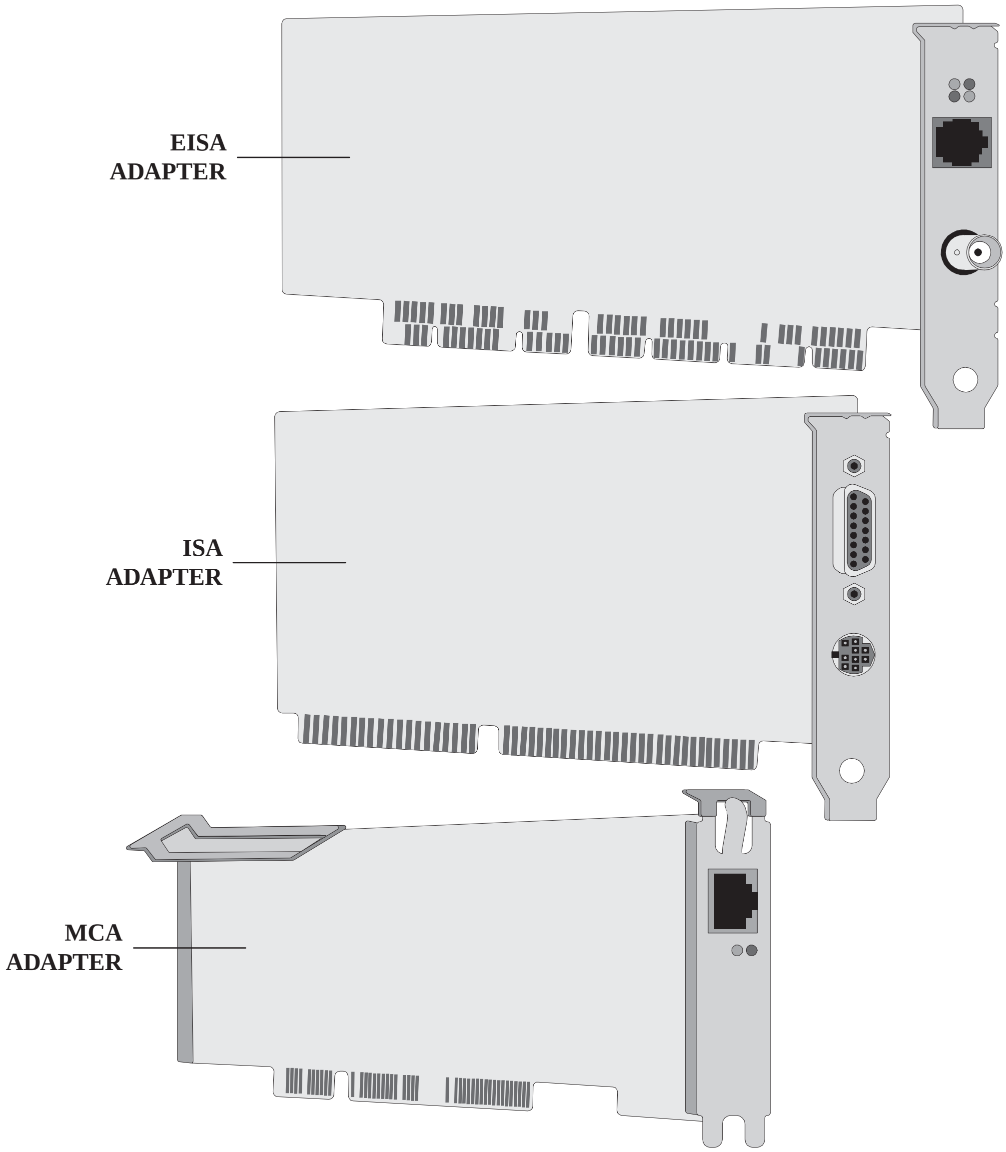


EISA adapters, like MCA adapters, are configured through software, which is simple for technicians. Also, EISA adapters can do bus-mastering like the MCA adapters. However, EISA never really caught on as well as the designers hoped.

All three architectures, ISA, MCA and EISA, are limited by speed. EISA expansion slots are useful because ISA and EISA adapters fit and work in the expansion slots. MCA is very consistent in how all adapters are configured. MCA and EISA both support software configuration and bus-mastering which are a great improvement over ISA. Motherboard Figure #12 compares ISA, MCA, and EISA adapter connectors.

MOTHERBOARD – FIGURE #12

EISA, ISA, and MCA Adapters



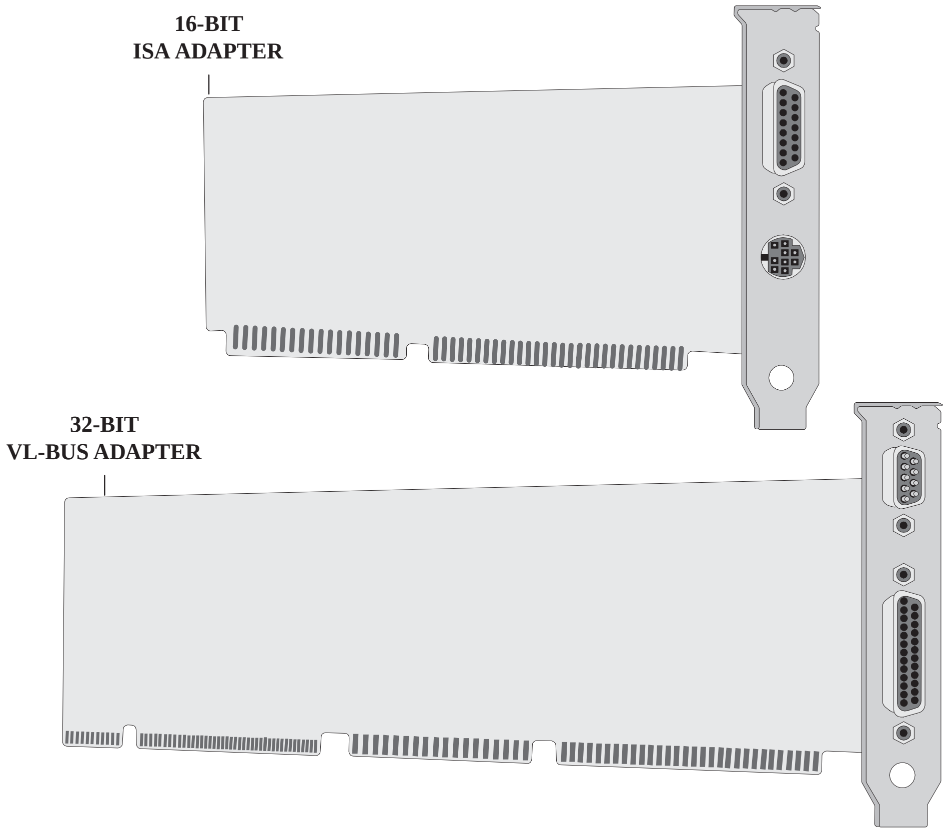
VL-BUS

One of the biggest industries affected by the slowness of ISA, EISA, and MCA is the video industry. Video needs a wide, fast path to transmit all the 1s and 0s to generate millions of colors, create detailed pictures, and provide video motion. So, the video industry developed their own local bus standard called the **VL-bus** or VESA (Video Electronics Standards Association) bus. Other industries have taken advantage of the VL-bus, including hard drive, network, and memory adapter manufacturers. The VL-bus standard was formulated for the 80486 microprocessor and is a 32-bit standard. In theory, the VL-bus can operate at speeds up to 66MHz (but some testing has shown that errors can occur when transmitting on the VL-bus at 66MHz).

VL-bus adapters will *not* fit in ISA, MCA, or EISA expansion slots, and require their own expansion bus. The VL-bus slot looks just like a MCA slot except for its location on the motherboard. A VL-bus expansion slot is an extra connector added to the end of an ISA, EISA, or MCA expansion slot. Motherboard Figure #13 shows a VL-bus adapter and an ISA adapter.

MOTHERBOARD – FIGURE #13

VL-Bus Adapter and ISA Adapter



Notice in Motherboard Figure #13 how the VL-bus adapter has three different connectors on it. Two of the VL-bus connectors are just like an ISA adapter's connectors, but the third connector to the far left is what makes the adapter a VL-bus.

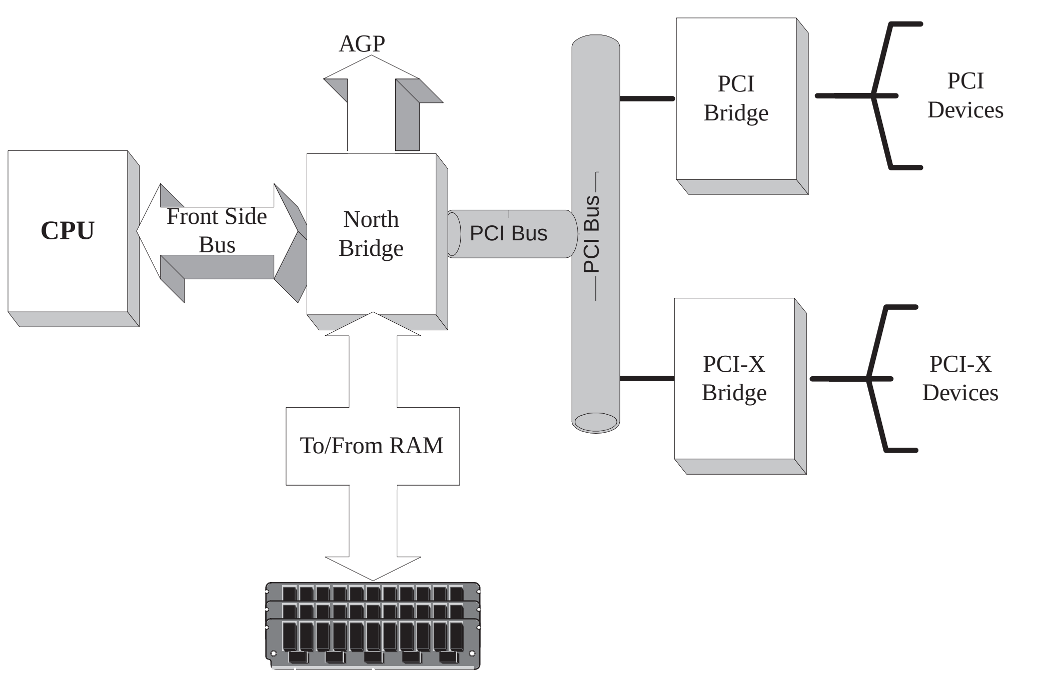
VL-bus expansion cards configure through jumpers and switches. However, some VL-bus adapter manufacturers provide the capability of software configuration. More configuration issues are covered in Chapter 3.

PCI (PERIPHERAL COMPONENT INTERCONNECT)

The most popular local bus is **PCI** (**Peripheral Component Interconnect**) bus. PCI comes in four varieties: (1) 32-bit 33MHz, (2) 64-bit 33MHz, (3) 64-bit 66MHz, and (4) the new proposed standard called PCI-X 64-bit 133MHz. The PCI bus has almost reached its limit in terms of speed. The PCI-X bus is backwards compatible with the previous versions of the bus, but allows faster speeds. A chip called the PCI bridge controls the PCI devices and PCI bus. With the PCI-X bus, a separate bridge controller chip is added. Motherboard Figure #14 shows how the PCI-X bus integrates into the system board.

MOTHERBOARD – FIGURE #14

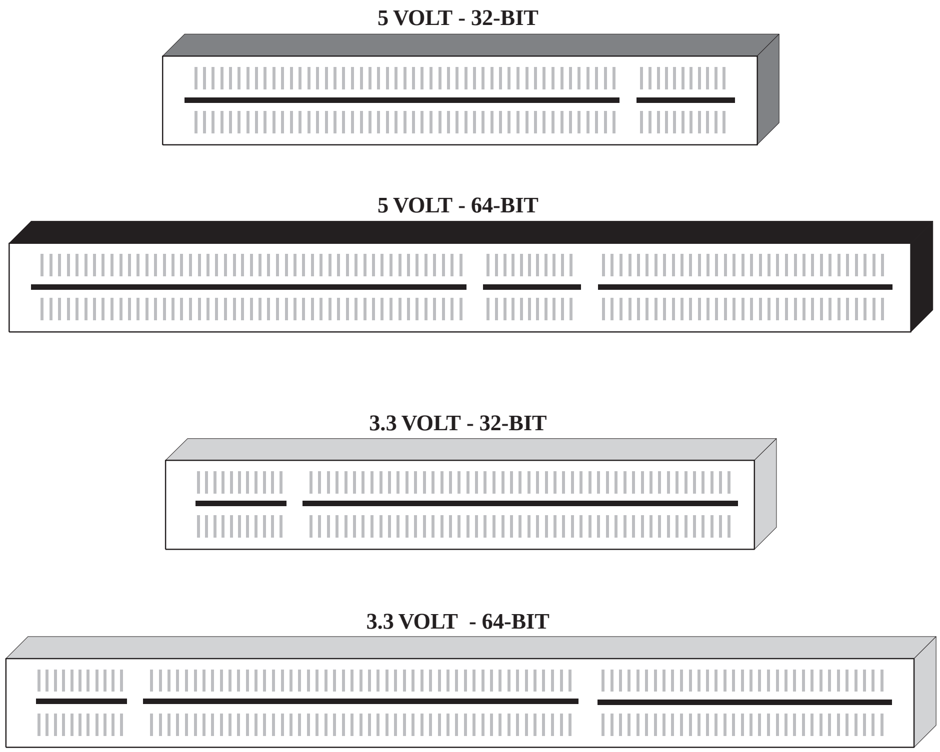
PCI-X Block Diagram



PCI expansion slots are not extensions of another architecture's expansion slots, as is the case with VL-bus connectors. Instead, PCI expansion slots are separate connectors. The expansion slots come in four configurations based on voltage level and number of bits that transfer in or out of the slot. Motherboard Figure #15 shows the different types of individual PCI expansion slots.

MOTHERBOARD – FIGURE #15

3.3 Volt and 5 Volt PCI Expansion Slots



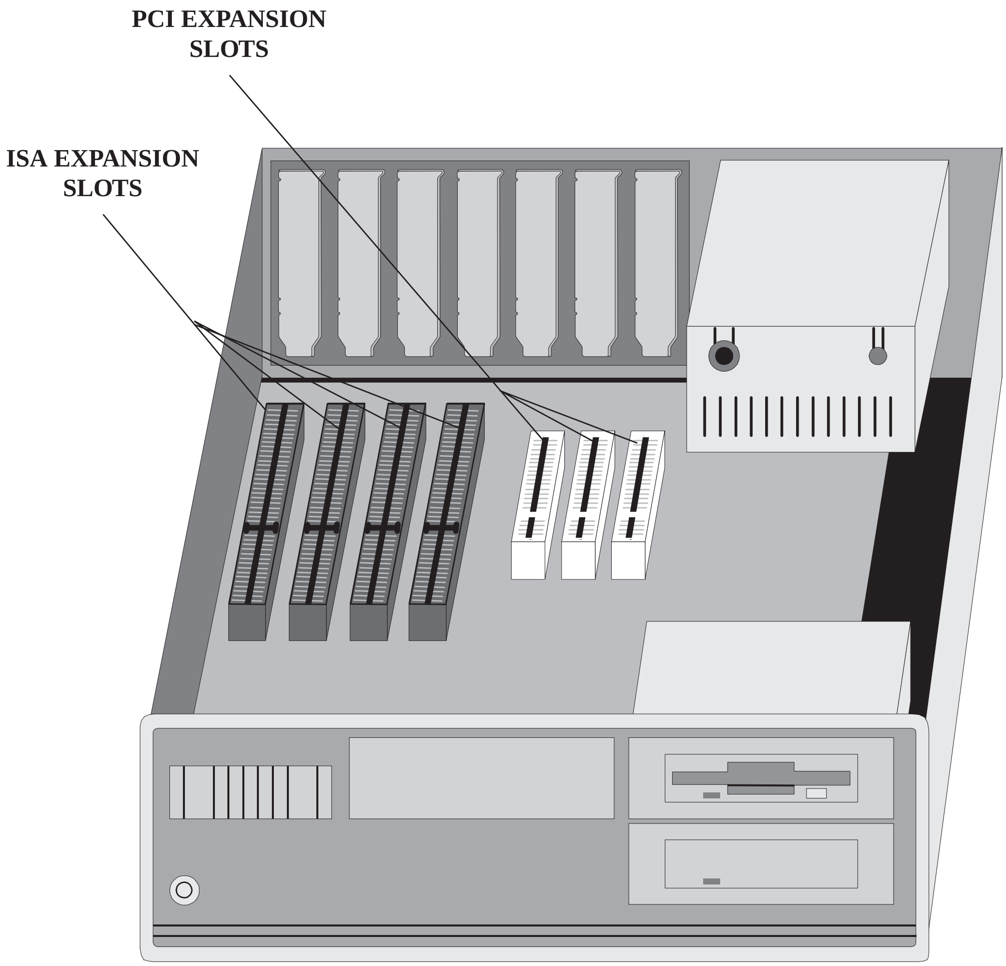
Both PCI configurations have a 32-bit and a 64-bit version. The 64-bit expansion slot adds more pins to the expansion slot. The PCI expansion slot as a separate connector has been the most popular type of PCI expansion slot until lately. One type of PCI expansion slot, sometimes called a combo slot, is a connector that combines both ISA and PCI. The expansion slot allows insertion of either one ISA adapter *or* one PCI adapter. The connector is one molded piece, but the piece contains both an ISA expansion slot and a PCI expansion slot for maximum flexibility.

PCI adapters are configured with software and the standard supports bus-mastering. This means that the adapter can perform data transfers without going through the microprocessor. PCI can now handle concurrent operations. Not all PCI slots support bus-mastering. Always refer to the motherboard documentation.

Many adapters are now available for PCI expansion slots. Unlike VL-bus, the PCI standard can be used with both PCs and Apple computers. PCI expansion cards can take advantage of the speed and throughput of today's microprocessors such as Intel's Pentium III and Pentium 4 as well as AMD's Athlon processors. PCI expansion slots are farther from the back of the computer than ISA, EISA, or MCA slots. The VL-bus slot is also the same dimension. Most motherboards today come with ISA and PCI slots. Reference Motherboard Figure #16 for an example of a motherboard with PCI and ISA expansion slots.

MOTHERBOARD – FIGURE #16

PCI with ISA Expansion Slots



AGP (ACCELERATED GRAPHICS PORT)

AGP (**Accelerated Graphics Port**) is a bus interface for graphics adapters developed from the PCI bus. Intel does the majority of the development for AGP and the specification was originally designed around the Pentium II processor. AGP speeds up 3-D graphics, 3-D acceleration, and full-motion playback.

With AGP, the processor on the video adapter can directly access RAM on the motherboard when needed. This helps with video-intensive applications. 3-D graphics, for example, are resource-intensive and use a lot of memory. Software developers can produce better and faster 3-D graphics using AGP technology. The best performance is achieved when applications use the RAM on the AGP adapter. However, because more memory than the amount on the adapter is needed, motherboard RAM is the next best option. Previous video adapters have been limited by the bottleneck caused by going through an adapter and a bus shared with other devices. With AGP, the video subsystem is isolated from the rest of the computer.

The different versions of AGP are known as 1X, 2X, 4X, and 8X. All versions transfer 32-bits at a time. The difference between the versions is how many transfers take place in each clock cycle. With 1X, one transfer occurs every cycle; 2X makes two transfers; 4X completes four transfers; and 8X does eight transfers every clock cycle. 2X is the most common version. The specifications are shown as 1.0 (which was for the 1X and 2X versions), 2.0 (which specified the 1X, 2X, and 4X versions), and 3.0 (which specifies the 4X and 8X standards). AGP data transfers occur 32-bits at a time at 66MHz, which allows a data transfer rate of 264MBps (Megabytes per second). AGP2X, the next generation of AGP, has a 528MBps data transfer rate. AGP4X has a data transfer rate of 1GBps, four times as much data as the original AGP. AGP4X has been optimized to work with Pentium III, Athlon, and higher processors. The latest recommendation is for AGP8X that has a data transfer rate up to 2GBps.

An extension to the 2.0 specification is called AGP Pro. AGP Pro was designed for more powerful graphics workstations. With AGP Pro, the connector is longer, has improved cooling, allows an adapter to draw up to 110 watts, and supports both the 2X and 4X modes. All original AGP adapters fit in the AGP Pro connector. In order to install an AGP 4X video adapter two things are required: (1) an AGP 2.0 compliant 4X video adapter and an AGP 2.0 compliant motherboard that supports 4X mode. The 8X version is supposed to use the same spot, but is only backwards compatible with the 4X mode. Products for the AGP 8X mode are expected in 2003. Motherboard Table #5 summarizes AGP information.

MOTHERBOARD – TABLE #5

AGP Versions

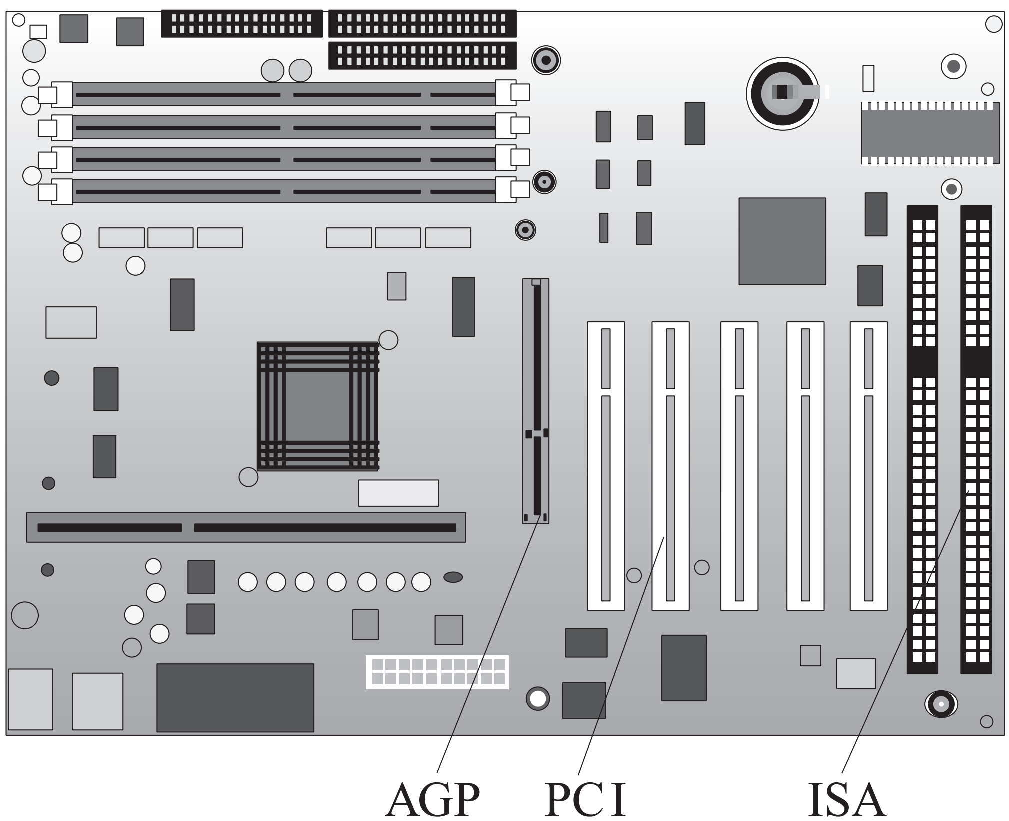
AGP Version	1X	2X	4X	8X
Bus Speed	66MHz	133MHz	266MHz	533MHz
Transfer Rate	256MBps	512MBps	1GBps	2GBps
Data Path	32 bits	32 bits	32 bits	32 bits
Connector Voltage	3.3V	3.3V	1.5V	1.5V

In order to implement AGP, the motherboard must have an AGP expansion slot, the chipset (covered later in the chapter) must support AGP, and an appropriate operating system, such as Windows 95 OSR2.1, Windows 98, Windows Me, or Windows 2000, must be installed.

Some motherboards allow you to set the amount of memory the AGP can use. The most common default setting is 64MB. This setting is known as the AGP Aperture and is configured through the BIOS Setup program (covered in the next chapter). If the computer has an ample amount of RAM, increasing this setting can increase performance especially in applications (such as games) that use 3D graphics. AGP slots are normally brown (compared with PCI slots, which are usually white). Motherboard Figure #17 shows an illustration of an AGP slot compared with PCI and ISA expansion slots.

MOTHERBOARD – FIGURE #17

AGP Expansion Slot



USB (UNIVERSAL SERIAL BUS)

The **USB** (**Universal Serial Bus**) was developed cooperatively by Compaq, DEC, IBM, Intel, Microsoft, NEC, and Northern Telecom. USB allows connection of up to 127 external devices without degradation of speed. Devices that can use USB include keyboards, mice, joysticks, modems, speakers, phones, video phones, storage devices, printers, scanners, digital cameras, webcams, and CD-ROMs. Operating systems that support USB include Windows 95 Service Release 2, Windows 98, Windows Me, Windows NT, and Windows 2000. USB devices are hot-swappable, that is they can be plugged into the computer or hub while the computer is powered. USB devices support plug and play.

The original release of USB includes two speeds, 12Mbps and 1.5Mbps. The 12Mbps rate is for devices such as modems, CD-ROMs, printers, scanners, monitors, and digital cameras. The higher bandwidth can also easily connect to high-speed interfaces such as ISDN or T1 phone lines. A T1 line is a high-speed, leased phone line for voice and data transmission that allows for speeds up to 1.544Mbps. The 1.5Mbps USB rate is for lower speed devices such as mice and keyboards.

USB version 2.0 supports speeds up to 480Mbps that will be used for videoconferencing cameras and higher resolution scanners and printers. USB 2.0 is backwards compatible with USB1.1, which means that the cables used with USB 1.1 can be used with 2.0 devices and all USB devices work with USB 2.0. Computers now ship with the USB connectors on the motherboard. A USB hub is used to connect more than two devices. The number of devices that connect to the hub depends on the number of hub ports. Hubs can also be connected together with a maximum of 16.4 feet between each hub. Full speed devices can connect to the hub or computer at a maximum of 16.4 feet and low speed devices can connect at a maximum of 9.8 feet. A maximum of five hubs can be used with a maximum range of 88.5 feet.

USB devices can obtain power from the USB bus or from an external power supply. Devices such as mice, keyboards, and joysticks obtain power from the bus. Monitors, printers, and scanners are examples of devices that have an external power supply. Some USB hubs can provide power to connected devices. These hubs are known as powered hubs and they contain their own transformers to supply power to the bus so the USB devices do not overtax the computer's power supply.

A USB cable has four wires—two for data and two for power. There are two types of USB connectors and ports—Type A and Type B. A standard USB cable has a Type A male connector on one end and a Type B male connector on the other end. Type A cables and ports are flat and wider than the Type B. The port on the computer is a Type A port. The Type A connector inserts into the Type A port. The Type B connector attaches to the Type B port on the USB device. The USB ports and cables are so different they cannot be inserted incorrectly. Hubs normally have Type A ports on them. Some devices come with one cable end permanently attached and a Type A connector on the other end of the cable. A few USB devices use nonstandard connectors and come with their own cable. Watch out for these! The USB organization has a logo for devices that meet the USB standard. Motherboard Figure #18 illustrates the Type A and Type B connectors.

MOTHERBOARD – FIGURE #18

USB Type A and Type B Connectors

The Universal Serial Bus devices are plug and play devices. A motherboard-based USB Host controller and the system software manage the bus. An older system without a USB host controller can be upgraded with a PCI adapter with two USB connectors.

IEEE 1394 (FIREWIRE)

Texas Instruments and Apple Computer, Inc developed the **IEEE 1394** serial bus. IEEE 1394 is commonly known as FireWire and it supports speeds higher than traditional serial buses. The IEEE 1394 bus allows automatic installation and configuration of up to 63 devices such as a modem, keyboard, mouse, monitor, scanner, hard drive, CD-ROM, printer, and an audio/video device. Each device can connect to up to 14.7 feet away and up to 16 devices can be on a single chain. The maximum distance for all devices combined is approximately 236 feet. IEEE 1394 supports speeds of 100Mbps, 200Mbps, or 400Mbps. A proposed addition to the existing standard, IEEE 1394b or FireWire2, expands the bandwidth to 800Mbps and increases cable lengths to 100 meters.

The big excitement over the standard stems from its ability to handle digital audio and video devices such as VCRs, camcorders, and televisions. Audio and video equipment have traditionally been proprietary devices and connecting them to computers was nearly impossible. The existing computer buses could not accommodate the throughput necessary for quality audio and video transfer. A 30-frames-persecond, high quality video at a 640x480 resolution, using 16.7 million colors transfers at 221Mbps, is too fast for the standard computer serial bus. FireWire has the potential to affect video for microcomputers dramatically.

IEEE 1394 supports plug and play like USB and the devices are hot swappable. IEEE 1394 devices (like USB devices) can receive power from the IEEE 1394 bus, or they can have an external power source, but FireWire is more expensive to implement than USB. Windows 98, Windows Me, and Windows 2000 support FireWire. When a device is attached or removed, all IEEE 1394 devices are reset. They reinitialize and all devices are assigned a unique number.

The IEEE 1394 bus is actually a peer-to-peer standard, meaning that a computer is not needed. Two IEEE 1394-compliant devices can be connected together (such as a hard drive and a digital camera) and data transfer can occur across the bus. Many compare IEEE 1394 with USB or place them in competition with one another; but in the computer world, there are applications for each. IEEE 1394 was designed for high-speed audio and video devices and the standard has much greater throughput for applications such as video conferencing.

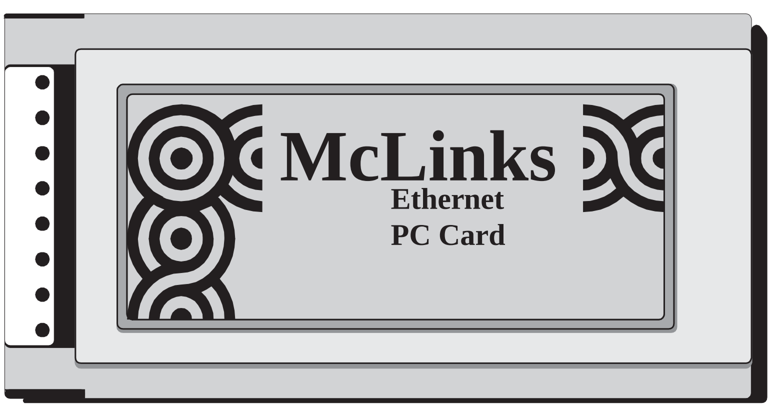
PC CARD

The **PC Card** architecture, previously known as PCMCIA (Personal Computer Memory Card International Association), was originally designed to upgrade memory in laptop computers. However, because the standard expanded, PC Cards are now available for modems, hard drives, network adapters, and so forth. The PC Card's local bus can also be installed in a desktop computer, but that is not common.

The original standard was a 16-bit local bus standard with 64MB of memory addressing. The new standard called **CardBus** allows 32-bit transfers at speeds up to 33MHz (133Mbps). CardBus was designed as a combination of the old PC Card architecture and PCI. The PC Card's CardBus also supports bus-mastering, direct memory accessing (DMA) covered in Chapter 3, and up to 4GB of memory addressing. PC Cards are about the size of a credit card, though thicker. Motherboard Figure #19 shows a PC Card.

MOTHERBOARD – FIGURE #19

PC Card (PCMCIA)



The number of PC Card slots available on a computer varies among manufacturers and computer models. A PC Card inserts into the PC Card slot. However, each PC Card can control more than one PC Card slot. In theory, any PC Card can be used for any type of device. However, their use is normally denoted by the PC Card's thickness. There are three major PC Card types of different sizes known as Type I, Type II, and Type III. The Type I PC Cards are 3.3mm thick and are normally memory cards. These memory cards can be RAM, FLASH memory, OTP (One-Time-Programmable) memory, and SRAM.

Upgrading memory in a 486 or higher laptop with a 16-bit PC Card is not the best solution. Because of the 16-bit transfers, a PC Card memory upgrade should be done only as a last resort. However, for some laptops, this is the only option.

Type II PC Cards are 5mm thick and used for modem and network functions. A laptop computer with a Type II PC Card slot accepts Type II and Type I PC Cards in the slot, but only one at a time! The easiest way to think of this is that the thinner cards fit in the thicker slots, but a thick card cannot fit in the thinner slots.

Type III PC Cards are 10.5mm thick are for rotating devices such as hard drives, CD-ROMs, floppy drives, etc. Type III PC Card slots also accept Type I and II PC Cards. Motherboard Table #6 recaps the PC Card types, sizes, and uses. This table is important to those studying for the A+ Certification.

MOTHERBOARD – TABLE #6

PC Cards

PC Card Type	Size	Usage
I	3.3mm	Memory and applications
II	5mm	Modems and network adapters
III	10.5mm	Storage devices such as floppy drive, hard drives, and CD-ROMs

PC Cards now support power management in the following ways: as security tokens, GPS (Global Positioning System), wireless network adapters, sound cards, video capture/frame grabber cards, TV tuners, and video conferencing cards.

A **SmartMedia** card is used with digital cameras, voice or sound recorders, PDA, electronic musical instruments, faxes, printers, scanners, and game machines. The SmartMedia card is smaller than a credit card and is used to hold pictures and audio files similar to a floppy disk. In order to connect a SmartMedia card to a PC Card slot, an adaptor must be inserted into the PC Card slot.

The **ZV port** (**zoomed video port**) allows direct data transfer from a PC Card to a video controller. The data is transferred over the ZV bus instead of the system bus. With this new bus a notebook computer can connect to a video device such as a camera.

The **CardBay** standard allows laptop computers to be compatible with the USB and IEEE 1394 serial interfaces. CardBay supports all versions of USB and all USB operating modes. With CardBay, a controller switches the CardBay card to the appropriate bus (USB or IEEE 1394). If the CardBay card is USB, the USB bus configures it and treats it just like any other USB device. CardBay does not require a driver, nor does it have to be supported by an operating system. CardBay is backwards compatible with previous PC Cards.

PC Cards ship with software called device drivers to allow the adapters to operate. The device drivers are frequently operating system dependent. Be sure the PC Card is supported by the operating system installed on the laptop. After configuration, some PC Cards can be hot swapped, that is, they can be inserted into the expansion slot after the computer has been powered on.

FUTURE BUSES

Great progress has been made in CPU and memory enhancement. However, the I/O (input/output) bus is the number one bottleneck for a computer. The I/O bus is what connects the motherboard components and devices to the CPU and memory. The I/O architectures of the past use what is known as a shared bus technology. Devices must compete and share the same path to the microprocessor. PCI and AGP have alleviated the bottleneck to some degree, but the congestion still exists.

PCI is on its last legs. PCI-X is probably the last version of PCI to be seen in a computer. The future lies in new I/O architectures. The ones to watch are HyperTransport, InfiniBand, 3GIO, and RapidIO. The trend is toward simultaneous point-to-point connections, allowing two devices to communicate without interfering with any other communication session.

AMD is the force behind the **HyperTransport** architecture, which is a serial-link design scalable to 128GBps and beyond. HyperTransport has a great deal of industry support and input into the design and is compatible with PCI-based products. Being compatible with existing devices and adapters is important to an industry where billions of dollars are invested in hardware each year. With HyperTransport, devices can be daisy chained, connected one device to another like Christmas light sets. Each communication consists of two unidirectional point-to-point links. Transmission can occur in 4, 8, 16, and 32 bits in each direction. The HyperTransport architecture can be applied to computers, network workstations, network servers, network routers, network switches, handheld devices, and game consoles. The architecture is not limited to the motherboard. Some articles have described HyperTransport as the “universal link.”

A similar technology is the InfiniBand architecture. Compaq, Dell, Hewlett-Packard, IBM, Intel, Microsoft, and Sun Microsystems are behind this I/O architecture and form a group known as IBTA (InfiniBand Trade Association). **InfiniBand** uses a point-to-point connection between devices, CPUs, servers, networks, server clusters, etc. The connections are made through a switching fabric. Switching fabric is a combination of hardware and software that allows data to move between two devices without interfering with communications occurring between other devices. InfiniBand is a high-speed bi-directional serial link between an HCA and a TCA. An HCA (Host Channel Adapter) connects memory to the switch fabric. A TCA (Target Channel Adapter) connects end devices to the switch fabric.

InfiniBand can use 2, 8, or 24 channels. Half the channels are used for sending and the other half are used for receiving with theoretical bandwidths of 5Gbps, 20Gbps, and 60Gbps. The link that is created is only there for the duration of the communication session. When the devices finish communicating, the link is torn down. The InfiniBand architecture is compatible with PCI, PCI-X, and Fibre Channel, making it a viable choice for the future.

Intel recently announced its idea for the future called 3GIO (Third Generation I/O). 3GIO is a point-to-point serial interface that supports copper and optical interfaces. 3GIO is supposed to support speeds in excess of 10GHz.

RapidIO is the result of work done by Motorola and Mercury Computers, who have joined with numerous other technology companies to form the RapidIO Trade Association. **RapidIO** is an architecture designed for network and embedded applications (signal processing, data storage, and multimedia), but which can be applied to I/O interconnection for chip-to-chip, board-to-board, and device-to-device communication. RapidIO technology permits PCI and PCI-X devices to coexist in the same computer because the PCI bridges can be connected together using RapidIO switches.

The current specification has 8- and 16-bit versions. The 8-bit version allows for bandwidths up to 20Gbps and the 16-bit version up to 40Gbps. The RapidIO Trade Association states “RapidIO can be thought of as the mechanism to connect devices together to form the computer system.” Motorola originally designed RapidIO as an interface used with their microprocessors, but the technology can be applied to compatibles and networks.

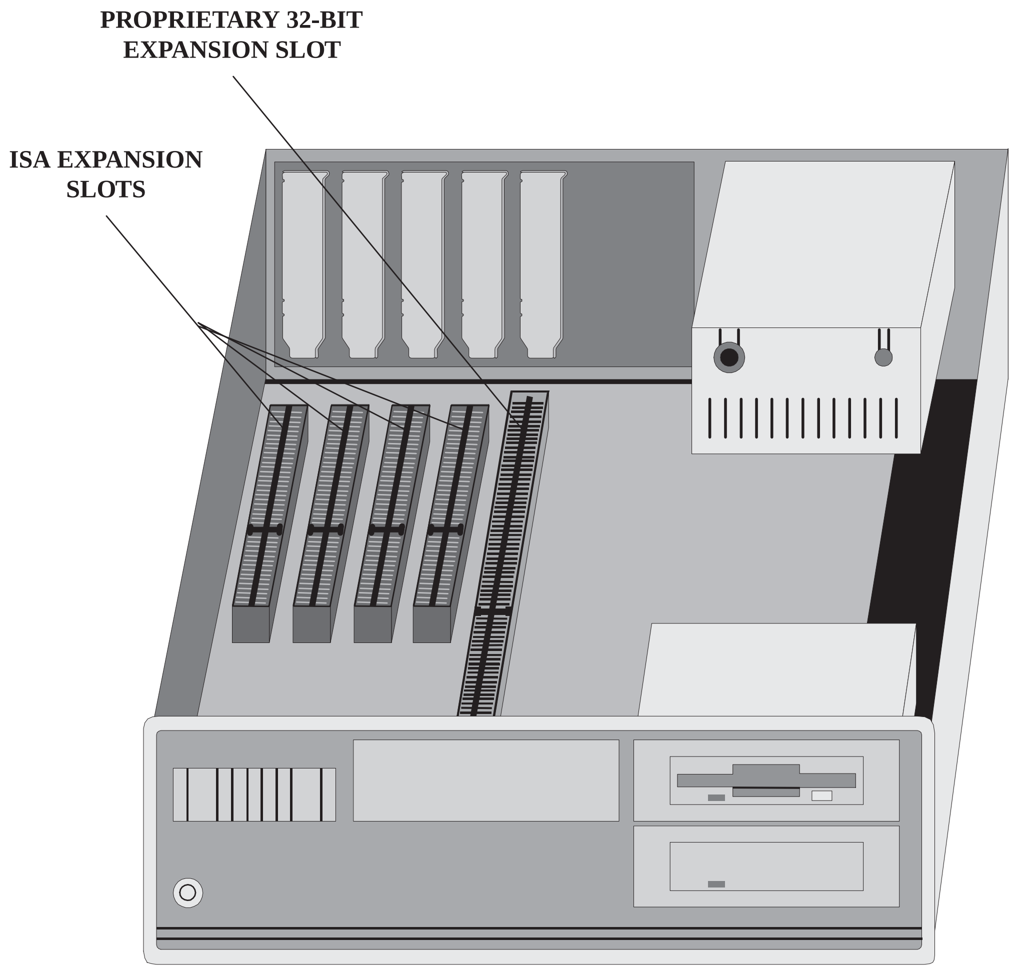
Technicians must stay current with emerging technologies such as these. Once one or two architectures are integrated into the motherboard, the technician must support them. The Internet has opened up immense resources for technicians to stay current. A technician should subscribe to at least one magazine (on-line or traditional) to stay abreast of these issues.

PROPRIETARY LOCAL BUS SLOTS

Some older computers have an expansion slot built into the motherboard that is neither a VL-bus slot nor a PCI slot. These expansion slots are proprietary: the adapters that fit in them are expensive and must be purchased from the slot manufacturer (if it is still in business). Motherboard Figure #20 shows a proprietary 32-bit expansion slot on a motherboard.

MOTHERBOARD – FIGURE #20

Proprietary 32-Bit Expansion Slot



Beware of proprietary slots! Expansion cards are usually hard to obtain and the documentation for adapters is even scarcer.

The different architectures and local buses can be overwhelming. Motherboard Table #7 allows viewing the differences at a glance.

MOTHERBOARD – TABLE #7

Architecture and Bus Overview

Architecture or Local Bus	Bits	Speed	Bus-Mastering
ISA	8/16	8/10MHz	Y (only 1 adapter)
MCA	16/32	10MHz	Y
EISA	32	10MHz	Y
VL-bus	32	25/33MHz	Y
PCI	32/64	33/66/133MHz	Y
AGP	32	66/133/266/533MHz	N/A
USB	1 (serial bus)	1.5Mbps/12Mbps/ 480Mbps	Y
IEEE 1394	1 (serial bus)	100Mbps/200Mbps/ 400Mbps/800Mbps	Y
PC Card	16/32	33MHz	Y

CHIPSETS

The principle chips on the motherboard that work in conjunction with the microprocessor are known as a **chipset**. These allow certain features on the computer. For example, chipsets control the maximum amount of motherboard memory, the type of RAM chips, the motherboard's capacity for two or more microprocessors, and whether the motherboard supports the latest version of PCI. Common chipset manufacturers include Intel, Via Technologies, Acer Labs (ALI), Silicon Integrated Systems (SiS), AMD, and OPTi.

Usually a chipset goes with a particular microprocessor and determines which memory chips a motherboard can have. Chipsets determine a lot about what a motherboard *can* allow or *can* support. When buying a motherboard, pick both a proper microprocessor anda good chipset.

Let's take a look at some different Intel chipsets. Intel's 440AX chipset supports a 100MHz external bus, PC100 SDRAM, AGP X1 and X2 modes, Ultra DMA/33 and 66, USB, and two memory banks. Intel's 440EX and 810 chipsets are used with the Celeron microprocessor. The 450NX chipset supports up to four Pentium III Xeon microprocessors, 100MHz external bus, 16MB and 64MB EDO DRAM, a maximum of 8GB of RAM and bus-master IDE. Intel's 850 chipset supports Pentium 4, 400MHz bus, 4 RIMMs, up to 4GB PC 600/800 RDRAM, AGP4X, four USB ports, and the USMA100 ATA standard. The AMD-760 Athlon chipset supports AGP4x, 266MHz front side bus, 4GB RAM, PC1600 and PC2100 DDR SDRAM, and the USMA100 ATA standard.

A technician must keep well informed of the chipsets on the market; customers will always ask for recommendations about motherboard upgrades and new computer purchases.

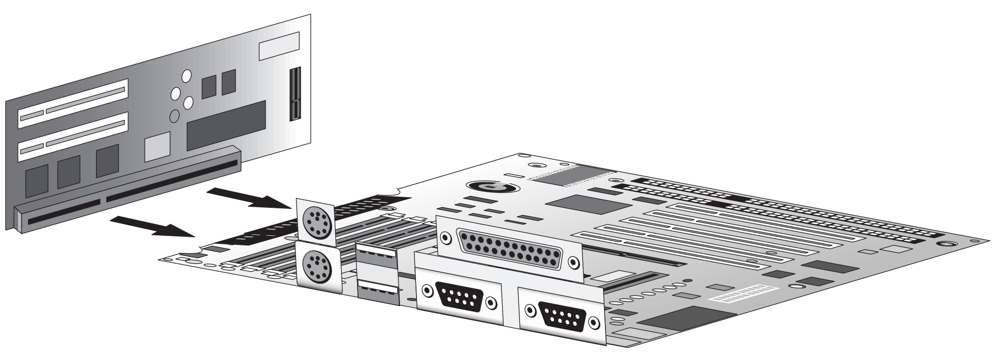
TYPES OF MOTHERBOARDS

Motherboards come in different sizes known as **form factors**. The most common motherboards are the AT, baby AT, ATX, NLX, µATX (MicroATX), FlexATX, and ITX. AT motherboards were named after IBM's original AT computer motherboard. Clones that used a smaller motherboard were referenced as baby AT motherboards. The ATX motherboard is similar in size to the baby AT except it is rotated 90 degrees. The microprocessor no longer sits near the expansion slots on an ATX motherboard. The ATX provides easier installation of full-length cards, easier cabling, and more cost-effective cooling. Look back to Motherboard Figure #17 for an example of an ATX motherboard.

The NLX motherboard is designed around the Pentium II and higher microprocessors and provides more space for expansion. The NLX design has a riser board that contains the expansion slots. Motherboard Figure #21 shows an NLX motherboard layout.

MOTHERBOARD – FIGURE #21

NLX Motherboard



The µATX (MicroATX) motherboard has a maximum size of 9.6 inches by 9.6 inches and fits in a standard ATX case or other smaller tower models. FlexATX is smaller than the MicroATX form factor, is 9 inches by 7.5 inches, and is backwards compatible with ATX and µATX cases. An even smaller motherboard (8.5 inches by 7.5 inches) is the ITX form factor, which is made for a smaller power supply.

Manufacturers can also design their case so that it requires a proprietary motherboard. With these designs, a replacement motherboard must be purchased from the original manufacturer and is usually more expensive.

When building a computer or replacing a motherboard, it is important to obtain the correct form factor so the board fits in the computer case.

UPGRADING AND REPLACING MOTHERBOARDS

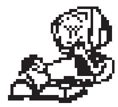
Whenever upgrading a motherboard, several issues must be taken into account. The following list helps guide a technician through making the decision (or helping a customer make a decision) of whether or not to upgrade a motherboard.

1. Why is the computer being upgraded? For example, does the computer need more memory? Are more expansion slots needed? Does the computer need a bigger and faster microprocessor to run certain operating systems or applications? Sometimes, upgrading the motherboard does not help unless the other computer components are upgraded. The most expensive and fastest motherboard in the world will not run applications well unless it has the proper amount of memory. Hard drives are another issue. If software access is slow, the solution might not be a new motherboard, but a faster and larger hard drive, more cache memory, or more RAM.
2. Which type (ISA, EISA, MCA, PCI, or VL-bus) and how many adapters are needed from the old motherboard? Does the new motherboard have the required expansion slots?
3. Could any devices such as the hard drive or CD-ROM that currently require an adapter, plug directly into the upgraded motherboard? This would free up expansion slots as well as speed up the devices.
4. What type of chipsets does the new motherboard support? What features, if any, would this bring to the new motherboard? What expense is incurred if the new chipset is purchased? Will the chipset from the old motherboard operate in the new motherboard?
5. Will the new motherboard fit in the case of the computer to be upgraded?
6. Does the motherboard allow for future microprocessor upgrades?
7. How much memory (RAM) does the motherboard allow? What memory chips are required on the new motherboard?

Before replacing a motherboard, the adapters must be removed from the expansion slots. Also, the power connectors must be disconnected from the motherboard, any external connectors, such as keyboard, mouse, and printer, must be disconnected, and the CPU and RAM must be removed. Replacement motherboards do not normally come with RAM or a microprocessor, so the old ones are removed from the bad motherboard. Make note of the CPU orientation before removing it from the motherboard. When installing the CPU into the replacement motherboard, refer to these notes. Most motherboards support a variety of microprocessors.

Make note of any jumper settings on the old motherboard. Set the new motherboard's settings to match the old settings if the two boards are identical.

Motherboards contain most of the circuitry for a microcomputer and are very important to its operation. Technicians must keep current with the options, features, microprocessors, and chipsets. Most technicians subscribe to computer magazines to help them fulfill this responsibility.

 Name ______________________________

MOTHERBOARD REVIEW QUESTIONS

1. What is a microprocessor?

2. List two CPU manufacturers.

3. What is a PC?

4. What is a bus?

5. What is the difference between the internal data bus and external data bus?

6. T / F A computer's word size and external data path are always the same number of bits.

7. T / F The Pentium II has a 64-bit external data path.

8. What is a microprocessor's pipeline?

9. Why did Intel use the Single Edge Connector (SEC) cartridge on the new Pentium II and Pentium III microprocessors?

10. What is the easiest way to distinguish the 80486, Pentium, and Pentium Pro microprocessors?

11. You insert an AMD K5 CPU into a motherboard and the chip inserts easily. However, the system will not boot. What is one possible problem?

12. What are the three versions of K6 AMD processors?

13. What is the most powerful AMD processor? [K8 \ Pentium 4 \ Greece \ Athlon]

14. How many pins does a Socket A PGA have?
15. T / F A Pentium III fits into a Slot A.
16. What is the difference between MMX and MMX2?
17. List one advantage an Intel MMX microprocessor has over a microprocessor without MMX.
18. What is the name of AMD's popular technology for 3-D graphics rendering?
19. What is the difference between an 80486SX microprocessor and an 80486DX microprocessor?
20. T / F A Celeron processor needs an external math coprocessor for maximum performance.
21. Which microprocessor speed is the fastest 10MHz, 25MHz, 100MHz, or 266MHz?
22. List two methods for determining microprocessor speed.
23. Is the microprocessor speed the same speed as the chips on the motherboard?
24. A 1.2GHz processor is installed onto a motherboard that has a 100MHz bus. What multiplier is used?
25. What is the CPU speed for a 66MHz motherboard with a multiplier of 2?
26. List two advantages of a Pentium microprocessor over an 80486 microprocessor.
27. What is L3 cache?
28. What is the difference between a front side bus and a back side bus?
29. T / F With DIB, the path to L2 cache is shared with the PCI controller.

30. How does DIB speed up computer operations?

31. How would you know what overdrive chip a system could handle?

32. What type of socket or slot is used for Intel's Pentium 4?

33. A customer wants to upgrade her microprocessor. What questions are you going to ask her before making a recommendation?

34. How can you tell if a motherboard accepts a faster or more powerful microprocessor?

35. T / F A 3.3 volt microprocessor automatically converts the incoming 5 volts to a lower voltage.

36. Describe how to remove a CPU that is packaged in a cartridge.

37. A motherboard has no visible jumpers or switches. How would the multiplier be set on this type of system board?

38. When overclocking, what setting should be changed first?

39. What is the most common problem with overclocking?

40. List two operating systems that support multiple CPUs.

41. T / F The Celeron processor can be used in multiple CPU systems.

42. T / F A 800MHz and a 1.2GHz Athlon can be installed on the same motherboard.

43. What is a computer architecture?

44. Name three microcomputer architectures.

45. List three common buses.

46. Why must a technician be familiar with the different architectures?

47. What is ISA's biggest drawback?

48. Why should a memory expansion adapter never be placed in an expansion slot?

49. T / F Computers today still use ISA.

50. List two drawbacks to the MicroChannel Architecture.

51. What is bus-mastering?

52. T / F An EISA adapter can operate in an ISA slot.

53. List one limitation common to microcomputer architectures.

54. List the four PCI versions.

55. T / F PCI-X is backwards compatible with 32-bit 33MHz PCI.

56. T / F PCI is a better bus standard than VL-bus.

57. T / F PCI is set up via jumpers and switches on the PCI adapter.

58. Match the following definitions with the most correct term.

_____ VL-bus	A.	A local bus primarily used in laptop computers
_____ PC Card	B.	A local bus standard developed by the video industry
_____ PCI	C.	A 64-bit local bus standard

59. What is a bus interface for graphic adapters developed to speed up 3-D applications?

60. What is different about AGP Pro compared to AGP?

61. A customer wants to install a 4X AGP video adapter into her system. What would you have the customer check?

62. At what speeds can USB operate under the original specification?

63. What is the maximum number of USB hubs that can be connected together?

64. T / F USB scanners normally receive power from an external power supply.

65. What type of USB port is found on motherboards?

66. How many devices can connect on a single IEEE 1394 chain?

67. What speeds are currently supported by FireWire?

68. What types of devices are best suited for the IEEE 1394 bus?

69. How many bits at a time does the CardBus transfer?

70. What are the three types of PC Cards and for what are they used?

71. What new laptop standard allows portable computers to use USB devices and IEEE 1394 serial devices?

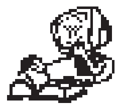
72. What is AMD's I/O serial architecture called?

73. What I/O architecture uses the terms HCA and TCA?

74. What are some features a computer chipset provides?

75. What form factor is 9.6-inch x 9.6-inch?

76. List at least three recommendations to keep in mind when upgrading or replacing a motherboard.



Name ________________________________

MOTHERBOARD FILL-IN-THE-BLANK

1. The main chip found on the motherboard that executes software instructions is the __________.
2. In computer technology, a 1 or a 0 is a __________.
3. A combination of eight 1s and 0s is a __________.
4. Approximately 1,000 (one thousand) bytes are a __________.
5. Approximately 1,000,000 (one million) bytes are a __________.
6. Approximately 1,000,000,000 (one billion) bytes are a __________.
7. Approximately 1,000,000,000,000 (one trillion) bytes are a __________.
8. The number of bits that the microprocessor processes at one time is the microprocessor's __________.
9. The AMD __________ CPU is similar to Intel's Pentium.
10. The AMD K6-2 and K6-III processors fit into a __________ socket.
11. The AMD __________ CPU is a scaled-down version of the Athlon.
12. __________ microprocessors have 57 multimedia instructions built into them.
13. __________ is the acronym used to describe the technology that allows multiple data items to use one instruction.
14. A microprocessor speed is measured in __________ or __________.

15. To keep today's microprocessors cool __________ or __________ are used.

16. A __________ converts 5VDC down to a voltage appropriate for the microprocessor.

17. A plastic cover over two pins that enables a computer option is a __________.

18. The __________ setting is the speed at which the CPU's external bus operates.

19. The type of memory that has always been found inside the microprocessor is __________.

20. The type of memory previously outside the microprocessor on the motherboard, but now inside the microprocessor packaging is __________.

21. The type of cache memory written immediately to regular memory is known as __________.

22. The type of cache memory written to regular memory whenever the microprocessor is not busy is known as __________.

23. Cache chips can be __________ chips or a __________ memory module.

24. __________ provides a front side bus and a back side bus.

25. The AMD Athlon inserts into a __________-pin socket commonly known as Socket __________ or into a Slot __________ connector.

26. A __________ socket has a lever beside it to facilitate CPU insertion and removal.

27. Pin 1 on a processor is indicated by a __________ or a __________ corner.

28. Increasing CPU speed is commonly known as __________.

29. In order to install two or more processors, the operating system must support __________ and the operating system and applications must support it as well.

30. AMD's __________ and __________ processors can be installed as dual processors.

31. The oldest architecture is __________.

32. An __________ allows an adapter to be added to a motherboard or a riser board.

33. An adapter that communicates directly with another adapter without going through the microprocessor uses __________.

34. The __________ was a standard created by VESA.

35. The 64-bit 66MHz PCI version is commonly called __________.

36. The __________ allocates how much RAM the AGP adapter can use from motherboard RAM.

37. __________ allows connectivity for up to 127 devices.

38. A customer has four USB devices and only two ports on his system. A USB __________ can be used to connect all USB devices and provide for future devices.

39. USB cable connectors are either Type __________ or Type __________.

40. USB devices normally have a __________ port.

41. Another name for the IEEE 1394 standard is __________.

42. The __________ architecture is mainly for laptop computers.

43. The __________ port allows a camera to be connected to a laptop computer.

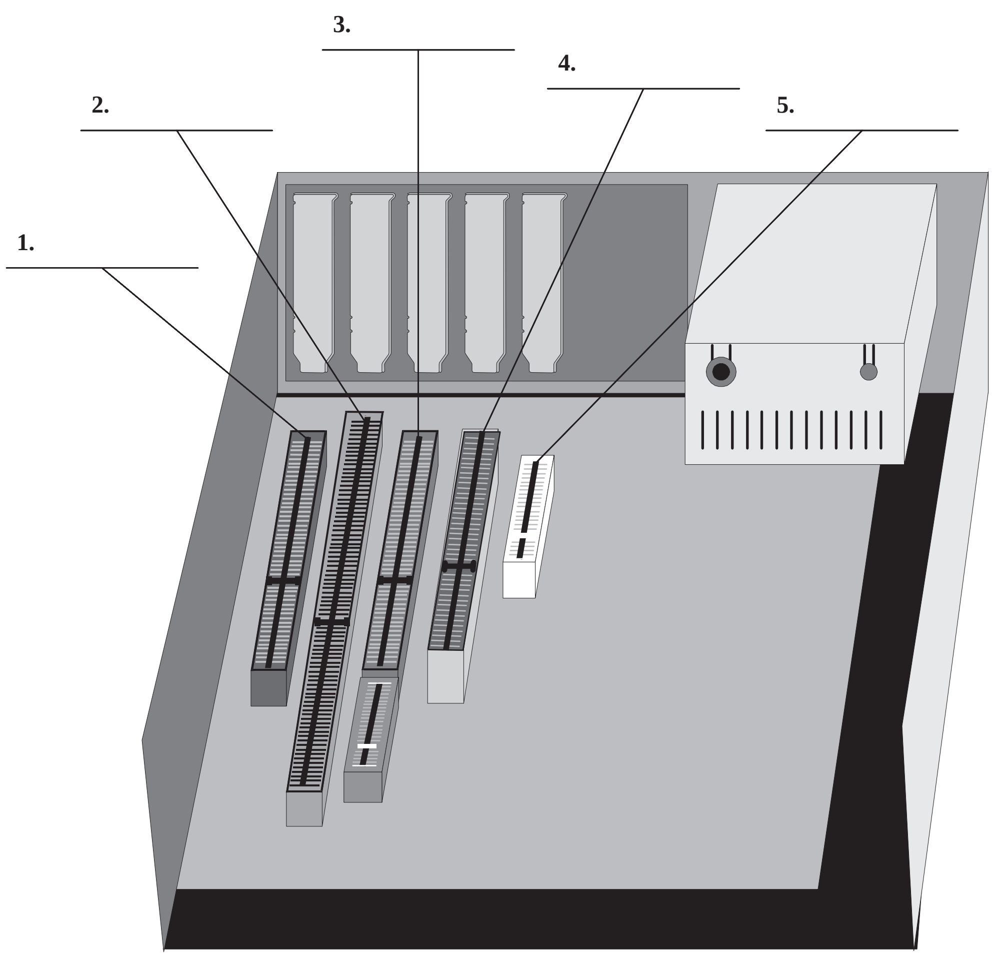
Name ______________________________

EXPANSION SLOT IDENTIFICATION EXERCISE

Using Motherboard Exercise Figure #1, label the expansion slots.

MOTHERBOARD EXERCISE – FIGURE #1

Expansion Slot Identification



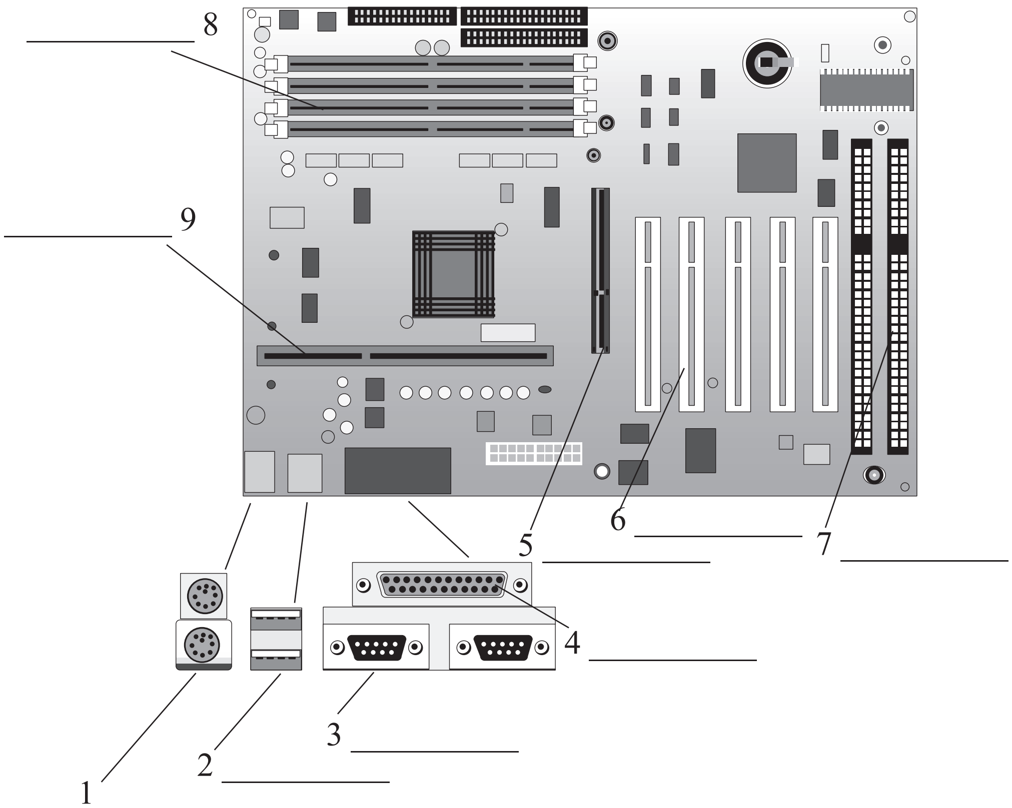
Name ______________________

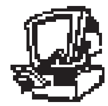
ATX MOTHERBOARD PARTS IDENTIFICATION EXERCISE

Using Motherboard Exercise Figure #2, label each of the ATX motherboard parts.

MOTHERBOARD EXERCISE – FIGURE #2

ATX Motherboard Parts Identification Exercise





Name ______________________________

ADAPTER AND EXPANSION SLOT IDENTIFICATION EXERCISE

Objective: To identify the adapter type and the architecture or local bus expansion slot type by looking inside a computer

Parts: Computer with adapters installed

Step 1. Remove the cover from a computer shown to you by your instructor.

Step 2. Identify all adapters installed in the microcomputer as ISA, EISA, MCA, VL-bus, PCI, AGP or PCMCIA/PC Card. Use Motherboard Exercise Table #1 to list the adapter type (video, hard drive controller, network adapter, etc.) and the architecture or local bus expansion slot used for the adapter.

Note: You can sometimes identify the adapter type by observing the cables attached to the adapter. For example, the hard drive controller has one or two cables that attach to the hard drive. Many computers have multi-function adapters able to control more than one device such as the floppy and hard drive.

MOTHERBOARD EXERCISE – TABLE #1

Adapter Type (video, network, sound, floppy, hard, etc.)	Expansion Slot Type (ISA, EISA, MCA, VL-bus, PCI, AGP, or PC Card)
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	
9.	
10.	

Name ________________________________

ADAPTER'S EXPANSION SLOT IDENTIFICATION EXERCISE

Objective: To identify the adapter type and the architecture or local bus expansion slot type by looking at an adapter

Parts: Various adapters

Step 1. Obtain an adapter from your instructor.

Step 2. By looking at the adapter, (1) determine the type of adapter—video, hard drive controller, or network adapter— and (2) determine the expansion slot architecture the adapter uses. Record your results in Motherboard Exercise Table #2.

MOTHERBOARD EXERCISE – TABLE #2

Adapter Type (video, network, sound, floppy, hard, etc.)	Expansion Slot Type (ISA, EISA, MCA, VL-bus, PCI, AGP, or PC Card)
1.	
2.	
3.	
4.	
5.	
6.	
7.	
8.	
9.	
10.	

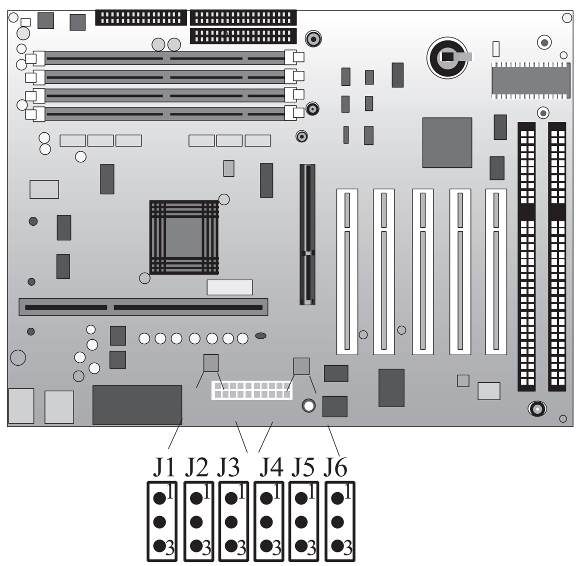
Name ________________________________

MICROPROCESSOR UPGRADE
PAPER CONFIGURATION EXERCISE

Look at the drawing shown in Motherboard Exercise Figure #3. Using the documentation included with the figure, draw a jumper (a rectangular box) around the pins to be jumpered if installing a Pentium II 300MHz microprocessor.

MOTHERBOARD EXERCISE – FIGURE #3

Pentium II Microprocessor Upgrade Configuration Exercise

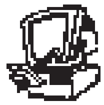


BUS FREQUENCY

Frequency	J1	J2	J3
66MHz	1-2	1-2	1-2
66MHz	1-2	1-2	1-2
66MHz	1-2	1-2	1-2
66MHz	1-2	1-2	1-2

PENTIUM II CPU FREQUENCY

Frequency	J4	J5	J6
233MHz	2-3	1-2	1-2
266MHz	2-3	1-2	2-3
300MHz	1-2	2-3	1-2
333MHz	1-2	2-3	2-3



Name ______________________________

DETERMINING CPU FREQUENCY

The multiplier and bus speed are used to determine CPU frequency. Determine the CPU frequency, bus speed, or multiplier used when given two of the three parameters. Fill in the missing parameter using Motherboard Exercise Table #3.

MOTHERBOARD EXERCISE – TABLE #3

CPU Frequency	Bus Speed	Multiplier
__________	66MHz	3
250MHz	83MHz	__________
850MHz	__________	8.5
__________	133MHz	7.5
166MHz	66MHz	__________
300MHz	__________	3.5
__________	60MHz	1.5
1.13GHz	133MHz	__________
150MHz	__________	2

Name ______________________________

PROCESSOR SPEED, PROCESSOR SOCKET, USB PORTS, AND IEEE 1394 (FIREWIRE) PORTS

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

Parts: Access to the Internet

Computer

Step 1. Boot a computer and determine the microprocessor speed by watching the computer boot. Write the speed in the space below.

Step 2. Power off the computer. Remove the cover. What type of processor socket or slot is on the motherboard. If unsure, use the Internet as a resource. Write the processor socket or slot type in the space below.

_____ ***Instructor's Initials***

Step 3. Look at the back of the computer where the ports are located. Does the computer have USB ports? If so, how many USB ports does the computer have? If the computer has at least one USB port, what type of connector is it? Write all of the answers in the space below.

Step 4. Locate a picture of an IEEE 1394 port or connector on the Internet. Write the URL for where you found this information in the space below.

Step 5. Using the Internet, locate one vendor that makes a motherboard that supports IEEE 1394 or has an integrated IEEE 1394 port. Write the vendor's name and the URL where you found the information in the space below.

Name ________________________________

INTERNET DISCOVERY

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

Parts: Access to the Internet

The following scenario relates to questions 1-10:

Your customer has a Super Micro SUPER P4DC6 motherboard. Using documentation found on the Internet, answer the following questions.

Question 1: Does the motherboard support multiple CPUs?

Question 2: What chipset is installed?

Question 3: How many 64-bit 66MHz PCI slots are on the motherboard?

Question 4: What form factor does this motherboard use?

Question 5: What processor is used on this motherboard?

Question 6: What processor speeds are supported?

Question 7: Does the motherboard have a ZIF socket or a processor slot?

Question 8: What is the CNR motherboard slot used for?

Question 9: What type of memory does this motherboard accept?

Question 10: The Super P4DC6 motherboard uses the term “Clock Ratio” for the clock multiplier. What settings are supported by this motherboard?

Question 11: Locate a web site that lists information about various Intel chipsets and write the URL in the space below.

Question 12: Find a vendor for a motherboard that accepts an AMD Athlon 1.4GHz processor with a 266MHz front side bus. Write the vendor’s name in the space below.

Question 13: Find an Internet site that describes the difference between the North Bridge and the South Bridge and write a brief description of each term.

NOTES