# Central Processing Unit (CPU)

The CPU in a PC is the Microprocessor (80386, 80486, Pentium, Cyrix 5x86, etc.).

You should be aware that there are several brands of CPU's. The most popular as of 1997 are probably the Pentium (many versions), AMD K series, CYRIX Mx series, and Motorola microprocessors. CPU's are primarily of two types: Socket 7 and Single Edge Contact (SEC). Intel CPU's prior to the Pentium II were Socket 7, as are the CYRIX and AMD CPUs. The Pentium II is a SEC CPU, and it is believed that in the future most if not all Intel CPUs will be SEC design.

In my opinion, the CPU is the "brain" of the computer; however, even your brain needs some stimuli to process information. So, the CPU needs an electrical system, an input (senses), etc. to work; just like your body needs direction and motivation to do things. Electricity, in computers, is like the heart, blood, and calories(energy) in your body.

A CPU that has no operating system is useless. It is like your brain on the day you were born - all you knew was to eat; the CPU along with the BIOS at boot time, knows only that it has to load an Operating System and check out its parts. As you grew older, you learned; as the operating system is loaded the computer learns enough to operate. Enough.

EVERY PART of a PC must be functioning to truly process data into information!

When you turn on your computer, something called the "BOOT PROCESS" takes place.

The boot process is essentially the following:

1. The CPU is cleared, the CPU register is set to F000 hex, which is the address of the BIOS ROM chip.

2. The boot program in ROM BIOS is loaded into memory.

3. The boot program performs a set of "Power On Self-Tests (POST)" to determine if all its parts are in working order.

4. The disk drives (normally A: and C:) are checked for a boot record. When found, it loads the "Boot Record" into memory at address 7C00, and BIOS then transfers control to the boot record address.

5. The boot record then loads IO.SYS file which contains extensions to the ROM BIOS, and includes a program called SYSINIT that handles the rest of the boot process. The boot record is then replaced in RAM by other program code.

6. SYSINIT assumes control and loads MSDOS.SYS into RAM. MSDOS.SYS assists BIOS to manage files, execute programs, and handle hardware interrupts.

7. SYSINIT finds the "config.sys" file and uses MSDOS.SYS to execute the commands in the "config.sys" file.

8. SYSINIT then tells MSDOS.SYS to load the "command.com" into memory. Part of the command.com is loaded into memory as part of BIOS. Then the internal DOS commands from "Command.COM" loads into conventional RAM.

9. The third part of COMMAND.COM finds the "autoexec.bat" file and executes it.

10. The PC is now fully booted!

This is the basics of how an INTEL processor BOOTs. Newer processor will have minor differences and some different control procedures.

No matter the brand, they are all cute little chips, with many "pins", which in newer machines, fit in "ZIF" sockets and are removeable.

YOU CANNOT PUT JUST ANY "UPGRADE" IN ANY PC. YOU MUST BUY ONE THAT IS COMPATIBLE WITH YOUR MOTHERBOARD, YOUR CLOCK SPEED, YOUR BIOS, ETC.

An Intel Pentium Microprocessor (CPU) as shown above, has multiple components as follows:

1. **Bus Interface Unit (BUI)** - links the CPU with the rest of the PC. It retrives the instruction from RAM and gives it to the Prefetch unit. The BUI has a 64-bit path (bus) to RAM. It also has two other 64-bit paths to the "code cache" and the "data cache". These are 8KB storage units used for instructions and data. The code and data remain in these cache areas until needed by other CPU components.

2. **Branch Predictor Unit**. This has a direct interface to the "code cache" and to the Instruction Prefetch and Decode Unit. It looks at the code, to determine which of the two ALUs can handle them most efficeitnly. It attempts to keep each of the ALUs working constantly.

3. **Fetch/Decode Unit**.

   a. Instruction Prefetch Unit (buffer) - retrieves the code from the Branch Predictor unit, and queues instructions for processing by the decode unit.

   b. DeCode Unit - the Instruction Prefetch Unit gives the instruction to the decode unit. The Decode Unit then translates the instruction and gives it to the execution unit, or in case of floating or decimal numbers it gives them to the Floating Point Unit.

4. **Execution Unit** - coordinates the steps to complete each instruction.

   a. Control Unit -It tells the Protection Test Unit where the operands of an instruction are located in DATA cache, or RAM.

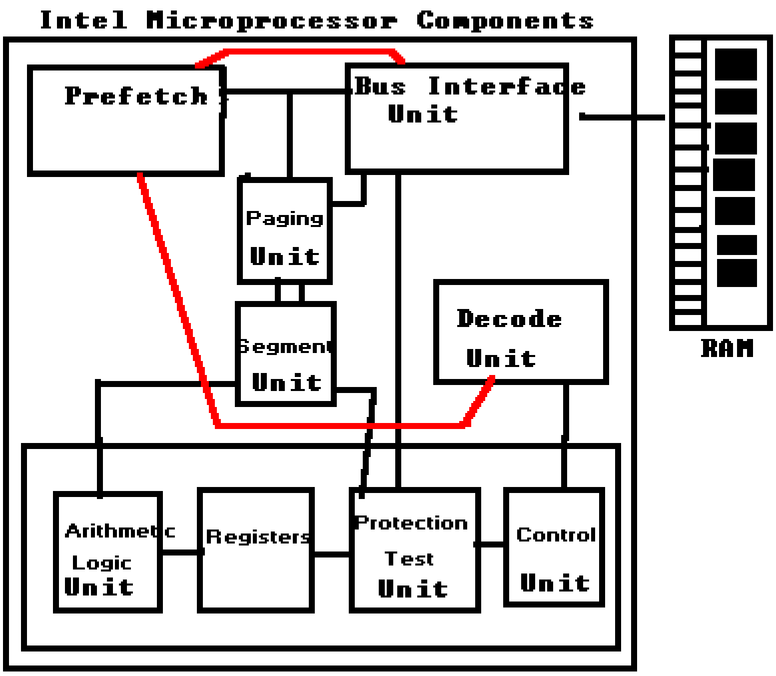
   b. Protection Test Unit - makes sure the operations are legal.

   c. Registers - data to be processed is moved into the registers.

   d. Arithmetic Logic Unit - Normally, in older processors, there is just one of these; however, in the Pentium there are two ALU processors. They process the information in the registers according to the instruction being executed. It then lets the control unit handle the results of the instruction.The control unit uses the Bus Interface to send the results to memory, storage device, etc.

e. Floating Point Unit. Handles any numbers with decimal fractions (67.45, 5E-10, etc.).

The microprocessor is just one of many components on the "motherboard". Without all the other parts such as BIOS, CMOS, the BUS, memory, etc. the CPU does not function. AND - the parts will not function without a CPU!




**INTEL PROCESSOR Models and Descriptions**

| Model | Year | Register | Bus | Physical Address | Comment |
|---|---|---|---|---|---|
| 4004 | 1971 | 4 | 4 | 1k | First Microprocessor on a chip |
| 8008 | 1972 | 8 | 8 | 16k | First 8-bit Microprocessor |
| 8080 | 1974 | 8 | 8 | 64k | First General Purpose CPU on a chip |
| 8085 | 1974 | 8 | 8 | 64k | Re-packaged 8080 |
| 8086 | 1978 | 16 | 16 | 1M | First 16-bit CPU on a chip |
| 8088 | 1980 | 16 | 8 | 1M | Used in the IBM PC |
| 80186 | 1982 | 16 | 16 | 1M | 8086 + I/O support on chip |
| 80188 | 1982 | 16 | 16 | 1M | 8088 + I/O support on chip |
| 80286 | 1982 | 16 | 16 | 16M | Address space increased dramatically |
| 80386 | 1985 | 32 | 32 | 4GB | 32-bit CPU on a chip |
| 80386SX | 1988 | 32 | 16 | 4GB | 80386 scaled down with a 80286 bus |
| 80486 DX, DX2 SX, DX4 | 1989 | 32 | 32 | 4GB | Highly optimized 80386 with an integrated numeric coprocessor, except on the SX models |
| Pentium | 1993 | 64 | 64 | 4GB | Dual 32-bit ALUs, dual instruction pipelines, superscalar architecture |
| Pentium Pro | 1995 | 64 | 64 | 4GB | Designed for 32 Bit Multitasking Operating Systems |

## MMX and the Central Processing Unit (CPU)

Multi-Media Extensions (MMX) was originally a set of 57 computer instructions dedicated to handling and accelerating multimedia and communications processes on a PC. It was originally expected to be a set of software; but has been integrated into the CPU of notable CPU manufacturers such as Intel, Cyrix, and AMD.

Advantages of MMX technology include:

1. Accelerate multimedia processing
2. Accelerate communications processing
3. Enhance images
4. Clarify audio
5. Sharpen video
6. Frees up the CPU for other tasks.

Intel will phase out the older Pentium and Pentium Pro in favor of the Pentium II and the Pentium with MMX capability. In actuality, the last two will last a short before the Intel Deschutes and more advanced microprocessors hit the market over the next 3 years or so. In either case, you can expect most processors to be available with MMX embedded in the CPU.

## Pentium II Processor

The Pentium II introduces some new technologies that will likely influence future CPU development. Note: All references to Intel microprocessors are "registered trademarks". The Intel website at "www.intel.com" is the place to go for further discussion of the Pentium II.

1. SIZE: It is approximately 5.5 inches long x 2.5 inches wide x .6 inches thick. Some other criteria are:

    a. The Intel Pentium II Processor Fact Sheet says that there are 3 speeds - a 233, a 266, and a 300 MHz clock speed.

    b. The "system bus" speed is 66 mhz for all three clocks speeds.

    c. It is a .35 micron processor.

    d. L1 cache operates at the system clock speed - 233, 266, or 300 mhz.

    e. L2 cache operates at the these speeds 117, 133, and 150 for the above clock speeds.

    f. The CPU voltage is 2.8V for all speeds - should be low heat.

    g. Approximately 7.5 million transistors!

2. Single Edge Contact (SEC) Cartridge (242 pins). This is unique because it provides an interface to the motherboard without the myraids of pins normally associated with a "socket 7" type CPU. This is important, but it will probably preclude upgrading any previous CPU's to a Pentium II.

3. Dual Independent Bus (DIB) technology was actually introduced with the Pentium Pro. Intel says it works like this:

   a. There are two buses called the "L2 Cache bus" and "system bus" which is the processor-to-main memory bus.

   b. Both buses can be used by the processor at the same time.

   c. The DIB architecture enables the L2 cache of the Pentium II processor to run twice as fast as older Pentium processors.

   d. The system bus is "pipelined" so multiple simultaneous transactions which accelerates the flow of information.

   e. Intel states in its web page, that the DIB architecture improvements offer up to three times the bandwidth performance over a single bus architecture processor.

   f. The DIB architecture will support the evolution of 66MHz system memory bus to higher speeds in the future.

4. INTEL claims that the future versions of the Pentium II will be "slot 1" compatible.

5. The Pentium II uses the same Dual Independent Bus (DIB) architecture as used with the Pentium Pro Processor.

6. INTEL says that the core and L2 cache are endlosed in a plastic and metal cartridge.

However, I read in a magazine (don't want to say which, they were were probably trying to sell their Pentium Pro based PCs quickly) that the L2 cache was external to the CPU and the following was supposed to be true at the time of the article:

Some of the systems specifications are slightly misleading. For instance, a Pentium Pro with 256MB of L2 Cache which runs at the 200MHz speed of the processor since it is on chip; while the Pentium II at 233MHZ had a separate L2 cache chip running at 116.5MHz which effectively slows it below the total performance of the Pentium Pro 200. This will have been rectified you can besure, and the 266 and 300 MHz Pentium II will also have improved performance. And you can be sure that Pentium II processor will rapidly make the other Pentium Processors obsolete. However, other upgrades to 1998-2000 processors will make the Pentium II rather blaise.

Remember this: The speed of the CPU is not always the only factor in the efficiency of your PC. The buses and their speeds, the cache (L1 and L2), BIOS, memory speed, chip sets, etc. are factors that allow the CPU to reach its potential. The Pentium II has them.

## REDUCED INSTRUCTION SET COMPUTERS (RISC)

After the initial years of the PC (let's say 1980-1986), the search for more efficient PCs, capable of greater processing power, speed, and felexibility went into high gear.

**RISC Computers**

To understand the idea of RISC computers, let me introduce the CISC computer. First, during the 1980s, and into the 1990s, most PCs were categorized as "Complex Instruction Set Computers". The CISC computer is organized to reduce the number of instructions executed by having complex instructions which perform multiple functions in one instruction.

The CISC development was motivated by:

- The desire to have a low memory bandwidth because memory was slow and expensive.
- The desire to offer high-level complex instructions to a compiler.
- Reduce the semantic gap.
- Facilitate compilation.

As time passed (about 1984) the concept of "reduced instruction set computers" came about. A study was done, which indicated that approximately 80% of the work in a computer was performed by approximately 20% of the instructions. This resulted in more in depth analysis of what happens with instructions, and eventually the design of the first RISC machines.

RISC machines usually process simple instructions much faster than CISC machines; however, they are less efficient processing complex instructions. The following table can be used as a comparison in total processing time.

The instructions for RISC machines were chosen based on which were used most frequently, and could be accomplished in as few clock cycles as possible, preferably 1 clock cycle.

Typically, there are approximately 50 instructions in a RISC microprocessor. Complex Instructions are usually performed by combinations of these 50 instructions.

Most CPU manufacturers make RISC based chips, and Intel is rapidly going to RISC capabilities.

**RISC Versus CISC Machines**

| **Instruction** | **CISC** | **RISC** |
|---|---|---|
| Simple Instruction | 4 cycles | 1 cycle |
| Complex Instructions | 8 cycles | 14 cycles |
| Cycle Time | 100 ns | 75 ns |
| Nr. Instructions | 1 million | 1 million |
| Simple Instructions | 80% | 80% |
| Complex Instructions | 20% | 20% |

Given these parameters, lets compare the total processing time:

CISC: (1,000,000) x (.80 x 4 cycles + .20 x 8 cycles) x (100 ns) = 0.48 secs.

RISC: (1,000,000) x (.80 x 1 cycle + .20 x 14 cycles) x (75 ns) = 0.27 secs.

(1,000,000) x (.80 x 1 cycle + .20 x 14 cycles) x (100 ns) = 0.36 secs

So, you can see there is some improvement at either a 75 or 100 ns speed on a RISC machine.

Examples of RISC microprocessors are the Intel 860 and 960; Motorola 88000 family, DEC Alpha chip; PowerPC, RISC 6000, and Sun SPARC.

## CPU Power On Self Test (POST)

EVERY PART of a PC must be functioning to truly process data into information! When you turn on your computer the boot process performs the "POST" test after the ROM BIOS is loaded into memory:

The "POST" tests are made to determine if all its parts are in working order.

The POST process consists of checking each of the following parts of the computer:

1. CPU
2. Power System
3. Speaker
4. Disk Drives
5. Monitor
6. Keyboard
7. Memory, etc.

The POST process is responsible for the "beeps" you hear when booting, and also the messages the error messages such as: "keyboard error press to continue for setup"

ROM BIOS program starts the POST tests using permanent records stored on chips and the steps are:

1. The CPU to checks itself and the POST programs.
2. Sends signals over the system bus to all devices to make sure they are working.
3. The "kernal" and the timing are checked.
4. Memory on the display adapter is tested, and the adapter's BIOS code is made a part of the system's BIOS and memory configuration.
5. RAM is tested to make sure all RAM chips are working properly.

6. Checks to see the keyboard is working properly.
7. Checks to see if the Disk Drives are working.
8. Compares the results of the POST tests against CMOS to see if what it found matches the CMOS setup record.
9. Finds devices that have their own BIOS and includes it in the system BIOS.
10. Newer systems may run a "Plug and Play (PnP) operation.

If everything in the POST worked, the PC is now going to load the operating system.