



كلية المأمون الجامعة

قسم هندسة الحاسوب

[MICROPROCESSORS ARCITECTURE]

[Chapter1: Introduction to the Microprocessor]

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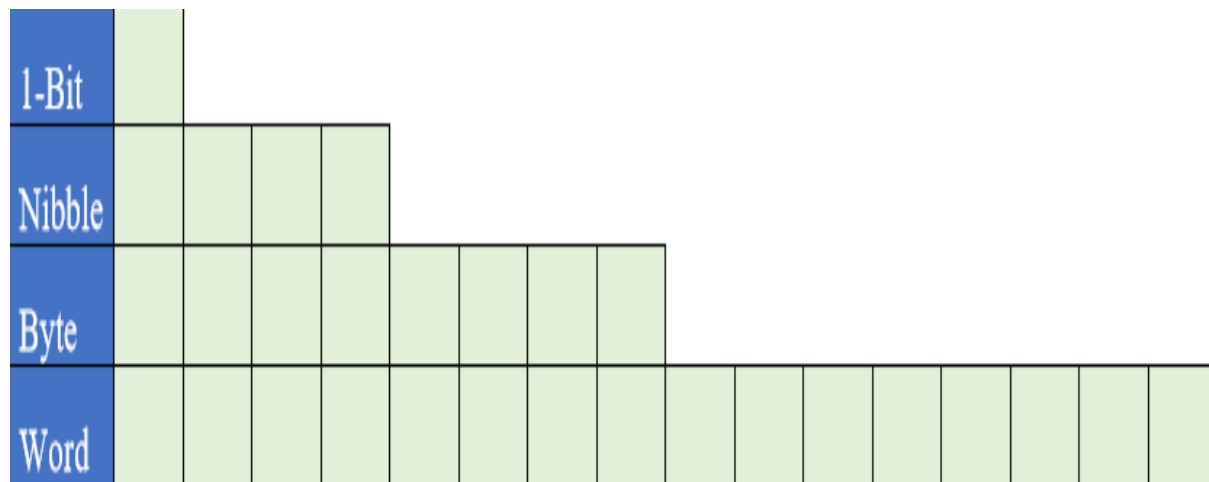
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Some Important Terminology

memory	Size
Bit	1 bit
Nibble	4 bit
Byte	8 bit (1 byte)
Word	16-bit (2 bytes)
kilobyte (KB)	2^{10} bytes (1024 byte)
megabyte (MB)	2^{20} bytes (1024 KB)
gigabyte (GB)	2^{30} bytes (1024 MB)
terabyte (TB)	2^{40} bytes (1024 GB)



Types of Number Systems

There are various types of number systems in mathematics. The four most common number system types are:

1. Decimal number system (Base- 10)
2. Binary number system (Base- 2)
3. Octal number system (Base-8)
4. Hexadecimal number system (Base- 16)

Decimal Number System (Base 10 Number System)

The decimal number system has a base of 10 because it uses ten digits from 0 to 9. In the decimal number system, the positions successive to the left of the decimal point represent units, tens, hundreds, thousands and so on. This system is expressed in decimal numbers. Every position shows a particular power of the base (10).

Example of Decimal Number System: The decimal number 1457 consists of the digit 7 in the units position, 5 in the tens place, 4 in the hundreds position, and 1 in the thousands place whose value can be written as:

$$(1 \times 10^3) + (4 \times 10^2) + (5 \times 10^1) + (7 \times 10^0)$$

$$(1 \times 1000) + (4 \times 100) + (5 \times 10) + (7 \times 1)$$

$$1000 + 400 + 50 + 7$$

$$1457$$

Binary Number System (Base 2 Number System)

The base 2 number system is also known as the Binary number system wherein, only two binary digits exist, i.e., 0 and 1. Specifically, the usual base-2 is a radix of 2. The figures described under this system are known as binary numbers which are the combination of 0 and 1. For example, 110101 is a binary number.

We can convert any system into binary and vice versa.

Example

Write $(14)_{10}$ as a binary number.

Solution:

2	14	
2	7	0
2	3	1
	1	1

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$$(14)_{10} = (1110)_2$$

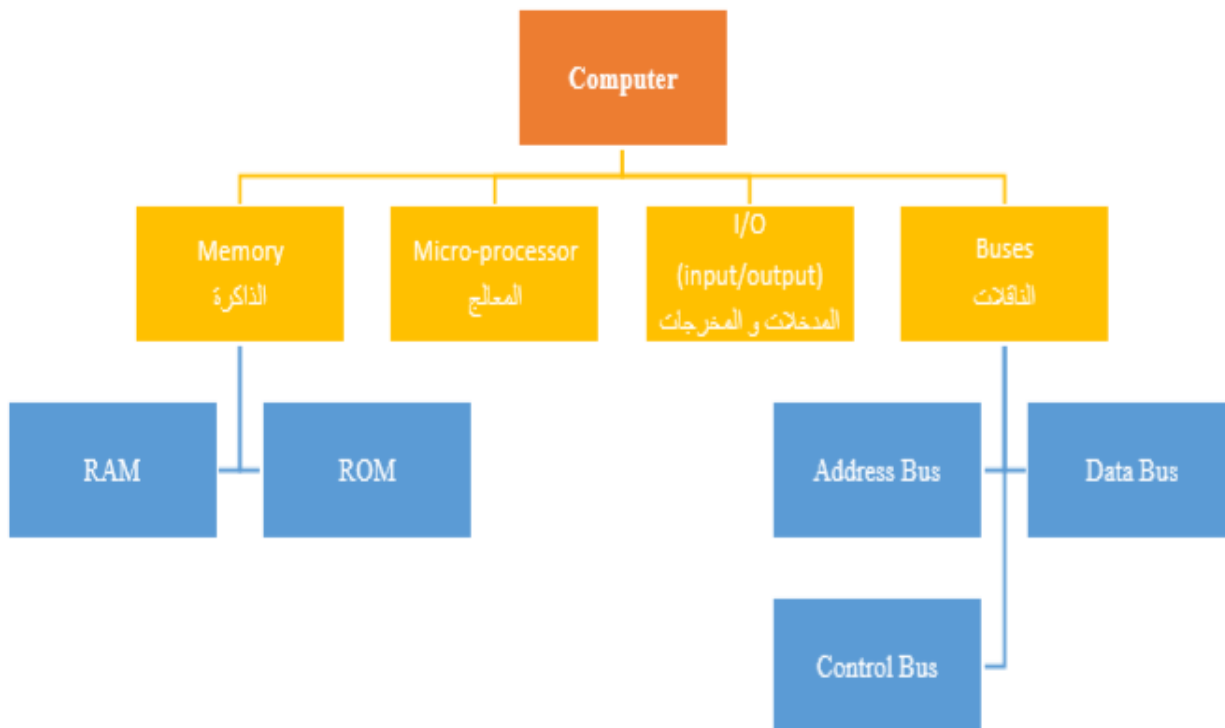
Hexadecimal Number System (Base 16 Number System)

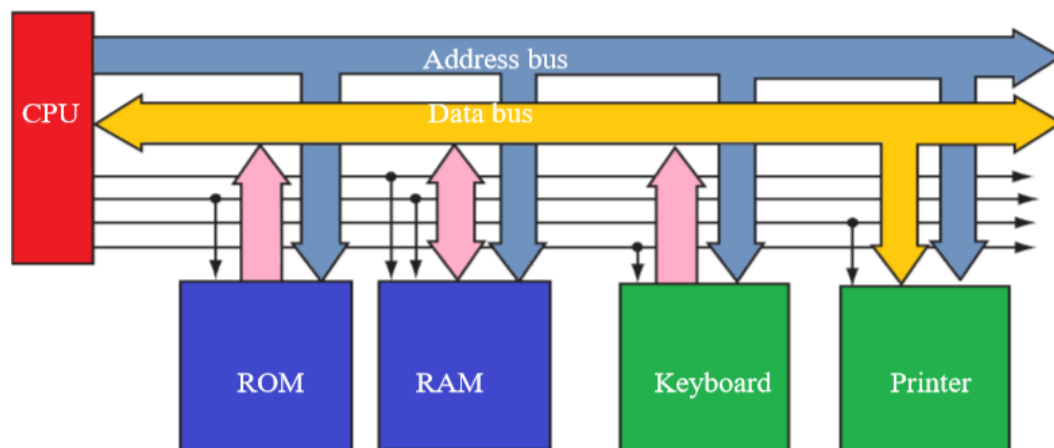
In the hexadecimal system, numbers are written or represented with base 16. In the hexadecimal system, the numbers are first represented just like in the

decimal system, i.e. from 0 to 9. Then, the numbers are represented using the alphabet from A to F. The below-given table shows the representation of numbers in the hexadecimal number system.

Hexadecimal	0	1	2	3	4	5	6	7	8	9	A	B	C	D	E	F
Decimal	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
Binary	0000	0001	0010	0011	0100	0101	0110	0111	1000	1001	1010	1011	1100	1101	1110	1111

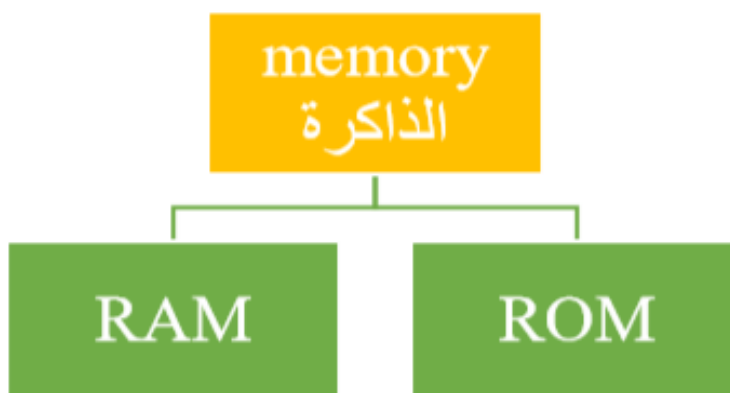
Internal Organization of Computers





There are Two types of memory used in microcomputers:

RAM and ROM



RAM (ذاكرة مؤقتة)	ROM (ذاكرة دائمة)
RAM stands to Random Access Memory (called Read / Write Memory)	ROM stands for read-only memory
RAM is used by the computer for temporary storage of programs that it is running	It contains programs and information essential to operation of the computer
RAM is sometimes called Volatile memory	It is called nonvolatile memory

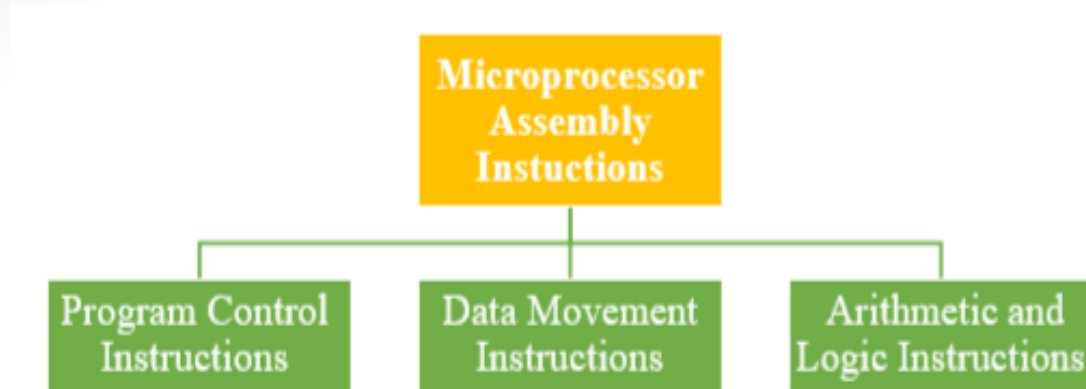
Internal Organization of Computers

Component	Function
RAM (Random Access Memory)	• RAM is used by the computer for temporary storage of programs that it is running • RAM is sometimes called Volatile memory
ROM (Read only memory)	• ROM contains programs and information essential to operation of the computer • It is called nonvolatile memory
CPU (Central Processing Unit)	• CPU Execute information stored in memory
I/O (input/output) Devices	• I/O provide a mean of communication with CPU
Bus	• Bus is a group of wires that interconnect components in a computer system • The buses that interconnect the sections of a computer system transfer address, data, and control information between the microprocessor and its memory and I/O systems a. The address bus requests a memory location from the memory or an I/O location from the CPU. If I/O is addressed, the address bus contains a 16-bit I/O address from 0000H through FFFFH. b. The data bus Transfers information between the microprocessor and its memory and I/O address space. c. The control bus Contains lines that select the memory or I/O and cause them to perform a read or write.

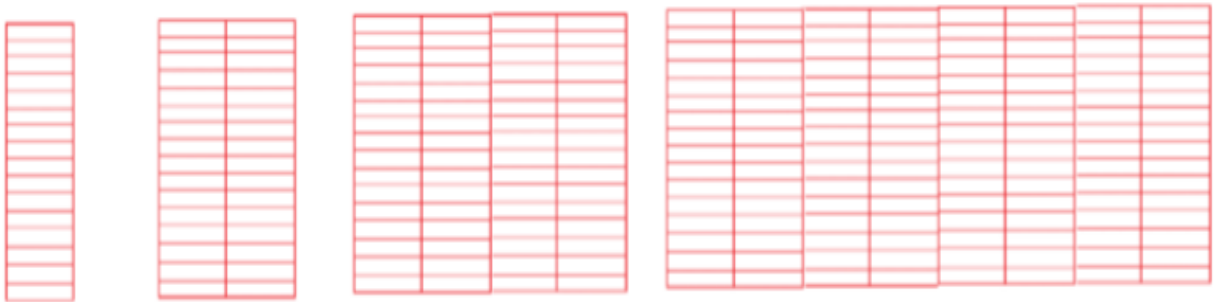
Brief History of the CPU

- 1 .Data transfer between itself and the memory or I/O systems.
- 2 .Simple arithmetic and logic operations.

3 .Program flow via simple decisions



Memory width Vs Memory size



1. The 4004 Microprocessor

- The world's first microprocessor the Intel 4004.
- A 4-bit microprocessor-programmable controller on a Chip
- Addressed 4096, 4-bit-wide memory locations.
- The 4004-instruction set contained 45 instructions.
- Main problems with early microprocessor were:
 - speed(slow)
 - word width(4bits)

- and memory size(4KB).

Intel 4004

Introduced in 1971

Clockspeed : 108 -740 KHz

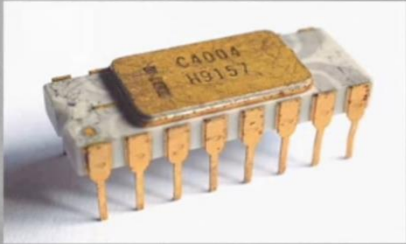
Type : 4-bit, single-core

Number of transistors : 2,300

Manufacturing technology : 10 microns

Fun fact :

- The 4004 is Intel's first microprocessor.
- It powered the Busicom calculator and paved the way for the personal computer



The image shows a photograph of the Intel 4004 microprocessor chip. It is a small, rectangular, gold-colored integrated circuit with 16 pins. The chip is mounted on a white ceramic carrier. The text "4004" and "H9157" is visible on the chip.

2. The 8008 Microprocessor

- Intel released 8008 in 1971.
- extended 8-bit version of 4004 microprocessor.
- Addressed expanded memory of 16K bytes.

3. The 8080 Microprocessor

- Intel introduced 8080 microprocessors in 1973.
- first of the 8-bit general purpose microprocessor
- 8080 addressed four times more memory.64K bytes.

Intel 8080

Introduced in 1974

Clockspeed : 2 MHz

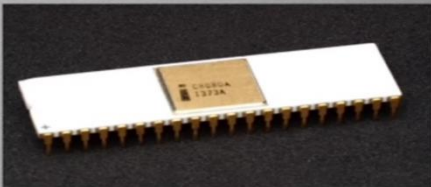
Type : 8-bit, single-core

Number of transistors : 4,500

Manufacturing technology : 6 microns

Fun fact :

- The 8080 is an improved version of the 8008.
- Altair, the first successful personal computer is based on 8080



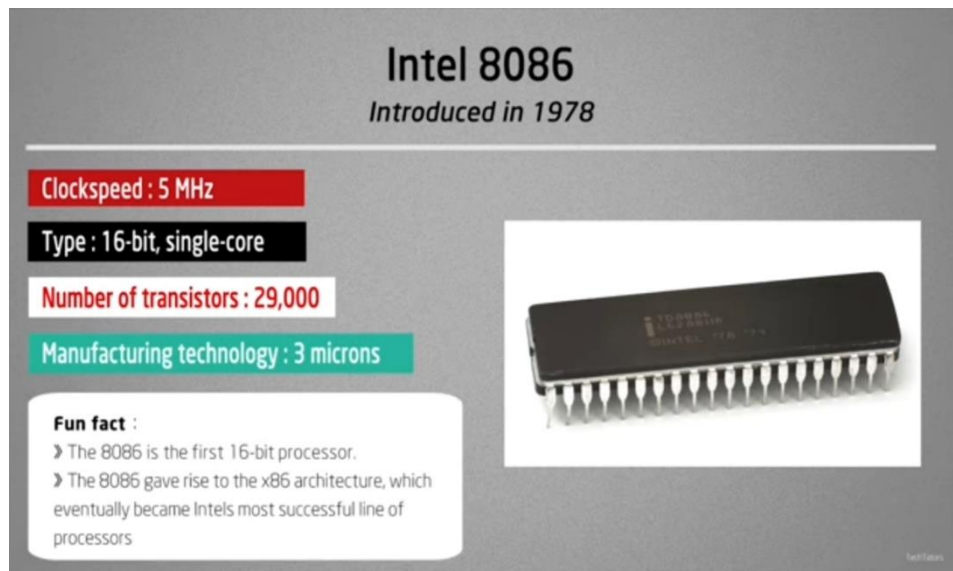
The image shows a photograph of the Intel 8080 microprocessor chip. It is a larger, rectangular, gold-colored integrated circuit with 40 pins. The chip is mounted on a white ceramic carrier. The text "8080" and "1372A" is visible on the chip.

4. The 8085 Microprocessor

- In 1977 Intel Corporation introduced 8085 (an updated version of the 8080)
- Last 8-bit, general-purpose microprocessor developed by Intel.
- Main advantages of 8085 were its:
 - internal clock generator
 - higher clock frequency

5. The 8086 and 8088 Microprocessor

- In 1978 Intel released the 8086; a year or so later, it released the 8088.
- Both devices are 16-bit microprocessors.
- 8086 & 8088 addressed 1M byte of memory.
- The number of instructions increased.
- Another feature was a 4- or 6-byte instruction cache or queue that prefetched instructions before they were executed.



6. The 80286 Microprocessor

- Intel introduced the 80286 in 1983 (an updated 8086)
- Almost identical to the 8086 and 8088.
- Addressed 16M-byte memory system instead of a 1M-byte system.

Intel 286

Introduced in 1982

- Clockspeed : 6 MHz**
- Type : 16-bit, single-core**
- Number of transistors : 134,000**
- Manufacturing technology : 1.5 microns**

Fun fact :

- Bill Gates famously dubbed the 286 as a “brain dead chip,” since it wasn’t able to run multiple MS-DOS applications in windows environment.



The image shows a square, dark-colored microprocessor chip with gold pins around the edges. The text "intel 80286" is printed on the top, with "NB0286" and the Intel logo below it.

7. The 80386 Microprocessor

- Applications demanded faster microprocessor speeds, more memory, and wider data paths. Led to the 80386 in 1986 by Intel.
- major overhaul of 16-bit 8086–80286 architecture
- Intel’s first practical microprocessor to contain a 32-bit data bus and 32-bit memory address

Intel 386

Introduced in 1985

- Clockspeed : 16 MHz**
- Type : 32-bit, single-core**
- Number of transistors : 275,000**
- Manufacturing technology : 1.5 microns**

Fun fact :

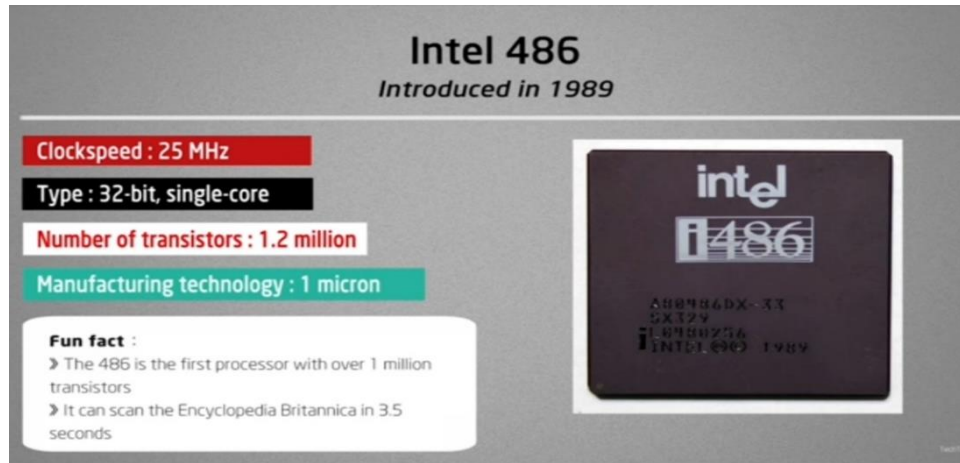
- The 386 had more than 100 times as many transistors as the first intel processor 4004
- It can scan the Encyclopedia Britannica in 12.5 seconds



The image shows a square, dark-colored microprocessor chip with gold pins around the edges. The text "intel 386 DX" is printed on the top, with "A38330DX-25 IV" and "L110201 INTEL 0035" below it.

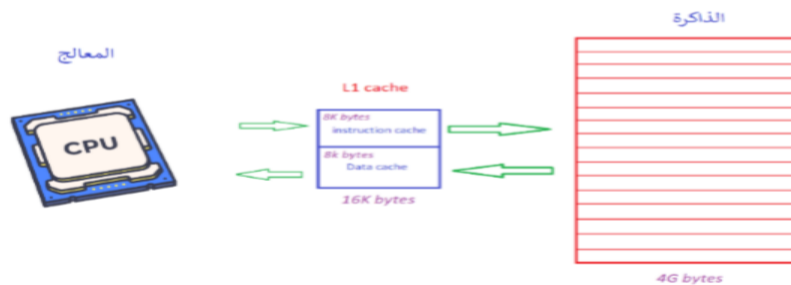
8. The 80486 Microprocessor

- In 1989 Intel released the 80486.
- 80386-like microprocessor.
- 8K-byte cache memory system.



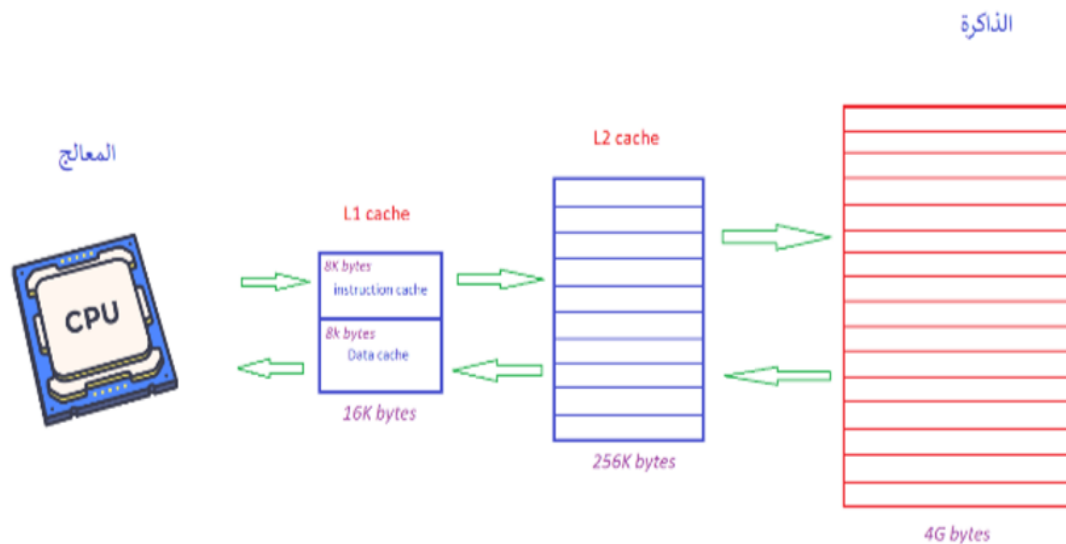
9. The Pentium Microprocessor

- Originally labeled the P5 or 80586.
- Cache size was increased to 16K bytes from the 8K cache found in 80486.
 - 8K-byte instruction cache
 - 8K-byte data cache.
- Memory system up to 4G bytes.
- Data bus width increased to a full 64 bits.



10. The Pentium Pro Microprocessor

- A recent entry, formerly named the P6.
- Pentium Pro contains 2 levels of cache.
 - Internal 16K level-one (L1) cache. 8K data, 8K for instructions
 - 256K level-two (L2) cache
 - Pentium Pro uses three execution engines, to execute up to three instructions at a time
 - Pentium Pro can address 4G-byte or a 64G-byte memory system.



11. The Pentium II Microprocessor

- Pentium II, released 1997.
- L2 cache on main circuit board of not fast enough to function properly with Pentium II
- The Pentium II incorporated Intel technology.

Intel Pentium II

Introduced in 1997

Clockspeed : 300 MHz

Type : 32-bit, single-core

Number of transistors : 7.5 million

Manufacturing technology : 0.25 micron

Fun fact :

» The Pentium II was also designed for workstations and servers that utilize demanding business applications



12. The Pentium III Microprocessor

- Faster core than Pentium II
- Additional FP instructions to support 3D graphics.

Intel Pentium III

Introduced in 1999

Clockspeed : 500 MHz

Type : 32-bit, single-core

Number of transistors : 9.5 million

Manufacturing technology : 0.25 micron

Fun fact :

» The Pentium III was the first x86 CPU to include a unique, retrievable, identification number called PSN (Processor Serial Number). But due to privacy concerns, Intel eventually removed the PSN feature



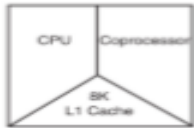
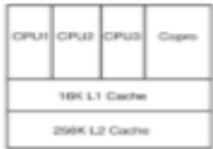
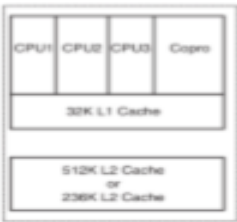
13. The Pentium 4 Microprocessor

- most recent version of Pentium called Core2.
- uses Intel P6 architecture.
- Pentium 4 available to 3.2 GHz and faster.

14. The Future Microprocessor (Itanium)

- This new generation of Intel processor makes use of a 64-bit organization with the IA-64 architecture.
- The Itanium architecture allows greater parallelism than traditional architectures.
- 128 general-purpose integer and 128 floating-point registers; 64 predicate registers.
- Many execution units to ensure enough hardware resources for software.

The Multi-core microprocessors

Microprocessor	Block Diagram
80486	
Pentium	
Pentium Pro	
▪ Pentium II ▪ Pentium III ▪ Pentium 4, or Core2	

Year	CPU	Properties	Bus width	Address bus	Memory Size
1971	4004	- World's first microprocessor - The 4004-instruction set contained 45 instructions. - Main problems with early microprocessor were: ➤ speed (slow) ➤ word width (4bits) ➤ memory size (4K bytes)	4 bits		4 KBytes
1972	8008	extended 8-bit version of 4004 microprocessor	8-bit		16K bytes
1973	8080	The world's first 8-bit general-purpose microprocessor.	8-bit	16	64K bytes
1977	8085	- In 1977 Intel Corporation introduced 8085 (an updated version of the 8080) - Last 8-bit, general-purpose microprocessor developed by Intel. - Main advantages of 8085 were its: ➤ internal clock generator ➤ higher clock frequency	8-bit	16	64K bytes
1978	8086	16-bit general-purpose microprocessor. 6-byte instruction cache	16-bit	20	1M byte of memory
1979	8088	16-bit general-purpose microprocessor. 4-byte instruction cache	16-bit	20	1M byte of memory
1983	80286	- This extension of the 8086 with memory 16-MByte. - Almost identical to the 8086 and 8088.	16-bit	24	16 MB
1986	80386	Applications demanded faster microprocessor speeds, more memory, and wider data paths.	32-bit	32	

		- Led to the 80386 in 1986 by Intel. - major overhaul of 16-bit architecture.			
1989	80486	- Full cache technology - instruction pipelining.	32-bit	32	8K-byte cache memory
1993	Pentium	- Originally labeled the P5 or 80586. 32 bit machine - Single core - Data bus width increased to a full 64 bits.	32-bit	32	16K-byte cache 4G bytes memory
Year	CPU	Properties	Bus width	Address bus	Memory Size
	Pentium Pro	A recent entry, formerly named the P6 32 bit machine - Single core - Pentium Pro uses three execution engines, to execute up to three instructions at a time. - Pentium Pro can address 4G-byte or a 64G-byte memory system.	32-bit	32 or 36	- Internal 16 K level1 (L1) cache 256K level-two (L2) cache 4GB or 64GB memory size
1997	Pentium II	32-bit machine - Single core - The Pentium II incorporated Intel MMX technology	32-bit		
1999	Pentium III	32-bit machine - Single core - Additional FP instructions to support 3D graphics	32-bit		
2000	Pentium 4	- The new generation of Intel processors makes use of a 64-bit organization with the IA-64 architecture. - The Itanium architecture allows greater parallelism than traditional architectures. 128 general-purpose integer and 128 floating-point registers; 64 predicate registers.	64-bit		

		Many execution units to ensure enough hardware resources for software.			
Future	Itanium	- The new generation of Intel processors makes use of a 64-bit organization with the IA-64 architecture. - The Itanium architecture allows greater parallelism than traditional architectures. 128 general-purpose integer and 128 floating-point registers, 64 predicate registers. - Many execution units to ensure enough hardware resources for software.	64-bit		