

CPE 408330

Assembly Language and Microprocessors

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Chapter 1: Introduction to Microprocessors & Microcomputers

Microprocessor vs. Microcomputer

- ▶ A microprocessor is a central processing unit (CPU) on a single chip and is entirely useless on its own.
- ▶ A microcomputer is a *stand-alone system** based on
 - Microprocessor
 - Memory components
 - Interface components
 - Timing and control circuits
 - Power supply
 - An enclosure (e.g. a cabinet or package)

**Stand-alone system* : A system that is able to operate independently

Microprocessor

- ▶ A silicon chip that contains a CPU. In the world of personal computers, the terms microprocessor and CPU are used interchangeably. At the heart of all personal computers and most workstations sits a microprocessor. Microprocessors also control the logic of almost all digital devices, from clock radios to fuel-injection systems for automobiles.

Microcomputer Categories

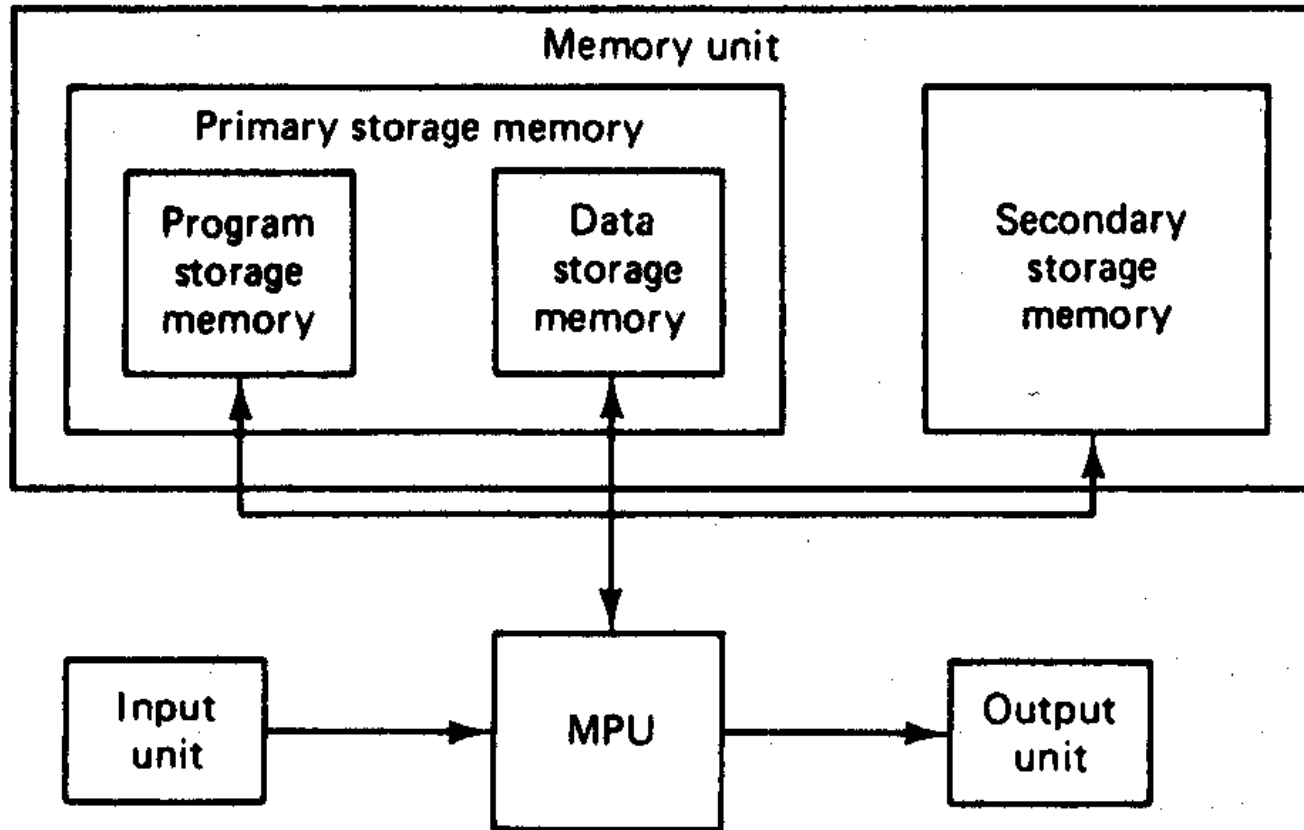
The microcomputer falls into 2 categories

1. The General-Purpose Digital Computer
2. The Embedded Computer
 - Dedicated to specific applications
 - Transparent (“invisible”) to the user.
(eg. Automatic Bank Teller machine)

1.1 The IBM and IBM-Compatible Personal Computers (PCs).

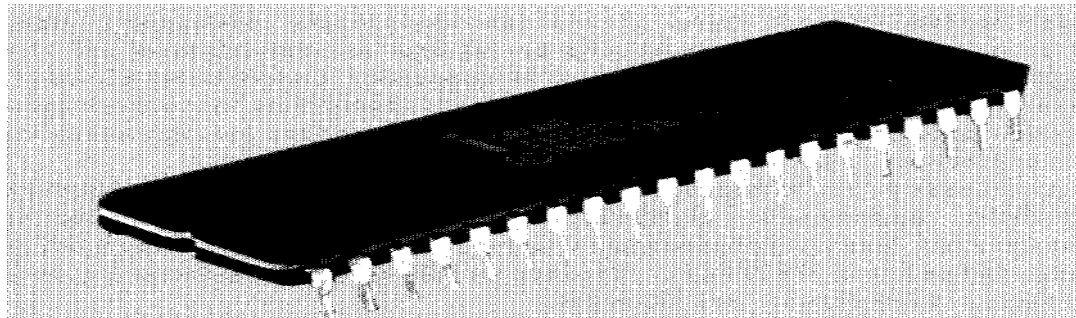
- ❑ Most important advances in computer technology: 16-bit and 32-bit microprocessors.
- ❑ Pioneered by Intel since 1970's and dominated by INTEL since 1980's:
 - 4-bit 4004 in 1971
 - 8-bit 8008 in 1972
 - 8-bit 8080 and 8085 in 1974
 - 16-bit 80286 and 8086, brains of famous IBM PC
 - 32-bit 80286 (1982), 80386 (1985), 80486 (1989), Pentium (1993), Pentium II (1997), Celeron and Pentium III (1999) and Pentium 4 (2000)
 - 64-bit Itanium (2001)
 - Latest 64-bit Pentium 4 and Xeon (2005)

1.2 General Architecture of a Microcomputer System



1.2 General Architecture of a Microcomputer System

- ❑ The 8088 and 8086 microprocessor:
 - 8088 – 8-bit external bus, 16-bit internal architecture.
 - 8086 – 16-bit external bus, 16-bit internal architecture.
- ❑ MPU performs arithmetic operation and logical decision



1.2 General Architecture of a Microcomputer System

❑ Input Unit:

- Keyboard, joystick, mouse, scanner.

❑ Output Unit:

- CRT display, LCD display, printer.

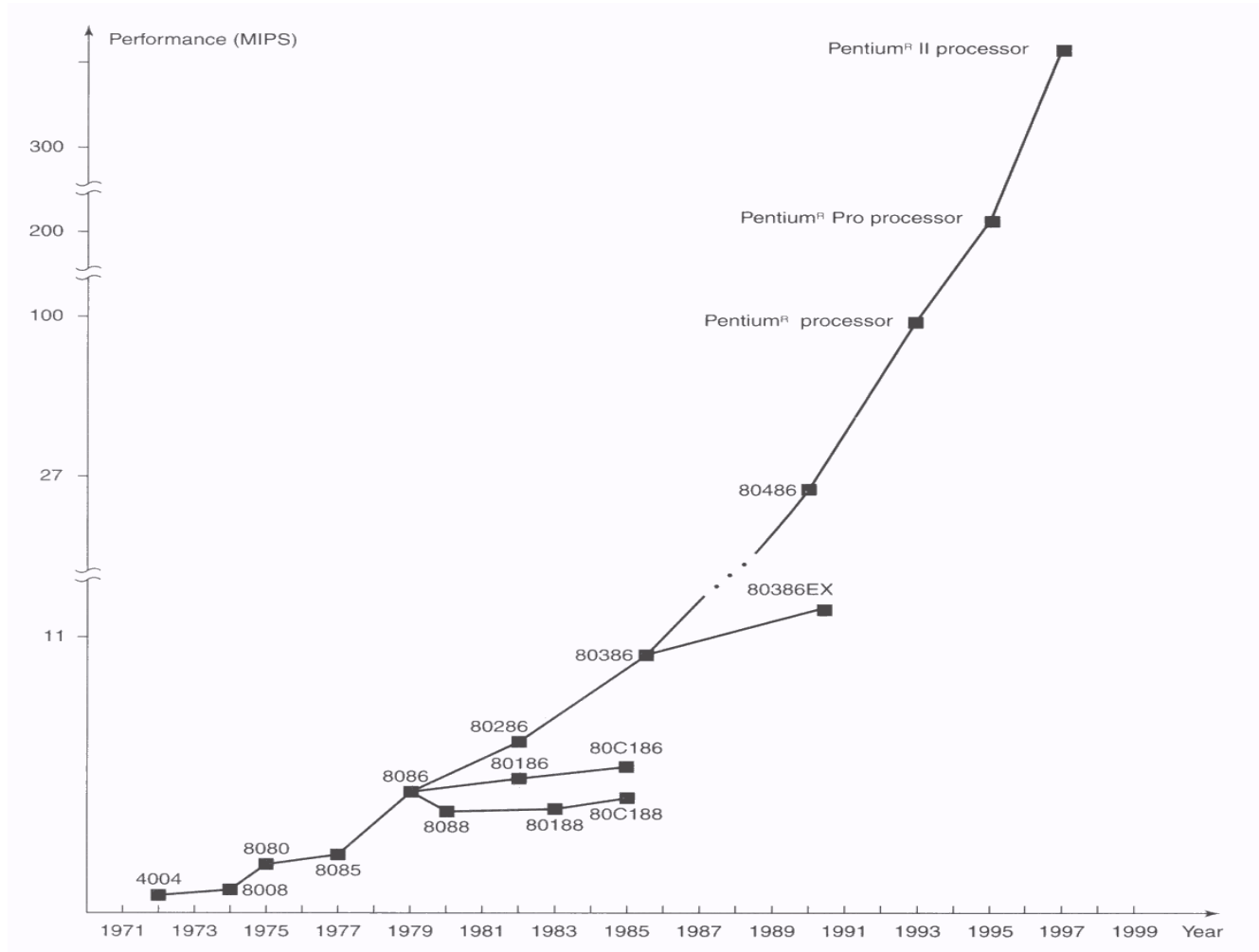
❑ Memory Unit:

- Primary storage memory: ROM, RAM.
- Secondary storage memory: floppy-diskette, hard disk drive, CD-ROM, CD-RW, magnetic tape

1.3 Evolution of the Intel Microprocessor Architecture

- ❑ 1971 Intel introduces its first microprocessor, the 4004, which contained 2250 transistors. The 4004 was designed to process data arranged as 4-bit words.
- ❑ Beginning in 1974, a second generation of microprocessors was introduced. These devices, the 8008, 8080, and 8085, were 8-bit microprocessors.

1.3 Evolution of the Intel Microprocessor Architecture



1.3 Evolution of the Intel Microprocessor Architecture

□ Moore's law is good for the last 26 years!

1971: 4004	2,250 transistors
1972: 8008	2,500 transistors
1974: 8080	5,000 transistors
1978: 8086	29,000 transistors
1982: 80286	120,000 transistors
1985: 80386	275,000 transistors
1989: 80486 DX	1,180,000 transistors
1993: Pentium	3,100,000 transistors
1997: Pentium II	7,500,000 transistors
1999: Pentium III	24,000,000 transistors
2000: Pentium IV	42,000,000 transistors
2006: Pentium D	376,000,000 transistors

1.4 Number Systems

□ Decimal number system

- The number of symbols used is called the **base** or **radix** of the number system.
- **Most Significant Digit (MSD)** and **Least Significant Digit (LSD)**.

The diagram illustrates the decimal number system. On the left, a vertical column of digits from 0 to 9 is shown. To the right of this column is a table with two rows. The top row is labeled 'Weights' and contains powers of 10 from 10^{+3} to 10^{-3} . The bottom row contains the corresponding numerical values: 1000, 100, 10, 1, a decimal point, 1/10, 1/100, and 1/1000. Above the first four columns of the table is the label 'MSD' (Most Significant Digit), and above the last four columns is 'LSD' (Least Significant Digit). An arrow points from the digit '4' in the vertical column to the '1' in the '1' column of the table, which is labeled 'Reference digit'.

0								
1								
2								
3								
4								
5								
6								
7								
8								
9								

(a) Decimal number system symbols. (b) Digit notation and weights.

1.4 Number Systems


□ Binary number system

- $1100_2 = 1(2^{+3}) + 1(2^{+2}) + 0(2^{+1}) + 0(2^0)$
 $= 1(8) + 1(4) + 0(2) + 0(1)$

- ▶ $= 12_{10}$

- ▶ $12_{10} = 000000000000001100_2$

				MSB					LSB		
				2^{+3}	2^{+2}	2^{+1}	2^0	.	2^{-1}	2^{-2}	2^{-3}
0				8	4	2	1	.	1/2	1/4	1/8
1	Weights										


Reference bit

(a) Binary number system symbols. (b) Bit notation and weights.

1.4 Number Systems

- ❑ Conversion between decimal and binary numbers

Decimal number	Binary number
0	0
1	1
2	10
3	11
4	100
5	101
6	110
7	111
8	1000
9	1001
10	1010
11	1011
12	1100
13	1101
14	1110
15	1111

1.4 Number Systems

□ Example:

Evaluate the decimal equivalent of binary number 101.01_2 .

□ Solution:

- $101.01_2 = 1(2^{+2}) + 0(2^{+1}) + 1(2^{+0}) + 0(2^{-1}) + 1(2^{-2})$
 $= 1(4) + 0(2) + 1(1) + 0(1/2) + 1(1/4)$
▶ $= 5.25_{10}$

1.4 Number Systems

- Example:

Convert the decimal number 31_{10} to binary form. Also, express the answer as a byte-wide binary number.

- Solution:

<u>2</u>	31	→	1	LSB
<u>2</u>	15	→	1	
<u>2</u>	7	→	1	
<u>2</u>	3	→	1	
<u>2</u>	1	→	1	MSB
<u>0</u>				

$$31_{10} = 11111_2$$

1.4 Number Systems

- Example:

Convert the decimal fraction 0.8125_{10} to binary form. Also, express the answer as a byte-wide binary number.

- Solution:

$2 * 0.8125$	\rightarrow	1	MSB
$2 * 0.625$	\rightarrow	1	
$2 * 0.25$	\rightarrow	0	
$2 * 0.5$	\rightarrow	1	
$2 * 0$			

$$0.8125_{10} = .1101_2$$

1.4 Number Systems

□ Hexadecimal number system

- Machine language programs, addresses, and data are normally expressed as hexadecimal number.

0
1
2
3
4
5
6
7
8
9
A
B
C
D
E
F

	MSD					LSD	
Weights	16^{+3}	16^{+2}	16^{+1}	16^0	.	16^{-1}	16^{-2}
	4096	256	16	1	.	1/16	1/256

Reference digit

(a) Hexadecimal number system symbols. (b) Digit notation and weights.

1.4 Number Systems

□ Example:

What the decimal number $102A_{16}$ represent?

□ Solution:

- $$\begin{aligned} 102A_{16} &= 1(16^{+3}) + 0(16^{+2}) + 2(16^{+1}) + A(16^0) \\ &= 1(4096) + 0(256) + 2(16) + A(1) \\ &= 4138_{10} \end{aligned}$$

1.4 Number Systems

- Example:

Convert the decimal number 4138_{10} to hexadecimal form.

- Solution:

16	4138		
16	258	→	A
16	16	→	2
16	1	→	0
	0	→	1

LSB

MSB

$$4138_{10} = 102A_{16}$$

1.4 Number Systems

- ❑ Conversion between hexadecimal and binary numbers.
 - An H is frequently used instead of a subscript 16 to denote that a value is a hexadecimal number.

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

MSB		LSB		
$2^{15}2^{14}2^{13}2^{12}$	$2^{11}2^{10}2^92^8$	$2^72^62^52^4$	$2^32^22^12^0$	Bits
16^3	16^2	16^1	16^0	Digits
MSD		LSD		

- (a) Equivalent binary and hexadecimal numbers.
(b) Binary bits and hexadecimal digits.

1.4 Number Systems

- ❑ Conversion between decimal, binary, and hexadecimal numbers:

Decimal number	Binary number	Hexadecimal number
0	00000000	00
1	00000001	01
2	00000010	02
3	00000011	03
4	00000100	04
5	00000101	05
6	00000110	06
7	00000111	07
8	00001000	08
9	00001001	09
10	00001010	0A
11	00001011	0B
12	00001100	0C
13	00001101	0D
14	00001110	0E
15	00001111	0F

1.4 Number Systems

□ Example:

Express the binary number
 1111100100001010_2 .

□ Solution:

$$\begin{aligned} \bullet \quad 1111100100001010_2 &= 1111 \quad 1001 \quad 0000 \quad 1010 \\ &= \quad F \quad \quad 9 \quad \quad 0 \quad \quad A \\ &= F90A_{16} \\ &= F90AH \end{aligned}$$

1.4 Number Systems

□ Example:

What is the binary equivalent of the number $C315_{16}$?

□ Solution:

- $C315_{16} = 1100\ 0011\ 0001\ 0101$
 $= 1100001100010101_2$

