

EEE 410 – Microprocessors I

Spring 05/06 – Lecture Notes # 1

Outline of the Lecture

- **Microcomputers and Microprocessors**
- **Evolution of Intel 80x86 Family Microprocessors**
- **Binary and Hexadecimal Number Systems**

MICROCOMPUTERS AND MICROPROCESSORS

There are three major parts of a Computer System.

1. **Central Processing Unit (CPU)**: Also simply called as the microprocessor and acts as the brain coordinating all activities within a computer.
2. **The Memory**: The program instructions and data are primarily stored.
3. **The Input/Output (I/O) Devices**: Allow the computer to input information for processing and then output the results. I/O Devices are also known as computer peripherals.

The integrated Circuit (IC) chip containing the CPU is called the **microprocessor** and the entire computer including the microprocessor, memory and I/O is called a **microcomputer**.

The CPU is connected to memory and I/O devices through a strip of wires called a **bus**. The bus inside a computer carries information from place to place. In every computer there are three types of busses:

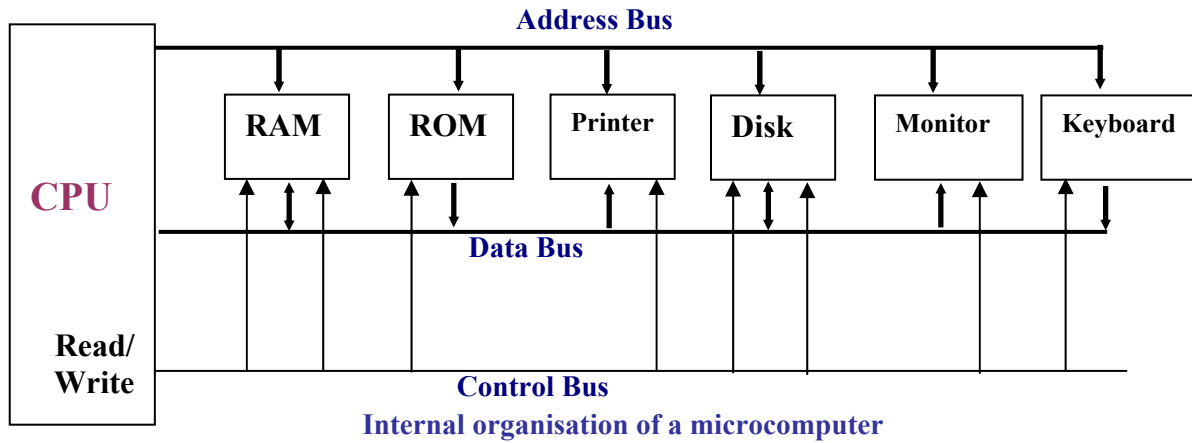
1. **Address Bus**: The address bus is used to identify the memory location or I/O device the processor intends to communicate with. The width of the Address Bus ranges from 20 bits (8086) to 36 bits for (Pentium II).
2. **Data Bus**: Data bus is used by the CPU to get data from / to send data to the memory or the I/O devices. The width of a microprocessor is used to classify the microprocessor. The size of data bus of Intel microprocessors vary between 8-bit (8085) to 64-bit (Pentium).
3. **Control Bus**. How can we tell if the address on the bus is memory address or an I/O device address? This where the control bus comes in. Each time the processor outputs an address it also activates one of the four control bus signals: Memory Read, Memory Write, I/O Read and I/O Write.

➤ The address and control bus contains output lines only, therefore it is unidirectional, but the data bus is **bidirectional**.

➤ There two types of memory used in microcomputers:

- ◆ **RAM (Random Access Memory/ Read-Write memory)** is used by the computer for the temporary storage of the programs that is running. Data is lost when the computer is turned off. So known as **volatile** memory.
- ◆ **ROM (Read Only Memory)** the information in ROM is permanent and not lost when the power is turned off. Therefore, it is called **nonvolatile** memory.

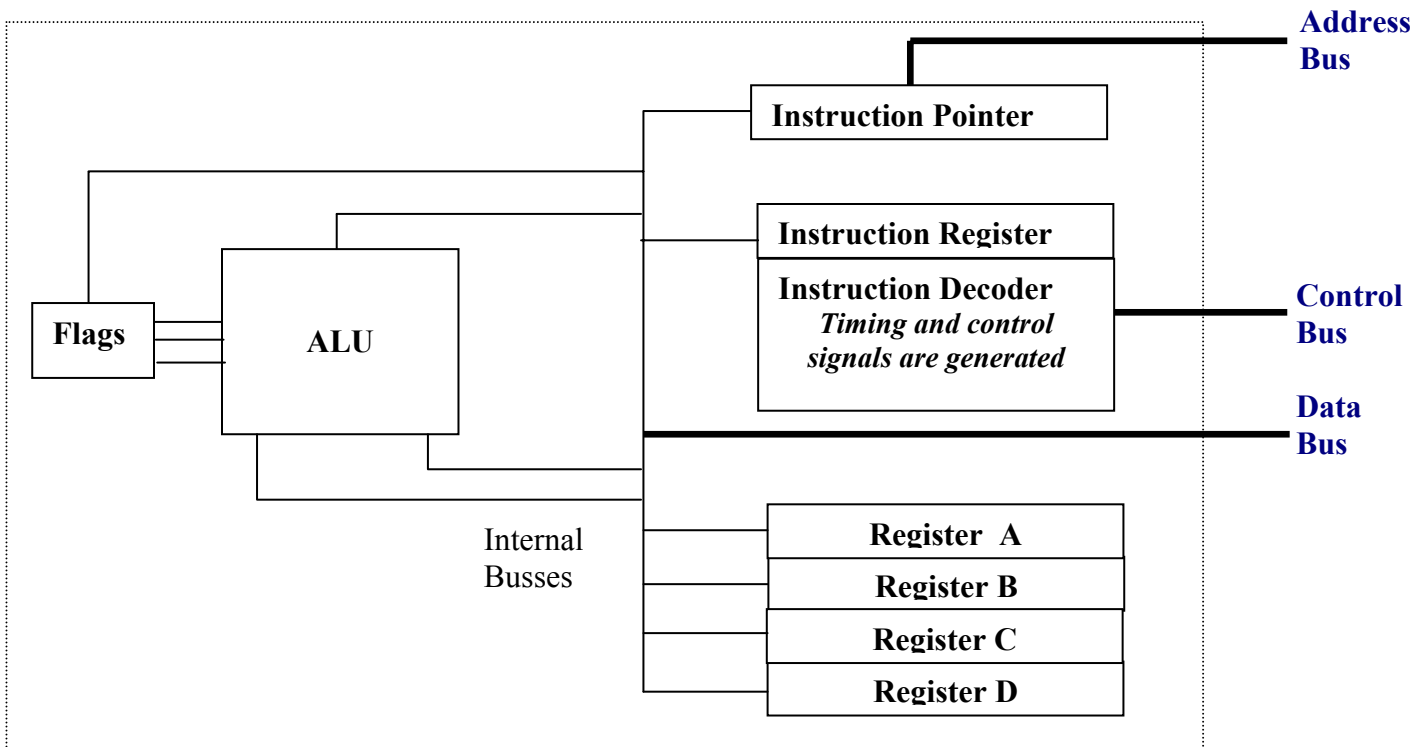
Note that RAM is sometimes referred as **primary storage**, where magnetic /optical disks are called **secondary storage**.



Inside the CPU:

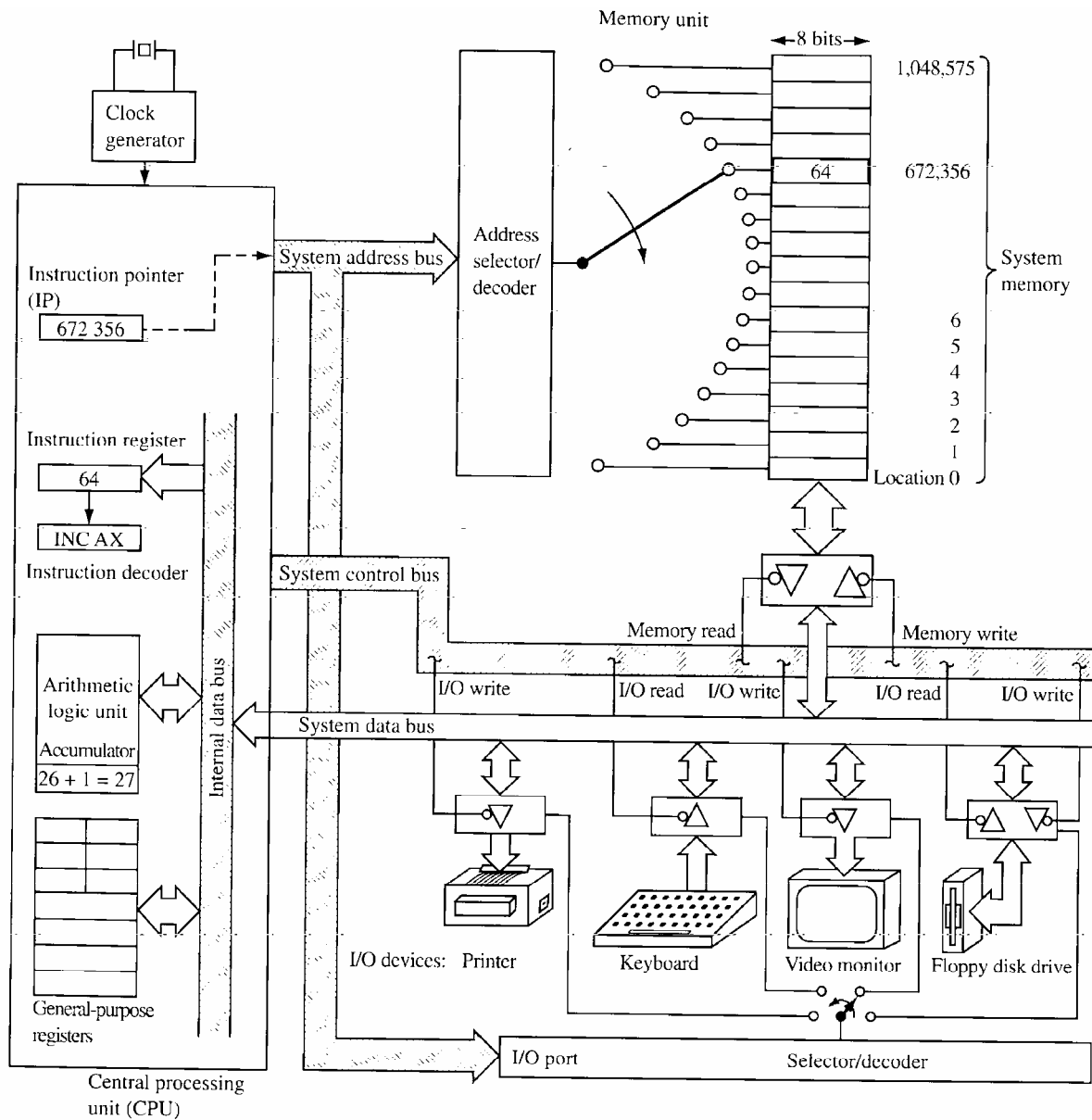
A program stored in the memory provides instructions to the CPU to perform a specific action. This action can be a simple addition. It is function of the CPU to **fetch** the program instructions from the memory and **execute** them.

1. The CPU contains a number of **registers** to store information inside the CPU temporarily. Registers inside the CPU can be 8-bit, 16-bit, 32-bit or even 64-bit depending on the CPU.
2. The CPU also contains **Arithmetic and Logic Unit (ALU)**. The ALU performs arithmetic (add, subtract, multiply, divide) and logic (AND, OR, NOT) functions.
3. The CPU contains a program counter also known as the **Instruction Pointer** to point the address of the next instruction to be executed.
4. **Instruction Decoder** is a kind of dictionary which is used to interpret the meaning of the instruction fetched into the CPU. Appropriate control signals are generated according to the meaning of the instruction.



Internal block diagram of a CPU

The Figure below demonstrates the interaction between the CPU, memory and I/O Devices.



Brief History of the Computers

- **1946** The first generation of Computer **ENIAC** was started to be used based on the vacuum tube technology.
- **1958** the first transistorized computer **TRADIC** was announced by IBM.
- **1959** **first IC** was invented.
- **1960s** ICs were started to be used in **CPU boards**.
- 1970s entire CPU was put in a single chip. (**1971** the first microprocessor of **Intel 4004** (4-bit data bus and 2300 transistors)
- Late 1970s Intel 8080/85 appeared with 8-bit data bus and 16-bit address bus and used from traffic light controllers to homemade computers.
- **1981** First **PC** was introduced by IBM with Intel **8088** microprocessor.
- Motorola emerged with 6800. Apple Machintosh computers started to use 68000 series of microprocessors.

✚ EVOLUTION OF INTEL 80x86 FAMILY MICROPROCESSORS

Processor	Year Intro.	Transistors	Clock Rate (MHz.)	External Data Bus	Internal Data Bus	Add. Bus
4004	1971	2,250	0.108	4	8	12
8008	1972	3,500	0.200	8	8	14
8080	1974	6,000	3	8	8	16
8085	1976	6,000	6	8	8	16
8086	1978	29,000	10	16	16	20
8088	1979	29,000	10	8	16	20
80286	1982	134,000	12.5	16	16	25
80386DX	1985	275,000	33	32	32	32
80386SX	1988	275,000	33	16	32	24
Pentium C	1993	3,100,000	66 -200	64	32	32
Pentium MMX	1997	4,500,000	300	64	32	32
Pentium Pro	1995	5,500,000	200	64	32	36
Pentium II	1997	7,500,000	233-450	64	32	36
Pentium III	1999	9,500,000	550-733	64	32	36
Itanium	2001	30,000,000	800-...	128	64	64

✚ BINARY AND HEXADECIMAL NUMBER SYSTEMS

As human being we **use base 10 (decimal)** arithmetic

Computers use **base 2 (binary)** system.

Base 16 Hexadecimal number system is a convenient way of represented binary numbers.

ASCII (binary format of the alphanumeric code) is explained.

Decimal and Binary number systems:

-There is a speculation of the fact that Humans use base 10 system is because they have 10 fingers. But there is no speculation behind the fact that the computers use binary system. The binary system is used in computers, because 1 and zero represent the two voltage levels of on and off.

There are 10 digits in Decimal system: 0,1,2,3,4,5,6,7,8,9

There are only 2 digits in Binary system: 0,1 (Binary digits are referred as *bits*)

Converting from decimal to binary:

Example: Convert 25₁₀ to binary:

			Remainder	
25/2	=	12	1	LSB (least significant bit)
12/2	=	6	0	
6/2	=	3	0	
3/2	=	1	1	
1/2	=	0	1	MSB (most significant bit)

Therefore, 25₁₀ = 11001₂

Converting from binary to decimal:

Example: Convert 110101₂ to decimal:

110101 ₂ =		Decimal	
	1x2 ⁰	=1x1	= 1
	0x2 ¹	=0x2	= 0
	1x2 ²	=1x4	= 4
	0x2 ³	=0x8	= 0
	1x2 ⁴	=1x16	= 16
	1x2 ⁵	=1x32	= + 32
			53

110101₂ = 53₁₀

Hexadecimal Number system:

Hexadecimal system is defined to be the base 16 number system and is used as a convenient representation of binary numbers.

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

Converting from binary to hex (hexadecimal):

Example: Convert 100111110101₂ to hex:

$$= \begin{array}{ccc} 1001 & 1111 & 0101 \\ & 9 & F & 5 \end{array}$$

Therefore, 100111110101₂ = 9F5 Hex

Converting from hex to binary:

Example: Convert hex 29B to binary:

$$= \begin{array}{ccc} 2 & 9 & B \\ 0010 & 1001 & 1011 \end{array} \text{ Dropping zeros, } 29B = 1010011011$$

Converting from decimal to hex (hexadecimal):

Example: Convert 45₁₀ to hex:

		Quotient	Remainder	
45/16	=	2	13 (hex D)	LSD (least significant bit)
2/16	=	0	2	MSD (most significant bit)

Therefore, 45₁₀ = 2D₁₆ = 2DH

Converting from hex to decimal:

Example: Convert 6B2₁₆ to decimal:

6B2 ₁₆ =		Decimal	
	2 x 16 ⁰ = 2 x 1 =	2	
	11 x 16 ¹ = 11 x 16 =	176	
	6 x 16 ² = 6 x 256 = +	1536	
		1714	Therefore, 6B2 ₁₆ = 1714 ₁₀

Addition and subtraction in binary numbers:

Addition Example:

$$\begin{array}{r} 1101 \\ 1001 \\ + 10110 \\ \hline 101100 \end{array}$$

A + B	Carry	Sum
0 + 0	0	0
0 + 1	0	1
1 + 0	0	1
1 + 1	1	0

Binary Addition

Subtraction of Binary Numbers:

Given binary numbers x and y. x-y is performed by taking 2's complement of y and adding to x.

$$11001001 - 10011101 \Rightarrow 2\text{'s complement of } 10011101 = \begin{array}{r} 01100010 \text{ (1's complement)} \\ + 1 \\ \hline 01100011 \text{ (2's complement)} \end{array}$$

$$\begin{array}{r} 11001001 \\ + 01100011 \\ \hline 1\ 00101100 \end{array}$$

Addition and subtraction in hex numbers:

Addition Example:

23D9	LSD :	9 + 14 = 23	23-16=	7 with a carry to next digit
+ 94BE		1+13+11 = 25	25-16=	9 with a carry to next digit
B897		1+3+4 =		8
	MSD	2 + 9 =		B

Subtraction Example:

59F	LSD :	15 - 8 = 7
- 2B8		25 (9+16) - 11 (B) = 14, which is E
2E7	MSD	4 (5-1) - 2 = 2

ASCII Code : (American Standard Code for Information Interchange)

Hex	Symbol	Hex	Symbol
41	A	61	a
42	B	62	b
42	C	62	c
44	D	64	D
45	E	65	E
46	F	66	F
47	G	67	G
48	H	68	H
49	I	69	I
4A	J	6A	J
4B	K	6B	K
4C	L	6C	L
4D	M	6D	M
4E	N	6E	N
4F	O	6F	O
50	P	70	P
51	Q	71	Q
52	R	72	R
53	S	73	S
54	T	74	T
55	U	75	U
56	V	76	V
57	W	77	W
58	X	78	X
59	Y	79	Y
5A	Z	7A	Z

Some important terminology:

bit 0
nibble 0000
byte 0000 0000
word 0000 0000 0000 0000
double-word 0000 0000 0000 0000 0000 0000 0000 0000
quad-word 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000 0000

1 **kilobyte** is 2^{10} bytes. (Abbreviation K is used) Some floppy disks holds 356K bytes of data.
1 **megabyte** is 2^{20} bytes. (a little over a million 1,048,576)
1 **gigabyte** is 2^{30} bytes (over 1 trillion)
1 **terabyte** is 2^{40} bytes