Lecture 2

Computer Architecture

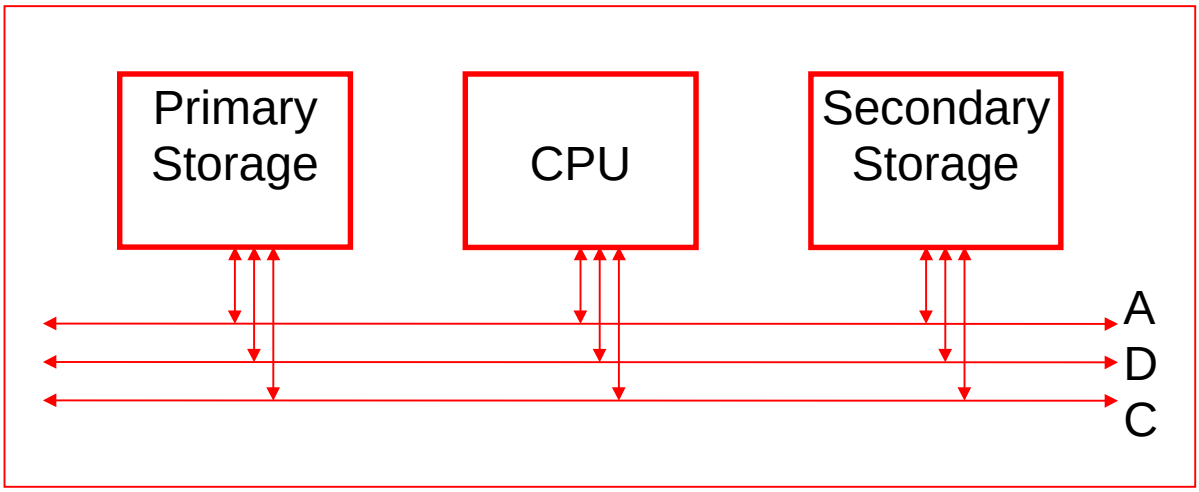
Text: Chapter 1

What are the components of a Computer?

- Central Processing Unit
  - Program instruction execution.
  - Arithmetic
  - Decision making and program flow

- Primary Storage (Internal Memory)
  - Binary numbers only which may be either program instructions or program data.

- Secondary Storage
  - Long-term storage such as disk and tape.

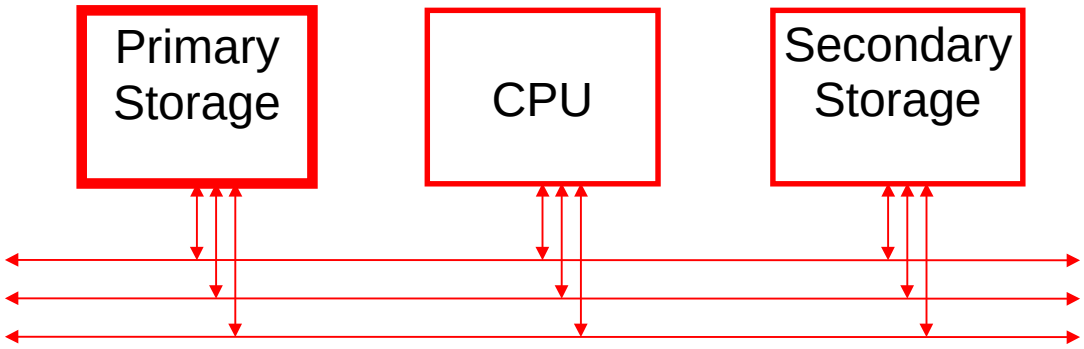


All three units are connected by the **System Bus**

The bus carries three kinds of information:

Address
Data
Control

Numbers from the Hardware View



Primary storage is organized into units of 8 bits
Each is called a **BYTE**

Each byte in memory is given a number, called an **ADDRESS:**

Byte address	*0*	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*A*	*B*	*C*	*D*
Value	03	00	FF	FF	40	20	21	60	61	90	91	E1	7B	80

Only the **values** are stored in memory, not the addresses.

Q:

What is range of two's complement values a byte may hold?

Q:

If the address numbers are 20 bits long, what is the maximum number of bytes that may be addressed?

A larger unit of storage is the **WORD** (16 bits):

A word is two bytes.
The address of a word is the address of its first byte:

Byte address	*0*		*2*		*4*		*6*		*8*		*A*	*C*		
Value	03	00	FF	FF	40	20	21	60	61	90	91	E1	7B	80

Q:

What is the two's complement range for a word?

Other units of storage:

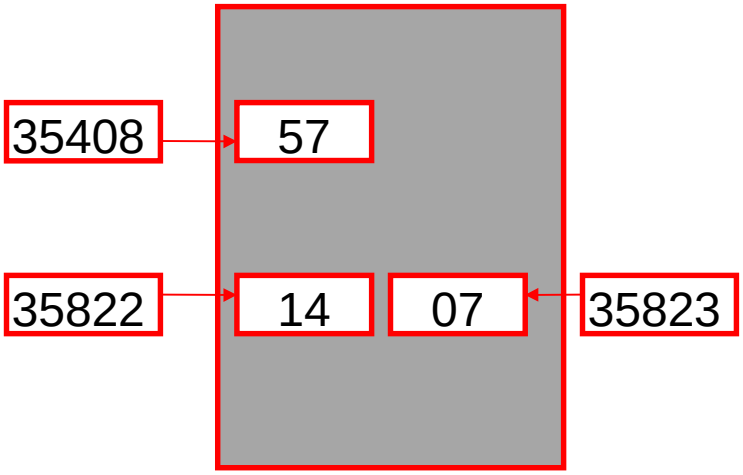
Doubleword	4-bytes (32 bits)
Quadword	8-bytes (64 bits)
Paragraph	16-bytes (128 bits)

Numbers of Bytes			
Kilobyte	2^{10} bytes	1024	Thousand
Megabyte	2^{20} bytes	1,048,576	Million
Gigabyte	2^{30} bytes		Billion
Terabyte	2^{40} bytes		Trillion

Words are stored in **reverse order:**

Suppose a byte with the value 87 (57h') is stored in memory in location number 35408h,

and a word with value 1812 (0714h) is stored in memory in location number 35822h:



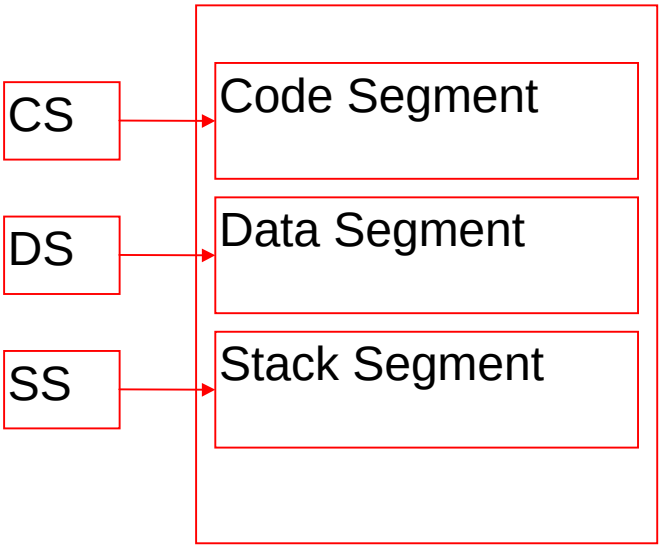
Memory Organization

The CPU must know where data items are, and where the program is.

The items are stored in memory in what is called a **SEGMENT**.

The CPU contains **REGISTERS** which contain the addresses of the program's three main components:

Code	**Code Segment Register**	**CS**
Data	**Data Segment Register**	**DS**
Stack	**Stack Segment Register**	**SS**



A segment must begin on a Segment Boundary (an address evenly divisible by 16). (Recall, there are 16 bytes in a paragraph).

Hint: A hex number is evenly divisible by 16 if it ends in 0.

How Does the CPU find a data item?

It needs to know two things..

Where is the segment?

Where is the byte within that segment?

The calculation is done by adding the address of the segment to the address of the byte within the segment.

Example:

Suppose the segment begins at address 38680h, and the byte of data is the 50th byte (byte number 0032h).

Note that there is no need to store the last digit of 38680h, as it will **always** be a zero (segments are on paragraph boundaries). The segment register, therefore, would contain 3868h.

The address is calculated as:

```
Segment address          38680
Address within segment    + 32

Address of the byte:     386B2
```

The Intel Processor (CPU) Family

Note that register sizes affect:

Maximum data size
Maximum number of bytes that can be addressed

Processor	Size of registers	Size of data bus	Size of Address	Bytes Addressed
8086	16 bits	16 bits	20 bits	1 MB (2^{20})
80286	16	16	24	16 MB (2^{24})
80386	32	32	32	4 GB (2^{32})
80486	32	32	32	4 GB (2^{32})
Pentium	32	64	32	4 GB (2^{32})

All of these processors have the following registers:

Segment Registers
- CS Code Segment
- DS Data Segment
- SS Stack Segment
- ES Extra Segment

General Purpose Registers
- AX Accumulator
- BX Base Register
- CX Counter Register
- DX Data Register

Pointer Registers
- IP Instruction Pointer
- BP Base Pointer
- SP Stack Pointer

Index Registers
- SI Source Index
- DI Destination Index

Flags Register

IBM PC Memory Organization