# Course Contents

## Unit-02: Computer Hardware (8 Hrs.)

**Introduction:** Central Processing Unit; Components of CPU; Instruction Format; Instruction Set; Instruction Cycle; Microprocessor; Computer Bus; Components of Computer Cabinet (Power Supply, Motherboard, memory chips, expansion slots, ports and interface, processor, cables and Storage devices)

**Computer memory:** Memory Representation; Memory Hierarchy; CPU Register; Cache Memory; Primary Memory(RAM, ROM); Secondary Memory(Magnetic Tape; Magnetic Disk; Optical Disk; Magneto-Optical Disk, Flash Memory Device), Access types of storage devices(sequential and direct)

**Input and Output Devices:** Input-Output Unit; Input Devices; Human Data Entry Devices; Source Data Entry Devices; Output Devices; I/O Port; I/O System

# Course Contents

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# Course Contents

## Unit-02:Computer Hardware

In this chapter:

- Need to aware of the main components of the computer, their functions and the interconnection between the different components of the computer.
- Different hardware components of the computer.

3 related terms:

- Computer architecture
- Computer organization
- Computer design.

# Course Contents

## Unit-02: Computer Hardware (8 Hrs.)

- Computer architecture refers to the structure and behavior of the computer. It includes the specifications of the components, for example, instruction format, instruction set and techniques for addressing memory, and how they connect to the other components.
- Computer organization focuses on the organizational structure. It deals with how the hardware components operate and the way they are connected to form the computer.
- Computer design focuses on the hardware to be used and the interconnection of parts.

Different kinds of computer, such as a PC or a mainframe computer may have different organization; however, basic organization of the computer remains the same.

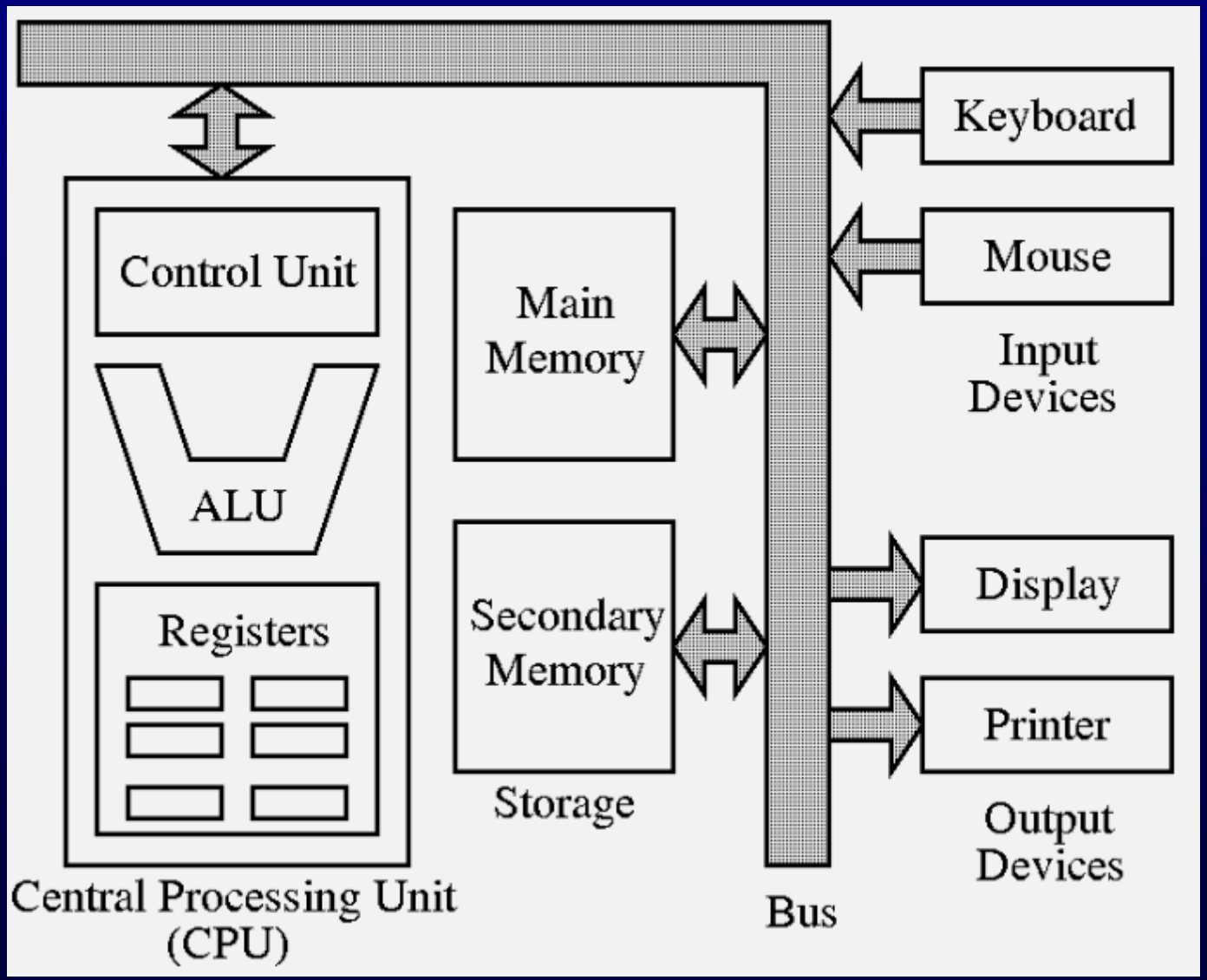
# Computer Hardware

All general purpose computers require the following hardware components: (Mainly 3 components- CPU, I/O & Memory)

1. **Central Processing Unit (CPU):** The 'brain' of the computer, the component that actually executes instructions.
2. **Input device:** Usually a keyboard or mouse is used to read data and programs into the computer.
3. **Output device:** A display screen, printer, etc. that lets you see what the computer has accomplished.
4. **Memory:** It enables a computer to store, at least temporarily, data and programs.
5. **Mass storage device:** It allows a computer to permanently store large amounts of data. Common mass storage devices include disk drive and tape drive.

# Computer Hardware

## The Computer System Hardware:



# Computer Hardware

## 8085 Block Diagram:

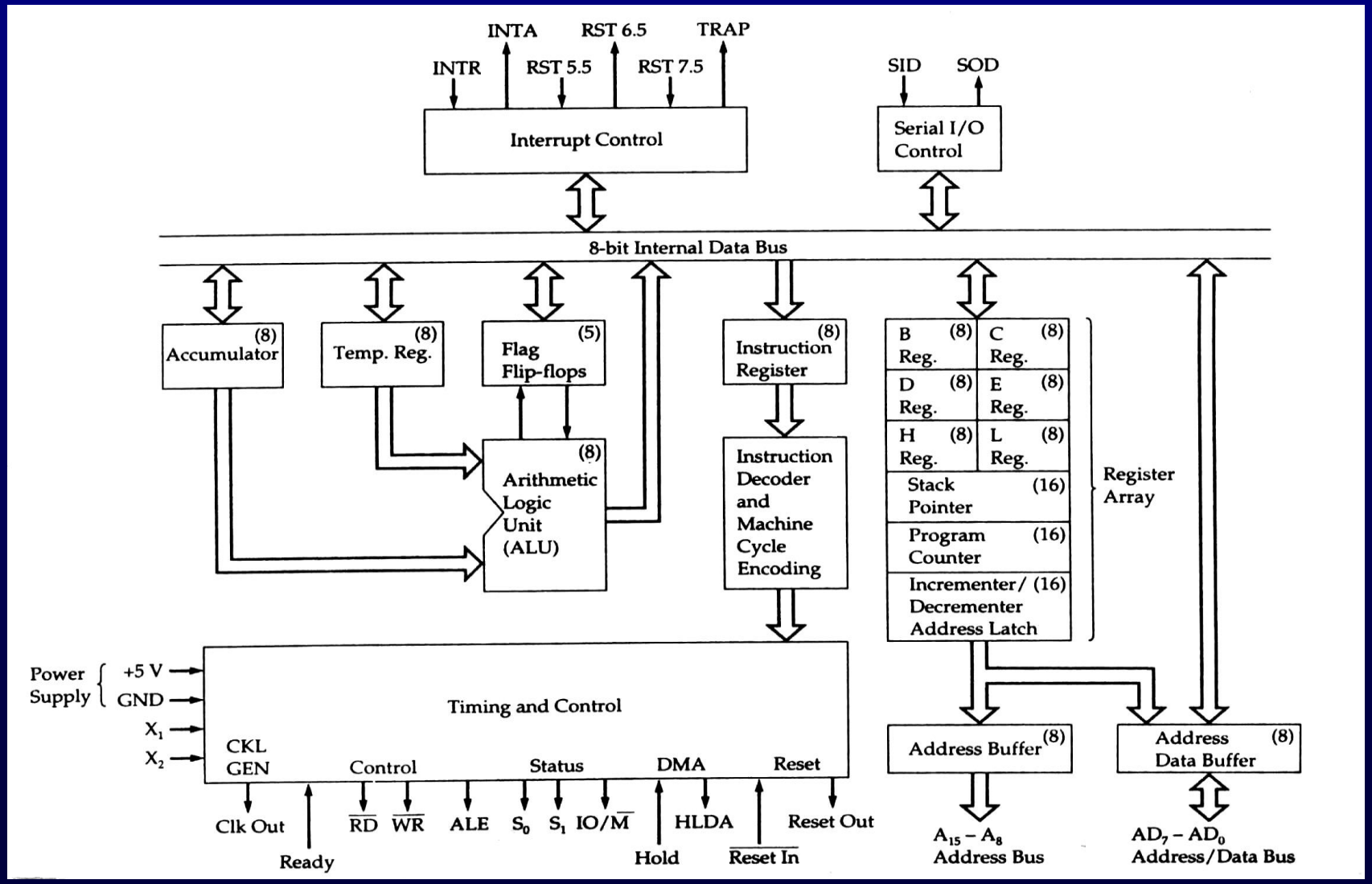



**Figure: Intel 8085 CPU Block Diagram**

# Computer Hardware

**Functions and Components of a Computer:**

A computer does mainly the following four functions:

1. Receive input —Accept data/information from outside through various input devices like the keyboard, mouse, scanner, etc.
2. Process information—Perform arithmetic or logical operations on data/ information.
3. Produce output—Communicate information to the outside world through output devices like monitor, printer, etc.
4. Store information—Store the information in storage devices like hard disk, floppy disks, CD, etc.

The hardware components of the computer specialize to do above four functions.

# Computer Hardware

**Functions and Components of a Computer:**

- Computer hardware falls into two categories: processing hardware and the peripheral devices.
- The Processing hardware consists of the Central Processing Unit (CPU) where the data processing is done.
- Peripheral devices allow people to interact with the CPU.

Together, they make it possible to use the computer for a variety of tasks.

# Computer Hardware

## Central Processing Unit (CPU)

- Part of the computer that executes program instructions is known as the processor or Central Processing Unit (CPU).
- CPU executes the stored program instructions, i.e. instructions and data are stored in memory before execution.
- For processing, CPU gets data and instructions from the memory. It interprets the program instructions and performs the arithmetic and logic operations required for the processing of data.
- Then, it sends the processed data or result to the memory.
- CPU also acts as an administrator and is responsible for supervising operations of other parts of the computer.

The CPU has 3 parts —The **Control Unit (CU)** and the **Arithmetic Logic Unit (ALU)** **and h**as a **set of registers** which are temporary storage areas for holding data, and instructions.

# Computer Hardware

## Arithmetic - Logic Unit (ALU):

- Arithmetic Logic Unit, usually called the ALU, performs two types of operations - arithmetical and logical.
- Arithmetical operations are the fundamental mathematical operations consisting of addition, subtraction, multiplication, division and logical operations.

# Computer Hardware

**Registers:**

- Computers also have several additional storage locations called registers.
- These appear in the Control Unit and ALU and make processing more efficient.
- Registers are a sort of special hi-speed storage areas that hold data and instructions temporarily during processing.
- They are parts of the Control Unit and ALU rather than the memory.
- Their contents can, therefore be handled much faster than the contents of the memory.

# Computer Hardware

**Registers:**

Some of the important registers in CPU are as follows—

# Computer Hardware

## Registers:

Some of the important registers in CPU are as follows—

- Accumulator (ACC) stores the result of arithmetic and logic operations.
- Instruction Register (IR) contains the current instruction most recently fetched.
- Program Counter (PC) contains the address of next instruction to be processed.
- Memory Address Register (MAR) contains the address of next location in the memory to be accessed.
- Memory Buffer Register (MBR) temporarily stores data from memory or the data to be sent to memory.
- Data Register (DR) stores the operands and any other data.

# Computer Hardware

## Registers:

- The number of registers and the size of each (number of bits) register in a CPU helps to determine the power and the speed of a CPU.
- The overall number of registers can vary from about ten to many hundreds, depending on the type and complexity of the processor.
- The size of register, also called word size, indicates the amount of data with which the computer can work at any given time. The bigger the size, the more quickly it can process data. The size of a register may be 8, 16, 32 or 64 bits. For example, a 32–bit CPU is one in which each register is 32 bits wide and its CPU can manipulate 32 bits of data at a time. Nowadays, PCs have 32–bit or 64–bit registers.
- 32-bit processor and 64-bit processor are the terms used to refer to the size of the registers. Other factors remaining the same, a 64-bit processor can process the data twice as fast as one with 32-bit processor.

# Computer Hardware

## Control Unit (CU)

- The control unit tells the rest of the computer system how to carry out a program's instructions.
- It directs the movement of electronic signals between memory which temporarily holds data, instructions and processes information - and the ALU.
- It also directs these control signals between the CPU and input/output devices.

# Computer Hardware

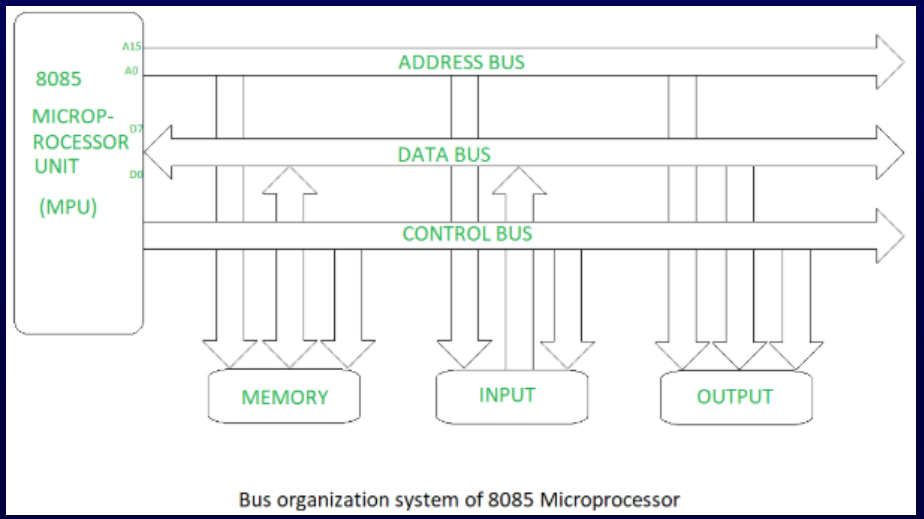
**Memory:**

- Memory - also known as the primary storage or main memory - is a part of the microcomputer that holds data and instructions.
- Contents of the memory is held only temporarily, that is, it is stored only as long as the microcomputer is turned on.
- When you turn the machine off, the contents are lost.
- The capacity of the memory to hold data and program instructions varies in different computers.

# Computer Hardware

## Addresses:

- To locate the characters of data or instructions in the main memory, the computer stores them in locations known as addresses.
- A unique number designates each address.
- Addresses can be compared to post office mailboxes.
- Their numbers remain the same, but contents continuously change.



Bus organization system of 8085 Microprocessor

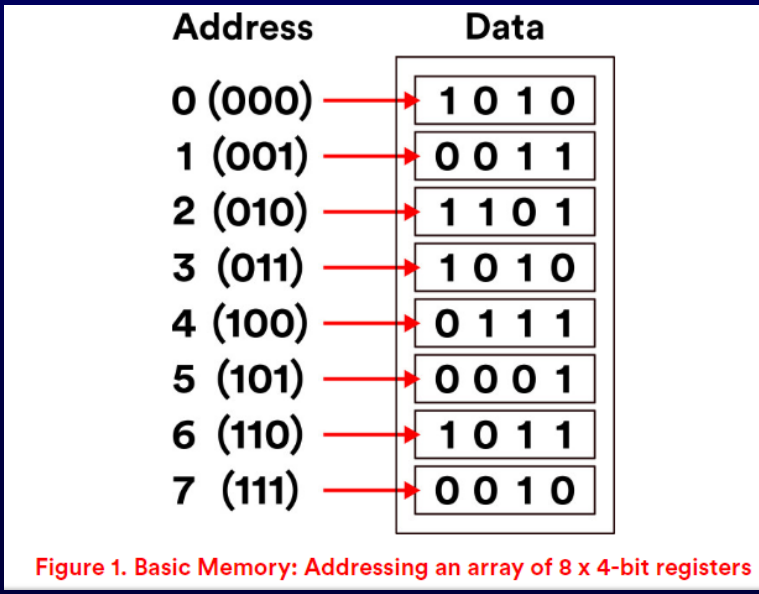


Figure 1. Basic Memory: Addressing an array of 8 x 4-bit registers

# Computer Hardware

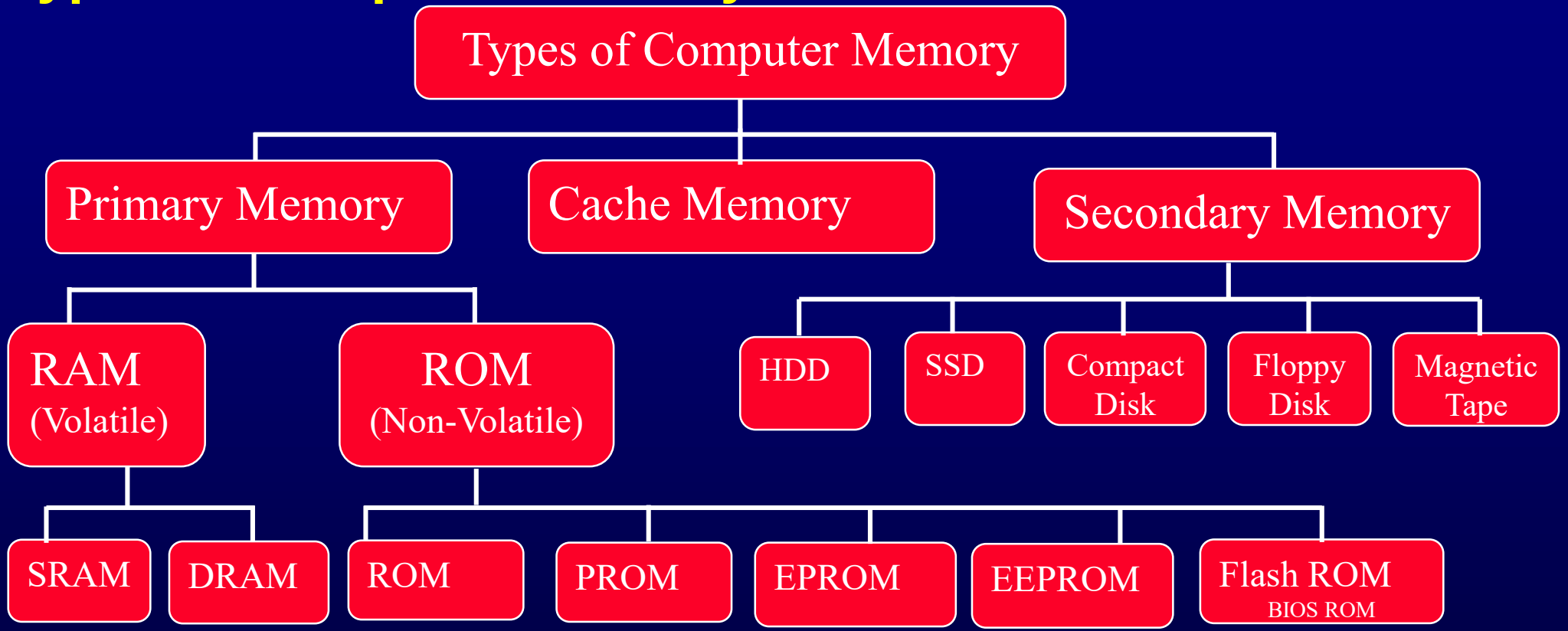
## Memory Unit:

1. Cache memory
2. Primary memory
3. Secondary memory

- Memories are made up of registers. Each register in the memory is one storage location. Storage location is also called as memory location. Memory locations are identified using Address. The total number of bit a memory can store is its capacity.
- A storage element is called a Cell. Each register is made up of storage element in which one bit of data is stored. The data in a memory are stored and retrieved by the process called writing and reading respectively.

# Computer Hardware

## Types of computer memory:



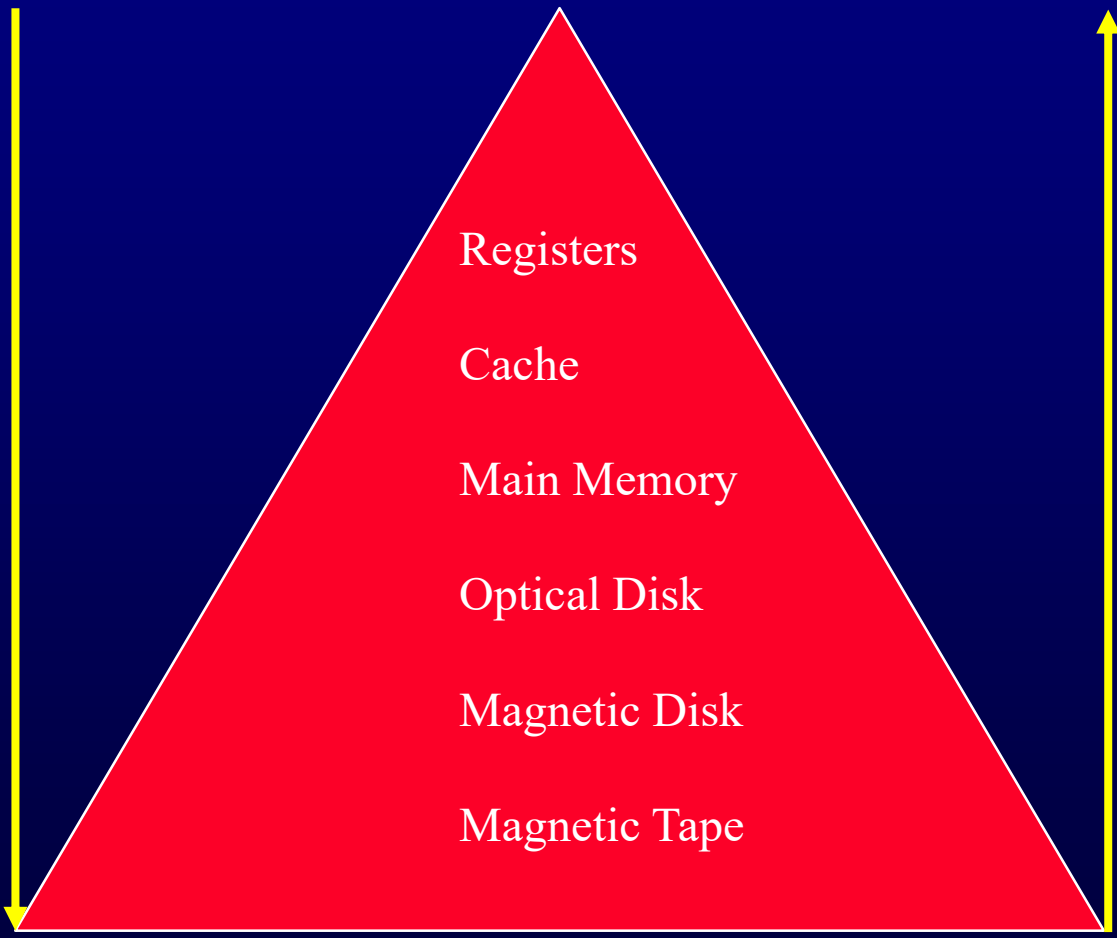

- Very first ROM is also called **Masked ROM**
- Single Data Rate: (SDR) DRAM
- Dual Data Rate :(DDR) DRAM
- DDR2 , DDR3, and DDR4, which offer better performance and are more energy efficient than DDR. Different versions are incompatible, so it is not possible to mix DDR2 with DDR3 DRAM in a computer system.

# Computer Hardware

## Memory Hierarchy:

- Faster access time
- Smaller Capacity
- Higher cost per bit stored

- Slower access time
- Larger Capacity
- Lower cost per bit stored




Registers

Cache (L1, L2 &L3)

Main Memory

Optical Disk

Magnetic Disk

Magnetic Tape

Memory Hierarchy

# Computer Hardware

## Memory Unit:

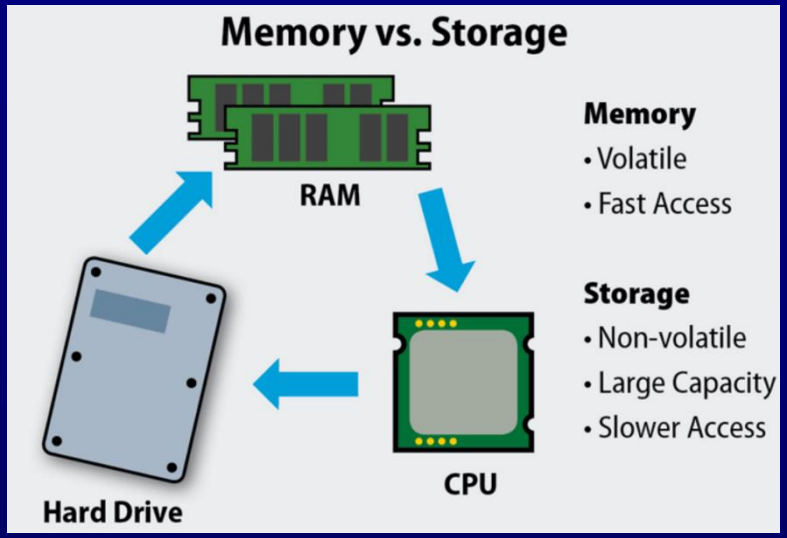
### Memory and its classification:

- A computer system is built using a combination of these types of computer memory, and the exact configuration can be optimized to produce the maximum data processing speed or the minimum cost, or some compromise between the two.

# Computer Hardware

## Memory Unit:

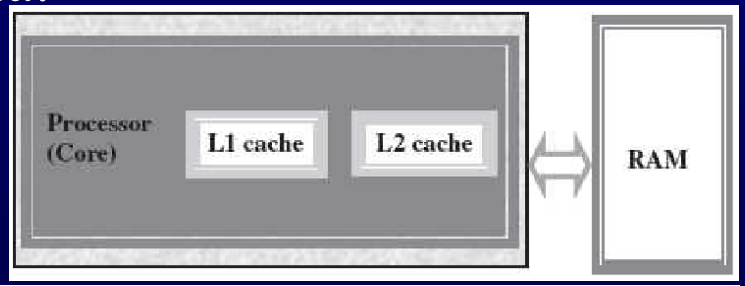
- Data and instructions that are required during the processing of data are brought from the secondary storage devices and stored in the RAM.
- For processing, CPU accessed data and instructions from the RAM and stored in the registers.
- The time taken to move the data between RAM and CPU registers is large.
- This affects the speed of processing of computer, and results in decreasing the performance of CPU.

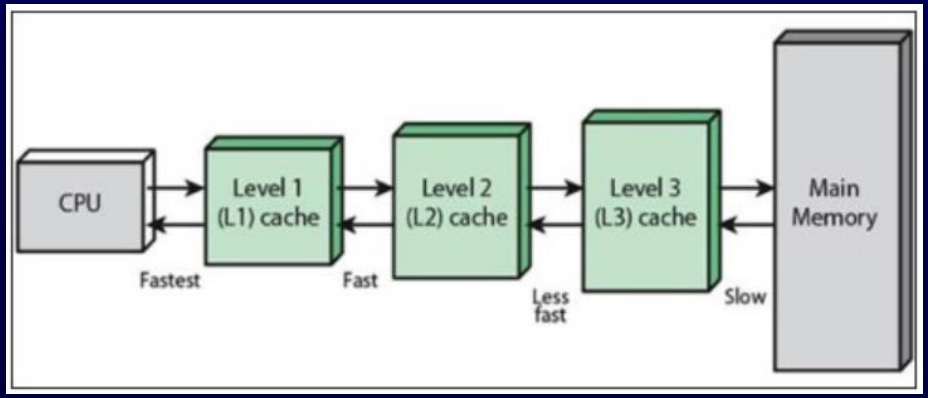


# Computer Hardware

## Cache Memory:

- Cache memory is a very high speed memory placed in between RAM and CPU. Cache memory increases the speed of processing.
- Cache memory is a storage buffer that stores the data that is used more often, temporarily, and makes them available to CPU at a fast rate. During processing, CPU first checks cache for the required data. If data is not found in cache, then it looks in the RAM for data.
- To access the cache memory, CPU does not have to use the motherboard's system bus for data transfer at a much faster rate by avoiding the system bus.
- Cache memory is very expensive, so it is smaller in size. Generally, computers have cache memory of sizes 256 KB to 2 MB.



# Computer Hardware

## Memory Unit:

| L1 | L2 | L3 |
|---|---|---|
| A cache memory that is directly built into the processor and is used to store the CPU's recently accessed information | A cache memory that is located outside and separated from the CPU chip core, although it is found on the same CPU chip package | A cache memory that is used by the CPU and is usually built onto the motherboard within the CPU module itself |
| Smallest cache | Larger than L1 but smaller than L3 cache | Largest cache |
| Called level 1 or primary or internal cache | Called level 2, secondary or external cache | Called level 3 or external cache |
| Fastest cache | Slower than L1 but faster than L3 | Slowest cache |
| Each core in the CPU has their own L1 cache memory | Each code in the CPU has their own L2 cache memory | All cores in the CPU share the same L3 cache memory |

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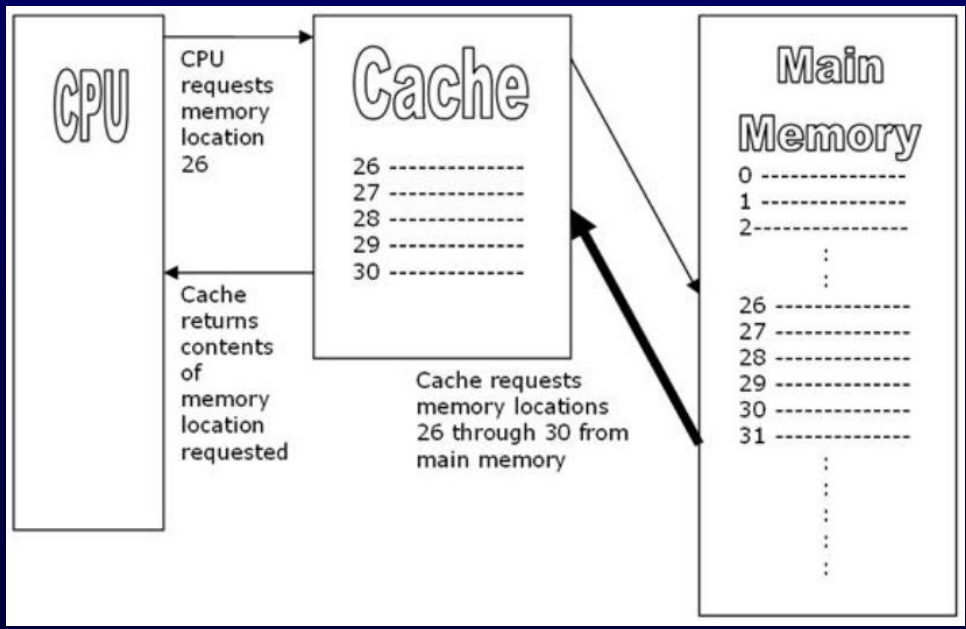


# Computer Hardware

## Primary Memory:

- Primary memory is the main memory of computer. It is used to store data and instructions during the processing of data. Primary memory is semiconductor memory.
- Primary memory two kinds - RAM and ROM.
- RAM gets erased when the computer is turned off. RAM provides temporary storage for data and instructions.
- The storage in ROM is permanent in nature for storing standard processing programs that permanently reside in the computer and programmed by the manufacturer.
- CPU accesses the data and the instructions from RAM, as it can access it at a fast speed than the storage devices connected to the input and output unit
- The input data that is entered using the input unit is stored in RAM. Similarly, the output data generated after processing is stored in RAM before being sent to the output device. Any intermediate results generated during the processing of program are stored in RAM. RAM provides a limited storage capacity, due to its high cost.

# Computer Hardware

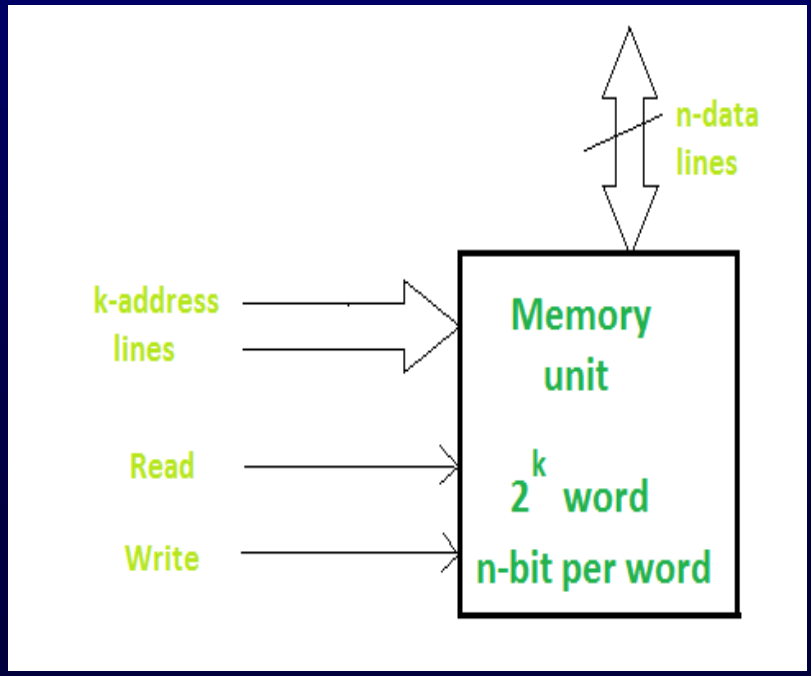
## Secondary Memory:

- The data and instructions that are currently not being used by CPU, but may be required later for processing, are stored in secondary memory.
- Secondary memory has a high storage capacity than the primary memory.
- Secondary memory is also cheaper than the primary memory.
- It takes longer time to access the data and instructions stored in secondary memory than in primary memory.
- The secondary memory stores data and instructions permanently (non-volatile).
- It provides back-up storage for data and instructions. Hard disk drive, floppy drive and optical disk drives are some examples of storage devices.

# Computer Hardware

## Memory Unit:

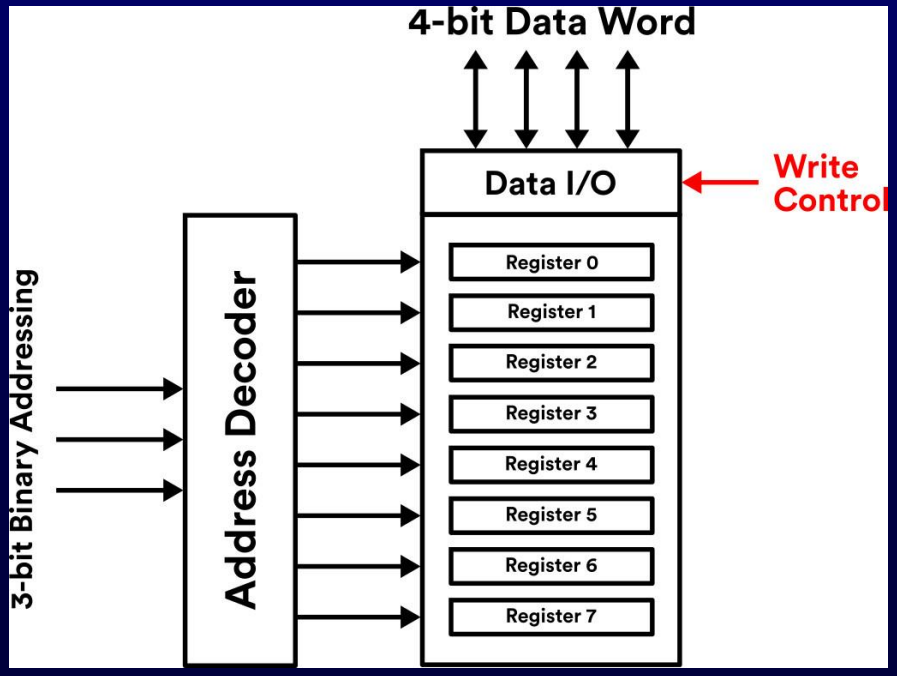
- A word is a group of bits where a memory unit stores binary information. A word with group of 8 bits is called a byte.
- A memory unit consists of data lines, address selection lines, and control lines that specify the direction of transfer.

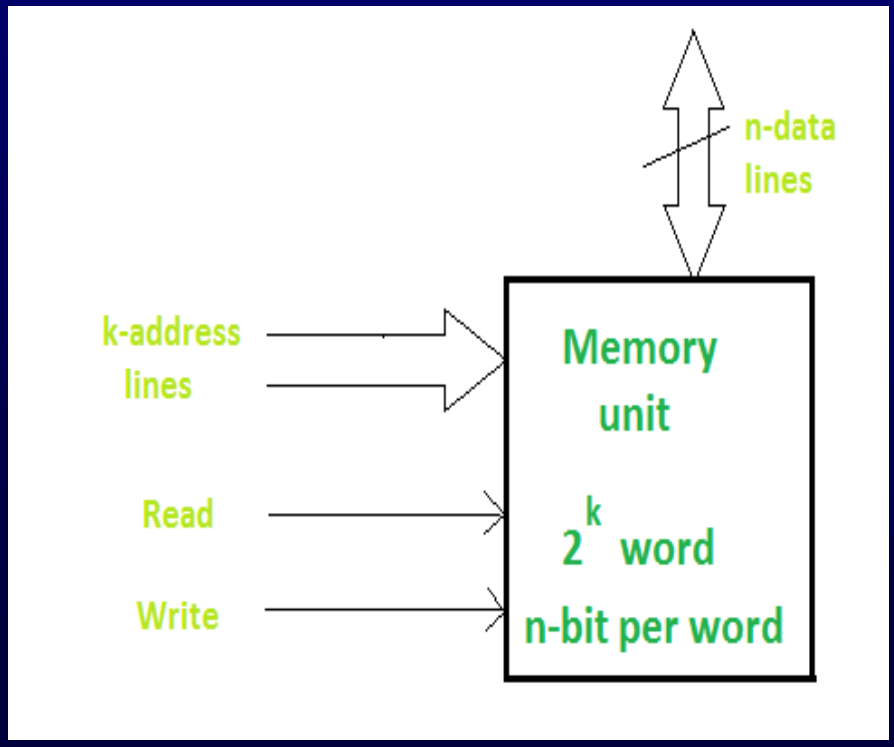


# Computer Hardware

## Memory Unit:

- Data lines provide the information to be stored in memory. The control inputs specify the direction transfer. The k-address lines specify the word chosen.
- When there are k address lines, 2k memory word can be accessed.



# Computer Hardware

## Instruction Format

A computer program is a set of instructions that describe the steps to be performed for carrying out a computational task. The program and the data, on which the program operates, are stored in main memory, waiting to be processed by the processor. This is also called the stored program concept.

An instruction format defines the different component of an instruction. The main components of an instruction are opcode (operations to perform) and operands (data on which instruction to be executed).

# Computer Hardware

## Instruction Format

An instruction format defines the different component of an instruction. The main components of an instruction are opcode (which instruction to be executed) and operands (data on which instruction to be executed).

1. High Level Language
2. Assembly Language
3. Machine Language

| Opcode | Operand | Binary Code | Hex Code | Task |
|---|---|---|---|---|
| MOV | C, A | 0100 1111 | 4FH | Copy the contents of the accumulator in the register C. |
| ADD | B | 1000 0000 | 80H | Add the contents of register B to the contents of the accumulator. |
| HLT | | 0111 0110 | 76H | |

| Opcode | Operand | Machine code/Hex code | Byte description |
|---|---|---|---|
| MVI | A, 7FH | 3E | First byte |
| | | 7F | Second byte |
| ADI | 0FH | C6 | First byte |
| | | 0F | Second byte |

Table 4 Examples of three byte instructions

| Opcode | Operand | Machine code/Hex code | Byte description |
|---|---|---|---|
| JMP | 9050H | C3 | First byte |
| | | 50 | Second byte |
| | | 90 | Third byte |
| LDA | 8850H | 3A | First byte |
| | | 50 | Second byte |
| | | 88 | Third byte |

# Computer Hardware

**Instruction Set:**

- A processor has a set of instructions that it understands, called as instruction set. An instruction set or an instruction set architecture is a part of the computer architecture. It relates to programming, instructions, registers, addressing modes, memory architecture, etc.
- An Instruction Set is the set of all the basic operations that a processor can accomplish.
- CPU Manufacturer design Hardware circuit together with Instruction set for that hardware circuit.
- **Example: 8085 has 246 such instructions.**

# Computer Hardware

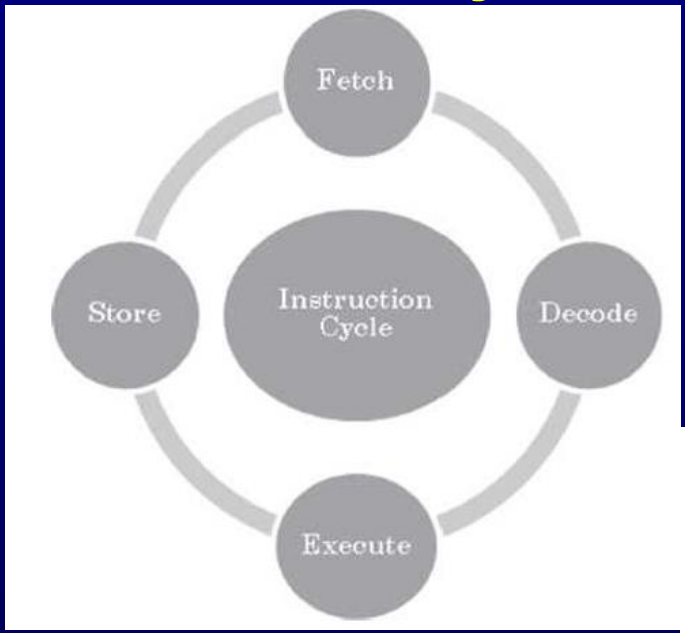
## Instruction Cycle:

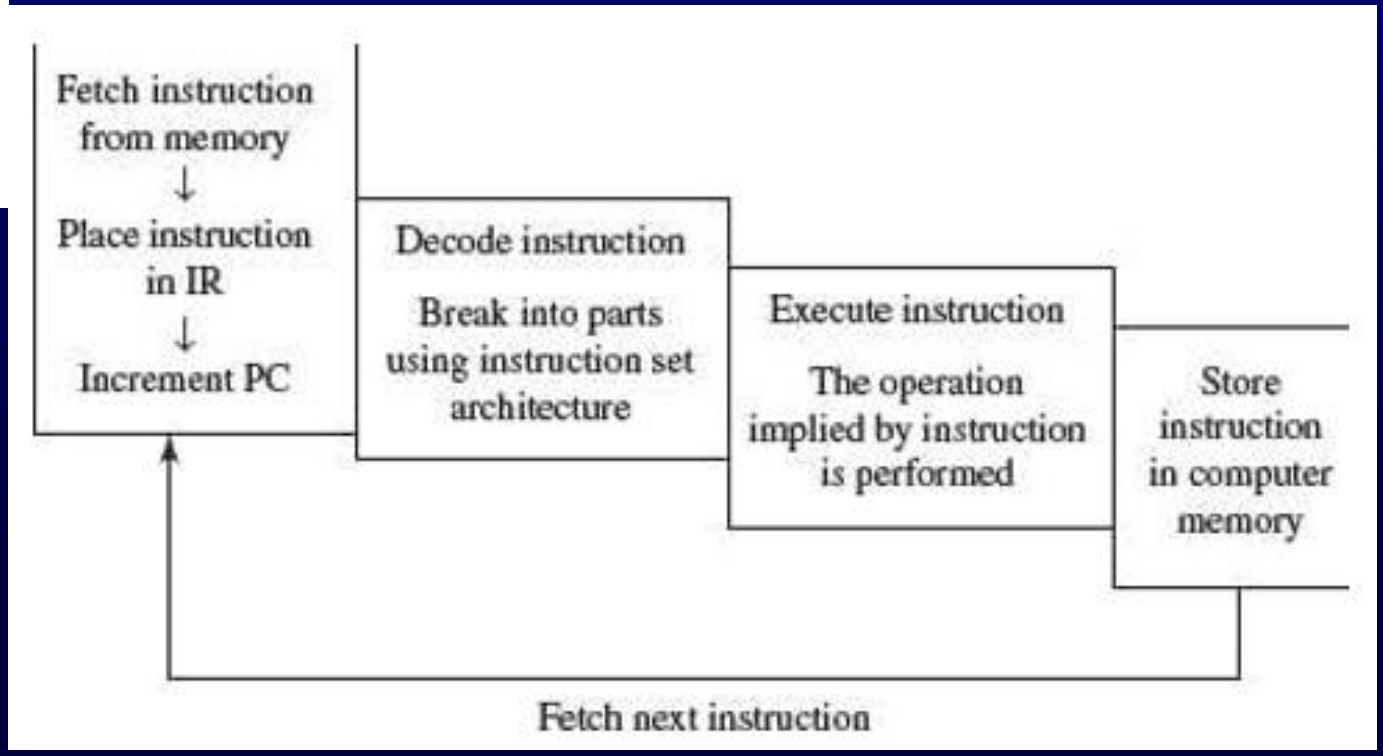
A instruction cycle involves four steps:

- Fetching The processor fetches the instruction from the memory. The fetched instruction is placed in the Instruction Register. PC holds the address of next instruction to be fetched and is incremented after each fetch.
- Decoding The instruction that is fetched is broken down into parts or decoded. The instruction is translated into commands so that they correspond to those in the CPU's instruction set. The instruction set architecture of the CPU defines the way in which an instruction is decoded.
- Executing The decoded instruction or the command is executed. CPU performs the operation implied by the program instruction. For example, if it is an ADD instruction, addition is performed.
- Storing CPU writes back the results of execution, to the computer's memory.

# Computer Hardware

## Instruction Cycle:



# Computer Hardware

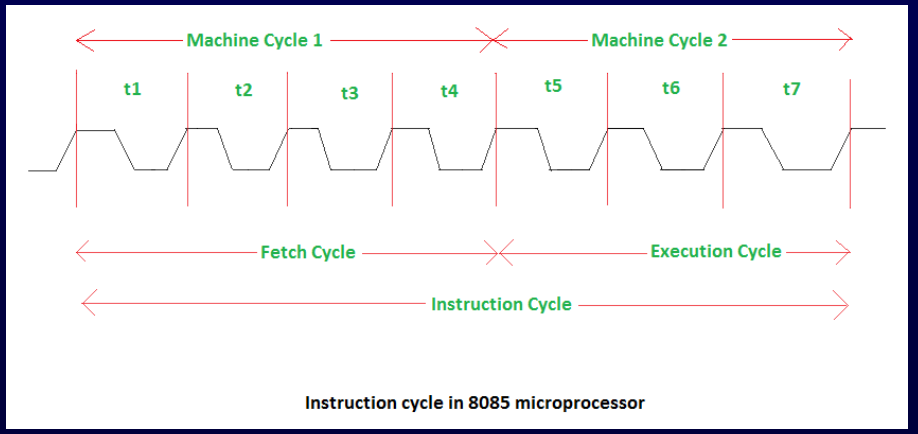
## Instruction Set:

- Two processors are different if they have different instruction sets. A program run on one computer may not run on another computer having a different processor. Two processors are compatible if the same machine level program can run on both the processors. Therefore, the system software is developed within the processor's instruction set.
- Microarchitecture is the processor design technique used for implementing the Instruction Set. Computers having different microarchitecture can have a common Instruction Set. Pentium and Athlon CPU chips implement the x86 instruction set, but have different internal designs.

# Instruction Cycle

- The time taken for the execution of one instruction is known as **Instruction Cycle**.
- It is the process by which a computer retrieves  a program instruction from its memory, determines what actions the instruction describes, and then carries out those actions.
- This cycle is repeated continuously by a computer's central processing unit (CPU) to read next instruction until program finish.
- In simpler CPUs the instruction cycle is executed sequentially, each instruction being processed before the next one is started.

| Opcode | Operand | Binary Code | Hex Code | Task |
|---|---|---|---|---|
| MOV | C, A | 0100 1111 | 4FH | Copy the contents of the accumulator in the register C. |
| ADD | B | 1000 0000 | 80H | Add the contents of register B to the contents of the accumulator. |
| HLT | | 0111 0110 | 76H | |



Instruction cycle in 8085 microprocessor

# Computer Hardware

**Microprocessor:**

- The central processing unit (CPU) is a chip that functions as the brains of the computer. It is made of transistors--millions of transistors.
- Microprocessors are also the circuitry that surround the CPU.
- The microprocessor is more than the CPU. It contains other processors, for example, the graphics processor unit. Sound cards and network cards are encased in microprocessors. So a CPU is part of a microprocessor, but a microprocessor is more than the CPU.

# Computer Hardware

**Microprocessor:**

- A processor's instruction set is a determining factor in its architecture. On the basis of the instruction set, microprocessors are classified as—Reduced Instruction Set Computer (RISC), and Complex Instruction Set Computer (CISC).
- The x86 instruction set of the original Intel 8086 processor is of the CISC type. The PCs are based on the x86 instruction set.

# Computer Hardware

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# Computer Hardware

## Microprocessor:

CISC architecture hardwires the processor with complex instructions, which are difficult to create otherwise using basic instructions. CISC combines the different instructions into one single CPU.

- CISC has a large instruction set that includes simple and fast instructions for performing basic tasks, as well as complex instructions that correspond to statements in the high level language.
- An increased number of instructions (200 to 300) results in a much more complex processor, requiring millions of transistors.
- Instructions are of variable lengths, using 8, 16 or 32 bits for storage. This results in the processor's time being spent in calculating where each instruction begins and ends.
- With large number of application software programs being written for the processor, a new processor has to be backwards compatible to the older version of processors. o AMD and Cyrix are based on CISC.

# Computer Hardware

## Microprocessor:

RISC has simple, single-cycle instructions, which performs only basic instructions. RISC architecture does not have hardwired advanced functions. All high-level language support is done in the software.

- RISC has fewer instructions and requires fewer transistors, which results in the reduced manufacturing cost of processor.
- The instruction size is fixed (32 bits). The processor need not spend time in finding out where each instruction begins and ends.
- RISC architecture has a reduced production cost compared to CISC processors.
- The instructions, simple in nature, are executed in just one clock cycle, which speeds up the program execution when compared to CISC processors.
- RISC processors can handle multiple instructions simultaneously by processing them in parallel.

Apple Mac G3 and PowerPC are based on RISC.

Processors like Athlon XP and Pentium IV use a hybrid of both technologies.

# Computer Hardware

## Microprocessor:

Pipelining improves instruction execution speed by putting the execution steps into parallel. A CPU can receive a single instruction, begin executing it, and receive another instruction before it has completed the first. This allows for more instructions to be performed, about, one instruction per clock cycle.

Parallel Processing is the simultaneous execution of instructions from the same program on different processors. A program is divided into multiple processes that are handled in parallel in order to reduce execution time.

# Computer Hardware

## Computer Bus:

- A bus is a set of wires used for interconnection, where each wire can carry one bit of data.
- A bus width is defined by the number of wires in the bus.
- A computer bus can be divided into two types—Internal Bus and External Bus.
- The Internal Bus connects components inside the motherboard like, CPU and system memory. It is also called the System Bus.

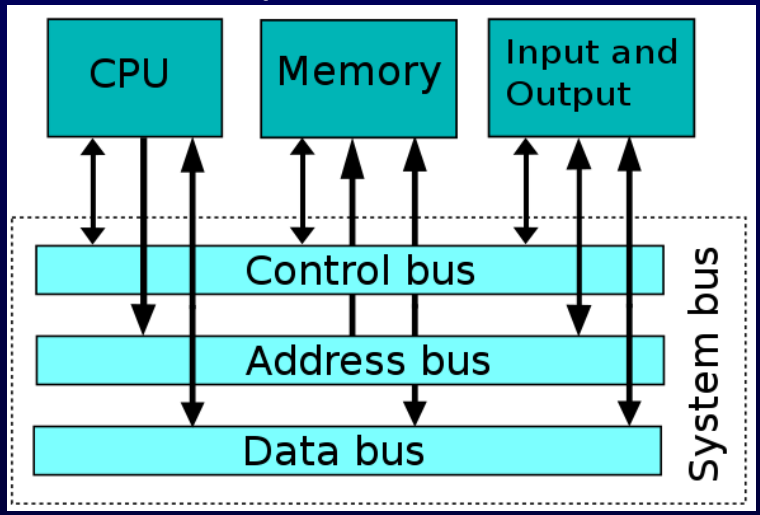



Figure shows interaction between processor and memory.

# Computer Hardware

## Computer Bus:

- The External Bus connects the different external devices, peripherals, expansion slots, I/O ports and drive connections to the rest of computer. The external bus allows various devices to be attached to the computer. It allows for the expansion of computer's capabilities. It is generally slower than the system bus. It is also referred to as the Expansion Bus.
- A system bus or expansion bus comprise of three kinds of buses — data bus, address bus and control bus.
- The interaction of CPU with memory and I/O devices involves all the three buses.
  - The command to access the memory or the I/O device is carried by the control bus.
  - The address of I/O device or memory is carried by the address bus.
  - The data to be transferred is carried by the data bus.

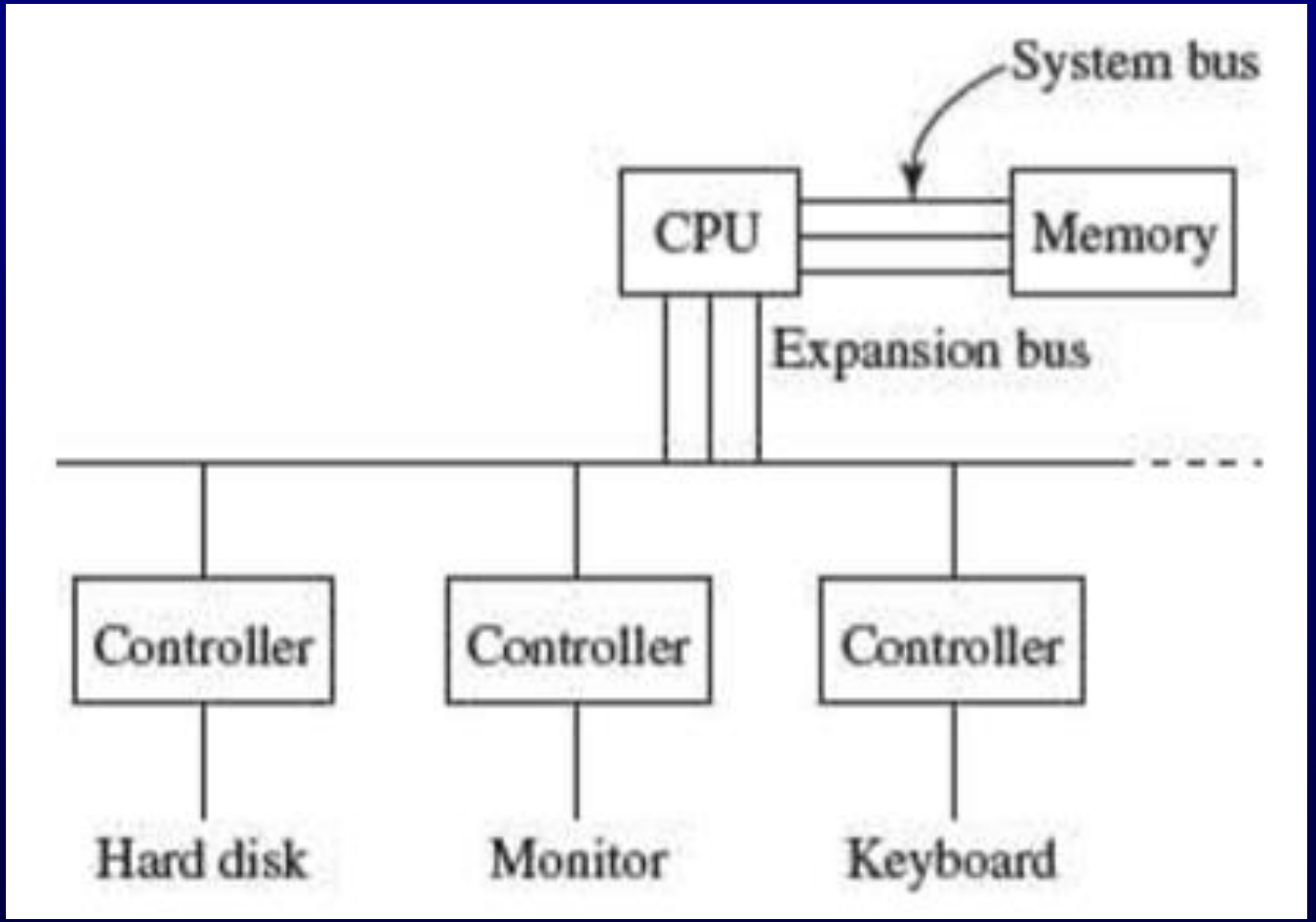
# Computer Hardware

The functions of data bus, address bus and control bus, in the system bus, are as follows—

- Data Bus transfers data between the CPU and memory. The bus width of a data bus affects the speed of computer. The size of data bus defines the size of the processor. A processor can be 8, 16, 32 or 64-bit processor. An 8–bit processor has 8 wire data bus to carry 1 byte of data. In a 16–bit processor, 16–wire bus can carry 16 bits of data, i.e., transfer 2 bytes, etc.
- Address Bus connects CPU and RAM with set of wires similar to data bus. The width of address bus determines the maximum number of memory locations the computer can address.
- Control Bus specifies whether data is to be read or written to the memory, etc

# Computer Hardware

Interaction between CPU, memory and peripheral devices



# Computer Hardware

## Expansion Bus:

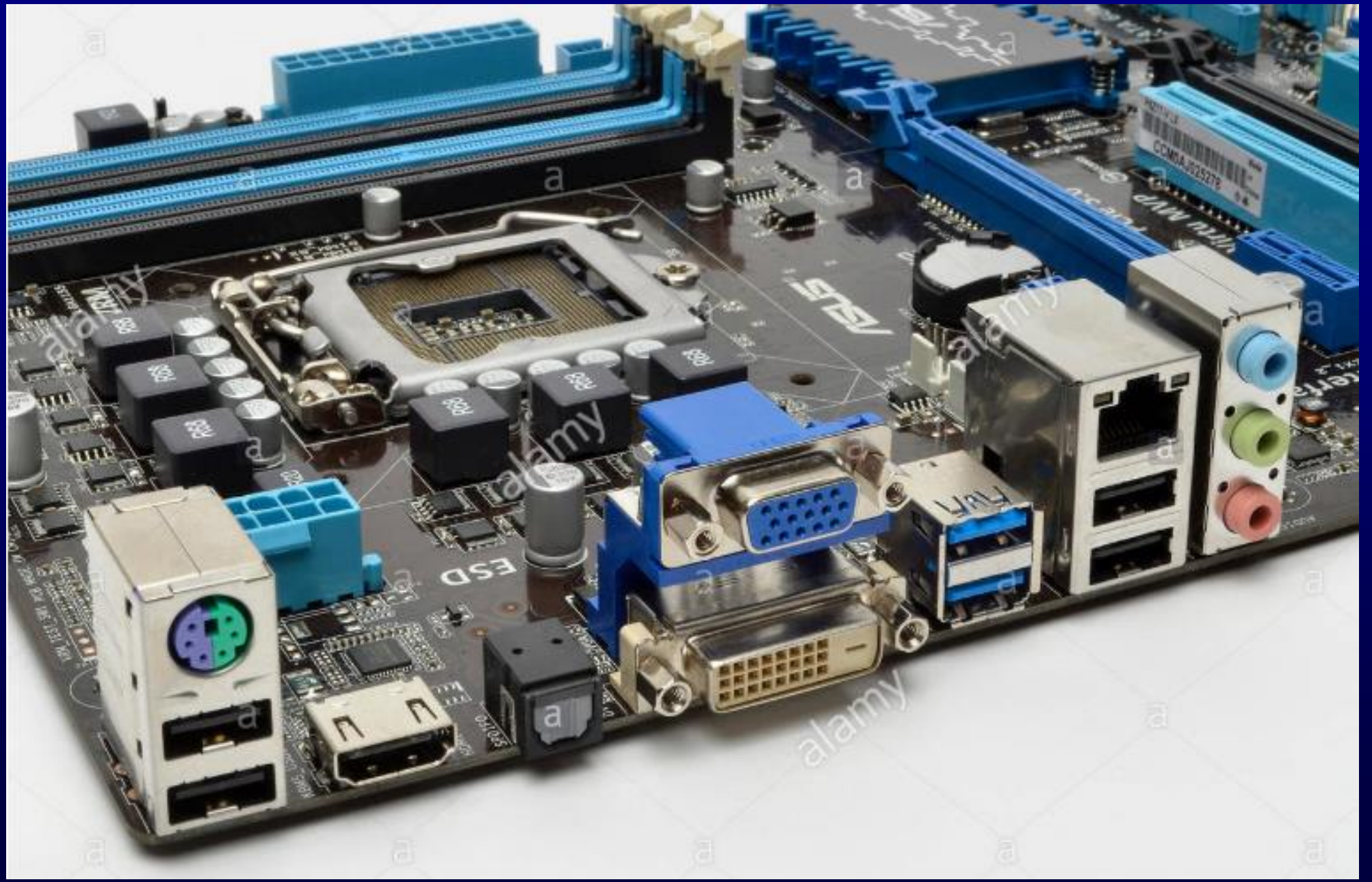
Functions of data bus, address bus and control bus, in the expansion bus, are as follows:

- The expansion bus connects external devices like monitor, keyboard and printer to ports on the back of computer. These ports are actually a part of the small circuit board or expansion card that fits into an expansion slot on the motherboard.
- Expansion slots make up a row of long plastic connectors at the back of the computer with tiny copper ‘finger slots’ in a narrow channel that grab the connectors on the expansion cards. The slots are attached to tiny copper pathways on the motherboard (the expansion bus), which allows the device to communicate with the rest of computer.

# Computer Hardware

## Expansion Bus:

- Data Bus is used to transfer data between I/O devices and CPU. The exchange of data between CPU and I/O devices is according to the industry standard data buses. The most commonly used standard is Extended Industry Standard Architecture (EISA) which is a 32-bit bus architecture. Some of the common bus technologies are—
  - Peripheral Component Interconnect (PCI) bus for hard disks, sound cards, network cards and graphics cards,
  - Accelerated Graphics Port (AGP) bus for 3–D and full motion video,
  - Universal Serial Bus (USB) to connect and disconnect different devices.
- Address Bus carries the addresses of different I/O devices to be accessed like the hard disk, CD ROM, etc.
- Control Bus is used to carry read/write commands, status of I/O devices, etc.



# Computer Hardware

## External Ports:

- The peripheral devices interact with the CPU of the computer via the bus. The connections to the bus from the peripheral devices are made via the ports and sockets provided at the sides of the computer.
- The different ports and sockets facilitate the connection of different devices to the computer. Some of the standard port connections available on the outer sides of the computer are— port for mouse, keyboard, monitor, network, modem, and, audio port, serial port, parallel port and USB port. The different ports are physically identifiable by their different shapes, size of contact pins and number of pins.

https://turbofuture.com/computers/buses

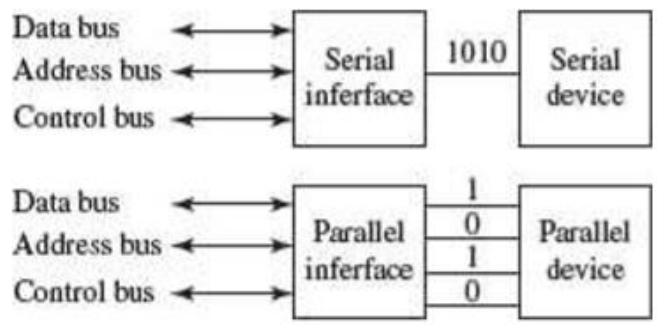
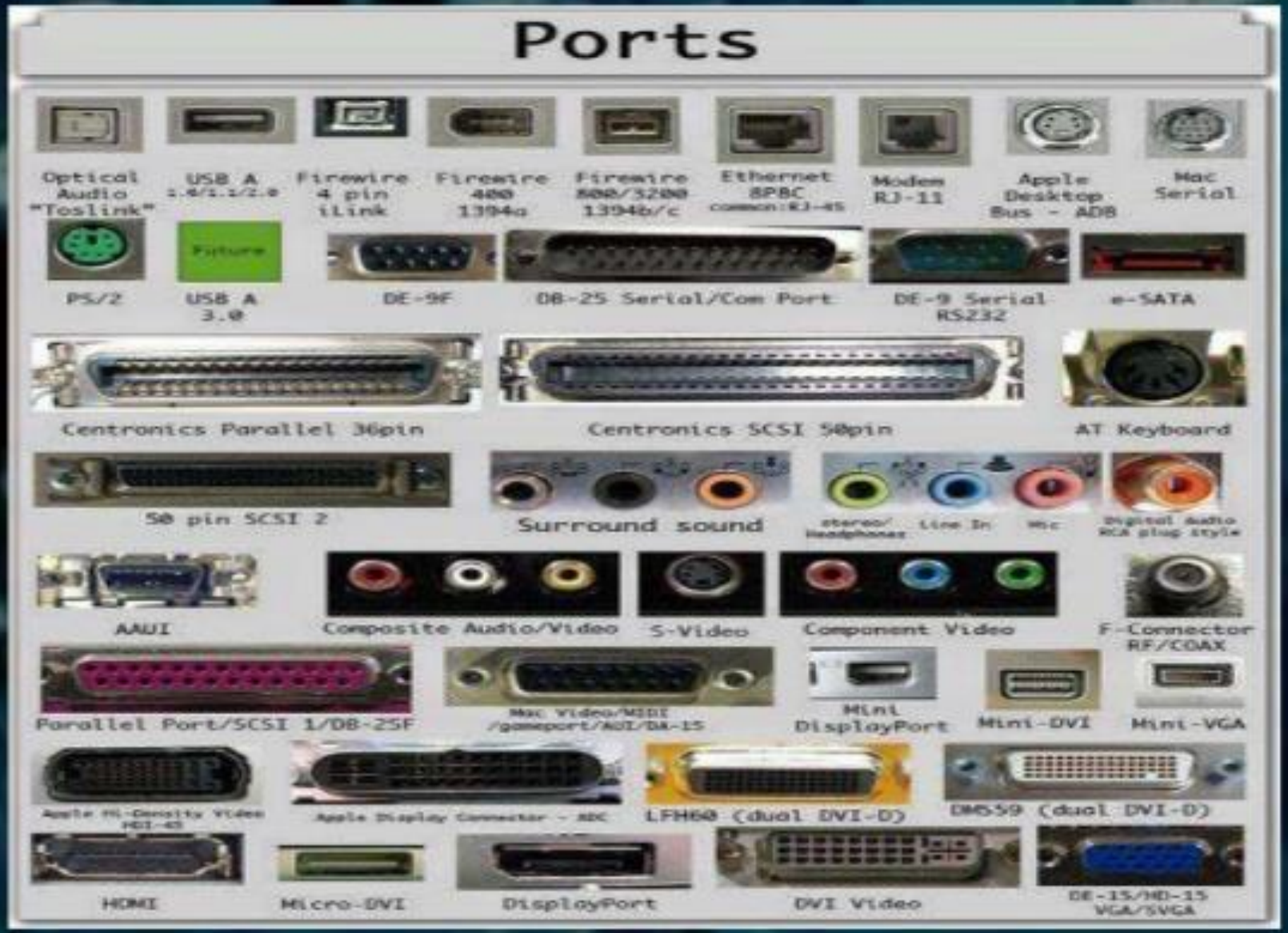



**Figure 2.12** Interaction of serial and parallel port interfaces

# I/O ports


Ports
Optical Audio "Toslink"
USB A
Firewire 4 pin iLink
Firewire 400 1394a
Firewire 800/3200 1394b/c
Ethernet 8P8C
Modem RJ-11
Apple Desktop Bus - ADB
Mac Serial
PS/2
USB A 3.0
DE-9F
DB-25 Serial/Com Port
DE-9 Serial RS232
e-SATA
Centronics Parallel 36pin
Centronics SCSI 50pin
AT Keyboard
50 pin SCSI 2
Surround sound
AAUI
Composite Audio/Video
S-Video
Component Video
F-Connector RF/COAX
Parallel Port/SCSI 1/DB-25F
Mini DisplayPort
Mini-DVI
Mini-VGA
LFH60 (dual DVI-D)
DMS59 (dual DVI-D)
HDMI
Micro-DVI
DisplayPort
DVI Video
DE-15/HD-15 VGA/SVGA

# Computer Hardware

## Performance of a computer:

Some of the factors that affect the speed and performance of the computer are:

- **Registers:** The size of the register (word size) indicates the amount of data with which the computer can work at any given time. The bigger the size, the more quickly it can process data.
- **RAM:** It is used to store data and instructions during execution of the instructions. Anything you do on your computer requires RAM. When the computer is switched on, the operating system, device drivers, the active files and running programs are loaded into RAM. If RAM is less, then the CPU waits each time the new information is swapped into memory from the slower devices. Larger the RAM size, the better it is.
- **System Clock:** The clock speed of a CPU is defined as the frequency with which a processor executes instructions or the data is processed. Higher clock frequencies mean more clock ticks per second. A CPU's performance is measured by the number of instructions it executes in a second, i.e., MIPS or BIPS.
- **Bus:** Data bus is used for transferring data between CPU and memory. The data bus width affects the speed of computer. In a 16–bit processor, 16–bit wire bus can carry 16 bits of data. The bus speed is measured in MHz Higher the bus speed the better it is. Address bus connects CPU and RAM with a set of wires similar to data bus. The address bus width determines the maximum number of memory locations the computer can address.
- **Cache Memory:** Two of the main factors that affect a cache's performance are its size (amount of cache memory) and level L1, L2 and L3. Larger the size of cache, the better it is. PCs nowadays have a L1 cache of 256KB and L2 cache of 1MB.

# Computer Hardware

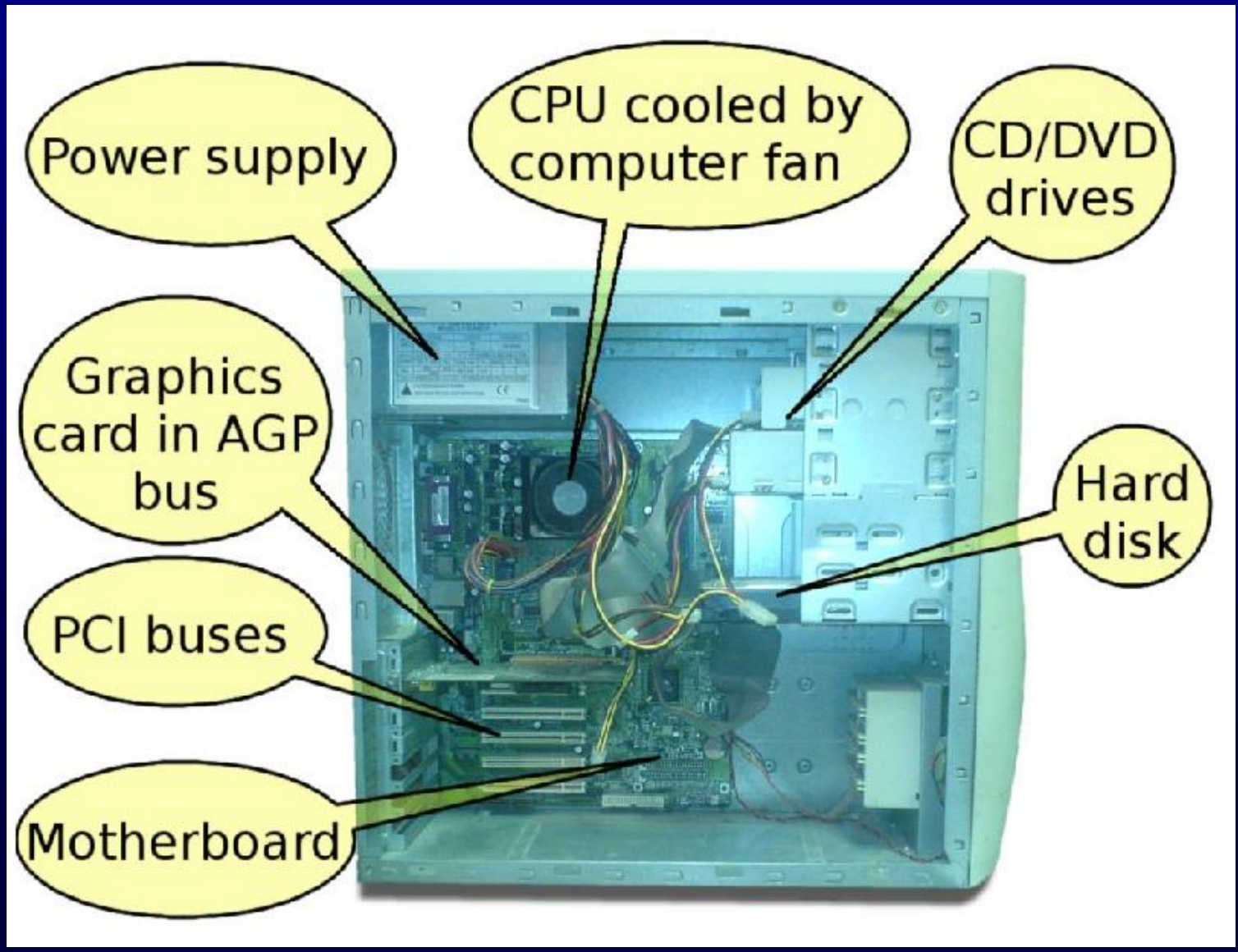
## Components of Computer Cabinet:

The components inside a computer cabinet include the power supply, motherboard, memory chips, expansion slots, ports and interface, processor, cables and storage devices.

- Power Supply,
- Motherboard,
- Memory chips,
- Expansion slots,
- Ports and interface,
- Processor,
- Cables and
- Storage devices

# The Computer System Hardware

**Inside a Computer Cabinet :**



# The Computer System Hardware

## Inside a Computer Cabinet :

Motherboard :

- The motherboard is the most important component in the PC. It is a large Printed Circuit Board (PCB), having many chips, connectors and other electronics mounted on it. The motherboard is the hub, which is used to connect all the essential components of a computer. The RAM, hard drive, disk drives and optical drives are all plugged into interfaces on the motherboard. The motherboard contains the processor, memory chips, interfaces and sockets, etc.
  - **Form factor :** refers to the motherboard's geometry, dimensions, arrangement and electrical requirements. Different standards have been developed to build motherboards, which can be used in different brands of cases. Advanced Technology Extended (ATX) is the most common design of motherboard for desktop computers.
  - Chipset :

# The Computer System Hardware

## Inside a Computer Cabinet :

Motherboard :

- **Chipset**: Chipset is a circuit, which controls the majority of resources (including the bus interface with the processor, cache memory and RAM, expansion cards, etc.) Chipset's job is to coordinate data transfers between the various components of the computer (including the processor and memory). It is important to choose a motherboard, which includes a recent chipset, in order to maximize the computer's upgradeability.
- **Processor socket:**
- **Basic Input Output System (BIOS):** basic program used as an interface between the operating system and the motherboard.
- Complementary Metal-Oxide Semiconductor (CMOS) Chip: BIOS ROMs are accompanied by a smaller CMOS memory chip. CMOS chip saves some system information, such as time, system date and essential system settings. CMOS is kept powered by a battery located on the motherboard. Information of the hardware installed in the computer (such as the number of tracks or sectors on each hard drive) is stored in the CMOS chip.

# The Computer System Hardware

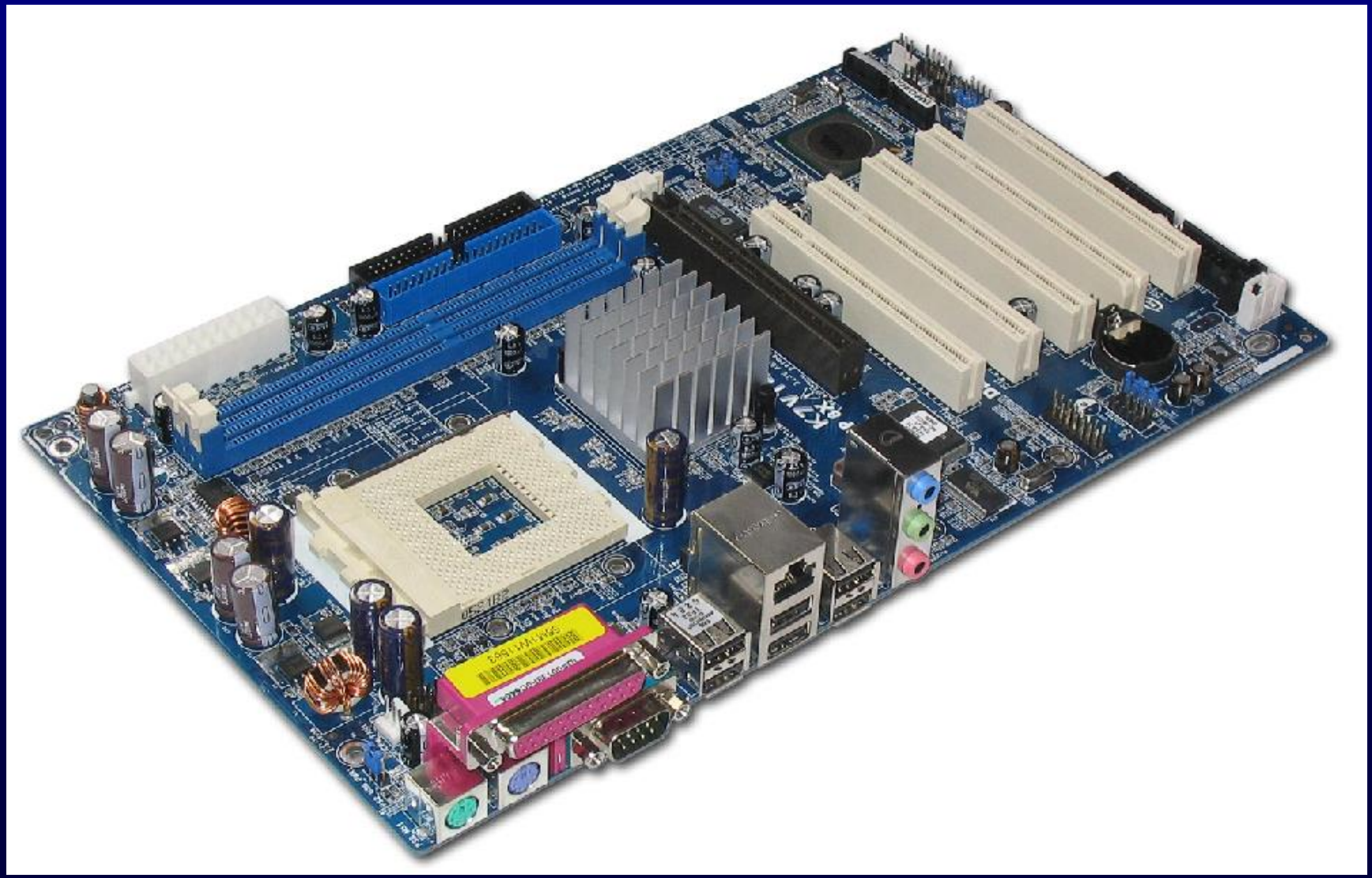
## Inside a Computer Cabinet :

### BIOS Vs CMOS

- Many people use the terms BIOS (basic input/output system) and CMOS (complementary metal oxide semiconductor) interchangeably, but in actuality, they are distinct, though related, components of a computer. The BIOS is the program that starts a computer up, and the CMOS is where the BIOS stores the date, time, and system configuration details it needs to start the computer.

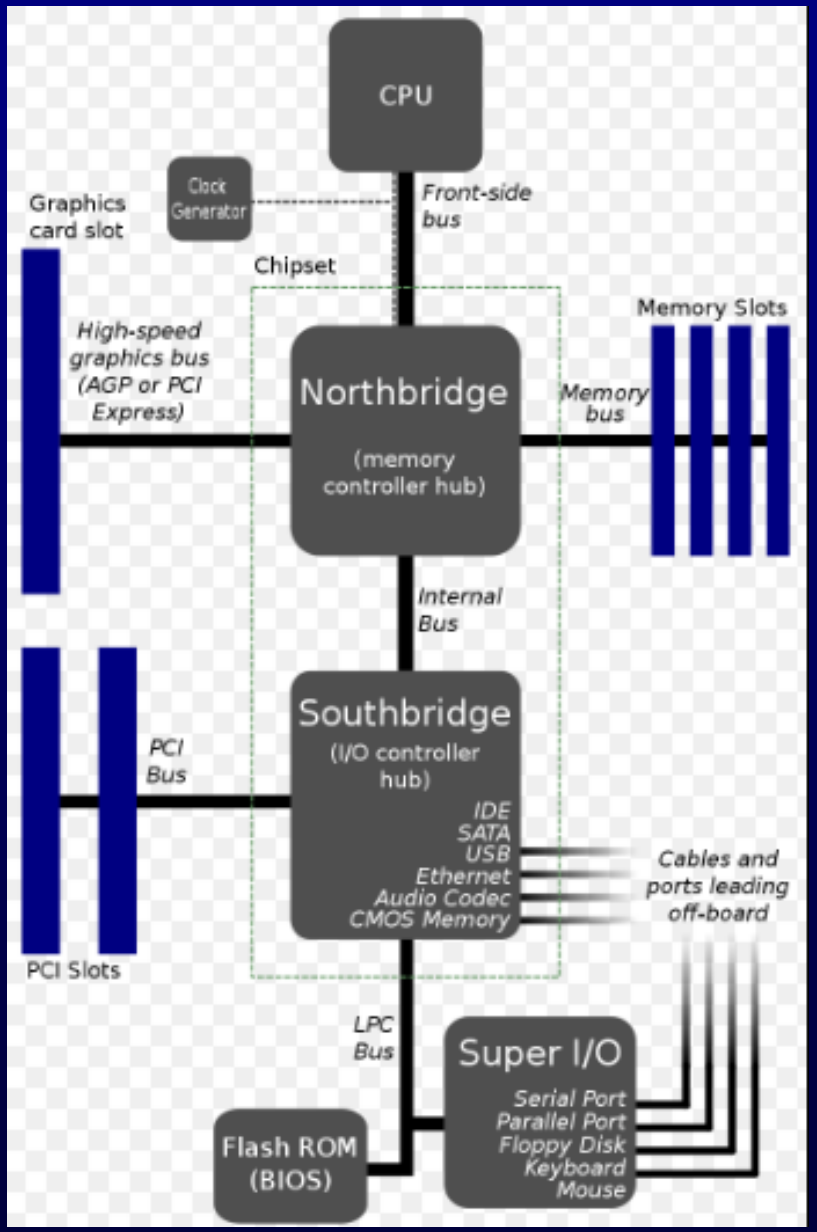
# The Computer System Hardware

**Motherboard:**



# The Computer System Hardware

**Chipset:**



# The Computer System Hardware

## Inside a Computer Cabinet :

### Ports and Interfaces:

- Motherboard has a certain number of I/O sockets that are connected to the ports and interfaces found on the rear side of a computer. You can connect external devices to the ports and interfaces, which get connected to the computer's motherboard.

**Expansion Slots:** The expansion cards are inserted in the expansion slots. These cards give the computer new features or increased performance. There are several types of slots:

- ISA (Industry Standard Architecture) slot—To connect modem and input devices.
- PCI (Peripheral Component InterConnect) slot—To connect audio, video and graphics. They are much faster than ISA cards.
- AGP (Accelerated Graphic Port) slot—A fast port for a graphics card.
- PCI (Peripheral Component InterConnect) Express slot—Faster bus architecture than AGP and PCI buses.
- PC Card—It is used in laptop computers. It includes Wi-Fi card, network card and external modem.

# The Computer System Hardware

## Inside a Computer Cabinet :

**Ribbon Cables:**

**Memory Chips:**

**Storage Device:**

**Processor:**

# Course Contents

## Unit-02: Computer Hardware (8 Hrs.)

Computer memory: Memory Representation; Memory Hierarchy; CPU Register; Cache Memory; Primary Memory(RAM, ROM); Secondary Memory(Magnetic Tape; Magnetic Disk; Optical Disk; Magneto-Optical Disk, Flash Memory Device), Access types of storage devices(sequential and direct)

# COMPUTER MEMORY

## Computer memory:

## Chapter Objectives:

- As we know, for processing of data and instructions, the processor uses its registers, cache memory, primary memory and secondary memory.
- As a computer user, we need to be aware of the memory present in a computer.
- This chapter describes the different kind of memories, their use and the interaction between them.

# COMPUTER MEMORY

## Chapter Objectives:

- What is the unit of memory representation in a computer?
- What is the significance of a byte?
- What are the two key factors that characterize the memory?
- List the key features of the internal memory
- List the key features of the main memory
- Which is the fastest memory?
- List the different memories available in the computer in order of their hierarchy with respect to the CPU.
- Why is primary memory faster than the secondary memory?
- Define a cache hit and cache miss.
- What is the purpose of the Registers?
- What is the purpose of the cache memory?

# COMPUTER MEMORY

## Chapter Objectives:

- List the characteristic features of the RAM.
- What is the meaning of volatile memory?
- Name the two categories of RAM chips.
- List the features of the DRAM memory chip.
- List the features of the SRAM memory chip.
- Define a **memory module**.
- What are the functions of Bootstrap loader, POST and CMOS chip?
- What is a bootstrap loader?
- List the different kinds of ROM memory.
- How are these different—PROM, EPROM and EEPROM?
- What is a flash memory?
- What are the features of the flash memory?

# COMPUTER MEMORY

## Chapter Objectives:

- What do you mean by sequential access?
- What is the meaning of direct access?
- Give an example of sequential access device and direct access device.
- Explain briefly the working of the magnetic tape.
- What is the significance of track and frame in a magnetic tape?
- How does a magnetic tape drive work?
- List the features of a magnetic tape.

# COMPUTER MEMORY

## INTRODUCTION:

- The computer's memory stores data, instructions required during the processing of data, and output results.
- Different types of memories, each having its own unique features, are available for use in a computer.
- The registers, cache memory, and RAM are fast memories and store the data and instructions temporarily during the processing of data and instructions.
- The secondary memory like magnetic disks and optical disks have large storage capacities and store the data and instructions permanently, but are slow memory devices.
- The memories are organized in the computer in a manner to achieve high levels of performance at the minimum cost.

# Memory Representation

## Memory Representation:

- The computer memory stores different kinds of data like input data, output data, intermediate results, etc., and the instructions.
- Binary digit or bit is the basic unit of memory. A bit is a single binary digit, i.e., 0 or 1.
- A bit is the smallest unit of representation of data in a computer.
- However, the data is handled by the computer as a combination of bits.
- A group of 8 bits form a byte. One byte is the smallest unit of data that is handled by the computer.
- One byte can store $2^8$, i.e., 256 different combinations of bits, and thus can be used to represent 256 different symbols.
- In a byte, the different combinations of bits fall in the range 00000000 to 11111111.
- A group of bytes can be further combined to form a word. A word can be a group of 2, 4 or 8 bytes.

# Memory Representation

## Memory Representation:

- 1 bit = 0 or 1
- 1 Byte (B) = 8 bits
- 1 Kilobyte (KB) = $2^{10}$ = 1024 bytes
- 1 Megabyte (MB) = $2^{20}$ = 1024KB
- 1 Gigabyte (GB) = $2^{30}$ = 1024 MB = 1024 *1024 KB
- 1 Terabyte (TB) = $2^{40}$= 1024 GB = 1024 * 1024 *1024 KB

# Memory Representation

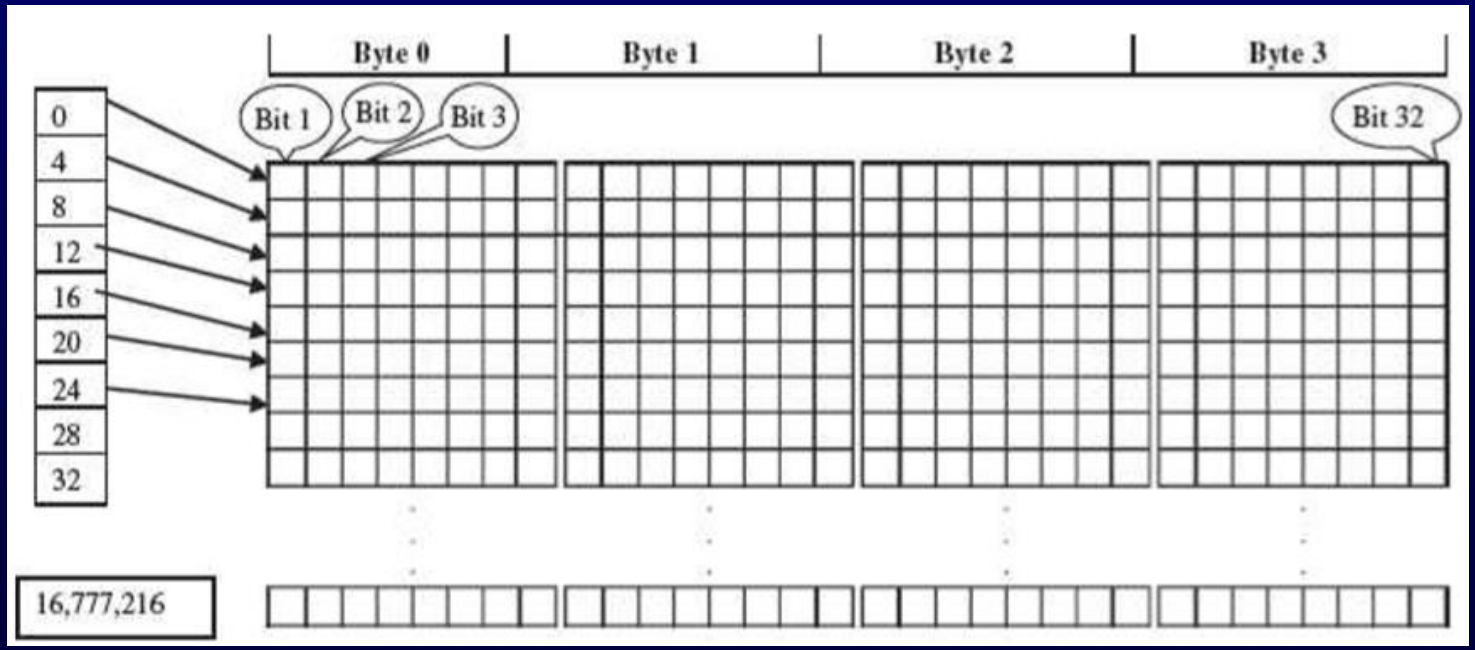
**Memory Representation:**

- The number of bytes and words used for an individual data value will vary depending on the storage format (OS, computer hardware) but in many cases, a single letter or character of text takes up **one byte** and an integer number takes up **one word**. A real or decimal number takes up **one or two words** depending on how it is stored.
- For example, the text *"hello"* would take up 5 bytes of storage, one per character.

# Memory Representation

## Memory Representation:

- Memory is logically organized as a linear array of locations. For a processor, the range of the memory addresses is 0 to the maximum size of memory. Figure shows the organization of a 16 MB block of memory for a processor with a 32-bit word length.



# Memory Hierarchy

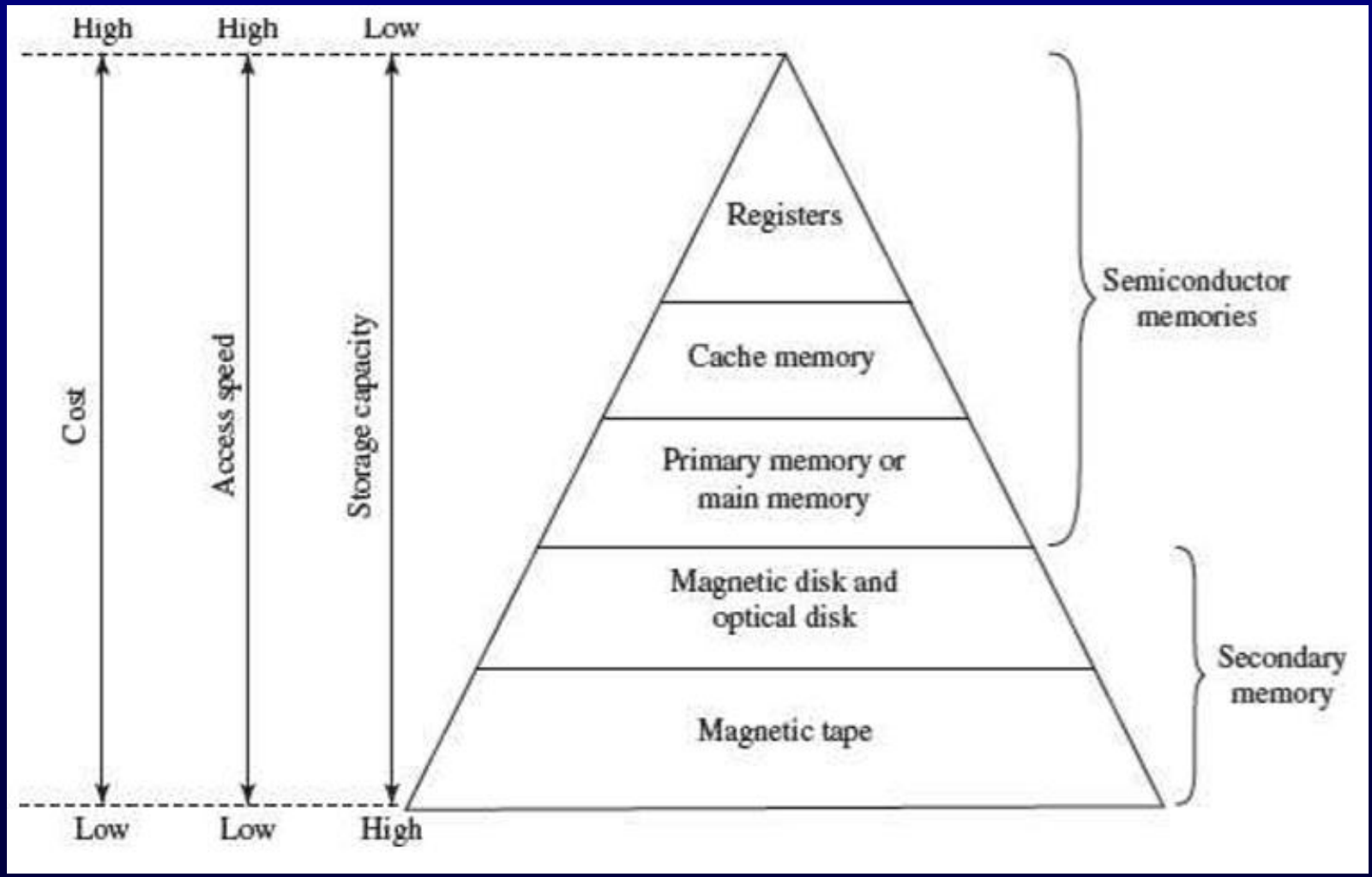
Memory is characterized on the basis of two key factors

1. Capacity
2. Access time

- Capacity is the amount of information (in bits) that a memory can store.
- Access time is the time interval between the read/ write request and the availability of data.
- The lesser the access time, the faster is the speed of memory.
- Ideally, we want the memory with fastest speed and largest capacity. However, the cost of fast memory is very high.
- The computer uses a hierarchy of memory that is organized in a manner to enable the fastest speed and largest capacity of memory.

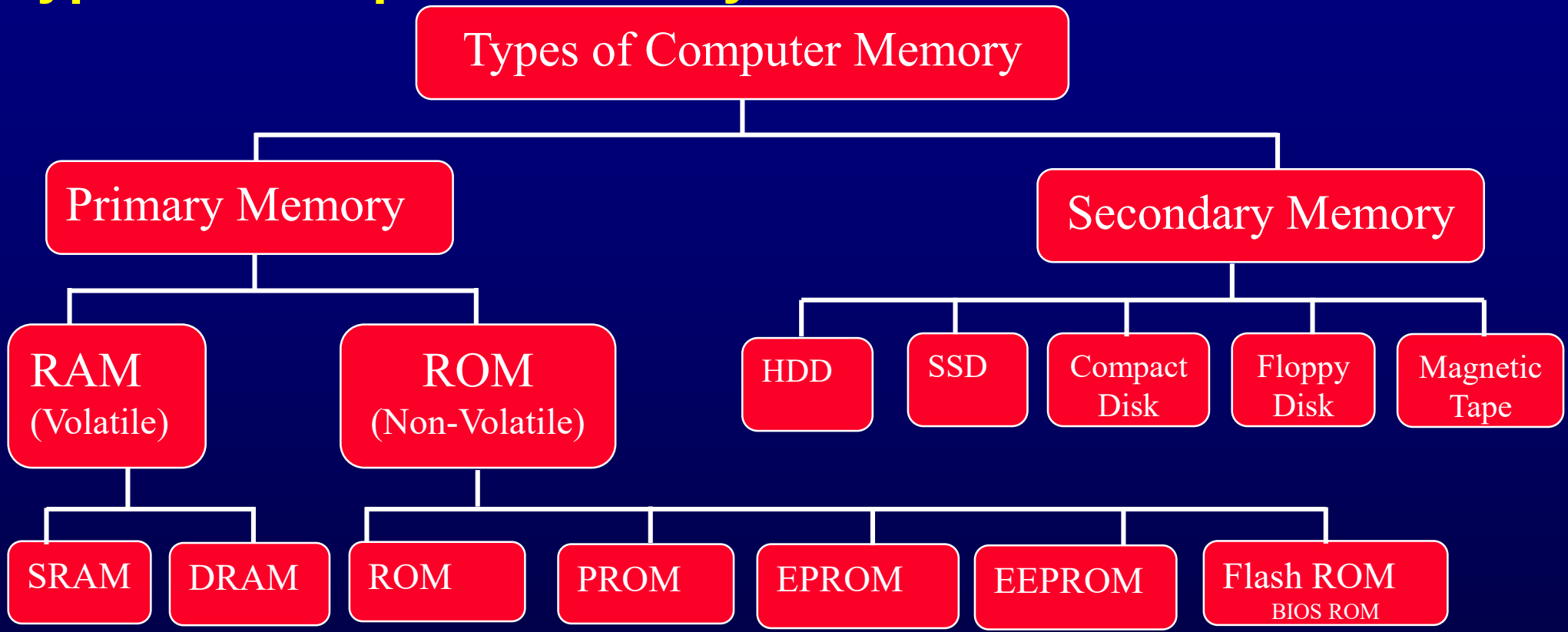
# Memory Hierarchy

The hierarchy of the different memory types is



# Memory Hierarchy

## Types of computer memory:




- Very first ROM is also called **Masked ROM**
- Single Data Rate: (SDR) DRAM
- Dual Data Rate :(DDR) DRAM
- DDR2 , DDR3, and DDR4, which offer better performance and are more energy efficient than DDR. Different versions are incompatible, so it is not possible to mix DDR2 with DDR3 DRAM in a computer system.

# Memory Hierarchy

- Computer used internal and external memory
- The internal memory consists of the registers, cache memory and primary memory used by the CPU to perform the computing tasks.
- The secondary memory is used to store the large amount of data and the software .

# Memory Hierarchy

## Internal Memory:

The key features of internal memory are

(1) limited storage capacity, (2) temporary storage, (3) fast access, and (4) high cost.

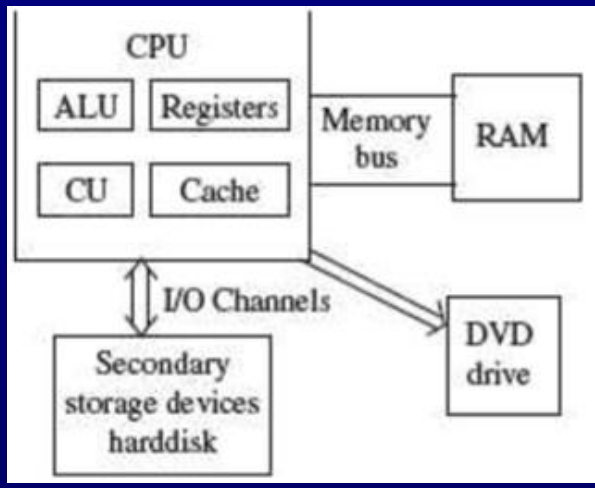
- Registers are the fastest and the most expensive among all the memory types. The registers are located inside the CPU, and are directly accessible by the CPU. The speed of registers is between 1-2 ns (nanosecond). The sum of the size of registers is about 200B.
- Cache memory is next in the hierarchy and is placed between the CPU and the main memory. The speed of cache is between 2-10 ns. The cache size varies between 32 KB to 4MB.
- Any program or data that has to be executed must be brought into RAM from the secondary memory. Primary memory is relatively slower than the cache memory. The speed of RAM is around 60ns. The RAM size varies from 512KB to 3GB (???).

# Memory Hierarchy

## Secondary Memory:

Key features of secondary memory storage devices are

(1) very high storage capacity, (2) permanent storage (non-volatile), unless erased by user, (3) relatively slower access, (4) stores data and instructions that are not currently being used by CPU but may be required later for processing, and (5) cheapest among all memory.




- The storage devices consist of two parts - drive and device. For example, magnetic tape drive and magnetic tape, magnetic disk drive and disk, and optical disk drive and disk.
- The speed of magnetic disk is around 60ms. The capacity of a hard disk ranges from 160 GB to 1,600 GB (1.6 Tera Bytes ???).
- Figure shows the interaction between CPU and memory.

# Memory Hierarchy

## Secondary Memory:

To get the fastest speed of memory with largest capacity and least cost, the fast memory is located **close** to the processor.

The secondary memory, which is not as fast, is used to store information permanently, and is placed **farthest** from the processor.

With respect to CPU, the memory is organized as follows:

- Registers are placed inside the CPU (small capacity, high cost, very high speed)
- Cache memory is placed next in the hierarchy (inside and outside the CPU)
- Primary memory is placed next in the hierarchy
- Secondary memory is the farthest from CPU (large capacity, low cost, low speed).

# Memory Hierarchy

## Secondary Memory:

- The speed of memories is dependent on the kind of technology used for the memory.
- The registers, cache memory and primary memory are semiconductor memories. They do not have any moving parts and are fast memories.
- The secondary memory is magnetic or optical memory, has moving parts and has slow speed.

# Memory Hierarchy

## CPU REGISTERS:

- Registers are very high-speed storage areas located inside the CPU.
- After CPU gets the data and instructions from the cache or RAM, the data and instructions are moved to the registers for processing.
- Registers are manipulated directly by the control unit of CPU during instruction execution. That is why registers are often referred to as the CPU's working memory.
- Since CPU uses registers for the processing of data, the number of registers in a CPU and the size of each register affect the power and speed of a CPU.
- The more the number of registers (ten to hundreds) and bigger the size of each register (8 bits to 64 bits), the better it is.

# Memory Hierarchy

## CACHE MEMORY:

- Cache memory is placed in between the CPU and the RAM.
- Cache memory is a fast memory, faster than the RAM.
- When the CPU needs an instruction or data during processing, it first looks in the cache. If the information is present in the cache, it is called a cache hit, and the data or instruction is retrieved from the cache. If the information is not present in cache, then it is called a cache miss and the information is then retrieved from RAM.
- The content of cache is decided by the cache controller (a circuit on the motherboard). The most recently accessed information or instructions help the controller to guess the RAM locations that may be accessed next. To get good system performance, the number of hits must far outnumber(more than) the misses.
- The two main factors that affect the performance of cache are its size and level (L1, L2 and L3).

# Memory Hierarchy

## PRIMARY MEMORY:

- Primary memory is the **main memory**. It is a chip mounted on the motherboard of computer. Primary memory is categorized into two main types
  1. Random Access Memory (RAM)
  2. Read Only Memory (ROM)
- RAM is used for the temporary storage of input data, output data and intermediate results.
- Unlike RAM, the data once stored in ROM either cannot be changed or can only be changed using some special operations.
- ROM is used to store the data that does not require a change.
- Flash memory is another form of rewritable read-only memory(ROM) that is compact, portable, and requires little energy.

# Memory Hierarchy

## Random Access Memory(RAM):

- RAM (volatile memory) is used to store data and instructions during the operation of computer.
  - The data and instructions that need to be operated upon by CPU are first brought to RAM from the secondary storage devices like the hard disk.
  - CPU interacts with RAM to get the data and instructions for processing.
- RAM provides random access to the stored bytes, words, or larger data units. This means that it requires same amount of time to access information from RAM, irrespective of where it is located in it.
- RAM can be read from and written to with the same speed.
- The size of RAM is limited due to its high cost. The size of RAM is measured in MB or GB.
- The performance of RAM is affected by
  - Access speed (how quickly information can be retrieved). The speed of RAM is expressed in nanoseconds.
  - Data transfer unit size (how much information can be retrieved in one request).

# Memory Hierarchy

## Random Access Memory(RAM):

- RAM affects the speed and power of a computer. More the RAM, the better it is. Nowadays, computers generally have 512 MB to 4 GB(**??**) of RAM.
- RAM is a microchip implemented using semiconductors.
- There are two categories of RAM, depending on the technology used to construct a RAM
  1. Dynamic RAM (DRAM)
  2. Static RAM (SRAM).

# Memory Hierarchy

## DRAM:

DRAM is the most common type of memory chip. DRAM is mostly used as main memory since it is small and cheap.

- It uses transistors and capacitors. The capacitor holds the bit of information 0 and 1. The transistor and capacitor are paired to make a memory cell. The transistor acts as a switch that lets the control circuitry on the memory chip read the capacitor or change its state.
- DRAM must be refreshed continually to store information. For this, a memory controller is used. The memory controller recharges all the capacitors holding a 1 before they discharge. To do this, the memory controller reads the memory and then writes it right back.
- DRAM gets its name from the refresh operation that it requires to store the information; otherwise it will lose what it is holding. The refresh operation occurs automatically thousands of times per second. DRAM is slow because the refreshing takes time.
- Access speed of DRAM ranges from 50 to 150 ns.

# Memory Hierarchy

SRAM:

- SRAM chip is usually used in cache memory due to its high speed.
- SRAM uses multiple transistors (four to six), for each memory cell. It does not have a capacitor in each cell.
- A SRAM memory cell has more parts so it takes more space on a chip than DRAM cell.
- It does not need constant refreshing and therefore is faster than DRAM.
- SRAM is more expensive than DRAM, and it takes up more space.
- It stores information as long as it is supplied with power.
- SRAM are easier to use and very fast. The access speed of SRAM ranges from 2 to 10 nanosecond.

# Memory Hierarchy

**Keys differences between DRAM and SRAM:**

- The key differences between DRAM and SRAM is that SRAM is 2 or 3 times **faster** than DRAM - but more expensive and bulkier.
- SRAM is usually available in **megabytes**, while DRAM is purchased in gigabytes.
- DRAM uses **more energy** than SRAM because it constantly needs to be refreshed to maintain data integrity
- SRAM does not need constant **refreshing** when it is powered up.

# Memory Hierarchy

## Memory Chip:

- The memory chips are available on a separate Printed Circuit Board (PCB) that is plugged into a special connector on the motherboard.
- Memory chips are generally available as part of a card called a **memory module**.
- There are generally two types of RAM modules
  1. Single Inline Memory Module (SIMM)
  2. Dual Inline Memory Module (DIMM).


- SIMM modules have memory chip on one side of the PCB. SIMM modules can store 8 bits to 32 bits of data simultaneously.
- DIMM modules have memory chips on both sides of the PCB. DIMM format are 64–bit memories. Smaller modules known as Small Outline DIMM (SO DIMM) are designed for portable computers. SO DIMM modules have 32–bit memory.

# Memory Hierarchy

## DRAM (Dynamic RAM):

- It is the most common type of RAM used in computers.
- The oldest type is known as Single Data Rate (SDR) DRAM
- Newer computers use faster Dual Data Rate (DDR) DRAM.
- DDR comes in several versions including DDR2 , DDR3, and DDR4, which offer better performance and are more energy efficient than DDR.
- It is not possible to mix DDR2 with DDR3 DRAM in a computer system. Different versions are incompatible.

# Memory Hierarchy

## DRAM (Dynamic RAM):

| DDR3 | DDR4 |
|---|---|
| DDR3 stands for Double Data Rate version 3. | Whereas DDR4 stands for Double Data Rate version 4. |
| The cost of DDR3 is less than DDR4. | While it's cost is higher or more than DDR3. |
| In DDR3, auto-refresh and self-refresh are performed to refresh its content. | While in DDR4, only self-refresh is performed to refresh its content. |
| DDR3 consumes low power than DDR2 but less than DDR4. | Whereas DDR4 consumes low power than DDR3. |
| The speed of DDR3 is slightly slow in comparison of DDR4. | While it's speed is faster than DDR3. |
| DDR3 has a maximum of 16 GB memory. | While DDR4 has no maximum limit or capability. |
| The clock speed of DDR3 vary from 800 MHz to 2133 MHz. | While the minimum clock speed of DDR4 is 2133 MHz and it has no defined maximum clock speed. |
| DDR3 has lower latency than DDR4. | While DDR4 has slightly more latency than DDR3. |

# Memory Hierarchy

## ROM Computer Memory:

- ROM (read-only memory) means data can be read from this type of memory, data cannot normally be written to it.
- It is a very fast type of computer memory which is usually installed close to the CPU on the motherboard.
- ROM is a type of non-volatile memory, which means that the data stored in ROM persists in the memory even when it receives no power. In that sense it is similar to secondary memory, which is used for long term storage.
- When a computer is turned on, the CPU can begin reading information stored in ROM without the need for drivers or other complex software to help it communicate.
- The ROM usually contains "bootstrap code" which is the basic set of instructions a computer needs to carry out to become aware of the operating system stored in secondary memory, and to load parts of the operating system into primary memory so that it can start up and become ready to use.
- ROM is also used in simpler electronic devices to store firmware which runs as soon as the device is switched on.

# Memory and its classification

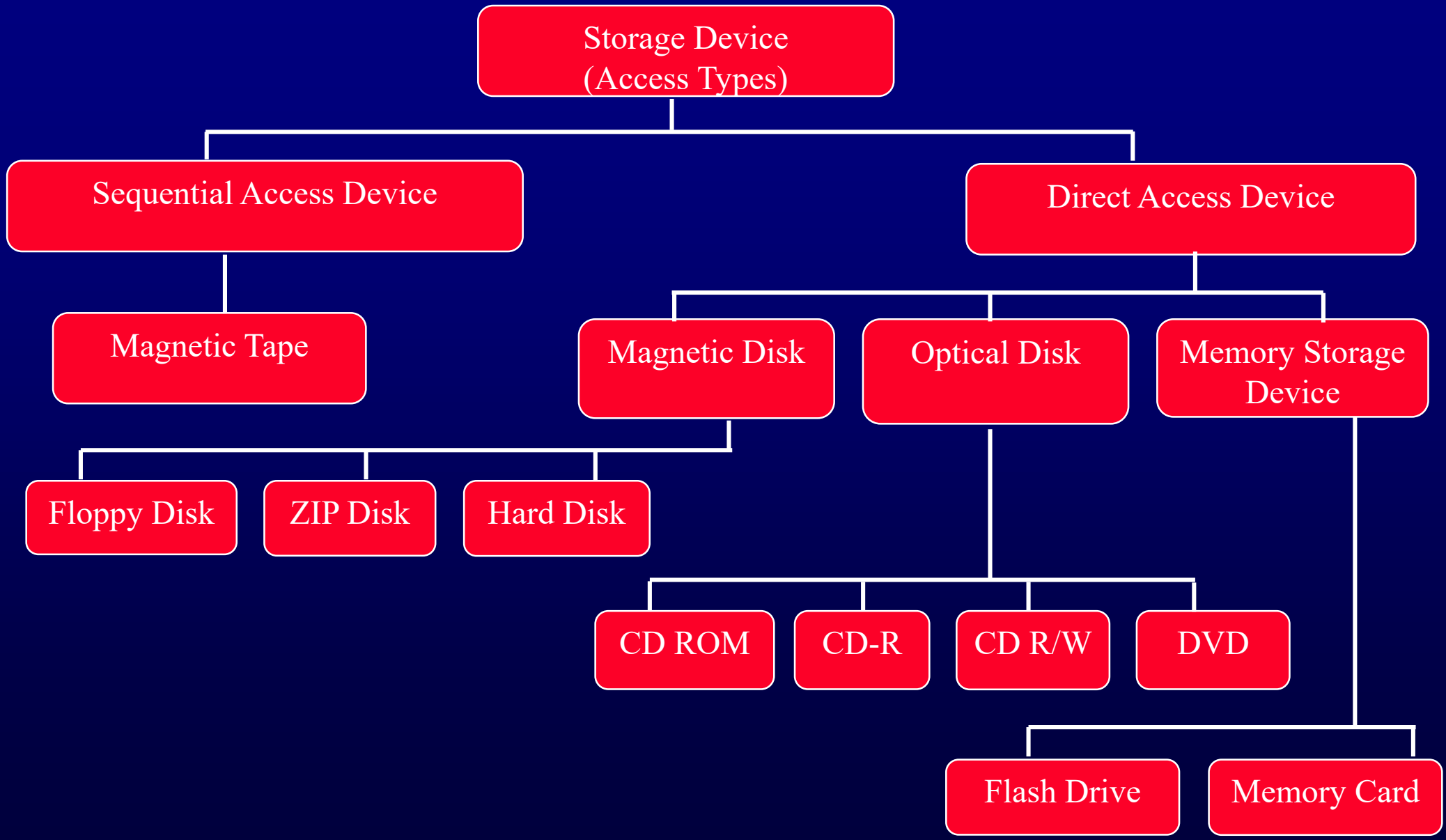
## Types of ROM:

- **ROM**(or **Masked ROM)** Preprogrammed set of data or instructions are stored in ROM. The contents of such ROMs have to be specified before chip production. ROM is available in several different types, including PROM, EPROM, EEPROM and Flash ROM.
- **PROM** (Programmable Read-Only Memory), and it is different from true ROM. ROM is programmed during the manufacturing process, a PROM is manufactured in an empty state and then programmed later using a PROM programmer or burner.
- **EPROM** (Erasable Programmable Read-Only Memory) and data stored in an EPROM can be erased and the EPROM reprogrammed. Erasing an EPROM involves removing it from the computer and exposing it to ultraviolet light before re-burning it.

# Memory and its classification

- **EEPROM** (Electrically Erasable Programmable Read-Only Memory). Distinction between EPROM and EEPROM is that the latter can be erased and written to by the computer system it is installed in. EEPROM is not strictly read-only. However in many cases the write process is slow, so it is normally only done to update program code such as firmware or BIOS code on an occasional basis.
- Flash ROM: Also called Flash BIOS or flash memory. This memory should be constantly powered and act as non-volatile memory in computer. Function of Flash ROM are
  - Power On Self Test(POST) – Checks the major hardware components
  - BIOS Setup program – built in utility in BIOS which control how the computer works i.e. system settings, find bootable devices, interrupt handlers and device drivers
  - Bootstrap loader: is a program to start the computer software for operation when the power is ON.

# Memory Hierarchy



# Memory Hierarchy

## Types of Secondary memory:

Secondary memory stores much larger amounts of data and information (for example, an entire software program) for extended periods of time. The data and instructions stored in secondary memory must be fetched into RAM before processing is done by CPU.

Magnetic tape drives, magnetic disk drives, optical disk drives and magneto-optical disk drives are the different types of storage devices.

## ACCESS TYPES OF STORAGE DEVICES:

The information stored in storage devices can be accessed in two ways:

1. Sequential access
2. Direct access

# Memory Hierarchy

## Sequential Access Devices:

- Sequential access means that computer must run through the data in sequence, starting from the beginning, in order to locate a particular piece of data.
- Magnetic tape is an example of sequential access device.
- Let us suppose that magnetic tape consists of 80 records. To access the $25^{th}$ record, the computer starts from first record, then reaches second, third etc. until it reaches the $25^{th}$ record. Sequential access devices are generally slow devices.

## Direct Access Devices:

- Direct access devices are the ones in which any piece of data can be retrieved in a non-sequential manner by locating it using the data's address. It accesses the data directly, from a desired location.
- Magnetic disks and optical disks are examples of direct access devices.

# Memory Hierarchy

## Access Types Storage Devices

1. **Sequential Access**
    1) Magnetic Tape
2. **Direct Access**
    1) Magnetic Disk
    2) Floppy Disk
    3) Hard Disk
    4) ZIP Disk (Magneto-Optical Disk)
    5) Optical Disk
        1) CD-R, CD-R/W, DVD-R, DVD-R/W

# Memory Hierarchy

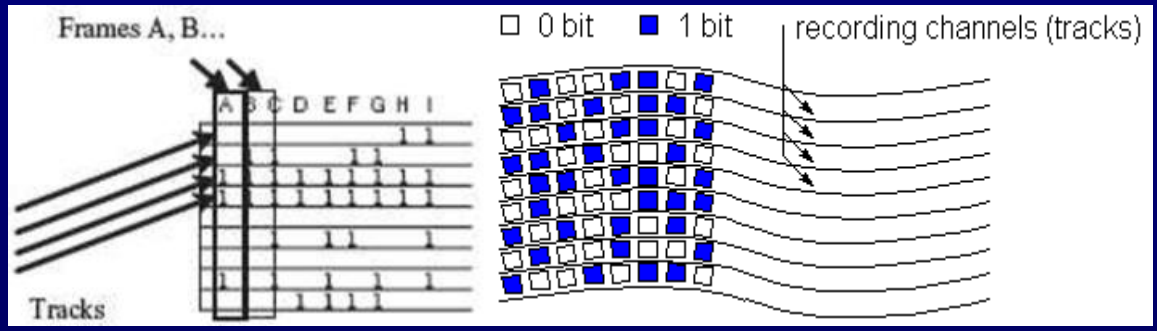
## MAGNETIC TAPE:

- Magnetic tape is a plastic tape with magnetic coating. Magnetic tapes are cheaper storage media. They are durable, can be written, erased, and re-written.
- Magnetic tapes are sequential access devices, which mean that the tape needs to rewind or move forward to the location where the requested data is positioned in the magnetic tape.
- Due to their sequential nature, magnetic tapes are not suitable for data files that need to be revised or updated often.
- They are generally used to store back-up data that is not frequently used or to transfer data from one system to other.

# Memory Hierarchy

## MAGNETIC TAPE:

- Legacy open reel tapes used 9 linear tracks (8 bits plus parity), while modern cartridges use 128 or more tracks.


- A frame stores one byte of data, and a track in a frame stores one bit. Data is stored in successive frames as a string with one data (byte) per frame.
- Data is recorded on tape in the form of blocks, where a block consists of a group of data also called as records. Each block is read continually. There is an Inter-Record Gap (IRG) between two blocks that provides time for the tape to be stopped and started between records.

# Memory Hierarchy

## MAGNETIC TAPE:

- Magnetic tape is mounted on a magnetic tape drive for access.
- The basic magnetic tape drive mechanism consists of the supply reel, take-up reel, and the read/write head assembly.
- The magnetic tape moves on tape drive from the supply reel to take-up reel, with its magnetic coated side passing over the read/write head.
- The storage capacity of the tape varies greatly. A 10–inch diameter reel of tape which is 2400 feet long can store up to 180 million characters.

# Memory Hierarchy

## MAGNETIC TAPE:

The features of magnetic tape are:

- Inexpensive storage device
- Can store a large amount of data
- Easy to carry or transport
- Not suitable for random access data
- Slow access device
- Needs dust prevention, as dust can harm the tape
- Suitable for back-up storage or archiving

# COMPUTER MEMORY

## Chapter Objectives:

- What do you mean by sequential access?
- What is the meaning of direct access?
- Give an example of sequential access device and direct access device.
- Explain briefly the working of the magnetic tape.
- What is the significance of track and frame in a magnetic tape?
- How does a magnetic tape drive work?
- List the features of a magnetic tape.

# COMPUTER MEMORY

## Questions: Magnetic Disk

- Explain briefly the working of the magnetic disk.
- What is the significance of track and sector in a magnetic disk?
- Define (i) seek time, (ii) latency time, (iii) data transfer rate, and (iv) access time of the magnetic disk.
- How is the access time of disk calculated? Explain in detail?
- List the features of the magnetic disk.
- What is the need of formatting the disk?
- Name the four areas that are created when the disk is formatted using FAT.
- Define (i) Boot sector, and (ii) File Allocation Table.
- How do you find data on a magnetic disk?
- What is the need of the root directory in a magnetic disk?

# Memory Hierarchy

## MAGNETIC DISK:

- Magnetic disk is a direct access secondary storage device.
- It is a thin plastic or metallic circular plate coated with magnetic oxide and encased in a protective cover. Data is stored on magnetic disks as magnetized spots. The presence of a magnetic spot represents the bit 1 and its absence represents the bit 0.

# Memory Hierarchy

**MAGNETIC DISK:** The working of magnetic disk:

The surface of disk is divided into concentric circles known as tracks. The outermost track is numbered 0 and the innermost track is the last track. Tracks are further divided into sectors. A sector is a pie slice that cuts across all tracks. The data on disk is stored in sector. Sector is the smallest unit that can be read or written on a disk. A disk has eight or more sectors per track.

- Magnetic disk is inserted into a magnetic disk drive for access. The drive consists of a read/write head that is attached to a disk arm, which moves the head. The disk arm can move inward and outward on the disk.

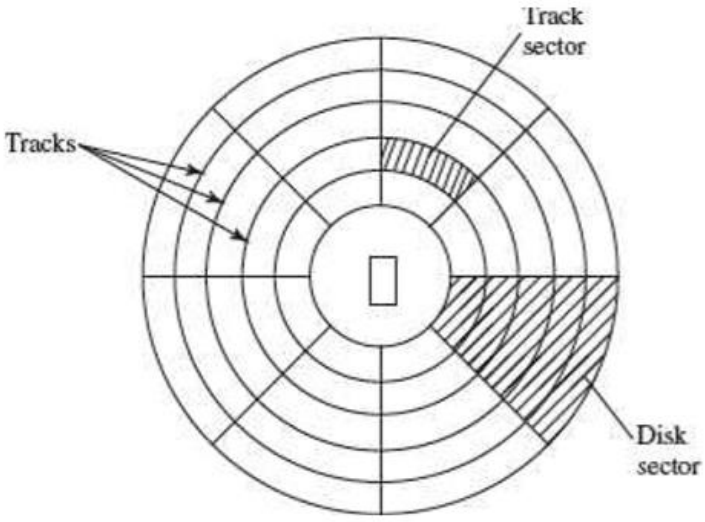



**Figure 3.10** Tracks and sectors of a disk

# Memory Hierarchy

**MAGNETIC DISK:** Accessing data on the disk requires the following:

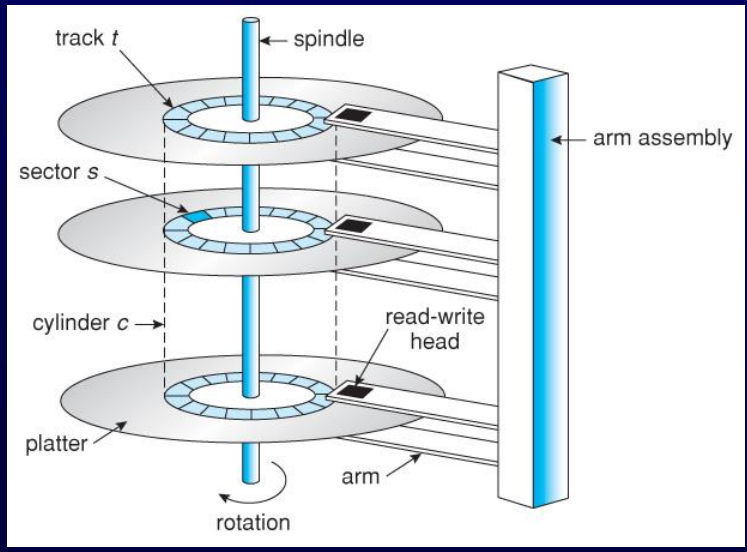
- The read/write head is positioned to the desired track where the data is to be read from or written to. The time taken to move the read/write head to the desired track is called the seek time.
- Once the read/write head is at the right track, then the head waits for right sector to come under it (disk is moving at high speed). The time taken for desired sector of the track to come under read/write head is called the latency time.
- Once the read/write head is positioned at the right track and sector, the data has to be written to disk or read from disk. The rate at which data is written to disk or read from disk is called data transfer rate.
- The sum of seek time, latency time and time for data transfer is the access time of the disk.

# Memory Hierarchy

## MAGNETIC DISK:

Accessing data on the disk requires the following:

- The storage capacity of disk drive is measured in gigabytes (GB).
- Large disk storage is created by stacking together multiple disks. A set of same tracks on all disks forms a cylinder. Each disk has its own read/write head which work in coordination.
- A disk can also have tracks and sectors on both sides. Such a disk is called double-sided disk.



# Memory Hierarchy

## MAGNETIC DISK:

The features of magnetic disk are:

- Cheap storage device
- Can store a large amount of data
- Easy to carry or transport
- Suitable for frequently read/write data
- Fast access device
- More reliable storage device
- To be prevented from dust, as the read/write head flies over the disk. Any dust particle in between can corrupt the disk.

# Memory Hierarchy

## MAGNETIC DISK:

Finding data on a magnetic disk is as follows:

- Disk need to format for use. Formatting includes assigning addresses to various locations on disk, assigning location of root directory and checking for defects on the surface of disk.
- During formatting, the tracks and sectors of a disk are labeled, which provides an address to each location of the disk.
- There are different methods to format a disk. File Allocation Table (FAT) is the commonly used logical format for disk formatting performed by Windows.
- The Windows XP and the Windows 2000 operating system use the New Technology File System (NTFS) file system. The NTFS file system offers better security and increased performance. It allows using of filenames that are more than eight characters long.

Floppy disk, hard disk and zip disk are the different types of magnetic disks.

# Memory Hierarchy

## MAGNETIC DISK:

Four areas are created when a disk is formatted using FAT

- Boot Sector: It contains the program that runs when the computer is started. The program checks if the disk has files required to run the operating system. It then transfers control to an operating system program which continues the startup process. Boot sector also contains information about the disk, like number of bytes per sector and number of sectors per track. This information is required by the operating system to access the data on the disk.
- File Allocation Table: It records the location of each file and status of each sector. While reading or writing to disk, operating system checks the FAT to find free area or locate where data is stored on disk, respectively.
- Root Directory: This is the main folder of disk. It contains other folders in it, creating a hierarchical system of folders. The root directory contains information about all folders on the disk.
- Data Area: The remaining area of the disk (after boot sector, FAT, root directory) is the data area. It stores the program files and data files that are stored on the disk.

# COMPUTER MEMORY

## Chapter Objectives: OPTICAL DISK

- List the key features of the optical disk.
- Why is optical disk generally slower than hard disk?
- List the key features of CD-ROM.
- List the key features of DVD-ROM.
- What are the approximate storage capacity ranges of the CD-ROM and DVD-ROM?
- What is a WORM disk?
- Write two features each of CD-R, CD-RW and DVD-R.
- What are magneto-optical disk?
- List the steps the computer performs when it is switched on till from the time it is ready for use.
- When you write a program and the electricity goes off, your program is lost if you have not saved it. Why?

# Memory Hierarchy

## OPTICAL DISK:

Optical disk is a flat and circular disk which is coated with reflective plastic material that can be altered by laser light. Optical disk does not use magnetism. The bits 1 and 0 are stored as spots that are relatively bright and light, respectively.

- An optical disk consists of a single spiral track that starts from the edge to the center of disk. Due to its spiral shape, it can access large amount of data sequentially, for example music and video. The random access on optical disk is slower than that of magnetic disk, due to its spiral shape.
- The tracks on optical disk are further divided into sectors which are of same length. Thus, the sectors near the center of disk wrap around the disk longer than the sectors on the edges of disk. Optical disks are generally slower than hard disks. Figure shows the tracks and sectors in a magnetic disk and optical disk

# Memory Hierarchy

## OPTICAL DISK:

- Optical disks can store large amount of data, up to 6 GB, in a small space. Commonly used optical disks store 600–700 MB of data.
- The access time for an optical disk ranges from 100 to 200 ms.
- There are two most common categories of optical disks—read-only optical disks and recordable optical disks.

## Optical Disk types are:

**Compact Disk (CD)**

**CD-R, CD-R/W**

Digital Video Disk-Read Only Memory (DVD-ROM)

**DVD-R, DVD-R/W**

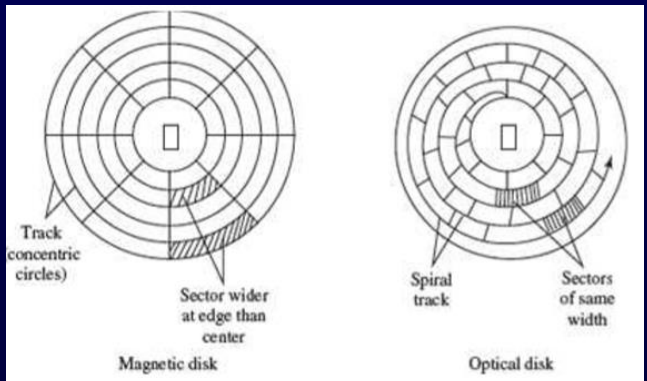



**Figure 3.15** Sectors and track in magnetic disk and optical disk

# Memory Hierarchy

## OPTICAL DISK: CD-ROM

- Originally, Compact Disk (CD) was a popular medium for storing music. Now, it is used in computers to store data and is called Compact Disk-Read Only Memory (CD-ROM).
- As the name suggests, CD-ROM is an optical disk that can only be read and not written on. CD-ROM is written on by the manufacturer of the CD-ROM using the laser light.
- A CD-ROM drive reads data from the compact disk. Data is stored as pits (depressions) and lands (flat area) on CD-ROM disk. When the laser light is focused on the disk, the pits scatter the light (interpreted as 0) and the lands reflect the light to a sensor (interpreted as 1).

# Memory Hierarchy

## OPTICAL DISK: CD-ROM

- As CD-ROM is read only, no changes can be made into the data contained in it.
- Since there is no head touching the disk, but a laser light, CD-ROM does not get worn out easily.
- The storage density of CD-ROM is very high and cost is low as compared to floppy disk and hard disk. (? )
- Access time of CD-ROM is less. CD-ROM drives can read data at 150Kbps. They come in multiples of this speed like—2x, 4x, 52x, 75x, etc.
- It is a commonly used medium for distributing software and large data.

# Memory Hierarchy

## OPTICAL DISK: DVD-ROM

- Digital Video Disk-Read Only Memory (DVD-ROM) is an optical storage device used to store digital video or computer data.
- DVDs look like CDs, in shape and physical size.
- It improves on CD technology.
- It is a high-density medium with increased track and bit density.
- DVD-ROM uses both sides of the disk and special data compression technologies. The tracks for storing data are extremely small.
- A full-length movie can be stored on a single disk.
- Each side of DVD-ROM can store 4.7 GB of data, so a single DVD can store 9.4 GB of data.
- New DVD-ROMs use layers of data track, to double its capacity. Such dual layer disks can store 17 GB of data.

# Memory Hierarchy

## OPTICAL DISK: Recordable Optical Disk

The recordable optical disks are:

- Compact Disk-Recordable (CD-R) is a Write Once-Read Many (WORM) disk. A CD-R disk allows the user to write data permanently on to the disk. Once the data is written, it cannot be erased. CD-R disk uses a laser that burns pits into the disk surface. It looks like a CD disk externally. To write to a CD-R disk, a device named CD-Writer or CD–burner is required. A CD-R disk can store 700 MB of data that can run for 80 minutes. CD-R is used to create music CDs in home computers, back up data from other storage devices, archives of large data, etc.
- Compact Disk-ReWritable (CD-RW) allows data to be written, erased and re-written on. The capacity of CD-RW is same as a CD. They generally do not play on all CD-ROM drives.
- Digital Video Disk-Recordable (DVD-R) allows recording of data on a DVD. A DVD writer device is required to write the data to DVD. The data once written on a DVD cannot be erased or changed.

# Memory Hierarchy

## MAGNETO-OPTICAL DISK:

The recordable optical disks are:

- A magneto-optical disk is a rewritable disk that makes use of both magnetic disk and optical technologies.
- Magneto-optical disks use laser beam to read data and magnetic field to write data to disk. These are optical disks where data can be written, erased and re-written.
- They are expensive and outdated. They were used during the mid 1990s. They have now been replaced by CD-RW and DVD-R.

# Memory Hierarchy

## Floppy Disk:

- Floppy disk (FD) is a flat, round, single disk made of Mylar plastic and enclosed in square plastic jacket.
- Floppy Disk Drive (FDD) is the disk drive for floppy disk.
- Floppy disk has a write-protect slide tab that prevents a user from writing to it.
- A floppy disk may be single-sided or double-sided disk, i.e., data can be read and written on one and both sides of floppy disk, respectively.
- They come in two basic sizes—5-¼ inch and 3-½ inch.
- The 5-¼ inch disk came around 1987. It can store 360 KB to 1.2 MB of data.
- The 3-½ inch disk has capacity of 400 KB to 1.44 MB. It usually contains 40 tracks and 18 sectors per track and can store 512 bytes per sector.

# Memory Hierarchy

## Zip Disk:

- They are high-capacity removable disk and drive.
- They have the speed and capacity of hard disk and portability of floppy disk.
- Zip disk are of the same size as floppy disk, i.e., 3–½ inch but have a much higher capacity than the floppy disk
- Zip disk and drive were made by Iomega Corp. It comes as a complete unit—disk, drive, connection cable, power cord and operating system. It can be connected to the computer system externally using a parallel chord or SCSI cable.
- Their capacity ranges from 100 MB to 750 MB. They can be used to store large files, audio and video data.

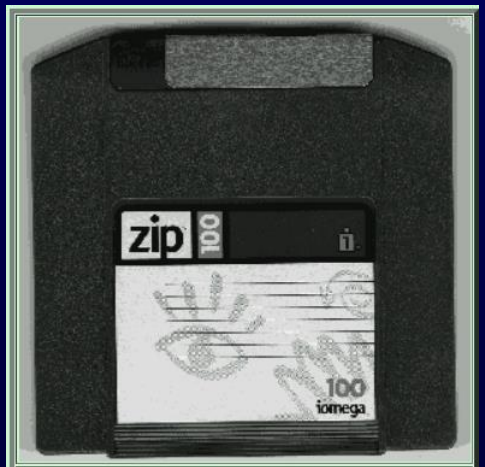


Figure 3: Iomega Zip Disk

# Memory Hierarchy

## USING THE COMPUTER MEMORY

The list of steps that the computer performs from the time it is switched on are:

- Turn the computer on.
- The computer loads data from ROM present in the BIOS. It makes sure that all the major components of the computer are functioning properly.
- The computer loads the BIOS from ROM. The BIOS provides the most basic information about storage devices, boot sequence, security, plug and play capability and other items.
- The computer loads the OS from the hard drive into the system's RAM. CPU has immediate access to the OS as the critical parts of the OS are maintained in RAM as long as the computer is on. This enhances the performance and functionality of the overall system.
- Now the system is ready for use.
- When you load or open an application it is loaded in the RAM. Since the CPU looks for information in the RAM, any data and instructions that are required for processing (read, write or update) is brought into RAM. To conserve RAM usage, many applications load only the essential parts of the program initially and then load other pieces as needed. Any files that are opened for use in that application are also loaded into RAM.

# Memory Hierarchy

## USING THE COMPUTER MEMORY

Continue…..

- The CPU requests the data it needs from RAM, processes it and writes new data back to RAM in a continuous cycle. The shuffling of data between the CPU and RAM happens millions of times every second.
- When you save a file and close the application, the file is written to the secondary memory as specified by you. The application and any accompanying files usually get deleted from RAM to make space for new data.
- If the files are not saved to a storage device before being closed, they are lost.

# Computer Hardware

## Unit-02:Computer Hardware

**Input and Output Devices:** Input-Output Unit; Input Devices; Human Data Entry Devices; Source Data Entry Devices; Output Devices; I/O Port; I/O System

# Computer Hardware

## Objectives of this chapter:

- We use the computer to process and do our job as we want.
- For that, we should be able to provide the data to the computer and also get the output from it.
- The input devices and output devices are used this purpose.
- The aim of this chapter is to introduce the different kinds of input and output devices.

# Input devices, Output devices, Interfaces

- What is input devices?
- Types of Input Devices?
- What is input interface and it's function?

- What is output devices?
- Types of output Devices?
- What is output interface and it's function?

- Difference between Device, Device Driver, Device Controller and I/O Ports.

# Computer Hardware

## INTRODUCTION:

- A computer interacts with the external environment via the input-output (I/O) devices attached to it.
- Input device is used for providing data and instructions to the computer. After processing the input data, computer provides output to the user via the output device.
- The I/O devices that are attached, externally, to the computer machine are also called **peripheral devices**.
- Different kinds of input and output devices are used for different kinds of input and output requirements.

# Input devices, Output devices, Interfaces

## Types of Input-output devices:

### 1. Input devices

a. Human data entry devices

- Keyboard
- Pointing devices—Mouse, trackball, joystick, digitizing tablet
- Pick devices—Light pen, touch screen

b. Source data entry devices

- Audio input device (microphone, sound card, speech recognition)
- Video input device (video camera, digital camera)
- Optical input devices—Scanner (hand held, flat bed), OCR, MICR, OMR, barcode reader

### 2. Output devices

a. Hard copy devices

- Printer—Impact printers (dot matrix, daisy wheel, drum), non-impact printers (ink-jet, laser)
- Plotter—Drum plotter, flatbed plotter
- Computer output on microfilm (microfiche)

b. Soft copy devices

- Monitor, visual display terminal, video output, audio response (speakers, headphone)

### 3. Input-Output Devices

- Hard disk drive, Floppy disk drive, USB drive, CD drive, DVD drive

# Input devices, Output devices, Interfaces

- **I/O port**
  - Parallel port, serial port, USB port, firewire port

- **Working of I/O system**
  - I/O devices, device controller, device driver

# Input devices, Output devices, Interfaces

## INPUT-OUTPUT UNIT:

- The I/O unit is composed of two parts
  1. Input unit
  2. Output unit.

- The input unit is responsible for providing input to the computer and the output unit is for receiving output from the computer.

# Input devices, Output devices, Interfaces

## Input Unit:

- The input unit gets the data and programs from various input devices and makes them available for processing to other units of the computer.
- Examples such as- keyboard, mouse, trackball and joystick, scanning images, voice recording, video recording, etc.
- Irrespective of the kind of input data, all input devices must translate the input data into a form that is understandable by the computer, i.e., in machine readable form.
- The transformation of the input data to machine readable form is done by the **input interface** of input device.

# Input devices, Output devices, Interfaces

## Output Unit :

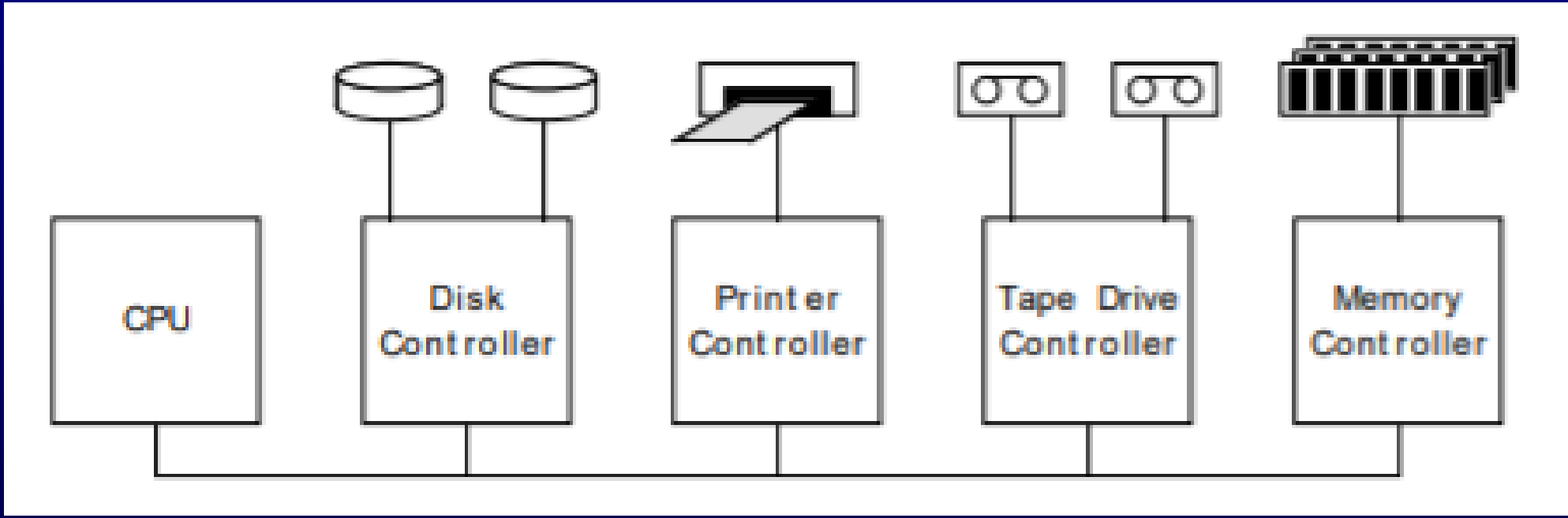
- The output unit gets the processed data from the computer and sends it to output devices to make them available to the user of computer.
- The output data is provided through output devices like display screen, printer, plotter and speaker.
- The processed data sent to the output device is in a machine understandable form. This processed data is converted to human readable form by the output interface of output device.

Note: In addition to input devices and output devices, some devices function as both input and output devices. The I/O devices provide the input to computer as well as get output from computer. The I/O devices are used by both the input unit and the output unit.

HDD, floppy drive, optical disk drive are examples of I/O devices.

# Input devices, Output devices, Interfaces

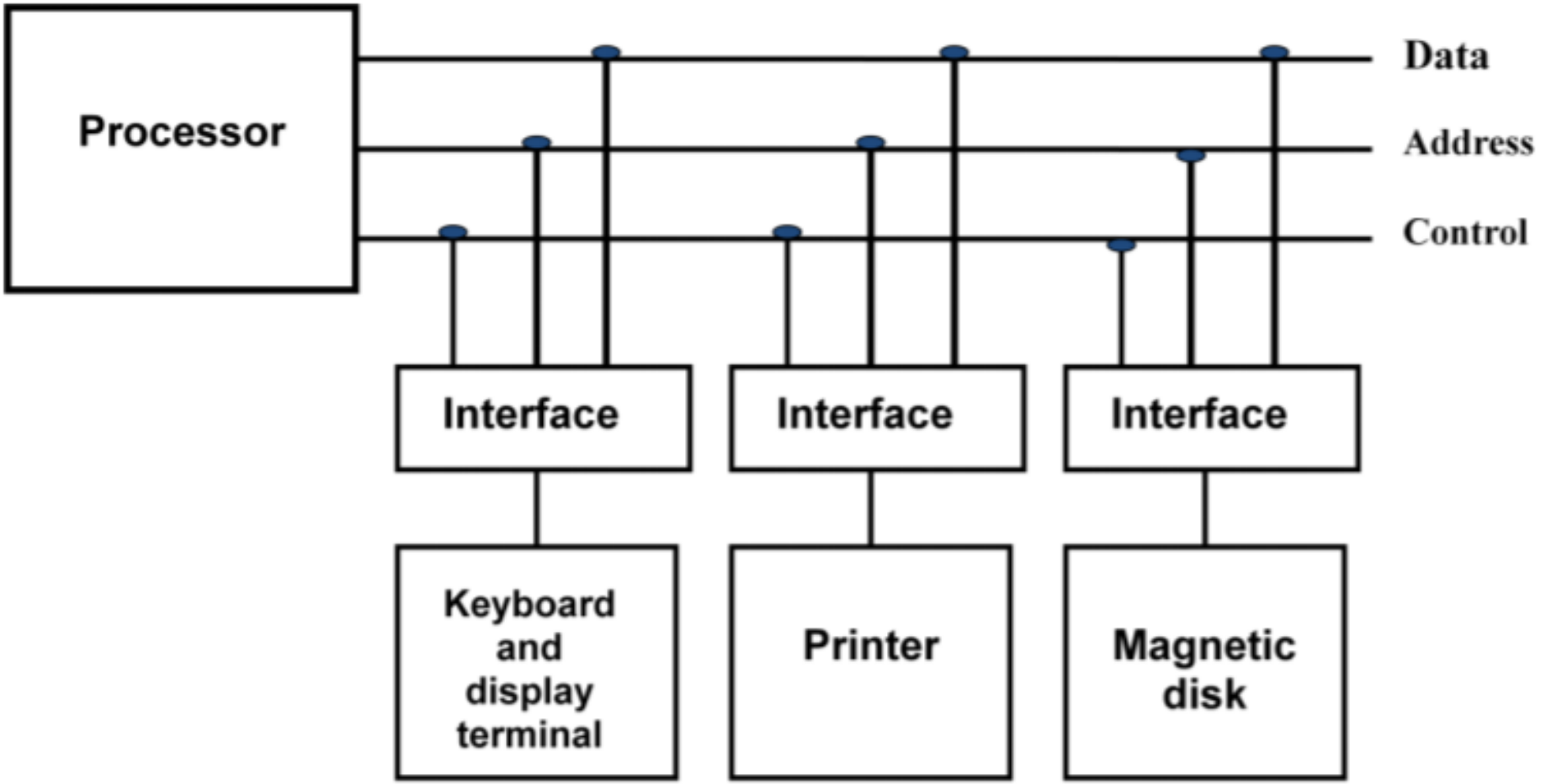
## Input - Output Interface:




CPU and device controllers all use a common bus for communication

# Input devices, Output devices, Interfaces

## Input - Output Interface:




Connection of I/O bus to input-output devices

# Input devices, Output devices, Interfaces

## Different I/O devices are:

- Input Devices: Keyboard, Mouse, Digitizing Tablet, Track Ball, Joystick, Touchscreen, Light Pen, Speech Recognition System, Digital camera, Scanner, Magnetic Ink Character Recognition (MICR), Optical Character Recognition (OCR), Optical Mark Recognition (OMR), Barcode Reader
- Output Devices: Monitor, Visual Display Terminal, Printer, Plotter, Computer Output on Microfilm (COM), Video Output System, Audio Response System
- Input Output Devices: Hard disk drive, Floppy disk drive, USB drive, CD drive, DVD drive

# Input devices, Output devices, Interfaces

## Categories of Input Devices

1. **Human Data Entry Devices**
   1) Keyboard
   2) Pointing Device (Mouse)
   3) Trackball
   4) Joystick
   5) Digitizing Tablet
   6) Pick Devices ( Light Pen, Touch Screen)
2. **Source data Entry Devices**
   1) Audio Input Device
   2) Video Input Device
3. **Optical Input Devices**
   1) Scanner (Hand-held Scanner, Flat-bed Scanner)
   2) OCR (Optical Character Recognition)
   3) MICR (Magnetic Ink Character Recognition)
   4) OMR (Optical Mark Recognition)
   5) Barcode Reader

# Input devices, Output devices, Interfaces

## Categories of Output Devices:

1. **Hard Copy Devices**
    1) Printer
    2) Plotter
    3) Computer Output on Microfilm (Microfiche)
2. **Soft Copy Devices**
    1) Monitor
    2) Visual Display Terminal
    3) Video Output (CRT, LCD, LED)
    4) Audio Response

# Input devices, Output devices, Interfaces

## Input devices are classified as follows:

### ➢ Human data entry devices

Input devices that require data to be entered manually to the computer are identified as human data entry devices. The data may be entered by typing or keying in, or by pointing a device to a particular location.

- Keyboard
- Pointing devices- mouse, trackball, joystick, digitizing tablet
- Pick devices - light pen, touch screen

### ➢ Source data entry devices

Source data entry devices are used for audio input, video input and to enter the source document directly to the computer. Source data entry devices do not require data to be typed-in, keyed-in or pointed to a particular location. Optical input devices allow computers to use light as a source of input.

- Audio input- speech recognition
- Video input- digital camera
- Scanner - hand-held scanner, flat-bed scanner
- Optical Scanner- OCR, OMR, MICR, barcode reader

# Input devices, Output devices, Interfaces

## Human data entry devices:

### 1. Keyboard

- Features
- Description
- Working

### 2. Pointing Devices

a) Mouse

- Features
- Description
  - Physical Mouse
  - Optical Mouse
- Working

b) Trackball

- Features
- Description
- Working

c) Joystick

- Features
- Description

d) Digitizing Tablet

- Features
- Description
- Working

e) Pick Devices

a) Light Pen

b) Touch Screen

# Input devices, Output devices, Interfaces

**Source data entry devices:**

1. Audio Input Device

2. Video Input Device

3. Optical Input Devices

   a) Scanner
   - Hand-held Scanners
   - Flat-bed Scanners

   b) Optical Character Recognition(OCR)

   c) Magnetic Ink Character Recognition (MICR)

   d) Optical Mark Recognition (OMR)

   e) Barcode Reader

# Input devices, Output devices, Interfaces

## Human data entry devices:

### 1. Keyboard

- Features
- Description
- Working

### 2. Pointing Devices

a) Mouse

- Features
- Description
  - Physical Mouse
  - Optical Mouse
- Working

b) Trackball

- Features
- Description
- Working

c) Joystick

- Features
- Description

d) Digitizing Tablet

- Features
- Description
- Working

e) Pick Devices

a) Light Pen

b) Touch Screen

# Input devices, Output devices, Interfaces

## Keyboard :Features:

- Keyboard is a common input device, provided along with the computer and is used for entering the text data.
- For inputting the data, the user types the data using the keyboard.
- When the data is being typed, the display monitor displays the typed data.
- Cursor is a vertical line, an underscore, blinking line, etc. Cursor moves with each typed character.
- The position of cursor indicates the location on monitor where the typed-in character will be displayed.

# Input devices, Output devices, Interfaces

## Keyboard :Description

The keys on keyboard can be divided into several groups based on function:

- Typing (alphanumeric) keys. These keys include the same letter, number, punctuation, and symbol keys found on a traditional typewriter.
- Special (Control) keys. These keys are used alone or in combination with other keys to perform certain actions. The most frequently used control keys are CTRL, ALT, the Windows key, and ESC.
- Function keys. The function keys are used to perform specific tasks. They are labelled as F1, F2, F3, and so on, up to F12. The functionality of these keys differs from program to program.
- Cursor Movement (Navigation) keys. These keys are used for moving around in documents or Webpages and editing text. They include the arrow keys, HOME, END, PAGE UP, PAGE DOWN, DELETE, and INSERT and ARROW KEYS.
- Numeric keypad. The numeric keypad is handy for entering numbers quickly. The keys are grouped together in a block like a conventional calculator or adding machine.

# Input devices, Output devices, Interfaces

## Keyboard: Working

- When a key is pressed, keyboard interacts with a keyboard controller and keyboard buffer.
- The keyboard controller stores the code of pressed key in keyboard buffer and informs the computer software that an action has happened on the keyboard.
- The computer software checks and reads the keyboard buffer and passes the code of pressed character to the system software.
- Due to a time gap between pressing of a key on keyboard and reading by the system software, keyboard buffer is designed to store many keystrokes together.

# Input devices, Output devices, Interfaces

## 2. Pointing Devices

- Pointing devices are used for providing the input to computer by moving the device to point to a location on computer monitor.
- The input data is entered by moving the pointing device, not by typing.
- The cursor on the computer monitor moves with the moving pointing device. Operations like move, click and drag can be performed using the pointing devices.
- Mouse, trackball, joystick and digitizing tablet are some of the common pointing devices.

# Input devices, Output devices, Interfaces

## Pointing Device: Mouse

The mouse can be used in five different ways, as follows:

Pointing points to a location or object on the computer screen. Moving the mouse by hand moves the cursor on computer screen. The cursor moves in the direction in which the mouse moves.

Left Click or Click means pressing the left button of mouse and releasing it. Clicking is used to select a button, command or icon on the screen.

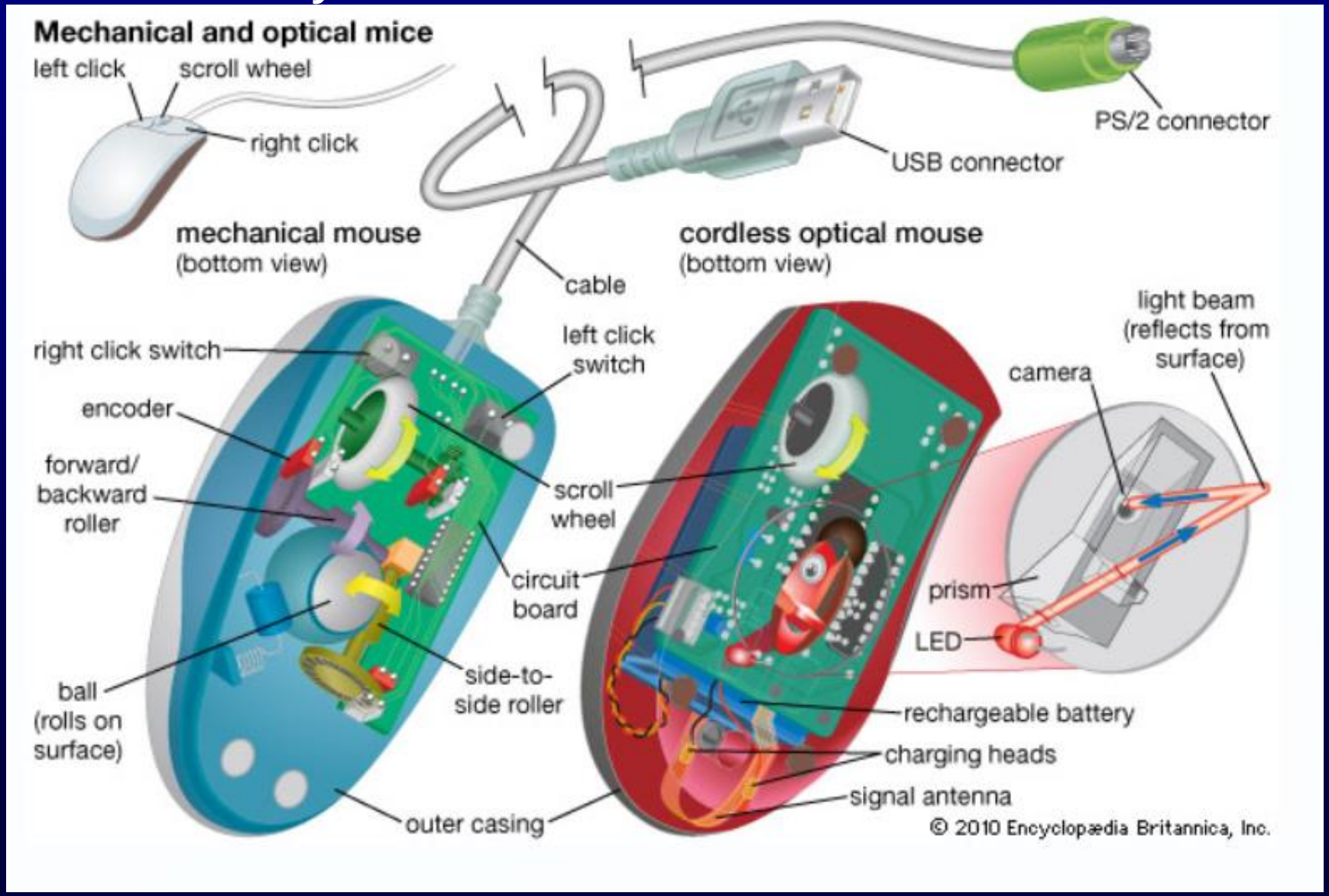
Right Click involves pressing the right button on mouse and releasing it. Right click displays a menu that contains options like cut, copy, paste, font, paragraph, etc. for the item on which the mouse is pointing.

Double Click means pressing the left button of mouse twice successively, without moving the mouse, and then releasing the mouse. It is used to start a program or open a folder.

Drag and Drop drags an object and drops it at another location. Drag means pointing mouse to an object on screen, pressing the left button of mouse, keeping it pressed and moving the mouse to point to a new location. The object gets dragged to the new location along with the mouse. When the left button of mouse is released, the object gets dropped at the new location. Drag and drop is used for moving folders, files and icons to new locations on the screen.

# Input devices, Output devices, Interfaces

Human data entry devices: Mouse



# Input devices, Output devices, Interfaces

Human data entry devices: TrackBall

# Input devices, Output devices, Interfaces

Human data entry devices: Joystick

# Input devices, Output devices, Interfaces

Human data entry devices: Digitizing Tablet

# Input devices, Output devices, Interfaces

Human data entry devices: Light Pen

# Input devices, Output devices, Interfaces

Human data entry devices: Touch Screen

# Input devices, Output devices, Interfaces

Human data entry devices: Audio Input Device

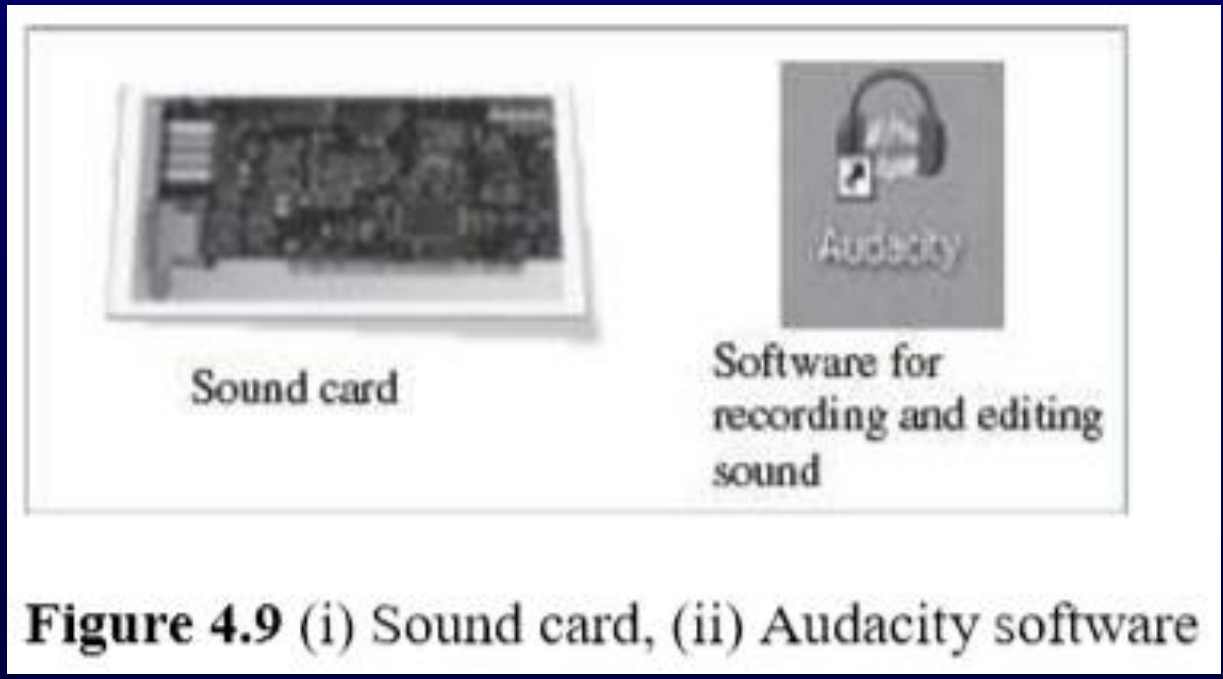



**Figure 4.9** (i) Sound card, (ii) Audacity software

# Input devices, Output devices, Interfaces

Human data entry devices: Video Input Device

# Input devices, Output devices, Interfaces

## Optical Devices: Scanner

Example are - FlatBed and HandHeld scanners.

### Types of Scanners

- Scanners convert printed data or images into an electronic data format that a computer can store or process as required.
  - A scanned image can be saved, modified, and even e-mailed as you would with any other file.

All-in-one scanner

Flatbed scanner

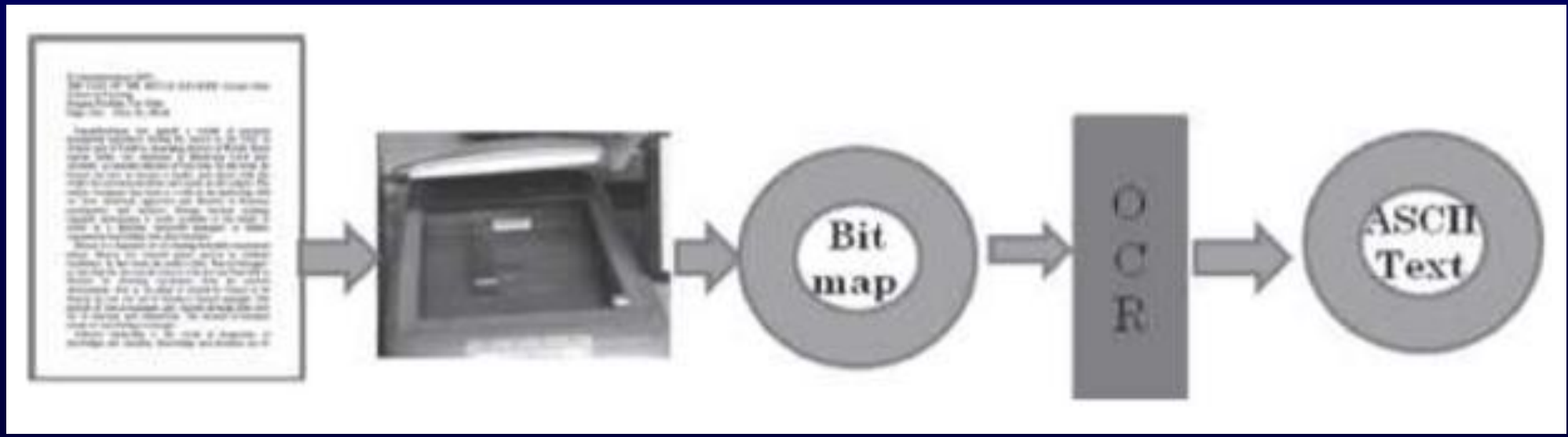
Drum scanner*

Handheld scanner

Flat Bed Scanner at Work

# Input devices, Output devices, Interfaces

Optical Devices: Optical Character Recognition (OCR)



# Input devices, Output devices, Interfaces

Optical Devices: Magnetic Ink Character Recognition (MICR)

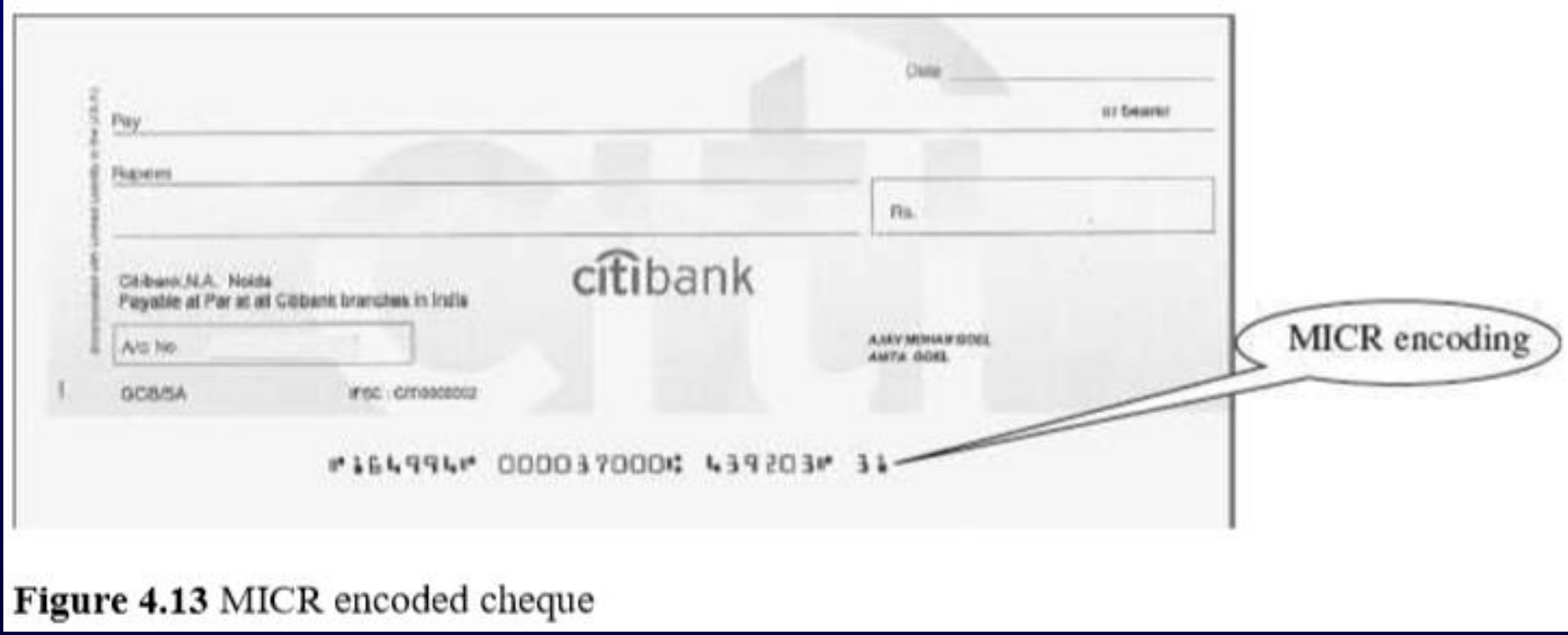



**Figure 4.13** MICR encoded cheque

# Input devices, Output devices, Interfaces

## Optical Devices: Optical Mark Recognition (OMR)

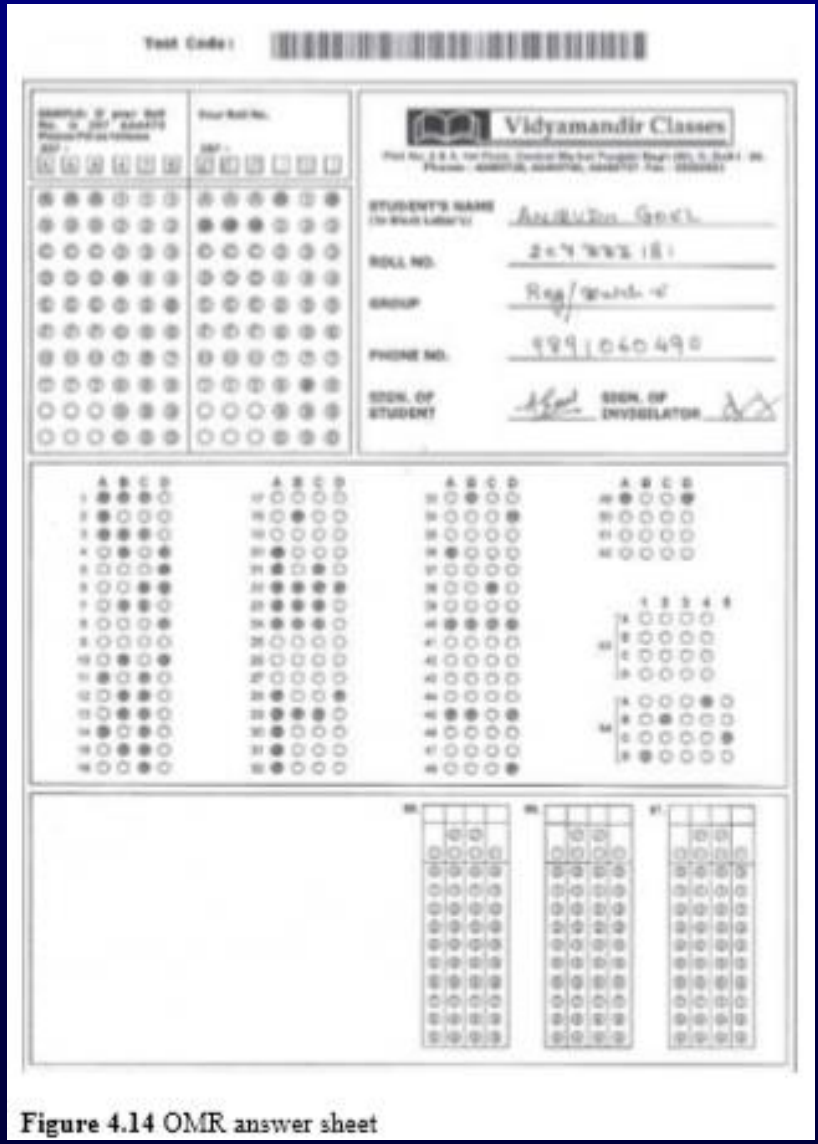



**Figure 4.14** OMR answer sheet

# Input devices, Output devices, Interfaces

Optical Devices: Barcode Reader

# Input devices, Output devices, Interfaces

Output Devices:

- Hard Copy Devices

a) Printer
b) Plotter
c) Computer Output on Microfilm (microfiche)

- Soft Copy Devices

a) Monitor
b) Visual Display Terminal
c) Video Output
d) Audio Response

# Input devices, Output devices, Interfaces

Output Devices: Printer

Impact printers

1. Dot Matrix Printers
2. Daisy Wheel Printers
3. Drum Printers are line printers.

Non-Impact Printers

1. Ink-jet Printers
2. Laser Printers

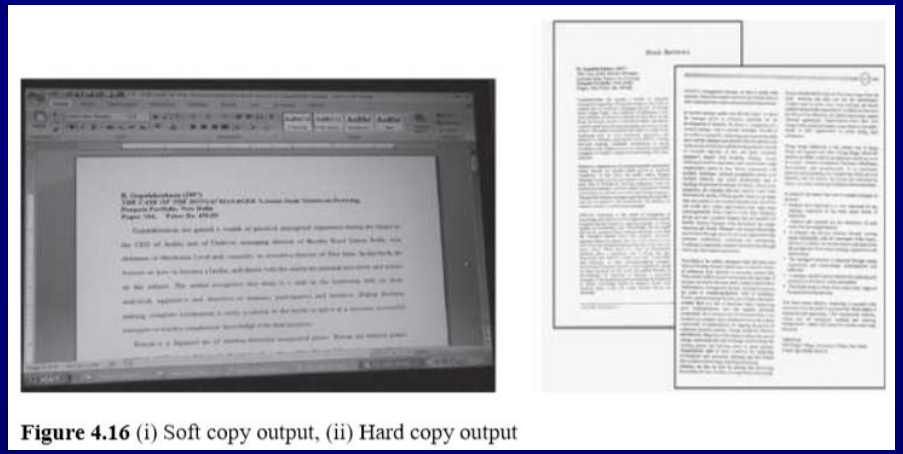
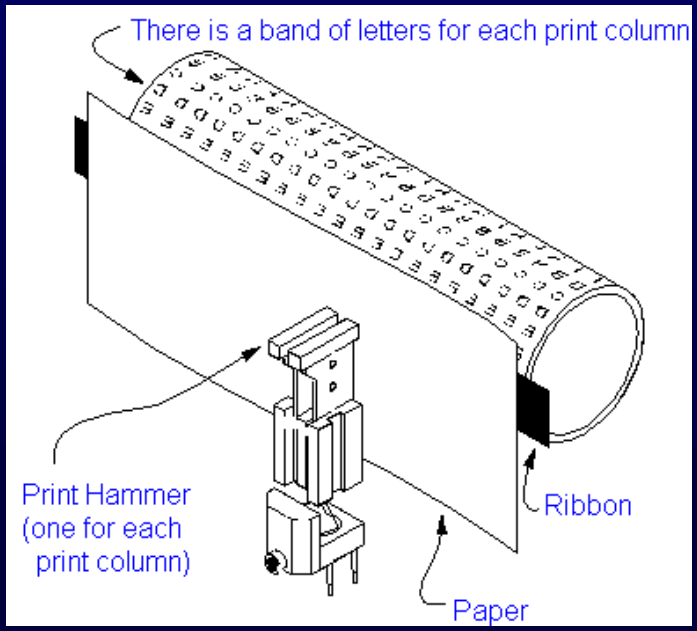


**Figure 4.16** (i) Soft copy output, (ii) Hard copy output

# Input devices, Output devices, Interfaces

Output Devices: Drum Printer

- Drum Printers are line printers.
- Impact printer that prints an entire line at a time.
- Can print only predefined style that is embossed on drum.
- Can not print images and different font styles.
- Can not be used for color printing
- Speed: 300 – 2000 lines per minute.



# Input devices, Output devices, Interfaces

Output Devices: Printer

Daisy Wheel Printers

# Input devices, Output devices, Interfaces

Output Devices: Plotter

# Input devices, Output devices, Interfaces

Output Devices: Computer Output on Microfilm

……..

# Input devices, Output devices, Interfaces

## Output Devices: Soft Copy Devices - Monitor

The number of colors displayed by a color monitor varies with the kind of color adapter attached to it—CGA, EGA, VGA, XGA and SVGA. The CGA monitor supports four colors and SVGA supports around 16,000,000 colors. Monitors are available in various sizes like 14, 15, 17, 19 and 21 inches.

An image on the monitor is created by a configuration of dots, also known as pixels. The clarity of image on the computer screen depends on three factors:

1. Resolution of Screen—the number of pixels in horizontal and vertical direction. More the number of pixels, the sharper is the image. The common resolution of computer screen is 800x600 and 1024x768,
2. Dot Pitch—the diagonal distance between two colored pixels on a display screen, and
3. Refresh Rate—the number of times per second the pixels are recharged so that their glow remains bright.

Monitors may be Cathode Ray Tube (CRT) monitors that look like a television or Liquid Crystal Display (LCD) monitors that have a high resolution, flat screen, flat panel display. Nowadays, LCD monitors are generally used.

# Input devices, Output devices, Interfaces

Output Devices: Visual Display Terminal

**Figure 4.25** (i) LCD projector, (ii) A presentation in progress using LCD projector

# Input devices, Output devices, Interfaces

Output Devices: Visual Display Terminal

**Figure 4.25** (i) LCD projector, (ii) A presentation in progress using LCD projector

# Input devices, Output devices, Interfaces

## I/O PORT:

- The peripheral devices can be connected to computer in several ways. Devices such as network adapters and sound cards are connected to expansion slots inside the computer.
- Printers and scanners are connected to ports on the backside of the computer. Also in a portable computer, the PC Card connects to the PC Card slot on it.
- The I/O ports are the external interfaces that are used to connect input and output devices like printer, modem and joystick to the computer.
- The I/O devices are connected to the computer via the serial and parallel ports, Universal Serial Bus (USB) port, Firewire port, etc.

# Input devices, Output devices, Interfaces

## I/O PORT:

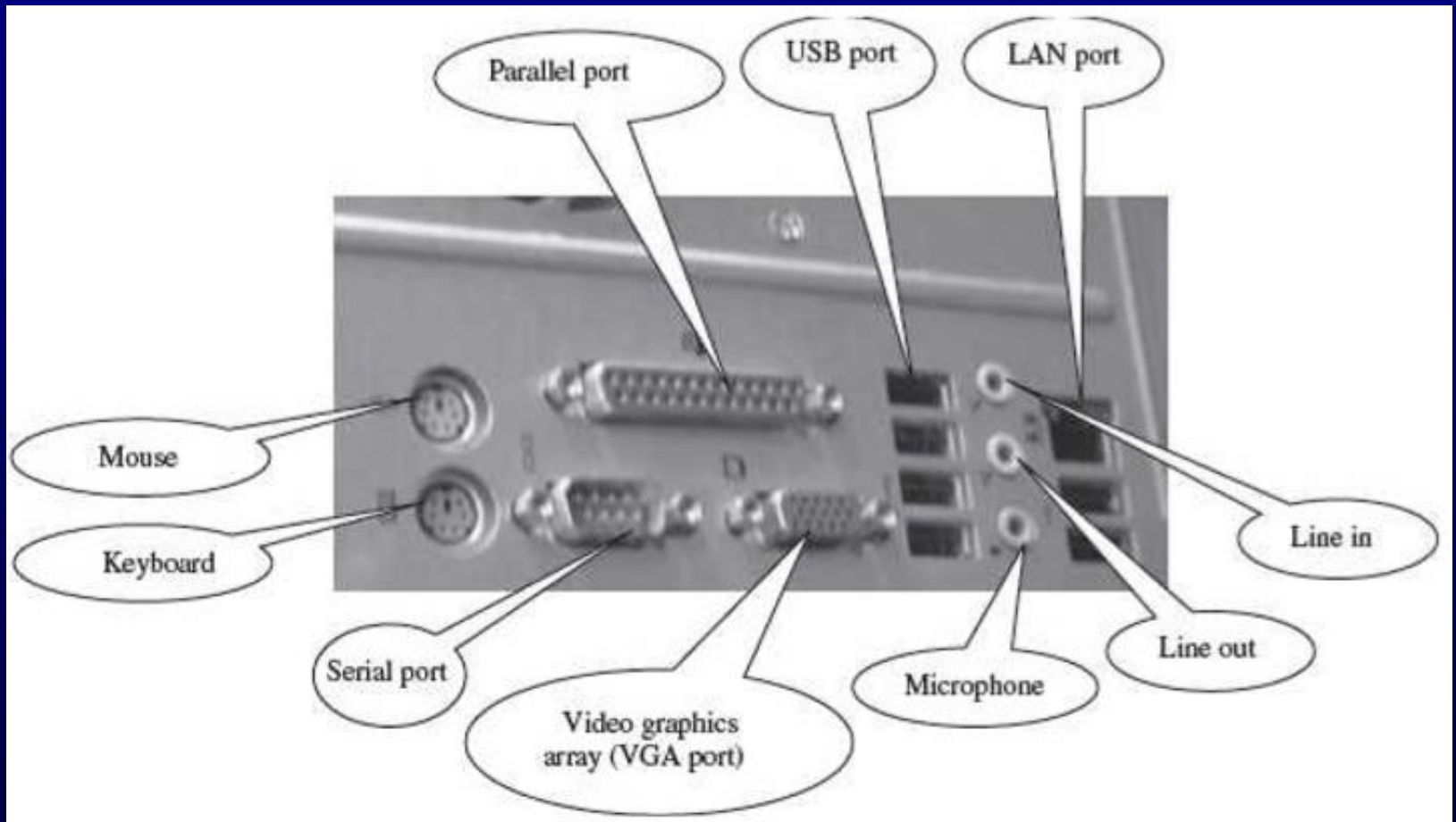



**Figure 4.27** Backside of computer cabinet with different ports

# Input devices, Output devices, Interfaces

## WORKING OF I/O SYSTEM:

- The working of I/O system combines I/O hardware and I/O software. The I/O hardware includes ports, buses and device controllers for different devices, and I/O devices.
- The I/O software is the device driver software that may be embedded with operating system or comes with each device.

**Operating system ------ Device Drivers -------- Device Controllers -------- Devices**

# Input devices, Output devices, Interfaces

**WORKING OF I/O SYSTEM:** The working of I/O system is described as follows:

- I/O Devices are attached to computer via the ports of computer. There are many standard ports available on the backside of the computer case like serial port and parallel port. If one or more devices use a common set of wires, it is called a bus. For example, PCI bus, PCI Express bus, etc.
- Device Controller operates on a bus, a port or a device. It controls the signals on the wires of port or bus. The controllers have one or more registers for data and control signals. Controller may be simple like a serial port controller for a serial port, or, complex like a SCSI controller. Some devices have their own built-in controllers.
- Device Driver is software via which the operating system communicates with the device controllers. Each device has its own device driver, and a device controller which is specific to the device. The device drivers hide the differences among the different device controller and present a uniform interface to the operating system.
- Application programs use an I/O device by issuing commands and exchanging data with the device driver. The device driver provides correct commands to the controller,
- interprets the controller register, and transfers data to and from device controller registers as required for the correct device operation.