BAKLIWAL FOUNDATION

COLLEGE OF ARTS, COMMERCE & SCIENCE

BCA I YEAR I SEMESTER

BCA1.3 COMPUTER FUNDAMENTALS

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UNIT I

1.1 BASIC COMPONENTS OF DIGITAL COMPUTERS

Computers are machines that can store and process information. It processes raw data to give information as output. The raw data is given as input, and the computer transforms it under the influence of a set of special instructions called Programs, to produce the desired output (referred to as Information).

The first electronic digital computer was developed in the late 1940s and was used primarily for numerical computations. By convention, Digital Computers are electronic devices that process information or data presented in the binary form (0 and 1). A binary digit is called a bit.

A computer system is subdivided into two functional entities: Hardware and Software. The hardware consists of all the electronic components that comprise the physical entity of the device. The software of the computer consists of the instructions and data that the computer manipulates to perform various data-processing tasks.

1.1.1 BLOCK DIAGRAM OF A COMPUTER

The basic components of any computer are the same, namely:

- Input Devices
- Central Processing Unit (CPU)
- Bus
- Output Devices

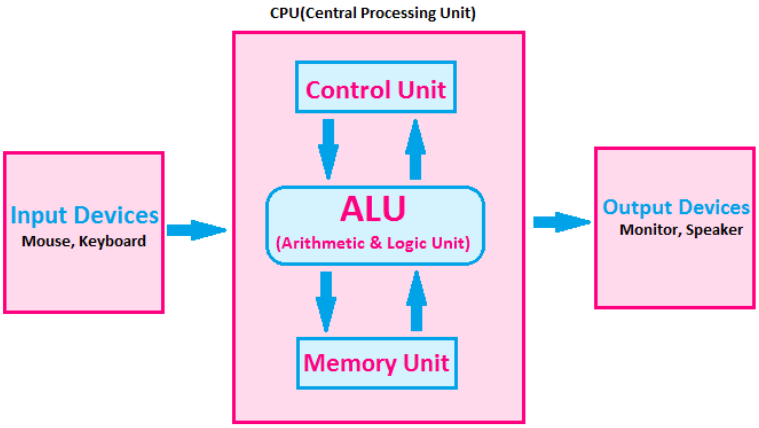


Fig 1.1 Block Diagram – The basic components of a computer

Input

All data entering the computer passes through the input device. Input blocks are made up of different devices. The devices such as mouse, keyboards, scanners, etc., act as the input to the computer. Data to be processed passes through input block. Computers accept raw data in binary format. It then processes the data and produces the desired output.

The three main functions of the input block are:

- Receive data for processing by the user.
- Converts data into a machine-readable format.
- It sends the data directly to the main memory for storage.

Its sole purpose is to connect you and your computer. Also, it allows for easy communication between them.

CPU - Central Processing Unit

The central processing unit, or CPU, is the brain of a computer. It works in the same way as the human brain. Just as the brain controls all human activities, the CPU controls all tasks. The central processing unit also performs all arithmetic and logical operations on the computer. The CPU now consists of two blocks: the Arithmetic Logic Block (ALU) and the Control Block (CU). ALU and CU help in translating instructions and performing several operations. Whenever needed, the computer may access its memory to fetch data relevant to the current operation.

The **ALU** performs basic arithmetic operations like addition, subtraction, multiplication, and division. It performs all kinds of calculations necessary for your data. It then sends the data back to storage. Blocks also perform logical operations such as AND, OR, equal to, less than, etc.

The **CU** is the controller of all tasks. All of this is done inside your computer. The memory block sends a set of commands to the control unit. The control unit then translates these commands in turn. These commands are converted into control signals. These control signals help prioritize and plan tasks. Thus, the control unit coordinates tasks within the computer in synchronization with input and output devices.

The Memory block stores all data that needs to be processed and the data resulting from these processes. The memory block acts as a hub for all data. Memory blocks work in sync with the CPU. This helps to speed up data access and processing. This makes the job easier and faster. There are two types of computer memory.

- **Primary Memory** - This type of memory cannot store large amounts of data. Stored data is temporary. It can be erased after power off. Therefore, it is also called temporary memory or main memory. One good example is the RAM - Random Access Memory.

- **Secondary memory** - Secondary memory is used for persistent storage. It is also called permanent memory or auxiliary memory. A hard drive is an example of a secondary storage device. Even if there is a power outage, data is not easily erased.

Working of a CPU

All the CPUs regardless of their origin or type perform a basic instruction cycle that consists of three steps named Fetch, Decode and Execute

Fetch

A program consists of a number of instructions. Various programs are stored in memory. During this step, the CPU reads instruction that is to be operated from a particular address in the memory. The program counter of the CPU keeps the record of the address of the instructions.

Decode

A circuitry called an instruction decoder decodes all the instructions fetched from the memory. The instructions are decoded to various signals that control other areas of the CPU.

Execute

In the last step, the CPU executes the instruction. For example, it stores a value in the particular register and the instruction pointer then points to other instruction that is stored in the next address location.

Clock Speed

The speed of the processor is measured by the number of clock cycles a CPU can perform in a second. The more the number of clock cycles, the more instructions (calculations) it can carry out. The CPU speed is measured in Hertz. Modern Day processors have speed units of GHz. (1GHz=1 million thousand cycles per second).

Output

It's not surprising what the output block is used for. Any information sent to the computer after processing is received by the user via an output device. Below the output block are devices such as printers, monitors, projectors, etc. The output block presents data in an understandable format. E.g. - Printer for paper copying, Monitor is for display purposes. The output block receives data from the computer in binary format. It then converts it to a human-readable format.

Buses

A system bus is a facet of computer architecture that transmits and shares data throughout the computer and between devices. It's the primary way for a computer to process information because it connects the main processor to all other internal hardware components of a computer. Essentially, a system bus is a pathway made up of electronic cables that carry the data back and forth from the computer's central processing unit (CPU) to other areas of the computer.

The specific design of a system bus changes based on the style, size and needs of each specific computer system. The size and design for the system bus itself dictate the speed of data transfers and how much data the bus can transfer at one given time. However, the basic functions of a system bus include:

Internal function: Also known as a memory bus, an internal system bus connects the hardware that's inside the computer to local devices within the computer's system.

External function: Also known as an expansion bus, an external system bus uses electronic pathways that connect primarily to external devices outside the computer's system. For example, connecting your computer to a wireless printer or mouse makes use of an external system bus.

Data sharing: The main function of a system bus is to transfer data from one place to another using a parallel structure, and the amount of data shared at one time depends on the size of the system bus.

Addressing: It alerts the system where to take certain pieces of data. This function allows users to transfer information about certain data between locations in the computer's main memory.

Power: This function supplies power to each of the various devices connected to the main computer system. It helps the computer's system bus operate at an appropriate speed.

1.2 CENTRAL PROCESSING UNIT (CPU)

In a computer system, there is a device roughly the size of a large postage stamp, known as the central processing unit (CPU). In a computer system, all major calculations and comparisons are made inside the CPU. It is also responsible for activating and controlling the operations of other units of a computer system.

CPU is the main part of a computer system. Basically, CPU is an electronic circuit made of different types of semiconductor devices. It performs all tasks of a computer. The main function of a CPU is to take input signals from the input devices of the computer system such as Mouse, Keyboard, Microphone, etc, and process them. After processing the input signals CPU creates the output signals and supplies them to the output devices such as Monitor, Speaker, Printer, etc.

The CPU resides inside a box known as the system unit, along with various support devices and tools for storing information. CPU reads and executes program instructions, performs calculations, and makes decisions. The CPU is mainly responsible for storing and retrieving information on disks and other media. It also handles information from one part of the computer to another and directs the flow of traffic throughout the computer system. Thus the CPU has mainly two parts - Control Unit (CU) and Arithmetic-Logic Unit (ALU).

1.2.1 PRIMARY MEMORY

The data and instructions which are entered into the computer system through input devices (keyboard, mouse etc.) have to be stored inside the computer before the actual processing starts. Similarly, after processing, the results produced by the computer must be kept somewhere inside the computer system before being passed onto the output devices (monitor/screen or printer). Thus, the storage unit (primary/main memory) of a computer system is designed to take care of all these needs.

The memory unit is the electronic device that holds data and instructions for processing. It consists of binary cells (i.e., 0 or 1 signals) to store the information. Thus,

- The memory unit that directly communicate with the CPU is called the primary storage or primary memory or main storage or main memory.
- It basically stores the necessary programs of system software, which are required to execute the user's program.
- When we load software from floppy disk, pen drive, hard disk or CD-ROM, it is stored in the main memory.

There are two types of computer (main) memory inside the computer:

1. RAM (Random Access Memory)
2. ROM (Read Only Memory)

1.2.2 ARITHMETIC AND LOGICAL UNIT (ALU)

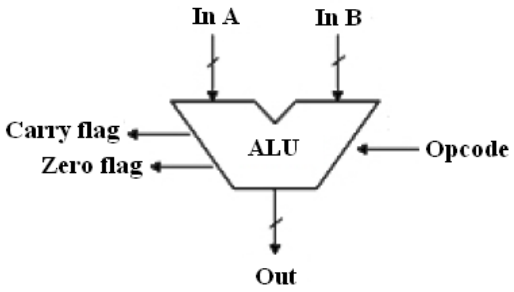


Fig 1.2 The ALU in the CPU

The arithmetic Logic unit (ALU) of a computer system is the place where the actual execution takes place.

- All the Arithmetic calculations such as addition, subtraction, multiplication, and division are performed and all comparisons (decisions) are made in the ALU.
- Relational operator (=, <, >), i.e., equal to, less-than and greater-than are used to describe the comparison operations by the ALU.
- ALU carries out arithmetic operations on integer (whole number) and real (with a decimal point) operands. It performs simple logical tests for integers operands only.
- The data and instructions, stored in the primary memory prior to the processing, are transferred as and when need to the ALU, when processing takes place.
- No processing is done in the primary storage unit (or memory).
- Intermediate results generated in the ALU are temporarily transferred back to the primary storage unit until needed at later time.
- Data may thus move from primary storage to ALU and back again to storage many times before the processing is over.
- After the completion of processing, the final results, which are stored in the storage unit, are released to an output device (monitor/screen or printer).

- The accumulator is used to accumulate results. It is the place where the answers of many operations are stored temporarily before being sent to the computer's memory (see Figure 6). Only the final result is transmitted to the memory unit for storage.

- To understand the operation of CU, ALU etc., let us execute the statement (or command) R=n1+n2. This statement adds two numbers n1 and n2 and places the result in a location X

1.2.3 CONTROL UNIT (CU)

How does the input device know that it is the time for it to feed data into the storage unit (or memory)? How does the ALU know what should be done with the data once those are received? And, how the final results are sent to output device (monitor/screen or printer etc.), not the intermediate result? All this is possible because of the control unit (CU) of the computer system. By selecting, interpreting and seeing to the execution of the program instructions, the control unit is able to maintain order and direct the operation of the entire system.

The control unit (CU) basically does the following things:

- It manages and coordinates the entire computer system.
- The CU is responsible of carrying out program instructions and telling the rest of the computer system what to do.

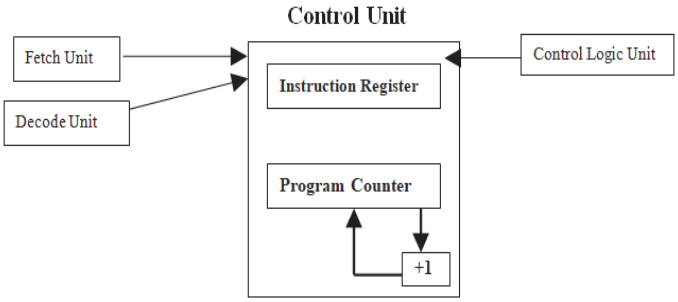


Fig 1.3 Control Unit in the CPU

It obtains the instructions from the program stored in the main memory, interprets the instructions and issues signals that cause other units of the system to execute them.

- The Instruction Register contains a current instruction once it has been fetched from the primary memory. The control unit uses the instruction contained in the Instruction Register to decide which circuits need to be activated. Program counter contains the address of the next instruction to be fetched for execution.

- It communicates with both the arithmetic logic unit and main memory.

- The control unit co-ordinates the activities of the other two units as well as all peripheral and auxiliary storage devices linked to the computer.

- The CU instructs the arithmetic logic unit which arithmetic operations (such as addition, subtraction etc.) or logical operation (comparison between two number) is to be performed through control logic unit.

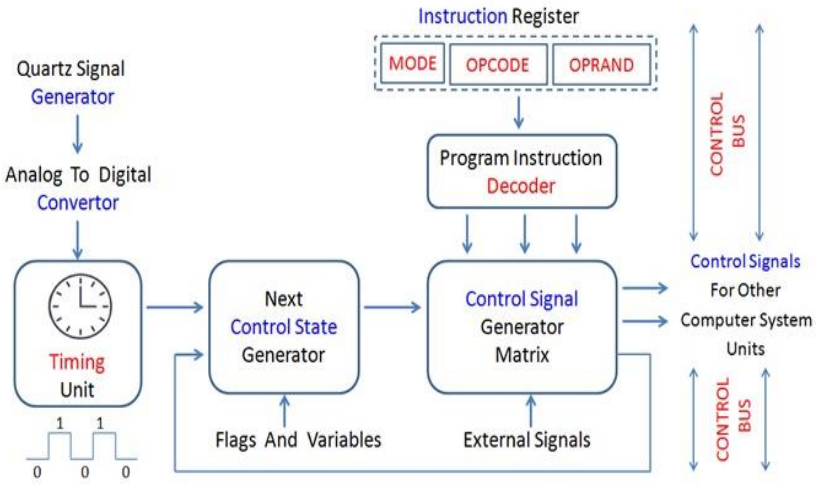


Fig 1.4 Flow of signals in a Control Unit

- Specialized electronic circuits (fetch and decode unit) in the control unit is designed to fetch and decode program instructions held in the main memory.

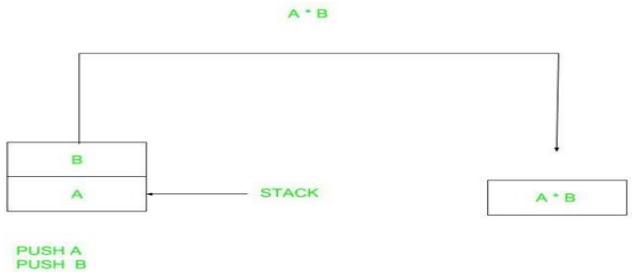
- Each instruction is read from the memory into the instruction register. The process of reading an instruction is often referred to as the fetch-execute process.

1.2.4 INSTRUCTION FORMAT

We will use X = (A+B)*(C+D) expression to showcase the procedure.

On the basis of number of address instruction are classified as:

Zero Address Instructions



A stack based computer do not use address field in instruction. To evaluate a expression first it is converted to revere Polish Notation i.e. Post fix Notation.

Expression: X = (A+B)*(C+D)

Postfixed : X = AB+CD+*

TOP means top of stack

M[X] is any memory location

PUSH A TOP = A

PUSH B TOP = B

ADD TOP = A+B

One Address Instructions

This uses an implied ACCUMULATOR register for data manipulation. One operand is in accumulator and other is in register or memory location. Implied means that the CPU already knows that one operand is in accumulator so there is no need to specify it.

Expression: X = (A+B)*(C+D)
AC is accumulator
M[] is any memory location
M[T] is temporary location

```
LOAD A      AC = M[A]
ADD  B      AC = AC + M[B]
STORE       T       M[T] = AC
LOAD C      AC = M[C]
```

Two Address Instructions

This is common in commercial computers. Here two addresses can be specified in the instruction. Unlike earlier in one address instruction the result was stored in accumulator here result can be stored at different location rather than just accumulator, but require more number of bit to represent address.

Here destination address can also contain operand.

Expression: X = (A+B)*(C+D)
R1, R2 are registers
M[] is any memory location

```
MOV  R1, A  R1 = M[A]
ADD  R1, B  R1 = R1 + M[B]
MOV  R2, C  R2 = C
```

Three Address Instructions

This has three address field to specify a register or a memory location. Program created are much short in size but number of bits per instruction increase. These instructions make creation of program much easier but it does not mean that program will run much faster because now

instruction only contain more information but each micro operation (changing content of register, loading address in address bus etc.) will be performed in one cycle only.

opcode	Destination address	Source address	Source address	mode

Expression: X = (A+B)*(C+D)

R1, R2 are registers

M[] is any memory location

ADD R1, A, B R1 = M[A] + M[B]

ADD R2, C, D R2 = M[C] + M[D]

MUL X, R1, R2 M[X] = R1 * R2

1.3 BUS

A bus is a communication system in computer architecture that transfers data between components inside a computer, or between computers. The term encompasses all the components related to hardware (wire, optical fiber, etc.) and software, including communication protocol.

The following are a few points to describe a computer bus:-

- A bus is a group of lines/wires which carry computer signals.
- A bus is the means of shared transmission.
- Lines are assigned for providing descriptive names. — carries a single electrical signal, e.g. 1-bit memory address, data bits series, or timing control that turns the device on or off.
- Data can be transferred from one computer system location to another (between different I / O modules, memory, and CPU).
- The bus is not only cable but also hardware (bus architecture), protocol, program, and bus controller.

What are the different components of a bus?

Each bus possesses three distinct communication channels. Following are the three components of a bus: –

- The address bus, a one-way pathway that allows information to pass in one direction only, carries information about where data is stored in memory.
- The data bus is a two-way pathway carrying the actual data (information) to and from the main memory.
- The control bus holds the control and timing signals needed to coordinate all of the computer's activities.

Functions of a computer bus

- **Data sharing** – All types of buses used in network transfer data between the connected computer peripherals. The buses either transfer or send data in serial or parallel transfer method. This allows 1, 2, 4, or even 8 bytes of data to be exchanged at a time. (A Byte is an 8-bit group). Buses are classified according to how many bits they can move simultaneously, meaning we have 8-bit, 16-bit, 32-bit, or even 64-bit buses.
- **Addressing** – A bus has address lines that suit the processors. This allows us to transfer data to or from different locations in the memory.
- **Power** – A bus supplies the power to various connected peripherals.

Structure and Topologies of Computer buses

- **Power** line provides electrical power to the components connected
- **Data** lines carrying data or instructions between modules of the system
- **Address** lines indicate the recipient of the bus data
- **Control** lines control the synchronization and operation of the bus and the modules linked to the bus

Different types of computer buses

Computers normally have two bus types:-

- **System bus** – This is the bus that connects the CPU to the motherboard's main memory. The system bus is also known as a front-side bus, a memory bus, a local bus, or a host bus.
- A number of **I / O Buses**, (I / O is an input/output acronym) connecting various peripheral devices to the CPU. These devices connect to the system bus through a 'bridge' implemented on the chipset of the processors. Other I / O bus names include "expansion bus," "external bus" or "host bus"

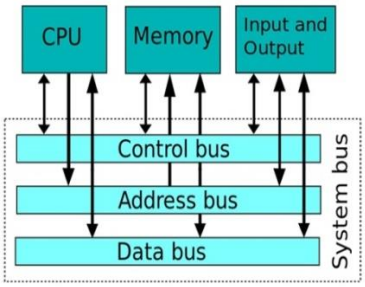


Fig 1.5 Address Data and Control Busses

1.3.1 DATA BUS

In general, a data bus is broadly defined. The first standard for data bus was 32-bit, whereas newer 64-bit systems can handle much greater amounts of data. Other data bus widths include 1-bit, 4-bit, 8-bit, and 16-bit.

A data bus can transfer data to and from the memory of a computer, or into or out of the central processing unit (CPU) that acts as the device's "engine." A data bus can also transfer information between two computers.

Newer, wider data buses can handle higher bitrates, and the amount of data they can transfer is known as bandwidth. The speed at which information is exchanged between components is regulated by a bus controller. Information coming from the CPU, for example, will always travel at a much higher speed than data coming from other components.

However, in a computer, everything must travel at the same speed, and bus controllers serve this purpose. Earlier, first-generation data buses had no controller, and consisted of simple bundles of wire that connected computer memory to the various peripheral devices.

A data bus can operate as a parallel or serial bus depending on how the data is carried. A parallel bus is used in more complex connections that must carry more than one bit at a time. Common examples include Peripheral Component Interconnect (PCI) Express and Small Computer System Interface (SCSI) connections. Data is carried on many wires simultaneously.

Serial buses use a single wire to send and receive data between components, and usually consist of a relatively small amount of wires, so they're somewhat simpler than parallel connections. Common examples of a serial bus include Universal serial bus (USB) and serial advanced technology attachment (SATA) connections.

Every computer also contains both internal (or local) data buses and external data buses. A local data bus connects all the components of the motherboard, while an external one connects the motherboard to every other peripheral device.

In today's complicated computing systems, data is often in transit, running through various parts of the computer's motherboard and peripheral structures. With new network designs, the data is also flowing between many different pieces of hardware and a broader cabled or virtual system. Data buses are fundamental tools for helping facilitate all of the data transfer that allows so much on-demand data transmission in consumer and other systems.

1.3.2 CONTROL BUS

A control bus is a computer bus that is used by the CPU to communicate with devices that are contained within the computer. This occurs through physical connections such as cables or printed circuits.

The CPU transmits a variety of control signals to components and devices to transmit control signals to the CPU using the control bus. One of the main objectives of a bus is to minimize the lines that are needed for communication. An individual bus permits communication between devices using one data channel. The control bus is bidirectional and assists the CPU in synchronizing control signals to internal devices and external components. It is comprised of interrupt lines, byte enable lines, read/write signals and status lines.

Although a CPU can have its own distinctive set of control signals, some controls are common to all CPUs:

- Interrupt Request (IRQ) Lines: Hardware line used by devices to interrupt signals to the CPU. It allows the CPU to interrupt its current job to process the present request.
- System Clock Control Line: Delivers the internal timing for various devices on the motherboard and CPU.

The majority of system buses are made up of 50 to 100 distinct lines for communication. The system bus consists of three types of buses:

- Data Bus: Carries the data that needs processing
- Address Bus: Determines where data should be sent
- Control Bus: Determines data processing

Communication between the CPU and control bus is necessary for running a proficient and functional system. Without the control bus the CPU cannot determine whether the system is receiving or sending data. It is the control bus that regulates which direction the write and read information need to go. The control bus contains a control line for write instructions and a control line for read instructions. When the CPU writes data to the main memory, it transmits a signal to the write command line. The CPU also sends a signal to the read command line when it needs to read. This signal permits the CPU to receive or transmit data from main memory.

1.3.3 ADDRESS BUS

In the diagram above we have a simple diagram of a computer system, and you can see the address bus. The Address bus will carry the data that specifies the address of a memory location, to either write to that location, or to read from that location.

Notice that there is a one-way connection from the processor to the address bus and a one-way connection from the address bus to the main memory or the I/O devices. The Address bus is a one direction bus (Unidirectional), which allows the processor (CPU) to get access to addressable units such as a memory location, or an I/O controller or device.

The Address bus has a role in the the retrieval of data from a memory location by the CPU. The CPU will send the address of the memory location of the data required on the address bus. The data in that memory location will then be sent back via the data bus, and will be received by the CPU for processing.

The width of the address bus refers to its number of parallel lines. It determines the number of bits that can be used to form an address of a memory location. It is typically a multiple of a byte (e.g. 8, 16, 32, or 64 bits).

If the width of the address bus is 8 bits, then there are 2, to the power 8 or 256 numbers that can be used to address memory locations.

If the width of the address bus is 16 bits, then there are 2, to the power 16 or 65,536 numbers that can be used to address memory locations.

As a rule, the width of the address bus determines the maximum number of addressable memory locations, i.e. the maximum memory capacity of a computer system. This is called the address space and it can affect processor performance (CPU Performance).

1.4 NUMBER SYSTEMS

The technique to represent or express counts or numbers is called number system. There are several various types of number systems such as the whole numbers and the real numbers. But in the context of computers, we define other types of number systems. They are:

- The **decimal** number system
- The **binary** number system
- The **octal** number system
- The **hexadecimal** number system

Decimal number system is the most common number system. Other popular number systems include binary number system, octal number system, and hexadecimal number system.

Numbering System		
System	Base	Digits
Binary	2	0, 1
Octal	8	0,1,2,3,4,5,6,7
Decimal	10	0,1,2,3,4,5,6,7,8,9
Hexadecimal	16	0,1,2,3,4,5,6,7,8,9,A,B,C,D,E,F

1.4.1 BINARY SYSTEM

In digital electronics, we write the numbers using only the two digits "0" and "1". A computer can understand only the “on” and “off” state of a switch. The combination of 1 and 0 forms the binary numbers. These numbers represent various data. As two digits are used to represent numbers, it is called a binary or base 2 number system. The binary number system also uses positional notation. But in this case, each digit is multiplied by the appropriate power of two based on its position.

For example, $(101101)_2$ in decimal is

$= 1 \times 2^5 + 0 \times 2^4 + 1 \times 2^3 + 1 \times 2^2 + 0 \times 2^1 + 1 \times 2^0$

$= 1 \times 32 + 0 \times 16 + 1 \times 8 + 1 \times 4 + 0 \times 2 + 1 \times 1$

$= 32 + 8 + 4 + 1$

$= (45)_{10}$

1.4.2 OCTAL SYSTEM

Octal is nothing but the number we write using the eight digits 0, 1, 2, 3, 4, 5, 6, 7 and since one or some of these eight digits is used in octal, the octal system is said to have a base of 8.

For example, $(24)_8$ in decimal is
$= 2\times8^1+4\times8^0$
$= (20)_{10}$

1.4.3 DECIMAL SYSTEM

Decimal is nothing but the number we use in our day to day life. Whatever number we write in our day to day life, we use the ten digits 0, 1, 2, 3, 4, 5, 6, 7, 8, 9. As it uses 10 digits to represent a number, it is also called the base 10 Number system. Each digit has a value based on its position called place value. The value of the position increases by 10 times as we move from right to left in the number.
For example, the value of $(786)_{10}$ is
$= 7 \times 10^2 + 8 \times 10^1 + 6 \times 10^0$
$= 700 + 80 + 6$

1.4.4 HEXADECIMAL SYSTEM

In this system, 16 digits used to represent a given number. Thus it is also known as the base 16 number system. Each digit position represents a power of 16. As the base is greater than 10, the number system is supplemented by letters. Following are the hexadecimal symbols: 0, 1, 2, 3, 4, 5, 6, 7, 8, 9, A, B, C, D, E, F. Here, A = 10, B = 11, C = 12, D = 13, E = 14, F = 16. Whatever number we have in regular, it will be written in hexadecimal using these 16 digits.

Decimal	Binary	Octal	Hexadecimal
0	0000	0	0
1	0001	1	1
2	0010	2	2
3	0011	3	3
4	0100	4	4
5	0101	5	5
6	0110	6	6
7	0111	7	7
8	1000	10	8
9	1001	11	9
10	1010	12	A
11	1011	13	B
12	1100	14	C
13	1101	15	D
14	1110	16	E
15	1111	17	F
16	10000	20	10
17	10001	21	11
18	10010	22	12
19	10011	23	13
20	10100	24	14

Fig 1.6 The equivalent values in different number systems

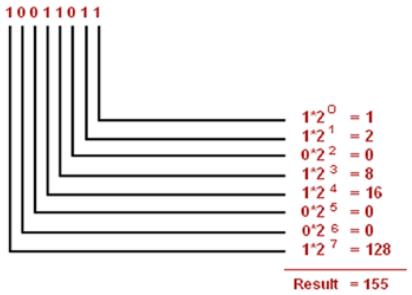
1.4.5 DATA CONVERSION

Conversion from Decimal to Binary and Binary to Decimal

Decimal = 41

Division	Quotient	Remainder
41/2	20	1
20/2	10	0
10/2	5	0
5/2	2	1
2/2	1	0
1/2	0	1

Binary = 101001



Binary = 10011011

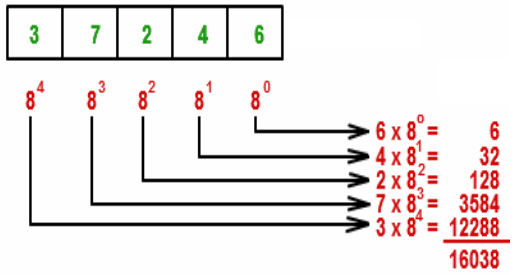
Decimal = 155

Conversion from Decimal to Octal and Octal to Decimal

Decimal = 415

Division	Quotient	Remainder
415/8	51	7
51/8	6	3
6/8	0	6

Octal = 637



Octal = 37246

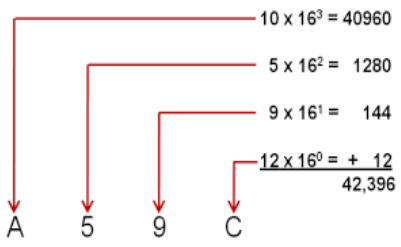
Decimal = 16038

Conversion from Decimal to Hexadecimal and Hexadecima to Decimal

Decimal = 4156

Division	Quotient	Remainder
4156/16	259	12 – C
259/16	16	3
16/16	1	0
1/16	0	1

Hexadecimal = 103C



Hexadecimal = A59C

Decimal = 42396

1.4.6 BINARY ARITHMETIC

Binary Addition

	Carry Over	Result
0 + 0	0	0
0 + 1	0	1
1 + 0	0	1
1 + 1	1	0
1 + 1 + 1	1	1

$$\begin{array}{cccc} 0 & 0 & 1 & 1 \\ +\,0 & +\,1 & +\,0 & +\,1 \\ \hline 0 & 1 & 1 & 10 \end{array}$$

When adding more than single-digit binary number, carry into, higher order columns as is done when adding decimal numbers. For example 11 and 10 are added as follows:

$$\begin{array}{r} 11 \\ +\,10 \\ \hline 101 \end{array}$$

Binary Subtraction

Inputs		Outputs	
A	B	Difference	Borrow
0	0	0	0
0	1	1	1
1	0	1	0
1	1	0	0

When doing subtracting, it is sometimes necessary to borrow from the next higher-order column. The only it will be necessary to borrow is when we try to subtract a 1 from a 0. In this case a 1 is borrowed from the next higher-order column, which leaves a 0 in that column and creates a 10 i.e., 2 in the column being subtracted. The following example illustrate binary subtraction.

$$\begin{array}{r} 111 \\ -\,101 \\ \hline 010 \end{array}$$

Thus 1 0 1 – 1 1 1 = - 010 = - 10

Binary multiplication:

Binary multiplication is performed in the same manner as decimal multiplication. It is much easier, since there are only two possible results of multiplying two bits. The Binary multiplication obeys the four basic rules.

$$0 \times 0 = 0$$

$$0 \times 1 = 0$$

$1 \times 0 = 0$

$1 \times 1 = 1$

Example: Multiply the following binary numbers.

(a) 101×11 (b) 1101×10

© 1010×101 (d) 1011×1010

Solution:

(a)
$$\begin{array}{r} 101 \\ \times\ 11 \\ \hline 101 \\ 101 \\ \hline 1111 \end{array}$$

(b)
$$\begin{array}{r} 11101 \\ \times\ 10 \\ \hline 0000 \\ 1101 \\ \hline 11010 \end{array}$$

©
$$\begin{array}{r} 1010 \\ \times\ 101 \\ \hline 1010 \\ 0000 \\ 1010 \\ \hline 110010 \end{array}$$

(d)
$$\begin{array}{r} 1011 \\ \times\ 1010 \\ \hline 0000 \\ 1011\times \\ 0000\times \\ 1011\times \\ \hline 1101110 \end{array}$$

Binary Division:

Division in the binary number system employees the same procedure as division in the decimal system, as will be seen in the following examples.

Example: Perform the following binary division.

(a) $110 \div 11$ (b) $1100 \div 11$

Solution:

(a)
$$\begin{array}{r} 10 \\ 11 \overline{)\ 110} \\ 11 \\ \hline 00 \\ 00 \\ \hline 00 \end{array}$$

(b)
$$\begin{array}{r} 100 \\ 11 \overline{)\ 11000} \\ 11 \\ \hline 00 \\ 00 \\ \hline 00 \\ 00 \\ \hline 00 \end{array}$$

Binary division problems with remainders are also treated the sameas in the decimal system, as illustrates the following example.

Example: Perform the following binary division:

(a) $1111 \div 110$ (b) $1100 \div 101$

Solution:

(a)	10. 1 110 1111.00 110 1 10 1 10 0 0 0	(b)	10. 011 110 1 100.00 1 01 100 000 1000 101 110 101 1 (reminder)

1.5 ASCII, BCD, EBCDIC

1.5.1 AMERICAN STANDARD CODE FOR INFORMATION INTERCHANGE (ASCII)

The ASCII code was established by the American National Standards Institute (ANSI) in the early 1960s as a standardized way of presenting and reading Latin-based alphanumeric keyboard characters.

Digital computers use a binary code that is arranged in groups of eight, rather than seven, digits, or bits; each such eight-bit group is called a byte. Consequently, ASCII is commonly embedded in an eight-bit field, which consists of the seven information bits and a parity bit that is used for error checking or for representing special symbols. This eight-bit system increases the number of characters ASCII can represent to 256.

To represent text digitally, each character needs to have its own unique bit-pattern. Bit-patterns are combinations of 1s and 0s used to represent data inside of a computer. The bit-pattern used for each character becomes a numeric character code.

A character can be any of the following:

- Letters (upper and lower case letters have separate codes)
- Punctuation (e.g.?/|\£$)
- Numbers (0–9)
- Non-printing commands (e.g. Enter, Delete, F1)

Extended ASCII, as the eight-bit code is known, was introduced by IBM in 1981 for use in its first PC, and it soon became the industry standard for personal computers. In extended ASCII, 32 code combinations are used for machine and control commands, such as “start of text”, “carriage return”, and “form feed”. Control commands do not represent printable information, but rather they help control devices, such as printers, that may use ASCII. For example, the binary sequence 00001000 represents “backspace.” Another group of 32

combinations is used for numerals and various punctuation marks, another for uppercase letters and a few other punctuation marks, and yet another for lowercase letters.

However, even extended ASCII does not include enough code combinations to support all written languages. Asian languages, for instance, require thousands of characters. This limitation gave rise to new encoding standards—Unicode and UCS (Universal Coded Character Set)—that can support all principal written languages.

1.5.2 BINARY CODED DECIMAL (BCD)

The advantage that Binary Coded Decimal (BCD) has over Binary is that there is no limit to number size. For every decimal number added, you add 4-bits or one nibble. Binary numbers are limited to the largest number that can be represented by 8, 16, 32 and 64 bits. It is easier to convert decimal numbers to and from BCD than Binary.

BCD is usually converted to Binary for arithmetic processing since computers only process 0's and 1's.

Decimal digit	BCD Code		
	8 4 2 1	4 2 2 1	5 4 2 1
0	0 0 0 0	0 0 0 0	0 0 0 0
1	0 0 0 1	0 0 0 1	0 0 0 1
2	0 0 1 0	0 0 1 0	0 0 1 0
3	0 0 1 1	0 0 1 1	0 0 1 1
4	0 1 0 0	1 0 0 0	0 1 0 0
5	0 1 0 1	0 0 1 1	1 0 0 1
6	0 1 1 0	1 1 0 0	1 0 1 0
7	0 1 1 1	1 1 0 1	
8	1 0 0 0	1 1 1 0	1 0 1 1
9	1 0 0 1	1 1 1 1	1 1 0 0

- It is a fast and efficient system that converts the decimal numbers into binary numbers as compared to the existing binary system.
- These are generally used in digital displays where is the manipulation of data is quite a task.
- Thus BCD plays an important role here because the manipulation is done treating each digit as a separate single sub-circuit.

The BCD equivalent of a decimal number is written by replacing each decimal digit in the integer and fractional parts with its four bit binary equivalent. The BCD code is more precisely known as 8421 BCD code, with 8,4,2 and 1 representing the weights of different bits in the four-bit groups, Starting from MSB and proceeding towards LSB. This feature makes it a

weighted code , which means that each bit in the four bit group representing a given decimal digit has an assigned weight.

The main advantage of binary coded decimal is that it allows easy conversion between decimal (base-10) and binary (base-2) form. However, the disadvantage is that BCD code is wasteful as the states between 1010 (decimal 10), and 1111 (decimal 15) are not used.

1.5.3 EXTENDED BINARY CODED DECIMAL INTERCHANGE CODE (EBCDIC)

This is a coding system used to represent characters-letters, numerals, punctuation marks, and other symbols in computerized text. A character is represented in EBCDIC by eight bit. EBCDIC mainly used on IBM mainframe and IBM mid-range computer operating systems. Each byte consists of two nibbles, each four bits wide. The first four bits define the class of character, while the second nibble defines the specific character inside that class.

EBCDIC is different from, and incompatible with, the ASCII character set used by all other computers. The EBCDIC code allows for 256 different characters. For personal computers, however, ASCII is the standard. If you want to move text between your computer and a mainframe, you can get a file conversion utility that will convert between EBCDIC and ASCII.

EBCDIC was adapted from the character codes used in IBM's per-electronic PUNCHED CARD machines, which made it less than ideal for modern computers. Among its many inconveniences were the use of non-contiguous codes for the alphabetic characters, and the absence of several punctuation characters such as the square brackets [] used by much modern software.

1.6 LANGUAGE EVOLUTION

1.6.1 GENERATION OF LANGUAGES

There are five generations of Programming languages. They are:

- First Generation Languages: These are low-level languages like machine language.
- Second Generation Languages: These are low-level assembly languages used in kernels and hardware drives.
- Third Generation Languages: These are high-level languages like C, C++, Java, Visual Basic, and JavaScript.
- Fourth Generation Languages :These are languages that consist of statements that are similar to statements in the human language. These are used mainly in database programming and scripting. Examples of these languages include Perl, Python, Ruby, SQL, MatLab(MatrixLaboratory).
- Fifth Generation Languages: These are the programming languages that have visual tools to develop a program. Examples of fifth-generation languages include Mercury, OPS5, and Prolog.

The first two generations are called low-level languages. The next three generations are called high-level languages.

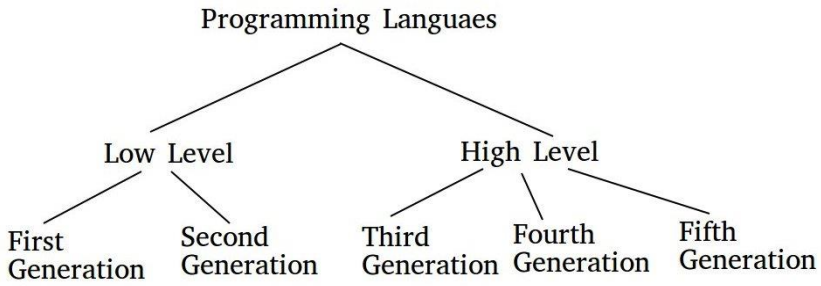


Fig 1.8 The Classification of Computer Languages based on generation

1.6.1.1 Machine Language

1. First Generation Language :

The first generation languages are also called machine languages/ 1G language. This language is machine-dependent. The machine language statements are written in binary code (0/1 form) because the computer can understand only binary language.

Advantages :

1. Fast & efficient as statements are directly written in binary language.

2. No translator is required.

Disadvantages :

1. Difficult to learn binary codes.

2. Difficult to understand – both programs & where the error occurred.

1.6.1.2 Assembly Language

2. Second Generation Language :

The second-generation languages are also called assembler languages/ 2G languages. Assembly language contains human-readable notations that can be further converted to machine language using an assembler. Assembler – converts assembly level instructions to machine level instructions. Programmers can write the code using symbolic instruction codes that are meaningful abbreviations of mnemonics. It is also known as low-level language.

Advantages :

1. It is easier to understand if compared to machine language.

2. Modifications are easy.

3. Correction & location of errors are easy.

Disadvantages :

1. Assembler is required.

2. This language is architecture /machine-dependent, with a different instruction set for different machines.

1.6.1.3 High Level Language

3. Third Generation Language :

The third generation is also called procedural language /3 GL. It consists of the use of a series of English-like words that humans can understand easily, to write instructions. Its also called High-Level Programming Language. For execution, a program in this language needs to be translated into machine language using Compiler/ Interpreter. Examples of this type of language are C, PASCAL, FORTRAN, COBOL, etc.

Advantages :

1. Use of English-like words makes it a human-understandable language.

2. Lesser number of lines of code as compared to above 2 languages.

3. Same code can be copied to another machine & executed on that machine by using compiler-specific to that machine.

Disadvantages :

1. Compiler/ interpreter is needed.

2. Different compilers are needed for different machines.

4. Fourth Generation Language :

The fourth-generation language is also called a non – procedural language/ 4GL. It enables users to access the database. Examples: SQL, Foxpro, Focus, etc.

These languages are also human-friendly to understand.

Advantages :

1. Easy to understand & learn.

2. Less time required for application creation.

3. It is less prone to errors.

Disadvantages :

1. Memory consumption is high.

2. Has poor control over Hardware.

3. Less flexible.

5. Fifth Generation Language :

The fifth-generation languages are also called 5GL. It is based on the concept of artificial intelligence. It uses the concept that rather than solving a problem algorithmically, an application can be built to solve it based on some constraints, i.e., we make computers learn to

solve any problem. Parallel Processing & superconductors are used for this type of language to make real artificial intelligence.

Example: PROLOG, LISP, etc.

Advantages :

1. Machines can make decisions.

2. Programmer effort reduces to solve a problem.

3. Easier than 3GL or 4GL to learn and use.

Disadvantages :

1. Complex and long code.

2. More resources are required & they are expensive too.

1.7 CHARACTERISTICS OF GOOD LANGUAGE TRANSLATORS

Language Processors –

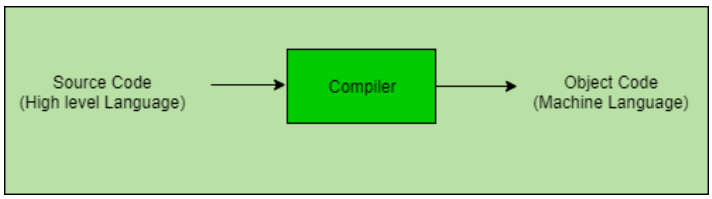
Compilers, interpreters, translate programs written in high-level languages into machine code that a computer understands. And assemblers translate programs written in low-level or assembly language into machine code. In the compilation process, there are several stages. To help programmers write error-free code, tools are available.

Assembly language is machine-dependent, yet mnemonics used to represent instructions in it are not directly understandable by machine and high-Level language is machine-independent. A computer understands instructions in machine code, i.e. in the form of 0s and 1s. It is a tedious task to write a computer program directly in machine code. The programs are written mostly in high-level languages like Java, C++, Python etc. and are called source code. These source codes cannot be executed directly by the computer and must be converted into machine language to be executed. Hence, a special translator system software is used to translate the program written in a high-level language into machine code is called Language Processor and the program after translated into machine code (object program/object code).

1.7.1 COMPILER

The language processor that reads the complete source program written in high-level language as a whole in one go and translates it into an equivalent program in machine language is called a Compiler. Example: C, C++, C#, Java.

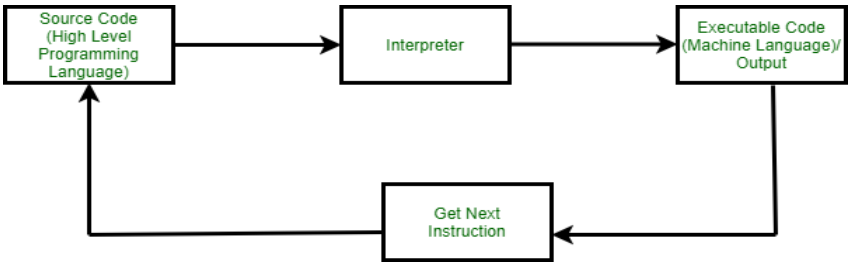
In a compiler, the source code is translated to object code successfully if it is free of errors. The compiler specifies the errors at the end of the compilation with line numbers when there are any errors in the source code. The errors must be removed before the compiler can successfully recompile the source code again



1.7.2 INTERPRETER

The translation of a single statement of the source program into machine code is done by a language processor and executes immediately before moving on to the next line is called an interpreter. If there is an error in the statement, the interpreter terminates its translating process at that statement and displays an error message. The interpreter moves on to the next line for execution only after the removal of the error. An Interpreter directly executes instructions written in a programming or scripting language without previously converting them to an object code or machine code.

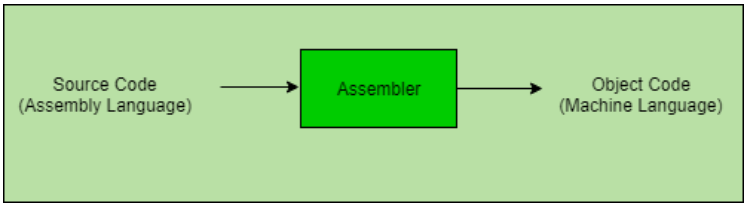
Example: Perl, Python and Matlab.



1.7.3 ASSEMBLER

The Assembler is used to translate the program written in Assembly language into machine code. The source program is an input of an assembler that contains assembly language instructions. The output generated by the assembler is the object code or machine code understandable by the computer. Assembler is basically the 1st interface that is able to communicate humans with the machine. We need an Assembler to fill the gap between human and machine so that they can communicate with each other. code written in assembly language is some sort of mnemonics(instructions) like ADD, MUL, MUX, SUB, DIV, MOV and so on. and the assembler is basically able to convert these mnemonics in Binary code. Here, these mnemonics also depend upon the architecture of the machine.

For example, the architecture of intel 8085 and intel 8086 are different.



Difference between Compiler and Interpreter

Compiler	Interpreter

Compiler	Interpreter
A compiler is a program that converts the entire source code of a programming language into executable machine code for a CPU.	An interpreter takes a source program and runs it line by line, translating each line as it comes to it
The compiler takes a large amount of time to analyze the entire source code but the overall execution time of the program is comparatively faster.	An interpreter takes less amount of time to analyze the source code but the overall execution time of the program is slower.
The compiler generates the error message only after scanning the whole program, so debugging is comparatively hard as the error can be present anywhere in the program.	Its Debugging is easier as it continues translating the program until the error is met.
The compiler requires a lot of memory for generating object codes.	It requires less memory than a compiler because no object code is generated.
Generates intermediate object code.	No intermediate object code is generated.
For Security purpose compiler is more useful.	The interpreter is a little vulnerable in case of security.
Examples: C, C++, Java	Examples: Python, Perl, JavaScript, Ruby

1.8 SOURCE AND OBJECT PROGRAM

1.8.1 SOURCE CODE

Source code refers to high level code or assembly code which is generated by human/programmer. Source code is easy to read and modify. It is written by programmer by using any High Level Language or Intermediate language which is human-readable. Source code contains comments that programmer puts for better understanding.

Source code is provided to language translator which converts it into machine understandable code which is called machine code or object code. Computer cannot understand direct source code, computer understands machine code and executes it. It is considered as fundamental component of computer. In simple we can say source code is a set of instructions/commands

and statements which is written by a programmer by using a computer programming language like C, C++, Java, Python, Assembly language etc. So statements written in any programming language is termed as source code.

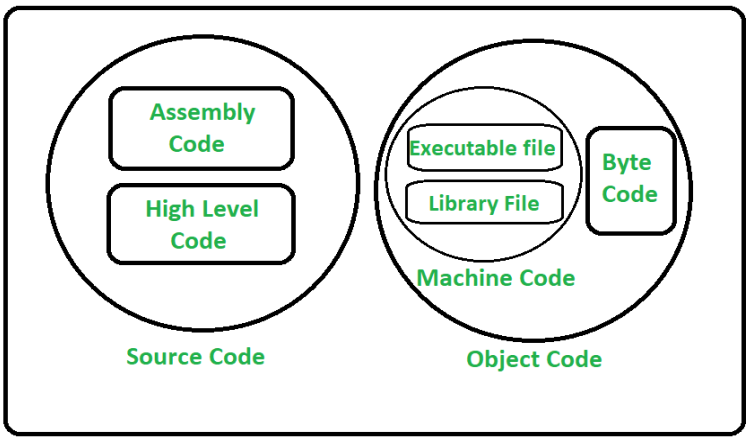


Fig 1.9 Source code and Object code

1.8.2 OBJECT CODE

Object code refers to low level code which is understandable by machine. Object code is generated from source code after going through compiler or other translator. It is in executable machine code format. Object code contains a sequence of machine understandable instructions to which Central Processing Unit understands and executes.

Object file contains object code. It is considered as one more of machine code. Some object file examples are common object file format (COFF), COM files and ".exe" files. It is the output of a compiler or other translator. We can understand source code but we cannot understand object code as it is not in plain text like source code rather it is in binary formats.

Difference between Source Code and Object Code :

	SOURCE CODE	OBJECT CODE
01	Source code is generated by human or programmer.	Object code is generated by compiler or other translator.
02	Source code is high level code.	Object code is low level code.
03	Source code is written in plain text by using some high level programming language.	Object code is translated code of source code. It is in binary format.
04	Source code is human understandable.	Object code is not human understandable.

05	Source code is not directly understandable by machine.	Object code is machine understandable and executable.
06	It is written in a high-level language like C, C++, Java, Python, etc., or assembly language.	It is written in machine language through compiler or assembler or other translator.
07	It can be easily modified.	It cannot be modified.
08	It contains comments for better understanding by programmer.	It does not contain comments for understanding by machine.
09	It contains less number of statements than object code.	It contains more number of statements than source code.
10	It is less close. towards machine.	It is more close towards machine.
11	Performance of source code is less than object code as it is less close towards machine.	Performance of object code is more than source code as it is more close towards machine.
12	Source code is input to compiler or any other translator.	Object code is output of compiler or any other translator.
13	Source code is not system specific.	Object code is system specific.
14	It can be changed over time.	Source code needs to be compiled or translated by any other translator to get modified object code.
15	Language translators like compiler, assembler, interpreter are used to translate source code to object code.	Object code is machine code so it does not require any translation.
16	The source line of code gives the readability and understand-ability to the user. Use of fewer lines of code gives better performance by giving same results in most cases.	This is not the case with object code.

1.9 Questions

1. How would you represent 10111 in the decimal number system?

2. The LSB and MSB in the following octal number 1220 are ___ and ___.

3. Explain the block diagram of a computer.

4. What are the different generations of computer language? Explain in detail.

5. What are language processors?

6. Explain in detail the different number systems in computers.

Note:

Number of Binary Digits (bits)	Common Name
1	Bit
4	Nibble
8	Byte
16	Word
32	Double Word
64	Quad Word

Number of Bytes	Common Name
1,024 (2^{10})	kilobyte (kb)
1,048,576 (2^{20})	Megabyte (Mb)
1,073,741,824 (2^{30})	Gigabyte (Gb)
a very long number! (2^{40})	Terabyte (Tb)

UNIT II

2.1 MEMORY

2.1.1 STATIC AND DYNAMIC MEMORY

In C and C++ , there are three fundamental ways of using memory:

1. Static memory, in which an object is allocated by the linker for the duration of the program. Global variables, static class members, and static variables in functions are allocated in static memory. An object allocated in static memory is constructed once and persists to the end of the program. Its address does not change while the program is running. Static objects can be a problem in programs using threads (shared-address-space concurrency) because they are shared and require locking for proper access.

2. Automatic memory, in which function arguments and local variables are allocated. Each entry into a function or a block gets its own copy. This kind of memory is automatically created and destroyed; hence the name automatic memory. Automatic memory is also said “to be on the stack,”

3. Free store, from which memory for objects is explicitly requested by the program and where a program can free memory again once it is done with it (using the new and delete operators). When a program needs more free-store, it sends new requests to the operating system. Typically, the free store (also called dynamic memory or the heap) grows throughout the lifetime of a program.

2.1.2 RANDOM ACCESS MEMORY (RAM)

- Random Access Memory (RAM) is really the main store and is the place where the program and software we load gets stored. When CPU runs a program, it fetches the program instructions from the RAM and carries them out. Similarly, if the CPU needs to store the final results of calculations, it stores those in RAM. Thus, you (CPU) can both READ data from RAM and WRITE data into the RAM.
- If your computer has large RAM, you can run larger programs.
- RAM is known as volatile memory, that is, the stored data are lost, if the power goes off.
- Mother board is a microcomputer circuit board that contains slots for connecting peripherals like RAM modules, CPU and adapter cards. Motherboards also have electronic circuitry for handling such tasks as I/O signals from those peripheral devices. A motherboard is the backbone of a computer system: The power of a PC highly depends on the peripherals that its motherboard supports.
- In older days, the first home PC’s uses a 64 KB of RAM memory. Today’s modern computers need a minimum of 64 MB (recommended 128 MB or 256 MB) to run Windows or Linux Operating system with latest number of software. A RAM memory chips come in many different sizes ranging from 1 MB to 2 GB.

Static Random Access Memory (SRAM): Data is stored in transistors and requires a constant power flow. Because of the continuous power, SRAM doesn't need to be refreshed to remember the data being stored. SRAM is called static as no change or action i.e. refreshing is not needed to keep the data intact. It is used in cache memories.
Advantage: Low power consumption and faster access speeds.
Disadvantage: Fewer memory capacities and high costs of manufacturing.

Dynamic Random Access Memory (DRAM): Data is stored in capacitors. Capacitors that store data in DRAM gradually discharge energy, no energy means the data has been lost. So, a periodic refresh of power is required in order to function. DRAM is called dynamic as constant change or action(change is continuously happen) i.e. refreshing is needed to keep the data intact. It is used to implement main memory.
Advantage: Low costs of manufacturing and greater memory capacities.
Disadvantage: Slow access speed and high power consumption.

SRAM	DRAM
It stores information as long as the power is supplied.	It stores information as long as the power is supplied or a few milliseconds when power is switched off.
Transistors are used to store information in SRAM.	Capacitors are used to store data in DRAM.
Capacitors are not used hence no refreshing is required.	To store information for a longer time, contents of the capacitor needs to be refreshed periodically.
SRAM is faster need compared to DRAM.	DRAM provides slow access speeds.
It does not have a refreshing unit.	It has a refreshing unit.
These are expensive.	These are cheaper.
SRAMs are low-density devices.	DRAMs are high-density devices.
In this bits are stored in voltage form.	In this bits are stored in the form of electric energy.
These are used in cache memories.	These are used in main memories.
Consumes more power and generates more heat.	Uses less power and generates less heat.

2.1.3 ROM (ROM)

- A Read-Only memory (RAM) is one in which information is permanently stored. Computer almost always contains a small amount of Read-Only Memory (RAM).
- ROM is used for storing special set of instruction, which the computer needs when it start up (boot up).
- Unlike RAM, the information from ROM can only be READ and it is not possible to WRITE fresh information to it. That is the CPU can only fetch or READ instructions from ROM. This is the reason why it is called ROM.
- When we switch the computer off, the contents of the ROM does not get erased. Therefore, it is non-volatile memory. Thus, a Read Only Memory (ROM) is one in which information is permanently stored. The following figure shows a relationship between the CPU and main memory (RAM and ROM).

2.1.4 PROM (PROM)

- A variation of ROM chip is programmable read only memory (PROM). A PROM is a memory chip on which data can be written only once.
- ROM chips are supplied by computer manufacturer and it is not possible for a user to modify the programs stored inside the ROM chip. PROM refers to the kind of ROM that the user can burn information into. In other words, PROM is a user-programmable memory.
- Once a program has been written on to a PROM chip, the recorded information cannot be changed i.e., the PROM becomes a ROM and it is only possible to read the stored information.
- PROM is also a non-volatile memory i.e., the stored information remains even if power is switched off.
- The basic difference between PROM and a ROM is that a PROM is manufactured as blank memory, whereas a ROM is programmed during the manufacturing process. To write data on a PROM chip, you need a special device called a PROM programmer or a PROM burner. The process of programming a PROM is sometimes called burning the PROM.

2.1.5 EPROM (EPROM)

It is a memory chip that is non-volatile in nature that is it can hold the data even after the power supply is stopped. It can be reused again and again as it is easily programmable and erasable. The chip can be reprogrammed to store new information by using a special device called a PROM programmer or a PROM burner.

In 1967, Dawon Kahng and Simon Sze at Bell Labs proposed that the floating gate of a MOSFET(metal-oxide-semiconductor field-effect transistor) could be used for the cell of a

reprogrammable ROM (read-only memory). With this concept in mind, Dov Frohman of Intel invented EPROM in 1971. Frohman designed the Intel 1702, a 2048-bit EPROM, which was announced by Intel in 1971.

Characteristics

- Each and every EPROM is programmed by electronic devices.
- The data contained in EPROM is erased by exposing it to ultraviolet light.
- EPROM can store data minimum for 10-20 years.
- Erasing window is kept covered to avoid unwanted exposure to UV light to avoid accidental loss of data.
- When an EPROM chip is in use, information can only be READ and the information remains on the chip until it is erased.
- An EPROM differs from a PROM in that a PROM can be written to only once and cannot be erased.
- EPROMs are widely used in personal computer they enable the manufacturer to change the contents of the PROM before the computer is actually delivered. This means that bugs can be removed and new versions installed shortly before delivery.

Advantages

- Easily erasable and programmable.
- Quite effective – As memory data can be erased again and again for use, therefore it eliminates the need of other external memory.

Disadvantages

- A particular selected data is not deleted instead whole data gets erased which is the cause of worry for the user.
- User needs to keep backup as whole data gets erased.
- It needs UV light to erase the data which is very rare.
- Process of erasing data is quite complex.

2.1.6 EEPROM (EEPROM)

EEPROM is a type of non-volatile primary memory and modified version of EPROM (Erasable Programmable Read-Only Memory) which uses electrical signals to erase and program the contents rather than UV signals which was used previously in EPROM. It is used as a chip in computers to store the digital data. There are two types of EEPROM – Serial EEPROM Parallel EEPROM

EEPROM was developed in 1978 at Intel by *George Perlegos*. Being a non-volatile memory means it retains all the data even power is off and stores a large capacity of data or bits compared to EPROM. It is used as flash memories in its later version and also, to store BIOS of the computer.

Characteristics

- Less time consuming: EEPROM takes 5-10 milliseconds to erase the content electronically unlike, EPROM takes minutes to erase the same content using UV signals.
- Programmable and erasable content: It can reprogrammed n number of times and that life cycle has to be defined by the manufacture and it can be maximum of 1 million life cycles in modern EEPROMs.
- No detaching of chip: To reprogram or erase the content, there is no need to take the chip out of the computer.

Advantages

- Fast erasing of data as it uses electrical signals and can erase all contents or can erase by particular byte.
- Data stored is non-volatile and retains even if the power is off.
- Easy to reprogram without taking it out from computer and does not require any additional equipments for reprogramming.

Disadvantages

- Data retention problem as insulator used is not a perfect insulator and manufacture provides data retention upto 10 years.
- It requires different voltages for reading, writing and erasing the content.

2.1.7 FLASH MEMORY

- Flash memory is non-volatile computer memory that can be electrically erased and reprogrammed.
- It is a technology that is primarily used in memory cards and USB flash drives (thumb drives, handy drive, memory stick, flash stick, jump drive, "Cap N' Go") for general storage and transfer of data between computers and other digital products.
- It is a specific type of EEPROM (Electrically Erasable Programmable Read-Only Memory) that is erased and programmed in large blocks.
- The application examples include: PDAs (personal digital assistants) and laptop computers, digital audio players, digital cameras and mobile phones.
- It has also gained popularity in the game console market, where it is often used instead of EEPROMs or battery-powered SRAM for game save data.
- Flash memory is non-volatile, which means that it does not need power to maintain the information stored in the chip.
- Flash memory offers fast read access times (although not as fast as volatile DRAM memory used for main memory in PCs) and better kinetic shock resistance than hard disks.

Popular flash memory devices

Memory Stick:

- A Memory Stick is an IC (Integrated Circuit) which is stored in a compact and rugged plastic enclosure.
- Memory Sticks are designed to store data and to enable the transfer of data between devices equipped with Memory Stick slots.

Compact Flash:

- A Compact Flash card is an IC (Integrated Circuit) which is stored in a compact and rugged plastic enclosure.
- Compact Flash cards are designed to store data and to enable the transfer of data between devices equipped with Compact Flash slots. Current Compact
- Flash capacities range up to 8GB.

SD Card:

- A SD Card (Secure Digital Card) is an IC (Integrated Circuit) which is stored in a compact and rugged plastic enclosure.
- SD Cards are designed to store data and to enable the transfer of data between devices equipped with SD Card slots.
- Current SD Card capacities range up to 16 GB.

Multimedia Card (MMC):

- A Multi-Media Card (MMC) is an IC (Integrated Circuit) which is stored in a compact and rugged plastic enclosure.
- Multi Media Cards (MMC) are designed to store data and to enable the transfer of data between devices equipped with Multi-Media Card (MMC) slots.
- Current Multi-Media Card (MMC) capacities range up to 2GB.

Types of Flash Memory

There are two types of Flash memory most commonly acknowledged: NAND and NOR Flash. NOR Flash was the first of the two to be introduced in 1988 by Intel, while NAND Flash was later introduced by Toshiba in 1989. Their main differences can be identified in their architecture. NOR and NAND are named for the way the floating gates of the memory cells that hold data are interconnected in configurations that resemble a NOR or a NAND logic gate.

NOR Flash

NOR Flash is optimized for random access capabilities where it is able to access data in any order and doesn't require following a sequence of storage locations. In terms of its architecture, each of NOR Flash's memory cells are connected in parallel where one end of the memory cell is connected to the source line and the other end is connected to the bit line. This allows the system to access individual memory cells.

NAND Flash

Conversely, NAND Flash is optimized for high-density data storage and gives up the ability for random access capabilities. NAND Flash cells are connected, usually eight memory transistors at time, in a series to the bit line called a string. Here, the source of one cell is connected to the drain of the next one. This series connection reduces the number of ground wires and bit lines.

In summary, NAND-based Flash memory is ideal for high capacity data storage, while NOR-based Flash memory is best suited for code storage and execution, generally in small capacities.

2.1.8 CACHE

- Cache Memory is a special high speed mechanism. It can be either a reserved part of main memory or an independent high speed storage device.
- In Personal Computers, There are two types of caching are commonly used are memory caching and disk caching.
- A memory cache, sometimes called a cache store or RAM cache, is a portion of memory made of high-speed static RAM (SRAM) instead of the slower and cheaper dynamic RAM (DRAM) used for Main Memory.
- Memory caching is effective because most programs access the same data or instructions over and over. By keeping as much of this information as possible in SRAM, the computer avoids accessing the slower DRAM.
- Some memory caches are built into the architecture of microprocessors.
- Disk caching works under the same principle as memory caching, but instead of using high-speed SRAM, a disk cache uses conventional main memory.
- The most recently accessed data from the disk is stored in a memory buffer. When a program needs to access data from the disk, it first checks the disk cache to see if the data is there.
- Disk caching can dramatically improve the performance of applications, because accessing a byte of data in RAM can be thousands of times faster than accessing a byte on a hard disk.

For example, Internet connection is the slowest link in computer. So the browser (Internet Explorer, Netscape, Opera, etc.) uses the hard disk to store HTML pages, putting them into a special folder on the disk. The first time you ask for an HTML page, the browser renders it and a copy of it is also stored on your disk. The next time, on your request to access this page, your browser will check if the date of the file on the Internet is newer than the one cached. If the date is the same, your browser uses the one on your hard disk instead of downloading it from Internet. In this case, the smaller but faster memory system is your hard disk and the larger and slower one is the Internet.

- There are other caches like **page cache, L1 cache, L2 Cache, virtual memory**.

L2 Cache: If there is some special memory bank in the motherboard which is small but very fast and two times faster than the main memory access. That's called a level 2 cache or an L2 cache.

L1 cache: If there is smaller but faster memory system directly into the microprocessor's chip and this memory will be accessed at the speed of the microprocessor and not the speed of the memory bus, That's an L1 cache.

2.2 STORAGE DEVICES

Physical components or materials on which data is stored are called storage media. Hardware components that read/write to storage media are called storage devices.

Two main categories of storage technology used today are magnetic storage and optical storage.

Primary magnetic storage

- Diskettes
- Hard disks (both fixed and removable)
- High capacity floppy disks
- Disk cartridges
- Magnetic tape

Primary optical storage

- Compact Disk Read Only Memory (CD ROM)
- Digital Video Disk Read Only Memory (DVD ROM)
- CD Recordable (CD R)
- CD Rewritable (CD RW)
- Photo CD

2.2.1 HARD DISK

A Hard disk is also known as a hard drive or fixed disk. It is said to be rigid magnetic disc that stores data. It is located within a drive unit. Hard disk is a non-volatile storage device that contains platters and magnetic disks rotating at high speeds. Non-volatile means the data retains when the computer shuts down.

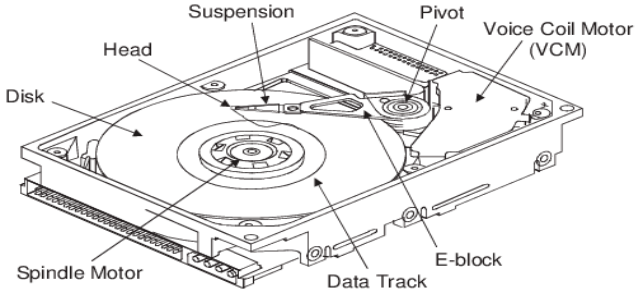


Fig 2.1 Parts of a hard disk

It is installed internally in our computer systems. Hard disk is located within a drive unit on the computer's motherboard and comprises one or more platters packed in an air-sealed casing.

Its main components include a read/write actuator arm, head actuator, read/write head, spindle, and platter. A circuit board (also called as the interface board or disk controller) is present on the back of a hard drive. It lets the hard drive to communicate with the computer.

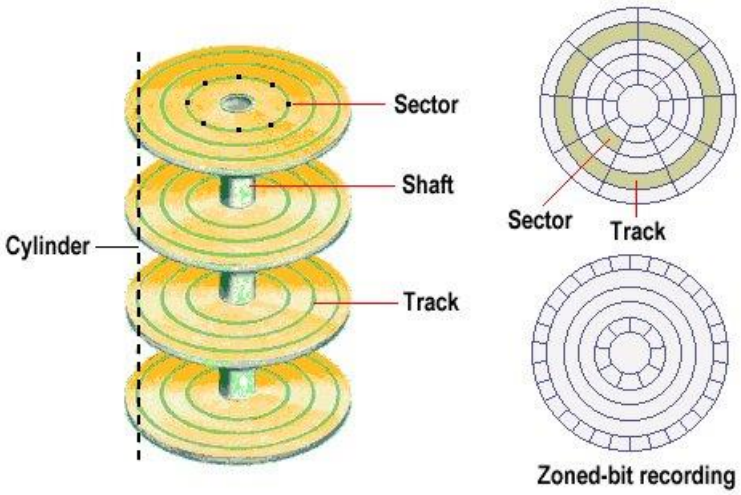


Fig 2.2 Data storage in a Hard disk

Function of Hard disk

The hard disk is a secondary storage device, which is designed to store data permanently. The secondary storage devices include a large storage capacity as compared to the primary storage devices. The data stored in a hard disk is retained when our computer

system shuts down. The data stored in the hard disk can be of many types such as the operating system, installed software, documents, and other files of computer. Hard disk was haintroduced in the year 1956 by IBM. The first personal computer contains a hard drive of less than 1 megabyte, while modern computers contain a hard drive of 1 terabyte.

Every computer contains atleast one hard drive to store data and software. In Windows operating system, the hard drive is known to be the C drive, and in MAC, it is simply called as the hard drive. The desktop computers which have external hard drives are used for backup purposes or additional storage.

The size of hard drives is measured in gigabytes and terabytes. Usually, 500GB hard disks are common in modern computers. As an instance, a song of length four-minute is approx. 4MB in size, and in 1 gigabyte, there are 1,000 megabytes, it means that a 500GB hard drive can store approx. 250,000 songs.

Advantages of the hard disk

- One of the significant advantages of a Hard Disk drive is that its cost is low.
- Another advantage of a Hard Disk is that it is readily available in the market.
- Hard Disk is faster than optical disks.
- The capacity for storing the data in HDDs is large.

Disadvantages of the hard disk

- The speed of reading and writing in HDD is slower than the RAM.
- HDDs are noisy.
- Another disadvantage of HDD is energy inefficiency.
- HDDs consume more power.
- The form factor of HDDs is heavier than the SSDs.

The hard disks are robust and can be used for a long time. But hard disks can be crashed, and the main reason is head crash. If the hard drive is crashed, we may lose all our documents, photos, etc., stored init.

2.2.2 ZIP DISK

A Zip drive is a medium-capacity and portable magnetic disk storage system launched by Iomega in the mid-1990s. It was popular at the time of launch as cost per storage unit was lower than that of hard disks, and it could store a larger amount of data than a floppy disk. The Zip drive was capable of fast datatransfer and was durable and reliable. The rise of other devices that later came to market, such as USB drives, were favored over the Zip drive and Zip disk, and these became obsolete soon afterward.

The Zip drive was available in 100- and 250-MB capacities. The initial versions of the drive could be connected to a computer by means of a parallel, SCSI or IDE port. The later versions had a USB interfaceand were thus simple to connect, being plug and play. The Zip drive was PC and Mac compatible and came with a manual and related software that provided ease-of-use features. The drive installed itself on a computer and would be assigned a new drive letter to distinguish itself from other drives. It could handle high-capacity Zip disks and had a large drive slot to fit the disks. The Zip drive also contained a retro-reflective spot for identifying the proper disk media in order to prevent damage to the disk and drive.

At the height of its popularity, the Zip drive was considered a larger version of the floppy drive and certain manufacturers included Zip drives internally in their devices. It was favored in the graphic arts vertical market and was also economical for home users at the time of launch for storing large data. Zipdrives were reportedly prone to click-of-death failures, which potentially resulted in media and data loss.

2.2.3 OPTICAL DISK

The most popular alternative to magnetic storage systems are optical storage media. The most widely used type of optical storage medium is the compact disk (CD), which is used in CD-ROM, DVD-ROM, CDR, CDRW and PhotoCD systems.

Since the mid 1990s nearly all PCs have been sold with a built in CD-ROM drive. Consumers are now buying more systems with DVD-ROM drives rather than standard CD-ROM units. These devices fall into the optical storage category because they store data on a reflective surface so that it can be read by a beam of laser light. A laser uses concentrated,

narrow beam of light, focused and directed with lenses, prisms and mirrors. The tight focus of the laser beam is possible because all the light is of the same wavelength.

CD-ROM

The familiar audio compact disk is a popular medium for storing music. In the computer world, the medium is called compact disk read only memory (CD-ROM). This uses the same technology used to produce music CDs.

The CD-ROM drive for music or data reads 0s and 1s from a spinning disk by focusing a laser on the disks surface. Some areas of the disk reflect the laser light into a sensor, other areas scatter the light. A spot that reflects the laser beam is interpreted as a 1 and the absence of a reflection is interpreted as a 0.

Data is laid out on a CD-ROM disk in a long, continuous spiral that starts at the outer edge and winds inwards towards the centre. Data is stored in the form of lands, which are flat areas on the metals surface, and pits, which are depressions or hollows. A land reflects the laser light into the sensor (a data bit of 1) and a pit scatters the light (a data bit of 0).

On a full CD-ROM the spiral of data stretches almost 3 miles long. A standard CD can store 650 MB of data or about 70 mins of audio.

CD-ROM Speeds

Compared to hard disk drives CD-ROM drives are quite slow, in part because the laser reads pits and lands one bit at a time. Another reason is the rotational speed of the disk. Like a track on a magnetic disk the track of an optical disk is split into sectors. However the sectors are laid out quite differently than they are on magnetic disks.

The sectors near the middle of the CD wrap farther around the disk than those near the edge. For the drive to read each sector in the same amount of time it must spin the disk faster when reading the sectors near the middle and slower when reading the sectors near the edge. Changing the speed of rotation takes time – enough to seriously impair the overall performance of the CD-ROM drive. The first CD-ROM drives read data at 150 KBps and were known as single speed drives. This rate is much slower than that of a typical hard drive which transfers data at rates of 5 – 15 MBps.

Presently CD-ROM drives read data 2 → 52 times faster than first models (300 → 7800 KBps). Even with the changing speed of the disk reading data from an optical medium is a relatively simple undertaking. Writing data however is another matter. The medium is a foil disk that is physically pitted to reflect or scatter the laser beam. The disk is then covered in a plastic coating and it is difficult to alter the surface of the disk after it has been stamped.

CD-ROM Uses

The fact that you must use special technologies to write data to an optical disk does not mean that this storage medium is not useful. In fact many applications rely on huge volumes of data that rarely change. Because of the high precision and data density possible with CD-ROM, a single CD typically can hold about 650 MB of data.

Software companies can distribute their products on CD-ROM. Because of the high capacity and the fact that 1 CD much cheaper to produce than a set of diskettes, many software publishers regard CDs as the distribution medium of choice.

DVD-ROM

Digital video (or versatile) disk read only memory, is a high-density medium capable of storing a full-length movie on a single disk the size of a CD.

Achieves such high storage capacities by using both sides of the disk and special data compression technologies. The latest generation of DVD-ROM use layers of data tracks; the laser beam reads data from the first layer and then looks through it to read data from the second layer.

Each side of a standard DVD-ROM can hold up to 4.7 GB. Dual layer DVD-ROM can hold 17 GB of data.

CD-R, CD-RW, PhotoCD

CD-R allows you to create your own CD-ROM disks that can be read by any CD- ROM drive. After the information has been written to the CD it cannot be changed.

Using CD-RW drives the user can write and overwrite data onto CDs. With a CD- RW data can be revised in the same manner as a floppy disk.

One popular form of recordable CD is PhotoCD, a standard developed by Kodak for storing digitised photographic images on a CD. Many film-developing stores now have PhotoCD drives that can store your photos and put them onto a CD.

2.2.4 PEN DRIVE

A pen drive, which is often known as a memory stick or USB stick, is a portable electronic device that is used to store different types of data such as photos, videos, music files, and other graphics documents. It can be easily carried to any place due to its compact size. The data from the pen drives can be easily assessed by attaching it to the USB ports provided on the computer's motherboards or mobile phones. Due to its ability to store a huge amount of data and that too with high data transfer speed, it has easily replaced the old data storing devices such as floppy disks, digital versatile discs (DVDs)and compact disks (CDs). The data storage capacity of the pen drives usually ranges from 2 GB to 128 GB, but the latest designed pen drives are also available in a few range of TBs. The weight of the standard pen drive is around 30 grams. The invention of pen drives has saved a lot of time as one need not waste the time on burning the CDs and finding the floppy disk labels to save or access the data. One can easily access or share the data by just plugging in the pen drive with the device.

The pen drive comprises a small printed circuit board (PCB), which is usually built of plastic or metallic body. This device used the technology of EPROM, i.e., Erasable Programmable Read-only Memory, which means the data stored in the pen drives can be read, written, and erased easily. The PCB is provided with a power circuit, integrated circuits, and USB connectors. One of the integrated circuits acts as the interface between the USB

connectors and the memory, and another integrated circuit is a NAND flash memory, which stores all the data. The data stored in the pen drive is controlled by a 12MHz clock signal crystal oscillator.

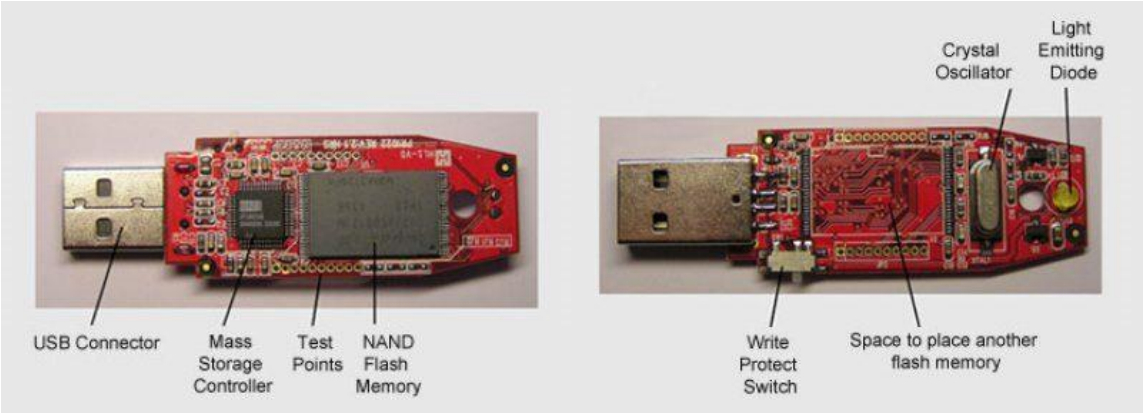


Fig 2.3 The internal structure of the pen drive.

Main Components of Pen Drive

1. USB Connector

The USB connector is the interface between the computer (where the pen drive is attached) and the NAND flash memory chip. It is secured by a removable cap. Mostly, the pen drives consist of a standard type-A USB connection that is connected to the port of the device, but nowadays, a faster version, i.e., USB Type-C connector is gaining more popularity. The electric power from the computer is consumed by the pen drive through the USB connector.

2. USB Mass Storage Controller/Controller Chip

The controller chip is called the brain of the pen drive. This chip helps to read or record the information/data on the NAND flash memory. It also helps to recover the data from the pen drive.

3. NAND Flash Memory Chip

The purpose of the NAND flash memory chip is to store the data. It also allows the users to erase the data stored in the pen drive so that new information can be transferred into it. The memory stored by the NAND flash chip is of non-volatile type, i.e., it does not need any power to retain the information. The primary purpose of using the NAND flash chip in the pen drive is to enhance the storage capacity. The NAND flash uses the electric circuits for storing the data and it stores the data in the forms of blocks. The NAND flash memory retains the data even when the power is cut-off as the metal oxide semiconductor layer provides the supply of an extra electric charge to retain the data. The NAND memory cells consist of two gates, i.e., control gate and floating gates. These gates help in controlling the transfer of data. The NAND gate stores the data as one byte (one word) at a time, but the data is erased in the blocks. The detailed working of the NAND flash memory chip, or we simply say the working of pen drive is explained further in this article.

4. Crystal Oscillator

The crystal oscillator is a small piece of quartz fitted in the pen drive, which vibrates at a specific frequency. It acts as a small clock inside the Pendrive, which manages the functioning/timing of each component inside the pen drive by providing accurate timings.

Other Components of Pen Drive

1. Outer Cover

It refers to the part of the USB that we see from the outside. It is generally built of plastic, metal, and sometimes wooden too. The sole purpose of the outer cover is to protect the internal components of the pen drive. Nowadays, the outer covers are also custom designed according to the user's demands.

2. LED

It is used to indicate the working condition of the Pendrive.

3. Test Points

Test points are certain locations/pins that are mounted during the manufacturing process on the pen drive. These points are used to check the working of the device and help in the repairing process in case of any failure.

4. Write Protect Switch

It is an optional component and is generally installed in pen drives if the user demands high data security. It is a tiny switch, which safeguards the data stored on the pen drive from the host devices. Pendrives with an inbuilt write-protect switch are very helpful if one is not aware of the security of the devices with which the pen drive is attached.

5. Second NAND flash Memory Chip Space

It is the additional slot, which is added into some pen drives during the manufacturing process, where another NAND flash memory chip can be installed to increase the storage capacity of the pen drive.

Understanding the Theory of Pen Drive

The chip used in the pen drive consists of a number of transistors, which acts like tiny switches. The data is stored in the pen drive in the form of 1s and 0s, and each of these values is stored at specific points in the memory. The transistor at a specific location gets switched on and allows an electric charge to flow through it to store the value '1.' The pen drives are comprised of different type of transistors, which stays on/off even when there is no power supply, which is why the data remains in the pen drive even if we disconnect it from the device. A normal transistor consists of three terminals, i.e., the source, drain and gate.

To easily understand the working of storage of the data in the pen drive, consider the transistor as a water pipe, the electricity flows through the transistor as the water flows through the pipe. Where the one end of the pipe from which the water enters is called the source, and

another end from which the water flows away is called the drain. There is a gate between the source and the drain. When the gate is shut off, no water, i.e., no electricity flows through, hence the transistor is switched off, and the transistor stores the value zero. It stores the value one when the gate of the transistor is opened, and the electricity flows through it but if the power supply is switched off, the transistor also gets switched off. When the power is switched on, and the transistor is still switched off (due to closed gate), and we don't know that whether the transistor was on or off before the power was switched off. In this case, the transistor forgets (loose) the information stored in it.

However, the transistors used in the pen drives are different. These transistors are provided with the second gate, which lies above the first gate. When the gate is opened, some amount of electricity gets leaked and stored in between both the gates and stores the data as the value one. In this way, the data is stored in the pen drives even when the power is switched off as the electricity is still present between the gates. The stored data can be erased by draining the electricity between both gates.

Working Principle of Pen Drive

The transistors used in the pen drives are like 'metal-oxide-semiconductor field-effect transistor (MOSFET) with the only difference that unlike MOSFET's it has two gates instead of one. 'Figure A' represents the inside structure of the MOSFET used in the Pendrive. As seen from the figure, it's an n-p-n junction, which consists of two gates, i.e., the control gate (upper gate) and the floating gate (lower gate). The gates are separate with an oxide layer through which current does not flow in the normal conditions. The transistor is switched off in this condition and has stored the value zero.

Now, let's understand that how does it store the data. The source and the drain region of the MOSFET are built of the n-type silicon, hence they have a high number of electrons; however, these electrons cannot directly flow from the source region to the drain region as there exists an electron-deficient, i.e., P-layer between them. However, we can force the electrons to enter the drain from the source by applying the positive voltage across the two contacts of the transistor, i.e., the bit line and the word line (as shown in the image below). During this situation, some of the electrons manage to pass through the oxide layer by the tunnelling process. These electrons stay over the floating gate. The electrons present on the floating gate is what we called that the transistor has stored the data as 'one.' The electrons remain on the floating gate even if the positive voltage is stoped or the external power supply is switched off.

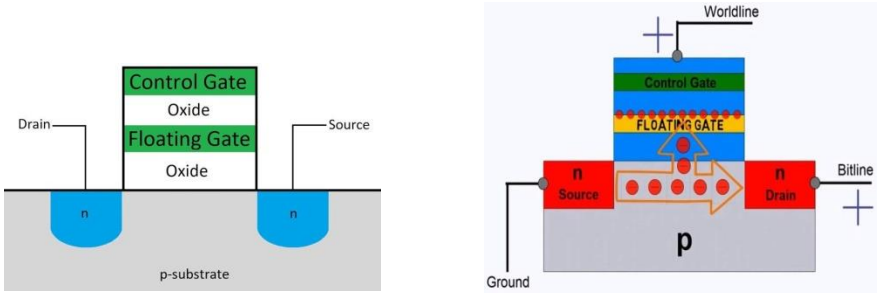


Fig The transistor in a pendrive and charge flow in it.

The data stored can be deleted by removing the electrons from the floating gate. This can be done by applying the negative voltage on the word line. In this case, the electrons will be

repelled back, and the floating gate gets clear, which eventually makes the value zero again. Hence, in this way, the data is stored and deleted in the pen drive.

Types of Pen Drive

Different types of pen drives are available depending upon the different features such as shape, size, design, and storage capacity. Some commonly used pen drives are described below.

1. OTG Pendrive

These pen drives can be directly connected to portable devices such as laptops and mobile phones. Hence, one can easily view the stored data, or transfer the data stored in the pen drives into your device.

2. Flash Drive

The Flash drives consist of different options of USB ports and different data transfer speeds, one can choose any out of them as per the requirement. Different options of USB includes USB 3.1, USB 3.2, and USB 2,0. The flash drives use flash memory for data storage.

3. Wifi Pen Drive

These pen drives do not require any port for the transfer of the data. The data can be accessed or transferred within the devices without any cable connection. You just need to connect your device with the wifi Pendrive for sharing or accessing the data. One need to plug in the wifi pen drives only at the time of charging.

5. Boot Flash Drive

The boot flash drives are specially designed pen drives, which are used to install the operating system in computers or laptops.

4. Different designed Pen Drives

Nowadays, the pen drive is available in different shapes and sizes. They are available in different designs to lure users. Some commonly used designs are

5. Different Storage Capacity Pen Drives

Every pen drive is manufactured with a certain storage capacity. The commonly available storage sizes of pen drives are 128 MB, 256MB, 8GB, 32 GB, 128GB, 256GB. The latest pen drives are even available in the storage capacity of 1TB and 2TB.

Applications of Pen Drives

- The most obvious application of the pen drive is storing the data and transferring the data into different devices. One can easily view the pictures, videos, or documents by simply plugging in the pen drive with the device.

- Nowadays, pen drives are also used for marketing purposes. The cheap pen drives are given free with the main product to lure the customers. Custom-designed pen drives with the logo of the company are also used as a medium of advertisements.
- Pen drives are used for data backup. The pen drives are widely used by small businesses as a backup medium. At the end of the working day, the data is stored in the pen drive and is secured safely.
- Pen drives help in creating the password reset disk. It is the feature provided by the Windows operating system, which can be used to reset the computer password.
- Pen drives allow the user to run some applications on the computer even without installing them. The applications are stored in the pen drive and they can be run on the computers by attaching the pen drive with them. Hence, one can use pen drives as the application career.
- Pen drives are also used for the booting process. Latest designed computers or laptops allow booting from the bootable pen drives. The coding required for the booting process is installed in these pen drives, and this configuration is known as the Live USB.

Advantages of Pen Drive

- The small size and the lightweight is one of the greatest advantages of the pen drives. One can easily carry his/her data to any location by storing it in the pen drive. Unlike the other storage devices like DVDs, CDs, and floppy disks, pen drives can be easily kept in the pocket.
- With the advancement of technology, some of the latest designed pen drives, even have the capacity to store data up to TBs. Hence, pen drives come in handy to store even a large amount of data.
- Pen drives have made the process of data transfer between the devices very easy. Earlier, computers or laptops were provided with CD drives or floppy drives, which were quite complicated for the data transfers, but modern computers and laptops are provided with USB ports, and one can easily transfer the data through the pen drives.
- The transfer rate of the pen drive is very high compared to other devices, and also it is quite cheaper than the other storage devices.
- Unlike, CDs and DVDs, pen drives are not prone to any scratches.

Disadvantages of Pen Drive

Although there are numerous benefits of using pen drives, there exist certain disadvantages too, which are discussed below.

- The pen drives are not long-lasting as each pen drive consists of a limited number of program-erasable cycles, i.e., the number of times the data is stored and deleted from the pen drive. Usually, the pen drive has around 100,000 program-erasable cycles, and after this limit, the data stored in the pen drive starts becoming corrupt.

- As discussed earlier, the small size of the pen drive makes it easy to carry it to different locations, but the chances of losing the pen drive due to its small size are one of the disadvantages of pen drives. One can easily drop the pen drives from his/her pocket, which could be dangerous as it may contain confidential data which can be assessed by the other person. Hence, the pen drives are more susceptible to getting lost as compared to the CDs and DVDs.
- The pen drives are more vulnerable to getting corrupt if not kept carefully. Hence, one needs to carefully handle the pen drive to increase its shelf life.
- The major disadvantage of the pen drives is that if the pen drive consists of any virus in it, then it can spread the virus to the other devices to which it gets connected. Hence, the pen drives should always be scanned first to protect the computer from getting infected.

2.2.5 BLU RAY

Blu-ray is an optical disc format such as CD and DVD. It was developed for recording and playing back high-definition (HD) video and for storing large amounts of data. Blu-ray uses a different type of laser to read the discs, allowing a single disc to store more data.

As Blu-ray can store more data, it can provide a much better picture and audio quality compared to the DVD format. The best blank Blu-ray discs have large capacities and can be written quickly. Blu-ray disc prices tend to be largely affordable, and a Blu-ray disc's capacity can be as large as 100GB.

Benefits of a Blu-Ray Disc

There are many benefits of a Blu-ray disc. However, the main perk a lot of users will agree with is its incredible storage capacity. A standard DVD holds 4.7 Gigabytes (GB) of data, enough to hold one movie. If a movie is longer than two hours, you will need two DVDs or a double-layer DVD that can store around 9GB. On the other hand, a double-layer Blu-ray disc can hold a massive 50GB of data.

Another benefit of Blu-ray discs provide is image resolution. Image resolution simply means how your picture looks when you're viewing the disc. This is usually what a lot of people care about when it comes to watching movies and TV shows at home. On a DVD, you won't be getting a high-definition movie compared to a Blu-ray disc. Blu-ray is made for HD, so you can rest easy knowing that you will be getting the best picture possible with 1080 HD capability for your Blu-ray movies.

How Does a Blu-Ray Disc Work?

Unlike current DVDs, which use a red laser to read and write data, Blu-ray uses a blue laser. A blue laser has shorter wavelengths (405 nanometers) than a red laser (650 nanometers). The smaller beam focuses more precisely, enabling it to read information recorded in pits that are only 0.15 microns long. This is more than twice as small as the pits on a DVD.

Each Blu-ray disc is about the same thickness (1.2 millimeters) as a DVD, but the two types of discs store data differently. In a DVD, the data is sandwiched between two 0.6mm

polycarbonate layers. Having a polycarbonate layer on top of the data can cause a problem called birefringence, in which the substrate layer refracts the laser light into two separate beams. If the beam is split too widely, the disc cannot be read. Also, if the DVD surface is not exactly flat and not perpendicular to the beam, it can lead to a problem known as disc tilt where the laser beam is distorted. The Blu-ray disc overcomes DVD-reading issues by placing the data on top of a 1.1 mm thick polycarbonate layer. Having the data on top prevents birefringence and therefore prevents readability problems. And, with the recording layer sitting closer to the objective lens of the reading mechanism, the problem of disc tilt is virtually eliminated. Because the data is closer to the surface, there is a hard coating on the outside of the disc to protect it from scratches and fingerprints.

What Type of File System Is Used by Blu-Ray Discs?

The name of the file system that is used by Blu-ray discs is called UDF, which is short for Universal Disk Format. While usage of UDF is most prevalent when it comes to DVDs, it is also used for newer optical disc formats.

Blu-Ray Vs. DVD

Although Blu-ray discs look exactly the same shape and size as DVDs, there are many differences between the media. This includes storage capacity, laser technology, disc construction, image resolution, and player compatibility.

Storage Capacity

Storage capacity is measured in GB – The more GB the disc has, the more information it can hold. A single layer DVD can store about 4.7GB of data, while a single layer Blu-ray disc can store approximately 25GB of data. It is about two hours of high-definition or 13 hours of standard definition.

Laser Technology

Both media use lasers to read the information stored on the disc. As the disc spins, the laser reads the information and transfers both picture and audio to the television. DVD players use a red laser at 650nm wavelength to read DVD discs. As the disc spins, the laser reads the information encoded on the media and produces an image and sound on your television.

Blu-ray players, on the other hand, use a blue laser to read the stored information. Blue laser wavelengths are shorter than the red at 405nm and are about two-and-a-half times smaller in diameter than red lasers. This allows for closer and more precise reading of information stored on the disc.

Disc Construction

Physically, Blu-ray and DVD discs look identical. Both media have grooves or pits on their bottom layer that enables the laser to penetrate through and read the stored information. Since DVDs are read with a red laser, the grooves on its underside need to be wide enough to accommodate the larger wavelength. Because the grooves are so far apart, you can only store 4.7GB of information on each layer of the disc. Blu-ray discs, however, are much thinner and

closer together. The blue laser used to read the disc has a shorter wavelength and is two and a half times thinner than the red laser. This allows the Blu-ray disc to squeeze almost five times as many grooves on to a disc exactly the same size as a DVD.

Image Resolution

Image resolution is measured by the number of vertical lines times the number of horizontal lines of light in a picture. It is represented by the number of horizontal lines going across the screen such as 480, 720, or 1080. The higher the number, the higher the resolution. Almost all DVDs have a shared definition resolution of 480 or an enhanced definition resolution of 520. These resolutions look great on a standard TV, utilizing all available pixels on the screen. However, the picture may look grainy once blown up to accommodate a widescreen HDTV. Blu-ray, however, was designed for a high-definition 1080 display. Since they can store 25GB of data, you can fit an entire HD movie on a single-layer disc.

Player Compatibility

It's important to note that Blu-ray discs cannot be played in a standard DVD player. However, all Blu-ray players currently on the market are backwards compatible and will still play standard DVDs. However, the DVD image displayed, while still decent, will not be high-definition quality like a Blu-ray disc.

Are Blu-Ray Discs Worth It?

In 2021, it's no surprise that most users' media consumption is streamed via the Internet. However, what could come as a surprise to many is that there are still plenty of users who search for Blu-ray versions of top films on Amazon. It's evident that users still recognize the value in better Blu-ray experience and are prepared to pay for the privilege of enjoying it. A lot of film and TV enthusiasts who follow actors' or directors' careers or pay particular attention to cinematography find value in owning Blu-ray disc movies (whether it's 4K Blu-ray disc or HDR Blu-ray disc). To these users, it's the only way to have media that is actually tangible outside of seeing it in a theater. There are also a lot of users out there noticing the disparity between their TV's picture quality (especially if it's a newer 4K TV) and its audio output. It doesn't make sense for them to stream movies and TV shows when it's not fully utilizing the technology of the TV. While there are also plenty of people who don't have much to say about the quality of content delivered by services such as Netflix, a dedicated Blu-ray player is simply just better. Even a wired ethernet internet connection results in compressed content when streaming.

While 1080p content on Netflix might look better than a sub-1080p DVD, Blu-ray and 4K Blu-ray discs are guaranteed to look better. Especially when you're watching high-quality, detailed content.

Even though there is an increase in streamed content compared to media consumption on DVDs and Blu-ray discs, it is still very much still worth it to buy Blu-ray discs. That is if you believe in consuming high-quality content, rather than streaming compressed media. If you're ready to invest in a superb movie experience, here are the best region-free blu-ray players to check out.

Medium	Capacity	Advantages	Disadvantages	Primary Uses	Storage mechanism
Hard Disk	Variable	Usually integrated into the PC very robust	Slower computer performance when diskis full	To store dataand files To store software	Magnetic
Floppy Disks	1.44 MB	Portable disk. Useful for booting older PC's Some older applicationsonly save to A drives	Very small storagecapacity Easily damaged Medium for propagation ofviruses	For transferring small files between computers	Magnetic
CD-ROM/ CD-R	650-700 MB	Portable & Medium storagecapacity Inexpensive Some types (CD-RW) can bereused i.e. rewritable disk. Can be used in certain modelsof DVD player	Some older computerscannot read CD-RW media CD-R discs are 'writeonce', which means once data is copied to it, new or additional data cannot be added	To store files and software To store archive material from hard disks To store scanned files such as exam papers To store applications from the Internet	Optical
Magnetic Tape	20 GB to 2 TB	Very large storage capacity Disks are durable, robust andrewritable Inexpensive	Data cannot be accessed immediately Required tape drive and third partysoftware Tape drives for large capacity tapes can be very expensive	To store files Ide al for large scale daily and weekly backup operations particularly for servers.	Magnetic
DVD-ROM DVD±R DVD±RW	4.7GB to 8.5GB	Large storage capacity Some types (DVD±RW) can be reused orrewritable. Can be used in certain modelsof DVD player.	Not all computers canread DVD±R or DVD±RW disks. DVD±R discs are 'write once', which means once data is copied to it, new or additional data cannotbe added	Same as CD-ROM/ CD-R/CD-RW	Optical

UNIT III

3.1 INPUT DEVICES

The computer will be of no use unless it is able to communicate with the outside world. Input/ Output devices are required for users to communicate with the computer.

In simple terms, input devices bring information INTO the computer and output devices bring information OUT of a computer system. These input/output devices are also known as peripherals since they surround the CPU and memory of a computer system. Input devices are hardware devices that allow data to be entered into a computer.

The computer will be of no use if it is not communicating with the external world. Thus, a computer must have a system to receive information from the outside world and must be able to communicate results to the external world. Thus, a computer consists of input/output devices. Input and output devices can also be written as I/O devices.

Input and output devices of a computer system are the devices that connect you to computer. Input devices let you to transfer data and user command into the computer system. I/O devices are used to interact with the computer system. For example, you can type in data by using a keyboard, or you can input data in picture form by using a scanner in computer system.

An input device presents data to the processing unit in a machine-readable form. Although the keyboard is a common input device for a small computer, a system may also support various other input devices such as Optical Character Recognition (OCR), Magnetic Ink Character Recognition (MICR), mark sense reader, etc.

Manual Input devices: Data is input into the computer by hand. Manual input devices require humans to do most of the work needed to get data into the system. (e.g.) Keyboard, Mouse, Tracker ball, Joystick, graphics tablet, digital camera, Webcam, microphone, touch screen, chip and pin

Direct Input devices (automatic input devices): Data is input into the computer directly by a machine or device. Direct input devices do not require much human interaction to get their data into a computer system. (eg.) Barcode scanner, Magnetic stripe reader, OMR reader, OCR reader, biometric scanner, Sensor.

3.1.1 KEYBOARD

The keyboard is the most common and widely used input device. It is made up of buttons called 'keys'. The keys are arranged into sections:

- Alphabet keys
- Function or F keys (F1, F2, F3)
- Numeric keys (one set above the alphabet keys and a numeric keypad on the right)
- Arrow keys

• Command keys (insert, delete, home, end, page up/down)

Keyboards are used to input **Text**, **numbers** and **instructions** into the computer. Most keyboards use a **QWERTY** key layout. This name comes from the first six letters on the top row of the alphabet keys.

Special keyboards called "**Ergonomic keyboards**" have built-in-hand-rest which prevents health issues such as RSI (Repetitive Strain Injury).Ergonomic keyboards have natural shape to reduce stress on wrist and hands.

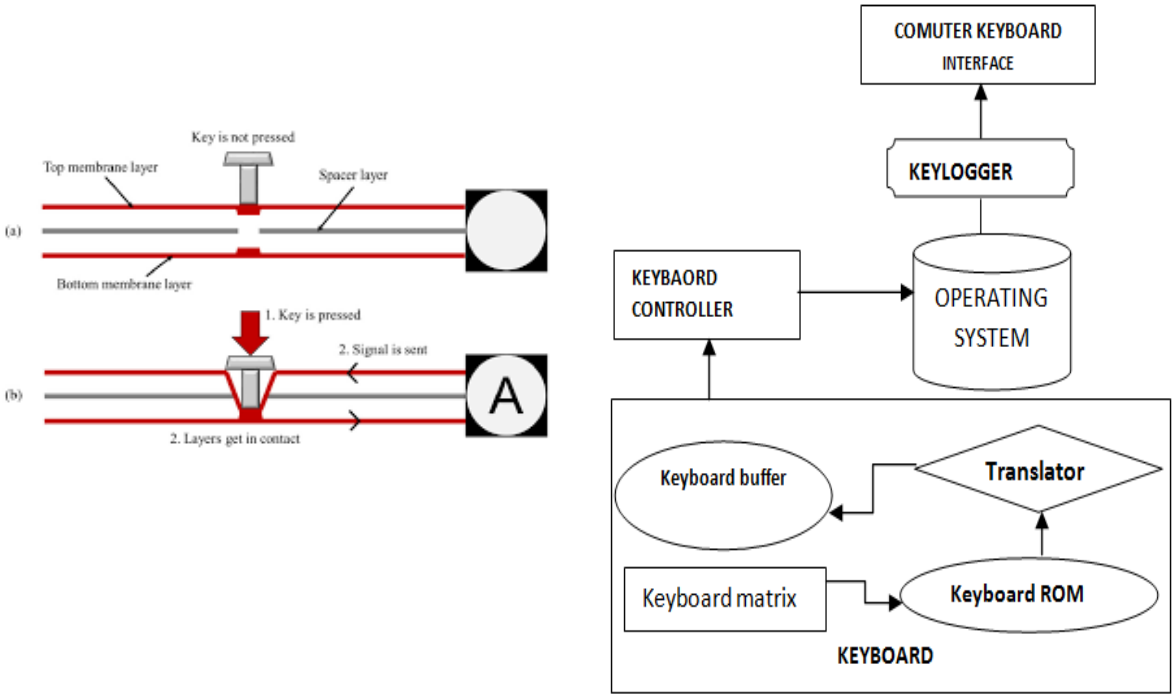


Fig 3.1 Working of a Keyboard

A **concept keyboard** is a specialized keyboard with no pre-set keys. It relies on a touch sensitive screen with the key or overlay displayed on the screen. Each key can be programmed with a wide range of different functions. The overlay is often used as a quick and easy way to input items with without needing to type anything or use a mouse. If you go to a fast food restaurant, the assistant will normally be using a concept keyboard. Pictures and icons can replace words and means that the assistant can quickly enter the order without having to use a keyboard.

Numeric keypads are used for entering numbers into a computer system. Some numeric keypads allow you to enter simple text and symbols. Numeric keypads are found in ATM (Automatic Teller Machines), telephones and chip and pin device. Electronic point of sale (EPOS) terminals has numeric keypads in case the barcode reader fails.

Uses of keyboard:

• Keyboards are used to enter text, numbers and instructions into applications like Word and Excel.

• Keyboards can also be used to enter commands(keyboard shortcuts) into the computer

Advantages of keyboards:

1. Enable fast entry of data.
2. Most computers come with a keyboard supplied
3. People need very little training to use keyboard.

Disadvantages of keyboards:

1. Keyboards are large and can take up a lot of desk space.
2. Keyboards are not suitable for creating diagrams.
3. Excessive use can lead to health problems such as repetitive strain injury (R.S.I.)
4. Entering data is slow compared to automatic methods. For example a barcode scanner will input data into the computer almost instantly.

Alphanumeric Keypad – It consists of keys for English alphabets, 0 to 9 numbers, and special characters like + − / * ( ) etc.

Function Keys – There are twelve function keys labeled F1, F2, F3… F12. The functions assigned to these keys differ from one software package to another. These keys are also user programmable keys.

Special-function Keys – These keys have special functions assigned to them and can be used only for those specific purposes. Functions of some of the important keys are defined below.

Enter – It is similar to the 'return' key of the typewriter and is used to execute a command or program.

Spacebar – It is used to enter a space at the current cursor location.

Backspace – This key is used to move the cursor one position to the left and also delete the character in that position.

Delete - It is used to delete the character at the cursor position.

Insert - Insert key is used to toggle between insert and overwrite mode during data entry.

Shift -This key is used to type capital letters when pressed along with an alphabet key. It is also used to type the special characters, located on the upper-side of a key that has two characters defined on the same key.

Caps Lock - Cap Lock is used to toggle between the capital lock features. When 'on', it locks the alphanumeric keypad for capital letters input only.

Tab - Tab is used to move the cursor to the next tab position defined in the document. Also, it is used to insert indentation into a document.

Ctrl - Control key is used in conjunction with other keys to provide additional functionality on the keyboard.

Alt - Also like the control key, Alt key is always used in combination with other keys to perform specific tasks.

Esc - This key is usually used to negate a command. Also used to cancel or abort executing programs.

Numeric Keypad - Numeric keypad is located on the right side of the keyboard and consists of keys having numbers (0 to 9) and mathematical operators (+ − * /) defined on them. This keypad is provided to support quick entry for numeric data.

Cursor Movement Keys - These are arrow keys and are used to move the cursor in the direction indicated by the arrow (up, down, left, right).

3.1.2 MOUSE

Mouse is a device that controls the movement of the cursor or pointer on a display screen. It is a small object you can roll along a hard and flat surface. As you move the mouse, the pointer on the display screen moves in the same direction. Mouse contains at least one button and sometimes as many as three, which have different functions depending on what program is running.

The mouse is a small device used to point to a particular place on the screen and select in order to perform one or more actions. It can be used to select menu commands, size windows, start programs etc.

The most conventional kind of mouse has two buttons on top: the left one being used most frequently. Mouse Actions

Left Click : Used to select an item.

Double Click: Used to start a program or open a file.

Right Click: Usually used to display a set of commands.

Drag and Drop: It allows you to select and move an item from one location to another. To achieve this place the cursor over an item on the screen, click the left mouse button and while holding the button down move the cursor to where you want to place the item, and then release it.

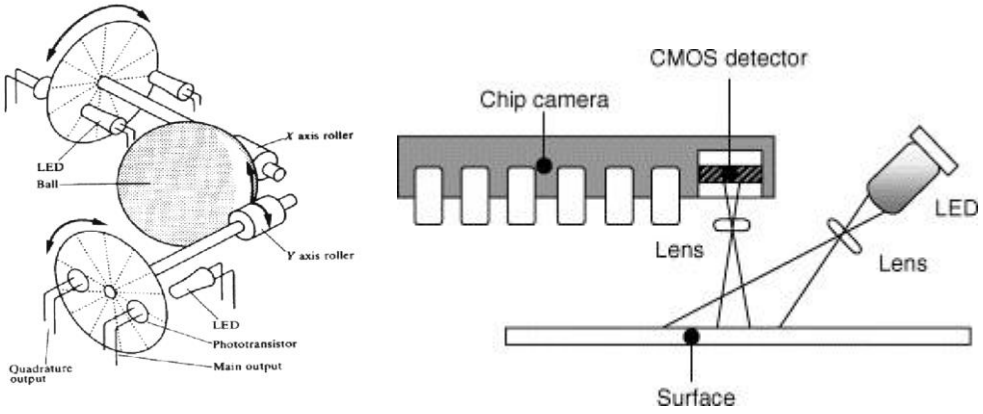


Fig 3.2 Working of a mechanical and optical mouse

Types of Mouse: Mouse could be mechanical, optical or cordless types. Further information regarding these types are as follows:

Mechanical Mouse: Mechanical Mouse uses ball for the movement of cursor on the computer screen. When the ball is rolled in any direction, a sensor of the mouse detects it and also moves the mouse pointer in the same direction.

Optical Mouse: Optical Mouse uses Laser rays for the movement of cursor on the computer screen. It is an advanced pointing device. Movement is detected by sensing changes in the reflected light rather than the motion of a rolling sphere.

Cord-Less Mouse: Cord-Less Mouse is battery driven and does not need any wire for the physical connection with the motherboard. It transmits data through infrared or radio signal. Computer mice are very useful in designing pictures and graphs and computer and video games by multimedia designers. A Mouse pad is required to move the mouse because it provides a smooth surface. However, an optical or laser mouse doesn't require a mouse pad.

Uses of Mouse:

1. Opening, closing, Maximizing and Minimizing programs and files.
2. Moving, grouping and deleting files
3. Controlling a pointer on a screen to select icons or move around the page.
4. Editing images in terms of size and position on the screen.

Advantages of Mouse:

1. Ideal for use with desktop computers.
2. Works well in conjunction with a keyboard for data entry.
3. It is small in size and do not take up much space.
4. Faster to select icons and options when compared to a keyboard.

Disadvantages of Mouse:

1. Excessive use can lead to health problems such as repetitive strain injury (R.S.I.)
2. Older style mouse which has roller balls can become clogged with grease and grime and lose their accuracy until cleaned.
3. Mouse needs a flat surface in order to work properly.
4. If the battery wears out in a wireless mouse, it cannot be used until it has been replaced

3.1.3 LIGHT PEN

A light pen is a pointing device that can detect the presence of light. Light pens are used by health care professionals (such as doctors and dentists) and design work. Light pen is a pointing

device which is similar to a pen. It is used to select a displayed menu item or draw pictures on the monitor screen. It consists of a photocell and an optical system placed in a small tube. When the tip of a light pen is moved over the monitor screen and pen button is pressed, its photocell sensing element detects the screen location and sends the corresponding signal to the CPU.

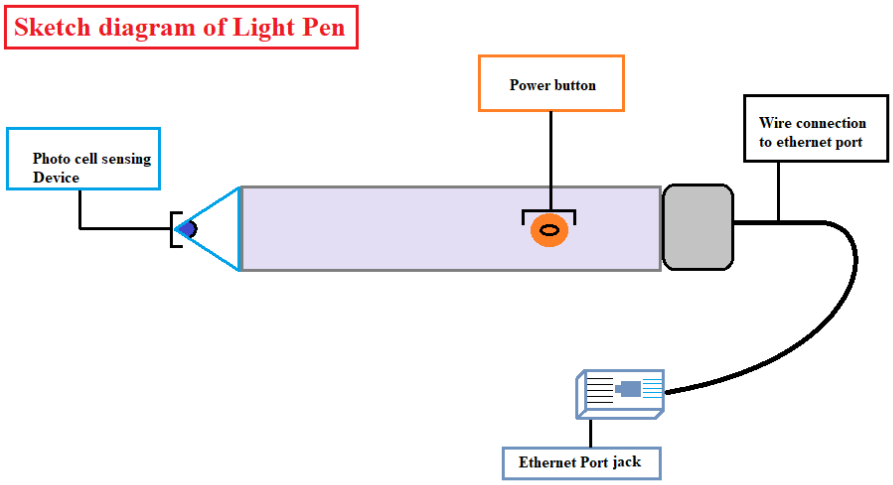


Fig 3.3 Working of a light pen

Advantages of light pens

- Using a light pen is more direct and precise than using a mouse.
- Light pen is also convenient for applications with limited desktop space.

Disadvantage of light pens

- Light pens normally require a specially designed monitor to work with.

3.1.4 TOUCH SCREEN

A touch screen is an input/output touch-sensitive display. Touch screens are often used for information kiosks located in department stores, hotels, airports, and museums. Touch screens are also used for ATM machines to allow easy access of bank accounts.

Touchscreens use light-emitting diodes (LEDs) to produce images. But how do people interact with the screen?

Touchscreens work using electricity. The screen is made of glass, an insulating material – it cannot carry an electric current. The surface of the screen is therefore coated with a thin layer of an electrically conducting material such as indium tin oxide. This is chosen because it is transparent.

The conducting layer is connected to a low voltage so that for a short time, there is a tiny electric current on the screen. This leaves it with a small electric charge.

When your finger touches the screen, some of the small electrical charge flows on to it. Don't worry – the voltages and amounts of electric charge are far too small to give you a shock.

Sensitive detectors round the edge of the screen can detect which point on the screen has lost charge so that it knows which point has been touched.

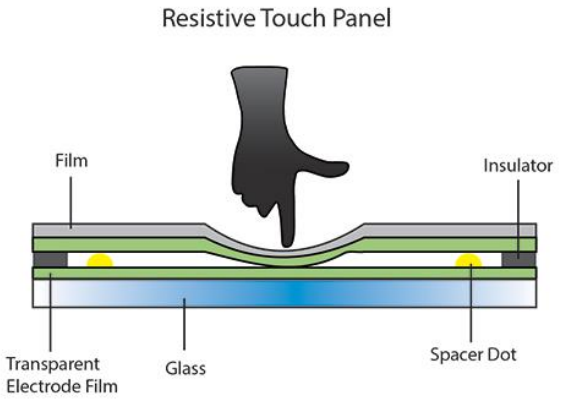


Fig 3.4 Working of Touch Screen

If you are wearing gloves the screen won't respond because the material of gloves is an insulator. That's why special gloves are sold which have electrically conducting fingertips for people who need to keep their hands warm when using a touchscreen.

Benefits

Touchscreens are becoming very familiar. They are used in:

- mobile phones and tablets
- bank cash machines, station ticket machines
- games consoles

3.1.5 VOICE INPUT

Speech or voice input devices convert a person's speech into digital form. These input devices, when combined with appropriate software, form voice recognition systems. These systems enable users to operate microcomputers using voice commands.

The voice-system or speech recognition system is a sophisticated input device that accepts voice or speech input from the user and transforms it into digital data that can be used to trigger graphic operations or enter data in specific fields. A dictionary is established for a particular operator (voice) by recording the frequency-patterns of the voice commands (words spoken) and corresponding functions to be performed. Later when a voice command is given by the same operator, the system searches for a frequency-pattern match in the dictionary and if found the corresponding action is triggered. If a different operator is to use the system then the dictionary has to be re-established with the new operator's voice patterns.

For example to control a computer, navigate telephone menus, etc. These require that the voice first be recognized. A microphone is used to input the spoken words, which are then analyses by the program. The sound is compared with other sounds stored in the computer, to find the matching word; this match may be interpreted as a command. This is an unreliable process because a user can make words sound different at different times, and different users will say

the same words differently. As a result, the software may have to be trained to recognize a particular user.

The “Microphones - Speech Recognition” is a speech Input device. To operate it, we require using a microphone to talk to the computer. Also we need to add a sound card to the computer. The Sound card digitizes audio input into 0/1s .A speech recognition program can process the input and convert it into machine-recognized commands or input.

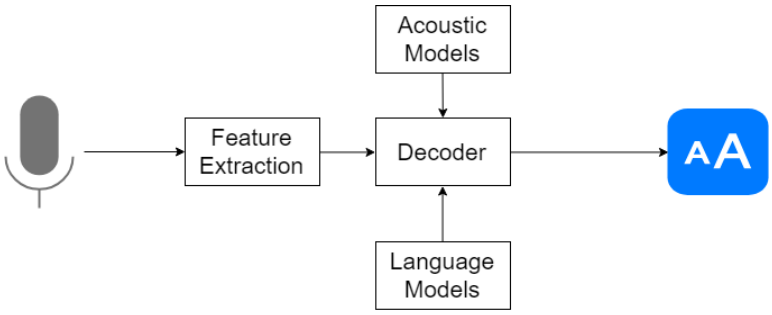


Fig 3.5 Working of a Speech Recognition Module

1. Used to input sounds/speech for use in a range of applications. For example

   - Narration in presentations or in web sites
   - Voice-over’s in movies
   - Speaking over the internet using VoIP(Voice over Internet Protocol)
   - Conducting video conferencing

2. Used in speech recognition software. For example

   - Converting speech into text for use in Word processors (useful for people who do not have use of their hands)

3.1.6 MICR

A magnetic ink character recognition (MICR) reader can read-text printed with magnetized ink. Magnetic ink character recognition is used most exclusively by the banking industry for processing checks. The characters represent the check number, the bank number, and the account number of customers.

An MICR can identify characters printed with a special ink that contain particles of magnetic material. This device particularly finds applications in banking industry. Since the MICR system can recognise only certain character styles, the characters have to be accurately formed.

Magnetic Ink Character Recognition is a character recognition system that uses special ink and characters. When a document that contains this ink needs to be read, it passes through a machine, which magnetizes the ink and then translates the magnetic information into characters.

MICR technology is used by banks for faster processing of large volumes of cheques. Numbers and characters found on the bottom of checks (usually containing the check number, sort number, and account number) are printed using Magnetic Ink. To print Magnetic Ink codes, we need a laser printer that accepts MICR toner.

MICR provides a secure, high-speed method of scanning and processing information. This technology is used for processing large volume of data. It speeds up data input for the bank because cheques can be directly fed into the input device as it also ensures accuracy of data entry. The most commonly used character set by MICR devices are known as E13B font which consists of the numerals 0 to 9, and four special characters.

MICR software scans documents for numerals and symbols printed in magnetic ink. The use of magnetic ink makes documents harder to copy. MICR is mostly used by bank cheque-processing systems for input of printed items on the bottom of each cheque.

Advantages:

1. It is highly accurate to recognize numerals and symbols even if they are overprinted by visible marks.

2. MICR is difficult to forge.

3. Documents can still be read when folded or written on.

Disadvantages:

1. MICR readers are expensive and only detect magnetic ink characters.

2. MICR readers and encoders are very expensive.

3. The system can only accept a few different character set**.**

3.1.7 OCR

Optical Character Recognition (OCR) software's are intelligent programs which can convert a scanned page of text into editable text either into a plain text file, a Word document or even an Excel spreadsheet which can be easily edited. OCR can also be used to scan and recognize printed, typewritten or even handwritten text.

The OCR software requires a raster image as an input, which may be an existing image file or an image transferred from a scanner. OCR analyzes the image to find blocks of image information that resemble possible text fields and creates an index of such areas.

Optical Character Recognition (OCR) is software which extracts the text from the imageof scanned document. OCR software compares the shape of each possible text character inthe image data with sample (template) for each character stored in computer. When itrecognizes a character then adds it in the output data sequence.

Most OCR readers include a small optical scanner for reading characters andSophisticated OCR software for analyzing what is read.

Advantages of OCR readers include

- Written data and printed data can be read at the same time.
- Hard copies of documents can be read directly into a computer without retyping.

- The characters converted can later be edited by word processing software.
- It is quicker to extract text from a document and to use it via word processor.
- It is useful for people with visual impairments because after extracting text from document, a text-to-speech software can be used to read it aloud.

Disadvantages of OCR readers include

- OCR readers often do not work well with handwritten characters or those in unusual fonts.
- The text recognized by OCR software is not always accurate.

3.1.8 OMR

Software is used to detect the presence of marks (shaded regions) in certain positions on a paper form. Unlike OCR, it cannot detect the characters. OCR software is used to extract marked answers in multiple-choice questions, survey results, votes in elections etc.

Advantage:

1. It is extremely fast and accurate because shaded regions are simple to detect.

Disadvantages:

1. Paper forms can be read accurately only if they are lined up properly.
2. The dirty marks on the paper can be read by OMR as well which leads to wrong results.

3.1.9 BARCODE READER

A barcode reader is an electronic device which is used to read printed barcodes. Barcodes represent alphanumeric data which is a combination of vertical lines (bars) that vary in width and length. It is a fast and effective way to input data. A Barcode reader uses a laser beam to read the series of thick and thin lines which represent the bar code number.

The bar code is 13 digits long and it has four main divisions. The First two digits of a bar code

represent the country, the second part represents the manufacturer's code (five digits). A barcode is a set of parallel lines in contrasting colours usually black lines on a white background. Barcodes are used to identify items of merchandise, resources, membership cards or documents. A barcode may represent numeric digits or alphanumeric characters. A barcode only tells about the manufacturer and product only. A barcode reader is usually used at Point-of-Sale (POS).

Lines of different widths and sizes representing data, that when read determine what the scanned object is. Barcodes are often used to help organize and index information or prices about an object. Barcodes used by the U.S. postal service that helps speed the delivery of mail is another perfect example of how a barcode could be used. The picture is an example of what a barcode of an address.

A barcode reader is a combination of scanner hardware and software. The scanner captures the image of barcode while software decodes the barcode in captured image.

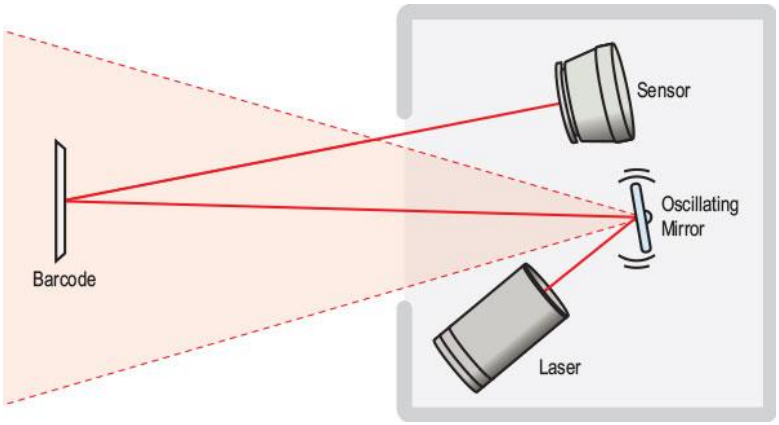


Fig 3.6 Working of a Barcode Scanner

Barcode readers and scanners

A barcode reader (BCR)or scanner, also known as a point of sale (POS) scanner is a hardware device capable of reading a barcode. It can also print out the details of the product or log information about that product into a database. A perfect example of a barcode reader is a super market barcode scanner that reads and logs the price of a product. In the picture is an example of a Barcode reader from HP. Today, many smart phones with the proper apps are also capable of scanning and reading barcodes.

At POS, a barcode reader consists of a scanner wand or a LASER scanner fixed at the operator's computer. In these dedicated scanners a suitable processor and a decoding software are built-in the scanner. It sends signals of decoded barcode to the computer for further processing.

Barcode Printers

A hardware device capable of printing out adhesive barcodes that can be attached to a product and identify a product and help keep inventory.

Advantages:

1. Codes can be entered much faster than keyboard.
2. Codes can be entered more accurately than a person.

Disadvantage:

1. Barcode is difficult to read or may be misread by barcode reader if it is obscured.

3.1.10 FLATBED SCANNER

Loading a Document

A scanner needs a source document from which to begin – anything from a photograph to a letter. In the case of a flatbed scanner, this document is placed against the top glass surface of

the scanner and the lid is closed over the document to prevent light from entering the device. The transparent glass keeps the document in place while allowing the sensors to detect document details. As in a camera, the dark conditions allow the scanner to control the amount of light reflected on the document surface.

Mechanics

Once the document is in place and the lid is closed, a moving belt slides a light source across the entire surface of the document. The motor in a scanner is finely tuned to make sure this light source travels at the same speed and creates the same amount of light across the whole document, ensuring a uniform exposure. The light shined on the document then reflects back into the machine and is reflected onto the lens by a series of mirrors.

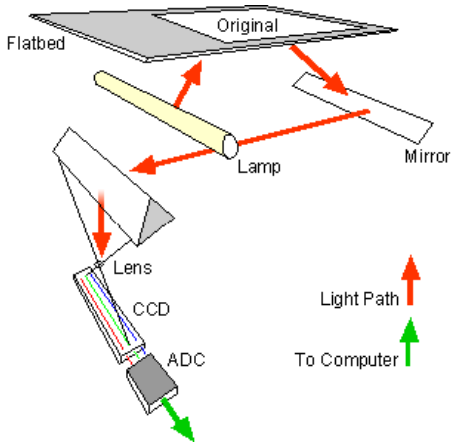


Fig 3.7 Working of a Flatbed Scanner

Optics

Much like a digital camera lens, a scanner lens includes a photosensitive element that detects differences in reflected light as different shades of color. Most scanners use an electronic light-sensitive circuit known as a charged couple device, although some high and low end scanners use different technologies like photomultiplier tubes or contact image sensors. All of these devices turn shades of light reflected off the document into digital information on shades of color to be located at different parts of the final document.

Sending a Document

The optic information from a scanner sensor is turned into digital pixel information in order to be saved as a digital file, such as a JPG, PNG or TIFF. A scanner relays this information to a computer through a wireless or connecting cable connection to save the digital file. After the transfer, the image file of the document is accessible on the computer and can be opened, saved, edited or deleted just like any other digital picture file.

3.2 OUTPUT DEVICES

Output device receives information from the CPU and presents it to the user in the desired from. The processed data, stored in the memory of the computer is sent to the output unit, which then converts it into a form that can be understood by the user. The output is usually produced in one

of the two ways – on the display device, or on paper (hard copy).Output devices return processed data that is information, back to the user.

- Any peripheral that receives or displays output from a computer.
- Computer hardware equipment used to communicate the results of data processing carried out by a computer to the outside world

An output device is any piece of computer hardware equipment used to communicate the results of data processing carried out by an information processing system (such as a computer) which converts the electronically generated information into human-readable form.

An output device is used to send data out of the system. The user sees the result after processing of data by the computer through output devices.

3.2.1 VDU

A monitor is a video display screen. Monitor is also called as Visual Display Unit (VDU) or Video Display Terminal (VDT).

Computer information is displayed, visually with a video adapter card and monitor. Information processed within the CPU, that needs to be visually displayed, is sent to video adapter. The video adapter converts information from the format used, in the same manner as a television displays information sent to it by a cable service.

When people talk about the capabilities of various monitors, one critical statistic is the resolution of the monitor. Most monitors have a resolution of at least 800 x 600 pixels. High-end monitors can have resolutions of 1024 x 768 pixels or even 1280 x 1024 pixels. Thus monitors are available either in low resolution or in high resolution.

- The device which displays computer output.
- The monitor displays the video and graphics information generated by the computer through the video card.
- Monitors are very similar to televisions but usually display information at a much higher resolution.

Monochrome Monitor – A monochrome monitor is a type of CRT computer display which was very common in the early days of computing, from the 1960s through the 1980s, before color monitors became popular. They are still widely used in applications such as computerized cash register systems

Color Monitor – Color monitors can display anywhere from 16 to over 1 million different colors. Color monitors are sometimes called RGB monitors because they accept three separate signals --red, green, and blue.

Types of Monitor

- Cathode Ray Tube (CRT)
- Liquid Crystal Display (LCD)

- Light-emitting Diode (LED)

Cathode Ray Tube (CRT)

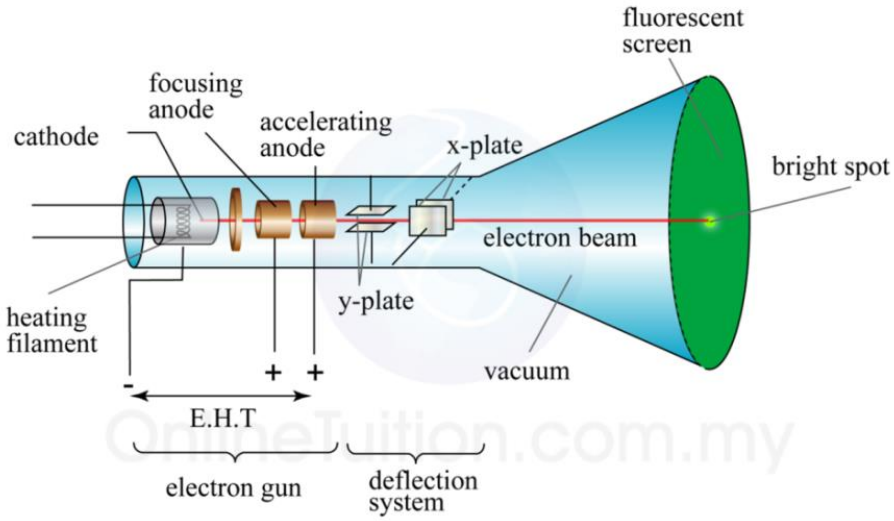


Fig 3.8 Working of a CRT

Cathode Ray Tube (CRT): CRT or Cathode Ray Tube Monitor is the typical monitor that you see on a desktop computer. It looks a lot like a television screen, and works the same way. This type uses a large vacuum tube, called cathode ray tube (CRT). They are Large, Heavy, Produce heat and Not expensive.

Liquid Crystal Display (LCD)

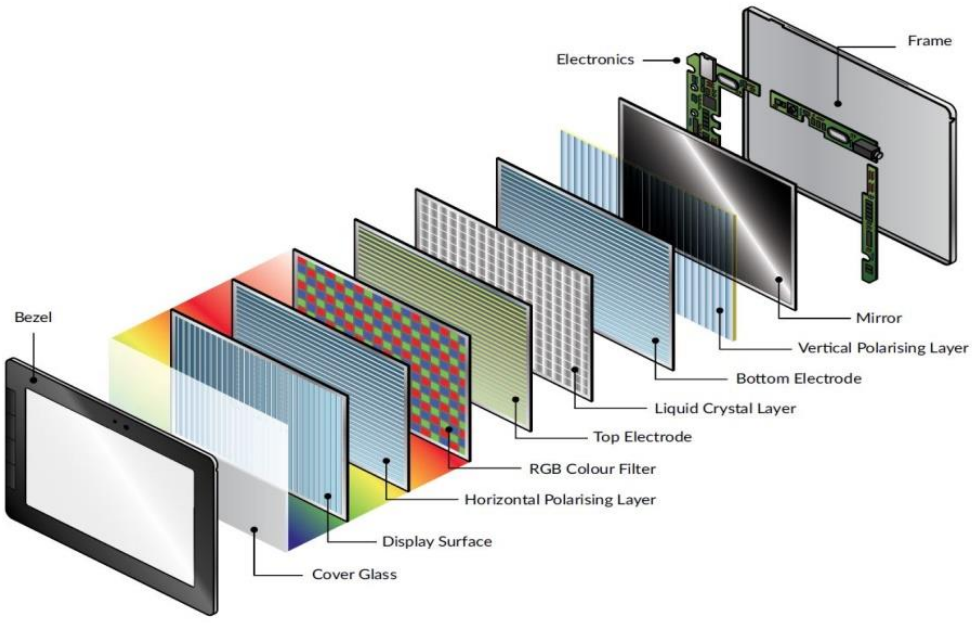


Fig 3.9 Working of LCD

Liquid Crystal Displays (LCD): This type of monitor is also known as flat panel monitor. Most of these employ liquid crystal displays (LCDs) to render images. These days LCD monitor are very popular. They take Less space, Lighter, Low power consumption and Expensive and Limited viewing angle

Light-emitting Diode (LED)

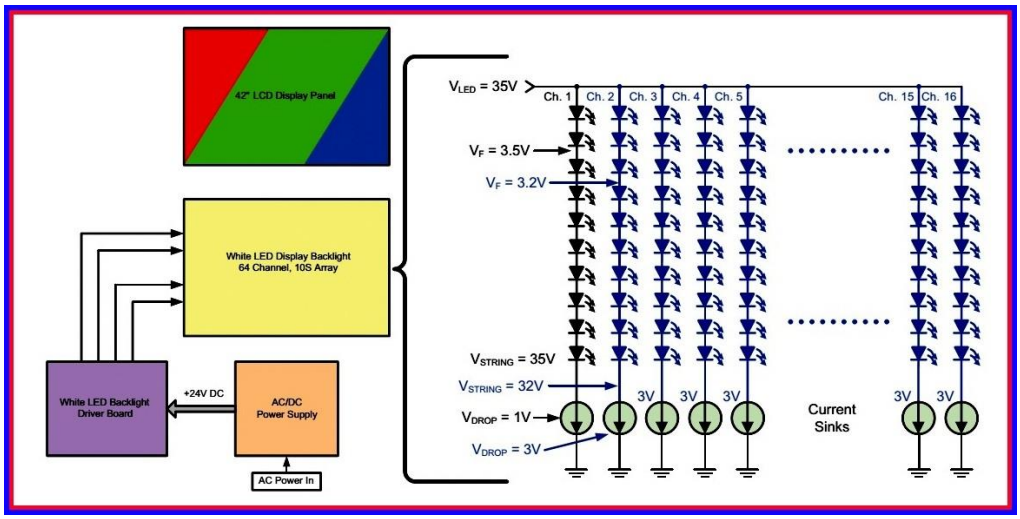


Fig 3.10 Working of LED Display

They have Less space, Lighter, very expensive and Provide higher contrast and better viewing angles than LCD monitor

3.2.2 PRINTERS

After a document is created on the computer, it can be sent to a printer for a hard copy (printout). Some printers offer special features such as colored and large page formats. Printers are used to produce paper (commonly known as hardcopy) output. Based on the technology used, they can be classified as Impact or Non-impact printers.

Impact printers use the typewriting printing mechanism wherein a hammer strikes the paper through a ribbon in order to produce output. Dot-matrix and Character printers fall under this category.

Non-impact printers do not touch the paper while printing. They use chemical, heat or electrical signals to etch the symbols on paper. Inkjet, Deskjet, Laser, Thermal printers fall under this category of printers.

3.2.2.1 Dot Matrix Printer

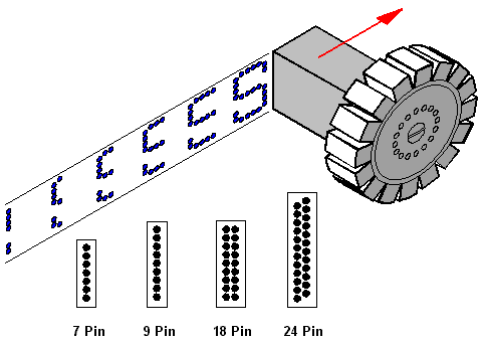


Fig 3.11 Working of a Dot Matrix Printer

The dot matrix printer was very popular at one point of time. It is a very versatile and inexpensive output device. In dot matrix printer the print head physically "hits" the paper through the ribbon and produces text (or images) by combinations of dots; hence the name dot matrix printer. Its speed is measured in characters per second (CPS). Although it is less expensive, it is louder, slower and produces lower print quality.

3.2.2.2 Laser Printer

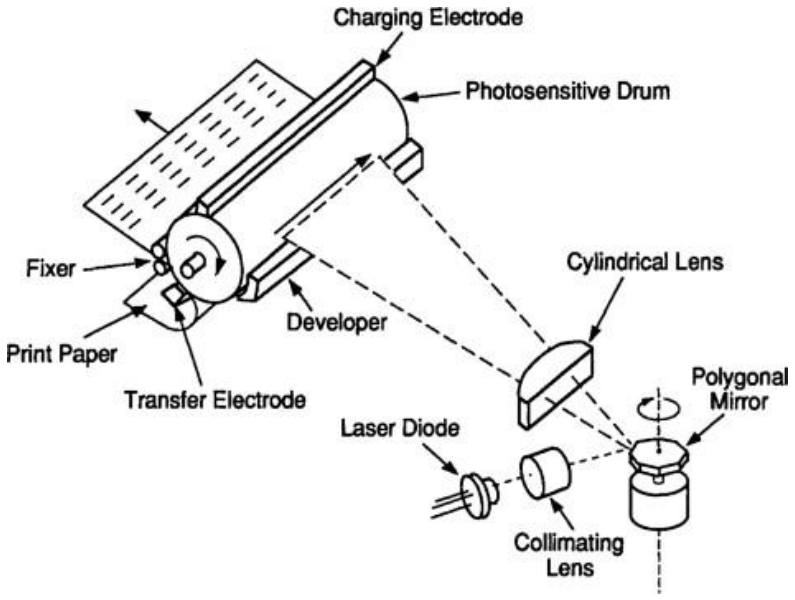


Fig 3.12 Working of a Laser Printer

A laser printer produces high quality print that one normally finds in publishing. It is extremely fast and quiet. Moreover, the operation of a laser printer is easy with automatic paper loading and no smudging or messing up of ink ribbons. The fastest laser printer can print up to 200 pages per minute in monochrome (black and white) and up to 100 pages per minute in colour.

3.2.2.3 Inkjet Printer

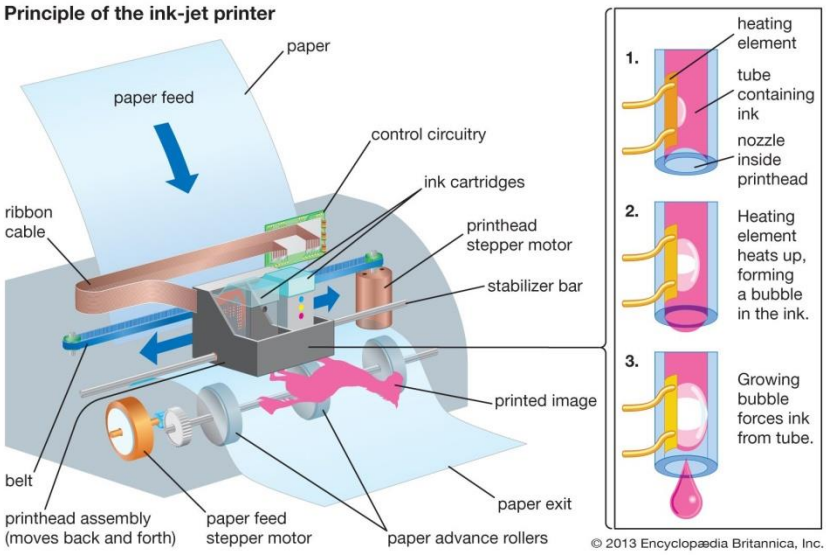


Fig 3.13 Working of an Inkjet Printer

An ink-jet printer creates an image directly on paper by spraying ink through as many as 64 tiny nozzles. Although the image it produces is not generally quite as sharp as the output of a laser printer, the quality of ink-jet images is still high.

In general, ink-jet printer offers an excellent middle ground between dot matrix and laser printer. Like laser printer, an ink-jet printer is quiet and convenient, but not particularly fast. Typically, an ink-jet printer is more expensive than a dot-matrix printer, but costs only half as much as a laser printer.

Line Printer: A line printer is generally used with large computer systems to produce text based data processing reports. Line printers are high-speed printers with speeds ranging anywhere from 100 to about 3800 lines per minute. In the past, print quality on line printers was not high. Developments in technology are improving the print quality on line printers. These are in the cost range of lacs of Rupees.

3.2.3 PLOTTERS

A Plotter is a device that draws pictures on a page as output, after receiving a print command from the computer. It is also called a graph plotter. In plotters pens are used to draw lines on the paper, which is placed in the plotter.

A plotter is a special kind of output device that, like a printer, produces images on paper, but does so in a different way. Plotters are designed to produce large drawings or images, such as construction plans for buildings or blueprints for mechanical objects. A plotter can be connected to the port normally used by a printer.

An array of different colored pens in a clip rack and a robotic arm is part of plotter. The instructions that a plotter receives from a computer consist of a color, and beginning and ending coordinates for a line. With that information, the plotter picks up the appropriate pen through its arm, positions it at the beginning coordinates drops the pen down to the surface of the paper and draws to the ending coordinates. Plotters draw curves by creating a sequence of very short straight lines.

Plotters are used to print graphical output on paper. It interprets computer commands and makes line drawings on paper using multi-color automated pens. It is capable of producing graphs, drawings, charts, maps etc.

Plotters produce high quality diagrams on the paper and their output quality is good. Engineers, architects and planners use plotters to generate high quality, high-precision graphic output of different sizes. For several design applications such as design of layout of an aircraft, car, and architectural design of a building and in other computer-aided design applications plotter are very useful

3.2.3.1 Drum Plotter

These plotters are of big size using rolls of paper of unlimited length. The drum plotters are generally smaller than flatbed plotters and they have lower resolutions than flatbed plotters. HP, Canon and Epson are the popular companies which manufacture good quality of platters.

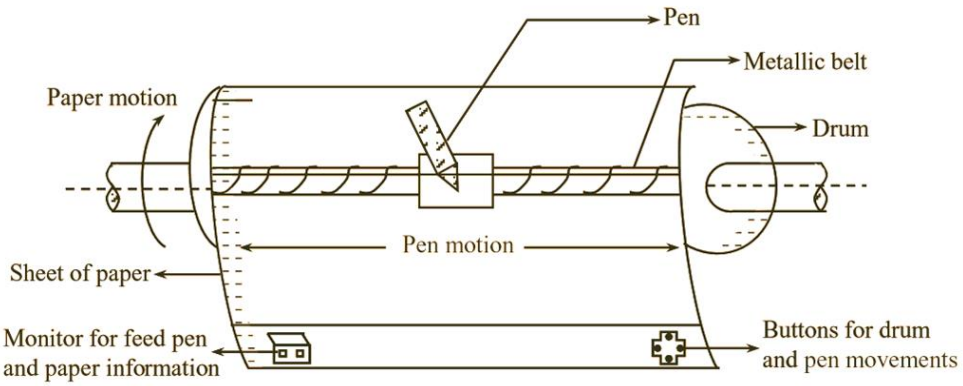


Fig 3.14 Working of a Drum Plotter

3.2.3.2 Flat-Bed Plotter

These plotters of small size are to be kept on table with restriction of paper size. A flatbed plotter plots on papers that are spread and fixed over a rectangular flatbed surface. Normally, the paper does not move and all the motion is provide by pen – holding mechanism. The pen mechanism moves the pen left, right, top and bottom side. The plot size is restricted by the area of the bed.
It is used to draw Cars, Ships, Airplanes Road and highway design etc.

Electrostatic Plotters

They use electrostatic charges to create images out of very small dots on specially treated paper. The paper is run through a developer to allow the image to appear. These are faster than pen plotters and can produce images of very high resolution.
Plotters are normally very slow motion because of excessive mechanical movement. Hence there is a great mismatch between the speed of the CPU and the speed of a plotter. Because of this reason, output is fist transferred by CPU to magnetic tapes and then the plotter is activated.

3.2.3.3 Inkjet Plotter

The inkjet plotter creates an image by spraying small droplets of ink on to paper. A popular choice for advertising agencies and graphic designers, inkjet plotters are used generally for large outputs, such as banners and billboards and large signs often seen along roadsides. They are available in thermal or piezoelectric models. Thermal inkjet plotters use heat to apply droplets of ink, while piezoelectric plotters use charged crystals to apply the ink. Inkjet plotters typically produce better quality graphics than other plotter types.

QUESTIONS

1. What is an input device? Explain any 2 devices.

2. What is MICR, OCR, OMR? Explain briefly.

3. Explain any 5 Output devices in detail.

UNIT IV

4.1 NETWORK

A network is a set of devices (often referred to as *nodes)* connected by communication links. A node can be a computer, printer, or any other device capable of sending and/or receiving data generated by other nodes on the network.

"Computer network'' means a collection of autonomous computers interconnected by a single technology. Two computers are said to be interconnected if they are able to exchange information. The connection need not be via a copper wire; fiber optics, microwaves, infrared, and communication satellites can also be used.

Networks come in many sizes, shapes and forms, as we will see later. They are usually connected together to make larger networks, with the Internet being the most well-known example of a network of networks.

There is considerable confusion in the literature between a computer network and a distributed system. The key distinction is that in a distributed system, a collection of independent computers appears to its users as a single coherent system. Usually, it has a single model or paradigm that it presents to the users. Often a layer of software on top of the operating system, called middleware, is responsible for implementing this model. A well-known example of a distributed system is the World Wide Web. It runs on top of the Internet and presents a model in which everything looks like a document (Web page).

A data communications system has five components

- **Message**. The message is the information (data) to be communicated. Popular forms of information include text, numbers, pictures, audio, and video.
- **Sender**. The sender is the device that sends the data message. It can be a computer, workstation, telephone handset, video camera, and so on.
- **Receiver.** The receiver is the device that receives the message. It can be a computer, workstation, telephone handset, television, and so on.
- **Transmission medium**. The transmission medium is the physical path by which a message travels from sender to receiver. Some examples of transmission media include twisted-pair wire, coaxial cable, fiber-optic cable, and radio waves.
- **Protocol.** A protocol is a set of rules that govern data communications. It represents an agreement between the communicating devices. Without a protocol, two devices may be connected but not communicating, just as a person speaking French cannot be understood by a person who speaks only Japanese.

Data Flow

Communication between two devices can be simplex, half-duplex, or full-duplex as shown in Figure.

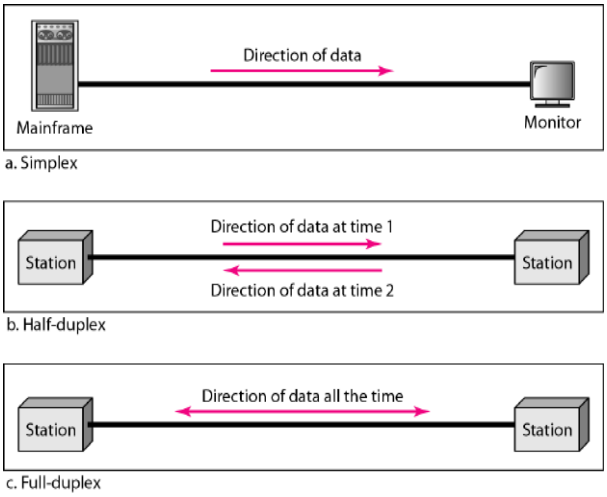


Fig 4.1 Modes of Communication

- ***Simplex***
  In simplex mode, the communication is unidirectional, as on a one- way street. Only one of the two devices on a link can transmit; the other can only receive (Figure a). Keyboards and traditional monitors are examples of simplex devices.
- ***Half-Duplex***
  In half-duplex mode, each station can both transmit and receive, but not at the same time. When one device is sending, the other can only receive, and vice versa (Figure b). Walkie-talkies and CB (citizens band) radios are both half- duplex systems.
- ***Full-Duplex***
  In full-duplex, both stations can transmit and receive simultaneously (Figure c). One common example of full-duplex communication is the telephone network. When two people are communicating by a telephone line, both can talk and listen at the same time. The full-duplex mode is used when communication in both directions is required all the time.

Network Criteria

A network must be able to meet a certain number of criteria. The most important of these are performance, reliability, and security.

1. Performance: Performance can be measured in many ways, including transit time and response time. Transit time is the amount of time required for a message to travel from one device to another. Response time is the elapsed time between an inquiry and a response. The performance of a network depends on a number of factors, including the number of users, the type of transmission medium, the capabilities of the connected hardware, and the efficiency of the software.

Performance is often evaluated by two networking metrics: throughput and delay. We often need more throughput and less delay. However, these two criteria are often contradictory. If we try to send more data to the network, we may increase throughput but we increase the delay because of traffic congestion in the network.

2. ***Reliability:*** In addition to accuracy of delivery, network reliability is measured by the frequency of failure, the time it takes a link to recover from a failure, and the network's robustness in a catastrophe.

3. ***Security***: Network security issues include protecting data from unauthorized access, protecting data from damage and development, and implementing policies and procedures for recovery from breaches and data losses.

4.1.1 NETWORK TERMINOLOGY

- **Nodes –** Any device connected to the network
- **Links –** Communication path between any 2 nodes
- **Connectivity –** Data connection follows 3 defined phases – Connection is established between 2 nodes, Data transferred between 2 nodes, Connection released between nodes
- **Switching –** Important technique for data transfer in WAN.
    - Circuit Switching
    - Message Switching
    - Packet Switching

4.1.2 TOPOLOGIES

4.1.2.1 Linear Topology

As the name suggests, the point-to-point is a network topology with a dedicated link between two endpoints, hence it is the simplest topology. The advantage of such a network is that all the available network bandwidth is dedicated to the two connected devices. You are not likely to use the point-to-point topology in your office network setup.

A line topology, a bus topology is a network setup in which each computer and network device are connected to a single cable or backbone.

Advantages of bus topology

- It works well when you have a small network.
- It's the easiest network topology for connecting computers or peripherals in a linear fashion.
- It requires less cable length than a star topology.

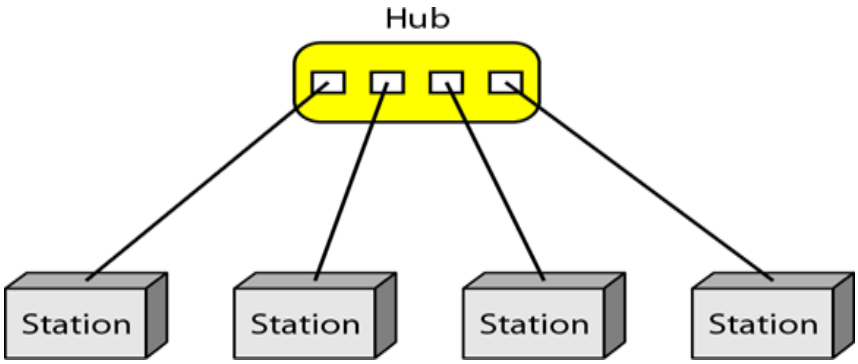
Disadvantages of bus topology

- It can be difficult to identify the problems if the whole network goes down.
- It can be hard to troubleshoot individual device issues.
- Bus topology is not great for large networks.
- Terminators are required for both ends of the main cable.

- Additional devices slow the network down.
- If a main cable is damaged, the network fails or splits into two.

4.1.2.2 Star Topology

A star network, star topology is one of the most common network setups. In this configuration, every node connects to a central network device, like a hub, switch, or computer. The central network device acts as a server and the peripheral devices act as clients. Depending on the type of network card used in each computer of the star topology, a coaxial cable or a RJ-45 network cable is used to connect computers together.



Advantages of star topology

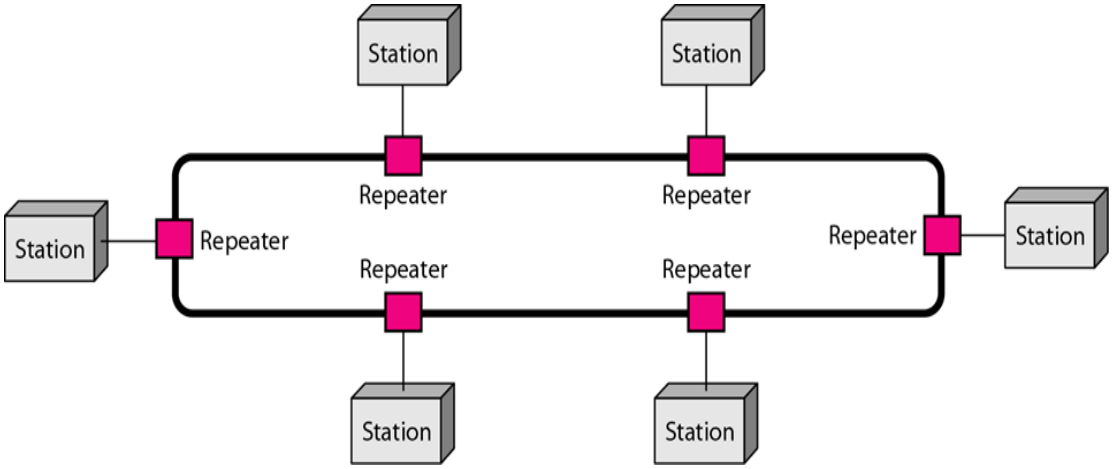
- Centralized management of the network, through the use of the central computer, hub, or switch.
- Easy to add another computer to the network.
- If one computer on the network fails, the rest of the network continues to function normally.
- The star topology is used in local-area networks (LANs), High-speed LANs often use a star topology with a central hub.

Disadvantages of star topology

- Can have a higher cost to implement, especially when using a switch or router as the central network device.
- The central network device determines the performance and number of nodes the network can handle.-
- If the central computer, hub, or switch fails, the entire network goes down and all computers are disconnected from the network

4.1.2.3 Circular Topology

A ring topology is a network configuration in which device connections create a circular data path. In a ring network, packets of data travel from one device to the next until they reach their destination. Most ring topologies allow packets to travel only in one direction, called a unidirectional ring network. Others permit data to move in either direction, called bidirectional. The major disadvantage of a ring topology is that if any individual connection in the ring is broken, the entire network is affected. Ring topologies may be used in either local area networks (LANs) or wide area networks (WANs).



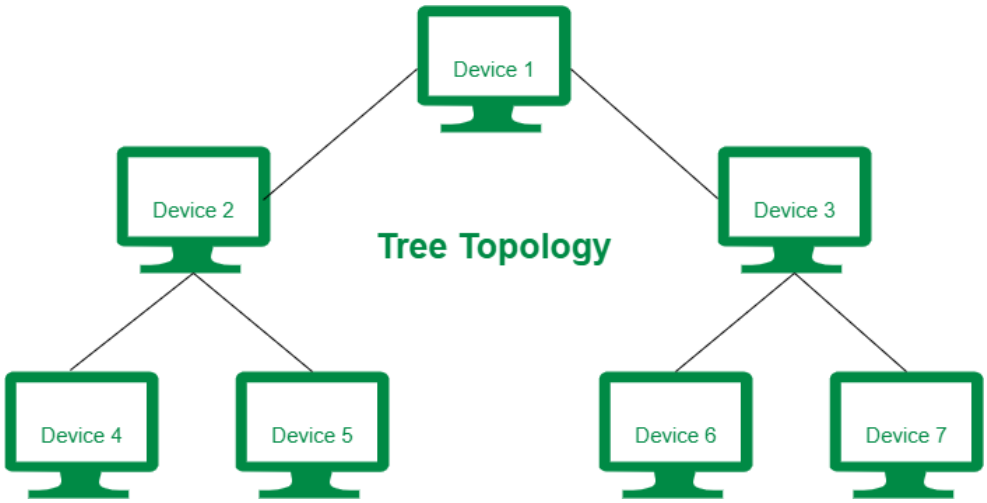
Advantages of ring topology

- All data flows in one direction, reducing the chance of packet collisions.
- A network server is not needed to control network connectivity between each workstation.
- Data can transfer between workstations at high speeds.
- Additional workstations can be added without impacting performance of the network.

Disadvantages of ring topology

- All data being transferred over the network must pass through each workstation on the network, which can make it slower than a star topology.
- The entire network will be impacted if one workstation shuts down.
- The hardware needed to connect each workstation to the network is more expensive than Ethernet cards and hubs/switches.

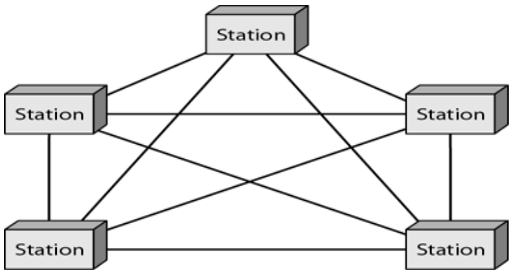
4.1.2.4 Tree Topology



Tree topology is a type of network topology in which the devices are organized in the form of a tree. In tree topology, a hierarchy is formed by the branching cable having no loops that connects the root with all other nodes for communication. Tree topology is more expensive because it is densely wired.

4.1.2.5 Mesh Topology

A mesh topology is the one where every node is connected to every other node in the network.



A mesh topology can be a full mesh topology or a partially connected mesh topology.

In a full mesh topology, every computer in the network has a connection to each of the other computers in that network. The number of connections in this network can be calculated using the following formula (n is the number of computers in the network): n(n-1)/2

In a partially connected mesh topology, at least two of the computers in the network have connections to multiple other computers in that network. It is an inexpensive way to implement redundancy in a network. In the event that one of the primary computers or connections in the network fails, the rest of the network continues to operate normally.

Advantages of a mesh topology

- Can handle high amounts of traffic, because multiple devices can transmit data simultaneously.
- A failure of one device does not cause a break in the network or transmission of data.
- Adding additional devices does not disrupt data transmission between other devices.

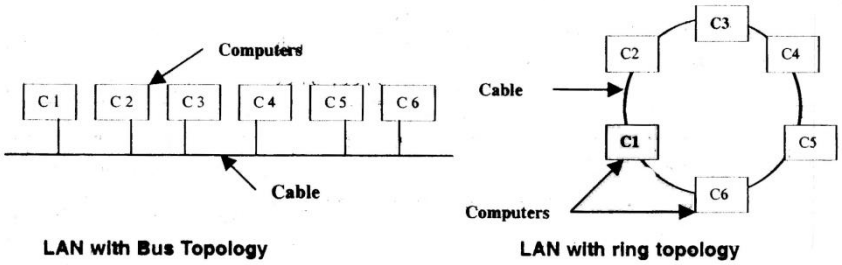
Disadvantages of a mesh topology

- The cost to implement is higher than other network topologies, making it a less desirable option.
- Building and maintaining the topology is difficult and time consuming.
- The chance of redundant connections is high, which adds to the high costs and potential for reduced efficiency

4.2 TYPES OF NETWORK

4.2.1 LAN(LAN)

A LAN is generally confined to a specific location, such as floor, building or some other small area. By being confined it is possible in most cases to use only one transmission medium (cabling). The technology is less expensive to implement than WAN because you are keeping all of your expenses to a small area, and generally you can obtain higher speed. They, are widely used to connect personal computers and workstations in company offices and factories to share recourses.



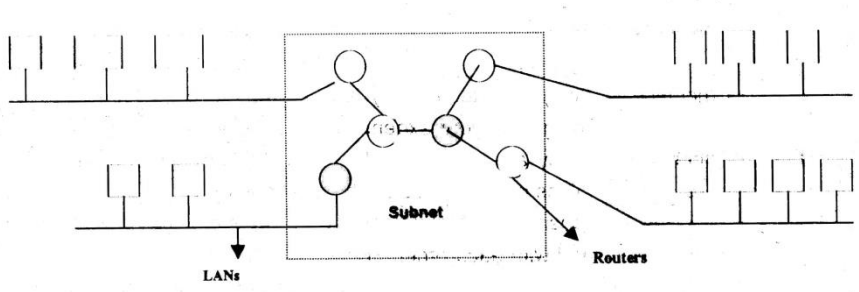
LANs often use a transmission all the machines are attached with each other. Traditional LANs runs at speed of 10 to 100 mbps have low delay and make very few errors. Never LANs may operate at higher speed up to 100 megabytes/sec.

Advantages	**Disadvantages**
Transmission of data and services is relatively higher than other network connections.	Need constant administration of experienced engineers for functioning.
The Network Server acts as a central unit for the whole network.	Probability of leak of sensitive data by LAN administration

4.2.2 WAN(WAN)

A wide area network spans a large geographical area, often a country or continent. It multiplies multiple connected LANs; that can be separated by any geographical distance. A LAN at the corporate headquarters in Indianapolis can be connected to a LAN at field office in Chicago and to another field office LAN in St. Louis to form a single Wide Area Network.

In most WANs the network contains numerous cables or telephone lines, each one connection a pair of routers. If two routers that do not share a cable nevertheless and wish to communicate, they must do it indirectly. On personal computers we are using modem to communicate indirectly with other computer.



Advantages	Disadvantages
This network covers a high geographical area and is used for large-distance connections.	High cost to set up the network and the Support of experienced technicians is needed to maintain the network.
They also use radio towers and connect channels for users.	It is difficult to prevent hacking and debug a large network.

4.2.3 MAN(MAN)

Metropolitan Area Network is basically a bigger version of LAN and normally uses same technology. It might cover a group of nearby corporate offices or a city and might be either private or public. On other hand, MAN is network running through out a metropolitan are such as a backbone for a phone service carrier. A MAN just has one or two cables and does not contain switching elements.

Advantages	Disadvantages
Provides Full-Duplex data transmission in the network channel for devices.	High probability of attack from hackers and cybercriminals due to large networks.
The network connection area covers an entire city or some parts using the optic cables.	The need for good quality hardware and the installation cost is very high

4.3 REPEATERS, BRIDGES, ROUTERS, BROUTERS, GATEWAY

4.3.1 REPEATERS

When an electrical signal is sent across a medium, It fades along the distance (known as attenuation) as a result of resistance from the medium itself. Naturally the longer the distance that it travelled, the more the signal fades. Eventually tie signal fades to a, point where the receiving station cannot recognise the original message (Orhas trouble doing so).

In short each transmission medium can be used for a certain distance. However you can exceed the physical medium's maximum effective distance by using an amplification, device called as Repeater. It works at OSI physical layer. A repeater operas at the physical layer of

the OSI model and takes a signal from one LAN and sends it to another LAN-reconditioning and retiming it in the process. The reconditioning usually amplifies and boosts the signal's power. If the signal has travelled a distance it is weak, and so on, the amplification can also be done on noise receivers.

The repeaters job is simple: it detects the signal, amplifies and retimes it, and sends it through all the ports except the one on which the signal was seen. It is important to note that since the repeater has no real knowledge of the data it is carrying, no error checking is performed. Therefore any error are passed from one segment to the next without any ability to stop it. Many networks limit the number of repeaters between the transmitting and receiving stations. On other side, by not performing any filtering, the -repeater does not slow down the network's speed or performance. The signal has travelled a distance is weak, and so on, the amplification can also be done on noise received.

Pros and Cons of repeaters

Pros	**Cons**
Allow you to extend the network over large distances.	Have no knowledge of addressing or data types.
Do not affect the speed of network	Can't ease network congestion problems

4.3.2 BRIDGES

Bridges connects two separate networks to form a logical one by operating at the data link layer of the OSI model. Bridges rely on MAC addresses for their operation. Unlike repeaters, bridges examine the packet's destination address before forwarding it to other segments. A bridge extends the maximum distance of your network by connecting separate network segments, and selectively pass signals from one medium segment to another.

Bridges isolate the media access mechanisms of the LANs to which they are connected. If a packet has a destination address on the same network segment as the source of the signal, the bridge ignore the signal. If the destination address is different from the source address network segment, the bridge sends the message along in a fashion similar to what a repeater would. Since bridges are selective about which data packets can be transferred, they are useful in solving traffic bottlenecks it must be noted, however that bridges do not reduce traffic caused by broadcast packets or broadcast storms.

Although they are effective for a small number of LANs, bridges lose many of their benefits as the number of LANs grows. Bridges only operates at the data link layer, and the best source routing information is a component of the network layer.

Bridges offer following advantages over hubs :

- Divide a large network segment into smaller segments and hence reduce data traffic and improves network performance.
- Filter local data traffic by not allowing them to cross other

network segmentshence reducing overall network traffic.

- Provide exclusive bandwidth (10 Mbps) to each node connected to a port on abridge as opposed to shared bandwidth provided by hubs.
- Can be used to connect network segments of dissimilar media.

Pro	Cons
Can act as a repeater and extend distance	Slower than repeaters due to the need toexamine addresses
Easy to install, load, and configure	Can't perform effective balancing on largernetworks
Can restrict flow and ease congestion	More expensive than repeaters
Useful for protocols that can't be routed	Can’t prevent broadcast storms
Have good cost – to – performance ration	Certain application might not run on bridgenetworks.

4.3.3 ROUTERS

Routers are the most complicated of the three devices so far, operating at the network layer of the OSI model. While bridges are limited to examine data packets MAC addresses, routers go beyond this and-can examine the network address-which has routing information encoded in it. Routers can use this information to make intelligent decisions about routes and paths.

In the simplest form routers like bridges-can be used to connect network segments. Whereas bridges only know to forward what they don't recognised, routers are aware of multiple paths that lead to a destination address and know which path is best.

Each network segment is assigned a specific address and is then referred to as a sub network or subnet. Each node on the network is then assigned an address. Every data packet sent contains the destination network address and node address. The optimum path can then be determined by looking at infernal routing table.

One of the biggest differences Between brides and routers is the ability to identify where data is going, the router must initialize and maintain the routing table and determine the next hop in the packet’s journey, a router is expected to be able to identify the address and only send packets for which it has a network address. If a machine address isn't found in the routing table, the packet is discarded.

To get at the network layer and find the information it needs, the router must first strip off the Data Link Layer. After it finds the information, it repackages the data packets. A key advantage of routers comes into play during this operation: Since the data is unpacked and

repacked, there wan opportunity transform the data to the data frame needed for a particular architecture.

Routers are normally responsible for performing the following functions :

Route selection -

A router is maintaining the information in its routing table about how to reach remote networks. It will then make routing decisions based on that information

Logical addressing-

A device that operates at layer 3 requires some form of logical addressing. These addresses will be used to determine route selection.

Segmentation-

Routers can be provide by a powerful method of segmenting your networks to allow optimum utilization of available bandwidth.

Advantages of using Routers

No broadcasts – Because router operates at Layer 3 of the OSI mode), no Layer 2 broadcasts wiII be forwarded through a router.

Manageability – Routers have a better knowledge of the network topology than bridges and switches do and have the ability to support more protocols than bridges and switches

Increased bandwidth – By segmenting your networks with routers, your nodes/ hosts will have more access bandwidth

Packet fragmentation and reassembling - Routers provide, packet fragmentation / reassembly functions, as well as better Security.

Pros	Cons
Can perform more functions than bridges	Considerably more difficult to install thanBridge
Can interconnect network segments of differing architectures.	More expensive than repeaters or bridges
Can manage load balancing and sharing	Work only with routable protocols
Can be used to control broadcast storms	Static routing can cause problems
Can choose the best path and make dynamic changes	Much slower than bridges or repeaters due to additional functions.

4.3.4 BROUTERS

Bridges can perform limited functions but can work with all protocols. Routers on the other hand, perform more complex functions but can work with only certain protocols. Brouters come into play as a combination of the best features of the two. If a routable packet is received, the brouter routes the data to the appropriate destination. If a no routable protocol sends data, however the brouter bridges the data based on the hardware address. In order to perform both functions, the brouter must contain both a routing table and a bridging table. As a result it operates at both the Network arid Data Link Layer. Brouters are more expensive and complex than bridges and routers.

4.3.5 GATEWAY

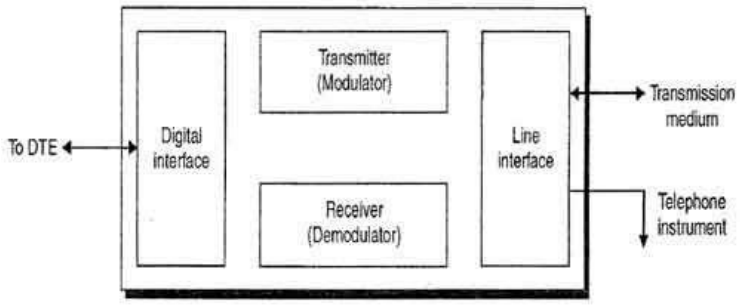
Gateways are often lumped into discussion about bridging and routing, when in fact the-service they perform is similar but different by one major factor: with a gateway, data is translated between two different data formats or network architectures.

Gateways perform much higher-level translations than any other component and thus work at the Application layer of the OSI module. When packets arrive at a gateway, all the information is stripped off the data until it reaches the layer where it can translate the information-using the format needed for the destination

Pros	**Cons**
Can connect completely different systems.	Very expensive than other devices.
Specialize in one task only	Difficult to install and configure. Depending oh the level of translation, can be very slow

4.4 MODEM, Wi-Fi NETWORK, BLUETOOTH AND INFRA-RED DEVICES

4.4.1 MODEM FOR COMMUNICATION BETWEEN PCs



Building blocks of a modem

Modem converts your computer digital signal to an analog transmission signal to use with telephone tines or microwave transceivers. Modem is necessary because telephone lines and microwave media uses electromagnetic waves, but your computer uses electric pulses. Modems are also useful when the signal from the transceiver is hot powerful enough to travel a required, distance without significant loss of data, modems can be used to amplify signals.

4.4.2 Wi-Fi NETWORK

Wi-Fi stands for Wireless Fidelity. Wi-Fi is a brand originally licensed by the Wi-Fi alliance to describe the underlying technology of wireless Local Area Networks (WLAN) based on IEEE 802.11 specifications. Wi-Fi was intended to be used for mobile computing devices, such as Laptops in LANs, but is now often used for increasingly more applications including Internet Access, gaming, and basic connectivity of consumer electronics such as televisions and DVD players.

A person with a Wi-Fi device such as computer, telephone or personal digital assistant (PDA) can connect to the internet when in proximity of an access point. The region covered by one or several access points is called a hot spot. Hot spots can be range from a single room to many square miles of overlapping hot spots.

Wireless Networks uses radio waves as its carrier. (RF 2.4 GHz to 5 GHz). The typical Wi-Fi setup contains one or more Access points (APs) and one or more clients. A AP broadcasts its SSID (Service Set Identifier, Network Name) via packets that called beacons, which are broadcasted every 100 ms. The beacons are transmitted at 1 Mb/s and are relatively short and therefore are not of influence on performance. Since 1Mb/s is the lowest rate of Wi-Fi it assures that the client who receives the beacon can communicate at at least 1Mb/s . Based on the settings (e.g. the SSID) , the client may decide whether to connect to an AP. Also the firmware running on the client Wi-Fi is of influence. Say two APs of the same SSID are in the range of the client, the firmware may decide based on signal strength to which of two APs it will connect. Wi-Fi uses spectrum near 2.4 GHz, which is a standardized and unlicensed by international agreement.

4.4.3 INTRODUCTION OF BLUETOOTH

Bluetooth wireless technology is a short range communications technology intended to replace the cables connecting portable unit and maintaining high levels of security. Bluetooth technology is based on Ad-hoc technology also known as Ad-hoc Pico nets, which is a local area network with a very limited coverage.

WLAN technology enables device connectivity to infrastructure based services through a wireless carrier provider. The need for personal devices to communicate wirelessly with one another without an established infrastructure has led to the emergence of Personal Area Networks (PANs).

- Ericsson's Bluetooth project in 1994 defines the standard for PANs to enable communication between mobile phones using low power and low cost radio interfaces.

- In May 1988, Companies such as IBM, Intel, Nokia and Toshiba joined Ericsson to form the Bluetooth Special Interest Group (SIG) whose aim was to develop a defacto standard for PANs.
- IEEE has approved a Bluetooth based standard named IEEE 802.15.1 for Wireless Personal Area Networks (WPANs). IEEE standard covers MAC and Physical layer applications.

Bluetooth specification details the entire protocol stack. Bluetooth employs Radio Frequency (RF) for communication. It makes use of frequency modulation to generate radio waves in the ISM band.

The usage of Bluetooth has widely increased for its special features.

- Bluetooth offers a uniform structure for a wide range of devices to connect and communicate with each other.
- Bluetooth technology has achieved global acceptance such that any Bluetooth enabled device, almost everywhere in the world, can be connected with Bluetooth enabled devices.
- Low power consumption of Bluetooth technology and an offered range of up to ten meters has paved the way for several usage models.
- Bluetooth offers interactive conference by establishing an adhoc network of laptops.
- Bluetooth usage model includes cordless computer, intercom, cordless phone and mobile phones.

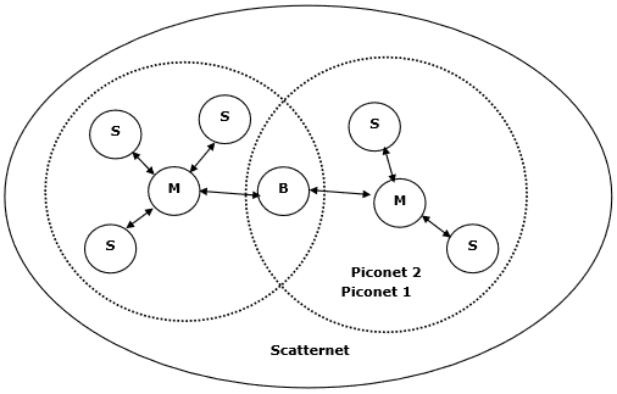


Figure: Piconets and Scatternets

Spectrum

Bluetooth technology operates in the unlicensed industrial, scientific and medical (ISM) band at 2.4 to 2.485 GHZ, using a spread spectrum hopping, full-duplex signal at a nominal rate of 1600 hops/sec. the 2.4 GHZ ISM band is available and unlicensed in most countries.

Range

Bluetooth operating range depends on the device Class 3 radios have a range of up to 1 meter or 3 feet Class 2 radios are most commonly found in mobile devices have a range of

10 meters or 30 feet Class 1 radios are used primarily in industrial use cases have a range of 100 meters or 300 feet.

Data rate

Bluetooth supports 1Mbps data rate for version 1.2 and 3Mbps data rate for Version 2.0 combined with Error Data Rate.

4.4.4 INTRODUCTION OF INFRARED DEVICES

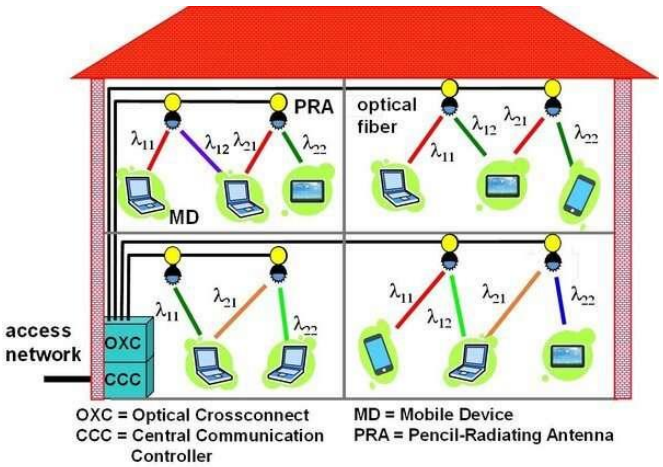
Infrared wireless refers to the process of sending data and communicating wirelessly on top of an infrared connection.

It is the use of infrared transmission technology in devices and equipment for sending data to other devices and/or controlling them wirelessly by human operators.

Infrared wireless is primarily implemented in short range areas and facilities, more specifically where there is the least amount of obstruction such as wooden or concrete walls. Infrared wireless is implemented through two different modes.

The first mode is called line of sight infrared wireless. This is the most common implementation of infrared wireless. The receiving device must be directly in line of sight of the infrared broadcasting device. The distance between both devices usually must not be greater than ten meters. Remote devices such as televisions, air-conditioners and other appliances works on line of sight infrared wireless technology.

The second mode is called scatter mode infrared wireless. In this mode, the infrared signals/rays are broadcasted within a specific room or vicinity. Any receiving device either in sight or out of sight can receive infrared signals directly or through reflection.



Infrared provides a secure, low-cost, convenient cable-replacement technology. It is well suited for many specific applications and environments. Some key infrared points are as follows:

- It provides adequate speeds—up to 16Mbps.
- Infrared devices use less power and therefore don’t drain batteries as much.

- Infrared is a secure medium. Infrared signals typically are a direct-line implementation in a short range and therefore do not travel far outside the immediate connection. This eliminates the problem of eavesdropping or signal tampering.
- Infrared is a proven technology. Infrared devices have been available for some time and as such are a proven, nonproprietary technology with an established user and support base.
- It has no radio frequency interference issues or signal conflicts.
- It replaces cables for many devices, such as keyboards, mice, and other peripherals.
- It uses a dispersed mode or a direct line-of-sight transmission.
- Transmissions travel over short distances.

4.5 NETWORK PROTOCOLS

This transmission media connects the systems, and a set of rules determines how they communicate. These rules are known as protocol. A network protocol is software installed on machine that determines the agreed-upon set of rules for two or more machines to communicate with each other.

Common protocols in the Microsoft family include the following.

• NetBEUI

• NWLink

• DLC (Data Link Control)

• TCP/IP (Transmission Control Protocol / Internet Protocol)

4.6 ARCHITECTURE

4.6.1 PEER-TO-PEER ARCHITECTURE

In a Peer-to-Peer network you take the machine currently in existence, install networking cards in them, and connect them through some type of cabling. Each machine is known as Peer and can participate in the sharing of files or resources. No server is required, so there is no additional cost for a dedicated machine, but there is also no real security.

Peer-to-Peer networks require an operating system that can understand networking and function in this (Peer-to-Peer) way. Microsoft Windows 95, Microsoft Windows 98, Windows NT server and Windows NT workstation can all function in Peer to-Peer environment.

If file and print sharing has been enabled on a Windows 95 system, for example, you can create a share by selecting a folder and choosing to share it. By default, no password is associated with it but you can choose to assign one that a user must know in order to access the resource. Access permission can be Read-Only, Full or depend on password this is

known as share level security. Access is gained when a user supplies the correct password to access the share.-

Peer-to-Peer networking works in small environments. If you grow beyond approximately 10 machines, the administrative overhead of establishing shares, coupled with the lack of tight security, creates a nightmare.

Advantages of peer-to-peer network

- Server is not required
- No additional cost for dedicated-machine

Disadvantages of peer-to peer network

- Provides share level security
- Can work in small environments only.

4.6.2 CLIENT/ SERVER

With the user level security, permissions are based *on* how the user logged on and was authenticated by the server. Every user has an account. In this environment, you can assign permissions to shared based on user permissions or group permissions. In short you must have server on the network in order to have user level security, but you can have share level security with or without server.

This scenario also known as client/server networks (explain previously in chapter 1), server-based networking's down side is that it requires a dedicated machine (the server); the upside is that you gain centralize administration, you can add ail users at one location, control logon scripts and backups; and so on. With centralized authentication, you can identify a user to your entire network based on his logon name and password, not based on each share he attempts to access.

Advantages of Server based network

- Provides user level security
- You always gain centralize administration
- Can work in big environments also

Disadvantages of server based network

- Dedicated machine is required
- Cost of the system is more compared to peer-to peer networks.

QUESTIONS

1. What is a Network? Give a short note

2. Explain the network topologies

3. Explain the Network Architectures