## Chapter-4

Data Communication

Data Communication are the exchange of data between two devices via some form of transmission medium such as wire cable. Communication can be defined as the exchange of information between one group or person and another group or person. This communication can be between people within the same organisation (internal communication) or with people or groups outside the organization (external communication).

The effectiveness of data communication system depends on four fundamental characteristics:-such as Delivery accuracy, timeliness, and jitter.

• **Delivery:-** The system must deliver data to the correct destination. Data must be received by user and only by the device.

• **Accuracy:-** The system must deliver the data accurately.

• **Timeliness:-** The system must deliver data in a timely manner. Data delivered late are useless.

• **Jitter:-** Jitter refer to the variation in the packet arrival time.

In Data communication there are 4 basic Terms:- Data, Signal, Signalling ad Transmission are frequently used.

• **Data:-** Data are entities that convey meaning. Data are representation of something whereas information refer to the content or interpretation of data.

• **Signals:-** Signals are electric or electromagnetic encoding of data.

• **Signalling:-** Signalling is propagation of signal along suitable communication medium.

• **Transmission:-** Transmission is communication of data achieved by the proposition and processing of signals.

• **Components:-** A data communication system has five component.

• **Message:-** The message is the information to be communicated. 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, video camera etc.
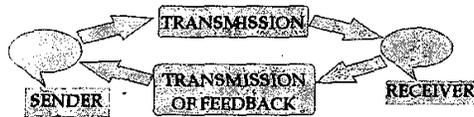
• **Receiver:-** The receiver is the device that receives the message. It can be a computer, workstation, telephone, video camera etc.

• **Transmission medium:-** Transmission medium Is the physical path by which a message travels from sender and to receiver. Example are twisted pair cable, fiber-optic etc.

• **Protocol:-** A protocol is a set of rules (written in the form of program) to perform specific task or action eg. Http, ftp etc.that govern data comniunication. It represents a agreement between the communicating devices.

• **Concept of Data Communication:-** The concept of data communication evolved from sharing the computation power of a compute along with various resources available in a computer environment such as printers, hard disk etc. Data communication can be.used to transfer as exchange confiPmation within one building, one city, across cities, countries and continents.

• **Data communication Code (Data encoding) -** Every character (letter, number, symbol) is composed of a group of bits called codes. The most widely used codes are the ASCII (American standards code for information interchange), EBCDIC (Extended Binary coded Decimal Interchange code.

	ASCII	EBCDIC
Controlling Authority	ANSI	IBM
Number of Bits	7	8
Number of characters	128	256

COMMUNICATION SPEED OR RATE

The speed at which two computers exchanges or transmit data is called communication rate on transmission speed. The unit of measurement of the speed is measured in bits per seconds (bps) or baud. Normal PC based communication transferred using 300 to Mbps whereas mainframe computers uses 19,200 baud.

Communication protocols/Standard:- Protocols is set of rules that perform specific task. In other words protocols are technical customs or guide-lines that govern the exchange of signal transmission and reception between equipments. Both hardware and software are designed to handle specific protocols.

Communication protocols are usually defined and approved by some international body such as ISO, CCITT or IEEE.

Some of function on protocols regulates are:-

• Control of information & transfer

• Structure and formats of data

• Error recoveries

• Retransmission cottrol

• interfaces management.

PROTOCOL LAYERS

The OSI (Open Systems Interconnection) Data Model:- It is ISO standard for computer networks design and functioning. It has 7 layers and each layer playing a specific role when applications are communicating over the net.

OSI LAYER DIAGRAM

Application layer

(Application Connected to Network)

Presentation layer

(Provide Standards data representation)

Session layer

(Manages sessions among applications)

Transport layer

(Provide end to end errors detection and correction)

Network layer

(Handles connection to the network by the higher layer)

Data link layer

(Provide safe Communication of data)

• **Physical layer:** ensures a safe and efficient transmission of data; consists of electronic circuits for data transmission.

• **Data link layer:** in charge Df data encapsulation under the form of frame and their interpretation at the physical layer.

•**Network layer:** in charge of packets transmission from a source A to a destination B.

• **Transport layer:** in charge of the delivery of packets from a sources process A to a destination process B.

• **Session layer:** in charge of the management of dialogue between sources and destination.

• **Presentation layer:** determines the format of the data transmitted to applications, data compressing/decompressing, encrypting etc.

• **Application layer:** contains the applications whic, are used by the end-user, such as PowerPoint, Word etc. The TCP/IP Model:- Consists of only 4 layers: application, transport, Internet and network layer.

TCP/IP Model

Application layer

(Application and processes running on the network)

Transport Layer

(Provide end to end data delivery services)

Internet layer

(Make datagram and handle data routing)

Network Interface layer

(Provide routing allowing process to the physical Networks)

• **Network Interface layer -** Provides the same functionality as the physical, the data link and network layers in the OSI model and Mapping between IP addresses and network physical addresses. Encapsulation of IP datagram, e.g packets, in format understandable by the network.

• **Internet layer:-** Based on the Internet Protocol (IP), which provides the frame for transmitting data from place A to place B.

• **Transport layer:-** Based on two main protocols: TCP (Transmission Control Protocol) and UDP (User Datagram protocol).

• **Application layer:-** Combines the functions of the 051 application, presentation, and session layers. And Protocols involved in this layer: HTTP, FTP, SMTP, DNS etc

Bandwidth:- The number of bits that can be transmitted over a network in a given time, usually measured Hz(Hertz). Broadband:- Broadband is a term referred to some technologies that offers high speed internet connectivity depending on framework and environment. It is a network connection with high enough bandwidth to allow for streaming audio and video. Broadband basically works through its bandwidth. As you increase the width of the band, so you get the speedy access to the internet

Analog and Digital Transmission:-

• Analog Signal:- An analog signal is one that is continuous with respect to time and may take on any value within a given range of values. Human voice, video and music when converted to electrical signal using suitable device produce analog signals. Landline phone uses analog signal.

• **Digital signal:-** A digital signal may take-on only a discrete set of values within a given range. Most computers and computer related equipment is digital.

Data Flow:- Communication between two devices can be Simplex, Half-Duplex, Full-Duplex.

• **Simplex:-** It is one way data transmission. e.g pager, radio, T.V - -

• **Half-Duplex:-** In Half- Duplex, each station can both transmit and receive but not at the same time. The half-duplex mode is like a one-lane road with traffic allowed in both direction. e.g:- Wireless, Walky-talky

• **Full-Duplex:-** In Full-Duplex mode, data can be transmit and receive at the same time. It is a two day data transmission simultaneously. e.g Telephone, video conferencing etc.

Data Communication Modes:- Data can be transmitted from source to destination in a number of ways. The different modes of data transmission are:-

• **Parallel and Serial Transmission :-** There is always need to exchange commands data and other control information between two communication system There are two option and these are:-

• **Serial Transmission:-** In Serial transmission bits are transmitted serially, one after another. There are single lines available for this transmission. This a very slow method for transmittingdata from one place to another.

• **Parallel transmission:-** All the bits of a byte are transmitted simultaneously on separate lines. There are multiple lines available for this transmission. This a very fast method for transmitting data from one place to another.

❖ **Asynchronous and Synchronous Transmission:-** One of the major difficulties in data transmission is that of synchronizing the receiver with the sender. The two mechanisms used for synchronization are:

Asynchronous transmission:- Asynchronous transmission sends single character at a time framed by start bit and 1 or 2 stop bits. Each frame begins with a start bit that enables the receiving device to adjust to the timing of the transmitted signal. This transmission is used to transmit character data and is ideally suited for characters that are transmitted at irregular intervals, such as when users are typing in character data from the keyboard.

Synchronous transmission:- In synchronous transmission, the whole block of data bits is transferred at once, instead of one character at a time. A sync signal is used to tell the receiving station that a new frame is arriving and to synchronies thereceiving station. Synchronous transmission is used when high-volumes of data re to be transmitted.

**Communication Hardware:- Communication hardware divided into three parts:**

• **Sender receiver hardware:** Sender and receiver hardware for handling communication messages, data transfer etc.

• **Node and workstation:-** In communication networks, a node is a connection point A physical network node is an active electronic device that is attached to a network, and is capable of sending receiving, or forwarding information over a communications channel. The device used to communicate a data communication network is called workstations. These workstation may. be terminal, printer ,telephone in other communication devices. A workstation known as terminal, client or slave.
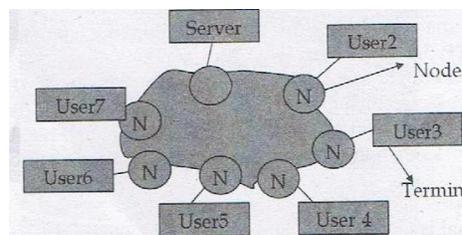
• **Multiplexer:-** Multiplexing is a device which convert multiple input signals into a single signal for transmission. Multiplexer is a device that combines several input information signals into one ouwut signal, which carries several communication channels. e.g A Telephone lines that use for our daily conversdtion can carry hundreds of conversation using multiplexing /

• **De-multiplexer:-** De-multiplexer is a device which divide single lines into a multiplex line.
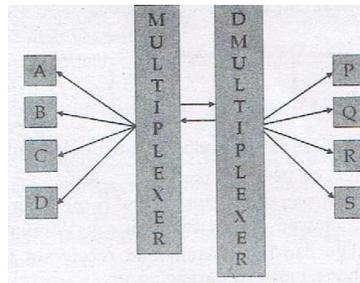
Types of multiplexer:

Frequency, Division Multiplexing (FDM):- combines two or mdre signals at the transmitter by frequency multiplying up the different signals by different amounts. This composite signal is then transmitted and the receiver separates the individual signals, frequency multiples down and produces the originals. FDM is still used with cable TV, some older analog cellular systems, and most commonly YOUR FM RADIO.

Time Division Multiplexing (TOM):- gives each signal a time slot for transmission e.g. A 10 micro-sec. B 10 micro- sec. C 10 micro-sec, A 10 micro-sec, B 10 micro-sec, C 10 micro-sec etc. There are two types of TDM, Synchronous TDM and Statistical TDM. Synchronous TDM is widely used with T carriers and ISDN. E.g T.V transmission.

Wavelength Division Multiplexing (WDM):- WDM is a modification of TDM and FDM. It performs the same function of multiplexing data, bu.t it uses different colored lasers to send multiple channels over the same physical line. WDM only runs ovçr fiber optic lines but has an advantage because it can combine multiple connection types such as ATM (Asynchronous Transmission Mode), OC, etc into one physical fiber lii.

Code division multiplexing (CDM):- An advanced technique that allows multiple devices to transmit on the same frequencies at the same time using different codes. It is used for mobile communication.

Communication device:- There are several types of communication devices or interface used in data communication. These devices are connection hqtween receiverand sender hardware involved data communication. Some of these devices are: Modem:- Modem is a combination of two words 'Mo+Dem'. Mo stand for Modulation and Dem stand for demodulation. Modem is a device which convert digital signals into analog signal and analog signal into digital signal. You an use modern with computer.
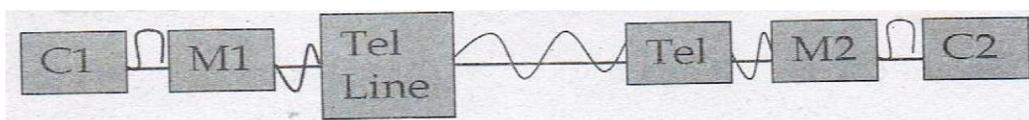
Codec:- Codec does opposite function as modern but can not be used with computer.
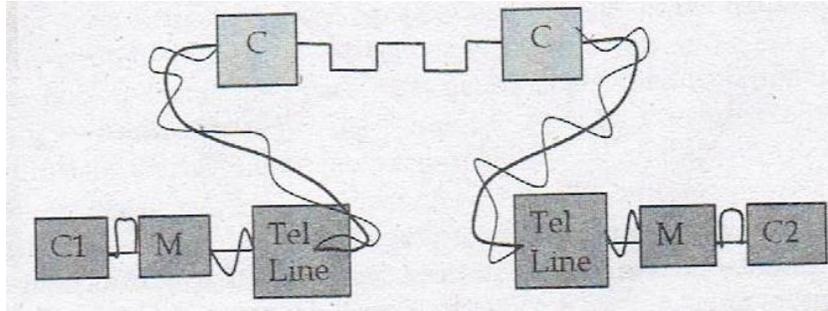
• **Communication channels:-** The most basic hardware is the media through which data is transferred. There are several, types of media available and the choice of media depends on cost of transmission, efficiency of data transmission and transfer rate.:-

• **Two wire open line:-** This is the simplest of all the transmission media. It consists of simple pair of metallic wires made of copper or aluminum of between 0.4 and 1 mm diameter. This is used for short distance, upto 50 m and can transfer upto 19,200 bps.

• **Twisted pair cable:-** A twisted pair consists of insulated conductors that are twisted together. It is used for communication upto distance of 1 K.M and can achieve transfer rate of 1-2 mbps. Twisted pair cable widely used in telephone network.

• **Coaxial cable:-** A coaxial cable consist ofa solid conductor running coaxial idside a solid or braided outer annular conductor. A coaxial cable can be used over a distance about 1 KM and can achieve a transfer rate of upto 100 mbps. A coaxial cable is of two typesf- a 75 ohm cable which is used by cable TV operator and the 50 ohm cable which is used in high speed broadband. /

• **Fiber optics cable:-** A fiber optics cable carries signals in the form of fluctuating liht in a glass or plastic fiber. It has veryhigh data transfer rates of about 1000 mbps. These are known as guided media.

• **Radiowave, microwave and satellite:-** Radiowave, microwave, satellite channels use electromagnetic propagation in open space. It coêrs large geographical area. These are known as un-guided media.

Network:- A network s a way or means of transmitting or receive of information from one or more sources. Architecture:- Networks can be broadly classified as using either a peer to peer or client/server Architecture.

• **Client Server Architedure:-** Client/Server Architecture is one in which the client (PC or workstation) is the requesting machine and the server is the supplying machine, both of which are connected via a LAN or WAN. The client contain the user interface and may perform some or all of the application processing. Server can be high speed micro computer, minicomputers or even mainframes.

A network architecture in which each computer or process on the network is either a client or a server. Servers are powerful computers or processes dedicated to managing disk drives (file servers), printers (print servers), or network traffic (network servers). Clients are PCs or workstations on which users run applications.
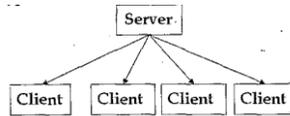
• **Peer-to-peer Architecture:-** A type of network in which each workstation has equal capabilities and responsibilities is called peer-to-peer network. Each workstation.act as both client and server/ There is no central repository for information and there is no central sert'er to maintain. Data and resources are distributed throughout the network and each user is responsible for sharing data and resources connected to their system. . This is simpler and less expensive network but not perform under heavy loads. A peer to peer network known as distributed network.
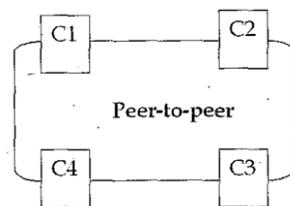
Difference between Client-Server and Peer to Peer Network Architectures

The main differente between client-server and peer to peer systems is that in the client-server-architecture, there are designated clients that request for services and servers that provide services, but in peer to eeer systems, peers act as both service providers and service consumers. Further, client-server systems require central file server and they are expensive to implement than peer to peer systems. On the other hand, in the client-server system, a dedicated file server provides level of access to the clients, providing better security than peer to peer systems wheresecurity is handled by the end users.

• **Computer Network:-** A computer network consists of two or more autonomous computers that are connected together in order to share resources (files, printers, modem etc), share application, allow electronic communication etc.

A computer network includes, the network operating system in the client and server machines, the cables, which connect different computers and all supporting hardware in between such as bridges, routers andswitches. In wireless system, antennas and towers are also part of the network.

Types of Computer Network:- Computer network are generally classified according to their structure and the area:

• Local Area Network (LAN):- In LAN, computers are connected locally within a room, building or in a small area. A LAN can range from simple (two computers) to complex (hundred of computers and peripherals).

• LANs connect workstations and personal computers. User can share data as well as devices like printers, fax etc and can use LAN to communicate with each other, by sending e-mail or chatting. Examples of LAN technology: Ethernet, Token Ring, and Fibber Distributed Data Interconnect (FDDI).

Characteristics of LAN are:-

• Configured to small area i.e it connects several devices over a distance of 5 to 10 KM.

• High Speed.

• Low error rates

• Data and hardware sharing between user.

• Operates at speed ranging from 10Mbps to 100 Mbps. Now a days 1000Mbps are available.
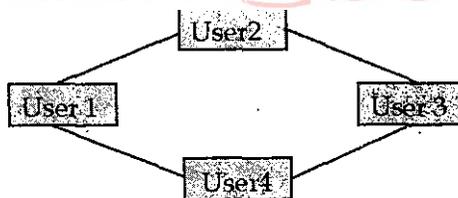
Network Topology:- Topology is physical arrangement of computer system in a network. Or refers to the shape of netwarks. Some of the most common network topologies are:-

• **Bus topology:-** In bus topology, all devices are connected tO a central cable, called the bus or backbone. The bus topology connects wàrkstations using a single cable. Each workstation is connect tp the next workstation in a point to point fashion. All workstation connect to the same cable. An extension to the bus topology is free topology.

Advantage of Bus topology:- Installation is easy and cheap. Connection are simple and easy to use. Data can be transmitted from the both sides.

Disadvantage of Bus topology:- A single fault in the cable stops all transmission. Fault identification is difficult.
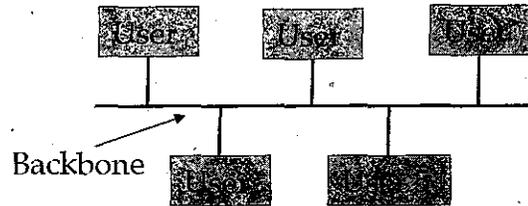
• **Ring topology: -** In ring topology, all devices are connected to one another in the shape of a closed loop, so that each device is connected directly to each other i.e the ring topology connects workstations in a closed loop. Data is transmitted around the ring in one direction only. Each station passing on the data to the next station till it reaches its destination. The common implementation of this topology is token ring.

Advantage of Ring topology:- Easy to install and modify the network and fault isolation is simplified. Disadvantage of Ring Topology:- Adding or removing computer disrupts the entire network. A break in the ring can stop the transmission in the entire network. Finding fault is difficult.

• **Star Topology:-** Star topology uses a central hub through which, all components are connected. A central hub is the host computer and at the end of each connection is a terminal. Communication on the connecting links between the stations and the central station of star topology can be bidirectional and are point to point

Advantage of Star Topology:- Expansion or modification is easy. Single computer failure does not affect the network.

Disadvantage of Star Network:- Failure in the central hub brings the entire network to halt.
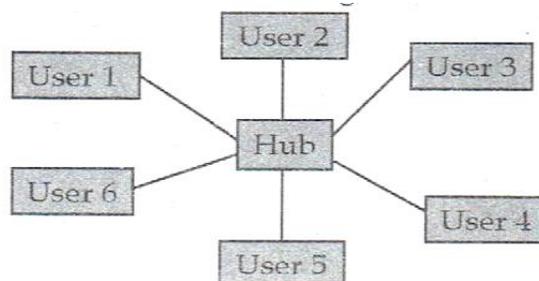
• **Tree topology:-** Tree topology is LAN topology in which only one route exists between any two node on the network. It is similar to the star topology but the nodes are connected to the secondary hub, which in turn is connected to the central hub.

Advantage of Tree Topology:- Installation and configuration of tree network is easy. Less expensive when compared to mesh topology.

Disadvantage of tree Topology:- Failure in central hub brings the entire network to a halt More cabling is requircd when compared to bus topology.
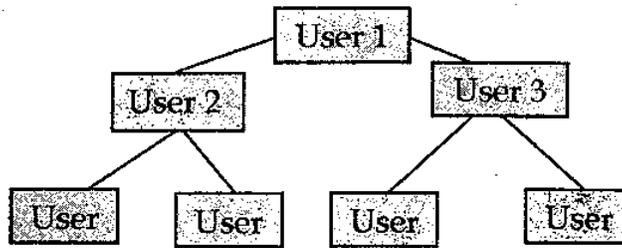
• **Mesh topology:-** Devices are connected with many redundant interconnections between network nodes. In a wel connected topology, every node has a connection to every other node in the network. Mesh topology are used in critical connection of host computers (typically telephone exchange). Alternate path allow each computer to balance the load to other computer systems in the network by using more than one connection path available.

Advantage of Mesh topology:- Failure in one of the computers does npt affect the entire network. Privacy between computers is maintained as messages travel along dedicated path.

Disadvantage of Mesh Topology:- Amount of caballing required is high. A large-number of I/O ports are required.
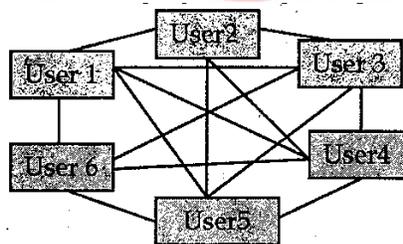
LAN HARDWARE AND SOFTWARE

LAN Hardware:- There are basic hardware component of LAN are:-

• **Transmission channel:-** Four types of channels are used for data communication in LAN. They are 1. Twisted pair; cable. 2. Coaxial cable 3. Radio waves. - -

• **Network Interface Unit (NIH):-** Network interface units connect each devices in the LAN network to shared transmission device. It contain rules and logic to access the LAN. NIU is also used to implement LAN protocols and for device attachment. Its function depends-on the type of topology used in LAN.

• **Servers:-** One of the major benefits of LAN is sharing expenñive resources such as storage devices, printer etc. This is achieved through providing servers on LAN. It is dedicated computer

that controls one or more resources. This contains both hardware and software interface for LAN. Three major categories of servers used in LANs are:-

• **File server:-** File server is used to share storage space for files. It is used to taking periodical backup and also provide gateway to other servers within ahd between LANs.

• **Printer server:-** Printer server is used to handle printing works of all workstation connected in the network.

• **Modem Server:-** In LAN environment also modem is required to get connected to other network or simply use a telephone. A modem server is used to share resource by ali.connected workstations in a network.

• **Work stations:-** In a network, computers are connected with servers or main computer known as workstation/terminal/client/slave.

LAN Software/Operating system:- Main software of LAN is operating system, manage workload with number of various type of server attiched to it. It has two aspects 1. Server software 2. Workstation software. LAN Operating system facilitates the sharing of expensive resources such as printer, storage space etc. There are various type of LAN operating system for example Novel Netware, Win NT, Win 2000 server, Unix etc.

• **Metropolitan Area Network (MAN):-** A type of computer network that is designed for a city or town is known as MAN. MAN is larger than LAN and smaller than WAN.

• **Wide Area Network (WAN):-** A Network that covers a large geographical area and covers different cities, states, and countries known as WAN. One LAN can be connected to other LAN over any distance via telephone and radio waves. A system of LANs connected in this way is called WAN.

LAN Devices:

• **Switch:-** A device that directs data packets along a path. It may include the function of a router. In general, a switch isa simpler and faster mechanism than a router as it does not maintain knowledge of the networks. A switch is not always required in a network.

• **Hub:-** A huh is a central connecting device in a network. Data arrives at the hub from one or more devices and is forwarded out using just one cable. For example, four cables from three computers and a printer are connected to a hub and then a single cable connects the hub to a server. A huh can also include a router. The data simply passed through the hub without any change.

WAN Devices:- Routing is responsible for searching a path between twa computng devices that wish to dommunicate and for forwarding the data packets on this path. Devices such as bridges, router and gateway provide this routing function. -

• **Bridges:-** Bridges-are used to connecttwo LANs that use identical protocols over a wide area. The bridge act as an address filter which picks up packets from one LAN that are intended for a destination on another LAN and passes these packets on the network. -

• **Router:-** Routers can be used to connectnetworks that may not be similar. Routers provide connectivity between two LANs or two WANs over large geographical distances.

• **Gateway:-** Gateways are used to connect two dissimilar LANs. A gateway is required to convert data packets from one protocol to another before forwarding it, as it connect two dissimilar networks.

Types of Wide Area Network:-

• **Public Network:-** Public Network are those networks which are installed and run by the telecom authorities and are made available to any organisation or individual who subscribe it.

• **Public Switched Telephone Network (PSTN):-** The feature of the PSTN are its low speed, the-analog nature of transmission, a restricted bandwidth and its widespread availability. PSTN is designed for telephone, modems. These are used for data communication. It is also used for FAX.

• **Public Switched Data Network (PSIJN):-** The term PSDN coyers a number of technologies. The main feature of PSDN are their high level of reliability and the high quality of the connection provided. It can support both low and high speeds at appropriate costs. It can also be used to link computer system and networks of one organisation to several other organisation. PSDN is very popular for connecting public and private mail system to implement electronic mail services with other companies.

• **Value added Services/Network (VAN/VAD):-** In CAN, the provider of such services must process, store and manipulate the data that is carried on the network. The technique is used in specific types of business in which it is advantageousto be able to share information with other companies in the same line. Electronic Data Interchange (EDI) is one area for value added services in which two trading partners exchange trading documents such as purchase orders, invoic&s, transportation etc using electronic means. Jn india, Videsh Sanchar Nigam Ltd. (VSNL) is a service provider.

• **Integrated Services Digital Network (ISDN):.** The ISDN is a networking concept providing for the integration of voice, video and data services using digital transmission media and combining both circuit and packet switching techniques. Uses can use their digital connection to

telephone company for transmitting both voice and data over the same twisted pair cable which connects their telephone.

• **Private Network:- P**rivate network is used by particular individual or organisation. It has its own standards and protocols. Private network may follow standards guideline or may not follow these guide lines. It depend upon the organisation or individuals for which it has been developed. e.g Intranet.

• **Virtual Private Network VPN):-**VPN uses a -technique known as tunnelling to transfer data securely on the Internet to a remote access server on your workplace network. Using a VPN helps you save money by using the public Internet instead of making long—distance phone calls to connect securely with your private network. There are two ways to create a VPN connection, by dialling an Internet service provider (ISP), or connecting directly to Internet.

Network Addressing: IP addresses are broken into 4 octets (IPv4) separated by dots called dotted decimal notation. An octet is a byte consisting of 8 bits. The lPv4 addresses are in the following form: 192.168.10.1.

TYPES OF ADDRESSES: There are two types of addresses:

A. Logical Address: The logical address is what the IP (Internet Protocol) address, can also be called virtual address, is and it looks like this 216.109.112.135. IP address can change and often does when you have a high speed Internet connection. It is in hierarchical fashion i-e a network part and a host part.

• **IP Version 4; Address:** IPV4 uses 32 bits to define each address. IPV4 uses four 1 byte decimal numbers separated by dots.

•**IP Version 6;** Address: IPVG uses 128 bits to define address. IPV6 uses hexadecimal numbers that are separated with colons. It is better for mobile network It has larger address space

B. Physical Address: The physical address is just like mailing address it is real, it is also called MAC address (Media Access Control address) and looks like this 00-56-7E-4A-DD-8D i-e in a hexadecimal form. It is different for every technology e.g Ethernet uses different physical addresses than other technologies available. The communicating applications (source/ destination applications) must also be identifiable.

Internet address:- Consists of 4 bytes separated by periods. Example: 136.102.233.49

• The R first bytes (R= 1,2,3) correspond to the network address;

• The remaining H bytes (H = 3,2,1) are used for the host machine.

• InterNIC Register: organization in charge of the allocation of the address ranges corresponding to networks.
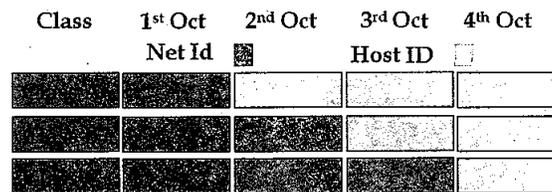
Criteria considered:-

  ➢ Geographical area (country)
  ➢ Organization, enterprise
  ➢ Department
  ➢ Host

There are two parts of an IP address: -

• Network ID

• Host ID

IP addresses divided into 5 classes. The various classes of networks specify additional or fewer octets to designate the network ID versus the host ID.

Class A: Class A addresses are specified to networks with large number of total hosts. Class A allows for 126 networks by using the first octet for the network ID. The first bit in this octet, is always set and fixed to zero. And next seven bits in the octet is all set to one, which then complete network ID. The 24 bits in the remaining octets represent the hosts ID, allowing 126 networks and approximately 17 million hosts per network. Class A network number values begin at 1 and end at 127.

Class B: Class B addresses are specified to medium to large sized of networks. Class B allows for 16,384 networks by using the first two octets for the network ID. The two bits in the first octet are always set and fixed to 1 0. The remaining 6 bits, together with the next octet complete network ID. The 16 bits in the third and fourth octet represent host ID, allowing for approximately 65,000 hosts per network. class B network number values begin at 128 and end at 191.

Class C: Class C addresses are used in small local area networks (LAN5). Class C allows, for approximately 2 niillioñ networks by using the first three octets for the network ID. In class C address three bits are always set and fixed to 1 1 0. And in the first three octets 21 bits complete the total network ID. The 8 bits of the last octet represent the host ID allowing for 254 hosts per one network. Class C network number values begin at 192 and nd at 223.

Class D and E: Classes D and F are not allocated to hosts. Class D addresses are used for multicasting, and class F addresses are not available for general use: they are reserved for future purposes.