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CHAPTER 1

Unit I

Introduction

Syllabus :

Introduction to data communication, Components, Data representation, Data flow, Networks, Network criteria, Physical structures, Network types, Local area network, Wide area network, Switching, The Internet, Accessing the Internet, Standards and administration Internet standards.

1.1 Introduction :

- The communication branch is the oldest branch of the electronics field. Telecommunication means communicating at a distance. A communication system is the means of conveying the information from one place to the other. This information can be of different types such as sound, picture, music, computer data etc.
- The field of communication engineering started developing rapidly in the nineteenth century when the telegraph, telephone and then the radio were invented. The development was still faster in the twentieth century when first the black and white and then colour TVs were brought in use. Then came the age of satellite communication, cable TV, mobile telephones etc.
- In order to understand the subject, it is necessary to understand the basic concepts in communication engineering such as, modulation, noise, demodulation, information theory etc.

1.2 Introduction to Data Communication :

- In this chapter we are going to discuss data communication and networking.
- The aim of data communication and networking is to allow the exchange of data such as audio, text and video between any points in world.
- The transfer of data takes place over a computer network. A network is like a path or a road over which the data travels smoothly from sender to destination.

1.2.1 Definition of Data Communication :

- Before exchanging information, the creaters and the users of data should agree upon how the information should be presented ?
- An information that is presented in such a form is called **data.**
- **Data communication** can be defined as the exchange of data between a source and destination over some kind of transmission medium, such as a co-axial cable, (Wired communication) or air (wireless communication).

1.2.2 Characteristics of Data Communication System :

The three important characteristics of a data communication system are :

1. Delivery 2. Accuracy 3. Timeliness

1. Delivery :

A data communication system (DCS) must deliver data only to the user who is intended to use it and not to any one else.

2. Accuracy :

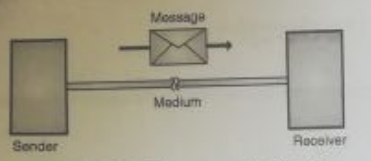
- Due to noise the data may get altered or corrected when it is travelling over a communication medium. Errors will be introduced and the accuracy of the received data is adversely affected.
- The data communication system (DCS) must be designed in such a way that the delivered data is accurate and free from any errors.

3. Timeliness :

- The time delay is unacceptable for the audio and video data, as it introduces errors in the reproduced sound or picture, so the DCS should deliver the data without any time delay.
- Such a data delivery is called as real-time transmission of data.

1.3 Components of Data Communication System :

- If we specifically consider the communication between two computers then the data communication system is as shown in Fig. 1.3.1.
- It has the following five components :
  1. Message
  2. Sender
  3. Medium
  4. Receiver and 5. Protocol



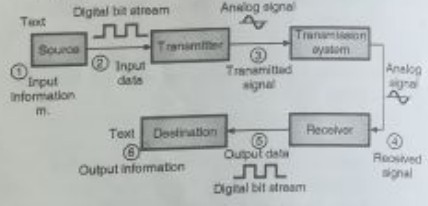
(L-2(a)) **Fig. 1.3.1 : Five components of a data communication system**

Description :

1. **Message :**
   - Message is nothing but information or data which is to be sent from sender to the receiver.
   - A message can be in the form of sound, text, number, pictures, video or combination of them.
2. **Sender :**
   Sender is a device such as a host, video camera, telephone, work station etc. which sends the message over the medium.
3. **Medium :**
   - The message originating from the sender needs a path over which it can travel to the receiver. Such a path is called as the medium or channel.
   - The examples of transmission medium are coaxial cable, twisted pair wire, fiber optic cable, radio waves (used in terrestrial or satellite communication).
4. **Receiver :**
   It is the device which receives the message and reproduces it. A receiver can be in the form of a workstation, telephone handset a TV receiver etc.
5. **Protocol :**
   Protocol is defined as the set of rules agreed by the sender and receiver. There can be different protocols defined for different functions. Protocols govern the exchange of data in true sense.

1.4 Data Communication Model :

- Fig. 1.4.1 shows the simplified data communication model.

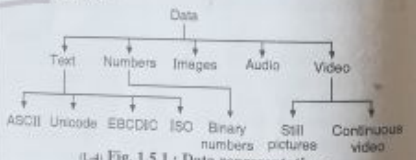


(L-3) **Fig. 1.4.1 : Data communication model**

- Suppose that the source and transmitter are the components of a personal computer. The user of this PC wants to send a message "m" to another PC.
- Then the message "m" will be in the form of a digital bit stream and called as **input data** as shown in Fig. 1.4.1.
- The senders PC is connected to some **transmission medium** such as a local network or a telephone line, by an input/output device (transmitter) such as a modem.
- The input data is applied to the transmitter as a sequence of digital bits on a transmission cable or communication bus.
- The transmitter is connected directly to the medium and converts the incoming digital bit stream into an analog signal suitable for transmission over the communication cable.
- The analog transmitted signal travels on the transmission medium and is subjected to a number of impairments (noise, attenuation etc.), before reaching the receiver.
- Due to these impairments, the received signal may appear completely different from the transmitted signal.
- The receiver tries to estimate the original signal based on the distorted received signal, and the knowledge of transmission medium.
- A sequence of digital bits is produced at the output of the receiver.
- These bits are then sent to the destination which is another PC. The signal "m" represents the output information which is presented to the user and can be seen on the computer screen for display or printed using a printer.

1.5 Data Representation :

- Data can be represented using different forms as shown in Fig. 1.5.1.



(L-4) **Fig. 1.5.1 : Data representation**

1.5.1 Text :

- A binary digit or bit can represent only two symbols as it has only two states "0" or "1".
- But this is not enough for communication between two computers because there we need many more symbols for communication. These symbols are required to represent :
  1. 26 alphabets with capital and small letters.
  2. Numbers from 0 to 9.
  3. Punctuation marks and other symbols.

- Therefore instead of using only single binary bits, a group of bits is used as a code to represent a symbol.
- The number of bits used per code word will be dependent on the total number of symbols to be represented e.g. if 5 bits are used per code word then 2^5 = 32 combination would be possible i.e. 32 distinct code words can be produced.
- If the word length is increased to 8 then the number of combinations would be 2^8 = 256, hence an 8-bit code can represent 256 symbols.
- A set of such code words is called as "code set". The following three code sets are very commonly used for the data representation.

Different codes used are :

1. ASCII (American Standard Code for Information Interchange)
2. EBCDIC (Extended Binary Coded Decimal Interchange code)
3. Baudot code
4. Extended ASCII
5. Unicode 6. ISO.

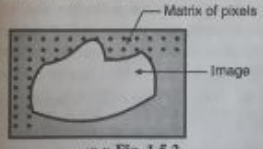
ASCII code is a 7-bit code whereas EBCDIC is an 8-bit code. ASCII code is more commonly used world wide while EBCDIC is used primarily in large IBM computers.

1.5.2 Numbers :

- The numbers are represented using bit patterns. The code such as ASCII or EBCDIC is not used for this purpose.
- This will simplify the mathematical operations on numbers to a great extent.

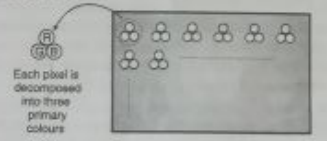
1.5.3 Images :

- Image is another form of data. They also are represented by bit patterns but with a different mechanism.
- The basic principle is as follows. An image is divided into a matrix of pixels (pixel means picture element).
- Each pixel is in the form of a small dot as shown in Fig. 1.5.2. We can use a large number of pixels for better resolution.
- Higher resolution ensures better quality of picture.



(G-8) **Fig. 1.5.2**

- After dividing the image into pixels, each pixel is represented by a unique bit pattern.
- For black and white image one 1 bit per pattern is sufficient to represent a pixel. 1 will represent white and 0 will represent black.
- If the gray shades are to be included then we can use 2 bit pattern to represent each pixel. Then 00 is black, 01 is dark gray, 10 is light gray and 11 represents white.
- If a coloured image is to be represented, then each coloured pixel is decomposed into three primary colours namely Red, Green and Blue (RGB), as shown in Fig. 1.5.3.

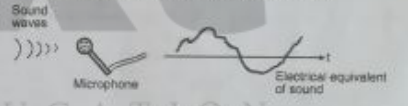


(G-4) **Fig. 1.5.3 : Pixels for coloured images**

- The intensity of each colour at each pixel is then converted into an 8 bit pattern. Thus colour image representation needs more number of bits. Thus the intensity information corresponding to each pixel is to be converted into a unique binary bit pattern.

1.5.4 Audio :

- Audio means sound. It is continuous with respect to time and not discrete like the text or numbers.



(G-5) **Fig. 1.5.4**

- A microphone is used to convert sound into an equivalent electrical signal. The audio signal should be converted into a digital signal before transmitting it over the medium.

1.5.5 Video :

- The principle behind video or moving pictures is the technique called **animation.** This technique is used in cartoons and motion pictures or films. It says - if we show a set of pictures at a sufficiently rapid pace, the human eye due to persistence of vision, feels that the picture is in continuous motion.
- If 24 pictures are shown in one second, our eye senses a continuous motion without any flicker effect.
- So if pictures of successive incremental actions stored in a disc or memory are retrieved at 24 pictures / second then we can play a video on the computer.
- A video camera captures images continuously at the rate of 24 pictures per second. These images can then be converted into binary form.

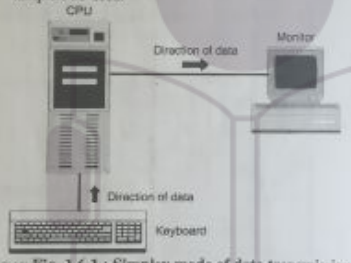
1.6 Types of Communication : Simplex, Half Duplex, Full Duplex (Data Flow) :

Based on whether the given communication system communicates only in one direction only or in both the directions, the communication systems are classified as :

- Simplex systems.
- Half duplex systems.
- Full duplex systems.

1.6.1 Simplex Systems :

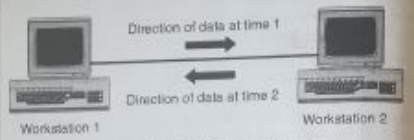
- In these systems the information is communicated in only one direction. For example the radio or TV broadcasting systems can only transmit. They cannot receive.
- In data communication system the simplex communication takes place as shown in Fig. 1.6.1.
- The communication from CPU to monitor or keyboard to CPU is unidirectional.
- Keyboard and traditional monitors are examples of simplex devices.



(G-10) **Fig. 1.6.1 : Simplex mode of data transmission**

1.6.2 Half Duplex Systems :

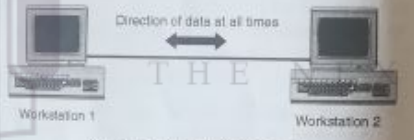
- These systems are bi-directional, i.e. they can transmit as well as receive but not simultaneously.
- At a time these systems can either transmit or receive, for example a transreceiver or walky talky set. Thus the direction of communication will keep changing itself.
- A data communication system working in the half duplex mode is shown in Fig. 1.6.2.
- Each station can transmit and receive, but not at the same time. When one device is ending the other one is receiving and vice versa.
- In half duplex transmission, the entire capacity of the channel is utilized by the transmitting (sending) system.



(G-11) **Fig. 1.6.2 : Half duplex system**

1.6.3 Full Duplex Systems :

- These are truly bi-directional systems as they allow the communication to take place in both the directions simultaneously.
- These systems can transmit as well as receive simultaneously, for example the telephone systems.
- A full duplex data communication system is shown in Fig. 1.6.3. Each station can transmit and receive simultaneously.
- In full duplex mode, signals going in either direction share the full capacity of link.
- The link may contain two physically separate transmission paths one for sending and another for receiving.
- Otherwise the capacity of channel is divided between signals travelling in both directions.



(G-12) **Fig. 1.6.3 : Full duplex mode**

1.7 Computer Networks :

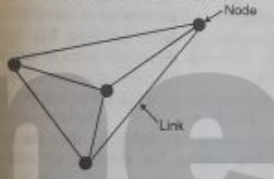
Network :

- Network is a broad term similar to "system". Network is a communication system which supports many users.
- In relation with the computers we can say that a "computer network" is a system which allows communication among the computers connected in the network.
- There are various ways of interconnecting the computers.

Protocol :

- For successful communication to occur, it is not enough for the "sender" to simply transmit the message and "assume" that the "receiver" will receive it properly.

- There are certain rules that must be followed to ensure proper communication.
- A set of such rules is known as a "protocol" of the data communication system.
- Many different protocols are used in the modern data communication system.
- The interconnection of one station to many stations is called as networking.
- A network is any interconnection of two or more stations that wish to communicate.
- **Node :** Each station in a communication network is called as a node. The nodes are connected in different way to each other to form a network.
- One of such networks is shown in Fig. 1.7.1.
- Many other forms of interconnections are possible. The most familiar network is the telephone system. It is the largest and most sophisticated network of all.



(G-13) **Fig. 1.7.1 : A simple communication network**

1.7.1 Introduction to Computer Networks :

- During 20th century the most important technology has been the information gathering, its processing and distribution.
- The computers and communication fields have been merged together and their merger has had a deep impact on the manner in which computer systems are organized.
- The old model in which a single computer used to serve all the computational needs of an organization has been replaced by a new one in which a large number of separate but interconnected computers do the job.
- Such systems are called as **computer networks.**
- Two computers are said to be interconnected if they interchange information. The connection between the separate computers can be done via a copper wire, fiber optics, microwaves or communication satellite.

Distributed system :

- A system with one control unit (master computer) and many slaves, or a large computer with remote printers and terminals is not called a **computer network, it is called a Distributed System.**
- In distributed system the existence of multiple autonomous computers is not visible to the user.
- With a computer network, the user has to conciously log onto a machine, submit jobs remotely, move files around etc. in short handle all the network management personally.
- With a distributed system nothing of this needs to be done explicitly, it all happens automatically because the system takes care of it without the users knowledge.
- Basically a distributed system is a software system built on top of a network. The software gives it a high degree of cohesiveness, (homoginity) and transparency to the system.

1.7.2 Computer Network Criteria :

- Network is a broad term similar to system. Network is a communication system which supports many users.
- In context with the computers we can say that, a "computer network" is a system which allows communication among the computers connected in the network.
- A network must be able to meet certain criteria. The most important of them are :
  1. Performance 2. Reliability 3. Security

Performance :

- Performance can be measured in different ways. We can measure it in terms of transit time and response time.
- **Transit time** is defined as the time required for a message to travel from one device to the other.
- **Response time :** It is the time elapsed between the instant of enquiry and the instant of giving response.
- The other factors deciding the performance are as follows :
  1. Number of users.
  2. Type of transmission medium.
  3. The hardware used. 4. The software used.

Reliability :

- The network reliability is important because it decides the frequency at which network failure takes place.
- It also decides the time taken by the network to recover and its robustness in the catastrophe.

Security :

The network security refers to protection of data from the unauthorized user or access. It also includes the data protection against damage and recovering it in the events of data losses.

1.8 Physical Structures :

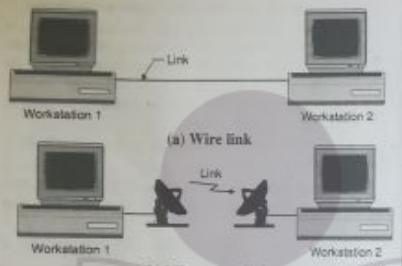
Two characteristics which can be used as the basis of distinguishing various data link configurations are topology and whether the link is half duplex or full duplex.

1.8.1 Type of Connections (Topology) :

- In a network two or more devices are connected to each other through connecting links.
- There are two possible ways to connect the devices. They are follows :
  1. Point to point connection
  2. Multipoint connection.

1.8.2 Point-to-Point Connection :

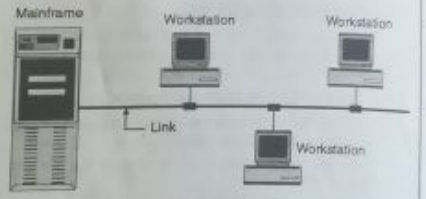
- A point to point connection provides a dedicated link between two devices as shown in Fig. 1.8.1. The meaning of the word dedicated is that the entire capacity of the link is reserved for transmission between these two devices only.
- It is possible to connect the two devices by means of a pair of wires (see Fig. 1.8.1(a)) or using a microwave or satellite link (wireless link) as shown in Fig. 1.8.1(b).



(G-8) **Fig. 1.8.1 : Point to point connection**

1.8.3 Multipoint Connection :

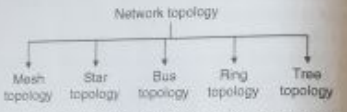
- A multipoint connection is also called as a multidrop connection.
- In such a connection more than two devices are connected to and share a single link as shown in Fig. 1.8.2.
- In the multipoint connection the channel capacity is shared among multiple users. If many devices share the link simultaneously, it is called spatically shared connection.
- But if users share it turn by turn then it is time sharing connection.



(G-9) **Fig. 1.8.2 : Multipoint configuration**

1.9 Network Topology Types :

- The word physical network topology is used to explain the manner in which a network is physically connected.
- Devices or nodes in a network get connected to each other via communication links and all these links are related to each other in one way or the other.
- The geometric representation of such a relationship of links and nodes is known as the topology of that network.
- The five basic network topologies are as shown in Fig. 1.9.1.

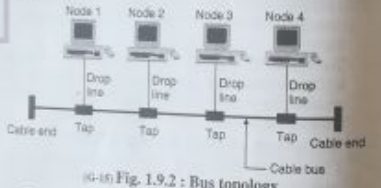


(G-14) **Fig. 1.9.1 : Classification of network topology**

- While selecting one of the above five topologies we have to consider the relative status of the device to be linked.
- These topologies can be classified into two types :
  1. Peer to peer 2. Primary – secondary
- Peer to peer is the relationship where the devices share the link equally. The examples are ring and mesh topologies.
- In Primary – secondary relationship, one device controls and the other devices have to transmit through it. For example star and tree topology.

1.9.1 Bus Topology :

- The bus topology is usually used when a network under consideration is small, simple or temporary as shown in Fig. 1.9.2.



(G-15) **Fig. 1.9.2 : Bus topology**

- On a typical bus network a simple cable is used without additional electronics to amplify the signal or pass it along from computer to computer. Therefore the bus is a passive topology.
- When one computer sends a signal on the cable; all the computers on the network receive the information. However only the one with the address that matches with the destination address stored in the message accepts the information while all the others reject the message.

- The speed of the bus topology is slow because only one computer can send a message at a time. A computer must wait until the bus is free before it can transmit.
- The bus topology requires a proper termination at both the ends of the cable in order to avoid reflections.
- Since the bus is a passive topology, the electrical signal from a transmitting computer is free to travel over the entire length of the cable.
- Without termination when the signal reaches the end of the cable, it returns back and travels back on the cable.
- The transmitted waves and reflected waves, if they are in phase add and if they are out of phase cancel.
- Thus addition and cancellation of wave results in a standing wave.
- The standing waves can distort the normal signals which are travelling along the cable. This can be avoided by terminating the bus on both ends in 50 Ω load impedance.
- The terminators absorb the electrical energy and avoid reflections.

Characteristics of the bus topology :

Following are some of the important characteristics of the bus topology :

1. This is a multipoint configuration. There are more than two devices connected to the medium and they are capable of transmitting on the medium. Hence the Medium Access Control (MAC) is essential for the bus topology.
2. The signal strength of the transmitted signal should be adequately high so as to meet the minimum signal strength requirements of the receiver.
3. Adequate Signal to Noise Ratio (SNR) should be maintained for better quality reception.
4. The signal should not be too strong. This is necessary to avoid the overloading of transmitter and hence the possibility of signal distortion.
5. This is called as signal balancing which is not an easy task at all. Specially the signal balancing becomes increasingly difficult with increase in the number of stations.

Transmission media for bus LANs :

We can use the following transmission media for the bus LANs :

1. Twisted pair 2. Baseband co-axial cable
3. Broadband co-axial cable 4. Optical fibre

Advantages of bus topology :

1. The bus topology is easy to understand, install, and use for small networks.
2. The cabling cost is less as the bus topology requires a small length of cable to connect the computers.
3. The bus topology is easy to expand by joining two cables with a BNC barrel connector.
4. In the expansion of a bus topology repeaters can be used to boost the signal and increase the distance.

Disadvantages of bus topology :

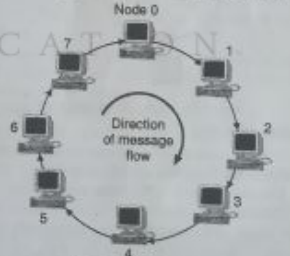
1. Heavy network traffic slows down the bus speed. In bus topology only one computer can transmit and other have to wait till their turn comes and there is no co-ordination between computers for reservation of transmitting time slot.
2. The BNC connectors used for expansion of the bus attenuates the signal considerably.
3. A cable break or loose BNC connector will cause reflections and bring down the whole network causing all network activity to stop.

Note :

- Ethernet 10 base 2 also known as thinnet is an inexpensive network based on the bus topology.
- A bus network behaves erratically if it is not terminated or improperly terminated.
- Token bus networks are defined by the IEEE 802.4 standard.

1.9.2 Ring Topology :

- In a ring topology, each computer is connected to the next computer, with the last one connected to the first as shown in Fig. 1.9.3.
- Rings are used in high-performance networks where large bandwidth is necessary e.g. time sensitive features such as video and audio.
- Every computer is connected to the next computer in the ring and each retransmits what it receives from the previous computer hence the ring is an active network.



(G-16) **Fig. 1.9.3 : Ring topology**

- The messages flow around the ring in one direction. There is no termination because there is no end to the ring.
- Some ring networks do token passing. A short message called a token is passed around the ring until a computer wishes to send information to another computer.
- That computer modifies the token, adds an electronic address and data and sends it around the ring.

- Each computer in sequence receives the token and the information and passes them to the next computer until either the electronic address matches the address of a computer or the token returns to its origin.
- The receiving computer returns a message to the originator indicating that the message has been received.
- The sending computer then creates another token and places it on the network, allowing another station to capture the token and begin transmitting.
- The token circulates until a station is ready to send and capture the token. Faster networks circulate several tokens at once.
- Some ring networks have two counter-rotating rings that help them recover from network faults.

Characteristics of ring LANs :

- The basic ring LAN is shown in Fig. 1.9.4, which shows that along with the nodes A, B, C, D equal number of repeaters are used and that the transmission is unidirectional.
- The data is travels in a sequential manner around the ring. Each repeater will receive regenerate and retransmit this data bit.

(G-17) **Fig. 1.9.4 : Ring topology**

Functions of a ring :

- A ring can operate as a communication network if it performs the following three functions :
  1. Data insertion
  2. Data reception
  3. Data removal
- The above mentioned functions are actually provided by the repeaters.
- Each repeater also acts as the device attachment point, so that the function of data insertion can be accomplished.
- Data is transmitted in the form of packets.
- Each packet consists of a destination address field. As this packet passes through a repeater, the destination address field is copied by the repeater.
- If the destination address field corresponds to the address of a device then that repeater copies the remaining contents of packet as well.
- Data insertion and reception can be done easily by the repeaters but the task of removing data removal is more difficult on a ring.
- As the ring is a closed loop, a packet will circulate on it indefinitely if it is not removed.
- A packet can be removed by the addressed repeater or each packet can be removed by the transmitting repeater itself after the packet has made one trip around the ring.
- The second approach is more desirable.

Problems faced in the ring topology :

1. If any link breaks or if any repeater fails then the entire network will be disabled.
2. To install a new repeater for supporting a new device, it is necessary to have the identification of two nearby, topologically adjacent repeaters.
3. It is necessary to take preventive measures to deal with the time jitter.
4. Due to the closed nature of the ring topology it is necessary to remove the circulating packets.

These problems except for the last one can be rectified by refinements of the ring topology.

Advantages of ring topology :

1. Every computer gets an equal access to the token.
2. There are no standing waves produced.

Disadvantages of ring topology :

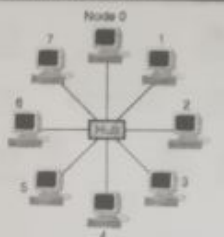
1. Failure of one computer on the ring can affect the whole network.
2. It is difficult to trouble short the ring.
3. Adding or removing the computers disturbs the network activity.

Note : Token ring networks are defined by the IEEE 802.5 standard.
Fibre Distributed Data Interface (FDDI) is a fast fibre-optic network based on the ring topology.

1.9.3 Star Topology :

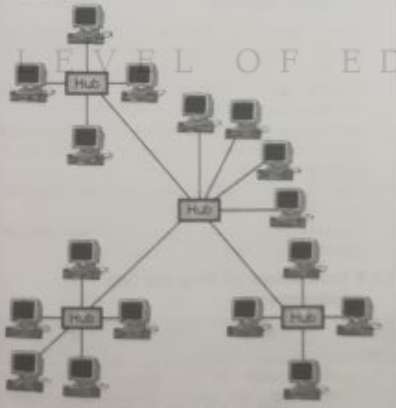
In a star topology all the computers are connected via cables to a central location where they are all connected by a device called a hub as shown in Fig. 1.9.5. There is no direct connections among the computers. All the connections are made via the central hub.

- Stars are used in concentrated networks, where the endpoints are directly reachable from a central location; when network expansion is expected and when the greater reliability of a star topology is needed.
- Each computer on a star network communicates with a central hub. The hub then resends the message to all the computers in a broadcast star network. It will resend the message only to the destination computer in a switched star network.



(G-18) **Fig. 1.9.5 : Star topology**

- The hub in a broadcast star network can be active or passive. An active hub generates the electrical signal and sends it to all the computers connected to it.
- This type of hub is usually called a multiport repeater. Active hubs require external power supply.
- A passive hub is a wiring panel or punch down block which acts as a connection point. It does not amplify or regenerate the signal. Passive hubs do not require electrical power supply.
- Several types of cables can be used to implement a star network. A hybrid hub can use different types of cable in the same star network.
- A star network can be expanded by placing another star hub as shown in Fig. 1.9.6.
- This arrangement allows several more computers or hubs to be connected to that hub. This creates a hybrid star network.



(G-19) **Fig. 1.9.6 : Expansion of star topology**

1.9.4 STAR LANs :

- In the star type LANs, the Unshielded Twisted Pair (UTP) is used as the transmission medium.
- This is because the unshielded twisted pair is a telephone wire which is available in each and every office building. The other advantages of using twisted wires are as follows :
  1. No no additional installation cost is required for the installation of LAN.
  2. Since the telephone wires cover the entire building it is possible to spread the network in every part of each building.
- The basic star topology is as shown in Fig. 1.9.7. This is called as a single level star topology.
- As shown in Fig. 1.9.7, the central element of the star topology is an active element called hub or repeater.
- Each station (A, B, C, ...) is connected to the hub with the help of two links one for transmitting and the other for reception of the data.

(G-20) **Fig. 1.9.7 : Single level star topology**

- When a single station transmits, the hub repeats the signal and sends it to each station.
- Typically the length of each link is 100 m. If the twisted pair is used and the length may increase upto 500 m if the optical fibre is used as transmission medium.
- It is important to note that if two stations transmit simultaneously, then there will be a collision between their transmitted signals.

Disadvantages of star topology :

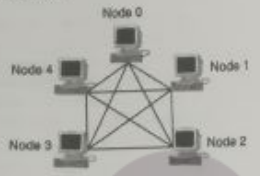
1. If the central hub fails, the whole network fails to operate.
2. Many star networks require a device at the central point to rebroadcast or switch the network traffic.
3. The cabling cost is more since cables must be pulled from all computers to the central hub.

Note : Ethernet 10 base T is a popular network based on the star topology.
Intelligent hubs with microprocessor that implement features in addition to repeating network. Signals provide for centralized monitoring and management of the network. It is the most flexible and the easiest to diagnose when there is a network fault.

1.9.5 Mesh Topology :

In a mesh topology every device is physically connected to every other device with a point to point dedicated link as shown in Fig. 1.9.8.

- The term dedicated means that the link carries data only between two devices connected on it.
- A fully connected mesh network therefore has n(n–1)/2 physical cables to connect n devices. To accommodate that many links every device on the network must have n–1 input/output ports.
- So too many cables are required to be used for the mesh topology.



(G-21) **Fig. 1.9.8 : Mesh topology**

Advantages :

1. The use of dedicated links guarantees that each connection can carry its own data reliably.
2. A mesh topology is robust because the failure of any one computer does not bring down the entire network.
3. It provides security and privacy because every message sent travels along a dedicated line.
4. Point to point links make fault diagnose easy.

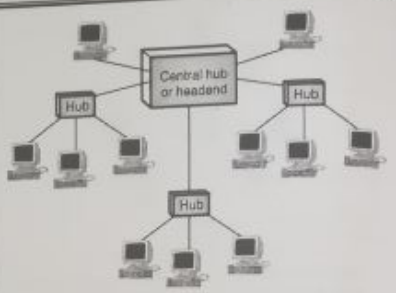
Disadvantages :

1. Since every computer must be connected to every other computer installation and reconfiguration is difficult.
2. Cabling cost is more.
3. The hardware required to connect each link input/output and cable is expensive.

Note : Mesh topology is usually implemented as a backbone connecting the main computers of a hybrid network that can include several other topologies.

1.9.6 Tree Topology :

- A tree topology is a variation of a star. As in a star, nodes in a tree are connected to a central hub that controls the entire network.
- However, every computer is not plugged into the central hub. Most of them are connected to a secondary hub which in turn is connected to the central hub as shown in Fig. 1.9.9.
- The central hub in the tree is an active hub which contains repeater. The repeater amplify the signal and increase the distance a signal can travel.
- The secondary hubs may be active or passive. A passive hub provides a simple physical connection between the attached devices.



(G-22) **Fig. 1.9.9 : Tree topology**

Advantages :

1. It allows more devices to be attached to a single hub and can therefore increase the distance of a signal can travel between devices.
2. It allows the network to isolate and attach priorities to the communications from different computers.

Disadvantages :

1. If the central hub fails the system breaks down.
2. The cabling cost is more.

Note : The advantages and disadvantages of a tree topology are generally the same as those of a star.

1.9.7 Logical Topology :

- Logical topology describes the manner in which the stations are logically connected to each other for the purpose of data unit exchange.
- Physical topology discussed earlier can be different from the logical topology, of the network.
- As an example consider the bus topology. The bus acts as a central controller. It receives data and forwards it to the various nodes.
- Thus the stations have a logical connection to the bus which acts as a centralized controller.
- Therefore the logical topology of a bus is star topology. eventhough the physical topology is bus.

1.9.8 Comparison of Ring and Star Topologies :

Sr. No.	Ring	Star
1.	Media failure on uni-directional or single loop ring causes complete network failure.	Media faults are automatically isolated to the failed segment.
2.	Relatively difficult to reconfigure.	Relatively easy to configure.

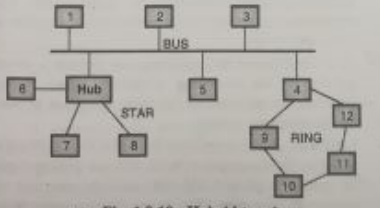
Sr. No.	Ring	Star
3.	It is difficult to troubleshoot.	Easy to troubleshoot.
4.	The failure of one computer can affect the whole network.	The failure of single computer or cable doesn't bring the network down.
5.	No computer has a monopoly over the network.	Failure of the central hub causes the whole network failure.
6.	Adding and removing computers disrupts the network.	Adding and removing the computers is relatively easier.

1.9.9 Comparison of Bus and Star Topologies :

Sr. No.	Bus	Star
1.	Uses a cable as bus or backbone to connect all nodes.	Uses a central hub to connect the nodes to each other.
2.	Baseband or broadband coaxial cable is used.	Twisted pair, coaxial cables or optical fiber cables are used.
3.	If a part of bus fails, the whole network fails.	Failure of the central hub will make the entire network collapse.
4.	Adding an new node is difficult.	Adding and removing a node is relatively easy.
5.	Fault diagnosis is relatively difficult.	Fault diagnosis is easy.

1.9.10 Hybrid Topology :

- We have discussed various basic topologies such as bus, ring, mesh, star etc.
- Hybrid topology is the one which makes use of two or more basic topologies mentioned above, together.
- There are different ways in which a hybrid network is created. Fig. 1.9.10 shows the hybrid topology in which bus, star and ring topologies are used simultaneously.



(G-23) **Fig. 1.9.10 : Hybrid topology**

- In Fig. 1.9.10, the nodes 1, 2, 3, 4 and 5 are connected in the bus topology, node 6, 7 and 8 form a star and the nodes 4, 9, 10, 11, 12 are arranged in a ring topology.
- The practical networks generally make use of hybrid topology. Many complex networks can be reduced to some form of hybrid topology.
- The hybrid topology which is to be used for a particular application depends on the requirements of that application.

1.9.11 Comparison of Star Bus and Star Ring Topologies :

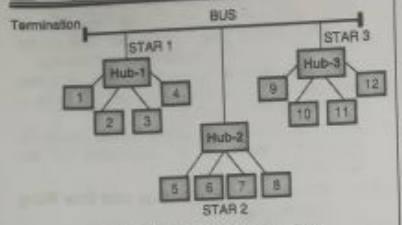
Sr. No.	Parameter	Star bus	Star ring
1.	Topology	Hybrid. It is a combination of star and bus topologies.	Hybrid. It is a combination of star and ring topologies.
2.	Configuration	Fig. A	Fig. B
3.	Peculiarity	Many stars are connected to a bus.	Many rings are connected in star.
4.	Applications	Suitable for large networks.	Suitable for interconnection of many small networks.

Fig. A

(G-24) **Fig. B**

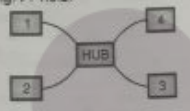
Ex. 1.9.1 : Draw the star bus topology connecting three star networks consisting of four computers.

Soln. : Fig. P. 1.9.1 shows the required star bus topology.



(G-25) **Fig. P. 1.9.1 : Star-bus topology**

Ex. 1.9.2 : Identify the network topology shown in Fig. P. 1.9.2.



(G-26) **Fig. P. 1.9.2**

Soln. : The given network uses the star topology.

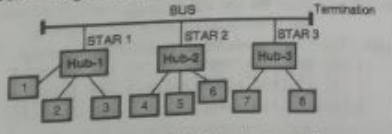
Ex. 1.9.3 : Identify the topology shown in Fig. P. 1.9.3. Comment on whether this topology is active or passive.

(G-27) **Fig. P. 1.9.3**

Soln. : This is the ring topology. The ring topology is an active network.

Ex. 1.9.4 : Draw with neat-labelled sketch of star-bus topology connecting 3 star networks having 3 computers in 2 stars and 2 computers in one star.

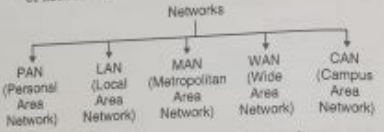
Soln. : Fig. P. 1.9.4 shows the required star-bus topology.



(G-28) **Fig. P. 1.9.4 : Star-bus network**

1.10 Network Classification by their Geography (Categories of Networks) :

- Computer network can be classified based on the geographical area they cover, i.e. the area over which the network is spread.
- Such a classification is shown in Fig. 1.10.1.
- In this section, we will discuss the following categories of networks :



(G-1400) **Fig. 1.10.1 : Network categories**

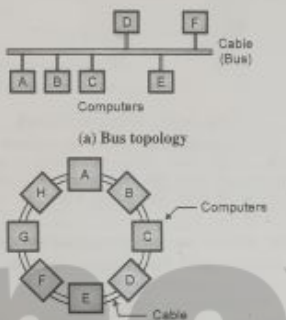
1.10.1 Local Area Networks (LAN) :

- The Local Area Network (LAN) is a network which is designed to operate over a small physical area such as an office, factory or a group of buildings. LANs are very widely used in a variety of applications.
- LANs are easy to design and troubleshoot. The personal computers and workstations in the offices are interconnected via LAN.
- The exchange of information and sharing of resources becomes easy because of LAN.
- In LAN all the machines are connected to a single cable. Different types of topologies such as Bus, Ring, Star, Tree etc. are used for LANs.
- LAN uses a layered architecture and they are capable of operating at hundreds of Mbits/sec.
- A Local Area Network (LAN) is usually a privately owned and links the devices in a single office, building or campus of upto a few kilometres in size as shown in Fig. 1.10.1.
- Depending on the needs of an organisation and the type of technology used, a LAN can be as simple as a few computers and a printer at home or it can contain many computers in a company and include voice, sound and video peripherals.
- LANs are widely used to allow resources to be shared between personal computers or workstations. The resources to be shared can be hardware like a printer or softwares or data.
- In a LAN one of the computer can become a server serving all the remaining computers called clients. Software can be stored on the server and it can be used by the remaining clients.
- LAN's are also distinguished from MAN's and WAN's based on the transmission media they use and topology. In general a given LAN will use only one type of transmission medium. The most common networking topologies used are bus, ring and star.

- The data rates for LAN can now range from 10 Mbps to 16 Gbps.

LAN topologies :

Various topologies are possible for the broadcast LANs such as bus topology or ring topology as shown in Fig. 1.10.2.



(G-32) **Fig. 1.10.2 : LAN topologies**

Static and Dynamic broadcast networks :

- The broadcast networks are further classified into two types namely :
  1. Static networks and
  2. Dynamic networks.
- This classification is based on how the common channel is allocated.
- In static allocation, each machine is allowed to broadcast only in its allotted time slot.
- But static allocation wastes the channel capacity when a machine does not want to transmit in its allotted time slot.
- Hence most of the systems try to allocate the channel dynamically i.e. on demand.

LAN components :

Some of the important LAN components are as follows :

1. Workstations.
2. File servers.
3. Gateway.
4. Network interfacing unit.
5. Active and passive hubs.
6. LAN cables or communication channels.

Workstation :

Workstation refers to the individual, single computer.

A communication capability is added to enable it for networking.

File server :

File server is a computer that allows the sharing of data, software and hardware resources by running special softwares.

Gateway :

It assists the transfer of data from one LAN to the other LAN.

Network Interfacing Unit (NIU) :

It is a unit which consists of hardware as well as software. It uses microprocessor to control the access and communication in a network.

LAN cables or communication channel :

A cable is used for connecting the computers in a LAN. The communication from one computer to others takes place over the cables. So cables are called communication channels. The twisted pair, coaxial cables or optical fiber cables are used in LANs.

Advantages of LAN :

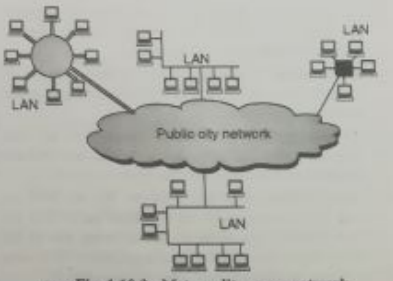
1. High reliability. Failure of individual computers does not affect the entire LAN.
2. It is possible to add a new computer easily.
3. The transmission of data is at a very high rate.
4. Sharing of peripheral devices such as printer is possible.

Applications of LAN :

1. File transfer and file access.
2. Personal computing.
3. Office automation.
4. Distributed computing.
5. Word and text processing.
6. Document distribution.
7. Remote access to database.
8. Electronic message handling.

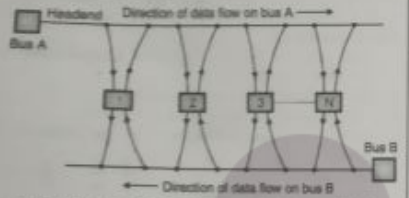
1.10.2 Metropolitan Area Network (MAN) :

- A MAN is basically a bigger version of a LAN and normally uses similar technology. It is designed to extend over a larger area such as an entire city.
- The MAN can be in the form of a single network such as a cable network or it can be a combination of multiple LANs as shown in Fig. 1.10.3.
- A MAN may be wholly owned and operated by a private company or it may be a service provided by a public company, such as a local telephone company (telco).



(G-33) **Fig. 1.10.3 : Metropolitan area network**

- A MAN is distinguished by the IEEE 802.6 standard or it is also known as Distributed Queue Dual Bus (DQDB).
- The DQDB consists of two unidirectional cables (buses) to which all the computers are connected as shown in Fig. 1.10.4.
- Each bus has a device which initiates the transmission activity called as the head-end.
- Traffic that is destined for a computer to the right of the sender uses the upper bus and to the left uses the lower bus as shown in Fig. 1.10.4.



(G-34)**Fig. 1.10.4 : Distributed queue dual bus architecture (DQDB)**

1.10.3 Wide Area Network (WAN) :

- When a network spans a large distance or when the computers to be connected to each other are at widely separated locations a local area network cannot be used.
- For such situations a Wide Area Network (WAN) must be installed. The communication between different users of "WAN" is established using leased telephone lines or satellite links and similar channels.
- It is cheaper and more efficient to use the phone network for the links.
- Most wide area networks are used for transferring large blocks of data between its users. As the data is from existing records or files, the exact time taken for this data transfer is not a critical parameter.
- An example of WAN is an airline reservation system. Terminals are located all over the country through which the reservations can be made.
- It is important to note here that all the terminals use the same centralized common data provided by the central reservation computer.
- Because of the large distances involved in the wide area networks, the propagation delays and variable signal travel times are major problems.
- Therefore most wide area networks are not used for time critical applications. As explained earlier they are more suitable for transfer of data from one user to the other which is not a time critical application. Wide area networks are basically packet switching networks.

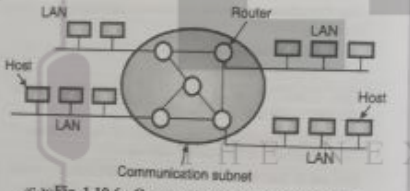
(G-35)**Fig. 1.10.5 : Wide area network**

- A WAN provides long distance transmission of data, voice image and video information over large geographical areas that may comprise a country, a continent or even the whole world as shown in Fig. 1.10.5.

Host : Host is a large computer. It can provide services to many computers. The services provided are :

1. Providing computing capabilities
2. Providing access to database.

- WAN contains a collection of machines used for running user (i.e. application) programs. All the machines called hosts are connected by a communication subnet as shown in Fig. 1.10.6.



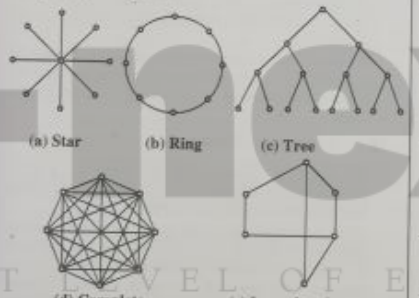
(G-36)**Fig. 1.10.6 : Communication subnet and hosts**

- The function of the subnet is to carry messages from host to host. The subnet consists of two important components; transmission lines and switching elements.
- Transmission lines move bits from one machine to another. The switching elements are specialised computers used to connect two or more transmission lines. When data arrive on an incoming line, the switching element has to choose an outgoing line on which it is to be forwarded.
- The switching elements are either called as packet switching nodes, intermediate systems, data switching exchanges or routers.
- When a packet is sent from one router to another via one or more intermediate routers, the packet is received at intermediate router. It is stored in the routers until the required output line is free and then forwarded. A subnet using this principle is called a point to point, store-forward or packet switched subnet.

- WAN's may use public, leased or private communication devices, and can spread over a wide geographical area. A WAN that is wholly owned and used by a single company is often called as an enterprise network.
- In most WANs the network contains a large number of cables or telephone lines each one connecting a pair of routers.
- If two routers which are not connected to each other via a cable want to communicate, then they have to do it indirectly via other routers.

Router interconnection topologies :

- Fig. 1.10.7 shows some of the possible router interconnection topologies in a point to point subnet.
- The LANs have a symmetric topology while WANs have irregular topologies.
- The WANs can also be formed using satellite or ground radio system. Satellite networks are inherently broadcast type so they are useful when the broadcast property is important.



(G-38)**Fig. 1.10.7 : Router interconnection topologies**

1.10.4 Comparison of LAN, WAN and MAN :

Sr. No.	Parameter	LAN	WAN	MAN
1.	Ownership of network	Private	Private or public	Private or public
2.	Geographical Area covered	Small	Very large (states or countries)	Moderate (city)
3.	Design and maintenance	Easy	Not easy	Not easy
4.	Communication medium	Coaxial cable	PSTN or satellite links	Coaxial cables, PSTN, optical fiber cables, wireless.
5.	Data rates (speed)	High	Low	Moderate
6.	Mode of communication	Each station can transmit and receive	Each station cannot transmit	Each station can transmit or receive.
7.	Principle	Operates on the principle of broadcasting	Switching	Both
8.	Propagation delay	Short	Long	Moderate
9.	Bandwidth	Low	High	Moderate

1.11 Internetworking :

- Earlier we have discussed the basic concepts in computer networking. An another very important concept is **Internetworking** which deals with connecting many computer networks together.
- A network of computer networks is known as **internetwork** or simply an **Internet** (note that i is small). The best example of an internetwork is Internet (note that I is capital).
- The difference between Networking and Internetworking may be states as follows : In networking all the devices (hosts) involved are compatible with each other. But in internetworking this may not be true.
- The networks that are being connected to each other through internetworking may or may not be compatible with each other, in many respects.
- For example the networks which are to be connected to form an internetwork can be an Ethernet, a token ring LAN and a WAN. All these networks are entirely different from each other, in terms of their topologies, signaling, transmission mechanism, wiring etc.
- Therefore in internetworking it is a challenge to handle these incompatibilities and bring all these networks together.
- The Internet is the biggest network of computer networks. The TCP/IP protocol is the backbone of Internet.

1.11.1 Why Internetworking ?

- Different networks such as LANs, MANs and WANs are designed with a specific task or application. So these networks won't have the same technology (hardware and protocols used).
- So the computers connected in the same network only can communicate to each others. It is not possible for a computer to communicate with some other computer outside its own network.

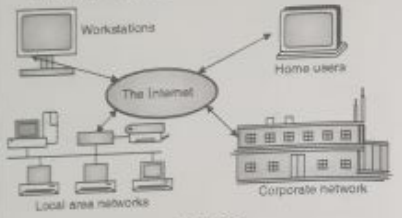
- For example an employee would be unable to communicate with the other computer connected to a printer or it would not possible to access a file on a computer which is on some other network and so on.
- This affected the productivity to a large extent in 1970's. So the concept of **universal service** came into existence.
- The simple meaning of universal service was that there was no dependence on the underlying physical technology or existence of separate physical networks.
- People wanted a single computer network to exist the way a telephone network exists. People should be able to use resources such as a printer or a file on any other computer without any hurdles.
- For this to become a reality it was necessary to connect all the computer networks together. This is why internetworking is essential.

1.11.2 The Problems in Internetworking :

- When internetworking is to be done, it must be remembered that the organizations involved have invested a lot of money on the infrastructure, cabling etc. of their existing network that they would like to reuse it when becoming the member of the internetwork.
- But it is not that simple to form a network merely by interconnecting wires from two networks. The problems are due to the incompatibilities in the electrical as well as the software aspects.
- The packet sizes used by different networks will be different, the methods of acknowledgement or error detection etc. can also be totally different. There could be many more differences between them other than these.
- Hence any two networks can not be connected to each other just by connecting a wire between them to form an internetwork.

1.12 Internet :

- This was the next step of ARPANET and NSFNET.
- Sometime in mid 1980s, people started thinking about the interconnection of many networks and the Internet came into existence.
- It started growing exponentially with all the types of existing networks getting connected to Internet.
- This was possible due to the use of TCP/IP reference model and TCP/IP protocol stack.
- The Internet is a globally existing network of networks consisting of a huge number of computers located in all the parts of the world.
- Already billions of people share it and the number is increasing every day.



(G-43) **Fig. 1.12.1**

- All the computers connected to the internet are part of this huge network. Networking is interconnection of computers. Generally the networking topologies used for networking are star, bus, ring, loop etc.
- When a limited number of computers are to be interconnected, the local area network (LAN) is used. But in the Internet the interconnection is achieved even via satellites.
- The power that a computer gets due to the Internet is amazing. It is now possible to send and receive the data within a few seconds of time from any part of the world.

1.12.1 Evolution of Internet :

- The origin of Internet can be traced to a U.S. Department of Defence (DoD) organization called Advanced Research Projects Agency (ARPA).
- ARPA developed a four node packet switching network called ARPANET in 1969. The network was intended to support the military research on fault tolerant computer networks. DoD wanted to ensure a reliable data transfer in the event of a nuclear war, even if parts of the network has been destroyed.
- As the years pass by, the network grew in size and by January 1983, the ARPANET no longer remained an experimental network but its control was passed over to Defence Communications Agency (DCA).
- The network then became available for the academic research, government employee and contractors.
- It was not until 1986, however that the dramatic growth of the Internet began. At this time, the National Science Foundation (NSF) which formed the National Science Foundation Network (NSFNET) linked five of its regional super-computer centres together to provide a national high speed backbone network across the United States.
- The world's fastest and most powerful computers were made available to a academic and scientific community.

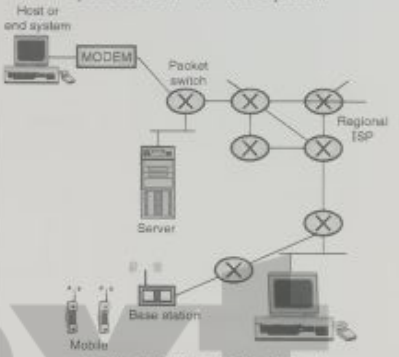
- In 1990 the ARPANET was officially decommissioned. Some of the major networks contributing to the growth of the internet are as follows :
  1. ARPANET
  2. USENET (User's network)
  3. CSNET (Computer science network)
  4. BITNET (Because it's time network)
  5. NSFNET (National science foundation network)
  6. WWW (World wide web)
  7. NREN (National research and education network)
  8. Intranet
- It is said that the Internet is growing at a rate of 20% per month. The data speeds have gone up considerably, which makes the access even more fast.
- The event which started as a military assistance program is now largely a private enterprise.

1.12.2 Net Structure :

- To understand how the Internet works, imagine complex network of roads. It consists of superhighways, highways, to the small roads on the countryside, all connected to each other in one way or the other. The nature of the internet is much similar to this.
- The high speed and powerful super computers connected to the Internet is the backbone of the system.
- The data that is being moved by these supercomputers is a few million bits per second.
- The regional networks are then connected to these supercomputers. The small computer network and individual users are then connected to this regional network.
- The data and information available on the Internet is increasing every day because every user can contribute to it.
- Due to this the entire net will never crash down. Even if a part of it closes down the remaining network keeps working.
- There is no central computer to control the internet. There is no central body which governs the Internet structure, though volunteer groups of individuals have set some standards for Internet technologies. No particular person, group or organization owns the Internet.

1.12.3 Parts of the Internet :

- Now we will discuss the basic hardware and software components of the Internet. Refer Fig. 1.12.2.
- As shown in Fig. 1.12.2 the Internet is made up of hosts, packet switches, servers, regional ISPs (Internet Service Providers), base stations, mobile units and different types of communication links.
- Now a days some nontraditional Internet end systems such as TV, cell phones, etc are also being used. We will call all the traditional and non-traditional devices as **hosts** or **end systems.**
- The end systems are interconnected by **communication links.** Different types of communication links are as follows :
  1. Coaxial cables
  2. Copper wires
  3. Optical fiber cable
  4. Radio spectrum



(G-44) **Fig. 1.12.2 : Parts of the Internet**

Packet switches :

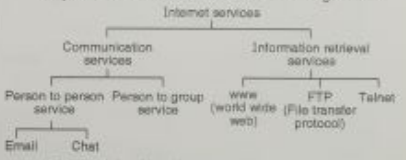
- The end systems are not directly connected to each other via communication links. Instead they are interconnected through the switching devices called as the **packet switches.** The two most popular packet switches are **routers** and **link-layer switches.**

1.12.4 Services on the Internet :

The services that are available on the Internet can be classified into two categories :

1. Communication services
2. Information retrieval services

They can be further classified as shown in Fig. 1.12.3.



(G-45) **Fig. 1.12.3 : Classification of services on Internet**

- The person to person service includes E-Mail. This is the most popular service and the most of the Internet traffic corresponds to the E-mail.
- The person to group service includes on line discussions between a user and many other participants from around the globe. A user can choose his topic of discussion from a list of more than 25, 000 topics.

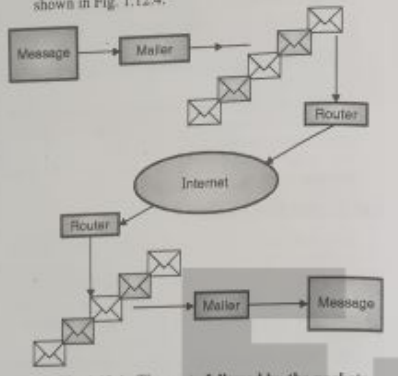
- The fast spreading popularity of the Internet is basically due to the information retrieval services. These services as shown in Fig. 1.12.3 include :
  1. The world wide web (www), which is world's largest and ever-growing data base.
  2. FTP or file transfer protocol, which allows remote accessing to the files which contain programs, technical handouts, reports etc.
  3. Telnet or remote login to commercial services.

1.12.5 A Service Description :

- The Internet allows distributed applications running on its end systems to exchange data with each other, eg web surfing, audio / video streaming, internet telephony, P2P, etc.
- The Internet provides two services to its distributed applications :
  1. A connection oriented reliable service.
  2. Connectionless unreliable service.
- Typically a distributed application uses one of these services (but not both).

1.12.6 Internet Protocols :

- The Internet protocol is like any other communication protocol is a set of rules which will govern every possible communication over the internet. Since the development of the ARPANET, TCP/IP together has emerged as the controlling body.
- It is being used in computers of not only in the U.S. but all over the world for all the types and sizes of computers. It has become the language of the Internet.
- TCP/IP are two protocols : Transmission control protocol and Internet protocol. These two protocols describe the movement of data between the host computers on Internet.
- The protocol however is a suite of many other protocols which provide for reliable communications across the Internet and the web.
- In the TCP/IP protocol suite, there are various layers, with each layer being responsible for different facets of communication.
- The Internet Protocol (IP) and Transmission Control Protocol (TCP) are together known as TCP/IP protocol. TCP/IP offers a simple naming and addressing scheme whereby different resources on Internet can be easily located.
- Information on Internet is carried in "packets". The IP protocol is used to put a message into a "packet". Each packet has the address of the sender and the recipient's address. These addresses are known as the IP addresses.
- Using the TCP protocol, a single large message is divided into a sequence of packets and each is put into an IP packet. The packets are passed from one network to another until they reach their destination.
- At the destination the TCP software reassembles the packets into a complete message. It is not necessary for all the packets in a single message to take the same route each time it is sent.
- The Internet is thus a "packet switched" network. The route followed by the packets of information are as shown in Fig. 1.12.4.



(G-46) **Fig. 1.12.4 : The route followed by the packets**

- The packets as shown in Fig. 1.12.4 are read by the routers and then are sent down to the destination address.

1.12.7 Internet Address :

- With so many computers and users using the Internet, it would be impossible to differentiate them without a proper addressing system.
- This addressing system assigns names and numbers to identify the computers on the Internet.
- The names are called as "domain names" and the numbers are called as "IP addresses". Every computer on the Internet will have both a domain name and an IP address.

An IP address :

- Each computer on the Internet is identified by its unique IP address. An IP address is made of four numbers and each one should be less than 256.
- Thus each set of numbers can have values from 1 to 255. An example of an IP address is
  202.64.254.10
- The numbers between the dots are called as "octets". The leftmost octet i.e. "202" represents the largest network and the rightmost octet "10" describes the specific machine which is being addressed.
- Although the IP addressing scheme can identify the computers on Internet, the numbers are impossible to remember. Therefore a method of recognizing the computers by names was deviced.

Domain name addressing :

- A smaller network making up the internet and having many computers within it is called a "domain".
- The domain may represent a type of organization or a geographical location. For example, all the computers on the Internet which belong to the educational institutions form a part of the "educational" or "edu" domain.
- Commonly used domain types are as follows :

Domain name	Description
com	A company or commercial organization
edu	Educational Institutes.
gov	Government organization
mil	Military sites
net	Network resources or Internet service provider.
org	Non profit or non commercial organizations.

- In order to accommodate different countries all over the world, a two letter abbreviation for every country in the world is added at the end of the domain name.
  e.g. techpub@pn2.vsnl.net.in
- Here the last two letters i.e. "in" represent "India". Commonly used abbreviations as country suffix are as follows :

Abbreviation	Country name
au	Australia
fr	France
ca	Canada
uk	United Kingdom
in	India

Take again the same example :

techpub@pn2.vsnl.net.in

Where reading from right to left,
in - India
net - Network Provider
vsnl - Organization Name, in this case it is VSNL
pn2 - Server or computer name
techpub - Users name

- The actual Internet protocol however will recognize only the IP number. The domain naming convention is introduced only for the user's convenience.
- Therefore there must be some mechanism to convert the domain names to the corresponding IP addresses, and vice versa.
- This is done by an electronic server called "domain name server" (DNS). It is an electronic directory which is maintained on almost all the host computers.

1.12.8 Internet Service Providers (ISPs) :

- Internet Service Providers (ISPs) all over the world offer various options and packages to the general public for internet access.
- With the privatization of the Internet services, various ISPs, are offering their services in India now. The major players currently are :
  1. Videsh Sanchar Nigam Limited (VSNL).
  2. Mahanagar Telephone Nigam Limited (MTNL).
  3. Satyam Infoway Limited (Satyam online).
  4. Bharti BT Internet Pvt. Limited (Mantra online).
  5. Reliance, Tata Indicom and many others.

1.12.9 Who Owns the Internet :

- The Internet is a decentralized network and no one runs or owns it. There is no organization or agency that controls the activity on the Internet.
- However there are a few organizations which co-ordinate and guide the technical parts of Internet. They are :
  1. Internet Engineering Task Force (IETF).
  2. Internet Research Task Force (IRTF).
  3. Internet Architecture Board (IAB).
- The Internet's communication protocols are developed and maintained by the IETF. The protocols are the methods by which computers on the Internet are connected.
- The long term research problem which may be critical to the Internet are looked into by the IRTF.
- Any major changes coming from the IETF are ratified by the IAB.

1.13 Accessing the Internet :

- Now we can access the Internet in a number of different ways. Earlier the only way to access the Internet was to obtain a telephone connection and then open an account with an ISP (Internet Service Provider). This type of Internet access is known as the basic access method and it is as shown in Fig. 1.13.1. So in this system the ISP will allow the user to access the Internet.

(G-1435) **Fig. 1.13.1 : Basic Internet access method**

- In modern era, the basic framework of Internet access has not changed considerably. But the ways of getting connected to the ISP from user's premises have changed to a great extent.
- The different possible ways are as follows :
  1. Dial up access 2. Cable modems

3. ADCL 4. Leased lines
5. ISDN

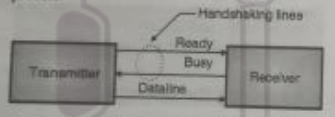
- One important thing to be noted is that all such methods still use the services of an ISP. They only provide different ways for the user to get connected to the ISP and Internet.

1.14 Protocols and Standards :

- Protocol and standards are the two frequently used words in data communication.
- Let us define them first and then explain them.

1.14.1 Protocols :

- In order to communicate successfully using serial digital data, some rules and procedures should be agreed upon at the sending and receiving ends of the system.
- Such rules and procedures are called as protocols. Different types of protocols are used in data communications.
- In data communications a message is more than one character. A group of characters forms a block.
- When a message is sent it is broken up into blocks. To identify a block one or more special characters are transmitted before and after the block.
- Some of the characters at the beginning and end of each block are used for "handshaking" purpose.
- Fig. 1.14.1 demonstrates the basic handshaking process.



(U-qu) **Fig. 1.14.1 : The handshaking process**

- The transmitter may send a "Ready" signal to the receiver indicating that it wants to send a character.
- The receiver identifies this signal and communicates its status on the "busy" line to the transmitter.
- If the receiver is busy then it is indicated by the receiver by sending a character on the busy line.
- The transmitter will send the data only when the receiver is not busy and the transmitter becomes ready.

1.14.2 Important Elements of a Protocol :

Some of the important elements of a protocol are :

1. Syntax 2. Semantics 3. Timing

1. Syntax :

Syntax means the structure or format of data. That means the order in which the data is presented.

2. Semantics :

- Semantics means the meaning of each section of bits, or how to interprete a particular pattern.
- It also tells us about what action is to be taken based on the interpretation.

3. Timing :

This aspect refers to two characters, namely the instant of sending the data and the speed at which it is to be sent.

1.14.3 Standards :

Data communication standards are classified into two categories :

1. De facto standards 2. De jure standards

De facto :

- The meaning of this word is "by fact" or "by convention".
- These are the standards that have not been approved by an organized body, but have been adopted as standards through widespread use.
- These standards are often established originally by the manufacturers.

De jure :

- The meaning of this word is "by law" or "by regulation".
- These are the standards that have been approved by an officially recognized body.

1.15 Standard Organizations for Data Communication :

Standards are developed by the standards creation committees, forums and government regulatory agencies.

Standard creation committees :

Some of the standard creation committees are :

1. International organization for standardization (ISO).
2. International Telecommunication Union - Telecommunication standards.
3. American National Standards Institute (ANSI).
4. Institute of Electrical and Electronics Engineers (IEEE).
5. Electronic Industries Association (EIA).

Regulatory agencies :

Federal communications commission (FCC) is the government regulator body in U.S. for all communication technology.

Standard organizations for data communications :

Some of the standard organizations for data communication are as follows :

1. **International Standard Organization (ISO) :**
   - ISO is the international organization for standardization. It creates sets of rules and standards for graphics, document exchange etc.
   - ISO endorses and coordinates the work of the other standard organizations.
2. **Consultative Committee for International Telephony And Telegraphy (CCITT) :**
   - The CCITT is now a standard organization for the United Nations.
   - Many government authorities and representatives are members of CCITT.
   - CCITT develops the recommended sets of rules and standards for telephone and telegraph communications.
   - CCITT has developed three sets of specifications as follows :
     1. V series for MODEM interfacing
     2. X series for data communication
     3. Q series for Integrated Services Digital Network (ISDN).
3. **American National Standards Institute (ANSI) :**
   ANSI is the official standard agency for United States.
4. **Institute of Electrical and Electronics Engineers (IEEE) :**
   IEEE is a U.S. based professional organization of electronics, computer and communications engineers.
5. **Electronic Industries Association (EIA) :**
   - EIA is a U.S. organization. It establishes and recommends industrial standards.
   - EIA has developed the RS (Recommended Standard) series of standards for data and telecommunications.
6. **Standards Council of Canada (SCC) :**
   SCC is the official standards agency for Canada. It has similar responsibilities to those of ANSI.

1.16 Internet Standards :

- An **Internet Standard** is defined as the specification which is used by and adhered by all the uses of the Internet.
- A specification is tested thoroughly before it is allowed to become the Internet standard.
- The procedure for a specification to become the Internet standard is as follows :
  1. A specification begins as an Internet draft.
  2. It remains an Internet draft i.e. a working document for 6 months.
  3. This draft can be then published as **Request For Comment (RFC).**
  4. Each such RFC is edited, given a number and made available to all the interested parties.
  5. RFCs are categorized as per their maturity levels.

Review Questions

- Q. 1 Explain simplex, half duplex and full duplex communication with examples.
- Q. 2 What is the difference between broadcast and point to point networks ?
- Q. 3 What is meant by internet work ?
- Q. 4 Write a short note on MAN.
- Q. 5 Write a short note on WAN.
- Q. 6 Compare LAN, WAN and MAN.
- Q. 7 Name the different network topology types.
- Q. 8 Explain the basic concepts of bus topology with the help of suitable diagram.
- Q. 9 State the important characteristics of bus topology.
- Q. 10 Name the transmission media used for bus LANs.
- Q. 11 State advantages and disadvantages of bus topology.
- Q. 12 Write a note on : Ring topology.
- Q. 13 What are the problems faced by the ring topology ?
- Q. 14 State the advantages and disadvantages of ring topology.
- Q. 15 Write a short note on star topology.
- Q. 16 What is the difference between single level star topology and two level star topology ?
- Q. 17 State the advantages and disadvantages of star topology.
- Q. 18 Write a short note on Mesh topology.
- Q. 19 State advantages and disadvantages of mesh topology.
- Q. 20 Write a short note on tree topology.
- Q. 21 Compare Ring and Bus.
- Q. 22 Compare Star and Ring.
- Q. 23 What are the important blocks of a data communication system ?
- Q. 24 What are the different methods of representing the data ?
- Q. 25 Explain the net structure of the Internet.
- Q. 26 State various services provided by the Internet.
- Q. 27 Name the Internet protocols.
- Q. 28 Write a note on : Internet address.
- Q. 29 State and explain various applications of Internet.

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