**5**

DATA COMMUNICATION AND NETWORKING

Notes

You have learnt about operating system and their functions, in the previous lesson. Now-a-days most people are using computers in their offices, homes, markets etc. Modern technology facilitates people to connect, share, and communicate with people sitting on one computer to another computer at different place. Data communications refers to the transmission of this digital data between two or more computers and a computer network or data network is a telecommunications network that allows computers to exchange data. The physical connection between networked computing devices is created using either a cable or wireless device. Internet, for example, is a prime example of networked computers communicating with each other using data transfer mechanisms. This lesson will introduce you the various aspects of computer network and data communications.

OBJECTIVES

After reading this lesson, you will be able to:

- describe basic elements of data communication system, transmission modes, digital and analog transmission;

- summarize communication terminologies (E-M spectrum, band, bandwidth and transfer rate);

- explain transmission media;

- list network devices (modem, RJ45 connector, ethernet card etc.);

- define malwares: virus, spam, hacking etc.;

- secure your system.
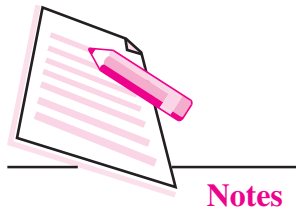
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5.1 DATA COMMUNICATION

In our day to day life we communicate with people around us by using telephone, mobile and letters. In the same way, computer can communicate or send information to another computer system placed anywhere in the world. All this is possible using some standard methods. These methods basically use electrical signals carried along a conductor, optical fibres or over wireless devices using satellites. The most fundamental unit of exchange is in the form of bits (0s and 1s) between two devices. Such information is encoded and then decoded at the beginning and end of data communication channels so that it is easily understood by humans.

For example, a computer teacher wants to convey some messages to his/her students. He will send the message from his computer (central computer) and all the students will receive the message on other computers connected to the central computer through networking. All this can happen in few seconds. So we can say that people can send or get information or communicate with people through e-mail. This is possible because of computer networking. So sending an email is an example of data communication via computer network called Internet. Note that data communication has a subtle difference from telecommunication as we know it. Data communication in the specific context of this lesson refers to data exchange between computers.

5.1.1 Basic Elements of Communication System

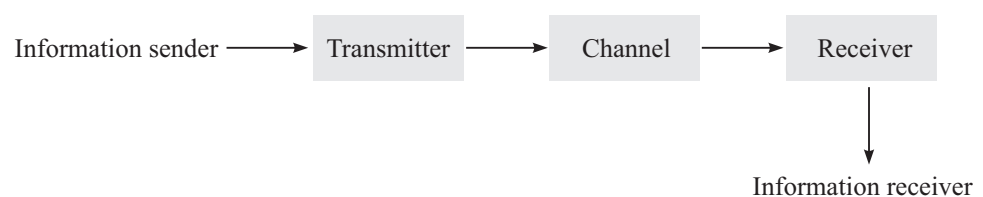The symbolic diagram of communication system is shown in Fig. 5.1

Fig. 5.1: Symbolic Diagram of Communication System

Basic elements of communication system are as follows-

Transmitter – converts the information in a suitable form before transmission.

The Channel – The physical medium or the communication channel used to send the information from the transmitter to the receiver.

The Receiver – It receives the information transmitted by the transmitter.

5.1.2 Transmission Modes

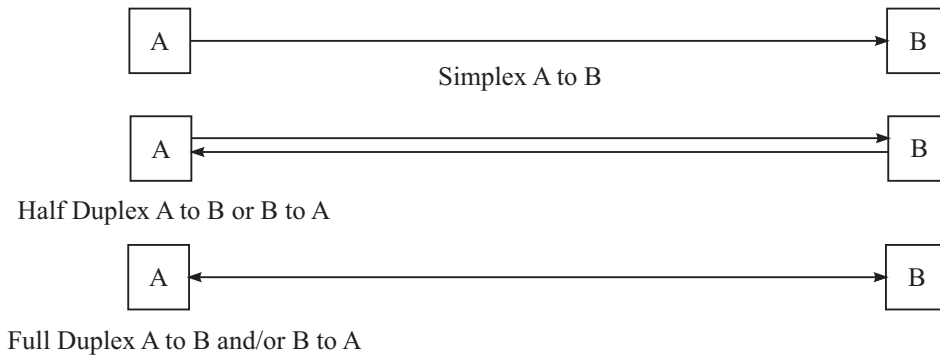There are three ways of transmitting data as shown in Fig. 5.2.

A ——————————→ B
Simplex A to B

A ←—————————— B

Half Duplex A to B or B to A

A ←—————————→ B

Full Duplex A to B and/or B to A

Fig. 5.2: Ways of Transmitting Data

Three types of transmission modes are-

Simplex: In this type of transmission, data can be sent only in one direction i.e., it's a uni-directional mode. The receiver only receives the data, but can not communicate back to the sender.

Half Duplex: In half duplex system, we can send data in both directions but sender can either receive the data or send the data at a particular time. So when the sender is sending the data, it cannot receive the data and vice versa.

Full Duplex: In this mode, we can send data in both directions as it is bidirectional mode. We can send and receive data at the same time.

5.1.3 Analog and Digital Transmission

Analog and digital transmission signal diagrams are shown in Fig. 5.3 below.
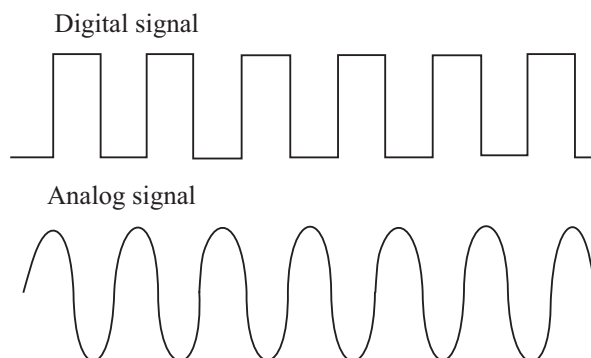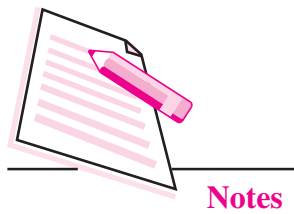
Digital signal

Analog signal

Fig. 5.3: Analog and Digital Signal Transmission

Data is transmitted from one point to another point through electrical signals that may be in digital or analog form.

Analog Transmission: In this transmission, information changes continuously and can take on many different values. It uses a continuous signal to transmit voice, data, image or other information between two systems. For example, telephones take sound vibrations and turn them into electrical vibrations of the same shape before they are transmitted over traditional telephone lines.

Digital Transmission: In this transmission, information is characterized by discrete states. A light bulb, for example, is on or off. A digital clock represents the time in one-minute intervals and does not change its numbers again until the next minute. So the transmission signal is not continuous but discrete. So the digital transmission is quite different from the analog one. The signal in digital transmission is much simpler. It's a series of 0s and 1s. So 1 (or On) is represented by peak of the signal and 0 (or Off) is represented by bottom of the signal.

5.2 COMMUNICATION TERMINOLOGY

The section below briefly summarizes the terminology used in communications using computers. It talks about bandwidth and electromagnetic spectrum.

1. **E-M Spectrum:** The electromagnetic spectrum is the range of all possible frequencies of electromagnetic radiation. The E-M spectrum of an object has a different meaning, and is instead the characteristic distribution of E-M radiation emitted or absorbed by the particular object. The E-M spectrum extends from the low frequencies used for modem radio communication to gamma radiation at the short wavelength (high frequency)end, covering wavelengths from thousands of kilometers down to a fraction of the size of an atom.

    Although the electromagnetic spectrum represents an enormous range of frequencies, not all the frequencies are suitable to purposes of human communications. Fig. 5.4 below shows the E-M Spectrum of various communication and network devices.
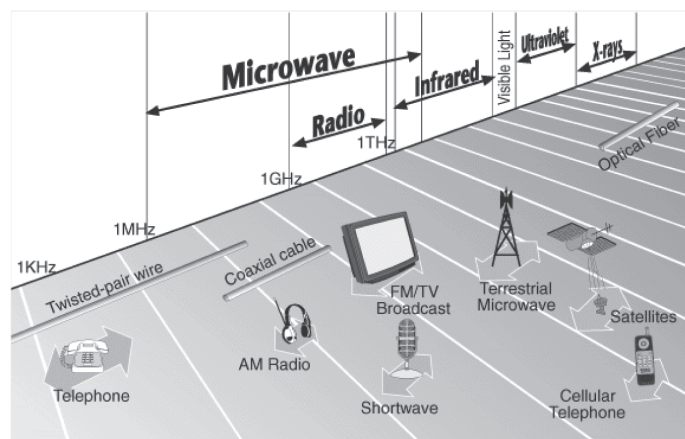

Fig. 5.4: E-M Spectrum of Communication Devices

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2. **Bandwidth:** It is the range of frequencies that make up a signal. There are three major classes of bandwidth that we refer to in telecommunications networks: narrowband, wideband, and broadband.

    A. Narrowband

    It can accommodate up to 64Kbps, which is also known as the DS-0 (Digital Signal level 0) channel. This is the fundamental increment on which digital networks were built. Initially, this metric of 64Kbps was derived based on our understanding of what it would take to carry voice in a digital manner through the network. If we combine these 64Kbps channels together, we can achieve wideband transmission rates.

    B. Wideband

    Wideband is a transmission medium or channel that has a wider bandwidth than the voice channel i. e., more than 64Kbps. This term is usually contrasted with narrowband.

    C. Broadband

    The most modern bandwidth used has broadband capacities. Broadband can be defined in different ways, depending on what part of the industry you are talking about. Technically speaking, it has been defined as being anything over 2Mbps. The term broadband refers to any type of transmission technique that carries several data channels over a common wire. For example, in home networking, broadband constitutes any form of high-speed Internet access using this transmission technique.

3. **Transfer Rate :** It is the amount of digital data that is moved from one place to another in a given time. Usually in second's time. The data transfer rate can be viewed as the speed of travel of a given amount of data from one place to another.

5.3 TRANSMISSION MEDIA

The transmission media that are used to convey information can be classified as guided or unguided. **Guided media** provides a physical path between transmitter and receiver.

Guided media include –

1. **Twisted Pair:** A twisted pair of wires consists of two insulated copper wires, typically about 1 mm thickness. The wires are twisted together in a helical shape. These are commonly used in local telephone communication.

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2. **Coaxial Cable:** Coaxial cable consists of a stiff copper wire as the core, surrounded by an insulating material. Higher data rates over longer distance can be achieved with coaxial cable.

3. **Optical Fiber:** This media is superior in data handling and for security purposes. Each fiber has an inner core of glass or plastic that conducts light. It's a flexible transparent fiber made using silica glass and has been drawn very thin. Optical fiber can be used as a medium for telecommunication and computer networking because it is flexible and can be bundled as cables. It is especially advantageous for long-distance communications, because light propagates through the fiber with little attenuation compared to electrical cables.

Unguided media employs an antenna for transmitting through air, vacuum, or water. Unguided media includes –

1. **Microwave Transmission:** In microwave transmission the waves travel in straight lines. It gives a much higher signal noise ratio, but the transmitting and receiving antennas must be accurately aligned with each other.

2. **Radio Waves:** Radio waves can be broadcasted in all directions from the source i.e., Omni-directional so that the transmitter and receiver do not have to be carefully aligned physically.

3. **Infrared Waves:** Infrared waves are widely used for short-range communication. The remote controls used on television, VCRs and stereos use infrared communication.

4. **Communication Satellite:** In satellite communication, signal transferring between the sender and receiver is done with the help of satellite. In this process, the signal which is basically a beam of modulated microwaves is sent towards the satellite. Then the satellite amplifies the signal and sends it back to the receiver's antenna present on the earth's surface. So, all the signal transferring is happening in space. Thus this type of communication is known as space communication.

5. **Bluetooth:** Bluetooth is a WPAN technology. Accordingly its radio characteristics include low power, short range, and medium transmission speed. It effectively exchanges data over short range. Today the Bluetooth market focuses on professional and field workers, who need to travel off-site but still require access to corporate communication and information.

6. **Wi-Fi:** Wi-Fi is a Local Area Network (LAN) - you will know more about LAN, later in this lesson. Wi-Fi depends on a high energy intake to offer a 100 meter range and much higher transmission rate. This speed makes Wi-Fi much more faster Bluetooth and similar to a high speed modem. For large file transfer and quick Internet access, Wi-Fi outperforms Bluetooth.

5.4 COMPUTER NETWORK

A computer network is a group of computers which are interconnected to exchange and share information. People can transfer or receive information at minimum cost and time, using computer networks. The Internet is a computer network that millions of people use every day. Other shared resources can include a printer or a file server. The Internet itself can be considered as a computer network.

Data or information available at a central computer can be easily shared, updated and accessed by all the other users connected to the central computer. Computer networks from ISPs to Wi-Fi and cellular networks are a key part of the information economy. These networks are the foundation for the Web. The connection between computers can be done via cabling, most commonly the Ethernet cable, or wirelessly through radio waves. Connected computers can share resources, like access to the Internet, printers, file servers, and others. A network is a multipurpose connection, which allows a single computer to do more.

5.4.1 Network devices

Computer network devices are also known as communication devices and they constitute a data communication network. These devices are routers, switches, hubs, LAN cards, gateway, modems, hardware firewall, Channel Service Unit (CSU)/Data Service Unit (DSU), ISDN terminals and transceivers. In an Ethernet or WAN network, the data communication cannot be performed without these devices. Being an IT professional or a network administrator, you must have good understanding of these devices. Some of these devices and their functionalities are described below:

1. **Modem**: A modem is a communication device that is used to provide the connectivity with the internet. Modem works in two ways i.e. modulation and demodulation. It converts the digital data into the analog and analog to digital. Figure below shows the position of modem when two computers are interacting with each other.
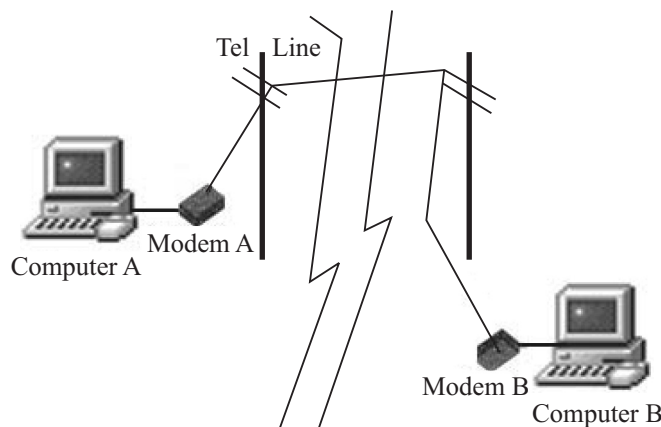

Fig. 5.5: Usage of Modem

2. **RJ45 Connector**: RJ45 is a type of connector commonly used for Ethernet networking. It looks similar to a telephone jack, but is slightly wider. Since Ethernet cable have a RJ45 connector on each end, Ethernet cables are sometimes also called RJ45 cables. The 'RJ' in RJ45 stands for 'registered jack' since it is a standardized network interface. The '45' simply refers to the number of the interface standard.

3. **Ethernet card:** An Ethernet card is one kind of network adapter. These adapters support the Ethernet standard for high-speed network connections via cables. Ethernet cards are sometimes known as network interface cards (NICs). Ethernet is the most commonly used local network technology deployed with transmission speeds heading upwards into the gigabits range. It is the most widely installed local area network (LAN) technology. Ethernet is a link layer protocol in the TCP/IP stack, describing how networked devices can format data for transmission to other network devices on the same network segment, and how to put that data out on the network connection.

4. **Routers:** Routers are networking devices used to extend or segment networks by forwarding packets from one logical network to another. A router is a device that forwards data packets along networks. A router is connected to at least two networks, commonly two LANs or WANs or a LAN and its ISP's network. Routers are located at gateways, the places where two or more networks connect. Routers are most often used in large Internet works that use the TCP/IP protocol suite and for connecting TCP/IP hosts and local area networks (LANs) to the Internet using dedicated leased lines.

5. **Hub:** A hub is the most basic networking device that connects multiple computers or other network devices together. Unlike a network switch or router, a network hub has no routing tables or intelligence on where to send information and broadcasts all network data across each connection. Most hubs can detect basic network errors such as collisions, but having all information broadcast to multiple ports can be a security risk and cause bottlenecks. Hubs connect computer together in a star topology network. Due to their design, they increase the chances for collision. Hubs operate in the physical layer of the ISO

Hubs can be of two types: Active hubs: These devices not only function as regenerator, but also provide multiple ports for several computers to connect in a network. Passive hubs: These devices only provide multiple ports for several computers to connect to a network.

model and have no intelligence. In the past network hubs were popular because they were cheaper than a switch and router. Today, switches do not cost much more than a hub, and are much better solution for any network.

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6. **Switches:** Switches are a special type of hub that offer an additional layer of intelligence to basic physical layer repeater hubs. A **switch** does essentially what a hub does, but more efficiently. By paying attention to the traffic that comes across it, it can "learn" where particular addresses are. A switch must be able to read the MAC address of each frame it receives. This information allows switches to repeat incoming data frames only to the addressed computer. Switches learn the location of the devices that they are connected to almost instantaneously. The net result is that most network traffic only goes where it needs to rather than to every port. On busy networks, this can make the network much faster.

7. **Gateways:** A network gateway is an internetworking system capable of joining together two networks that use different base protocols. A network gateway can be implemented completely in software, completely in hardware, or as a combination of both. So gateway is a device used to connect networks using different protocols. Gateways operate at the network layer of the OSI model.

   In order to communicate with a host of other networks, an IP host must be configured with a route to the destination network.

   Gateways are also called as protocol converters and translators.

8. **Bridges**:A bridge is a device that separates two or more network segments within one logical network (e.g. a single IP-subnet).A bridge is usually placed between two separate groups of computers that talk with each other, but not that much with the computers in the other group. The job of the bridge is to examine the destination of the data packets one at a time and decide whether or not to pass the packets to the other side of the Ethernet segment. The result is a faster, quieter network with fewer collisions. A bridge is used to join two network segments together; it allows computers on either segment to access resources on the other. They can also be used to divide large networks into smaller segments.
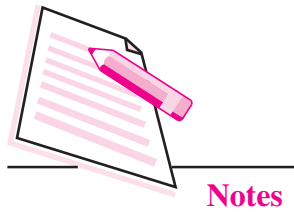
5.4.2 Types of Networks

A computer network, often simply referred to as a network, is a collection of computers and devices interconnected by communications channels that facilitate communications and allows sharing of resources and information among interconnected devices. Networks may be classified according to a wide variety of characteristics such as medium used to transport the data, communications protocol used, scale, topology, organizational scope, etc. Computer networks are now rapidly used by the all levels of society, like government bodies, schools,

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colleges and private sector etc. There are many types of computer networks, some of the important ones are described below:

1. **Local Area Network (LAN)** : Local Area Network is confined to small geographical area, like in a building or group of buildings. Data transfer rate of LAN is very high even faster than data transmitted through telephone lines. It's a group of computers all belonging to the same organization, and are linked within a small geographic area using a network. At security purpose level, it is not trust worthy because, for example, an employee of an organization can change the important data of the organization. Due to its small size, it is possible for one person to administrate a Local Area Network. The defining characteristics of LANs, in contrast to Wide Area Networks (WANs), include their usually higher data-transfer rates, smaller geographic area, and lack of need for leased telecommunication lines.

   LANs are typically used for single site where people need to share resources among themselves but not with the rest of the outside world. Think of an office building where everybody should be able to access files on a central server or be able to print a document to one or more central printers. Those tasks should be easy for everybody working in the same office, but you would not want somebody just walking outside to be able to send a document to the printer from their cell phone. If a local area network, or LAN, is entirely wireless, it is referred to as a Wireless Local Area Network, or WLAN.
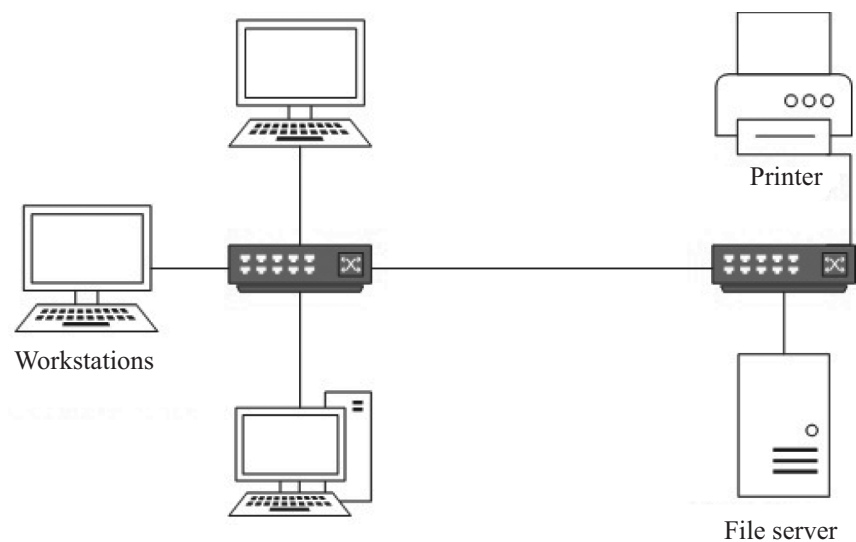

Fig. 5.6: Local Area Network (LAN)

2. **Metropolitan Area Network (MAN)** : Metropolitan Area Network or MAN is basically spread throughout a city, college campus or a small region. MANs are larger than LANs, and it enables its users to share information throughout

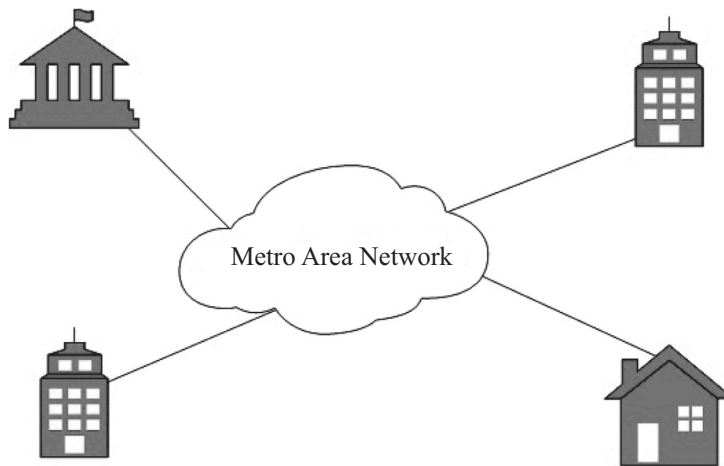the city. It is commonly used by schools, campuses, hospitals, large universities, large companies etc.

Fig. 5.7: Metropolitan Area Network (MAN)

3. **Wide Area Network (WAN)** : Wide Area Network covers comparatively large geographic area than LAN and MAN, for example an entire country. It uses public network telephone lines and lease lines. This type of network can even be spread over the world.WAN provides network to the LAN and MAN. This is very speedy and expensive. Wide Area Networks use optic fiber as their communication medium. Internet is best known example of public WAN.
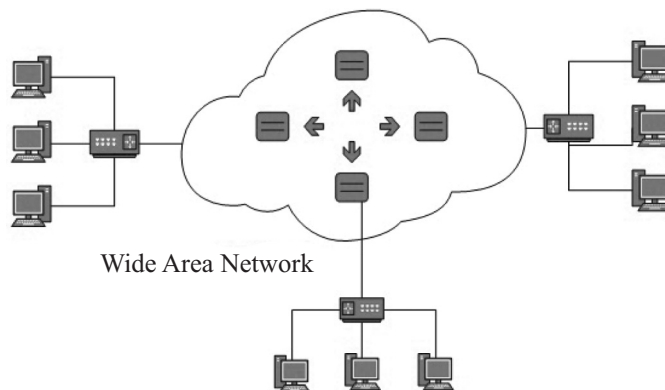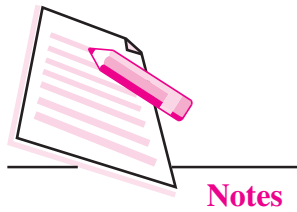

Fig. 5.8: Wide Area Network (WAN)

5.5 NETWORK TOPOLOGY

Network topology is the schematic description of a network arrangement, connecting various nodes (sender and receiver) through lines of connection. Topology is the schematic diagram showing how the networks are connected physically and logically. Physical topology is the physical layout of nodes,

workstations and cables in the network; while logical topology is the way information flows between different components. So network topology is the arrangement of the various elements of a computer network. Details of network topologies are given below and are represented in Fig. 5.9:
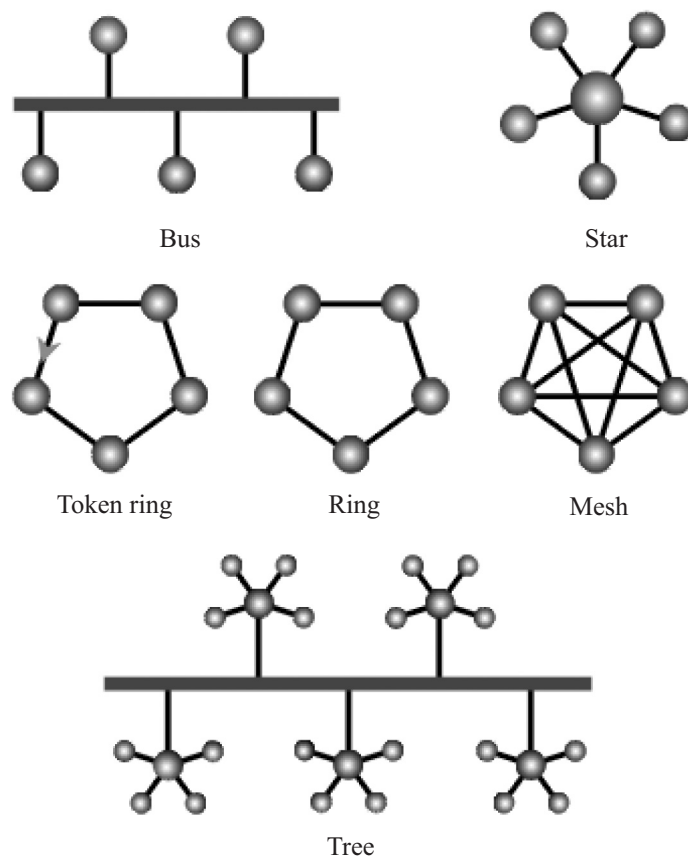

Bus   Star

Token ring   Ring   Mesh

Tree

Fig. 5.9: Network Topology

1. **Bus Topology:** In this type of topology all computers are connected by a single length of cable with a terminator at each end. The bus topology is the simplest and most widely used local area network design. Only one computer at a time can send a message. It transmits data only in one direction and every device is connected to a single cable. So it affects the speed of the network. It is cost effective and requires least amount of cable compared to other topologies. It is normally used in smaller networks and is very easy to understand. But it is slower and if the main cable fails, the entire network fails.

2. **Star Topology:** The star network is frequently used to connect one or more small computers or peripheral devices to a large host computer or CPU. Each computer on a star network communicates with a central hub that re-sends the message either to all the computers or only to the destination computer.

Every node has a dedicated connection to the central hub. It is fast with few nodes and low network traffic. It is easy to troubleshoot and easy to setup. But cost of installation is high and is expensive to use as well. If the host computer fails, the entire network gets affected.

3. **Token Ring:** A token ring network is a Local Area Network (LAN) in which all computers are connected in a ring or star topology and a bit- or token passing scheme is used in order to prevent the collision of data between two computers that want to send messages at the same time. The token ring protocol was developed by IBM. The access method used involves token passing. In token ring, the computers are connected so that the signal travels around the network from one computer to another in a logical ring.

4. **Ring Topology:** In this type of topology the workstations are connected in a circle using cable segments. In this layer each node is physically connected to only two other nodes i.e., adjacent pairs of workstations are directly connected. Ring topology can function without server. The ring topology may prove optimum when system requirements are modest and workstations are at scattered points.

5. **Mesh Topology:** It is a type of network setup where each of the computers and network devices are interconnected with one another. A mesh topology is most often used in large backbone networks in which failure of a single switch or router can result in a large portion of a network going down. A mesh network topology is a decentralized design in which each node on the network connects to at least two other nodes. Mesh networks can use a full mesh topology or a partial mesh topology. In a full mesh topology, each network node is connected to all the other nodes in the network. In a partial mesh topology, at least one node connects directly to every other node while others may only connect to those nodes they exchange data with on a frequent basis.

6. **Tree Topology:** The tree topology, also known as **Hierarchical topology** uses two or more star networks connected together. It could also employ a combination of bus and star topologies. This topology divides the network into multiple levels of network. It has a root node, intermediate node, and ultimate nodes. The tree network topology is ideal when the workstations are located in groups, with each group occupying a relatively small physical region. An example is a university campus in which each building has its own star network, and all the central computers are linked in a campus-wide system. It is easy to add or remove workstations from each star network. Entire star networks can be added to, or removed from, the bus.

Computer Science

Notes

INTEXT QUESTIONS 5.1

I. Choose the appropriate answer.

1. What are the basic elements of communication system?

   a. Conductor   b. Transmitter

   c. Channel & Receiver   d. b & c

2. The slowest transmission speed are those of ....

   a. Twisted pair wire   b. coaxial cable

   c. Fiber optic cable   d. Microwaves

3. A network that can function without server is a ....

   a. Ring network   b. Star network

   c. Bus network   d. All of the above

II. State whether the following statements are true or false:

1. WAN comparatively covers small geographic area.

2. Tree topology is also known as hierarchical topology.

5.6 NETWORK PROTOCOLS

A network protocol defines rules and conventions for communication between network devices. Network protocols include mechanisms for devices to identify and make connection with each other.

There are several protocols which are given below –

1. **FTP :** The File Transfer Protocol (FTP) is the most widely used protocol for file transfer over the network. FTP uses TCP/IP for communication.

2. **PPP :** PPP means Point to Point Protocol. It is a much more developed protocol than SLIP, in so far as it transfers additional data, better suited to data transmission over the internet.

3. **TCP/IP :** TCP(Transmission Control Protocol) and IP (Internet Protocol) are two different procedures that are often linked together. The linking of several protocols is common since the functions of different protocols can be complementary so that together they carry out some complete task.

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4. **HTTP :** Hypertext is well organized documentation system which uses hyperlinks to link the pages in the text documents. HTTP (i.e. Hypertext Transfer Protocol) works on client server model.

5. **HTTPS :** Hypertext Transfer Protocol Secure is a communication protocol for secure communication over a computer network.

6. **SLIP :** Serial Line Internet Protocol is the result of the integration of modern protocols prior to the suit of TCP/IP protocols. It is a simple Internet link protocol conducting neither address or error control, this is the reason that it is quickly becoming obsolete in comparison to PPP.

You will learn more detail about protocols in the next lesson.

5.7 MALWARES

Malware is short for malicious software and used as a single term to refer to virus, spyware, worms etc. Some examples of malware risks are:

1. **Virus :** Virus is a program written to enter in your computer and damage/alter your files/data. A virus might corrupt or delete data on your computer. Virus can also replicate themselves.

2. **Spam :** Spamming is a method of flooding the Internet with copies of the same message. Most spams are commercial advertisements which are sent as unwanted emails to users. Spams are also known as electronic junk mails.

3. **Hacking:** Computer hacking is the practice of modifying computer hardware and software to accomplish goal outside of the creator's original purpose. In computer security, a hacker is someone who seeks and exploits weaknesses in a computer system or computer network. Hackers may be motivated by a multitude of reason such as profit, challenge, enjoyment or to evaluate those weaknesses to assist in removing them.

5.8 SECURITY CONCEPT

Network devices – such as routers, firewalls, gateways, switches hubs and so on, create the infrastructure of local area networks and the Internet. Securing such devices is fundamental to protecting the environment and outgoing/incoming communications. Some security methods are –

1. **Firewall :** A firewall is a hardware device or software application installed on the borderline of secured network to examine and control incoming and outgoing network communications. Firewall provides protection from outside attacks.

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2. **Antivirus :** The word 'antivirus' refers to a group of features that are designed to prevent unwanted and potentially malicious files from entering your network. These features all work in different ways, which include checking for a file, size, name, or type or for the presence of a virus or grayware signature.

Cyber Ethics and IT : Cyber Ethics is the philosophic study of ethics pertaining to computers, encompassing user behaviour and what computers are programmed to do, and how this affects individuals and society.

INTEXT QUESTIONS 5.2

Fill in the blanks.

1. .... protocol is most widely used protocol for file transfer over the netwrok.

2. .... is a communicaiton protocol for secure communication over a computer network.

3. .... is a program written to enter in your computer and damage/alter your file/data.

WHAT YOU HAVE LEARNT

- The basic elements of data communication system i.e., sender, receiver, channel.

- Three types of transmission modes are simplex, half duplex and full duplex.

- Bandwidth is the range of frequencies that make up a signal.

- Computer network is a group of computers which are interconnected to exchange and share information.

- Hub is a common connection point in a network.

- Modem converts digital data into analog and analog to digital.

- Bridge is a device that separates two or more network segments within one logical network.

- Network protocol defines rules and conventions for communication between network devices.

- FTP, PPP, TCP/IP, HTTP, HTTPS, SLIP are some of the network protocols.

- Firewall provides protection from outside attacks.

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TERMINAL EXERCISE

1. Where can Bluetooth device be useful?

2. What is RJ45 connector?

3. What is Ethernet and how does it work?

4. What do you mean by network topology? Write the names of different types of network topologies.

5. What are the different types of networks? Write in detail.

6. Write a short note on TCP/IP, PPP, FTP protocols.

7. Write a short note on virus, spam, hacking.

8. What is antivirus software?

ANSWERS TO INTEXT QUESTIONS

5.1

I. 1. d   2. a   3. a

II. 1. False   2. True

5.2

1. File transfer

2. Hypertext Transfer Protocol Secure

3. Virus