11

Computer Networks

Key Concepts

- **Computer network**
  - Need for network
  - Some key terms
- **Data communication system**
- **Communication medium**
  - Guided medium
  - Unguided medium
  - Wireless communication technologies using radio waves
- **Data communication devices**
  - NIC, Hub, Switch, Repeater, Bridge, Router, Gateway
- **Data terminal equipments**
  - Modem, Multiplexer/ Demultiplexer
- **Network topologies**
  - Bus, Star, Ring, Mesh
- **Types of network**
  - PAN, LAN, MAN, WAN
- **Logical classification of networks**
  - Peer-to-peer
  - Client-Server
- **Identification of computers and users over a network**
  - MAC address
  - IP address
- **Network protocols**
  - TCP/IP (HTTP, FTP, DNS)
- **Uniform Resource Locator**

Have you surfed the Internet to search your examination result or to know whether you got admission to the Plus One course in a school of your choice? Have you visited an ATM counter to draw money? Have you transferred songs, images or movie clips from your computer to a cell phone or booked a train ticket using Internet? If your answer to any of these questions is 'yes', you have accessed the services of a computer network. In this chapter, we will learn more about the working of networks and their advantages. We will also discuss different media and devices, different types of networks and the rules to be followed in data communication using these devices.

11.1 Computer network

Computer network is a group of computers and other computing hardware devices (such as printers, scanners, modems, CD drives, etc.) connected to each other electronically through a communication medium. They can communicate with each other, exchange commands, share data, hardware and other resources. Computers on a network may be linked through cables, telephone lines, radio waves, satellites or infrared light beams.

11.1.1 Need for Network

Internet is a good example for a computer network. It is impossible to imagine a world

without e-mails, online newspapers, blogs, chat and other services offered through the Internet. Apart from these, there are many other advantages in using networked computers instead of stand-alone computers. Some of them are listed below.

- Resource sharing
- Price-performance ratio
- Communication
- Reliability
- Scalability

Resource sharing: The sharing of available hardware and software resources in a computer network is called **resource sharing**. For example, the content of a DVD placed in a DVD drive of one computer can be read in another computer. Similarly, other hardware resources like hard disk, printer, scanner, etc. and software resources like application software, anti-virus tools, etc. can also be shared through computer networks.

Price-performance ratio: One can easily share the resources available in one computer with other computers. The cost of purchasing licensed software for each computer can be reduced by purchasing network versions of such software. This will least affect the performance of such resources and lead to considerable savings in cost.

Communication: Computer network helps user to communicate with any other user of the network through its services like e-mail, chatting, video conferencing etc. For example, one can send or receive messages within no time irrespective of the distance.

Reliability: It is possible to replicate or backup data/information in multiple computers using the network. For example, the C++ files, photos or songs saved in one computer can also be saved in other computers in the same network. These can be retrieved from other computers in which they are saved in case of disasters (malfunctioning of computers, accidental deletion of files, etc.)

Scalability: Computing capacity can be increased or decreased easily by adding or removing computers to the network. In addition to this, the storage capacity of networks can also be increased by including more storage devices to the network.

11.1.2 Some key terms

Some of the key terms related to computer network are explained below:

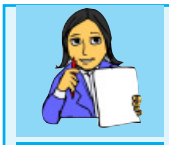
Bandwidth : Bandwidth measures the amount of data that can be sent over a specific connection in a given amount of time. Imagine you are in a

highway or a public road. The bigger the road, the more will be the number of vehicles that can travel on it. Moreover, the traffic here is faster than on a narrow road. On a narrow road, the traffic is likely to be congested. We can say that the bandwidth of a bigger road is higher than a narrow road.

Bandwidth describes the maximum data-transfer rate between computers in a network. In digital systems, bandwidth is measured in bits per second (bps). If the bandwidth is more, data travels faster and hence large amounts of data can be transferred within a particular time span across the network. For example, an Internet connection via cable modem may provide 25 Mbps of bandwidth.

Noise : Noise is unwanted electrical or electromagnetic energy that lowers the quality of data signals. It occurs from nearby radio transmitters, motors or other cables. The transfer of all types of data including texts, programs, images and audio over a network is adversely affected by noise.

Node : Any device (computer, scanner, printer, etc.) which is directly connected to a computer network is called a **node**. For example, computers linked to the computer network in the school are nodes. When we connect the Internet to our computer, our computer becomes a node of the Internet.



Let us do

Make a list of the hardware and software resources shared in your school network.

11.2 Data communication system

In a computer network, computing devices are connected in various ways, to communicate and share resources. **Data communication** is the exchange of digital data between any two devices through a medium of transmission. Figure 11.1 shows the representation of a general data communication system.

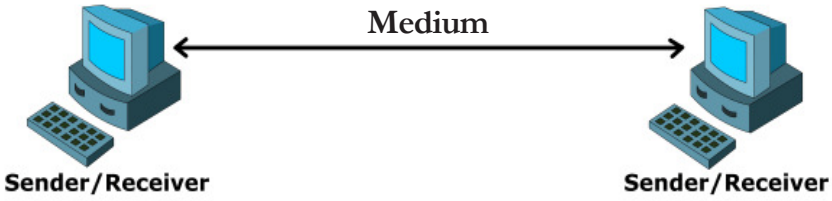


Fig. 11.1 : Data communication system

The following five basic elements are necessary for building any data communication system.

Message : It is the information to be communicated. Major forms of information include text, picture, audio, video, etc.

Sender : The computer or device that is used for sending messages is called the sender, source or transmitter.

Receiver : The computer or device that receives the messages is called the receiver.

Medium : It is the physical path through which a message travels from the sender to the receiver. It refers to the way in which nodes are connected.

Protocol : The rules under which message transmission takes place between the sender and the receiver is called a protocol.

11.3 Communication medium

Data communication is possible only if there is a medium through which data can travel from one device to another. The medium for data transmission over a computer network is called **communication channel** or **communication medium**. The communication medium between computers in a network are of two types: guided and unguided. In guided or wired medium physical wires or cables are used and in unguided or wireless medium radio waves, microwaves or infrared signals are used for data transmission.

11.3.1 Guided medium (Wired)

The coaxial cable, twisted pair cable (Ethernet cable) and optical fibre cable are the different types of cables used to transfer data through computer networks.

a. Twisted pair cable (Ethernet cable)

This is the most widely used media in small computer networks. It consists of four twisted pairs which are enclosed in an outer shield. These pairs are colour coded. Twisted pair cables are of two types: (i) Unshielded Twisted Pair (UTP) cables and (ii) Shielded Twisted Pair (STP) cables.

Unshielded Twisted Pair (UTP) cable: As its name suggests, the individual pairs in UTP cables are not shielded. Figure 11.2 shows the components of a UTP cable.

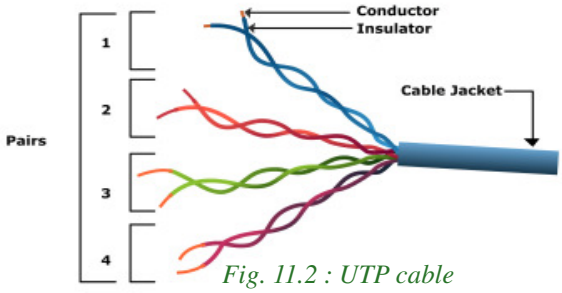


Fig. 11.2 : UTP cable

Characteristics of UTP cable

- Low cost cable available for setting up small networks.
- Thin and flexible cable.
- Ease of installation.
- Carries data upto a length of 100 m at a stretch.

Shielded Twisted Pair (STP) cable: It is the same cable as the UTP, but with each pair shielded individually. An outer shield then covers all the pairs like in UTP.

Characteristics of STP cable

- Shielding in STP offers better immunity against noise.
- It is more expensive than UTP cable.
- Compared to UTP cable, STP cable is difficult to install.

An RJ-45 connecter is used to connect UTP/STP twisted pair cable to a computer. Figure 11.3 shows the STP cable and RJ-45 connector.

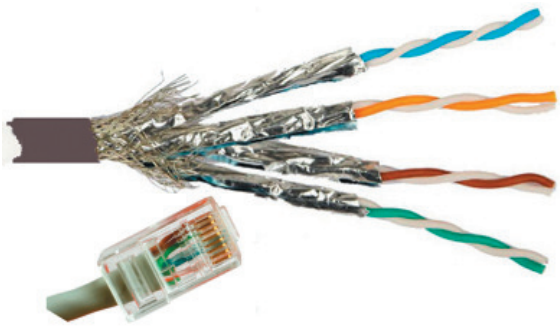


Fig. 11.3 : STP cable and RJ-45 connecter

b. Coaxial cable

A coaxial cable consists of an inner conductor surrounded by a tubular insulating layer which is further covered by a tubular conducting shield. It has an outer insulation to protect the cable too. Figure 11.4 shows the construction of a coaxial cable.

Characteristics of coaxial cable

- Carries data to longer distances (185 m - 500 m approx.) at a stretch.
- High bandwidth.
- Less electromagnetic interference due to the outer shield.
- Thicker than twisted pair.
- Less flexible than twisted pair.
- Difficult to install than twisted pair cable.

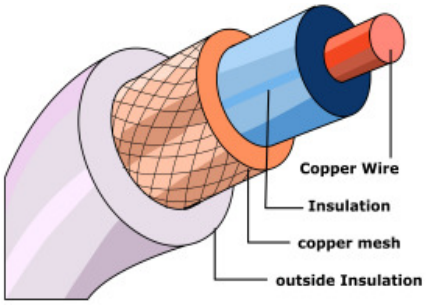


Fig. 11.4 : Coaxial Cable

c. Optical fibre cable

Optical fibres are long thin glass fibres through which data is transmitted as light signals. Data travels as fast as light and can be transmitted to far off distances. Figure 11.5 shows the major parts of an optical fibre cable.

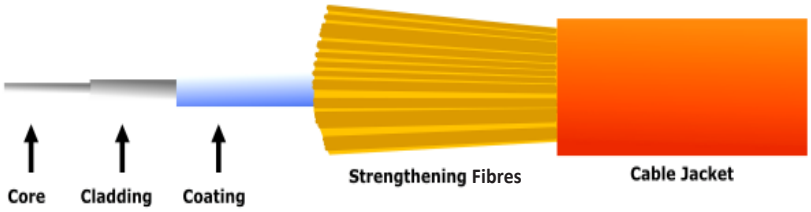


Fig. 11.5 : Optical fibre

Optical fibre has the following parts:

- Core - the thin glass rod at the centre through which the light travels.
- Cladding - the outer optical material surrounding the core that reflects the light back into the core.
- Coating - the plastic coating that protects the cable from damage and moisture.

These optical fibres are arranged in bundles of hundreds and thousands and are protected by the outer covering of the cable called jacket.

At the source end, the optical transmitter converts electrical signals into optical signals (modulation) using semiconductor devices such as light-emitting diodes (LEDs) or laser diodes. At the destination end, the optical receiver, consisting of a photo detector, converts light back to electric signals (demodulation) using the photoelectric effect. The speed of transmission and the distance of signals are higher for laser diodes than for LEDs.

Characteristics of optical fibre cable

- High bandwidth for voice, video and data applications.
- Carries data over a very long distance at a stretch.
- Not susceptible to electromagnetic fields, as it uses light for data transmission.
- The most expensive and the most efficient communication media available for computer networks.
- Installation and maintenance are difficult and complex.

11.3.2 Unguided medium (Wireless)

Electromagnetic waves are used for wireless communication on computer networks. Frequencies of waves are measured in Hertz (Hz). Based on their frequencies, electromagnetic waves are categorised into various types as shown in Figure 11.6. From this category we can infer that only radio waves, microwaves and infrared rays are used for wireless communication.

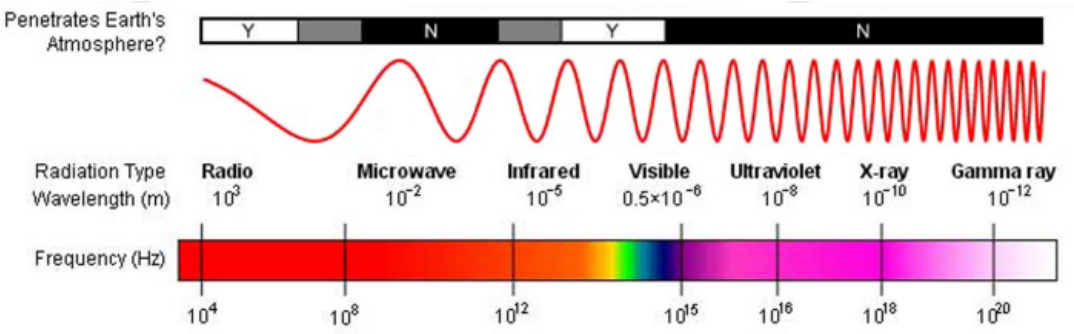


Fig. 11.6: Electromagnetic Spectrum

a. Radio waves

Radio waves have a frequency range of 3 KHz to 3 GHz. Radio waves can be used for short and long distance communication. These waves are easy to generate and can go over the walls of a building easily. That is why radio waves are widely used for communication-both indoors and outdoors. Cordless phones, AM and FM radio broadcast and mobile phones make use of radio wave transmission.

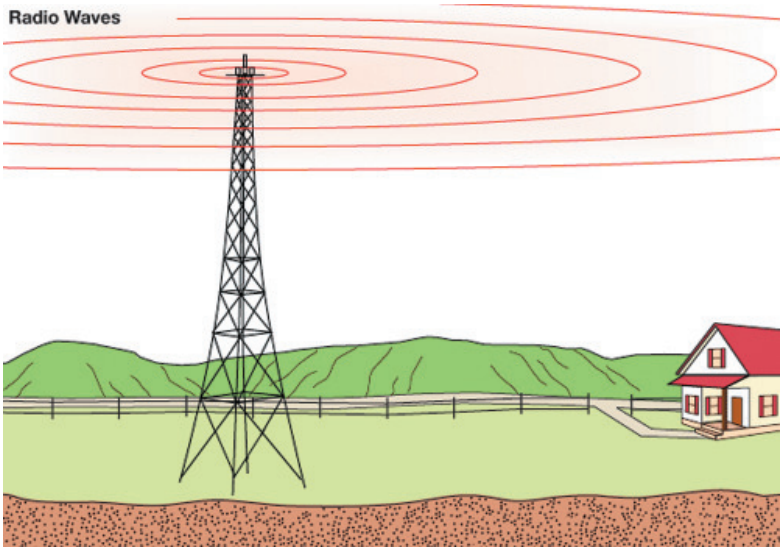


Fig. 11.7 : Radio wave transmission

Characteristics of radio wave transmission

- Waves are transmitted in all directions, therefore transmitting and receiving antennas need not be aligned face to face.
- Relatively inexpensive than wired media.
- Can penetrate through most objects.
- Transmission can be affected by motors or other electrical equipment.
- Less secure mode of transmission.
- Permissions from authorities concerned are required for the use of radio wave transmission.

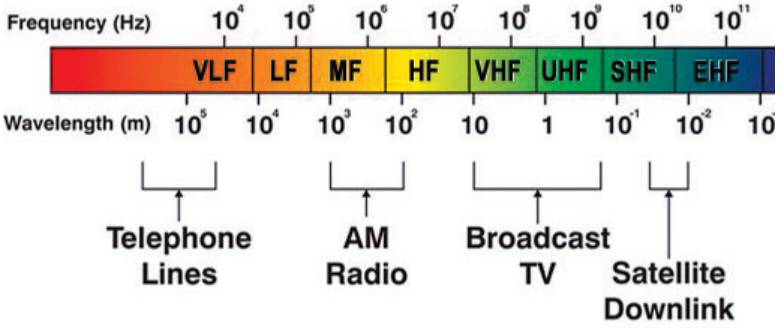


Fig. 11.8 : Spectrum of radio communication band

b. Micro waves

Micro waves have a frequency range of 300 MHz (0.3 GHz) to 300 GHz. Microwaves travel in straight lines and cannot penetrate any solid object. Therefore, high towers are built and microwave antennas are fixed on their top for long distance microwave communication. As these waves travel in straight lines the antennas used for transmitting and receiving messages have to be aligned with each other. The distance between two microwave towers depends on many factors including frequency of the waves being used and heights of the towers. Figure 11.9 shows the components of a microwave transmission system.

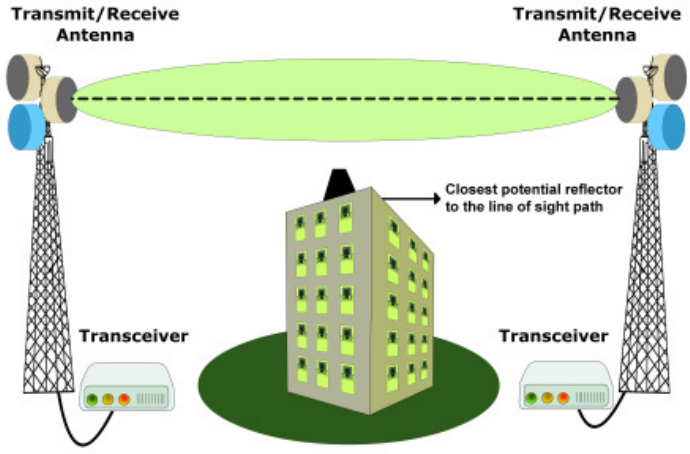


Fig. 11.9 : Microwave transmission

Characteristics of micro wave transmission

- Relatively inexpensive than wired media.
- Offers ease of communication over difficult terrain.
- The transmission is in straight lines. Therefore, the transmitting and receiving antennas need to be properly aligned (line of sight transmission).

c. Infrared waves

Infrared waves have a frequency range of 300 GHz to 400 THz. These waves are used for short range communication (approx. 5 m) in a variety of wireless communications, monitoring and control applications.

Home entertainment remote control devices, cordless mouse and intrusion detectors are some of the devices that utilise infrared communication (refer Figure 11.10).

Fig. 11.10 : Infrared transmission

Characteristics of infrared wave transmission

- A line of sight transmission; hence information passed to one device is not leaked.
- Only two devices can communicate at a time.
- The waves cannot cross solid objects. (You may stand between the remote control and your television set and check whether the remote control works.)
- The longer the distance the weaker the performance.

11.3.3 Wireless communication technologies using radio waves

a. Bluetooth

Bluetooth technology uses radio waves in the frequency range of 2.402 GHz to 2.480 GHz. This technology is used for short range communication (approx. 10 m) in a variety of devices for wireless communication. Cell phones, laptops, mouse, keyboard, tablets, headsets, cameras, etc. are some of the devices that utilise bluetooth communication (refer Figure 11.11).

Fig. 11.11 : Bluetooth transmission

Characteristics of bluetooth transmission

- Line of sight between communicating devices is not required.
- Bluetooth can connect upto eight devices simultaneously.
- Slow data transfer rate (upto 1 Mbps).

b. Wi-Fi

Wi-Fi network makes use of radio waves to transmit information across a network like cell phones, televisions and radios. The radio waves used in Wi-Fi ranges from a frequency of 2.4 GHz to 5 GHz. Communication across a wireless network is two-way radio communication. The wireless adapter in a computer translates data into radio signal and transmits it using an antenna. A wireless router receives the signal and decodes it. Once decoded, the data will be sent to the Internet or network through a wired Ethernet /wireless connection. Similarly, the data received from the Internet/network will also pass through the router and coded into radio signals that will be received by the wireless adapter in a computer as indicated in Figure 11.12. Nowadays, this technology is widely used to share Internet connection with laptops or desktops.

Fig. 11.12 : Wi-Fi transmission

Characteristics of Wi-Fi transmission

- Line of sight between communicating devices is not required.
- Data transmission speed is upto 54 Mbps.
- Wi-Fi can connect more number of devices simultaneously.
- Used for communication upto 375 ft (114 m).

c. Wi-MAX

Worldwide Interoperability for Microwave Access (Wi-MAX) originally based on 802.16e, combines the benefits of broadband and wireless. Wi-MAX has a frequency

range of 2 GHz to 11 GHz. Wi-MAX can provide high-speed wireless Internet access over very long distances (a whole city). Wi-MAX equipment exists in two basic forms - base stations, installed by service providers to deploy the technology in a coverage area, and receivers, installed by clients. Figure 11.13 shows the basic components of a Wi-MAX transmission.

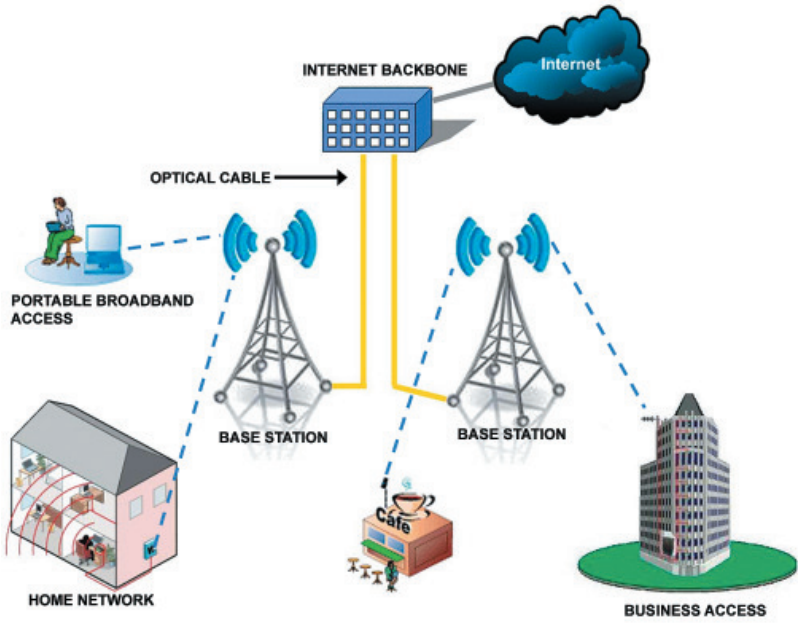


Fig. 11.13 : WiMAX transmission

Characteristics of Wi-MAX transmission

- Hundreds of users can connect to a single station.
- Provides higher speed connection upto 70 Mbps over an area of 45 Kilometres.
- Line of sight between communicating devices is not required.
- Weather conditions like rain, storm, etc. could interrupt the signal.
- Very high power consumption.
- High costs of installation and operation.

d. Satellite link

Long distance wireless communication systems use satellite links for transmitting signals. Usually, a signal travels in a straight line and is not able to bend around the globe to reach a destination far away. Signals can be sent to geostationary satellites in space and then redirected to another satellite or directly to a far away destination.

A geostationary satellite orbits the earth in the same direction and amount of time it takes to revolve the earth once. From the earth, therefore, the satellite appears to be stationary, always above the same area of the earth. These satellites carry electronic devices called transponders for receiving, amplifying, and re-broadcasting signals to the earth.

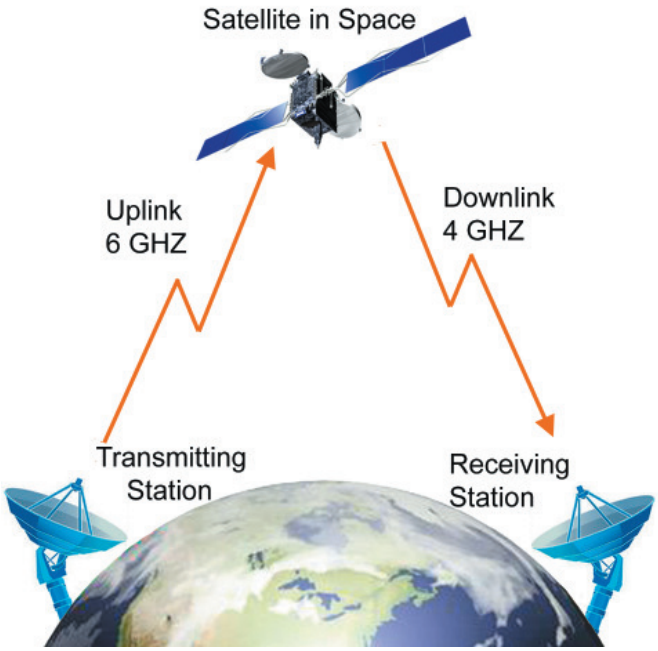


Fig. 11.14 : Satellite link

Transmission of signals from the earth to a satellite is called **uplink** and from a satellite to the earth is called **downlink**. There are multiple micro wave frequency bands which are used for satellites links. Frequency used for uplink varies from 1.6 GHz to 30.0 GHz and that for downlink varies from 1.5 GHz to 20.0 GHz. Downlink frequency is always lower than the uplink frequency.

The satellite system is very expensive, but its coverage area is very large. Communication satellites are normally owned by governments or by government approved organisations of various countries.

Characteristics of transmission using satellite link

- Satellites cover a large area of the earth.
- This system is expensive.
- Requires legal permission and authorisation.

Check yourself

1. Name the basic elements needed for a data communication system.
2. Define resource sharing.
3. Name two classifications of communication channels between computers in a network.
4. Name the connecter used to connect UTP/STP cable to a computer.
5. The cable media that use light to transmit data signals to very long distances is _____.
6. AM and FM radio broadcast and mobile phones make use of _____ medium for transmission.
7. The medium for communication used in home entertainment remote control devices, certain mouse, etc. is _____.
8. A short range communication technology that does not require line of sight between communicating devices is _____.
9. A communication system that is very expensive, but has a large coverage area when compared to other wireless communication systems is _____.

11.4 Data communication devices

A data communication device provides an interface between computer and the communication channel. These devices are used to transmit, receive, amplify and route data signals across a network through various communication media.

11.4.1 Network Interface Card (NIC)

Network Interface Card (NIC) is a device that enables a computer to connect to a network and communicate. It provides hardware interface between a computer and a network. It can be a separate circuit board that is installed in a computer or a circuit already integrated with the motherboard. NIC can prepare, send, receive and control data on the network. It breaks up data into manageable units, translates the protocols of the computer to that of the communication medium and supplies address recognition capabilities.

Fig. 11.15 (a) : NIC card

Fig. 11.15 (b) : Wireless NIC card

Figure 11.15 (a, b) shows the NIC card and wireless NIC card. Some NIC cards have wired connections (Ethernet), while others are wireless (Wi-Fi). Ethernet NICs include jacks for network cables, while Wi-Fi NICs contain built-in transmitters/ receivers (transceivers) and an antenna. NICs can transfer data at a speed of 1 Gbps.

11.4.2 Hub

Fig. 11.16 : Hub

A hub is a device used in a wired network to connect computers/ devices of the same network. It is a small, simple, passive and inexpensive device (refer Figure 11.16). Computers/devices are connected to ports of the hub using Ethernet cable. When NIC of one computer sends data packets to hub, the hub transmits the packets to all other computers connected to it. Each computer is responsible for determining its data packets. The computer for which the data packets are intended accepts it. Other computers on the network discards these data packets. The main disadvantage of hub is that it increases the network traffic and reduces the effective bandwidth, as it transmits data packets to all devices connected to it.

11.4.3 Switch

A switch is an intelligent device that connects several computers to form a network. It is a higher performance alternative to a hub. It looks exactly like a hub. Switches are capable of determining the destination and redirect the data only to the intendend node. Switch performs this by storing the addresses of all the devices connected to it in a table. When a data packet is send by one device, the switch reads the destination address on the packet and transmits the packet to the destination device with the

help of the table. A switch performs better than a hub on busy networks, since it generates less network traffic in delivering messages.

11.4.4 Repeater

A repeater is a device that regenerates incoming electrical, wireless or optical signals through a communication medium (refer Figure 11.17). Data transmissions through wired or wireless medium can travel only a limited distance as the quality of the signal degrades due to noise. Repeater receives incoming data signals, amplifies the signals to their original strength and retransmits them to the destination.

Fig. 11.17 : Wireless repeater

11.4.5 Bridge

A bridge is a device used to segmentise a network. An existing network can be split into different segments and can be interconnected using a bridge. This reduces the amount of traffic on a network. When a data packet reaches the bridge, it inspects the incoming packet's address and finds out to which side of the bridge it is addressed (to nodes on the same side or the other side). Only those packets addressed to the nodes on the other side, will be allowed to pass the bridge. Others will be discarded. The packet that passes the bridge will be broadcast to all nodes on the other side and is only accepted by the intended destination node. Figure 11.18 shows the function of a bridge.

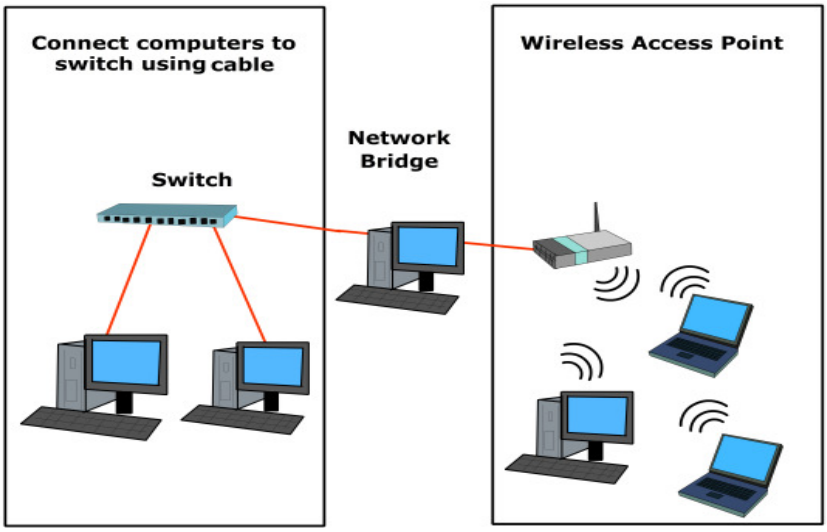


Fig. 11.18 : Bridge

11.4.6 Router

A router is a device that can interconnect two networks of the same type using the same protocol. It can find the optimal path for data packets to travel and reduce the amount of traffic on a network. Even though its operations are similar to a bridge, it is more intelligent. The router can check the device address and the network address and can use algorithms to find the best path for packets to reach the destination. Figure 11.19 shows the role of a router.

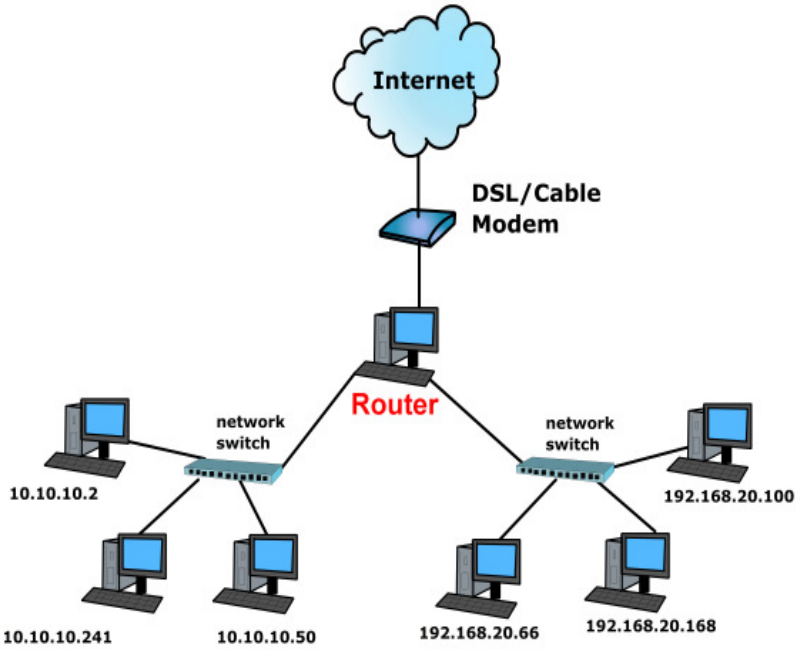


Fig. 11.19 : Router

11.4.7 Gateway

A gateway is a device that can interconnect two different networks having different protocols (refer Figure 11.20). It can translate one protocol to another protocol. It is a network point that acts as an entrance to another network. Its operations are similar to that of a router. It can check the device address and the network address and can use algorithms to find the

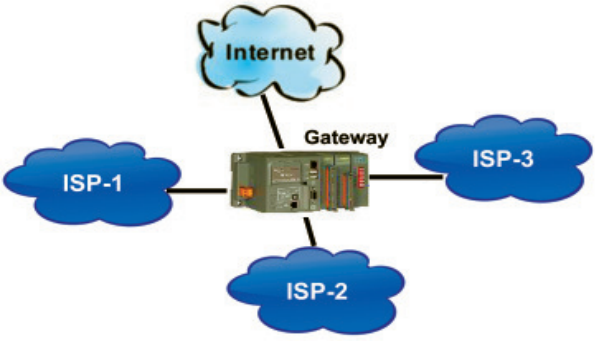


Fig. 11.20 : Gateway

best path for packets to reach the destination. Further, while interconnecting two networks with different protocols, there must be some mutual understanding between the networks. A gateway is capable of understanding the address structure used in different networks and seamlessly translate the data packet between these networks.

11.5 Data terminal equipments

A data terminal equipment (DTE) is a device that controls data flowing to or from a computer. It is connected to the transmission medium at the end of a telecommunication link. Here we discuss the most commonly used DTEs - modem and multiplexer.

11.5.1 Modem

A modem is an electronic device used for communication between computers through telephone lines (refer Figure 11.21). The name is formed from the first three letters of the two words modulator and demodulator. It converts digital signals received from a computer to analog signals (modulation) for telephone lines. It also converts the analog signals received back from telephone lines to digital signals (demodulation) for the computer. The speed of the modem determines how fast it can send and receive information through telephone lines. The speed of modem is measured in bits per second (bps).

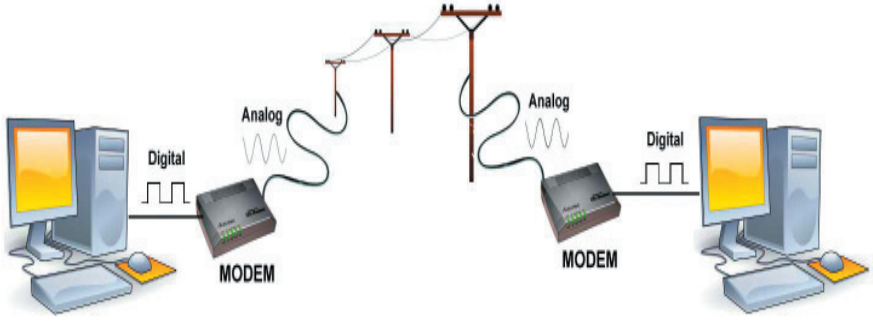


Fig. 11.21 : Communication using modem

11.5.2 Multiplexer/Demultiplexer

Have you ever wondered how 200 or more TV channels are transmitted through a single cable in a television network? It is called multiplexing. Similar is the case with data transmission over networks. Multiplexing is sending multiple signals on a physical medium at the same time in the form of a single, complex signal and then recovering the separate signals at the receiving end. Multiplexing divides the physical medium into logical segments called frequency channels. Multiplexer combines (multiplexes) the inputs from different sources and sends them through different channels of a medium. The combined data travels over the medium simultaneously.

At the destination, a demultiplexer separates (demultiplexes) the signals and sends them to destinations. Figure 11.22 shows the function of a multiplexer and demultiplexer.

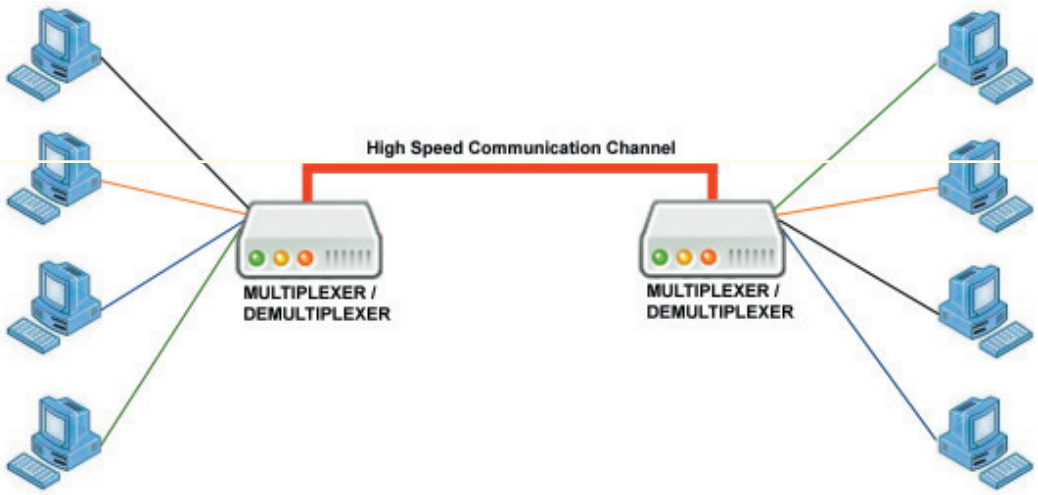


Fig. 11.22 : Multiplexer/De-multiplexer

Let us do

Make a list of networking devices and communication medium necessary to create a small computer network having a maximum of 10 nodes.

Check yourself

1. Compare hub and switch.
2. What is the use of a repeater?
3. The devices used to interconnect two networks of same type is _____.
4. Differentiate between router and bridge.
5. A device that can interconnect two different networks having different protocols is _____.
6. An electronic device used for communication between computers through telephone lines is _____.

11.6 Network topologies

Imagine that we have ten computers and we need to interconnect them to form a network. What are the ways by which we can interconnect them?

Using available media and based on certain conditions, there are different ways of interconnecting the nodes. The way in which the nodes are physically interconnected to form a network is called a **Topology.** Major topologies are bus, star, ring and mesh.

11.6.1 Bus topology

In bus topology (refer Figure 11.23) all the nodes are connected to a main cable called bus. If a node has to send data to another node, it sends data to the bus. The signal travels through the entire length of the bus. All nodes check the bus, and only the node for which data is addressed accepts it. A small device called terminator is attached at each end of the bus. When the signal reaches the end of the bus, the terminator absorbs the signal and removes it from the bus. Now the bus is free to carry another signal. This prevents the reflection of a signal back on the cable and hence eliminates the chances of signal interference. The process of transmitting data from one node to all other nodes is called broadcasting.

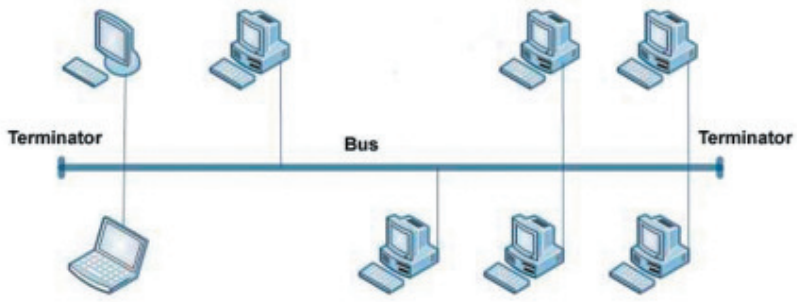


Fig. 11.23 : Bus topology

Characteristics of bus topology

- Easy to install.
- Requires less cable length and hence it is cost effective.
- Failure of a node does not affect the network.
- Failure of cable (bus) or terminator leads to a break down of the entire network.
- Fault diagnosis is difficult.
- Only one node can transmit data at a time.

11.6.2 Star topology

In star topology each node is directly connected to a hub/switch as shown in Figure 11.24. If any node has to send some information to any other node, it sends the

signal to the hub/switch. This signal is then broadcasted (in case of a hub) to all the nodes but is accepted only by the intended node. In the case of a switch, the signal is sent only to the intended node.

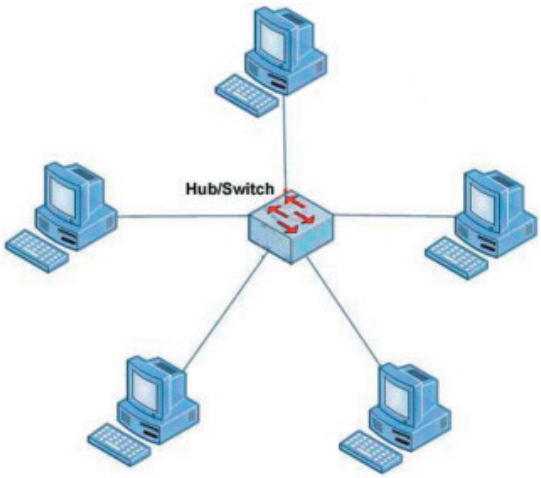


Fig. 11.24 : Star topology

Characteristics of star topology

- More efficient compared to bus topology.
- Easy to install.
- Easy to diagnose faults.
- Easy to expand depending on the specifications of central hub/switch.
- Failure of hub/switch leads to failure of entire network.
- Requires more cable length compared to bus topology.

11.6.3 Ring topology

In ring topology, all nodes are connected using a cable that loops in a ring or circle. A ring topology is in the form of a circle that has no start and no end (refer Figure 11.25). Terminators are not necessary in a ring topology. Data travels only in one direction in a ring. While they are passed from one node to the next, each node regenerates the signal. The node for which the signal is intended reads the signal. After travelling through each node, the signal reaches back to the sending node from where it is removed.

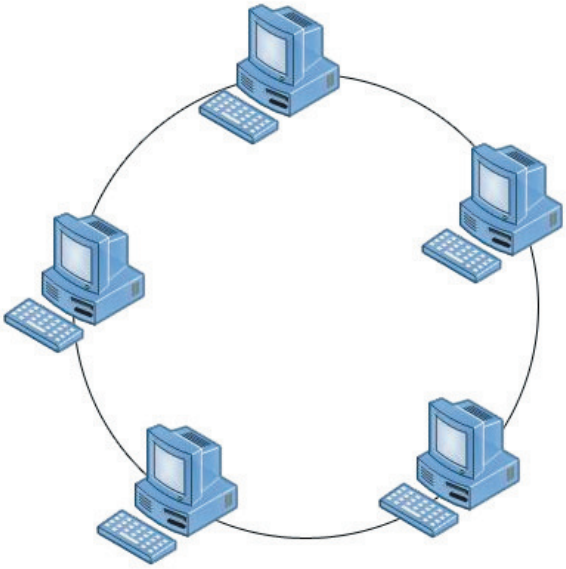


Fig. 11.25 : Ring topology

Characteristics of ring topology

- No signal amplification is required as each node amplifies the signal.
- Requires less cable length and hence is cost effective.
- If one node fails, entire network will fail.
- Addition of nodes to the network is difficult.

11.6.4 Mesh topology

In mesh topology, every node is connected to other nodes. So there will be more than one path between two nodes as shown in Figure 11.26. If one path fails, the data will take another path and reach the destination.

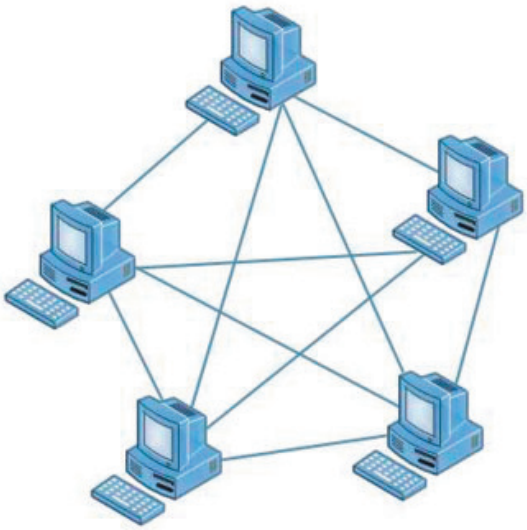


Fig. 11.26 : Mesh topology

Characteristics of mesh topology

- Network will not fail even if one path between the nodes fails.
- Expensive because of the extra cables needed.
- Very complex and difficult to manage.

Let us do

Identify the network topology used in your school lab.

11.7 Types of networks

A computer network may span any amount of geographical area. It can be on a table, in a room, in a building, in a city, in a country, across continents or around the world. On the basis of the area covered, computer networks are classified as:

- PAN - Personal Area Network
- LAN - Local Area Network
- MAN - Metropolitan Area Network
- WAN -Wide Area Network

11.7.1 Personal Area Network (PAN)

PAN is a network of communicating devices (computer, mobile, tablet, printer, etc.) in the proximity of an individual. It can cover an area of a radius with few meters (refer Figure 11.27).

When we transfer songs from one cell phone to another or from a PC to an MP3 player, a PAN is set up between the two. PAN can be set up using guided media (USB) or unguided media (Bluetooth, infrared).

Fig. 11.27 : Personal Area Network

11.7.2 Local Area Network (LAN)

LAN is a network of computing and communicating devices in a room, building, or campus. It can cover an area of radius with a few meters to a few Kilometers. A networked office building, school or home usually contains a single LAN, though sometimes one building can contain a few small LANs (Like some schools have independent LANs in each computer lab) as shown in Figure 11.28. Occasionally a LAN can span a group of nearby buildings.

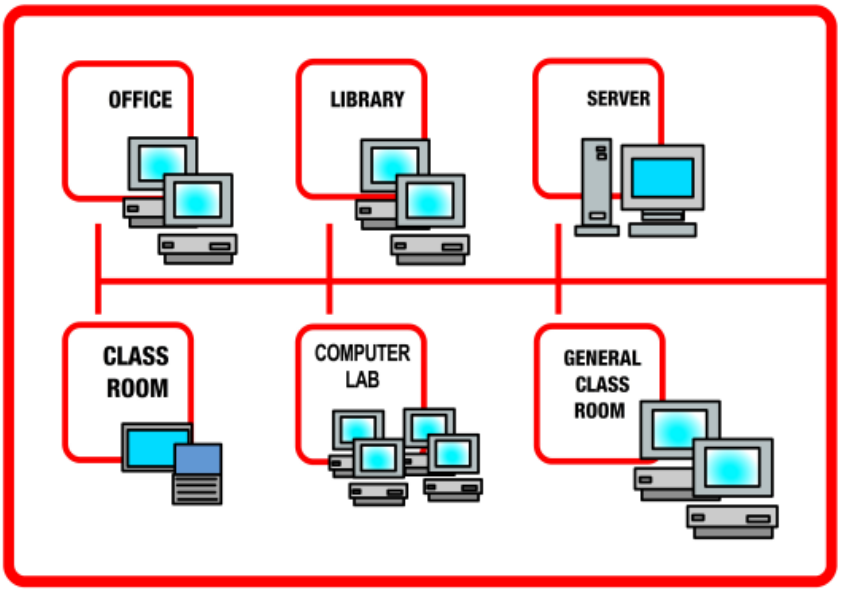


Fig. 11.28 : Local Area Network

In addition to operating in a limited space, a LAN is owned, controlled and managed by a single person or an organisation.

LAN can be set up using wired media (UTP cables, coaxial cables, etc.) or wireless media (infrared, radio waves, etc.). If a LAN is setup using unguided media, it is known as WLAN (Wireless LAN).

11.7.3 Metropolitan Area Network (MAN)

MAN is a network of computing and communicating devices within a city. It can cover an area of a few Kilometers to a few hundred Kilometers radius. MAN is usually formed by interconnecting a number of LANs and individual computers. All types of communication media (guided and unguided) are used to set up a MAN. MAN is typically owned and operated by a single entity such as a government body or a large corporation (refer Figure 11.29).

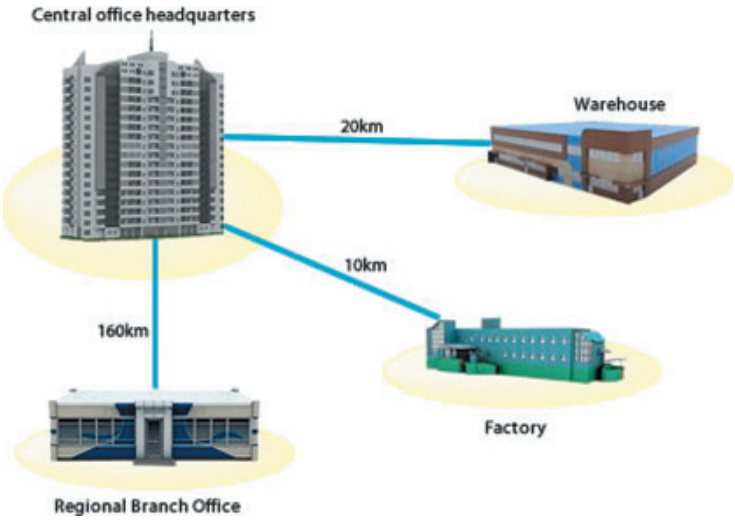


Fig. 11.29 : Metropolitan Area Network

11.7.4 Wide Area Network (WAN)

WAN is a network of computing and communicating devices crossing the limits of a city, country or continent. It can cover an area of over hundreds of Kilometers in radius. WAN usually contain a number of interconnected individual computers, LANs, MANs and maybe other WANs. All types of communication media (guided and unguided) are used to set up a WAN as shown in Figure 11.30. The best known example of a WAN is the Internet. Internet is considered as the largest WAN in the world. A network of ATMs, banks, government offices, international organisations,

offices, etc. spread over a country, continent or covering many continents are examples of WAN.

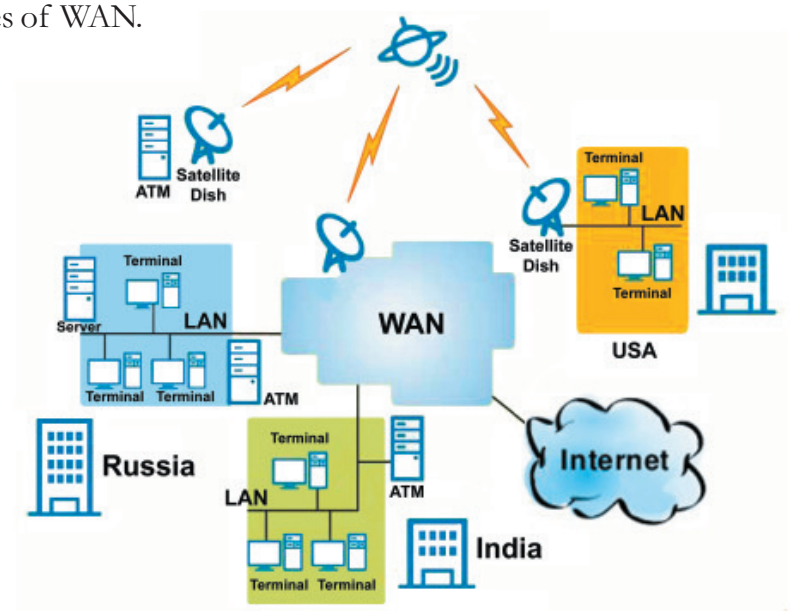


Fig. 11.30 : Wide Area Network

Table 11.1 summarises the characteristics of PAN, LAN, MAN and WAN.

Parameter	PAN	LAN	MAN	WAN
Area covered	Small area (Up to 10 m radius)	A few meters to a few Kilometers (Up to 10 Km radius)	A city and its vicinity (Up to (100 Km radius)	Entire country, continent, or globe
Transmission speed	High speed	High speed	Moderate speed	Low speed
Networking cost	Negligible	Inexpensive	Moderately expensive	Expensive

Table 11.1 : Characteristics summary of PAN, LAN, MAN, WAN

11.8 Logical classification of networks

This classification is based on the role of computers in the network and division falls into two categories: peer-to-peer and client-server.

11.8.1 Peer-to-Peer

A peer-to-peer network has no dedicated servers. Here a number of computers are connected together for the purpose of sharing information or devices. All the computers are considered equal. Any computer can act as a client or as a server at any instance. This network is ideal for small networks where there is no need for dedicated servers, like home network or small business establishments or shops.

11.8.2 Client-Server

The client-server concept is the driving force behind most of the networks. It is similar to going to a restaurant, reading the menu, calling the waiter (server) and then ordering one's preference from the menu. If the ordered item is available in the restaurant at that time, it is 'served' to whom the order was placed (client), else the request is refused.

In a network, the client-server architecture consists of high-end computer (called server) serving lower configuration machines called clients. A server provides clients with specific services (responses) upon client's request. The services include sharing of data, software and hardware resources. Figure 11.31 shows the general client-server architecture.

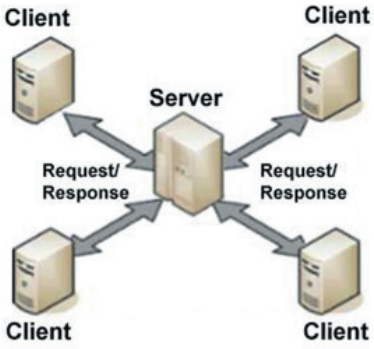


Fig. 11.31 : Client - Server

Client-server architecture is an example for centralised software management. When software is loaded on the server and shared among the clients, changes made to the software in the server will reflect in the clients also. So there is no need to spend time and energy for installing updates and tracking files independently on the clients.

Classifications for servers are

a) **File server** - A computer that stores and manages files for multiple users on a network.

b) **Web server** - A computer dedicated to responding to requests for web pages.

c) **Print server** - Redirects print jobs from clients to specific printers.

d) **Database server** - Allows authorised clients to view, modify and/or delete data in a common database.

Check yourself

1. In bus topology, when the signal reaches the end of the bus, _____absorbs the signal and removes it from the bus.
2. In _____topology each node is directly connected to a hub/switch.
3. In which topology is every node connected to other nodes?
4. Categorise and classify the different types of networks given below:
   ATM network, Cable television network, Network within the school, Network at home using bluetooth,Telephone network, Railway network
5. What is PAN?
6. What is a peer-to-peer network?

11.9 Identification of computers over a network

Imagine that you are in India and you wish to write a letter to your friend in America. What would you do? You write a letter, put it in an envelop, write your friend's address on it and write your address on the back. When the letter is posted in a post office in India, it is stamped with a unique seal and date. After going through a feasible route the letter reaches the post office in America, where it is stamped again with a unique seal and date. Then, the postman makes sure that it reaches the specified addressee. In a network, data is sent in the form of packets in a similar way.

Once a network has been set up, the nodes can communicate among themselves. But for proper communication, the nodes should be uniquely identifiable. If node X sends some information to node Y on a network, then it is mandatory that nodes X and Y are uniquely identifiable on the network. Let us see how this is achieved.

11.9.1 Media Access Control (MAC) address

A Media Access Control (MAC) address is a universally unique address (12 digit hexadecimal number) assigned to each NIC (Network Interface Card) by its manufacturer. This address is known as the MAC address. It means that a machine with an NIC can be identified uniquely through the MAC address of its NIC. MAC address of an NIC is permanent and never changes.

MAC addresses are 12-digit hexadecimal (or 48 bit binary) numbers. By convention, MAC addresses are usually written in one of the following two formats:

MM : MM : MM : SS : SS : SS or **MM – MM – MM – SS – SS – SS**

The first half (MM:MM:MM) of a MAC address contains the ID number of the adapter manufacturer. The second half (SS:SS:SS) of a MAC address represents the serial number assigned to the adapter (NIC) by its manufacturer. For example, in the following MAC address,

00:A0:C9 : 14:C8:35

The prefix 00:A0:C9 indicates that the manufacturer is Intel Corporation. And the last three numbers 14:C8:35 are given by the manufacturer (Intel in this example) to this NIC.

11.9.2 Internet Protocol (IP) address

An IP address is a unique 4 part numeric address assigned to each node on a network, for their unique identification. IP address is assigned to each machine by the network administrator or the Internet Service Provider. An IP address is a group of four bytes (or 32 bits) each of which can be a number from 0 to 255.

To make it easier for us to remember, IP addresses are normally expressed in decimal format as a "dotted decimal number" as indicated in Figure 11.32.

On a network, the IP address of a machine is used to identify it. IP protocol identifies a machine with its IP address to route the packets.

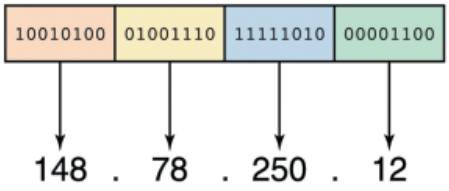


Fig. 11.32 : IP address

There are two versions of IP addresses: version 4 (IPv4) and version 6 (IPv6). IPv4 uses 32 bits and IPv6 uses 128 bits for an IP address. Using IPv4 only 2^{32} (approximately 4 billion) distinct devices can be addressed.

As the number of devices which need to be networked (mobile phones, home appliances, personal communication devices, etc.) is increasing at a very fast pace, IPv4 addresses are being exhausted. To address this problem IPv6 was developed and it is now being deployed. Using IPv6, 2^{128} (approximately 4 billion × 4 billion 4 billion 4 billion) distinct devices can be addressed.

Let us do

Identify the IP and MAC Id of each networked machine in your school and prepare a table as follows. (Use ipconfig /all at command prompt).

Sl No	Computer Name	IP	MAC
1.			
2.			
3.			

11.10 Network protocols

A network protocol is the special set of rules to be followed in a network when devices in the network exchange data with each other. Each protocol specifies its own rules for formatting data, compressing data, error checking, identifying and making connections and making sure that data packets reach its destination.

Several computer network protocols have been developed for specific purposes and environments. Some commonly used protocols are TCP/IP, SPx/IPx, etc.

TCP/IP

TCP/IP, Transmission Control Protocol/Internet Protocol, is a suite of communications protocols used to interconnect network devices on the local networks and the Internet. TCP/IP defines rules for how electronic devices (like

computers) should be connected to the Internet and how data should be transmitted between them.

When data is to be sent from one computer to another over Internet, it is first broken into smaller packets by TCP and then sent. When these packets are received by the receiving computer, TCP checks packets for errors. If errors are found, TCP submits requests for retransmission; else packets are assembled into the original message according to the rules specified in TCP protocol. Figure 11.33 shows the steps involved in the working of TCP/IP protocol. Delivery of each of these packets to the right destinations is done by Internet protocol (IP). Even though different packets of the same message may be routed differently, they will reach the same destination and get reassembled there. HTTP, FTP and DNS are three sub protocols of TCP/IP protocol suite.

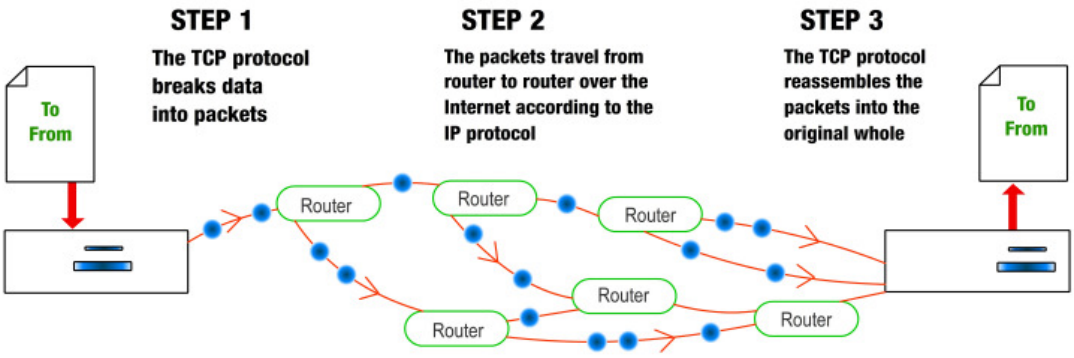


Fig: 11.33 : How TCP/IP works

a. HTTP

HTTP stands for Hypertext Transfer Protocol. It is a standard protocol for transferring requests from client-side and to receive responses from the server-side. The HTTP client (browser) sends a HTTP request to the HTTP server (web server) and server responds with a HTTP response. This pair of request and response is called an HTTP session (refer Figure 11.34).

The response from the server can be static such as a file already stored on the server, or dynamic, such as the result of executing a piece of code by the server as per the request from the client.

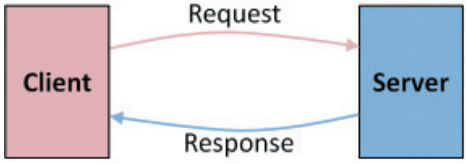


Fig. 11.34 : An HTTP session

The two important characteristics of HTTP are

- HTTP is transmission medium independent.
- HTTP is stateless (The server and client are aware of each other only during a request or response. Afterwards, each forgets the other).

b. FTP

FTP stands for File Transfer Protocol. It is a standard for exchanging of data and program files across a network. FTP is the easiest way to transfer files between computers via the Internet. It uses TCP and IP to perform uploading and downloading. A FTP client program installed in the computer can help in the uploading (sending files to another computer) and downloading (receiving files from another computer) of files.

FTP uses client–server architecture in servers with security features, username and password protection for file transfer. An FTP client program (Filezilla, Cute FTP, etc.) installed in the computer can help in the easy uploading and downloading of files.

c. DNS

DNS stands for Domain Name System. DNS returns the IP address of the domain name, that we type in our web browser's address bar. (like mobile phone automatically dialing the phone number when we select a name from contact list).

The DNS system has its own network. DNS implements a database to store domain names and IP address information of all web sites on the Internet. DNS assumes that IP addresses do not change (statically assigned). If one DNS server does not know how to translate a particular domain name, it asks another one, and so on, until the correct IP address is returned.

Let us do

Find and prepare notes on five protocols other than TCP/IP, HTTP, FTP, DNS.

11.11 Uniform Resource Locator (URL)

URL stands for Uniform Resource Locator. URL is a formatted text string used by web browsers, e-mail clients and other software to identify a network resource on the Internet. Every resource on the Internet has a unique URL. Network resources are files that can be plain web pages, other text documents, graphics, programs, etc.

URL consists of letters, numbers and punctuations. URL string can be divided into three parts.

a) Network protocol (also called the scheme)

b) Domain name (Host name or address)

c) File name

For example the URL http://www.dhsekerala.gov.in/index.html has three parts as shown in Figure 11.35. The detailed description of these three parts are given below:

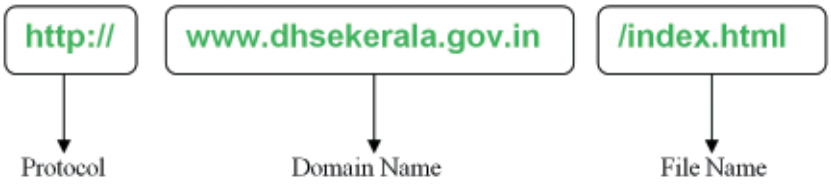


Fig: 11.35 : Components of an URL

a. Protocol

The protocol enables the browser to know what protocol is used to access the information specified in the domain.

b. Domain name

Domain name is the name assigned to a server through the Domain Name System (DNS). Domain names are used in URLs to identify the particular web server. Domain names provide Internet users with a short name that is easy to remember. Whenever we have to communicate with a computer on Internet, we can do so by using its IP address. But it is practically impossible for a person to remember the IP addresses of all the computers, one may have to communicate with. Therefore, a system has been developed which assigns names to computers (web servers) and maintains a database of these names and their corresponding IP addresses. These names are called domain names.Examples of some domain names are dhsekerala.gov.in, keralaresults.nic.in, google.com, gmail.com, etc.

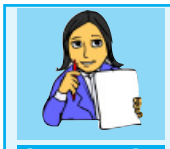
A domain name usually has more than one part: top level domain name or primary domain name and sub-domain name(s). For example, in the domain name above, 'in' is the primary domain name; 'gov' is the sub-domain of in and 'dhsekerala' is the sub-domain of 'gov'. There are only a limited number of top level domains and these are divided into two categories: Generic Domain Names and Country-Specific Domain Names. Examples of generic and country specific domain names are given in Table 11.2.

Generic Domain Names		Country Specific Domain Names	
.com	Commercial business	.in	India
.edu	Educational institutions	.au	Australia
.gov	Government agencies	.ca	Canada
.mil	Military	.ch	China
.net	Network organizations	.jp	Japan
.org	Organizations (nonprofit)	.us	United States of America

Table 11.2 : Generic and country specific domain names

c. File name

It is the file to be opened. In the example given in Figure 11.35, 'index.html' is the file that is to be accessed from the web server specified by the domain name.



Let us do

Make a list of valid URL, containing two examples for each generic domain name and country specific domain name. Also note down the file name opened by default (for file look at the URL in address bar after the site is opened).

Let us sum up

We learned about computer networks, the essential technology of the century, in this chapter. Importance of network was discussed by highlighting the various advantages it provides. We discussed the various communication media and their pros and cons. The devices used at various situations while forming a network was also discussed. Before discussing the types of network, we learned the different ways a network could be formed by discussing various topologies. We then discussed protocol and how TCP/IP send/receive data across the network. Methods to uniquely identify a node in the network were introduced and finally we concluded discussing URL.

Learning outcomes

After the completion of this chapter the learner will be able to

- identify and choose a communication medium.
- compare different types of network.
- explain the logical classification of networks.
- identify how data is sent across networks.
- design small networks.
- explain how a node is identified in a network.
- identify the various parts of a URL.

Sample questions

Very short answer type

1. The transmission media which carry information in the form of light signals is called _____.
   a. Coaxial b. Twisted
   c. WiFi d. Optical Fiber
2. Different networks with different protocols are connected by a device called _____.
   a. Router b. Bridge
   c. Switch d. Gateway
3. In _____ topology, the failure of any one computer will affect the network operation.
   a. Bus b. Ring
   c. Star d. none of these
4. To transmit signals from multiple devices through a single communication channel simultaneously, we use _____ device.
   a. Modem b. Switch
   c. Router d. Multiplexer
5. Bluetooth can be used for
   a. long distance communication b. short distance communication
   c. in mobile phones only d. none of the above
6. Satellite links are generally used for
   a. PANs b. LANs
   c. MANs d. all of the above

7. A domain name maps to
   a. URL
   b. an IP address
   c. website
   d. all of the above

Short answer type

1. Define bandwidth.
2. Switch and Hub are two devices associated with networking. Differentiate them.
3. What is an IP address? Give an example.
4. What is TCP/IP? What is its importance?
5. Define a computer network.
6. What is Bluetooth?
7. What is a Modem?
8. Distinguish between router and gateway.
9. Explain the need for establishing computer networks.
10. What are the uses of computer networks?
11. What is the limitation of microwave transmission? How is it eliminated?
12. Briefly describe the characteristics of Wi-Fi.
13. An International School is planning to connect all computers, spread over distance of 45 meters. Suggest an economical cable type having high-speed data transfer, which can be used to connect these computers.
14. What is NIC? What is its importance in networking?
15. Suppose that you are the administrator of network lab in one Institution. Your manager directed you to replace 10 Mbps switch by 10 Mbps Ethernet hub for better service. Will you agree with this decision? Justify your answer.
16. You need to transfer a biodata file stored in your computer to your friend's computer that is 10 kms away using telephone network
    a. Name the device used for this at both ends.
    b. Explain how the file is send and received inside the device, once a connection between two computers is established.
17. When is a repeater used in a computer network?
18. Compare infrared and Bluetooth transmission.
19. Identify and explain the device used for connecting a computer to a telephone network.
20. Briefly explain LAN topologies.

21. Briefly describe TCP/IP protocol.
22. What is a MAC address? What is the difference between a MAC address and an IP address?

Long answer type

1. How are computer networks classified, based on size?
2. Compare different LAN topologies.
3. Explain various types of guided communication channels.
4. Compare different unguided media.
5. Define the term protocol. Briefly describe any two communication protocols.
6. Briefly describe the various communication devices used in computer networks.
7. Which is/are communication channel(s) suitable for the following situations?
   a. Setting up a LAN.
   b. Transfer of data from a laptop to a mobile phone.
   c. Transfer of data from one mobile phone to another.
   d. Creating a remote control that can control multiple devices in a home.
   e. Very fast communication between two offices in two different countries.
   f. Communication in a hilly area.
   g. Communication within a city and its vicinity where cost of cabling is too high.