Data Communication and Computer

- **Introduction**
- **Importance of Networking**
- **Data Transmission Media**
- **Data Transmission across Media**
- **Data Transmission and Data Networking**
- **Computer Network (Multiplexing, Switching)**
- **Network Types**
- **Network Topology**
- **Communication Protocol**
- **Network Devices**
- **Wireless Networking**

Data Communication and Computer

- Importance of networking
  - Resource sharing, information sharing, as a communication medium, back-up and support
- Data transmission media
  - Twisted pair, coaxial cable, optical fiber, RF transmission, microwave transmission, satellite transmission
- Data transmission across media
  - Transmission modes - Simplex, half duplex, full-duplex
  - Transmission speed - Bandwidth, throughput, attenuation, distortion
  - Fundamentals of transmission - Electromagnetic waves, signals
    - Analog and digital signals
    - Modulation and demodulation - Amplitude, frequency, phase shift
    - Multiplexing - FDM, WDM
    - Asynchronous and synchronous transmission
- Data transmission and data networking
  - Switching - Circuit switching, message switching, packet switching

Data Communication and Computer

- Computer network
  - Network types - LAN, MAN, WAN
  - Network topologies - Bus, ring, star
  - Communication protocol - The seven layers of OSI model
  - Network devices - NIC, repeater, bridge, hub, switch, router, gateway
- Wireless networking - Bluetooth technology, wireless LAN, wireless WAN

Communication and Computer Network

Objectives of this Chapter:

- Computer networks facilitate exchange of information
- To connect the computers, need a data transmission media and understand how data gets transmitted across the media.
- We can create a network of computers across a room, building, city, state or the world to communicate.
- This chapter is to introduce to the data communication and the computer network.

Communication and Computer Network

Introduction:

- Communication is simply the act of transferring information/data from one place, person or group to another. Every communication involves (at least) one sender, a message, a recipient and medium used to establish the communication.
- The communication process involves—sender of information, receiver of information, language used for communication, and medium used to establish the communication.
- Communication between computers also follows a similar process.

Communication and Computer Network

Introduction:

- Data communication discusses the media used for transmission of data, how data can be transferred across the communication media and the relationship between data transmission and data networking.
- Computer network discusses different network types, network topologies, communication protocol and network communicating devices and brief explanation of wireless networks.
- A computer network is a group of computer systems and other computing hardware devices that are linked together through communication channels to facilitate communication and resource-sharing among a wide range of users.

Communication and Computer Network

Importance of Networking:

Networking of computer provides a communication link between the users, and provides access to information. Importance of networking of computer are as:

- Resource Sharing
- Information Sharing
- As a communication medium
- For Backup and support
- Centralized administration and support

Communication and Computer Network

Importance of Networking:

- Resource Sharing: Resources such as printers, fax machines and scanners are generally not required by each person at all times in an organization. Moreover, for small organizations it may not be feasible to provide such resources to each individual. Such resources can be made available to different users of the organization on the network.
- It results in availability of the resource to different users regardless of the physical location of the resource or the user, enhances optimal use of the resource, leads to easy maintenance, and saves cost too

Communication and Computer Network

Importance of Networking:

- Information Sharing

Networking facilitates sharing of information. Information stored on networked computers located at same or different physical locations, becomes accessible to the computers connected to the network.

- As a communication medium:

Networking helps in sending and receiving of electronic-mail (email) messages from anywhere in the world. Data in the form of text, audio, video and pictures can be sent via e-mail. This allows the users to communicate online in a faster and cost effective manner. Video conferencing is another form of communication made possible via networking. People in distant locations can hold a meeting, and they can hear and see each other simultaneously.

Communication and Computer Network

Importance of Networking:

- For Backup and support

Networked computers can be used to take back-up of critical data. In situations where there is a requirement of always-on computer, another computer on the network can take over in case of failure of one computer.

- Centralized administration and support

Can perform administration tasks from a central location. All computers and other components of a network can be managed by central support system. Any rules, security measures etc which are necessary in the network are implemented through server to all attached computers in the networks by transferring to all clients. So networking simplifies administration and support task from just a single location.

Communication and Computer Network

Data Transmission Media:

- Transmission media are the physical pathways that connect computers, other devices, and people on a network- the highways and byways that comprise the information superhighway.
- Each transmission medium requires specialized network hardware that has to be compatible with that medium.
  - The transmission medium is the physical path by which a message travels from sender to receiver.
  - Computers and telecommunication devices use signals to represent data.

Communication and Computer Network

Data Transmission Media:
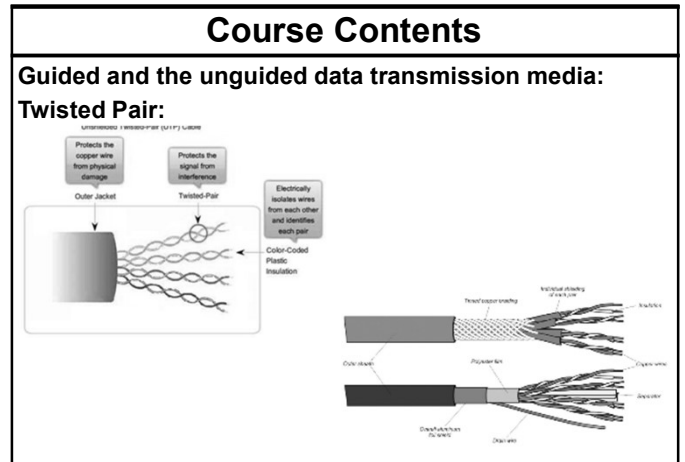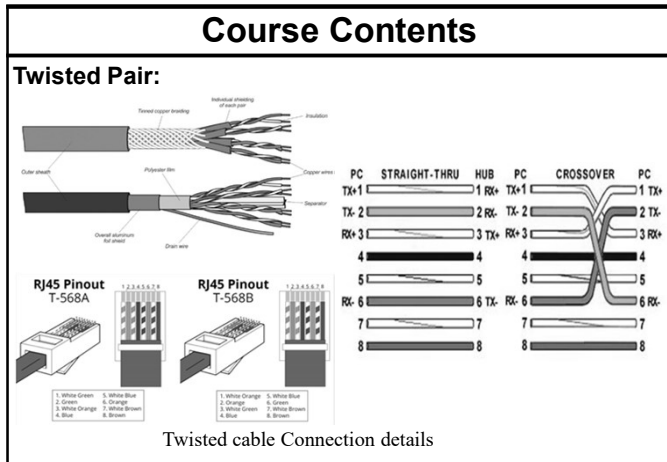
The transmission media can be grouped into.

- Conducted/wired or guided media: use a conductor such as a wire or a fiber optic cable to move the signal from sender to receiver. Examples are twisted pair wires, coaxial cables and optical fiber.
- Wireless or unguided media: use radio waves of different frequencies and do not need a wire or cable conductor to transmit signals. Examples are terrestrial microwave, satellite microwave, broadcast radio and infrared

Course Contents

Data Transmission Media;

The transmission media can be grouped into.
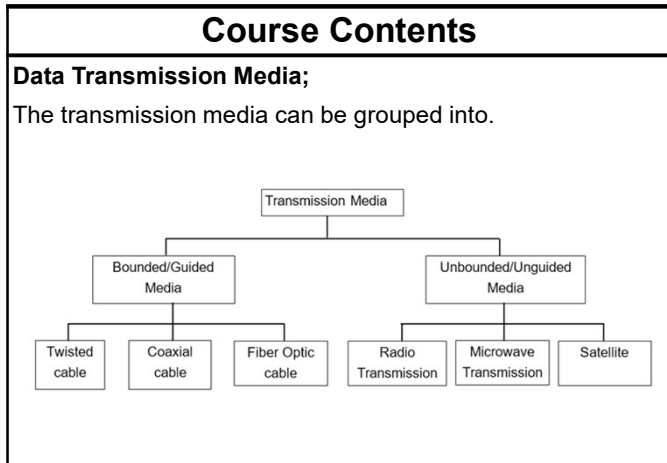
Course Contents

Twisted Pair (TP):

- A twisted pair cable consists of four pairs of copper wires coated with an insulating material like plastic or Teflon, twisted together. Twisting reduces electromagnetic interference.
- Twisted pair cabling is often used in data networks for short and medium length connections because of its relatively lower costs compared to optical fiber and coaxial cable(???).
- TP is of two kinds—Shielded Twisted Pair (STP), and Unshielded Twisted Pair (UTP).
- STP cable has an extra layer of metal foil between the twisted pair of copper wires and the outer covering. The metal foil covering provides additional protection from external disturbances. However, the covering increases the resistance to the signal and thus decreases the length of the cable. STP is costly and is generally used in networks where cables pass closer to devices that cause external disturbances.
- UTP is the most commonly used medium for transmission over short distances up to 100m. Out of the four pairs of wires in a UTP cable, only two pairs are used for communication.
- UTP cables are defined in different categories. The commonly used UTP cable is the Cat-5(?) cable which is used with fast Ethernet.

Course Contents

Twisted Pair:

Twisted cable Connection details

Course Contents

Guided and the unguided data transmission media:

Twisted Pair:

Course Contents

Coaxial Cable:

- A coaxial cable has a single inner conductor that transmits electric signals; the outer conductor acts as a ground. The two conductors are separated by insulation. The inner conductor, insulator, and the outer conductor are wrapped in a sheath of Teflon or PVC.

Coaxial cable (A: outer plastic sheath, B: woven copper shield, C: inner dielectric insulator, D: copper core
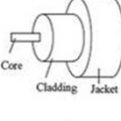
Course Contents

Coaxial Cable:

- The copper wire is used for both inner and outer conductor. The signal is transmitted over the surface of the inner conductor.
- In an ideal coaxial cable the electromagnetic field carrying the signal exists only in the space between the inner and outer conductors. This allows coaxial cable runs to be installed next to metal objects such as gutters without the power losses that occur in other transmission lines, and provides protection of the signal from external electromagnetic interference.
- A thicker coaxial cable can transmit more data than a thinner one.
- The commonly used coaxial cable is 10base2 that transmits over a distance of 185 m, and 10base5 that transmits over a distance of 500 m

Check 10Base2, 10Base5, 100Base-Tx mean ???

Course Contents

Optical Fiber:

- Optical fibers are being used for transmission of information over large distances more cost effectively than the copper wire connection. Communication systems are now unthinkable without fiber optics.
- Optical fiber transmits data as light signals instead of electric signals.
- An optical fiber cable consists of
  1) Core - optical fiber conductor (glass) that transmits light,
  2) Cladding - an optical material that surrounds the core to prevent any light from escaping the core, and
  3) Jacket - outer covering made of plastic to protect the fiber from damage.

Course Contents

Optical Fiber:

- Modern optical fiber cables can contain up to a thousand fibers in a single cable, so the performance of optical networks easily accommodate large demands for bandwidth on a point-to-point basis.
- Optical fibers come in two types:
  1) Single-mode fibers, and
  2) Multi-mode fibers
  - Single-mode fibers have small cores (about 3.5×10^{-4} inches or 9 microns in diameter) and transmit infrared laser light (wavelength = 1,300 to 1,550 nanometers).
  - Multi-mode fibers have larger cores (about 2.5×10^{-3} inches or 62.5 microns in diameter) and transmit infrared light (wavelength? 850 to 1,300 nm) from Light Emitting Diodes (LEDs).

Course Contents

Optical Fiber: The Advantages of Optical Fibers over wires are:

- Optical fibers do not cause electrical interference in other cables, since they use light signals.
- Due to much lower attenuation and interference, optical fiber has large advantages over existing copper wire in long-distance and high-demand applications.
- A fiber can carry a pulse of light much farther than a copper wire carrying a signal.
- Optical fiber can carry more information than a wire (light can encode more information than electrical signal).
- A single optical fiber is required for light to travel from one computer to another (two wires are required for electric connection).
- Because signals in optical fibers degrade less, lower-power transmitters can be used instead of the high-voltage electrical transmitters needed for copper wires.
- No amplification of the optical signal is needed over distances of hundreds of kilometers. This has greatly reduced the cost of optical networking, particularly over undersea spans where the cost reliability of amplifiers is one of the key factors determining the performance of the whole cable system.
- Optical fibers are ideally suited for carrying digital information, which is especially useful in computer networks.
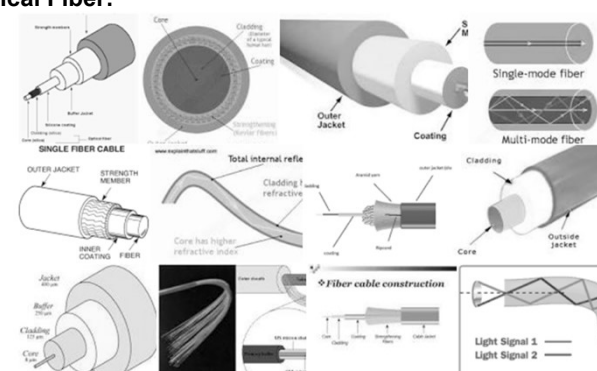- They are highly secure as they cannot be tapped and for lack of signal radiation.

Course Contents

Optical Fiber: The Disadvantages of Optical Fiber are:

- Installing an optical fiber requires special equipment.
- If a fiber breaks, finding the broken location is difficult.
- Repairing a broken optical fiber is difficult and requires special equipment.
- Due to its high installation costs, they are economical when the bandwidth utilization is high.

Course Contents

Optical Fiber:

Course Contents

Guided and the unguided data transmission media:

Radio Transmission:

The electromagnetic radio waves that operate at the radio frequency are also used to transmit computer data. This transmission is also known as Radio Frequency RF) transmission. The computers using RF transmission do not require a direct physical connection like wires or cable. Each computer attaches to an antenna hat can both send and receive radio transmission.

Course Contents

Guided and the unguided data transmission media:
Microwave Transmission:

- Microwave transmission refers to the technique of transmitting information over a microwave link.
- Microwaves have a higher frequency than radio waves.
- Microwave transmission can be aimed at a single direction, instead of broadcasting in all directions (like in radio waves). Microwaves can carry more information than radio waves but cannot penetrate metals.
- Microwaves are used where there is a clear path between the transmitter and the receiver.

Course Contents

Guided and the unguided data transmission media:
Microwave Transmission:

- Microwave transmission has the advantage of not requiring access to all contiguous land along the path of the system, since it does not need cables.
- They suffer from the disadvantages: a) needing expensive towers and repeaters, and b) are subject to interference from passing airplanes and rain.
- Because microwave systems are line-of-sight media, radio towers must be spaced approximately every 42 km along the route.

Course Contents

Guided and the unguided data transmission media:
Satellite Transmission:

- The communication across longer distances can be provided by combining radio frequency transmission with satellites. Geosynchronous satellites are placed in an orbit synchronized with the rotation of the earth at a distance of 36,000 km above the surface of the earth.
- Geosynchronous satellites appear to be stationary when viewed from the earth.
- The satellite consists of transponder that can receive RF signals and transmit them back to the ground at a different angle. A ground station on one side of the ocean transmits signal to the satellite which in turn sends the signal to the ground station on the other side of the ocean

Course Contents

Data Transmission across Media:

- Transmission modes - simplex, half-duplex, full-duplex
- Transmission speed - Bandwidth, throughput, attenuation, distortion
- Fundamentals of transmission - Electromagnetic waves, signals
  - Analog and digital signals
  - Modulation and demodulation - Amplitude, frequency, phase shift
  - Multiplexing - FDM, WDM
  - Asynchronous and synchronous transmission

Course Contents

Data Transmission across Media:

Transmission modes:

The direction in which data can be transmitted between any two linked devices is of three types

(1) Simplex,
(2) Half-duplex, and
(3) Full-duplex, or duplex.

Course Contents

Data Transmission across Media:

Transmission modes:
(1) Simplex,
Simplex transmission is unidirectional data transmission. Of the two linked devices, only one of them can send data and the other one can only receive data.
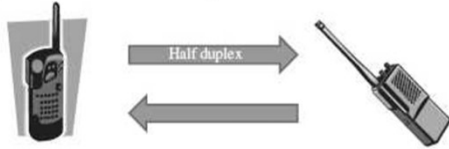
Course Contents

Data Transmission across Media:

Transmission modes:

2. Half-duplex

Half–duplex transmission is bi-directional data transmission, but the linked devices cannot send and receive at the same time. When one device is sending data the other can only receive.
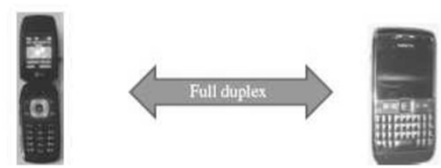

Course Contents

Data Transmission across Media:

Transmission modes:

2. Full-duplex

Full-duplex transmission is bi-directional and the linked devices can send and receive data simultaneously. The linked devices can send data and at the same time receive data.

Course Contents

Transmission Speed:

- When the signals are transmitted between two computers, two factors need to be considered - (1) Bandwidth, and (2) Distance.
- Bandwidth is the amount of data that can be transferred through the underlying hardware i.e. the communication medium, in a fixed amount of time. Bandwidth is measured in cycles per second (cps) or Hertz (Hz). The bandwidth of the transmission medium determines the data transfer rate.
- Throughput is the amount of data that is actually transmitted between the two computers. Throughput is specified in bits per second (bps). The throughput capability of the communication medium is also called bandwidth. The bandwidth of the communication medium is the upper bound on the throughput, because data cannot be sent at a rate more than the throughput of the communication medium.
- Higher throughput is achieved by using a large part of the electromagnetic spectrum (large bandwidth). Technology that uses large part of the electromagnetic spectrum to achieve higher throughput is known as broadband technology. The technology that uses small part of the electromagnetic spectrum is known as baseband technology.

Course Contents

Transmission Speed:

- Throughput is affected by the distance between the connected computers or devices. Even if a transmission medium is designed for a specific bandwidth, the throughput is affected by the distance of communication.
- The bandwidth of transmission medium is limited by the distance over which the medium needs to transmit the signal. The bandwidth decreases with the increase in the distance between the connected devices. When a signal has to travel long distance, the signal strength decreases; the signal strength is utilized to overcome the resistance offered by the connecting medium (cable or wire). The gradual deterioration of signal strength across long distances is called attenuation.
- Moreover, with increasing distance the external disturbance increases, which causes the signal to deteriorate and results in less amount of data to be transferred. The degradation of signal due to internal or external disturbances is called distortion.
- The bandwidth and distance of the transmission medium is selected so that it offers minimum attenuation and minimum distortion.
- The cat-5 UTP cable has a throughput of 100 Mbps over a distance of 100m. The 10base2 coaxial cable has a throughput up to 10Mbps over a distance of 185 m. The 10base5 coaxial cable has a throughput up to 10Mbps over a distance of 500 m.

Note : Attenuation (wave shape same) Vs Distortion (Wave shape distort)?

Course Contents

Transmission Speed: Bandwidth

- All signals that are transmitted consist of multiple frequencies. The range of frequencies a signal occupies is called the bandwidth of the signal. The bandwidth is measured in terms of Hertz (Hz).
- The bandwidth of a signal depends on the amount of information contained in it and the quality of it. The range of frequencies necessary for an analogue voice signal, with a fixed telephone line quality (recognizable speaker), is 300 - 3400 Hz. This means that the bandwidth of the signal is 3,100 Hz. A human voice contains much higher frequencies, but this bandwidth gives a good compromise between the quality of the signal and the bandwidth. To transmit audio, a much wider bandwidth of about 20 kHz is needed. The bandwidth of a television signal is in the order of 5,000,000 Hz or 5 MHz
- Bandwidth, together with noise, is the major factor that determines the information-carrying capacity of a telecommunications channel. The term bandwidth is often used instead of data rate or bit rate to express the capacity of a digital channel. Although they are closely related, they are not the same.

Course Contents

Fundamentals of Transmission:

- Telecommunication systems use electromagnetic waves to transfer information. Electromagnetic waves can travel through transmission media like copper wires, fiber optics or as radio waves. They can also travel in vacuum. Wireless communication uses electromagnetic waves for transmission of information. The transmission media through which the waves propagate are not perfect. As a result, the waves propagated via the transmission media get attenuated and distorted.
- The information to be transmitted does not always exist in a form that is compatible with the transmission medium. Waves that are compatible with the transmission medium must be generated to carry information. A signal is a wave that is suitable for carrying information over a transmission medium.
- Signals can be electric signals, light signals, electromagnetic signals or radio signals. Electric signals are used to carry information through copper wires, light signals for fiber optic cables, and radio signals for carrying information in free space. Electrical signals have limited bandwidth and cannot be used in long distance communication. They need to be amplified or regenerated. Light signals have a high bandwidth and are suited for long distance communication.

Course Contents

Analog and Digital Signals:

- Information carrying signals are of two types :
  (a) analog signal, and (b) digital signal

Figure 9.9 (a) Digital signal (b) Analog signal

Course Contents

Analog and Digital Signals:

- Analog Signal: An analog signal is a wave that continuously changes its information carrying properties over time. The wave may vary in amplitude or frequency in response to changes in sound, light, heat, position, or pressure etc. For example a telephone voice signal is analog. The intensity of the voice causes electric current variations. At the receiving end, the signal is reproduced in the same proportion.

- Digital Signal: A digital signal is a wave that takes limited number of values at discrete intervals of time. Digital signals are non-continuous, they change in individual steps. They consist of pulses or digits with discrete levels or values. The value of each pulse is constant, but there is an abrupt change from one digit to the next. Digital signals have two amplitude levels called nodes. The value of which are specified as one of two possibilities such as 1 or 0, HIGH or LOW, TRUE or FALSE, and so on.

- Analog and digital signals are compared on the basis of—(1) impact of noise, (2) loss of information, and (3) introduction of error.

Course Contents

Analog and Digital Signals:

- Analog signal has the potential for an infinite amount of signal resolution with A/D converter. Another advantage with analog signals is that they can be processed more easily than their digital equivalent. The primary disadvantage of the analog signals is the noise. The effects of noise create signal loss and distortion, which is impossible to recover, since amplifying the signal to recover attenuated parts of the signal, also amplifies the noise. Even if the resolution of an analog signal is higher than a comparable digital signal, the difference can be overshadowed by the noise in the signal. In digital systems, degradation can not only be detected, but corrected as well.

- Amplifier is any device or a circuit that changes, usually increases, the amplitude of an analog signal.

- Repeater is an electronic device that receives a signal and retransmits it at a higher level and/or higher power, so that the signal can cover longer distances. With physical media like Ethernet or Wi-Fi, data transmissions can only span a limited distance before the quality of the signal degrades. Repeaters attempt to preserve signal integrity and extend the distance over which data can safely travel. Actual network devices that serve as repeaters usually have some other name. Active hubs, for example, are repeaters. Active hubs are sometimes also called "multiport repeaters," but more commonly they are just "hubs."

Communication and Computer Network

Basic Analog communication system block diagram

Communication and Computer Network

Analog Signal Characteristics
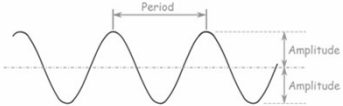
- Amplitude, Frequency and Phase

Communication and Computer Network

Period:

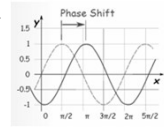Some functions (like Sine wave) repeat forever and are called Periodic Functions.

Communication and Computer Network

Amplitude:

The Amplitude is the height from the center line to the peak Or we can measure the height from highest to lowest points and divide that by 2.
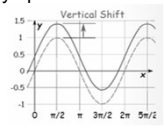
Communication and Computer Network

Phase:

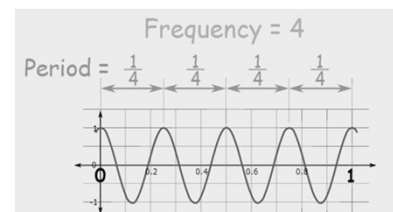The Phase Shift is how far the function is horizontally to the right of the usual position.

The Vertical Shift is how far the function is vertically up from the usual position.
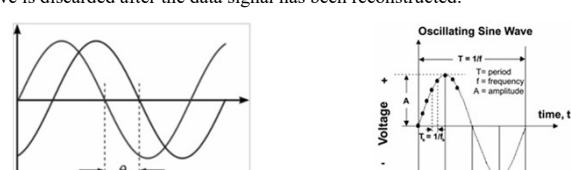
Communication and Computer Network

Frequency:

Frequency is how often something happens per unit of time (per "1").

Communication and Computer Network

Modulation and Demodulation

- The process of changing some characteristics (Amplitude, Frequency or Phase) of a carrier wave in accordance with the intensity of the signal is known as modulation. The resultant wave is called the modulated wave or radio wave. For transmission purposes, a high frequency carrier wave is used to carry the audio signals.

- The process of segregating the data signal and the carrier signal from the modulated carrier wave is called demodulation. At the receiving end, the carrier wave is discarded after the data signal has been reconstructed.

Communication and Computer Network

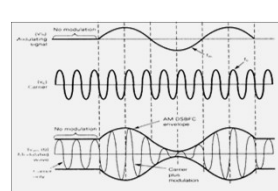**Types of Modulation**

There are 3 types of analog modulation

1. **Amplitude Modulation (AM)**
2. **Frequency Modulation (FM)**
3. **Phase Modulation (PM)**

Communication and Computer Network

Types of Modulation

There are 3 types of analog modulation

1. **Amplitude Modulation (AM):** When the amplitude of the high frequency carrier wave is changed in accordance with the intensity of the signal, it is called amplitude modulation. In amplitude modulation only the amplitude of the carrier wave is changed while the frequency of the modulated wave remains the same.
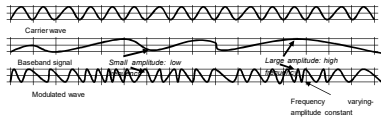
Communication and Computer Network

Types of Modulation

There are 3 types of analog modulation

2. **Frequency Modulation (FM):** When the frequency of the carrier wave is changed in accordance with the intensity of the signal it is called frequency modulation. In FM, only the frequency of the carrier is changed while the amplitude of the modulated wave remains the same.
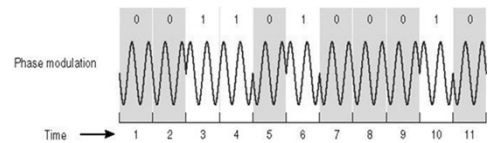
Carrier wave

Baseband signal   Small amplitude: low   Large amplitude: high

Modulated wave

Frequency varying- amplitude constant

Communication and Computer Network

Types of Modulation

There are 3 types of analog modulation

3. **Phase Modulation (PM):** Phase modulation is a change in the carrier phase angle, which can not change without affecting a change in frequency. Therefore PM is in a second form of frequnecy modulation (FM).

Phase modulation

Time → 1 2 3 4 5 6 7 8 9 10 11

Communication and Computer Network
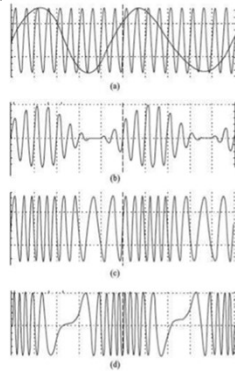
Types of Modulations

Figure 9.10 (a) Carrier wave with signal (b) Amplitude modulation (c) Frequency modulation (d) Wavelength modulation

---

Communication and Computer Network

Modems

➢ Modem is a device that has both a modulator and a demodulator. Modulator accepts data signals from the computer and modulates the carrier wave accordingly. Demodulator accepts modulated carrier wave and regenerates the original data signal from it. During data communication, modem is attached to the computer, both at the sender and the receiver side. Modems are used with all transmission media like RF modem for RF transmission and optical modem for transmission through fiber optics.

Communication and Computer Network

Multiplexing:

➢ Transmission medium have varying data carrying capacities. To utilize the full capacity of the transmission medium, computer networks use separate channels that allow sharing of a single physical connection for multiple communication. Multiple carrier signals are transmitted over the same medium at the same time and without interference from each other.

➢ The combining of multiple signals into a form that can be transmitted over a single link of a communication medium is called multiplexing.

➢ De-multiplexing is a technique of separating the merged signals and sending them to the corresponding receivers.

➢ The two basic multiplexing techniques are
   ➢ Frequency Division Multiplexing (FDM) and
   ➢ Wavelength Division Multiplexing (WDM).

Communication and Computer Network

Multiplexing:

S1 — D1
S2 — D2
S3 — D3
(a)

S1
S2   MULTIPLE-XOR   DEMULTIPLE-XOR   D1
S3   D2
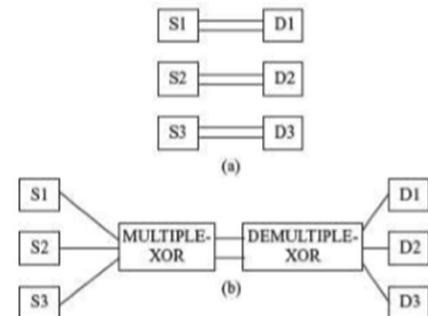(b)   D3

Figure 9.12 (a) No multiplexing (b) Multiplexing

Communication and Computer Network

Multiplexing:

➤ FDM combines different carrier frequencies signals into a single signal of higher bandwidth. The bandwidth of the communication medium link carrying the combined signal is greater than the sum of the bandwidth of the individual signals that are combined.

➤ FDM is used for high band - width analog transmission systems like broadband technology.

➤ WDM is similar to FDM except that FDM involves electromagnetic spectrum below light and WDM involves light signals. WDM uses very high frequencies. WDM combines different light signals coming from different sources into a larger band light signal across a single optical fiber. It also enables bi-directional communications over one strand of fiber.
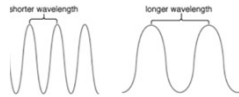
Communication and Computer Network

Asynchronous and Synchronous Transmission:

➤ One major difficulty in data transmission is that of synchronizing the receiver with the sender. Whenever an electronic device transmits digital (and sometimes analog) data to another electronic device, there must be a certain rhythm established between the two devices, i.e., the receiving device must have some way of knowing, within the context of the fluctuating signal that it is receiving, where each unit of data begins, and ends. The signal must be synchronized in a way that the receiver can distinguish the bits and bytes as the transmitter intends them to be distinguished. Two approaches exist to address the problem of synchronization.

• synchronous transmission, and

• asynchronous transmission.

Communication and Computer Network

Asynchronous and Synchronous Transmission:

➤ Synchronous communication is the characteristic of a communication system in which the sender must coordinate (i.e. synchronize) with the receiver before sending data. The network is designed to move the data at the precise rate, which is not affected by the increase or decrease in network traffic. Voice system network use the synchronous transmission.

➤ Asynchronous communication is a characteristic of a communication system in which the sender and receiver do not coordinate before the transmission of data. The receiver must be prepared to accept data at any time. The sender can wait when no data is available and send when data is available for sending. Most of the data networks use asynchronous transmission.

Communication and Computer Network

Data Transmission and Data Networking:

Two devices(computers) can communicate using two methods

1. Point to Point communication
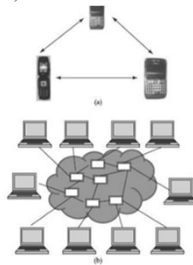2. Share communication facility (a network of nodes)

➤ Two devices directly linked via a communication medium (point to point communication) can send and receive data, to and from each other respectively.

➤ For long distance communication, instead of point to point connection, a network of nodes is used as a communication medium. The different computers attached to the network share the communication facility.

➤ The computer network provides a convenient interface that handles sending of multiple bytes of data across the network instead of handling data transmission at physical level.

Communication and Computer Network

Data Transmission and Data Networking:

Two devices(computers) can communicate using two methods

1. Point to Point communication
2. Share communication facility (a network of nodes)

Figure 9.15 (a) Point-to-point communication (b) Switching

Communication and Computer Network

Switching:

➤ A network cannot allow or deny access to a shared communication facility. All computers attached to the network can use it to send and receive data.

➤ Networks allow sharing of communication medium using switching.

➤ Switching routes the traffic (data traffic) on the network. It sets up temporary connections between the network nodes to facilitate sending of data. Switching allows different users, fair access to the shared communication medium.

There are three kinds of switching techniques:

1) Circuit switching
2) Message switching
3) Packet switching

Computer networks generally use packet switching, occasionally use circuit switching but do not use message switching.

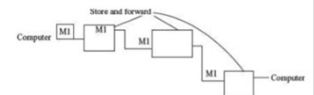## Communication and Computer Network

Circuit Switching:
- Circuit switching sets up end-to-end communication path between the source and the destination, before the data can be sent. The path gets reserved during the duration of the connection. Circuit switching is commonly used in the telephone communication network.
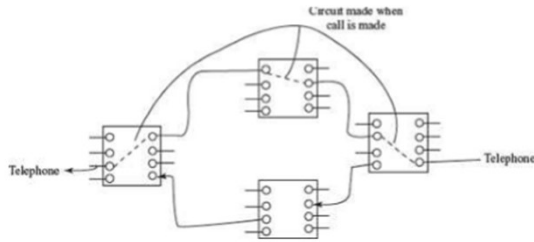
Communication and Computer Network

Message Switching:
- Message switching does not establish a physical path in advance between the sender and the receiver. It uses the 'store and forward' mechanism.
- In this mechanism, the network nodes have large memory storage. The message is received from the sender and stored in the network node, and when it finds a free route, it forwards the message to the next node till it reaches the destination.
- Message switching requires large data storage capacity and incurs delay in storing and forwarding of message. Message switching may block the network nodes for a long time. They are thus not suitable for interactive communication. Message switching is no more used in computer networks.

Communication and Computer Network

Packet Switching:
- Like message switching, packet switching does not establish a physical path between the sender and the receiver, in advance.
- Packet switching also uses the 'store and forward' mechanism. However, instead of a complete message, packets are sent over the network. Packet switching splits a message into small "packets" of defined size to be sent over the network. Each packet is numbered.
- A packet is a self-contained part of data that can be sent over the network. A packet contains the data to be transmitted and a header that contains information about the packet, like the source and destination addresses, size of packet, error checking bytes etc.
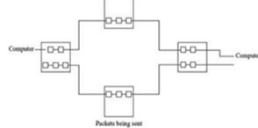
Communication and Computer Network

Packet Switching:
- Since the path through which the packets travel is not reserved, the packets may travel through different paths in the network and may not reach the destination in order. At the destination, the received packets are reassembled (according to the packet number), and the complete message is constructed.
- Packet switching is suited for interactive traffic. Packet switching limits the size of the packet and does not block a network node for a long time. Moreover, a node can transmit a packet before the arrival of another full packet, thus reducing the delay.
- Packet switching does not require dedicated communication link, and shares the underlying resources.
- Packet switching is commonly used for computer networks, including the Internet.

Data Communication and Computer Network

Computer Network:
- A computer network is an interconnection of two or more computers that are able to exchange information. The computers may be connected via any data communication link, like copper wires, optical fibers, communication satellites, or radio links. The computers connected to the network may be personal computers or large main frames. The computers in a network may be located in a room, building, city, country, or anywhere in the world.

Data Communication and Computer Network

Network Types:
- Computer network is broadly classified into three types
  1) Local Area Network (LAN),
  2) Metropolitan Area Network (MAN), and
  3) Wide Area Network (WAN).
- The different network types are distinguished from each other based on the following characteristics:
  1) Size of the network
  2) Transmission Technology
  3) Networking Topology
- The size of the network refers to the area over which the network is spread.
- Transmission technology refers to the transmission media used to connect computers on the network and the transmission protocols used for connecting.
- Network topology refers to the arrangement of computers on the network or the shape of the network.

Data Communication and Computer Network
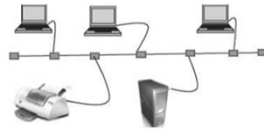
Network Types (Size of the network):
1.   Local Area Network:

What is LAN ?

What protocol does it use?

What topology does LAN use ?

Types of LAN ?
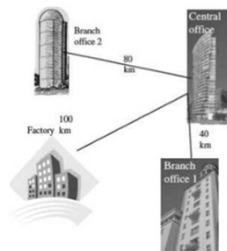

Data Communication and Computer Network

Network Types (Size of the network): 1. Local Area Network:

- LAN is a computer network widely used for local communication. LAN connects computers in a small area like a room, building, office or a campus spread up to a few kilometers. They are privately owned networks, with a purpose to share resources and to exchange information.
- The computers in a LAN are generally connected using cables. LAN is different from other types of network since they share the network. The different computers connected to a LAN take turns to send data packets over the cables connecting them. This requires coordination of the use of the network.
- Some of the transmission protocols used in LAN are Ethernet, Token bus, and FDDI (Fiber Distributed Data Interface) ring.
- Star, Bus, and Ring are some of the common LAN networking topologies. LAN runs at a speed of 10 Mbps to 100 Mbps and has low delays. A LAN based on WiFi wireless network technology is called Wireless Local Area Network (WLAN)

Data Communication and Computer Network

**Network Types (Size of the network):2. Metropolitan Area Network**

MAN is a computer network spread over a city. Cable television network is an example of MAN. The computers in a MAN are connected using coaxial cables or fiber optic cables. MAN also connects several LAN spread over a city.

Data Communication and Computer Network

Network Types (Size of the network): 2. Wide Area Network

WAN is a network that connects computers over long distances like cities, countries, continents, or worldwide. WAN uses public, leased, or private communication links to spread over long distances. WAN uses telephone lines, satellite link, and radio link to connect. The need to be able to connect any number of computers at any number of sites, results in WAN technologies to be different from the LAN technologies. WAN network must be able to grow itself. Internet is a common example of WAN.
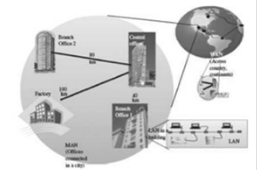
Data Communication and Computer Network

Network Topology:

There are different types of network topologies that are used in a network. The network topologies in the structure or the layout of the different devices and computers connected to the network. The topologies commonly used in LAN are

   1) Bus topology,
   2) Star topology, and
   3) Ring topology.

In some book, Network topologies are classified as

   1. BUS
   2. RING
   3. STAR
   4. MESH
   5. TREE
   6. HYBRID

Data Communication and Computer Network

Bus Topology:

- All devices on the network are connected through a central cable called a Bus.
- The data signal is available to all computers connected to the bus .
- The data signal carries the address of the destination computer.
- Each computer on the network checks the destination address as the data signal travels through the bus. The computer whose address matches makes a copy of the signal and converts it into data. The data signal on the bus does not get destroyed and still transmits along the bus, and is finally absorbed by the terminator attached to the end of the network.
- It is good for connecting 15–20 computers.
- A single coaxial cable is generally used in bus topology, to which the computers or devices are connected.
- Ethernet is a commonly used protocol in networks connected by bus topology.

Data Communication and Computer Network
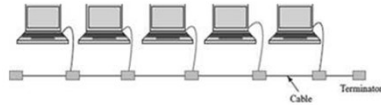
Bus Topology:

Advantages of Bus Topology
- It is cost effective.
- Cable required is least compared to other network topology.
- Used in small network
- It is easy to understand
- Easy to expand joining two cables together.

Disadvantages of Bus Topology
- Cable fails then whole network fails
- If network traffic is heavy or nodes are more the performance of the network decreases
- Cable has a limited length
- It is slower than the ring topology

Data Communication and Computer Network

Ring Topology:

- All devices in the network are connected in the form of a ring.
- Each device has a receiver and transmitter to receive the data signals and to send them to the next computer, respectively.
- Ring network does not have terminated ends, thus data signals travel in a circle. Ring topology uses token passing method to provide access to the devices in the network.
- The computers or devices are connected to the ring using twisted pair cables, coaxial cables or optic fibers.
- The protocols used to implement ring topology are Token Ring and Fiber Distributed Data Interface (FDDI).
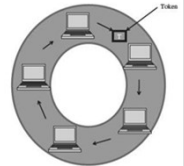
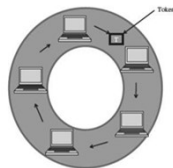## Data Communication and Computer Network

Ring Topology:

Advantages of Ring Topology
- Transmitting networks is not affected by high traffic or by adding more nodes as only the nodes having tokens can transmit data.
- Cheap to install and expand

Disadvantages of Ring Topology
- Trouble shooting is difficult in ring topology
- Adding or deleting the computers disturbs the network activity
- Failure of one computer disturbs the whole network.

Data Communication and Computer Network

Star Topology:

- All devices are connected through a central link forming a star-like structure.
- The central link is a hub or switch. The computers are connected to the hub or switch using twisted pair cables, coaxial cables or optic fibers.
- Star topology is the most popular topology to connect computer and devices in network.
- The data signal is transmitted from the source computer to the destination computer via the hub or switch.
- The common protocols used in star topology are Ethernet, Token Ring, and LocalTalk.
- In addition to the bus, ring, and star topologies, there are complex topologies like the tree topology, and the mesh topology used for networking in LAN.

Data Communication and Computer Network

Star Topology:

Advantages of Start Topology
- Fast performance with few nodes and low network traffic
- Hub can be upgraded easily
- Easy to troubleshoot
- Easy to set up and modify
- Only that nodes is affected which has failed and rest of the nodes can work smoothly.

Advantages of Start Topology
- Cost of installation is high
- Expensive to use
- If the hub effected then the whole network is stopped because all the nodes depend on the hub
- Performance is based on the hub that is it depends upon its capacity.

Data Communication and Computer Network

- In addition to the bus, ring, and star topologies, there are complex topologies like the tree topology, and the mesh topology used for networking in LAN.
- Table lists the advantages and disadvantages of the different LAN network topologies.
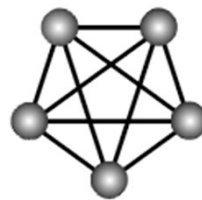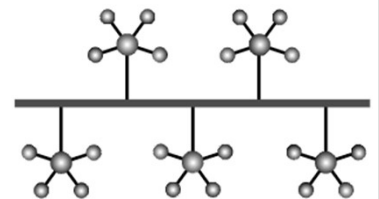

Mesh network   Tree network

Data Communication and Computer Network

Communication Protocol:

➢ All computers in the network use the protocol software. The network communication protocol is organized as a stack of layers with one layer built upon the other. Each layer has a specific function and interacts with the layers above and below it. The outgoing data from a computer connected to the network passes down through each layer and the incoming data passes up through each layer. The corresponding layers on the different machines are called **peers**. The peers interact with each other using the protocol.
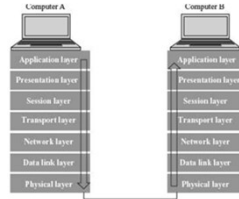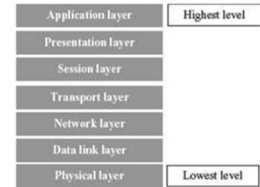

Data Communication and Computer Network

Communication Protocol: OSI Reference Model

The International Standards Organization (ISO) has developed a seven-layer reference model for data networks, known as Open System Interconnection (OSI) model. The OSI model specifies the functions of each layer. It does not specify how the protocol needs to be implemented. It is independent of the underlying architecture of the system and is thus an open system.

The seven layers of the OSI model are

(1) Physical layer,
(2) Data link layer,
(3) Network layer,
(4) Transport layer,
(5) Session layer,
(6) Presentation layer, and
(7) Application layer.

The functions of the different layers are as follows:

Data Communication and Computer Network

Communication Protocol:

➢ Physical Layer: This layer specifies the basic network hardware. Some of the characteristics defined in the specification are - interface between transmission media and device, encoding of bits, bit rate, error detection parameters, network topology, and the mode of transmission (duplex, half-duplex or simplex).

  Layer 1 is anything that carries 1's and 0's between two nodes.

➢ Data Link Layer: This layer specifies the functions required for node-to-node transmission without errors. It specifies the organization of data into frames, error detection in frames during transmission, and how to transmit frames over a network.

  Data Link layer is to deliver packets from one NIC to another. Layer 2 uses MAC addresses and is responsible for packet delivery from hop to hop.

➢ Network Layer: The network layer specifies the assignment of addresses (address structure, length of address etc.) to the packets and forwarding of packets to the destination i.e. routing.

  Layer 3 uses IP addresses and is responsible for packet delivery from end to end.

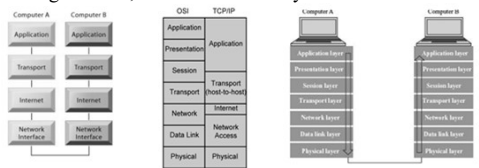
Data Communication and Computer Network

Communication Protocol:

➢ Transport Layer: It specifies the details to handle reliable transfer of data. It handles end-to-end error control and flow control, breaking up data into frames and reassembling the frames.

  Layer 4 is responsible for service to service delivery

➢ Session Layer: The session layer maintains a session between the communicating devices. It includes specifications for password and authentication, and maintaining synchronization between the sender and the receiver.

➢ Presentation Layer: This layer specifies the presentation and representation of data. Its functions include translation of the representation of the data into an identifiable format at the receiver end, encryption, and decryption of data etc.

➢ Application Layer: This layer specifies how an application uses a network. It deals with the services attached to the data. It contains the protocols used by users like HTTP, protocol for file transfer and electronic mail

---
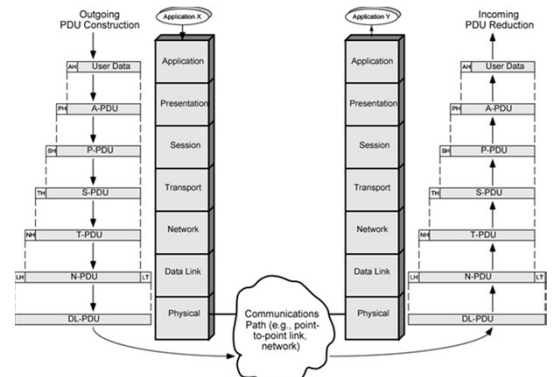
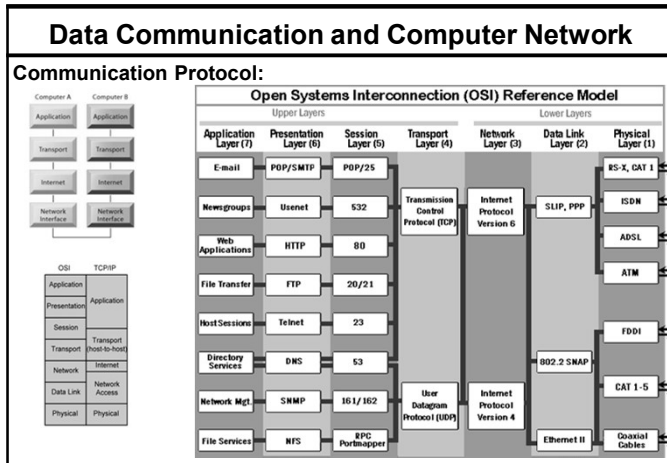## Data Communication and Computer Network

Communication Protocol:

➢ Each layer at the sender's side transforms the data according to the function it handles. For this it attaches headers to the data. At the receiver's side, the corresponding layer applies the inverse of the transformation that has been applied at the source.

➢ As an example, if the Data link layer at the sender's side adds an error detection code to the frame, then at the receiver's side, the Data link layer verifies the error detection code and removes it from the frame before passing it to the next higher level, i.e. the Network layer.

Data Communication and Computer Network

Communication Protocol:

Data Communication and Computer Network

Communication Protocol:

Data Communication and Computer Network

Communication Protocol:

- The 7-layer ISO reference model forms a framework for communication between the devices attached to the network. For different networks, the number of layers and their functions may vary.
- For example, the TCP/IP Internet protocol is organized into five layers.
- The X.25 Wide Area Network protocol (the first public data network) provides connectivity to Public Switched Telephone Network (PSTN) network and has three layers.

Data Communication and Computer Network

Communication Protocol:

- Protocol in a network is a set of rules used by a network for communication.
- Data networks are a combination of software and hardware components. The hardware includes transmission media, devices, and transmission equipments.
- The software allows the hardware to interact with one another and provide access to the network.
- The application programs that use the network do not interact with the hardware directly. The application programs interact with the protocol software, which follows the rules of the protocol while communicating.

Data Communication and Computer Network

Network Devices:

- The cables are used to transmit data in the form of signals from one computer to another. But cables cannot transmit signals beyond a particular distance.
- There is a need to connect multiple computers and devices.
- A concentrator is a device having two or more ports to which the computers and other devices can be connected.
- A concentrator has two main functions—(1) it amplifies the signal and (2) it provides an interface to connect multiple computers and devices in a network.
- Repeater, hub, switch, bridge, and gateway are examples of network connecting devices.
- Two or more LANs using different protocols may not be able to communicate with the computers attached to their network.
- For example, a LAN connected using Ethernet may not be able to communicate with a LAN connected using Token Ring.
- Bridge, Router, and Gateway are devices used to interconnect LANs.

Data Communication and Computer Network

Network Devices:

1. Network Interface Card
2. Repeater
3. Bridge
4. Hub
5. Switch
6. Router
7. Gateway

Data Communication and Computer Network

Network Devices: Network Interface Card

- A Network Interface Card (NIC) is a hardware device through which the computer connects to a network.
- NIC is an expansion card, it can be either ISA or PCI, or can be on-board integrated on a chipset. NIC has an appropriate connector to connect the cable to it. NIC for different LAN are different (NIC for token ring is different from NIC for Ethernet).
- NIC work at both the data link layer and physical layer of the OSI reference model.
- At the data link layer, NIC converts the data packets into data frames, adds the Media Access address (MAC address) to data frames. At the physical layer, it converts the data into signals and transmits it across the communication medium. The MAC address is a globally unique hardware number present on the NIC and is specified by the NIC manufacturer.
- NIC depends upon the configuration of the computer, unlike hub or switches that perform independently.

Data Communication and Computer Network

**Network Devices:** Network Interface Card

Data Communication and Computer Network

Network Devices: Repeater

- Repeaters are used to extend LAN. It has only two ports and can connect only two segments of a network. Multiple repeaters can be used to connect more segments. (Segment is a logical section of the same network).
- Repeaters operate at the Physical layer of OSI reference model.
- They are useful when computers in a network are located far away from each other.
- Repeaters amplify the signal so that the signal is as strong as the original signal. They can thus extend the reach of a network.
- Repeaters cannot be used if multiple computers need to be interconnected.
- Repeaters cannot identify complete frames. Thus, in addition to the valid transmissions from one segment to another, repeater also propagates any electrical interference occurring on a segment to other segment.

Data Communication and Computer Network
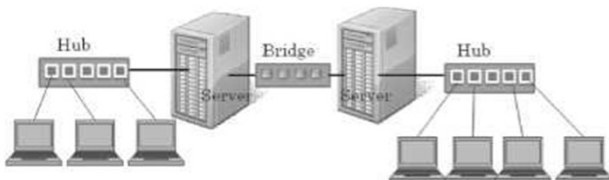
Network Devices: Repeater
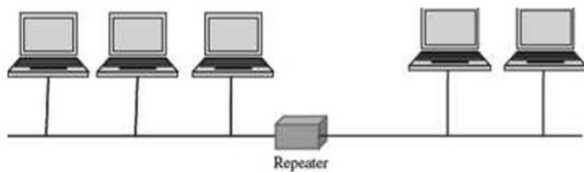
Data Communication and Computer Network

Network Devices: Bridge

- Bridge is used to connect two LAN segments like a repeater; it forwards complete and correct frames to the other segment. It does not forward any electrical interference signals to the other segment.
- Bridge forwards a copy of the frame to the other segment, only if necessary. If a frame is meant for a computer on the same segment, then bridge does not forward a copy of the frame to other segment.
- Bridge connects networks that use different protocol at the Data Link Layer. The frame format of data in the two networks is different. The bridge converts the frame format before transmitting data from one network to another, with translation software included in the bridge.
- A bridge is also used to divide a network into separate broadcast domains to reduce network traffic while maintaining connectivity between the computers.

Data Communication and Computer Network
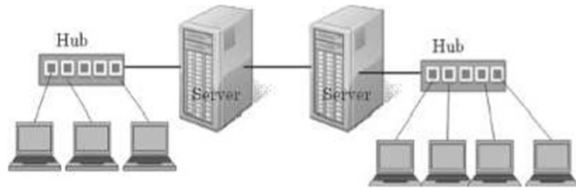
Network Devices: Bridge

Data Communication and Computer Network

Network Devices: Hub

- It is like a repeater with multiple ports. But, hub does not amplify the incoming signal.
- Hub operates at the Physical layer of OSI reference model, hence treats data as a signal.
- Hubs are used to connect multiple segments of the same network.
- Hubs are also used to connect computers to network that use Star topology.
- The port on the hubs can also be used to connect another hub, switch, bridge or router.
- Hubs increase the network traffic because they broadcast data to all the device connected all the ports of the hub.
- It is preferable to use a hub in a small LAN having about 8–10 computers connected to it.

Data Communication and Computer Network

Network Devices: Hub

Data Communication and Computer Network

Network Devices: Switch

- Like hub, switch also connects multiple computers in a network or different segments of the same network. A hub simulates a single segment that is shared by all computers attached to it (hub transmits the data to all computers attached to it). In a hub, at most two computers can interact with each other at a given point of time. However, in a switch each computer attached to a switch has a simulated LAN segment.
- Switches work at the Data Link Layer of the OSI reference model. Hence, switches consider data as frames and not as signals.
- A data frame contains the MAC address of the destination computer. A switch receives a signal as a data frame from a source computer on a port, checks the MAC address of the frame, forwards the frame to the port connected to the destination computer having the same MAC addresses, reconverts the frame back into signal and sends to the destination computer. (Switching is a technique that reads the MAC address of the data frame and forwards the data to the appropriate port). Switches, thus, regenerate the signals.
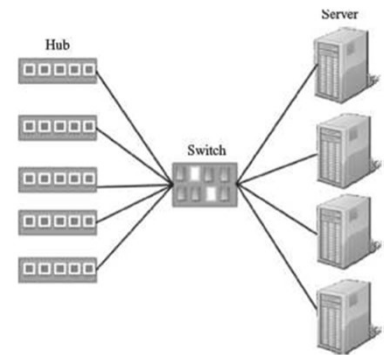
Data Communication and Computer Network

Network Devices: Switch

- Since a switch does not broadcast data, but sends the data from the source computer to the destination computer, a half of the computers attached to the switch can send data at the same time.
- Switch is also referred to as a multi-port bridge. In general, bridges are used to extend the distance of the network, and switches are primarily used for their filtering capabilities to create a multiple and smaller virtual LAN (a LAN segment can be connected to each port of the switch) from a single large LAN.

Data Communication and Computer Network
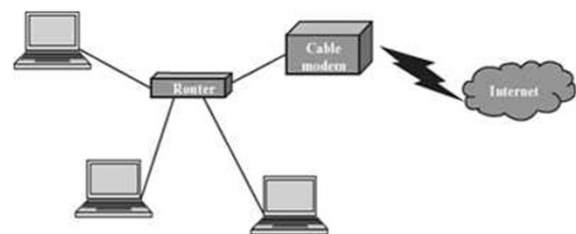
Network Devices: Switch

Data Communication and Computer Network

Network Devices: Router

- Router is used to connect heterogeneous networks.
- A router has a processor, memory, and I/O interface for each network to which it connects.
- A router connects networks that use different technologies, different media, and physical addressing schemes or frame formats. A router can connect two LANs, a LAN and a WAN, or two WANs.
- A router is used to interconnect the networks in the Internet.
- Router operates at the Network layer of the OSI model (layer 3).
- Physically, a router resembles a bridge, but is different from a bridge. A router determines which way is the shortest or fastest in a network, and routes packets accordingly. Since it works at the Network layer, it moves packets based on the IP addresses etc. In contrast, a bridge connects two LANs almost permanently.

Data Communication and Computer Network

Network Devices: Router
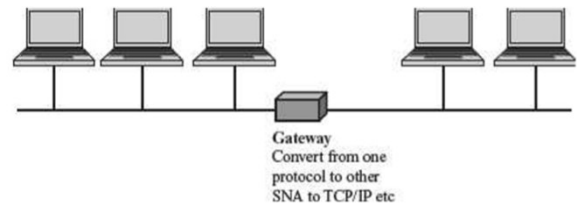
Data Communication and Computer Network

Network Devices: Gateway

- Gateway is a generic term used to represent devices that connect two dissimilar networks.
- A gateway at the transport layer converts protocols among communications networks. It can accept a packet formatted for one protocol and convert it to a packet formatted for another protocol, before forwarding it. An application gateway can translate messages from one format to the other.
- A gateway can be implemented in hardware, software, or in both hardware and software. Generally, gateway is implemented by software installed within a router.

Note: The network connecting devices—repeater and hub operate at the physical layer, bridge and switch operate at the data link layer, and the router operates at the network layer of the OSI model.

Data Communication and Computer Network

Network Devices: Gateway

Gateway
Convert from one
protocol to other
SNA to TCP/IP etc

Data Communication and Computer Network

Wireless Networking:

- Wireless technology is used to establish a wire-free connection or communication between two or more devices.
- Wired technology data is encoded as electric current and signals travel through wires but in wireless technology, data is encoded on electromagnetic waves that travel through air.
- The wireless technology is used for broadcasting in radio and television communication, for communication using mobile phones and pagers, for connecting components of computers using Bluetooth technology, for Internet connection using Wi-Fi, Wireless LAN, PDA, and in remote controls for television etc.

Data Communication and Computer Network

Wireless Networking:

- Wireless network is a computer network connected wirelessly. The communication is done through a wireless media like radio waves, infrared or Bluetooth.
- The wireless networks have two main components
  1. the wireless access points that include the transmitter along with the area it can cover
  2. the wireless clients like mobile handsets, laptops with Ethernet cards etc.
- The access point receives data frames from the computers attached to it wirelessly, checks the frames, and transmits them to their destination. The coverage area of a transmitter depends on the output power of the transmitter, its location, and the frequency used to transmit the data. Higher frequencies require a clear line of sight as compared to lower frequencies.
- The speed of wireless connection is determined by the distance of the wireless client device from the access point, the obstruction-free path (walls, trees etc.), interference, and the number of users using the network at a given time.

Data Communication and Computer Network

Wireless Networking:

- Wireless networks can be divided into three categories based on their use:
  1. Bluetooth technology to connect the different components of the computer in a room, a small office or home.
  2. Wireless LAN is used to connect computers and devices wirelessly in a LAN, for example, different computers or devices in an office or campus.
  3. Wireless WAN is used to connect wide area systems, for example access to Internet via mobile devices like cell phone, PDAs and laptops.

Data Communication and Computer Network

Wireless Networking:

Bluetooth Technology

- The different components of the computer like the keyboard, printer, monitor etc., are connected to the computer case via wires.
- Bluetooth technology is used to connect the different components wirelessly. A printer placed in a room may be connected to a computer placed in a different room using Bluetooth technology.
- Using Bluetooth does away with the wires required to connect the components to the computer and allows portability of components within a small area lying within the Bluetooth range.

Data Communication and Computer Network

Wireless Networking:

Wireless LAN

- Wireless LAN has some benefits over the wired LANs. In wireless LAN, there is flexibility to move the computers and devices within the network. It can connect computers where cabling is not possible. It is easy to expand by using an access point.
- Since no physical medium is required, wireless LANs are easy to install.
- Since data is transmitted using radio or infrared waves, there is no attenuation or distortion of the signal due to electromagnetic interference.
- Wireless LANs are used at home to connect devices on different floors or to set up a home network, to provide connectivity in public places like airports, railway stations, college campus, and hotels etc., where traveling users can access the network.
- Wireless LANs can also be connected to a WAN thus providing access to Internet to the user. IEEE 802.11 is a standard for wireless LAN.

Data Communication and Computer Network

Wireless Networking:

Wireless WAN:

- The radio network used for cellular telephone is an example of wireless WAN. Wireless WANs allow the users to access the Internet via their mobile devices. This provides flexibility to the user to access the Internet from any location where wireless connectivity exists.
- Almost all wireless networks are connected to the wired network at the back-end to provide access to Internet.
- Wireless networks also offer many challenges, like, the compatibility among different standards promoted by different companies, congested networks in case of low bandwidth, the high infrastructure and service cost, data security, battery storage capability of wireless device, and health risk.