Unit 7: Data Communication and Computer Network

Introduction

Data Communication:

- The foundation of it all! Data communication refers to the process of transmitting and receiving data (electronic information) between two or more devices.
- Imagine it like a conversation, but instead of words, you're sending and receiving digital signals.
- Common examples include sending an email, downloading a file, or browsing the internet.

Computer Networks:

- A computer network is essentially a collection of interconnected computing devices that can share resources and communicate with each other.
- These devices can be anything from personal computers and laptops to servers and printers.
- Networks allow us to share files, access the internet, and collaborate on projects remotely.

Importance of Networking

Networking of computers has several uses, described as follows:

- **Resource Sharing:** Networks function as a collaborative ecosystem. In an organization, resources such as printers and scanners can be made available to different users 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.

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

- **Communication Medium:** Networks create a vibrant communication channel. You can share ideas, exchange feedback, and brainstorm solutions with a diverse range of professionals. This open flow of communication fosters innovation and problem-solving, leading to better outcomes for everyone involved.

- **Centralized Administration and Support:** Networks can streamline administrative tasks and provide centralized support. Imagine a network within a company where IT

issues can be reported and resolved efficiently. This not only saves time and resources but also ensures everyone has access to the help they need.

- **Faster and Cheaper Communication:** Networks facilitate instant communication through emails, video conferencing, and messaging platforms. This not only reduces communication costs but also allows for quicker decision-making and improved collaboration.

- **Backup and Support:** Networked computers can be used to take back-up of critical data. A strong network also acts as a safety net. When facing challenges, you can turn to your network for guidance, support, and even referrals.

Types of Computer Network

Computer Network is broadly classified into three types as Local Area Network (LAN), Metropolitan Area Network (MAN), and Wide Area Network (WAN) based on size, transmission topology and networking topology.

LAN

A private network that connects devices within a limited geographical area, typically a home, office building, or school. LANs offer high bandwidth and low latency (delay) for fast communication between devices.

Wires and protocols used in a LAN must be of same type. It is simple and cheaper than other networking system. Security is provided because no any outsider can excess the resources of private network. Star, Bus, and Ring are some of the common LAN networking topologies. A LAN based on WiFi wireless network technology is called Wireless Local Area Network (WLAN).

Features

a.) It covers small geographical areas
b.) It uses guided transmission media
c.) All the components share common protocols
d.) Communication cost is low
e.) It is private network, so ownership is of single organization
f.) No special security is needed

MAN

A network that spans a larger area than a LAN, usually encompassing a city or town. MANs connect multiple LANs within a metropolitan area and can provide high-speed connections for businesses and organizations.

WAN

A network that covers a large geographical distance, such as a country, continent, or even the entire globe. WANs connect geographically dispersed LANs and MANs, often using leased lines, satellites, or other communication technologies. The internet itself is a prime example of a WAN.

Feature	Wide Area Network (WAN)	Metropolitan Area Network (MAN)
Geographical Scope	Covers a large geographical area (country, continent, globe)	Covers a metropolitan area (city, town)
Size	Largest among the three types (LAN, MAN, WAN)	Smaller than WAN, larger than LAN
Devices Connected	Geographically dispersed LANs, individual devices	Multiple LANs within a city, individual devices
Typical Technologies	Leased lines, satellites, microwave	Fiber optic cables, high-bandwidth wireless
Speed	Lower speed compared to LAN and MAN	Higher speed than WAN, lower than LAN
Latency	Higher latency due to longer distances	Lower latency compared to WAN
Cost	More expensive due to leased lines or satellite infrastructure	Less expensive than WAN, more expensive than LAN
Typical Use Cases	Connecting geographically distant offices, accessing cloud resources	Connecting businesses and organizations within a city, backbone for internet service providers

Management	More complex to manage due to diverse technologies and long distances	Easier to manage compared to WAN

Computer Network Architecture

Computer network architecture refers to the fundamental principle for the underlying structure of a computer network, including hardware, functional layers, interfaces and protocols used to establish communication and ensure the reliable transfer of information. There are two main types of network architectures that define how devices are connected and resources are shared

Peer to peer network

In peer-to-peer communication, there are no fixed client servers. It has work station connected to each other. It is also often referred as person-to-person communication model. It could be connecting two computers using USB for example or linking six or more computers in an office space using copper wire. It is often much simpler to set up then client server model. However, they lack some of the advantages, normally associated with network such as centrally management security and ease of backing of files.

Advantages

a) Easy to install and configure
b) Inexpensive to operate
c) Individual users control their own shares resources
d) Failure doesn't affect all computers
e) No additional hardware and software beyond a suitable operating system are needed
f) No dedicated administrators are required

Disadvantages

a) Network security applies only to single resource at a time
b) There is no centralized organizational scheme to locate or control excess to data.
c) Each machine must be backed up individually to protect backed up data.

Client/Server model

In the client/server model, all the computers are connected to a central device called server. Dedicated server is used to provide the certain services such as data base servers, web servers, file servers etc. Server is responsible to control, manage and provide service to the client in the network. A client request to the server for the services. The client and the server machines are connected by a network and involve request and reply.

Client server is a network architecture which separates the client from the server. In each instance client software can sent a request to a server or to application server. The term server most commonly applied to a complete computer system today.

Advantages

a) Simplified user accounts, user security and excess control to simplify network administration
b) Single password for network login delivers excess to all network resource
c) More powerful equipment means more efficient excess to network resources

Disadvantages

a) Dedicated hardware and special software (Network Operating System) add to the cost.
b) If server fails then the whole network fails
c) Increases expenses and need system administration to handle

Data Transmission Media

Data transmission across media refers to the way information travels from a source to a receiver. Computer transmission media includes cable and wireless technologies that allow network devices to contact one another. This information is converted into electrical or light signals and carried through a physical path called the **transmission media**.

Transmission media can be classified into two categories.

Guided Media: Also known as wired media, guided media uses physical cables to confine and direct the signal. The data signals are bounded by the cabling system so it is also called bounded media.

Examples include:

- Twisted pair cable: Commonly used in telephone lines and ethernet networks.
- Coaxial cable: Offers higher bandwidth than twisted pair and is used in cable TV and some computer networks.
- Fiber optic cable: Uses light pulses for transmission, enabling high speed and long-distance communication with minimal interference.

Unguided Media: Also known as wireless media, unguided media transmits signals through the air, water, or even space. The data signals are not bound to a cabling media so it is also called unbounded media.

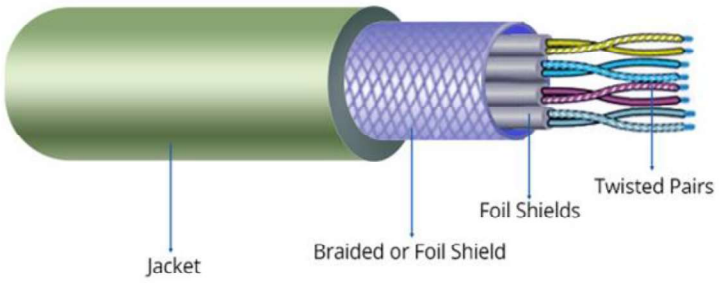
Examples include:

- Radio waves: Used in various applications like cellular networks, Wi-Fi, and Bluetooth.
- Microwaves: Used for long-distance communication, often for satellite communication.
- Infrared (IR): Used for short-range communication in devices like TV remotes and night vision.

Twisted Pair

Twisted pair cable is a common scheme for using copper wire as telecommunication cable. It consists of two insulated strands of copper wire twisted around each other. It is the most common cables used in local area network where length of the cable doesn't need to exceed 100m.

- Twisted pair ethernet cables are rated for both speed and link using a cat rating system.
- Cat 5 for example is rated for transmission speeds of 100 megabit per second for up to 100 meters. Cat 6 and Cat 6a on the other hand are rated for network speeds of 1 and 10 gigabit per second respectively over the same distance.
- Twisted pair cable normally use RJ-45 connector.



Twisted pair is of two kinds- Shielded Twisted Pair (STP), and Unshielded Twisted Pair (UTP).

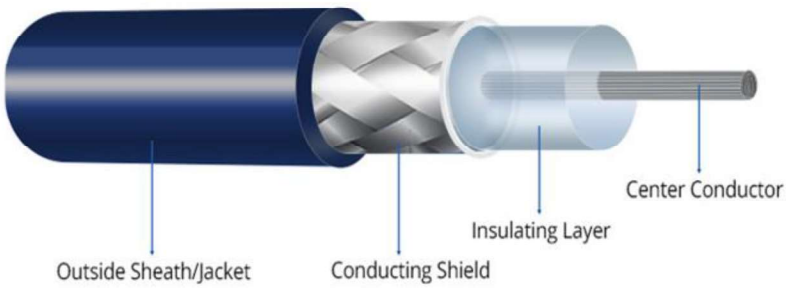
Feature	Unshielded Twisted Pair (UTP)	Shielded Twisted Pair (STP)
Shielding	No	Individual foil shielding for each pair and overall braid
Cost	Lower	Higher

Installation	Easier	More difficult
EMI Protection	Lower	Higher
Bandwidth	Lower	Higher (supports higher data rates)
Applications	Telephone networks, Low-cost LANs	High-performance LANs, Industrial environments with high EMI

Coaxial Cable

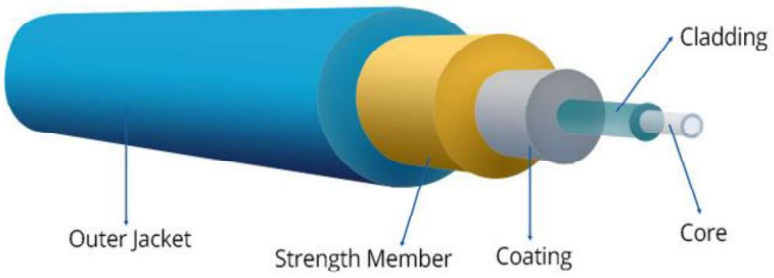
Coaxial cable (commonly called “coax”) is made of conductors that share a common axis, hence the same (“co axis”). Center of the cable is a relatively stiff solid copper wire or standard wire encased in insulating plastic foam. This is then encased in a braided metallic shield, which is finally covered by a protective outer jacket. The outer metallic sheath functions as a second conductor and a shield against noise. The signal is transmitted over the surface of the inner conductor.

- Coaxial cable normally uses an F type connector, BNC and N-series
- Carries signals of higher frequency ranges than twisted pair cable. Although coaxial cable has a much higher bandwidth, the signal weakens rapidly and requires the frequent use of repeaters.



Optical Fiber Cable

A fiber optic cable transmits signals in the form of light. Optical fiber use reflection properties of light to guide light through a channel. It consists of two main part core and cladding. Core is denser compared to cladding and is made up of plastic or glass. Cladding acts as a protective cover to core. The difference in density of core and cladding is such that a beam of light moving through the core is reflected off the cladding, instead of being refracted into it.



Advantages

- Fiber optic cable support higher bandwidths than either twisted-pair or coaxial cable.
- Less signal attenuation: Fiber optic transmission distance is significantly greater than that of other guided media. A signal can run for 50 km without requiring regeneration. We need repeaters every 5 km for coaxial or twisted pair cable.
- Electromagnetic noise cannot affect fiber-optic cables.
- Resistance to corrosive materials. Glass is more resistant to corrosive materials than copper.
- They are highly secure as they cannot be trapped and for lack of signal radiation.
- Light weight

Disadvantages

- Installing an optical fiber requires expertise and special equipment.
- Propagation of light is unidirectional. If we need bidirectional communication, two fibers are needed.
- Relatively more expensive so they are economical only when the bandwidth utilization is high.

Radio Transmission

- Uses radio waves, a type of electromagnetic wave with a lower frequency range (typically below 3 GHz).
- Signals travel long distances but can be omnidirectional (spread in all directions) or directional depending on the antenna.

- Applications:
    - AM/FM radio broadcasting
    - Walkie-talkies
    - Cellular phone networks (older generations)
- Advantages:
    - Wide coverage area
    - Relatively low cost
- Disadvantages:
    - Lower bandwidth compared to other options
    - Susceptible to interference from other radio signals and atmospheric conditions

Microwave Transmission

- Uses microwaves, a type of electromagnetic wave with a higher frequency range (typically 3 GHz to 300 GHz).
- Signals are highly directional and require line-of-sight between transmitter and receiver.
- Applications:
    - Wi-Fi networks (uses a specific range of microwaves)
    - Point-to-point communication links between buildings or towers
    - Satellite communication (microwave signals are used for uplink and downlink between Earth and satellites)
- Advantages:
    - High bandwidth, enabling faster data transmission
    - Less susceptible to interference compared to radio waves
- Disadvantages:
    - Limited by line-of-sight requirement
    - Not suitable for long-distance communication without repeaters

Satellite Transmission

- Relies on satellites orbiting Earth to relay signals.
- Uses microwaves for communication between Earth stations and satellites.
- Applications:
    - Satellite TV
    - Satellite internet
    - Long-distance communication across oceans or remote areas
- Advantages:
    - Wide coverage area, can reach remote locations
    - Enables communication over vast distances

- Disadvantages:
    - Requires complex infrastructure and satellites in orbit
    - Signal latency due to the distance traveled
    - Can be affected by weather conditions

Data Transmission across Media

Transmitting data across media implies sending bits through the transmission medium. The data is converted into electrical or light signals and carried through a physical path called the transmission media. For this, bits are encoded and sent as characters.

Transmission modes

Communication of data between more than one terminal is called transmission.
Communication can be simplex, half duplex and full duplex,

Simplex:
It is the type of communication in which data can only be transmitted in one direction. It is often used in contrast to duplex communication in which data can flow bidirectional between two devices.
In this transmission, sender sends data but receiver cannot acknowledge to the center.
A broadcast in which a signal transmission is sent to many more is a common type of simplex communication. For e.g. Radio broadcast, Television broadcasts, internet streaming

Half-Duplex
It is the type of communication in which data can flow back and forth between two devices but not simultaneously. Each device in a half-duplex system can send and receive data but only one device can transmit data at a time. In half duplex communication there is two-way communications between transmitter and receiver, but only one side active at a time. i.e. both the system can transmit the signal but only once at a time.
The half-duplex mode is like one lane road with two direction traffic. E.g. Wakie- Talkie

Full Duplex
If transmission is possible in two ways at a time, then it is called full duplex transmission. In full duplex both stations can transmit the signal simultaneously. It is like a two-lane street with two direction traffic at a same time. In this transmission signal going in either direction share the capacity of the line.
For e.g. Mobile communication, Telephone, satellite communication, etc.