IT 231 Foundation of Information Technology

Unit 5

Data Communication and Computer Network

Network

- Computer network: collection of hardware and software that enables a group of computer to communicate and share resources (data, software, hardware).
- Node: A node can be a computer, printer, or any other device capable of sending and /or receiving data generated by other nodes on the network.
- Interconnection of two or more than two nodes which are able to exchange information using transmission medium and protocols.

Use of Computer Network

- Resource Sharing
  - Sharing of Hardware
  - Sharing of Information
- Communication and Entertainment
- Research, Education and Business

Common Network Components

Server : any computer that make resources available to other computers on the network.

Client : any computer that use resources of a server

Resources : any hardware or software that is accessible by a client computer from server on a network.

Network Adapter: components of computers that enables two computers to send data out over the network media.

Network Protocol: set of rules that governs data communication

Bandwidth : amount of data that can be transmitted through any transmission medium in a fixed amount of time

Data Rate : speed at which the data actually moves through the cable.

Gateway: connect two dissimilar network architecture

Types of Transmission

Communication is the exchange of information between two or more than two devices.

Information can be exchange in the form of voice or data.

1. Voice Communication
2. Data Communication

Voice Communication

- Sharing of information through audio(voice)
- Very common form of voice communication is telephonic conversation.
- Nowadays, voice communication can be send and receive through various emergent technologies such as skype, Viber, IMO, WhatsApp etc. and also can send voice mail while user is unreachable or absence.

Data Communication

- The word data refers to information presented in whatever form is agreed upon by the parties creating and using the data.
- Data communication are the exchange of data between two devices via some form of transmission medium such as wired or wireless.
- The effectiveness of a data communications system depends on four fundamental characteristics: delivery, accuracy, timeliness, and jitter.

A data Communication model has:

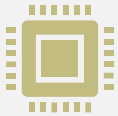
- **Source :** Generated data to be transmitted
- **Transmitter :** Convert data into transmittable signals
- **Transmission System :** Carries data
- **Receiver :** Convert received signal into data
- **Destination :** Takes incoming data

The effectiveness of data communication depends upon four fundamental characteristics:

Delivery : system must deliver data to the appropriate destination.

Accuracy : system must deliver data accurately (without any altered).

Timeliness : system must deliver data in timely manner. If late useless.



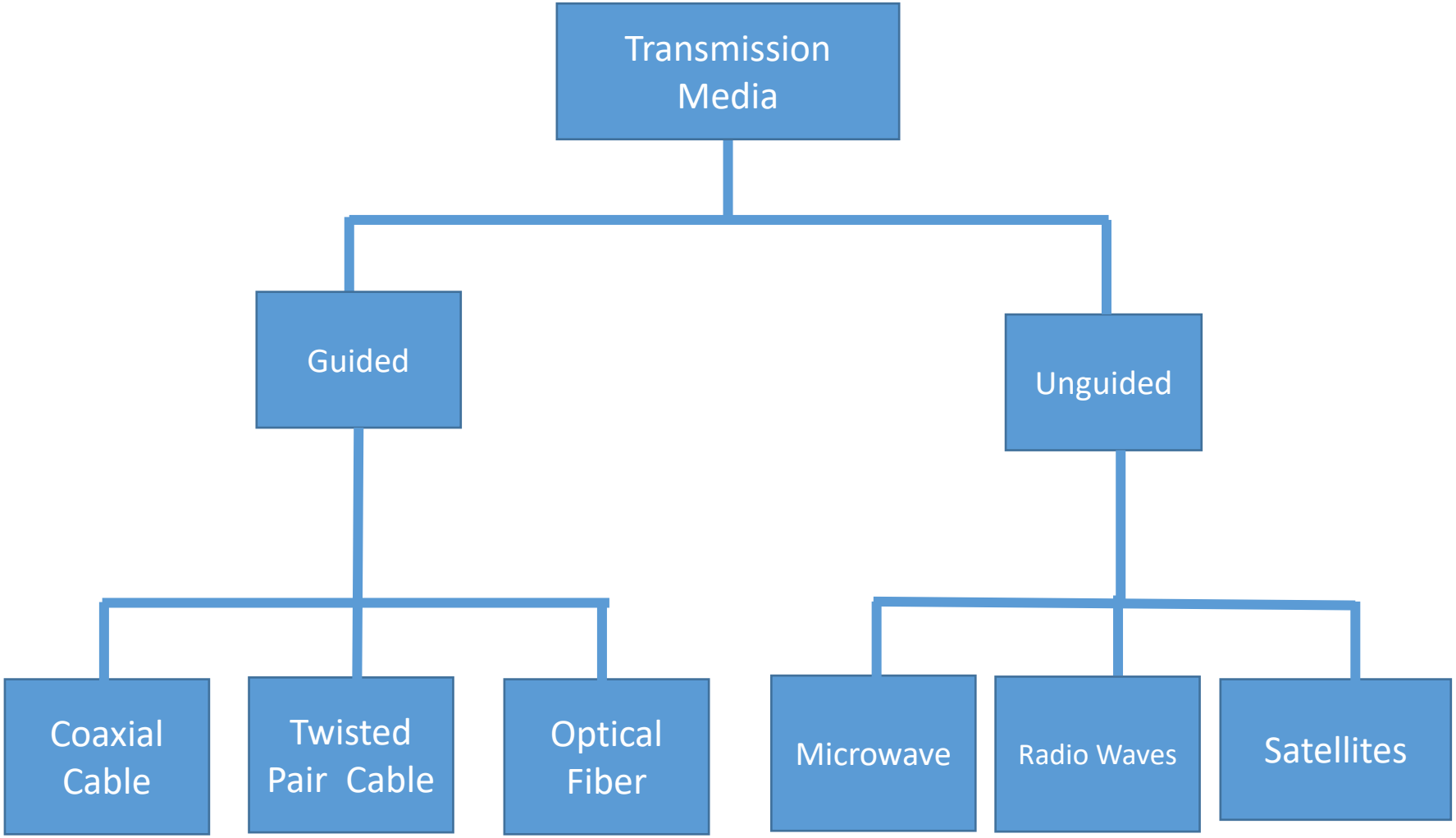
Jitter : variations in the packet arrival time.

Communication/Transmission Media

- A transmission medium can be broadly defined as anything that can carry information from a source to a destination.
- Communication devices uses signals to represent data and transmitted form one source to another in the form of electromagnetic energy.
- Such signals can be travel through vacuum, air and other transmission media.
- Transmission medium are classified as:

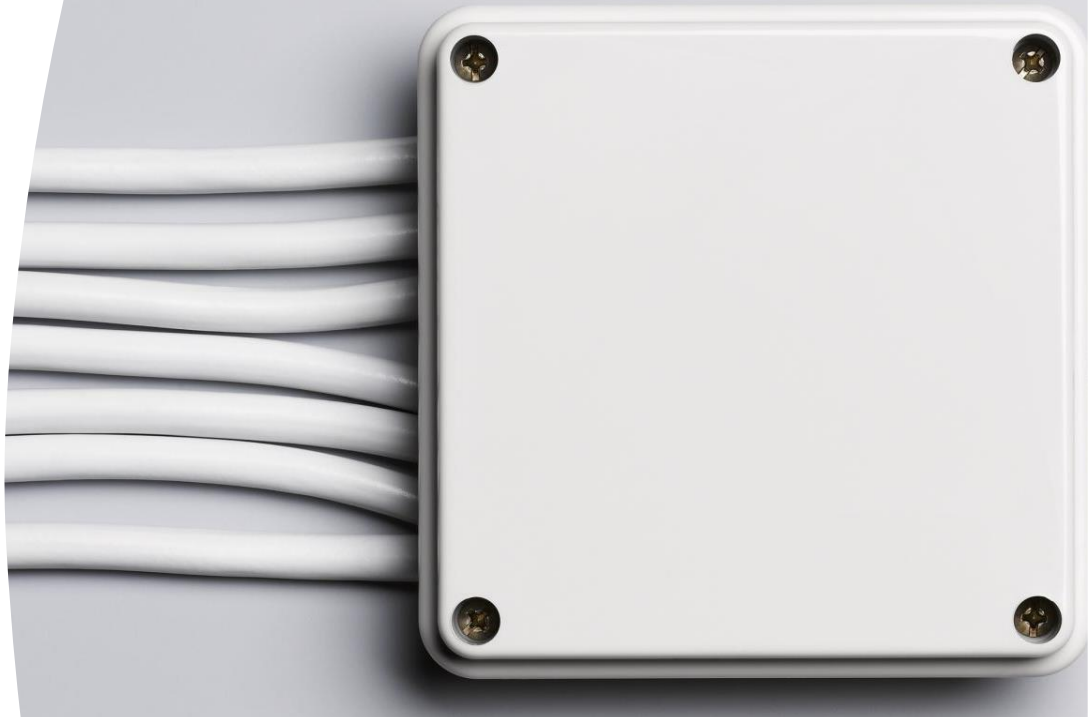
i) Guided Media

ii) Unguided Media


Transmission Media
Guided
Unguided
Coaxial Cable
Twisted Pair Cable
Optical Fiber
Microwave
Radio Waves
Satellites

Guided Media

- Transmission media, which provide a conduit form one device to another including twisted-pair cable, coaxial cable, and fiber-optic cable.
- Guided media transmit signals by sending electricity or light over a cable or wire.
- Twisted pair and coaxial cable transmit signal in the form of electric current and fiber transmit signal in the form of light.



Coaxial Cable

Coaxial cable has a single copper conductor at its center.

Coaxial cables have concentric layers of electrical conductors and insulating material.

Coaxial cable consist of four primary components:

- A core copper wire, which serves as the primary channel
- A dielectric plastic insulator, which surrounds the copper
- A braided copper/aluminum sheath beneath the insulator, is used to protect from external electromagnetic interference.
- The last layer, which is made of Teflon or plastic coating, is used to protect the inner layers from physical damage, such as fire and water.

Cont..

Two types of coaxial cable:

Thinnet :

Can carry signal up to 185 meters.

Flexible and easy to work with; good for connecting individual computers.

About a quarter of an inch think.

Thicknet

Can carry signal up to 500 meters.

Stiffer; used mainly as backbone to connect several thinnet.

About half an inch think

Note: Most common type of connector is BNC (T connector, L-shaped)

Twisted Pair Cable

- A type of cable that consists of two independently insulated wires twisted around one another.
- Each pair of would consist of a wire used for the positive data signal and a wire used for negative data signal.
- use of two wires twisted together helps to reduce crosstalk and electromagnetic induction.
- There are two types of twisted pair cables: Unshielded twisted pair (UTP) & Shielded twisted pair (STP)

Cont…

UTP

Each of the eight individual copper wires in UTP cable is covered by an insulating material. In addition, the wires in each pair are twisted around each other.

STP

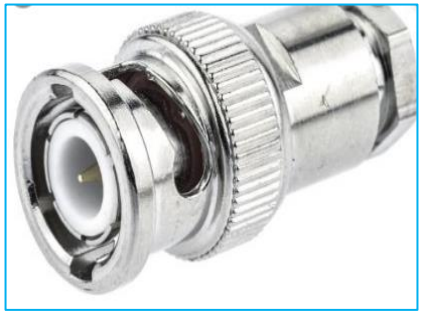
Shielded twisted-pair (STP) cable combines the techniques of shielding, cancellation, and wire twisting. Each pair of wires is wrapped in a metallic foil . The four pairs of wires then are wrapped in an overall metallic braid or foil.

Note: It uses a RJ line of connector (RJ45, RJ11, etc)

Connector

RJ 45

RJ 11



BNC

BNC T- Connector

Optical Fiber

- Optical fiber consists of thin glass fibers that can carry information at frequencies in the visible light spectrum and beyond.
- Optical fiber consist of narrow strand of glass class the core, around the core is a concentric layer of glass called cladding.
- Optical fiber is very thin (hair-thin) thread of a glass or plastic surrounded by several layers of protective materials.
- Optical fiber is fast with compare to others medium because fiber transmits rather than electric signals.

Unguided Media

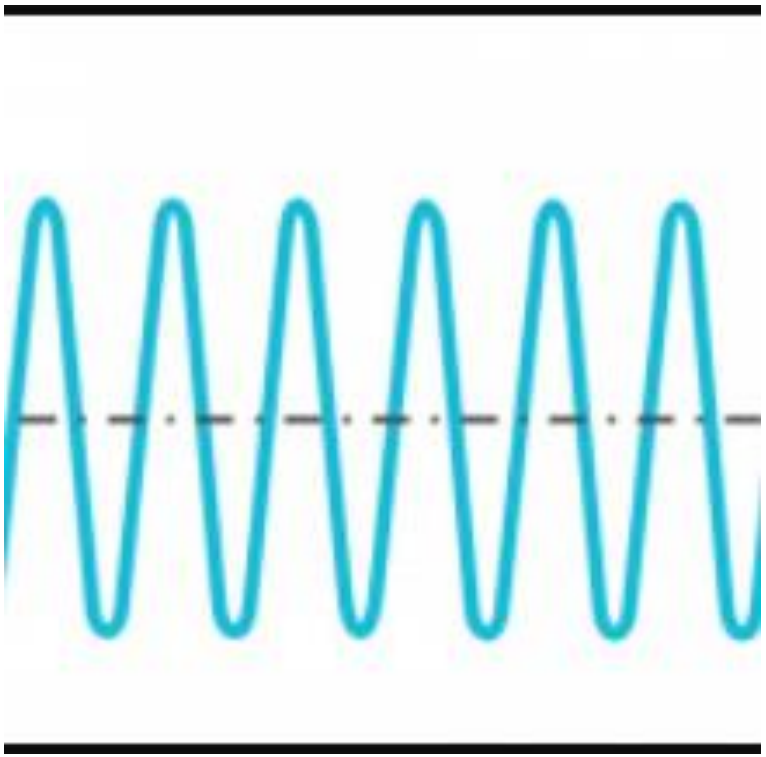
- In unguided media, data signals are not bound to a cabling media also called wireless media.
- Unguided media transmit data through the air.
- Data are transmitted through radio waves, laser or infrared signal, and earth and satellite based microwaves.

Types:

I. **Radio Waves**
II. **Microwaves**
III. **Communication Satellites**

Radio wave

- Electromagnetic waves ranging in frequencies between 3 KHz to 300 MHz
- **Omnidirectional** Waves. Line of sight communication is not needed in radio waves.
- Used in AM and FM Radio, cordless phones, paging, Wi-Fi etc.



Microwave

Electromagnetic waves having frequencies between 300 MHz to 300 GHz.

Unidirectional Waves, sending and receiving antenna need to be aligned.

It allows multiple receivers in a row to receive the signals without interference.

It is mainly used for short distance transmission. Repeaters are used at regular intervals of about 25 to 30 km in between the transmitting and receiving station. Transmission rate is about 16 Gbps.

Application of Microwave includes: cellular phones, television networks, wireless LAN,s satellites etc.

Communication Satellites

A satellite is a physical object that revolves around the earth at a known height. The satellite accepts the signal that is transmitted from the earth station, and it amplifies the signal. The amplified signal is retransmitted to another earth station.

The satellites are basically positioned 36,0000 km above equator with an orbit speed that exactly matches the earth's rotation speed.

Uplink frequency is the frequency at which, the first earth station is communicating with satellite.

The satellite transponder converts this signal into another frequency and sends it down to the second earth station. This frequency is called as **Downlink frequency**.

Note: second earth station can also communicate with the first one.

Satellite orbits

***Geostationary Orbit* (GEO) :** which is 22,236 miles (35,785 km) from Earth's surface.

***Medium Earth Orbit* (MEO) :** closer to Earth, Orbital altitudes range from 2,000 to 36,000 kilometers (1,200 to 22,400 mi) above Earth.

Low Earth Orbit (LEO) : circular orbit about 160 to 2,000 kilometers (99 to 1,243 mi) above the earth's surface and, correspondingly, a period (time to revolve around the earth) of about 90 minutes.

TYPES OF NETWORK

LAN

WAN(Wide Area Network)

MAN(Metropolitan Area Network)

LAN

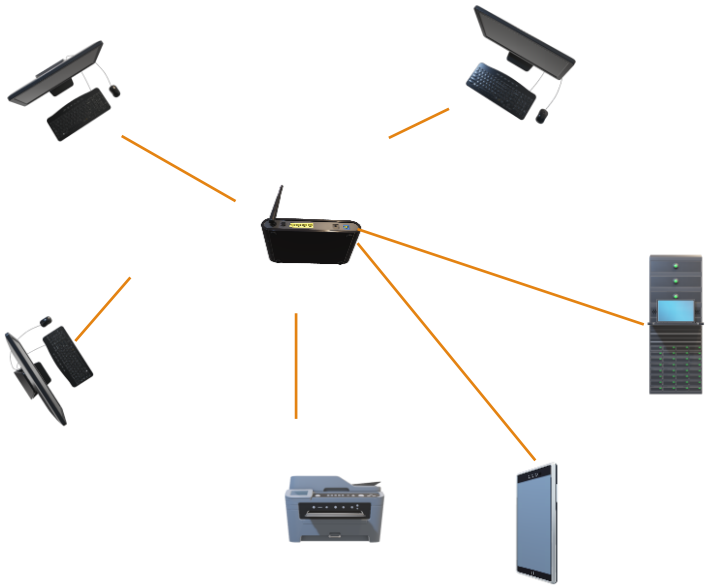
- A LAN is a network that is used for communicating among computer devices, usually within an office building or home.
- LAN's enable the sharing of resources such as files or hardware devices that may be needed by multiple users
- Is limited in size, typically spanning a few hundred meters, and no more than a mile
- Is fast, with speeds from 10 Mbps to 10 Gbps
- Requires little wiring, typically a single cable connecting to each device
- Has lower cost compared to MAN's or WAN's

LAN

LAN's can be either wired or wireless.

Twisted pair, coax or fiber optic cable can be used in wired LAN's.

Every LAN uses a protocol – a set of rules that governs how packets are configured and transmitted.



LAN

ADVANTAGES

Speed

Cost

Security

E-Mail

Resource Sharing

DISADVANTAGES

Cables may break

Server may fail

MAN

A metropolitan area network (MAN) is a large computer network that usually spans a city or a large campus.

A MAN is optimized for a larger geographical area than a LAN, ranging from several blocks of buildings to entire cities.

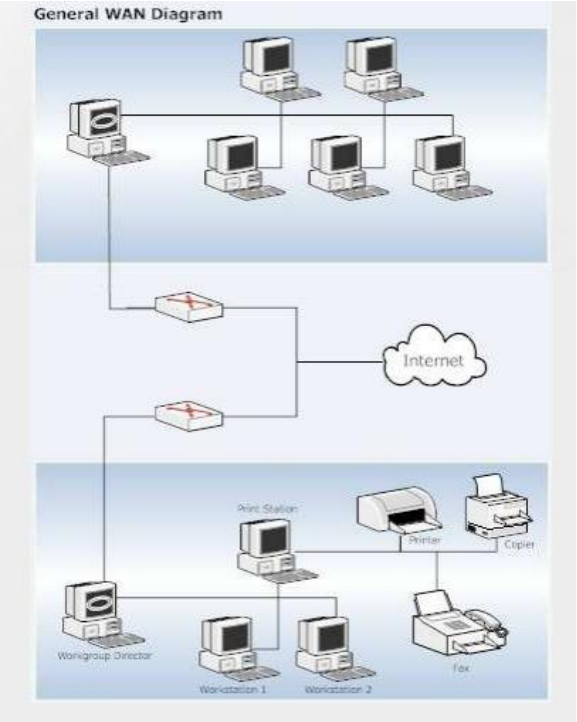
A MAN might be owned and operated by a single organization, but it usually will be used by many individuals and organizations

MAN

A MAN often acts as a high speed network to allow sharing of regional resources.

A MAN typically covers an area of between 5 and 50 km diameter.

Examples of MAN: Telephone company network that provides a high speed DSL to customers and cable TV network.


General WAN Diagram
Internet
Print Station
Printer
Copier
Workgroup Director
Workstation 1
Workstation 2
Fax

WAN

WAN covers a large geographic area such as country, continent or even whole of the world.

A WAN is two or more LANs connected together. The LANs can be many miles apart.

When network spans over a large distance or when the computers to be connected to each other are at widely separated locations a local area network cannot be used. A wide area network(WAN) is installed.

To cover great distances, WANs may transmit data over leased high-speed phone lines or wireless links such as satellites

WAN

Multiple LANs can be connected together using devices such as bridges, routers, or gateways, which enable them to share data.

The world's most popular WAN is the Internet.

The communication between different users of WAN is established using leased telephone lines, satellite links and similar channels.

It is cheaper and more efficient to use the phone network for the link.

Most WAN networks are used to transfer large blocks of data between its users.

Network Topologies

A network topology is the arrangement of computers, cables, and other components on a network or a map of geometrical shape of physical network of computers is network topology.

Or the term topology refers to the manner and complexity of interconnections between nodes on a network. It is the logical way of explaining how computers are connected each other and shows physically how they are linked.

There are different types of network topologies that are used in a network. The topologies commonly used in LAN are Bus topology, Star topology, and Ring topology.

BUS TOPOLOGY

In this topology all devices are connected to central wire by using some connector. This central wire is called bus and functions as a shared communication medium.

A device wanting to communicate with another device on the network sends a broadcast message onto the wire that all other devices see, but only the intended recipient actually accepts and processes the message.

BUS topology

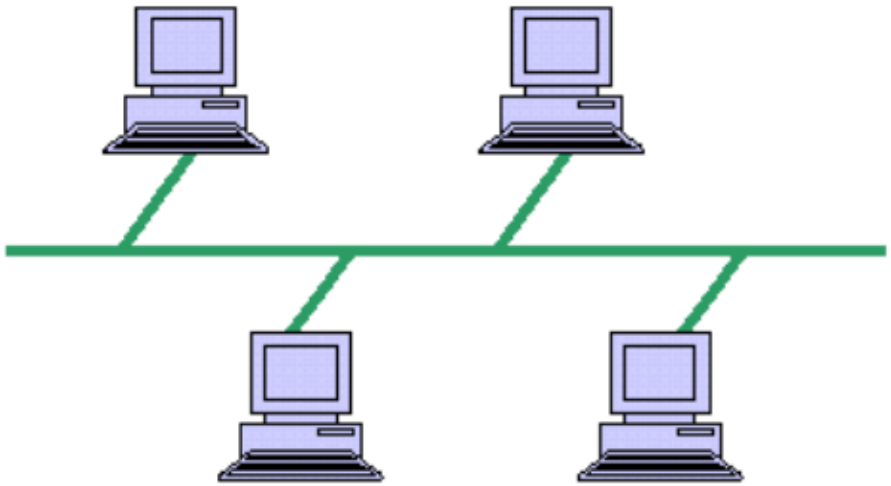
Advantages

- It is quite easy to set up.
- If one station of the topology fails it does not affect the entire system.
- No extra hardware is needed other than cables

Disadvantages

- Any break in the bus is difficult to identify
- No two nodes can transmit the data at the same time
- If new computers are added to the network, performance degrades

BUS topology



RING Topology

In a ring topology, every device is connected to two of its neighbors forming a closed loop called ring.

All messages travel through a ring in the same direction but the direction data transmission can be either "clockwise" or "counterclockwise".

RING TOPOLOGY

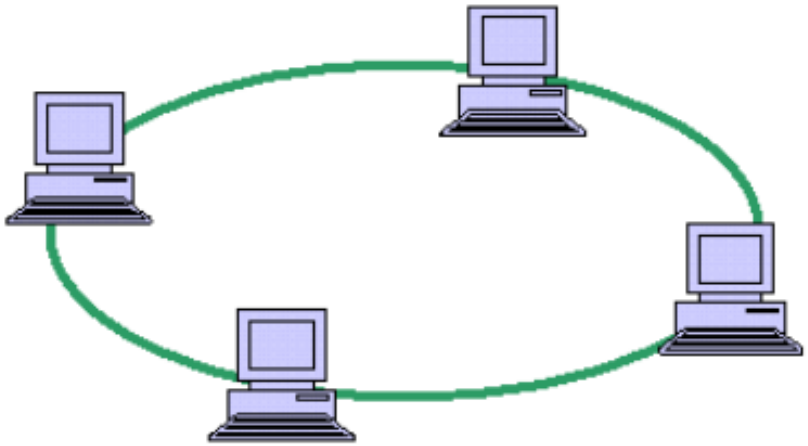
Advantages

- Cable faults are easily located, making troubleshooting easier
- Ring networks are moderately easy to install

Disadvantages

- Expansion to the network can cause network disruption
- A single break in the cable can disrupt the entire network.

RING Topology



Star Topology

All computers/devices connect to a central device called hub or switch.

Each device requires a single cable

Point-to-point connection between the device and hub.

Most widely implemented

Hub is the single point of failure

Star Topology

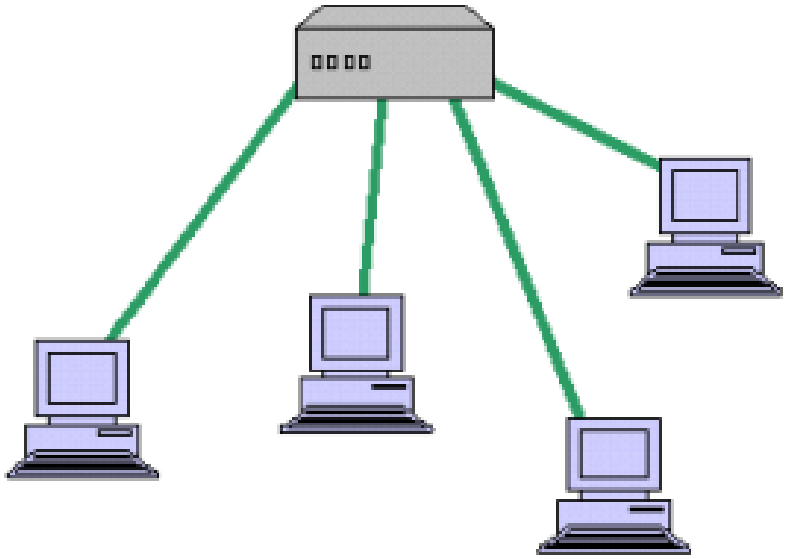
Advantages

- Flexibility in adding and deleting the node from the network
- Works faster than bus and ring topology.
- Failure of a cable or single computer only affects the single computer

Disadvantages

- Failure of hub/switch may the cause the entire system to be failed
- Extra hardware like hub or switch is needed, therefore expensive
- Requires more cable

Star Topology



Mesh topology

A type of network topology where each of the devices is interconnected with all other computers in the network is called mesh topology.

Traffic is carried only between two devices or nodes to which it is connected. Mesh topology requires n (n-2)/2 wires to link n devices.

High level of redundancy

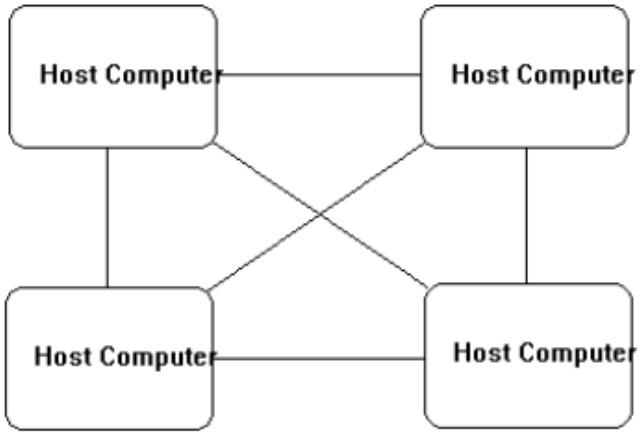
Mesh topology

Advantages

- The network can be expanded without disruption to current uses
- Failure of single point cable doesn't affect the system
- Provides redundant paths between devices

Disadvantages

- Complicated implementation
- Requires more cable than the other LAN topologies


Host Computer
Host Computer
Host Computer
Host Computer

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.

Communication Protocol

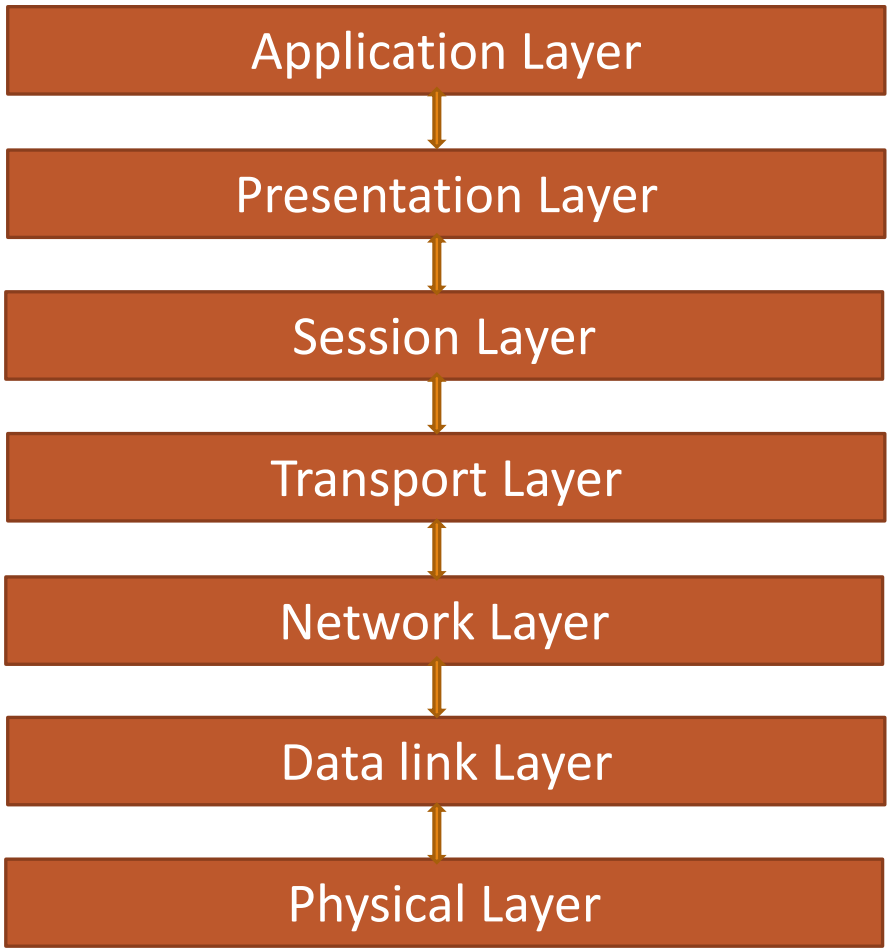
The outgoing data from a computer connected to the network passes down through each layer and the incoming data passes up through each layer.

The corresponding layers on the different machines are called peers. The peers interact with each other using the protocol.

Communication Protocol

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



Human computer interaction layer, where applications can access the network services

Ensure that data is in a usable format and is where data encryption occurs

controlling ports and sessions

Transmit data using transmission protocol TCP/IP and UDP

Decides which physical path the data will take

Defines the format of data on the network

Transmits raw bit stream over the physical medium

Physical Layer

The lowest level of OSI layer

The main functionality of the physical layer is to transmit the individual bits from one node to another node.

It establishes, maintains and deactivates the physical connection.

This layer includes the physical equipment involved in the data transfer, such as the cables and switches.

This is also the layer where the data gets converted into a bit stream, which is a string of 1s and 0s

Data link Layer

The data link layer establishes and terminates a connection between two physically-connected nodes on a network.

It **breaks up packets into frames and sends them from source to destination.**

This layer is composed of two parts—Logical Link Control (LLC), which identifies network protocols, performs error checking and synchronizes frames, and Media Access Control (MAC) which uses MAC addresses to connect devices and define permissions to transmit and receive data.

Network Layer

The network layer has two main functions.

One is breaking up segments into network packets, and reassembling the packets on the receiving end.

The other is routing packets by discovering the best path across a physical network. The network layer uses network addresses (typically Internet Protocol addresses) to route packets to a destination node

Transport Layer

The transport layer takes data transferred in the session layer and breaks it into “segments” on the transmitting end.

It is responsible for reassembling the segments on the receiving end, turning it back into data that can be used by the session layer.

The transport layer carries out flow control, sending data at a rate that matches the connection speed of the receiving device, and error control, checking if data was received incorrectly and if not, requesting it again.

Session Layer

The session layer creates communication channels, called sessions, between devices.

It is responsible for opening sessions, ensuring they remain open and functional while data is being transferred, and closing them when communication ends.

The session layer can also set checkpoints during a data transfer—if the session is interrupted, devices can resume data transfer from the last checkpoint.

Presentation Layer

The presentation layer prepares data for the application layer.

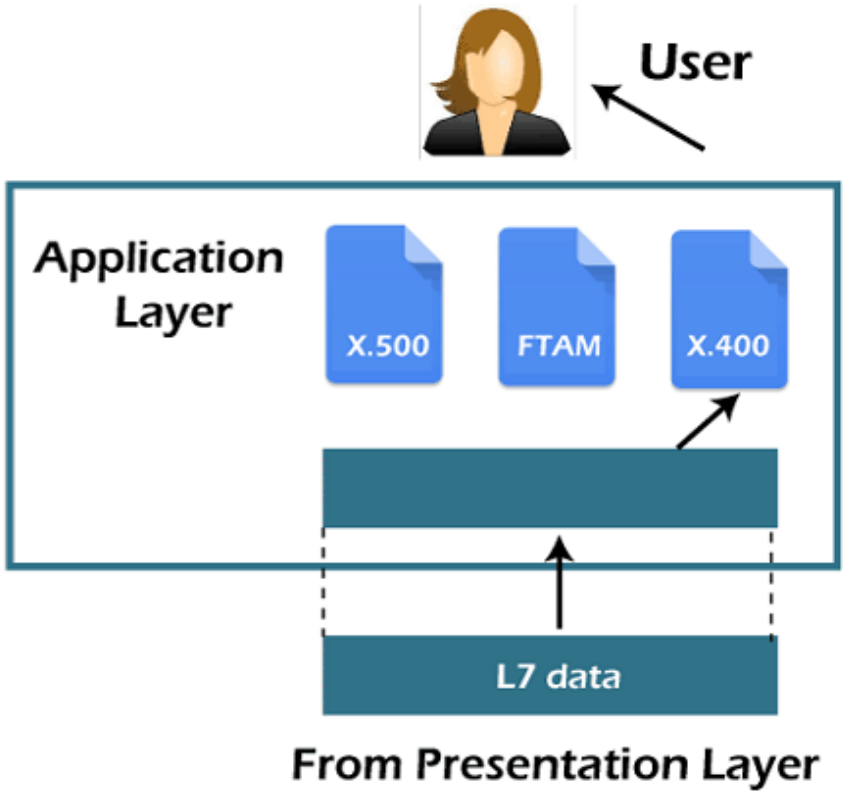
It defines how two devices should encode, encrypt, and compress data so it is received correctly on the other end.

The presentation layer takes any data transmitted by the application layer and prepares it for transmission over the session layer.

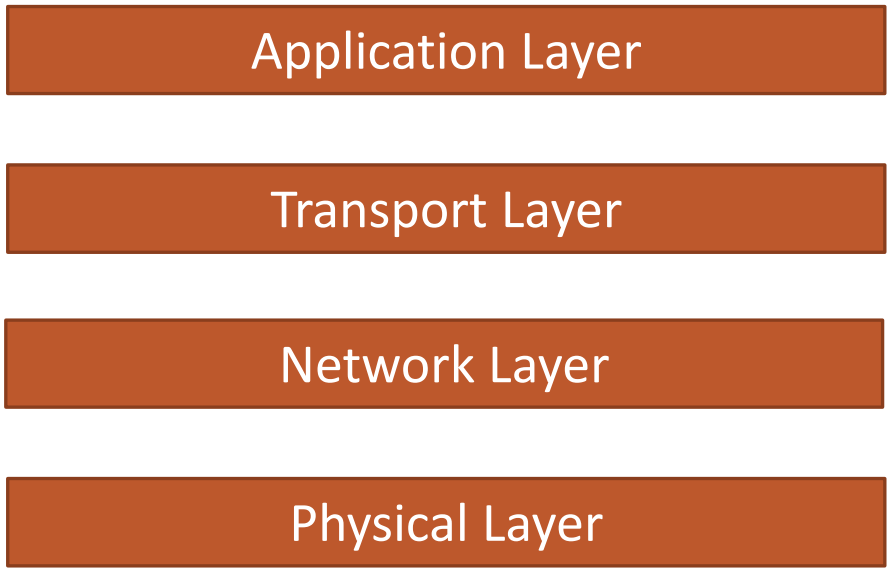
Application Layer

The application layer is used by end-user software such as web browsers and email clients. It provides protocols that allow software to send and receive information and present meaningful data to users.

A few examples of application layer protocols are the Hypertext Transfer Protocol (HTTP), File Transfer Protocol (FTP), Post Office Protocol (POP), Simple Mail Transfer Protocol (SMTP), and Domain Name System (DNS).


User
Application Layer
X.500
FTAM
X.400
L7 data
From Presentation Layer

TCP/IP


Application Layer
Transport Layer
Network Layer
Physical Layer