Dedicated Faculty, Committed Education
Darshan
Institute of Engineering & Technology

Unit-1:
Introduction to Computer Networks & Internet

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Outline

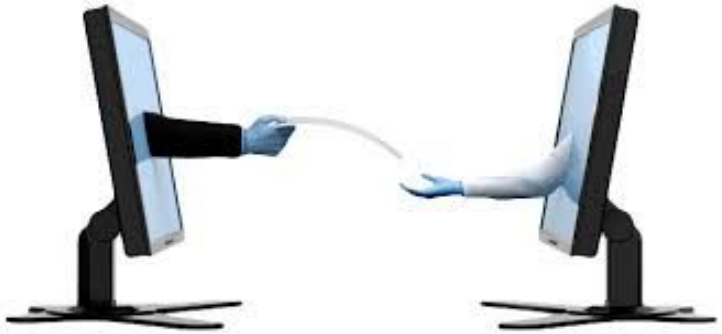
- What is Computer Network?
- Advantages of Computer Network
- Applications of Computer Network
- Type of Computer Network
- What is Internet?
- The Network Edge & The Network Core
- Transmission Media
- Network Topologies
- Protocol Layers
- Delay, Loss & Throughput

What is Computer Network?

- Computer Network is a system in which multiple computers are connected to each other to share information and resources.

Advantages of Computer Network

File Sharing



Flexible Access

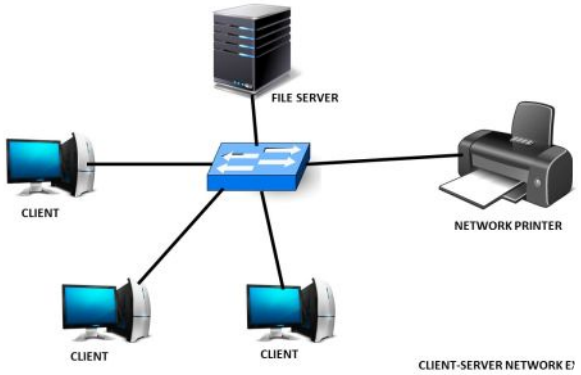
Entertainment

Better Communication

Advantages of Computer Network

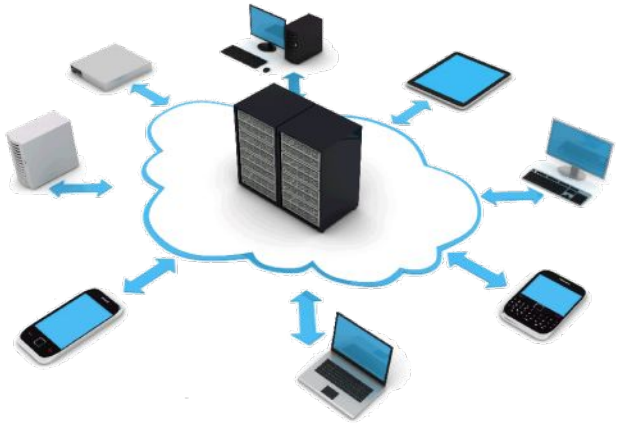
Internet Access

Inexpensive System



Instant and Multiple Access

Resource Sharing



Applications of Computer Network

Email Services

Teleconferencing

Business & Finance

File & Directory Services

& Many More….

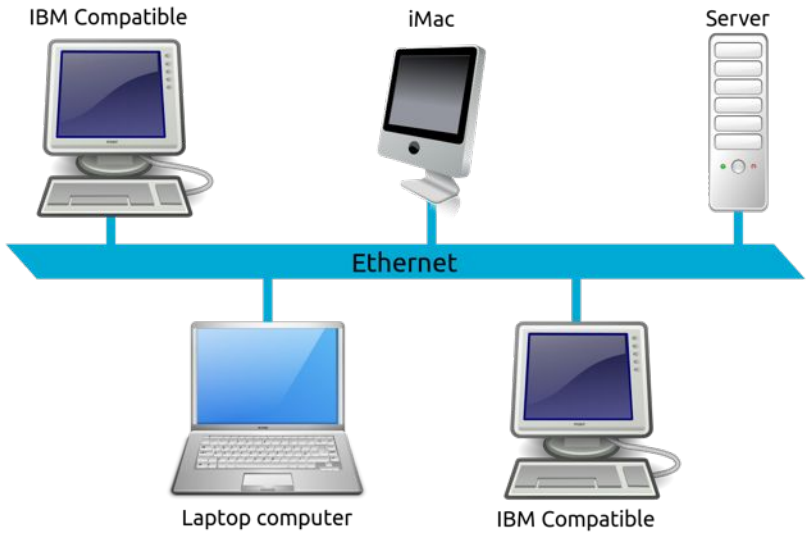
Types of Computer Network

- Computer networks can be categories by their size as well as their purpose.
- The size of a network can be expressed by the geographic area.
- Some of the different networks based on size are:

- Network
  - Local Area Network
  - (LAN)
  - Metropolitan Area Network
  - (MAN)
  - Wide Area Network
  - (WAN)

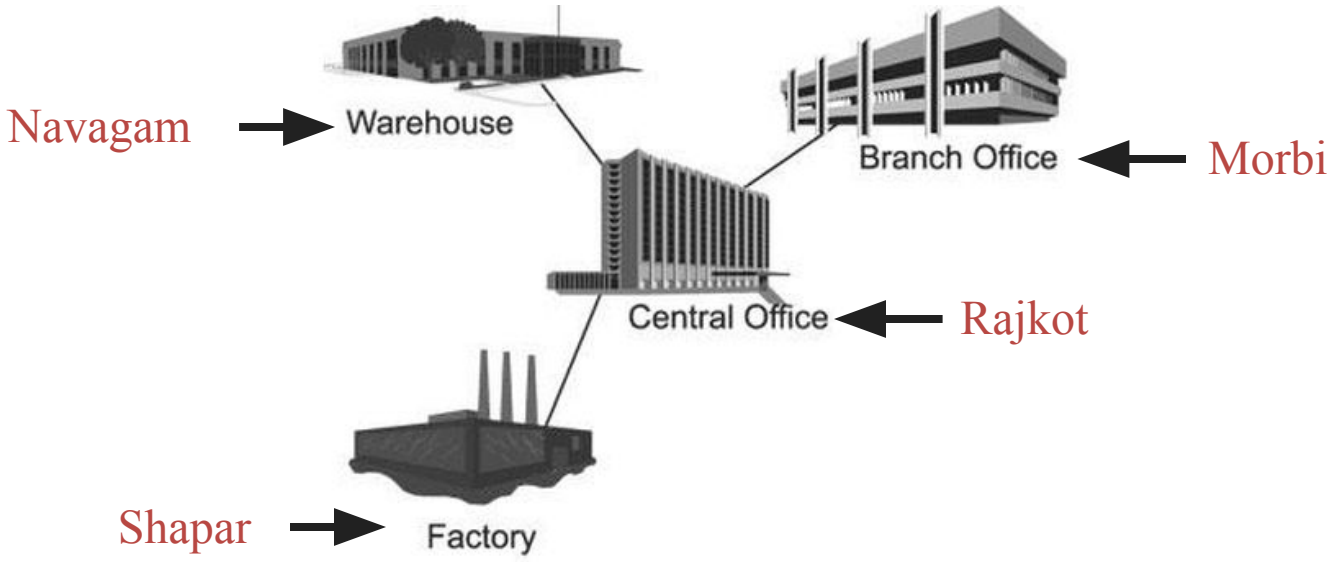
Local Area Network

- A local area network (LAN) is a computer network that interconnects computers within a limited area such as a residence, school, laboratory, university campus or office building.



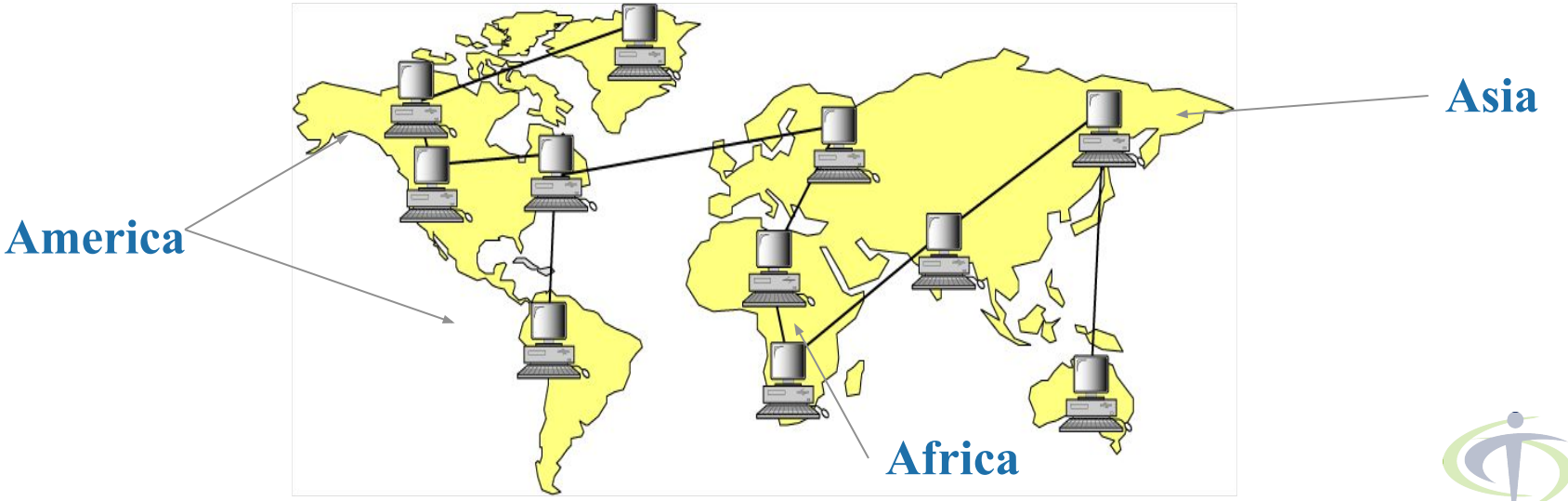
Metropolitan Area Network

- A metropolitan area network (MAN) is a computer network that interconnects with computer in a metropolitan area like city.
- MAN is a larger than LAN but smaller than the area covered by a WAN.
- It is also used to interconnection of several local area network.

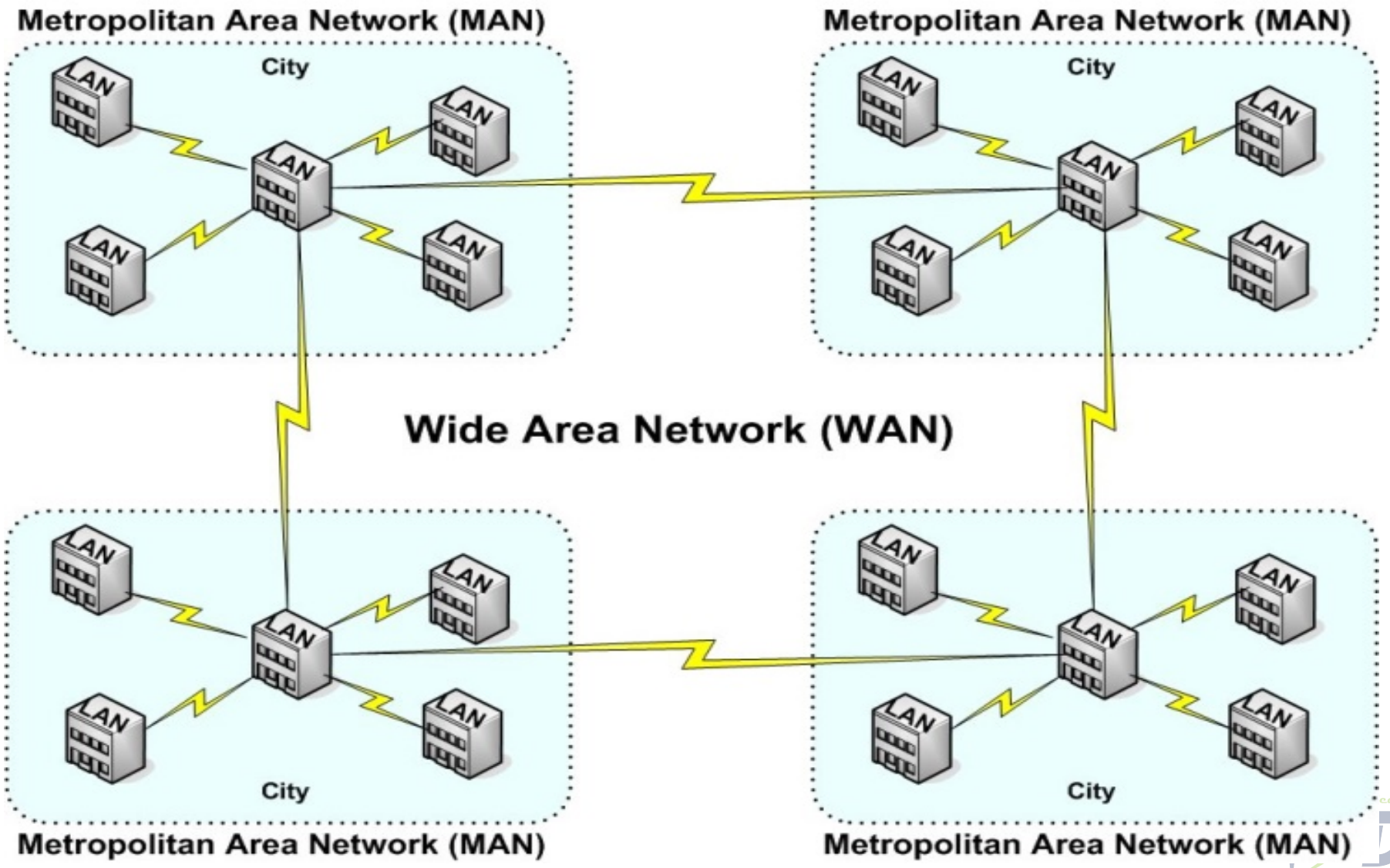


Wide Area Network

- A wide area network (WAN) is a computer network that exists over a large-scale geographical area.
- A WAN connects different networks, including local area networks (LAN) and metropolitan area networks (MAN).
- It may be located with in a state or a country or it may be interconnected around the world.



Types of Computer Networks - Summary

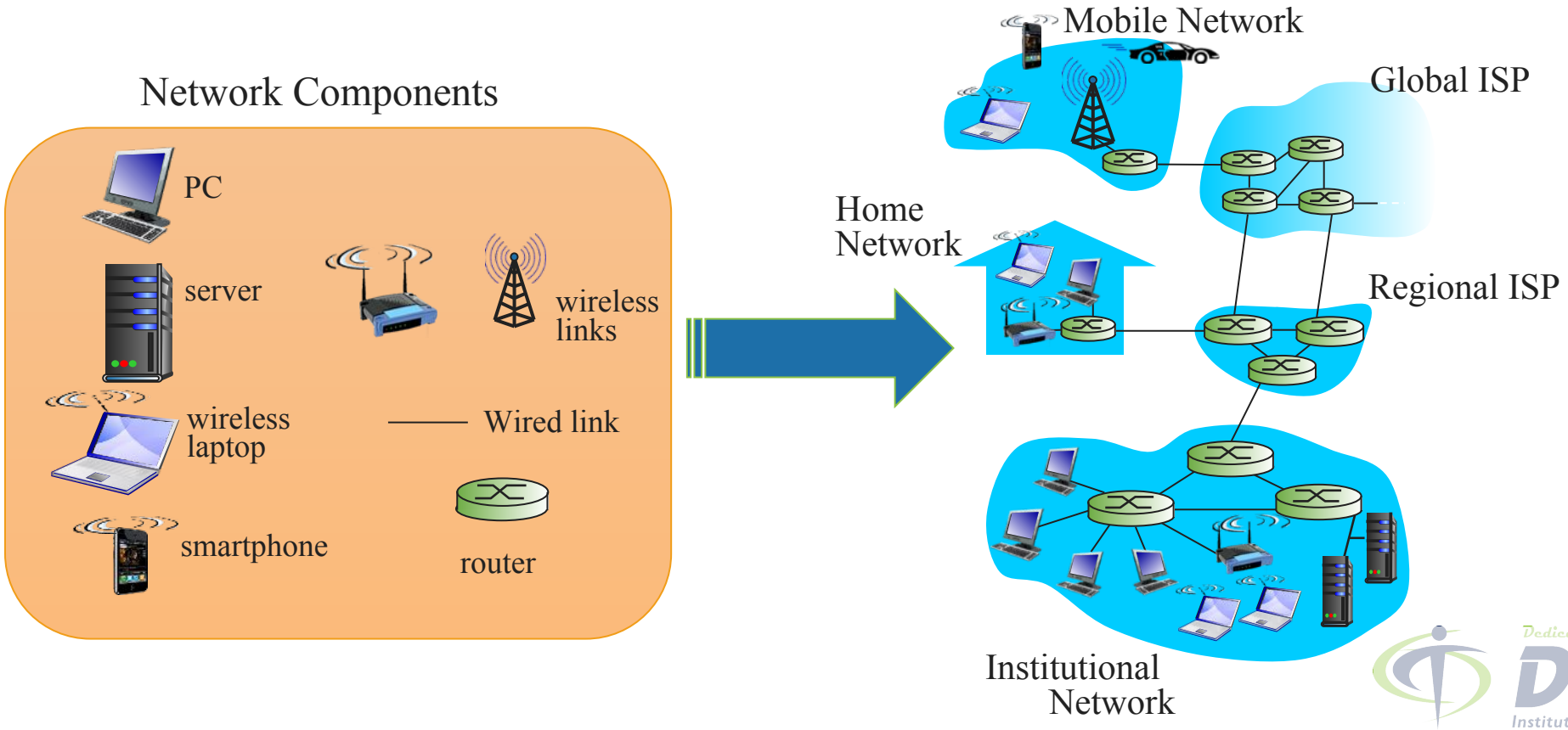


Types of Computer Networks - Summary

Comparison	LAN	MAN	WAN
Full Name	Local Area Network	Metropolitan Area Network	Wide Area Network
Meaning	A network that connects a group of computers in a small geographical area	It covers relatively large region such as cities, towns	It spans large locality & connects countries together. e.g. Internet
Ownership of Network	Private	Private or Public	Private or Public (VPN)
Design and Maintenance	Easy	Difficult	Difficult
Propagation Delay	Short	Moderate	Long
Speed	High	Moderate	Low
Equipment Used	NIC, Switch, Hub	Modem, Router	Microwave, Radio Transmitter & Receiver
Range(Approximately)	1 to 10 km	10 to 100 km	Beyond 100 km
Used for	College, School, Hospital	Small towns, City	State, Country, Continent

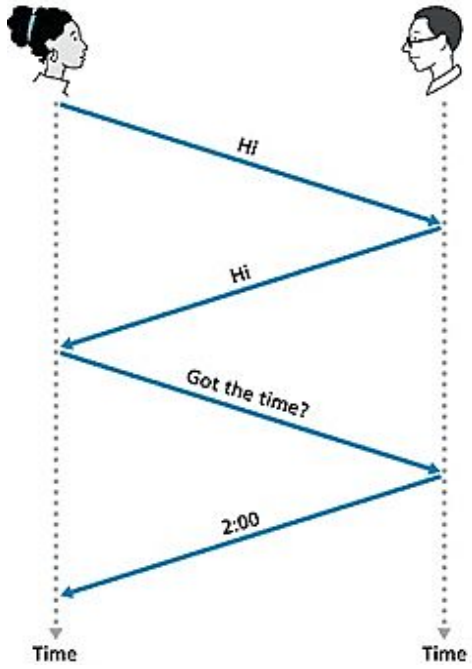
What is Internet?

- The internet is a type of world-wide computer network.
- The internet is the collection of infinite numbers of connected computers that are spread across the world.



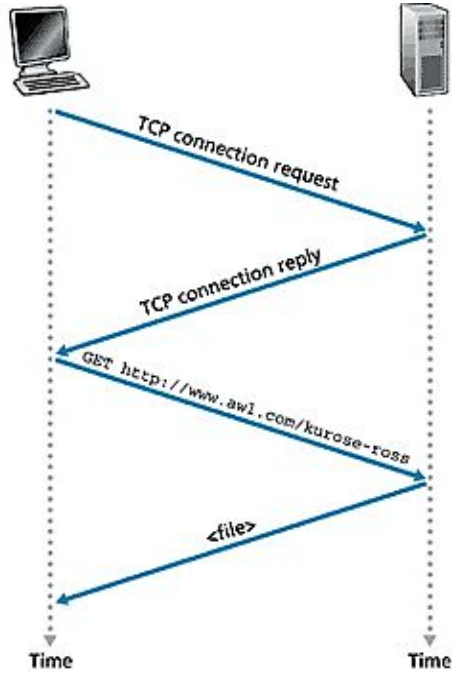
What is Protocol?

- Human Protocol(Language)
  - "what's the time?"
  - "I have a question"
  - Introduction Talk



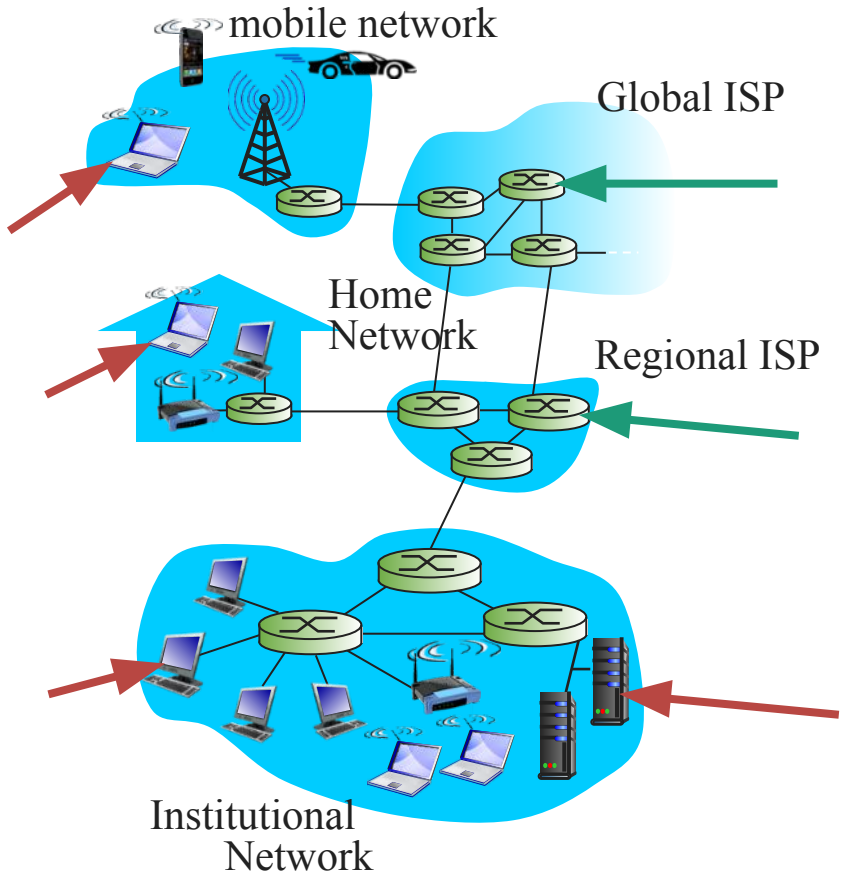
Protocol is define format, order of message that sent and received among network entities, and actions taken on message transmission and reception.

- Network Protocol
  - Set of rules
  - Machines rather than humans.
  - All communication activity in Internet governed by protocols.



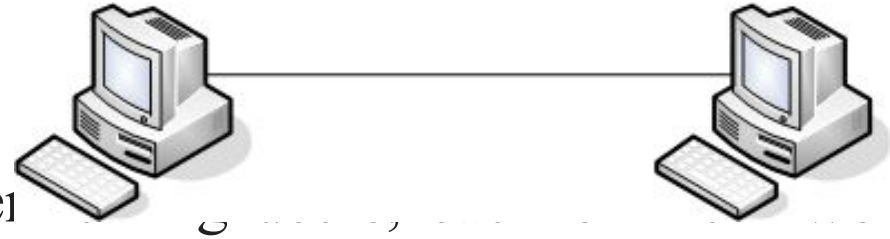
The Network Edge

- Computers and other devices are connected at the edge (end) of the network.
- These computers are known as hosts or end systems. Router is known as edge router.

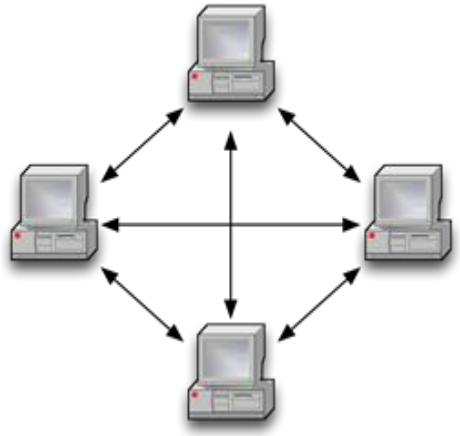


Peer to Peer Network

- Computers are connected together so that users can share resources and information.

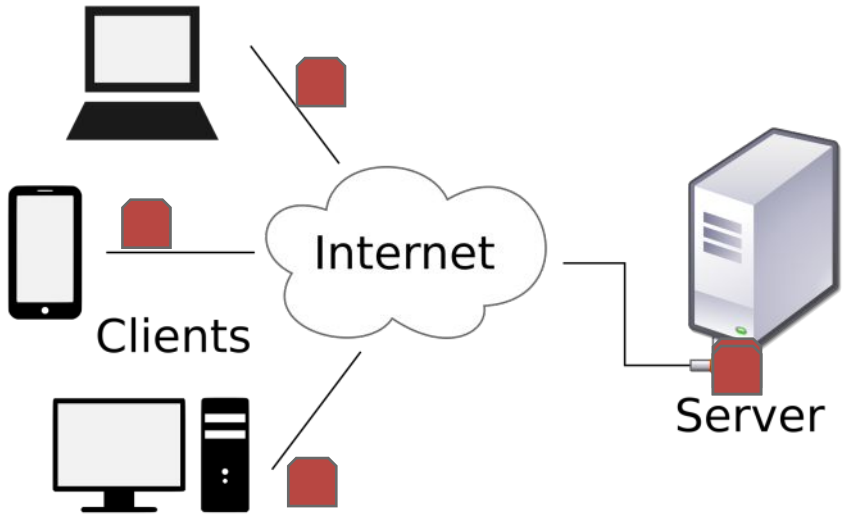


- There is no central server for authe[illegible]ks as both client and server.
- e.g. Bit Torrent



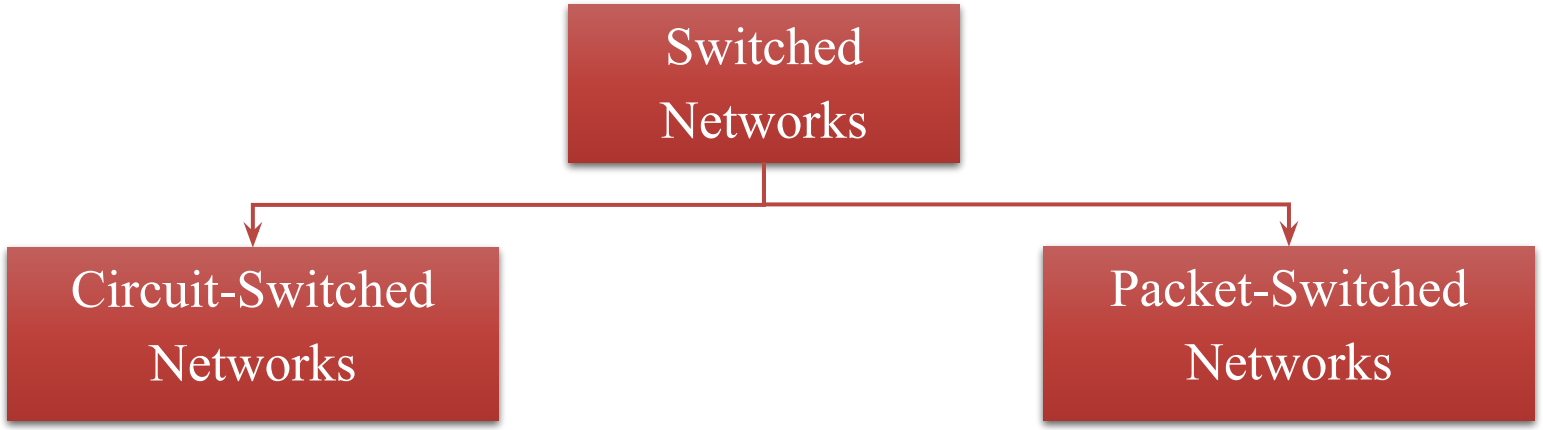
Client – Server Network

- Client: Request servers for a task.
  - Generally called desktop PCs or workstations.
- Server: Receive requests from the clients. Process and response them.
  - e.g. Web Server, Email Server



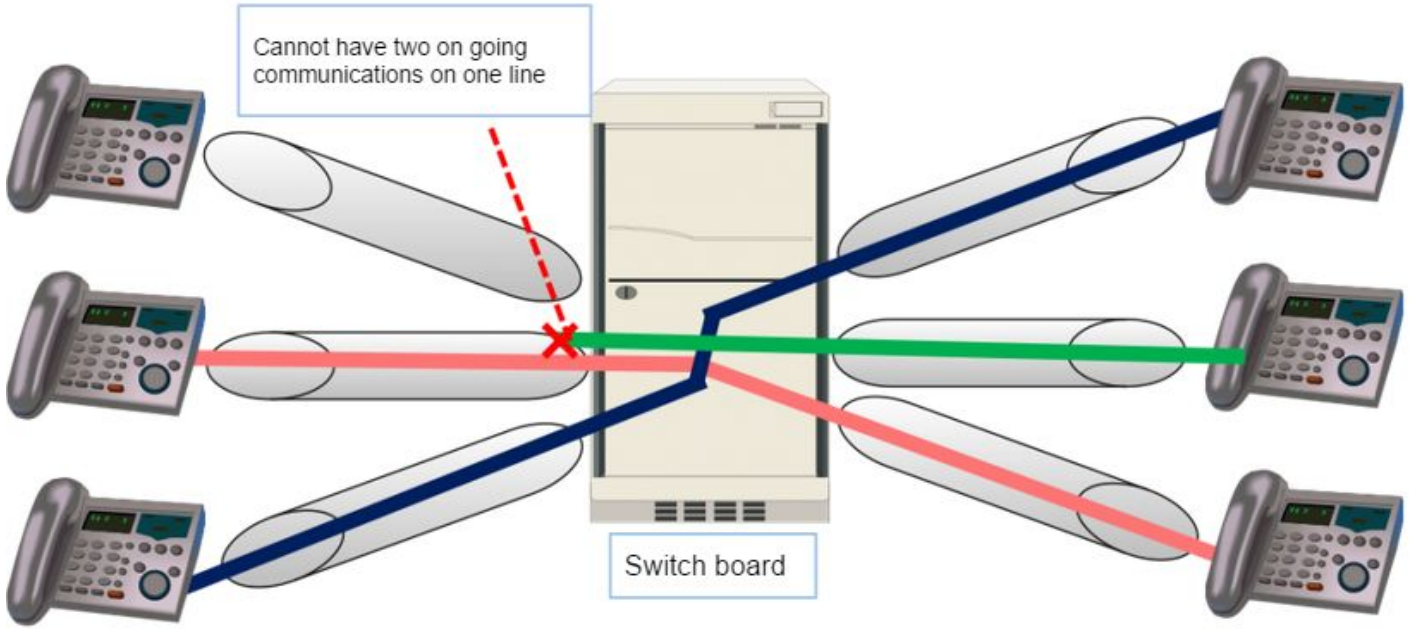
The Network Core

- Defines the connection of different network segments together and process to transmit data packets across the network.
- It is implemented through the use of switching techniques.



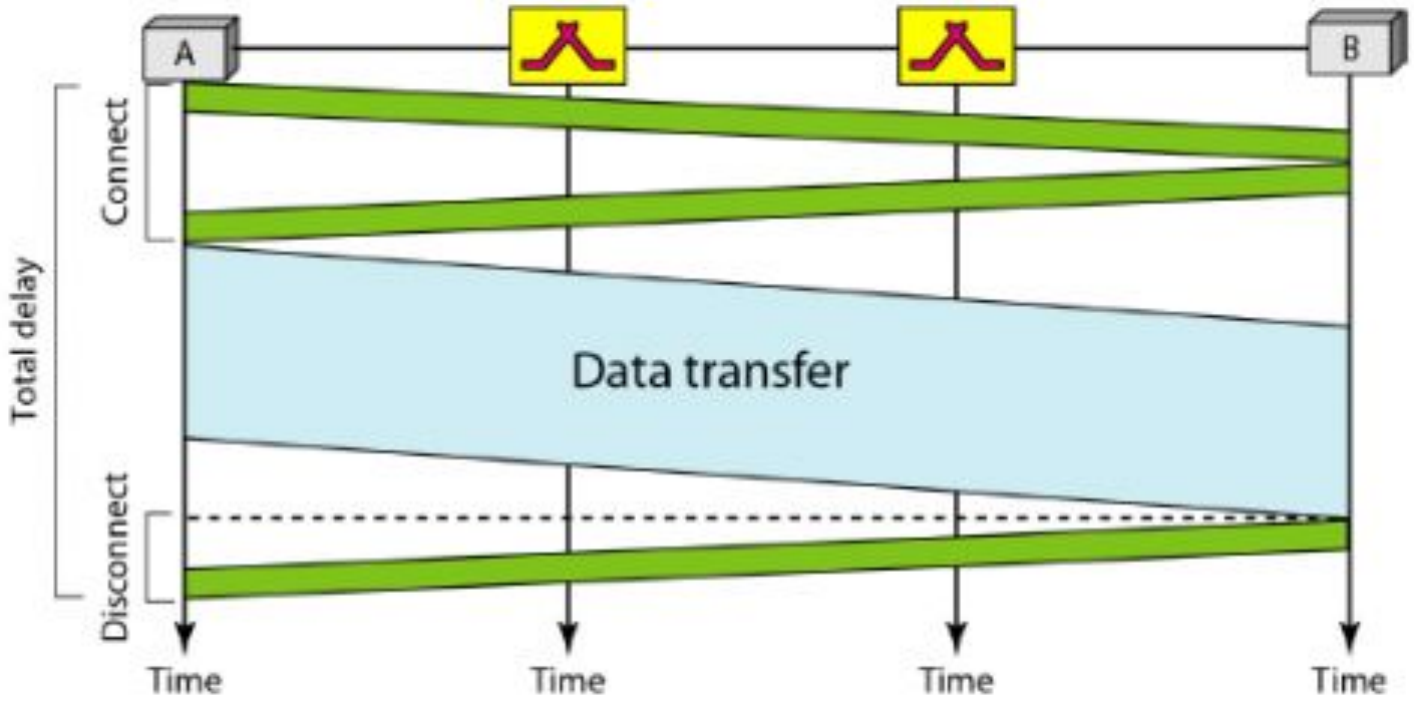
Circuit Switched Network

- A dedicated channel has to be established before the call is made between users.
- The channel is reserved between the users till the connection is active.
- For half duplex(one way) communication, one channel is allocated and for full duplex(two way) communication, two channels are allocated.
- It is mainly used for voice communication requiring real time services without delay.



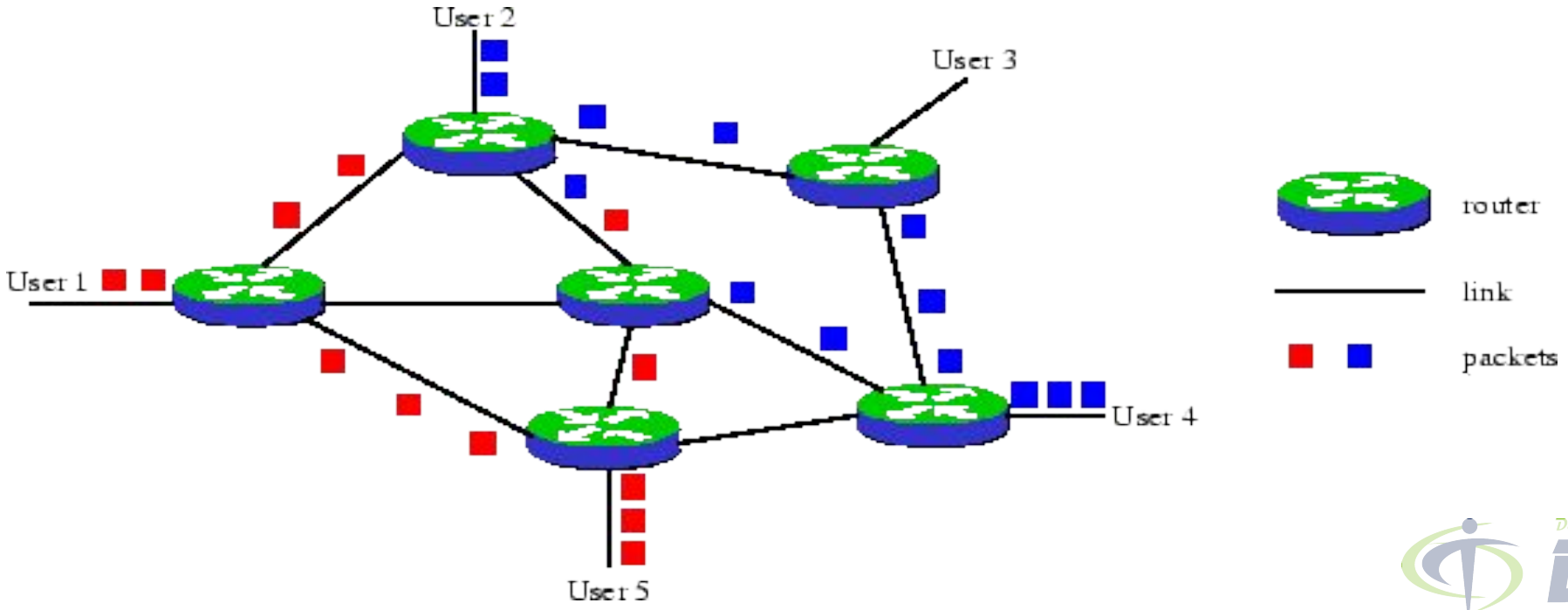
Circuit Switched Network – Cont…

- Communication via circuit switching involves three phases:
  1. Circuit Establishment
  2. Data Transfer
  3. Circuit Disconnect



Packet Switched Network

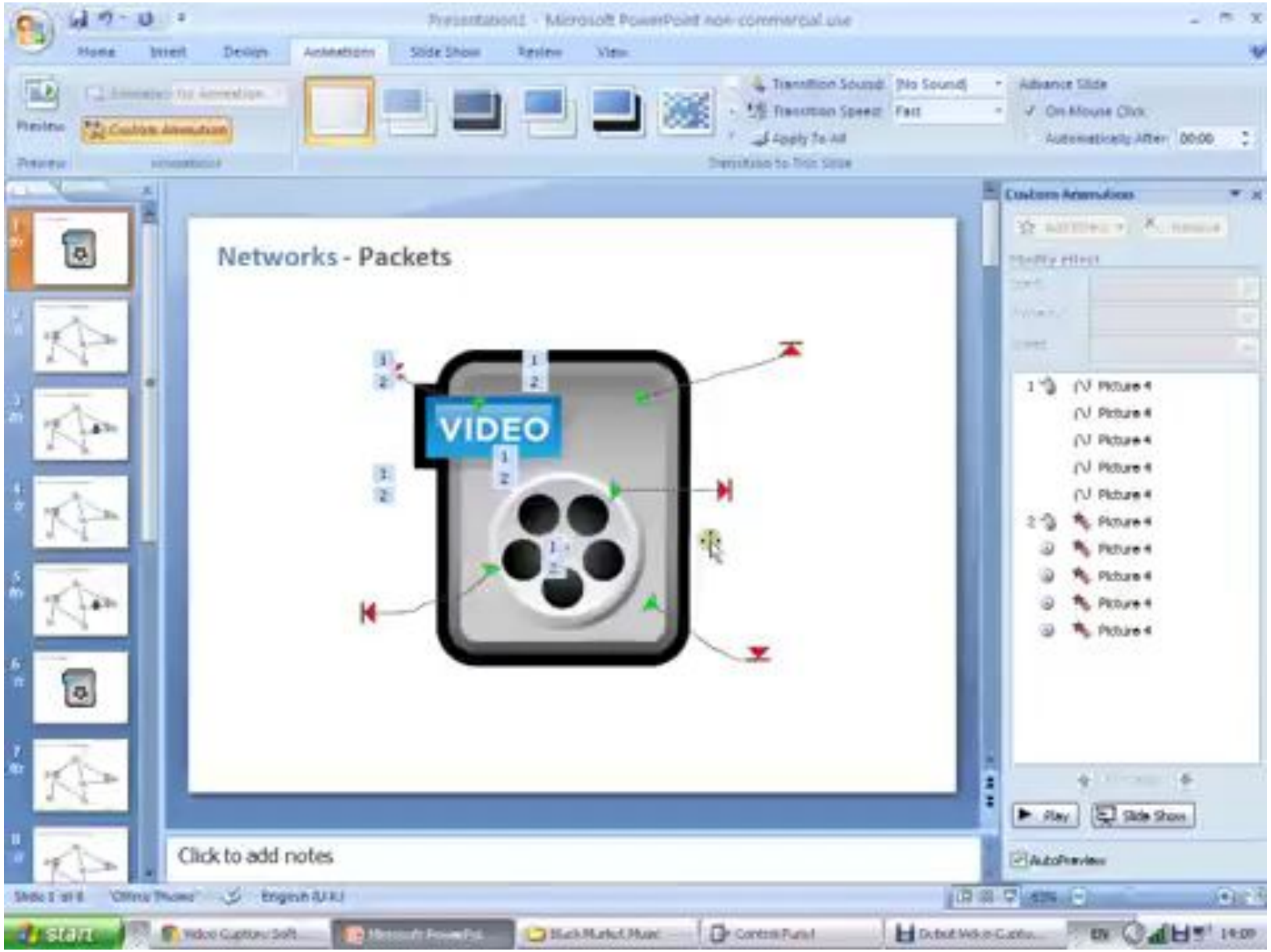
- It is not required to establish the connection initially.
- The connection/channel is available to use by users. But when traffic or number of users increases then it will lead to congestion in the network.
- Packet switched networks are mainly used for data and voice applications requiring non-real time scenarios.



Differences

Circuit Switching	Packet Switching
Dedicated path between source and destination	No dedicated path
All packets use same path	Packets travel independently
Reserve the entire bandwidth in advance	Does not reserve bandwidth
Bandwidth wastage	No bandwidth wastage
No store and forward transmission	Supports store and forward transmission

Switching Network



Transmission Media

Transmission Media

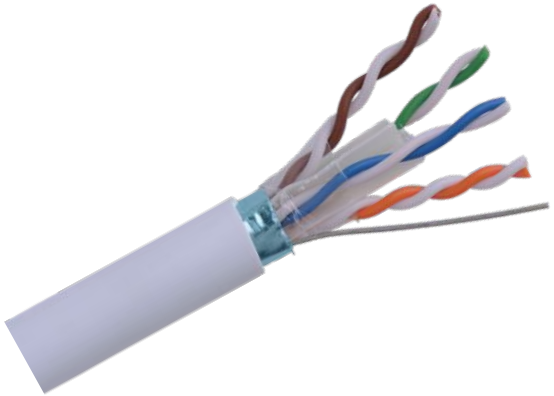
- A transmission media can be defined as any medium that can carry information from a source to a destination.

- **Transmission Media**
  - **Guided Media (Wired)**
    - **Twisted-Pair Cable**
    - **Coaxial Cable**
    - **Fiber Optic Cable**
  - **Unguided Media (Wireless)**
    - **Radio Wave**
    - **Microwave**
    - **Infrared Wave**

Guided Media

- Guided media are those that provide a wired - channel from one device to another.
- Three Guided media commonly used for data transmission are:

Twisted Pair Cable

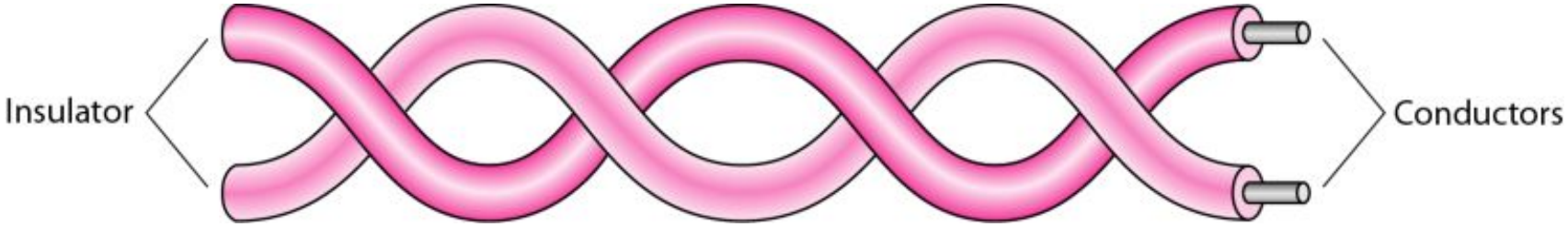


Coaxial Cable

Fiber Optic Cable

Twisted Pair Cable

- It is a physical media made up of a pair of cables twisted with each other.
- It is cheap as compared to other transmission media.
- Installation of the cable is easy, and it is a lightweight cable.
- The frequency range for cable is from 0 to 3.5KHz.
- It consists of two insulated copper wires arranged in a regular spiral pattern.

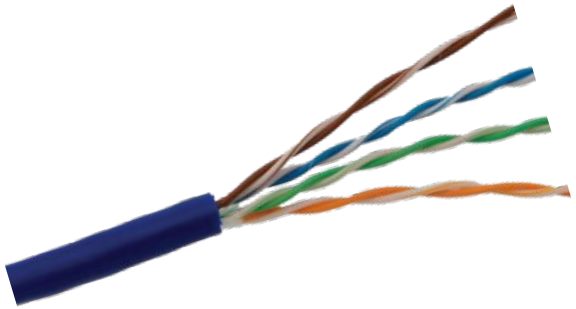


- The degree of reduction in noise interference is determined by the number of turns per foot.
- Increasing the number of turns per foot decreases noise interference.

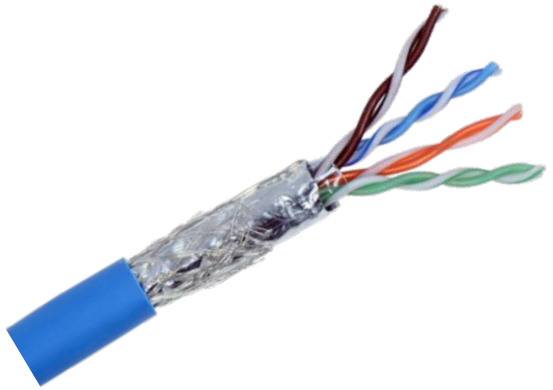
Twisted Pair Cable - Cont.

- Separately insulated
- It is widely used in different kinds of data and voice infrastructure.
- The use of two wires twisted together helps to reduce crosstalk and electromagnetic induction.
- Two types of twisted pair cable:

UTP
(Unshielded Twisted Pair)

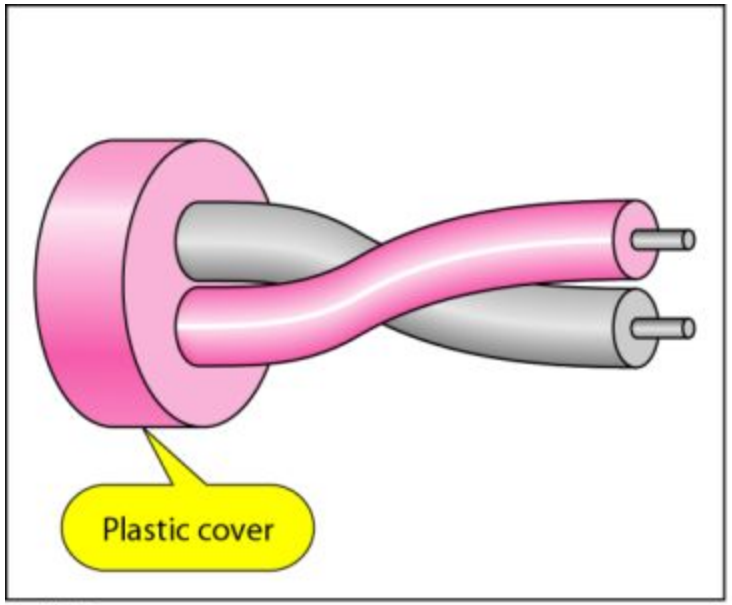


STP
(Shielded Twisted Pair)



Unshielded Twisted Pair Cable

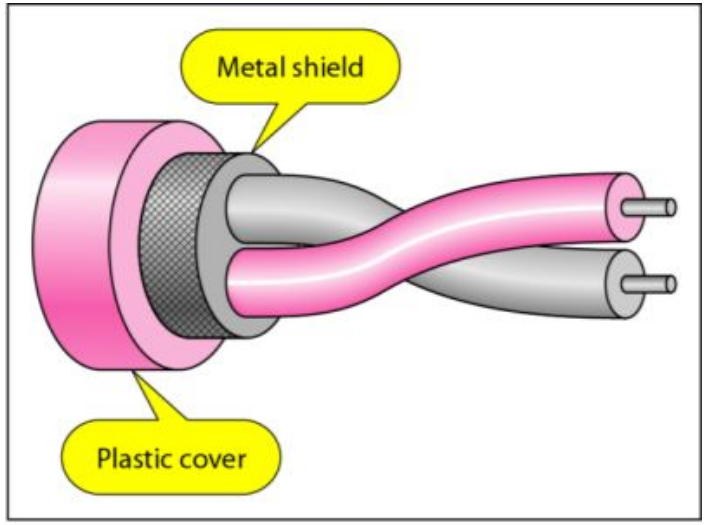
- An unshielded twisted pair is widely used in telecommunication.
  - Ordinary telephone wires.
  - Weak immunity against noise & interferences.
- Following are the categories of UTP:
  - Category 1: Used for telephone lines that have low-speed data.
  - Category 2 & 3 : It can support upto 4Mbps & 16Mbps.
  - Category 4: It can support upto 20Mbps.
    - Therefore, it can be used for long-distance communication.
  - Category 5: It can support upto 200Mbps.



- Advantages:
  - It is cheap.
  - Installation of the unshielded twisted pair is easy.
  - It can be used for high-speed LAN.
- Disadvantage:
  - This cable can only be used for shorter distances because of attenuation

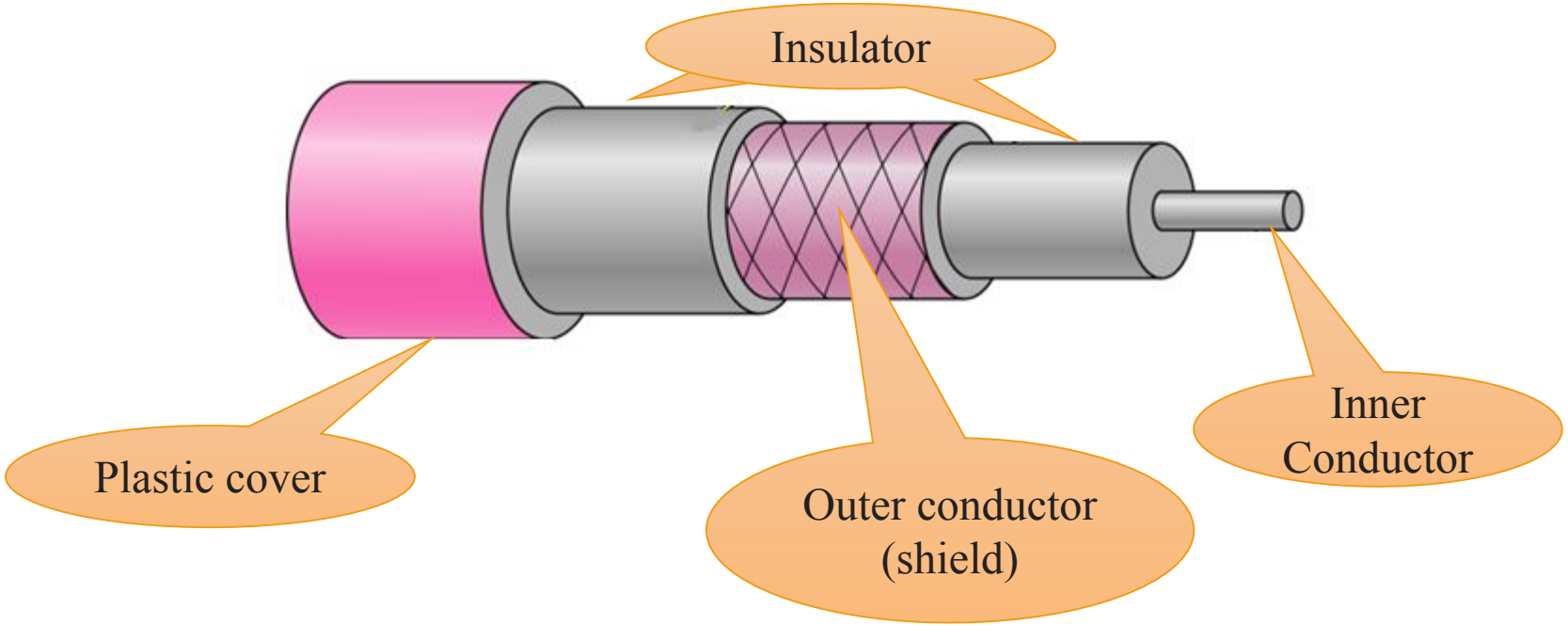
Shielded Twisted Pair Cable

- A shielded twisted pair is a cable that contains the mesh surrounding the wire that allows the higher transmission rate.
- An installation of STP is easy.
- It has a higher attenuation.



- It is shielded that provides the higher data transmission rate.
- It is more expensive as compared to UTP and coaxial cable.
- It has higher capacity as compared to unshielded twisted pair cable.
- Used in exterior network(outside of building).

Coaxial Cable



- Outer conductor is braided shield.
- Inner conductor is solid metal.
- Separated by insulating material, and whole cover by plastic cover.
- The middle core is responsible for the data transferring whereas the copper mesh prevents from the **EMI**(Electromagnetic interference).

Coaxial Cable – Cont.

- Used in television, long distance telephone transmission.
- It has excellent noise immunity.
- It has a higher frequency as compared to Twisted pair cable.
- Coaxial cable is of two types:

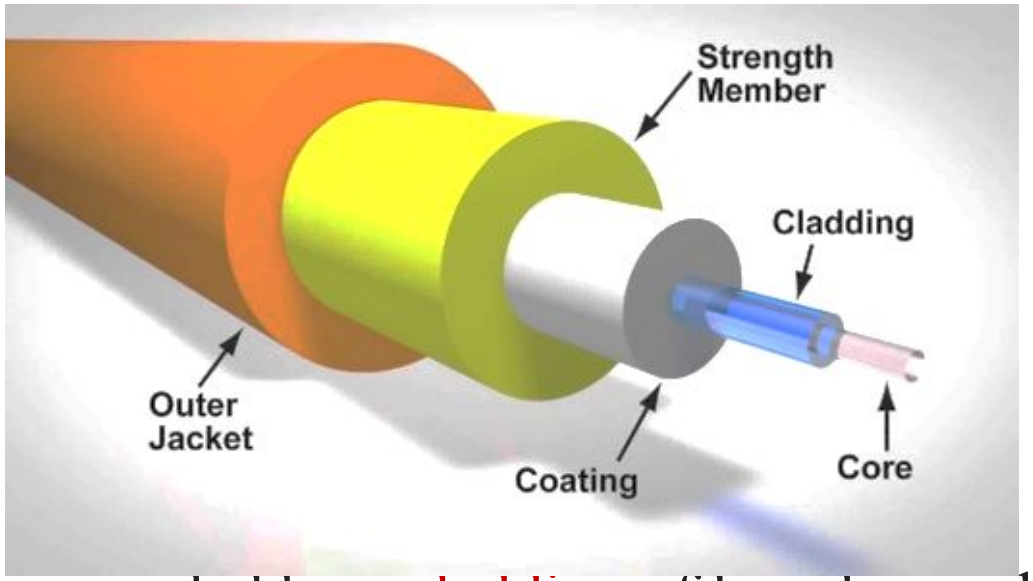
1. Baseband transmission:
   - It is defined as the process of transmitting a single signal at high speed.
2. Broadband transmission:
   - It is defined as the process of transmitting multiple signals simultaneously.

Coaxial Cable – Cont.

- Advantages Of Coaxial cable:
  - The data can be transmitted at high speed.
  - It has better shielding as compared to twisted pair cable.
  - It provides higher bandwidth.
- Disadvantages Of Coaxial cable:
  - It is more expensive as compared to twisted pair cable.
  - If any fault occurs in the cable causes the failure in the entire network.

Fiber Optic Cable

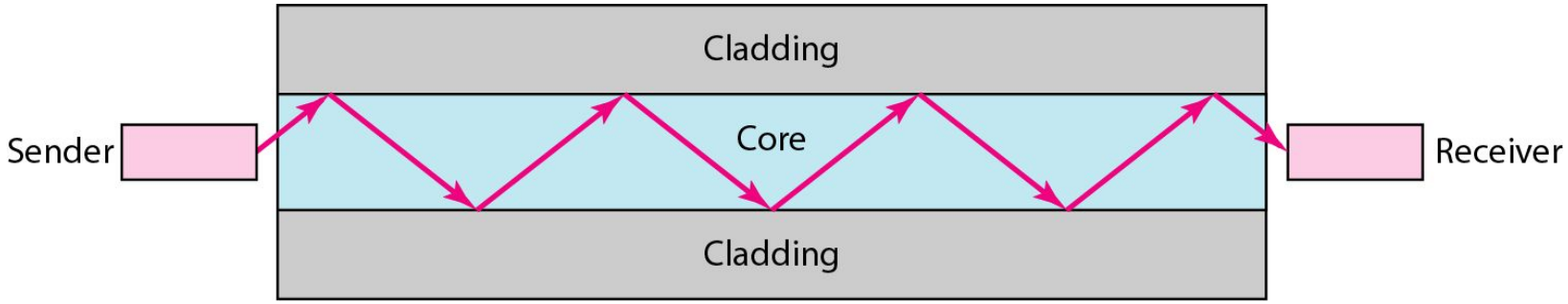
- A fiber-optic cable is made of glass or plastic and transmits signals in the form of light.



- A glass or plastic core is surrounded by a cladding of less dense glass or plastic.
- The difference in density of the two materials must be such that a beam of light moving through a core is reflected off the cladding instead of being refracted into it.
- Optical fibers use reflection to guide light through a channel.

Fiber Optic Cable – Cont.

- **Core:** The optical fibre consists of a narrow strand of glass or plastic known as a core.
- **Cladding:** The concentric layer of glass is known as cladding.
- **Jacket:** The protective coating consisting of plastic is known as a jacket.
- Light travels in a straight line as long as it is moving through a single uniform substance.



Fiber Optic Cable – Advantages

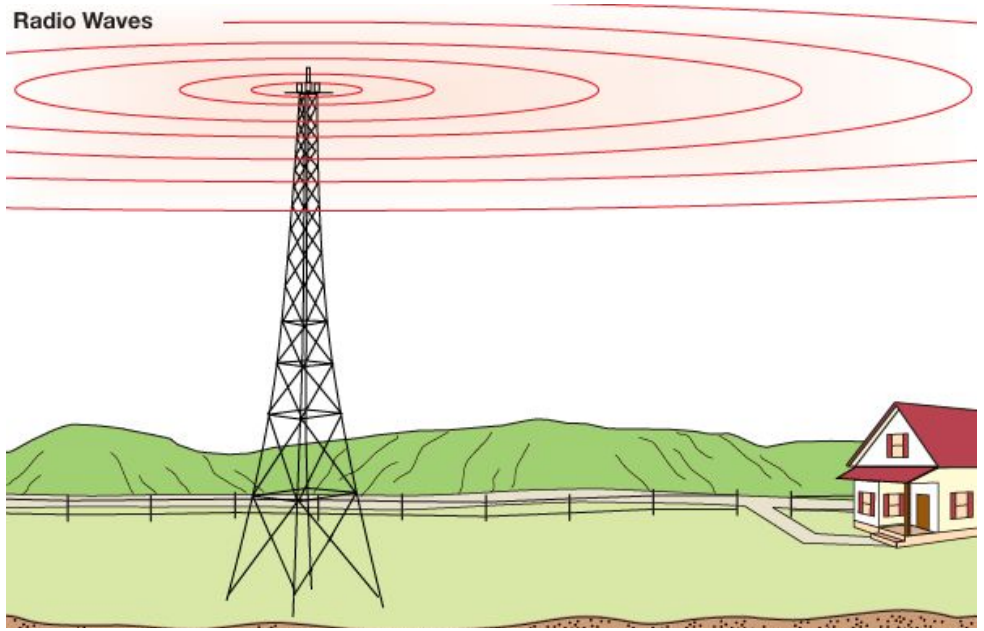
- It provide faster data transmission than copper wires.
- It carries the data at a longer distance as compared to copper cable.
- Small size & weight.
- Better Reliability.
- Used in high bandwidth network.
- High data rate & lower attenuation.

Unguided Media

- An unguided transmission transmits the electromagnetic waves without using any physical medium.
- Therefore it is also known as wireless transmission.
- In unguided media, air is the media through which the electromagnetic energy can flow easily.
- This type of communication is often referred to as wireless communication.
  1. Radio wave
  2. Microwave
  3. Infrared Wave

Radio Wave

- Radio waves are the electromagnetic waves that are transmitted in all the directions of free space.
- Radio waves are omnidirectional.
- The signals are propagated in all the directions.
- The range in frequencies of radio waves is from 3Khz to 1 khz.
- The sending and receiving antenna are not aligned.
- The wave sent by the sending antenna can be received by any receiving antenna.
- An example of the radio wave is FM radio.

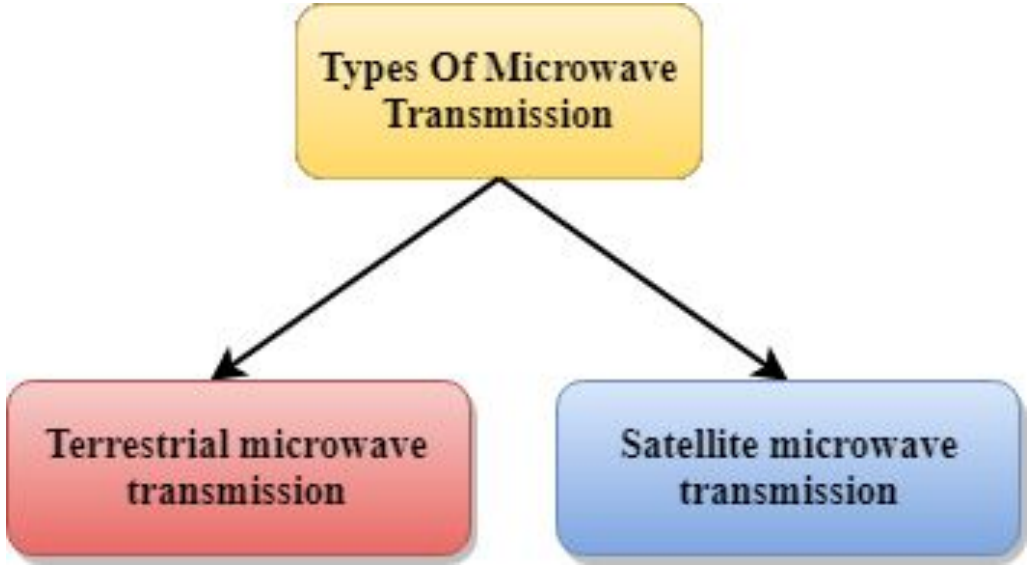


Radio Wave – Cont.

- **Applications:**
  - A Radio wave is useful for multicasting when there is one sender and many receivers.
  - An FM radio, television, cordless phones are examples of a radio wave.
- **Advantages:**
  - Radio transmission is mainly used for wide area networks and mobile cellular phones.
  - It covers a large area, and they can penetrate the walls.
  - Radio transmission provides a higher transmission rate.

Microwave

- Microwaves are of two types:



- Use directional antennas - point to point line of sight communications.
- Microwave communication.
- Used for unicast communication such as cellular telephones, satellite networks.
- Higher frequency ranges cannot efficiently penetrate walls.
- Frequency Range: 1GHz – 300GHz.

Microwave - Characteristics

- **Frequency range:** The frequency range of terrestrial microwave is from 4-6 GHz to 21-23 GHz.
- **Bandwidth:** It supports the bandwidth from 1 to 10 Mbps.
- **Short distance:** It is inexpensive for short distance.
- **Long distance:** It is expensive as it requires a higher tower for a longer distance.
- **Attenuation:** Attenuation means loss of signal. It is affected by environmental conditions and antenna size.

Microwave – Cont.

Advantages Of Microwave transmission :

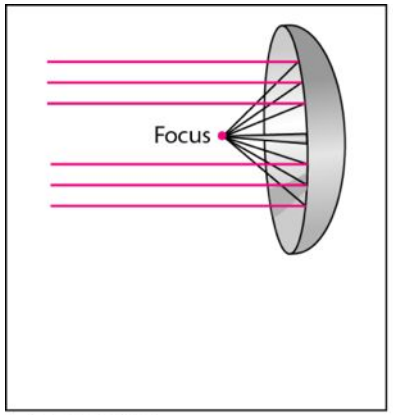
- Microwave transmission is cheaper than using cables.
- It is free from land acquisition as it does not require any land for the installation of cables.
- Microwave transmission provides an easy communication in terrains as the installation of cable in terrain is quite a difficult task.
- Communication over oceans can be achieved by using microwave transmission.

Disadvantages of Microwave transmission :

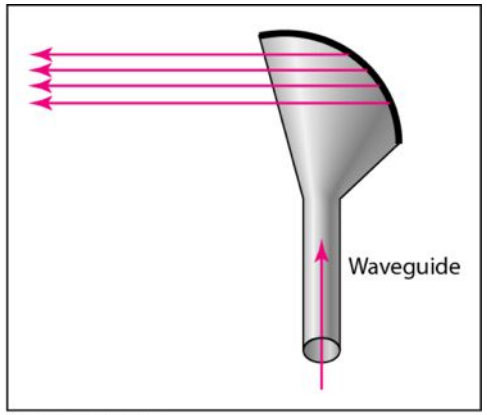
- **Eavesdropping:** An eavesdropping creates insecure communication. Any malicious user can catch the signal in the air by using its own antenna.
- **Out of phase signal:** A signal can be moved out of phase by using microwave transmission.
- **Susceptible to weather condition:** A microwave transmission is susceptible to weather condition. This means that any environmental change such as rain, wind can distort the signal.
- **Bandwidth limited:** Allocation of bandwidth is limited in the case of microwave transmission.

Terrestrial Microwave Transmission

- It is a technology that transmits the focused beam of a radio signal from one ground-based microwave transmission antenna to another.
- Microwaves are unidirectional as the sending and receiving antenna is to be aligned.



a. Dish antenna

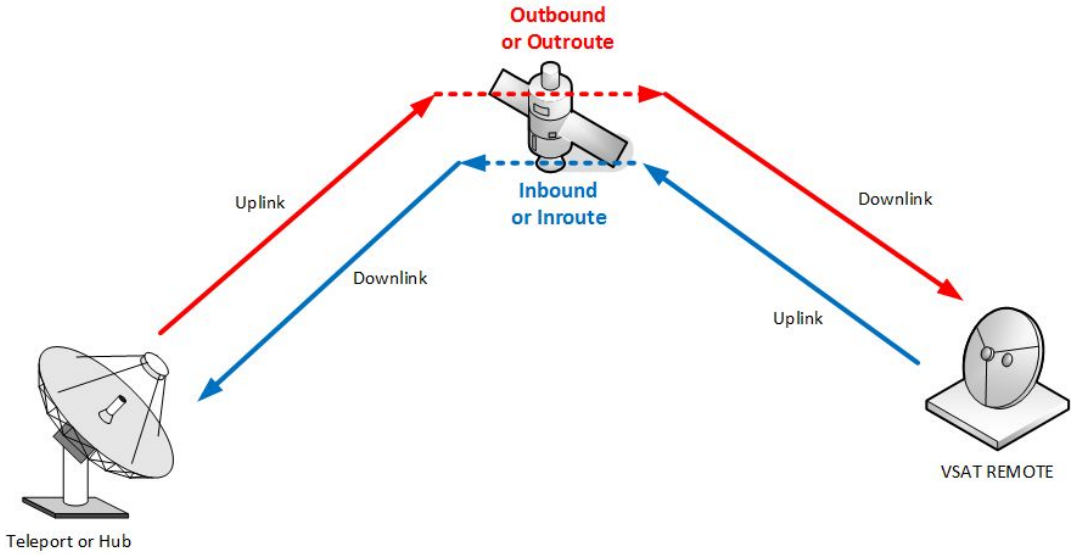


b. Horn antenna

- Antennas are mounted on the towers to send a beam to another antenna which is km away.
- It works on the line of sight transmission.
- The antennas mounted on the towers are the direct sight of each other.

Satellite Microwave Communication

- A satellite is a physical object that revolves around the earth at a known height.
- Satellite communication is more reliable nowadays as it offers more flexibility than cable and fibre optic systems.
- We can communicate with any point on the globe by using satellite communication.
- **How Does Satellite work?**
  - 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.



Satellite Microwave Communication – Cont.

Advantages Of Satellite Microwave Communication:

- The coverage area of a satellite microwave is more than the terrestrial microwave.
- The transmission cost of the satellite is independent of the distance from the centre of the coverage area.
- Satellite communication is used in mobile and wireless communication applications.
- It is easy to install.
- It is used in a wide variety of applications such as weather forecasting, radio/TV signal broadcasting, mobile communication, etc.

Disadvantages Of Satellite Microwave Communication:

- Satellite designing and development requires more time and higher cost.
- The Satellite needs to be monitored and controlled on regular periods so that it remains in orbit.
- The life of the satellite is about 12-15 years. Due to this reason, another launch of the satellite has to be planned before it becomes non-functional.

Infrared wave

- An infrared transmission is a wireless technology used for communication over short ranges.
- The frequency of the infrared in the range from 300 GHz to 400 THz.
- It is used for short-range communication.
- For Example, the data transfer between two cell phones, TV remote operation, data transfer between a computer and cell phone resides in the same closed area.

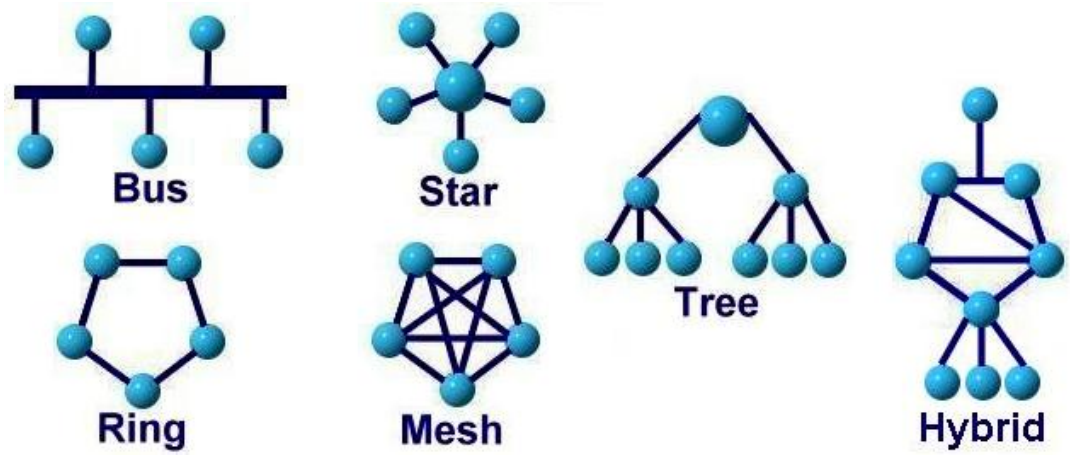
Infrared Wave - Characteristics

- Infrared waves cannot penetrate the walls.
- Therefore, the infrared communication in one room cannot be interrupted by the nearby rooms.
- An infrared communication provides better security with minimum interference.
- Infrared communication is unreliable outside the building because the sun rays will interfere with the infrared waves.

Network Topologies

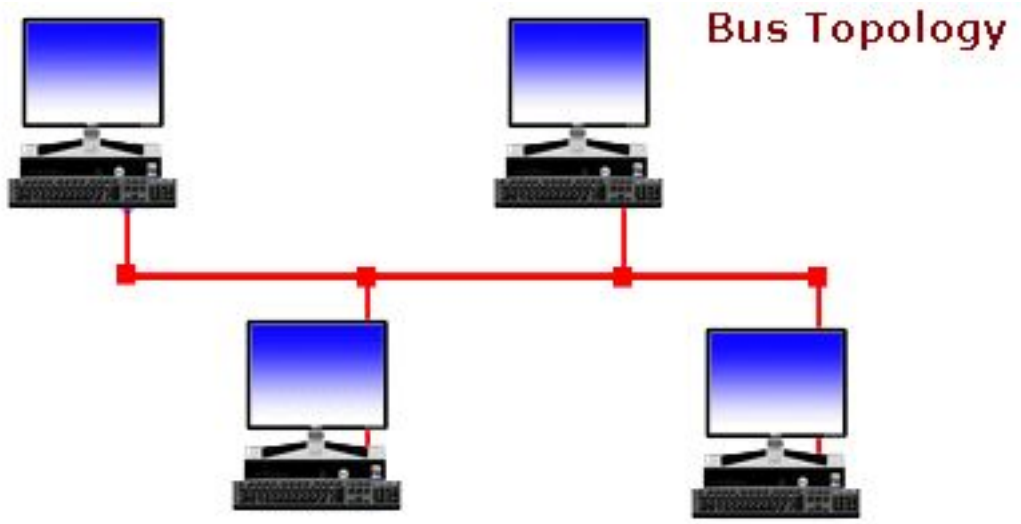
Network Topologies

- Network topology is the arrangement of the various components (links, nodes, etc.) of a computer network.
- Types of network topologies :
  1. Bus
  2. Ring
  3. Star
  4. Mesh
  5. Tree
  6. Hybrid



Bus Topology

- Every computer and network device is connected to single cable.
- It transmits data only in one direction.
- When a node wants to send a message over the network, it puts a message over the network.
- All the stations available in the network will receive the message whether it has been addressed or not.
- Used in small networks.
- Easy to expand joining two cables together.
- It is used in early LAN connection.



Bus Topology – Advantages

- **Low-cost cable:**
  - In this, nodes are directly connected to the cable without passing through a hub. Therefore, the initial cost of installation is low.
- **Moderate data speeds:**
  - Coaxial or twisted pair cables are mainly used in bus-based networks that support upto 10 Mbps.
- **Familiar technology:**
  - Bus topology is a familiar technology as the installation and troubleshooting techniques are well known, and hardware components are easily available.
- **Limited failure:**
  - A failure in one node will not have any effect on other nodes.

Bus Topology – Disadvantages

- **Extensive cabling:**
  - A bus topology is quite simpler, but still it requires a lot of cabling.
- **Difficult troubleshooting:**
  - It requires specialized test equipment to determine the cable faults. If any fault occurs in the cable, then it would disrupt the communication for all the nodes.
- **Signal interference:**
  - If two nodes send the messages simultaneously, then the signals of both the nodes collide with each other.
- **Reconfiguration difficult:**
  - Adding new devices to the network would slow down the network.
- **Attenuation:**
  - Attenuation is a loss of signal leads to communication issues. Repeaters are used to regenerate the signal.

Ring Topology

- It forms a ring as each computer is connected to another computer, with the last one connected to the first.
- Transmission is unidirectional & sequential way that is bit by bit.
- The data flows in a single loop continuously known as an endless loop.
- The data in a ring topology flow in a clockwise direction.
- Transmitting network 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.

Ring Topology – Advantages

- **Network Management:**
  - Faulty devices can be removed from the network without bringing the network down.
- **Product availability:**
  - Many hardware and software tools for network operation and monitoring are available.
- **Cost:**
  - Twisted pair cabling is inexpensive and easily available. Therefore, the installation cost is very low.
- **Reliable:**
  - It is a more reliable network because the communication system is not dependent on the single host computer.

Ring Topology – Disadvantages

- **Difficult troubleshooting:**
  - It requires specialized test equipment to determine the cable faults. If any fault occurs in the cable, then it would disrupt the communication for all the nodes.
- **Failure:**
  - The breakdown in one station leads to the failure of the overall network.
- **Reconfiguration difficult:**
  - Adding new devices to the network would slow down the network.
- **Delay:**
  - Communication delay is directly proportional to the number of nodes. Adding new devices increases the communication delay.

Star Topology

- Computers are connected to a single central hub through a cable.
- Fast performance with few nodes and low network traffic.
- Easy to troubleshoot & Easy to setup and modify.
- Only that node is affected which has failed rest of the nodes can work smoothly.
- Hub can be upgraded easily.

Star Topology - Advantages

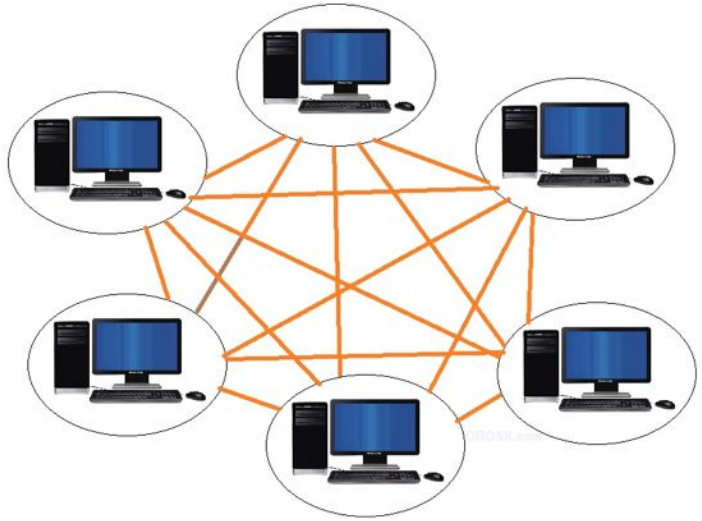
- **Efficient troubleshooting:**
  - All the stations are connected to the centralized network. Therefore, the network administrator has to go to the single station to troubleshoot the problem.
- **Network control:**
  - Complex network control features can be easily implemented in the star topology. Any changes made in the star topology are automatically accommodated.
- **Limited failure:**
  - As each station is connected to the central hub with its own cable, therefore failure in one cable will not affect the entire network.
- **Easily expandable:**
  - It is easily expandable as new stations can be added to the open ports on the hub.
- **Cost effective:**
  - Star topology networks are cost-effective as it uses inexpensive coaxial cable.
- **High data speeds:**
  - It supports a bandwidth of approx 100Mbps. Ethernet 100BaseT is one of the most popular Star topology networks.

Star Topology - Disadvantages

- **A Central point of failure:**
  - If the central hub or switch goes down, then all the connected nodes will not be able to communicate with each other.
- **Cable:**
  - Sometimes cable routing becomes difficult when a significant amount of routing is required.

Mesh Topology

- Point-to-point connection to other devices or fully connected.
- Traffic is carried only between two connected devices.
- Robust, costly but not flexible.
- Fault is diagnosed easily.
- More cable resource used in setup.



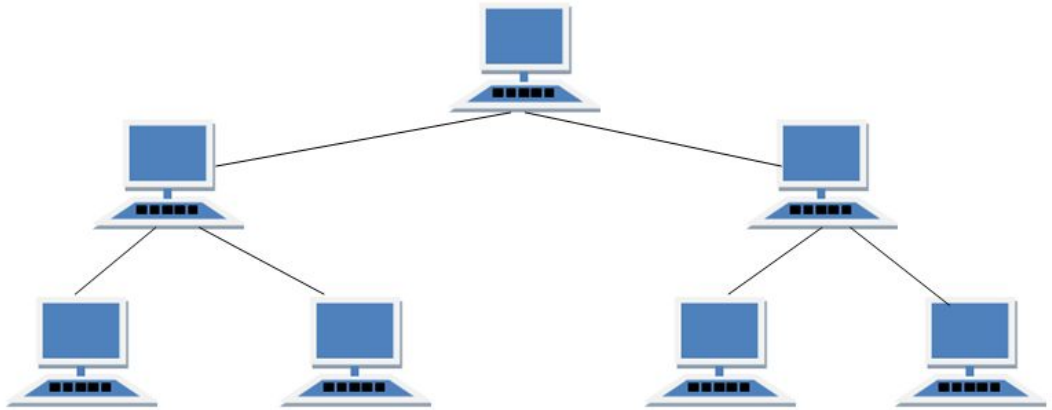
Mesh Topology - Advantages

- **Reliable:**
  - The mesh topology networks are very reliable as if any link breakdown will not affect the communication between connected computers.
- **Fast Communication:**
  - Communication is very fast between the nodes.
- **Easier Reconfiguration:**
  - Adding new devices would not disrupt the communication between other devices.

Mesh Topology - Disadvantages

- **Cost:**
  - A mesh topology contains a large number of connected devices such as a router and more transmission media than other topologies.
- **Management:**
  - Mesh topology networks are very large and very difficult to maintain and manage. If the network is not monitored carefully, then the communication link failure goes undetected.
- **Efficiency:**
  - In this, redundant connections are high that reduces the efficiency of the network.

Tree Topology



- It has a root node and all other nodes are connected to it forming a hierarchy.
- Also called hierarchical topology.
- Mostly used in Wide Area Network – WAN.
- Expansion of nodes is possible and easy.
- Easily managed and maintained.

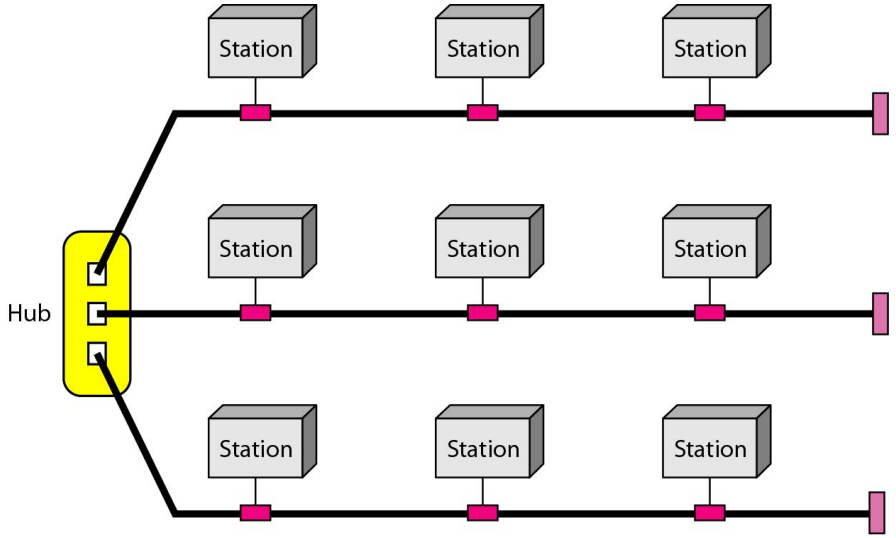
Tree Topology - Advantages

- **Support for broadband transmission:**
  - Tree topology is mainly used to provide broadband transmission, i.e., signals are sent over long distances without being attenuated.
- **Easily expandable:**
  - We can add the new device to the existing network. Therefore, we can say that tree topology is easily expandable.
- **Easily manageable:**
  - In tree topology, the whole network is divided into segments known as star networks which can be easily managed and maintained.
- **Error detection:**
  - Error detection and error correction are very easy in a tree topology.
- **Limited failure:**
  - The breakdown in one station does not affect the entire network.
- **Point-to-point wiring:**
  - It has point-to-point wiring for individual segments.

Tree Topology - Disadvantages

- **Difficult troubleshooting:**
  - If any fault occurs in the node, then it becomes difficult to troubleshoot the problem.
- **High cost:**
  - Devices required for broadband transmission are very costly.
- **Failure:**
  - A tree topology mainly relies on main bus cable and failure in main bus cable will damage the overall network.
- **Reconfiguration difficult:**
  - If new devices are added, then it becomes difficult to reconfigure.

Hybrid Topology



- A network structure whose design contains more than one topology is said to be hybrid topology.
- It is a combination of two or more topologies.
- Flexible & reliable as error detection and easy to troubleshoot.
- Scalable as size can be increased easily.

Comparison of Topologies

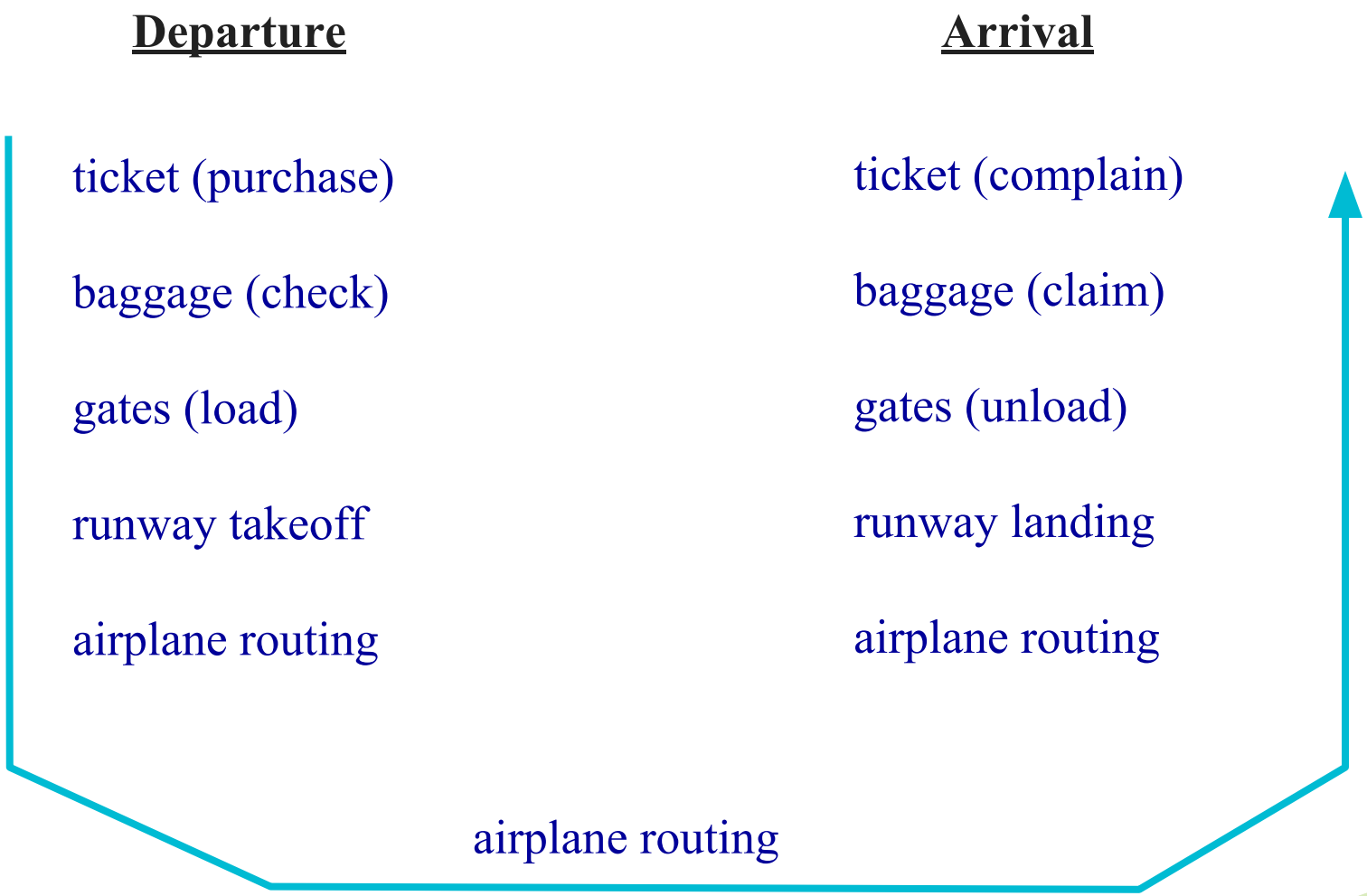
	Bus	Ring	Star	Mesh	Tree
Means	every computer and network device is connected to single cable.	Each computer is connected to another, with the last one connected to the first.	All the computers are connected to a single hub through a cable.	All the network nodes are connected to each other.	It has a root node and all other nodes are connected to it forming a hierarchy.
Cost	Average	Cheap	High	High	High
Used in	Small Network	Expand Network	Small Network	Expand Network	Expand Network
Troubleshoot	Easy, But Cables fail then whole network fails.	Difficult; Failure of one computer disturbs the whole network.	Easy; If the hub fails then the whole network is down.	Difficult; Installation and configuration is difficult.	Easy; Central root hub fails, network fails.

Protocol Layers

Protocols Layers

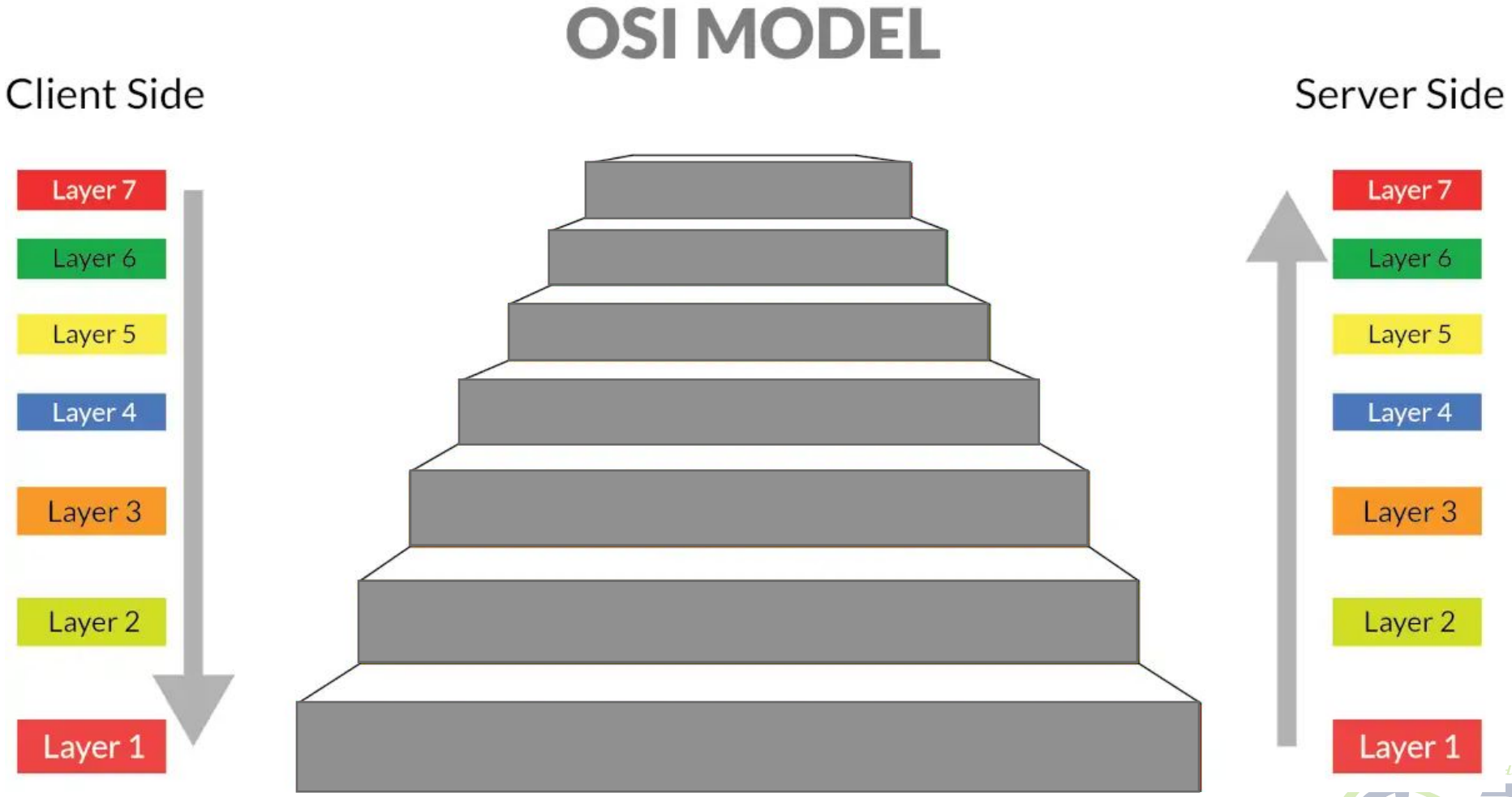
- To deals with connecting systems that are open for communication with other systems.
- OSI Layer Model (Open Systems Interconnection)
- Developed by the International Standards Organization (ISO) with seven different layers.
  1. Physical Layer
  2. Data Link Layer
  3. Network Layer
  4. Transport Layer
  5. Session Layer
  6. Presentation Layer
  7. Application Layer

Example – Air Plane Travel

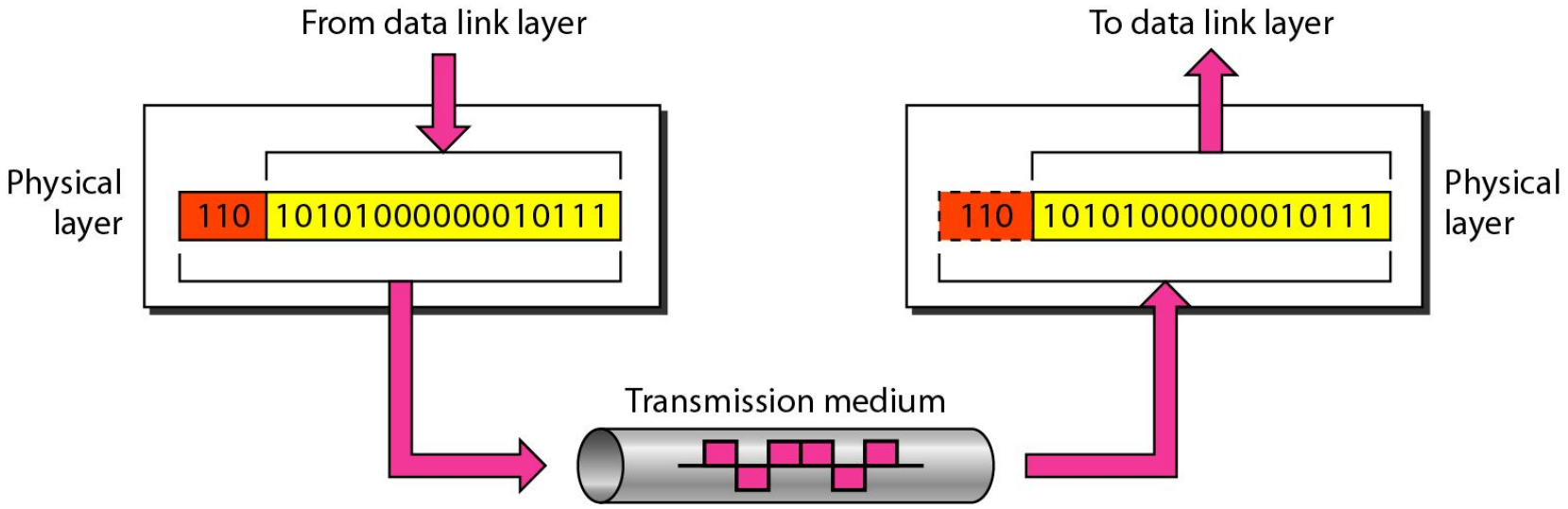


How OSI Layer Works?

Open Systems Interconnect (OSI) OSI Reference Model



Physical Layer



- The physical layer is responsible for movements of individual bits from one hop (node) to the next.

Physical Layer

- It is the **lowest layer** of the OSI model.
- It is **responsible for** the actual **physical connection** between the devices.
- It **establishes**, **maintains** and deactivates the **physical connection**.
- The physical layer contains information in the form of **bits.**
- The main functionality of the physical layer is to transmit the **individual bits from one node to another** node.
- This layer will get the signal and send it to the Data Link layer.
- Hub, Repeater, Modem, Cables are Physical Layer devices

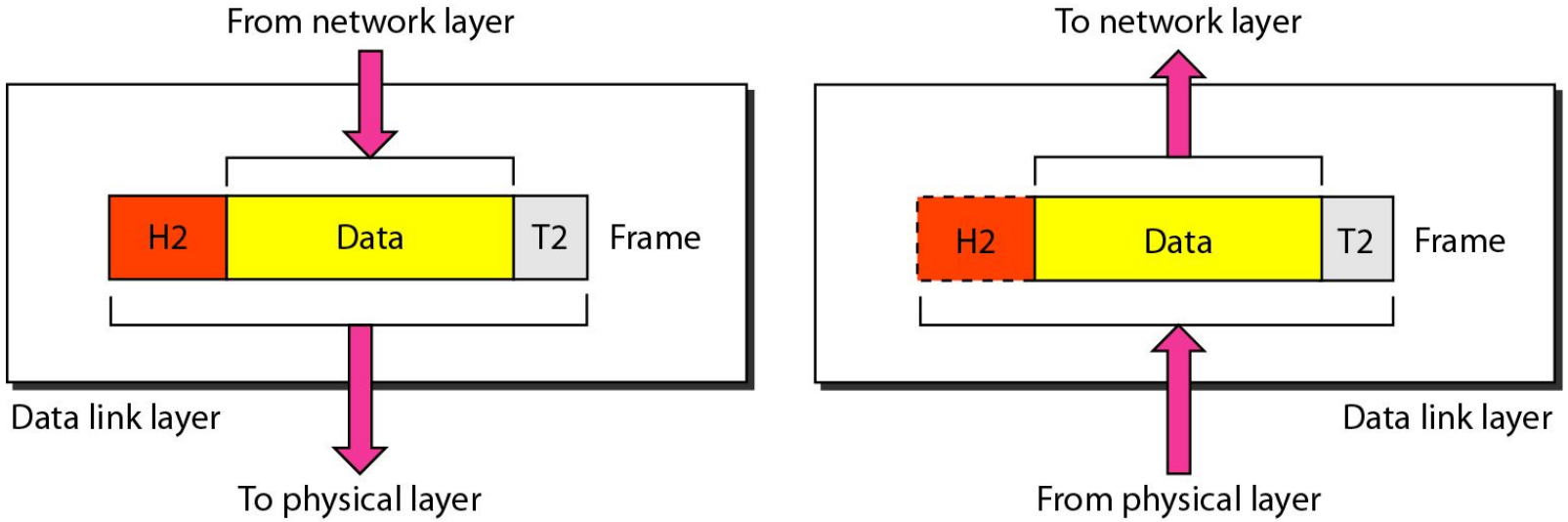
Functions of a Physical layer

- **Line Configuration:**
  - It defines the way how two or more devices can be connected physically.
- **Signals:**
  - It determines the type of the signal used for transmitting the information.
- **Bit synchronization:**
  - It provides the synchronization of the bits by providing a clock. This clock controls both sender and receiver thus providing synchronization at bit level.
- **Bit rate control:**
  - It also defines the transmission rate i.e. the number of bits sent per second.
- **Physical topologies:**
  - It specifies the way in which the different, devices/nodes are arranged in a network i.e. bus, star, or mesh topology.
- **Transmission mode:**
  - It also defines the way in which the data flows between the two connected devices.
  - The various transmission modes possible are Simplex, half-duplex and full-duplex.

Physical Layer – Cont…

- Carries the bit stream over a physical media.
- Physical Layer is concerned with:
  - Interface and Medium like guided cables
  - Representation of bits
  - Data rate
  - Synchronization of bits
  - Line configuration
  - Physical topology
  - Transmission mode

Data Link Layer



- The data link layer is responsible for moving frames from one hop (node) to the next.

Data-Link Layer

- This layer is **responsible** for the **error-free transfer** of data frames.
- It provides *hop-to-hop delivery.*
- It **defines** the **format of** the **data** on the network.
- It provides a **reliable** and efficient **communication**.
- It is mainly responsible for the **unique identification of** each **device** that resides on a local network.
- When a packet arrives in a network, it is the responsibility of DLL to **transmit** it **to** the **Host using** its **MAC address**
- *Packet in Data Link layer is referred to as* **Frame**
- Data Link layer is handled by the NIC (Network Interface Card) and device drivers of host machines
- Switch & Bridge are Data Link Layer devices.

Data-Link Layer

- Data Link Layer is divided into two sublayers:

Logical Link Control Layer

- It is responsible for transferring the packets to the Network layer.
- It identifies the address of the network layer protocol from the header.
- It also provides flow control.
- Error detection, using Ethernet trailer field frame check sequence (FCS).

Media Access Control Layer

- Provides physical addressing
- A Media access control layer is a link between the Logical Link Control layer and the network's physical layer.
- It is used for transferring the packets over the network.

- The packet received from the Network layer is further divided into frames depending on the frame size of NIC (Network Interface Card).
- DLL also encapsulates Sender and Receiver's MAC address in the header.

Functions of the Data-link layer

Framing:

- Framing is a function of the data link layer.
- The data link layer translates the physical's raw bit stream into packets known as Frames.
- Breaks messages into frames and reassembles frames into messages
- Attaching special bit patterns to the beginning and end of the frame.
- The Data link layer adds the header and trailer to the frame.

Physical Addressing:

- The Data link layer adds a header to the frame that contains destination and source addresses.
- The frame is transmitted to the destination address mentioned in the header.

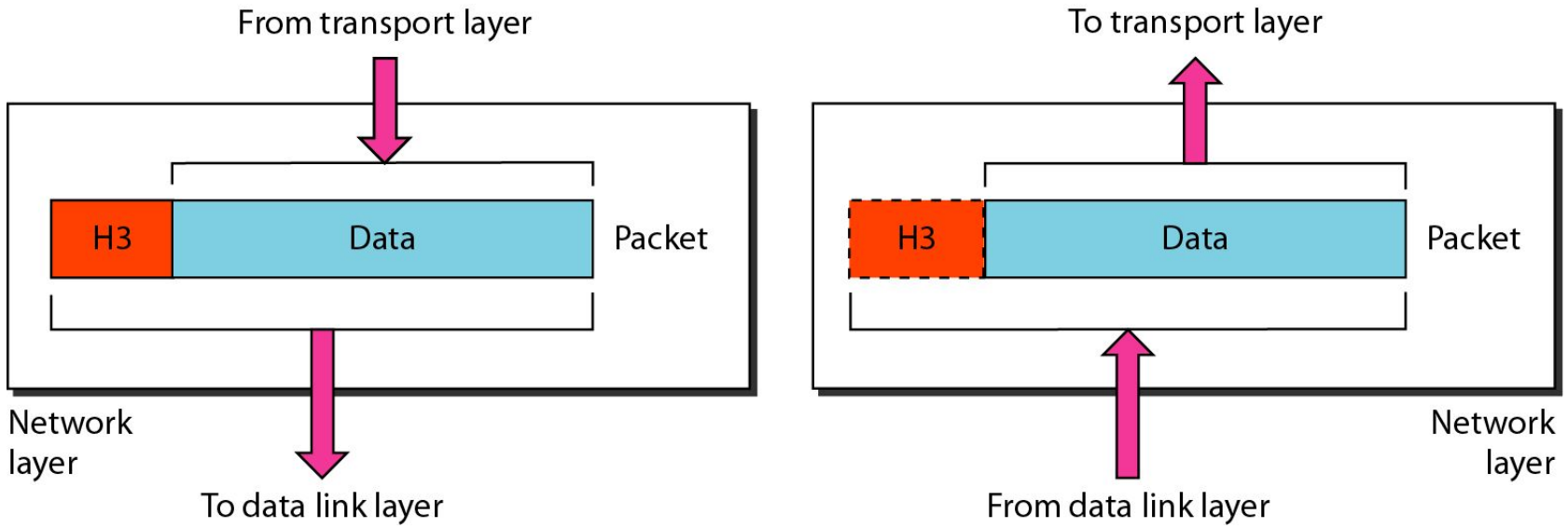
Functions of the Data-link layer

- **Flow Control**:
  - It is the main functionality of the Data-link layer.
  - It is the technique through which the constant data rate is maintained on both the sides so that no data get corrupted.
  - It keeps a fast transmitter from flooding a slow receiver.
- **Error Control**:
  - Adding a calculated value CRC (Cyclic Redundancy Check) that is placed to the Data link layer's trailer.
  - The CRC is added to the message frame before it is sent to the physical layer.
  - If any error seems to occur, then the receiver sends the acknowledgment for the retransmission of the corrupted frames.
  - Data link layer provides the mechanism of error control in which it detects and retransmits damaged or lost frames.
- **Access Control**:
  - When two or more devices are connected to the same communication channel, then
  - The data link layer protocols are used to define which device has control over the communication link at a given time.

Data Link Layer – Cont…

- Data link layer is concerned with:
  - Framing – divide bits stream into data unit (frame)
  - Physical addressing
  - Flow control – avoid over overwhelming
  - Error control – bit loses, retransmission
  - Access control

Network Layer



- The network layer is responsible for the delivery of individual packets from the source host to the destination host.

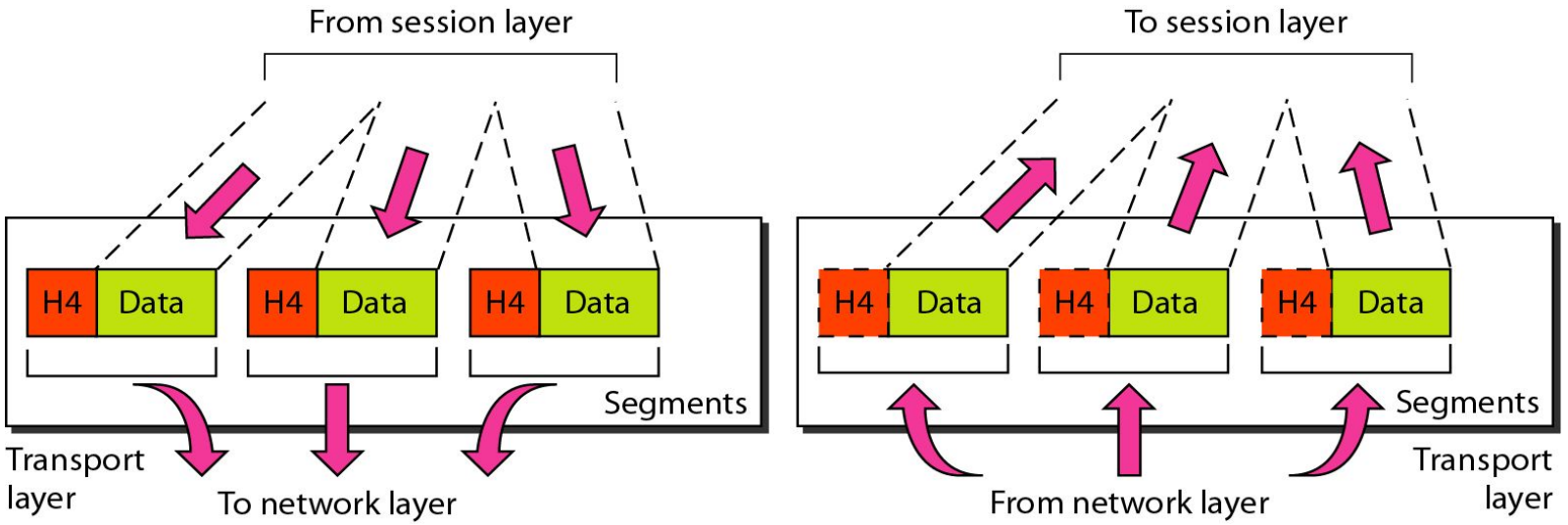
Functions of Network Layer

- **Internetworking**:
  - An internetworking is the main responsibility of the network layer.
  - It provides a logical connection between different devices.
- **Addressing**:
  - In order to identify each device on internetwork uniquely, the network layer defines an addressing scheme.
  - A Network layer adds the source and destination IP addresses to the header of the frame.
  - Addressing is used to identify the device uniquely and universally on the internet.
- **Routing**:
  - Routing is the major component of the network layer, and it determines the best optimal path out of the multiple paths from source to the destination.
- **Packetizing**:
  - A Network Layer receives the packets from the upper layer and converts them into packets.
  - This process is known as Packetizing.
  - It is achieved by internet protocol (IP).

Network Layer – Cont…

- In this layer, packet is combined with header and data.
- In case of data link layer, packet delivers on the same network.
- If two different networks are connected then packet is concern with network layer.
- Network layer is concerned with:
  - Logical addressing e.g. 192.168.1.1 (IP Address)
  - Routing

Transport Layer



- The transport layer is responsible for the delivery of a message from one process to another.

Functions of Transport Layer

At sender's side:

- Transport layer receives the formatted data from the upper layers, performs **Segmentation**,
- Implements **Flow & Error control** to ensure proper data transmission.
- It also **adds Source and Destination port numbers** (*which is associated with the receiver's application)* in its header and forwards the segmented data to the Network Layer.
- Generally, this destination port number is configured, either by default or manually.
- For example, a web server typically uses port number 80 by default.

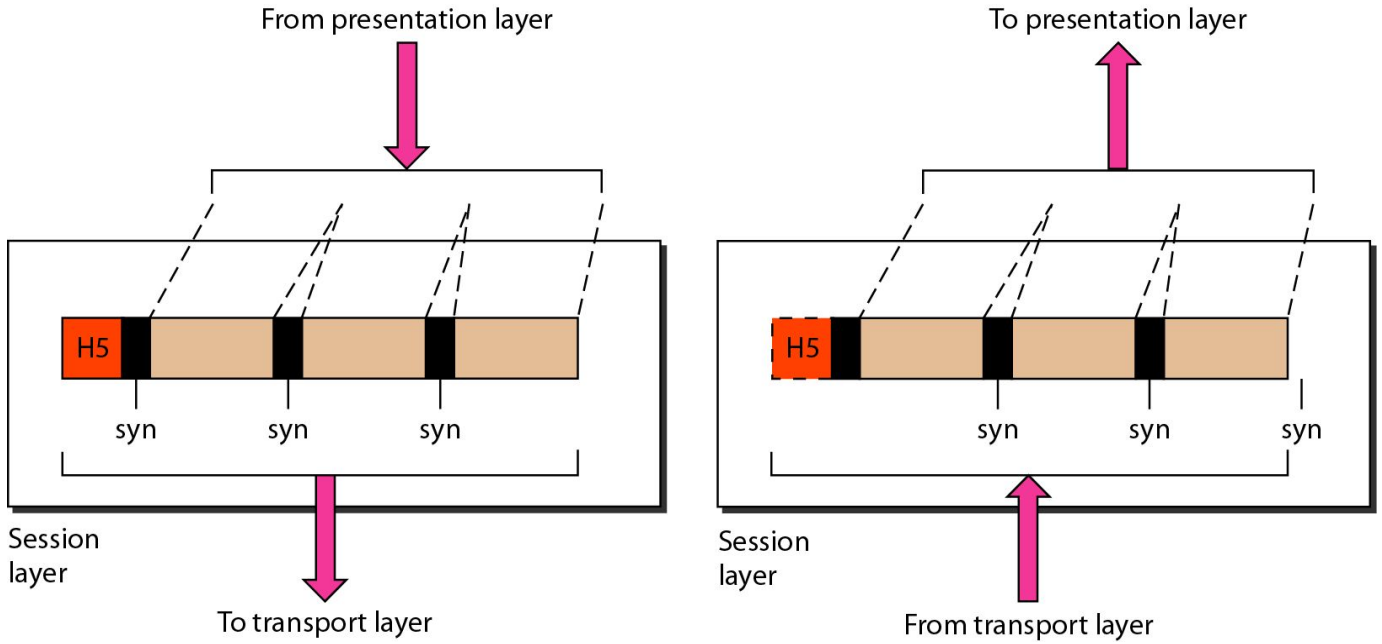
At receiver's side:

- Transport Layer reads the port number from its header and forwards the Data that it has received to the respective application.
- It also performs sequencing and reassembling of the segmented data.

Transport Layer – Cont…

- This layer ensures that the whole message arrives intact and in order.
- Transport layer is concerned with:
  - Service-point addressing (port address)
  - Segmentation and Reassembly
  - Connection Control
  - Flow and Error Control

Session Layer



- The session layer is responsible for dialog control and synchronization.

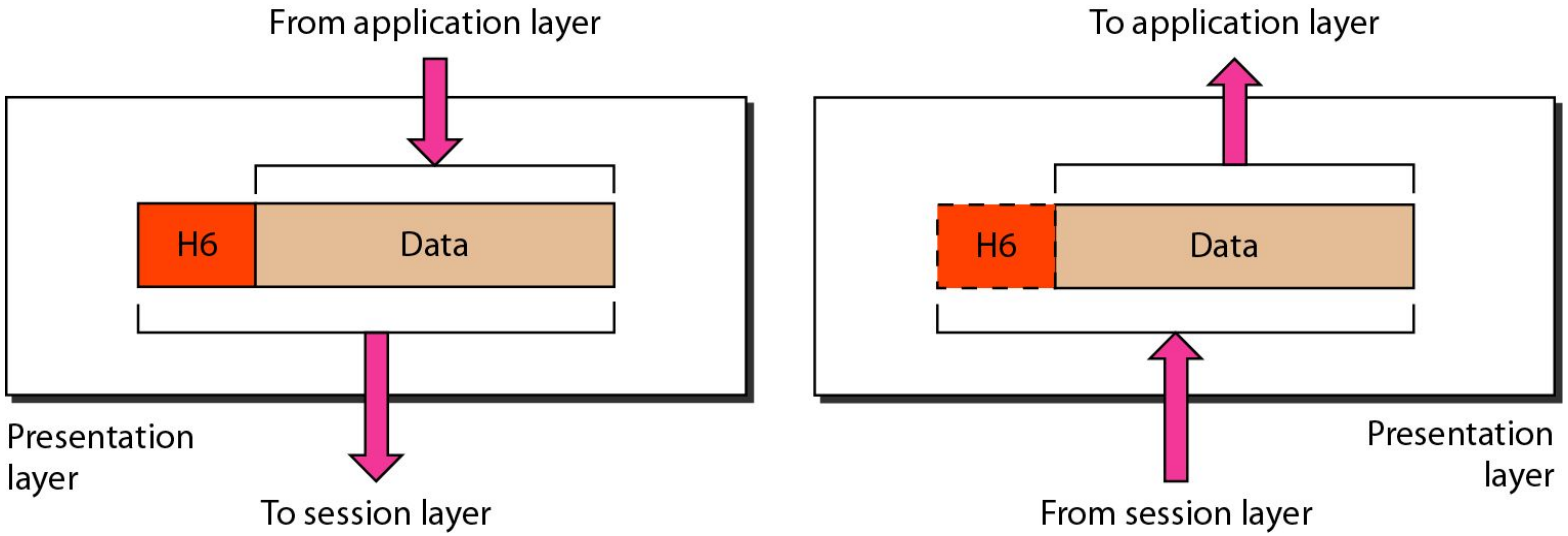
Functions of Session layer

- **Session establishment, maintenance, and termination:**
- The layer allows the processes to establish, use and terminate a connection.
- **Dialog control:**
- Session layer acts as a dialog controller that creates a dialog between two processes.
- In simple words, it allows the communication between two processes which can be either half-duplex or full-duplex.
- **Synchronization:**
- Session layer adds some checkpoints when transmitting the data in a sequence.
- If some error occurs in the middle of the transmission of data, then the transmission will take place again from the checkpoint.
- This process is known as synchronization and recovery.
- Data loss is avoided by it.

Session Layer – Cont…

- This layer is network dialog controller – establishes, maintains, synchronizes the interaction among computers.
- Session layer is concerned with:
  - Dialog control
  - Synchronization

Presentation Layer



- The presentation layer is responsible for translation, compression, and encryption.

Presentation Layer

- The presentation layer is also called the Translation layer.
- The data from the application layer is extracted here and manipulated as per the required format to transmit over the network.
- This layer is a part of the operating system that converts the data from one presentation format to another format.
- The Presentation layer is also known as the syntax layer.

Functions of Presentation layer

Translation:

- It acts as a data translator for a network, for example, ASCII to EBCDIC
- The processes in two systems exchange the information in the form of character strings, numbers and so on.
- Different computers use different encoding methods, the presentation layer handles the interoperability between the different encoding methods.
- It converts the data from sender-dependent format into a common format and changes the common format into receiver-dependent format at the receiving end.

Encryption:

- Encryption is needed to maintain privacy.
- Data encryption translates the data into another form or code.
- The encrypted data is known as the ciphertext and the decrypted data is known as plain text.
- A key value is used for encrypting as well as decrypting data

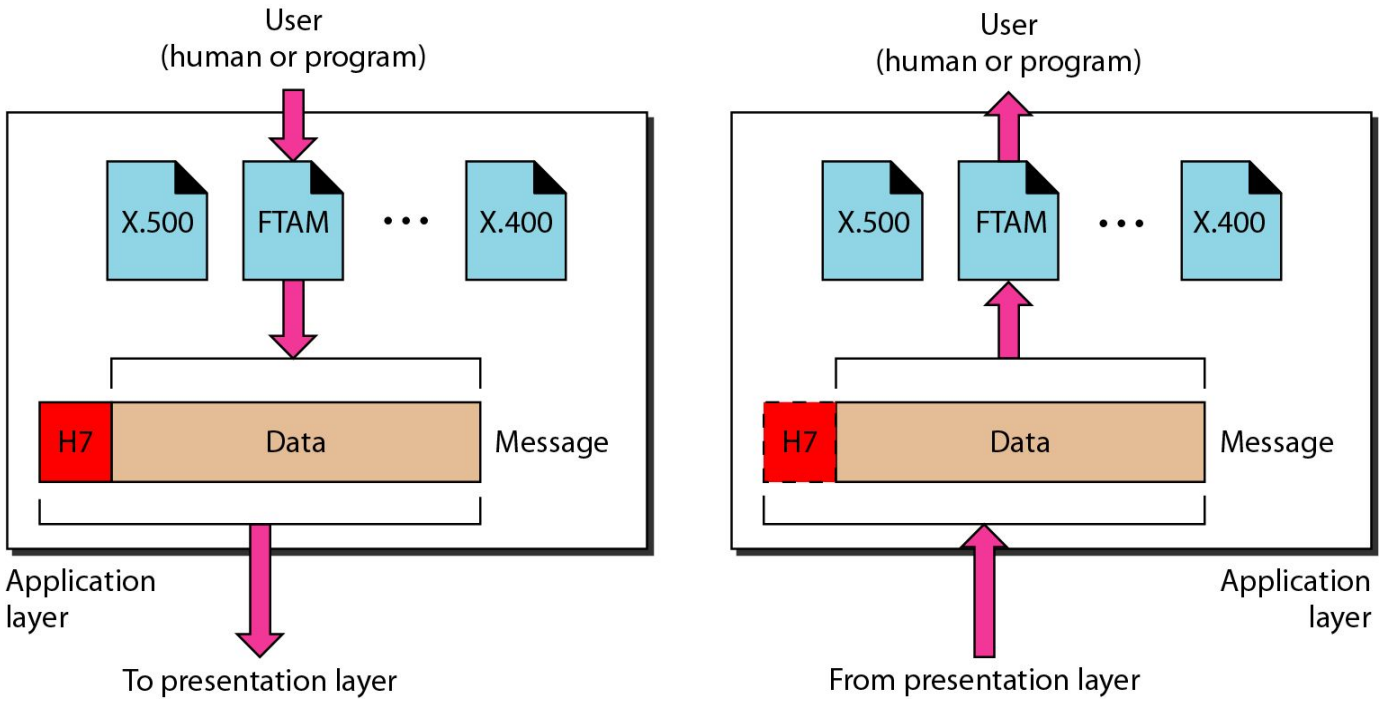
Compression:

- Data compression reduces the number of bits that need to be transmitted on the network
- Data compression is very important in multimedia such as text, audio, video.

Presentation Layer – Cont…

- This layer is concerned with the syntax which refers to order in which data is presented and semantics helps in interpreting a particular pattern.
- Presentation layer is responsible for:
  - Translation
  - Encryption
  - Compression

Application Layer



- The application layer is responsible for providing services to the user.

Application Layer

- Application layer, which is implemented by the network applications is the top most layer of the OSI OSI Reference Model.
- These applications produce the data, which has to be transferred over the network.
- This layer also serves as a window for users and the application services to access the network and for displaying the received information to the user.
- It handles issues such as network transparency, resource allocation, etc.
- This layer provides the network services to the end-users.
  - Example: Application – Browsers, Skype Messenger, etc.
- *Application Layer is also called Desktop Layer.*

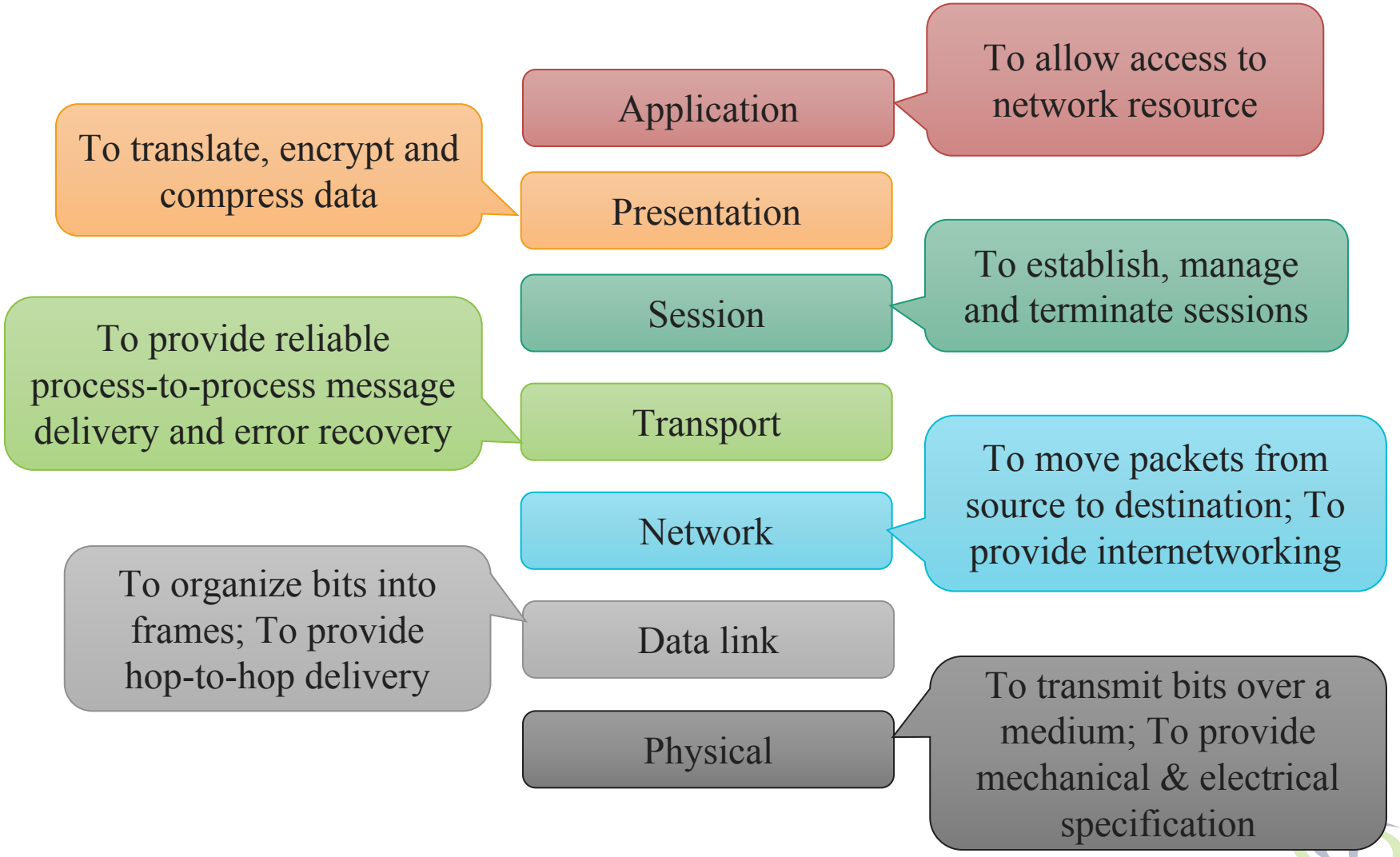
Functions of Application layer

- **File transfer, access, and management (FTAM):**
- An application layer allows a user to access the files in a remote computer, to retrieve the files from a computer and to manage the files in a remote computer.
- **Mail services:**
- An application layer provides the facility for email forwarding and storage.
- **Directory services:**
- An application provides the distributed database sources and is used to provide that global information about various objects.

Application Layer – Cont…

- This layer provides various services like:
  - Network virtual terminal
  - File transfer, access and management
  - Mail services
  - Directory services

Summary – OSI Layer

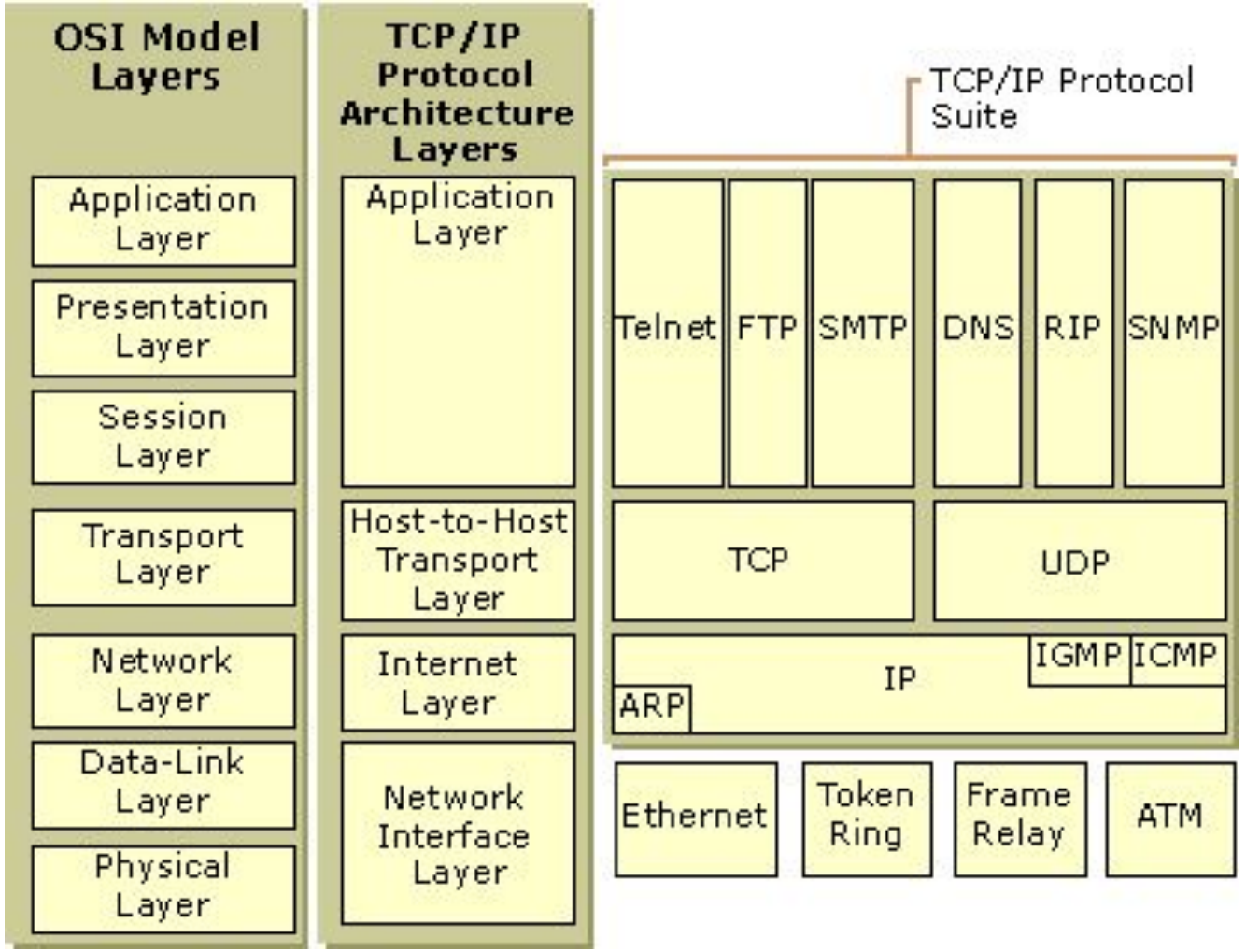


TCP/IP Reference Model

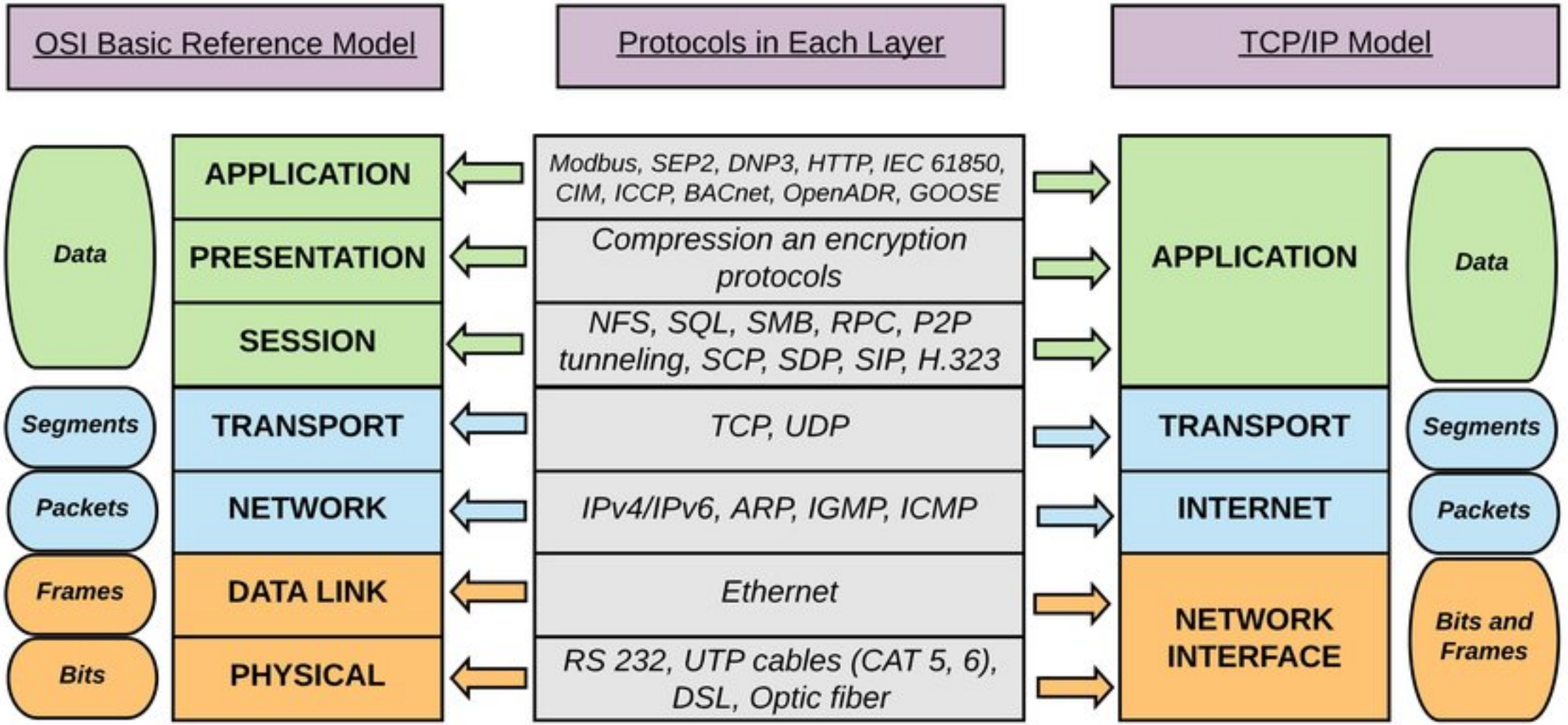
(Transmission Control Protocol/Internet Protocol)

- It was originally defined as having five layers:
- TCP/IP is a set of protocols developed to allow cooperating computers to share resources across the network.
  1. Application Layer
  2. Transport Layer
  3. Network Layer
  4. Data Link Layer
  5. Physical Network

TCP/IP Model Architecture



Comparison



Difference - OSI Model and TCP/IP Protocol Layers

OSI Model & TCP/IP Protocol Layer

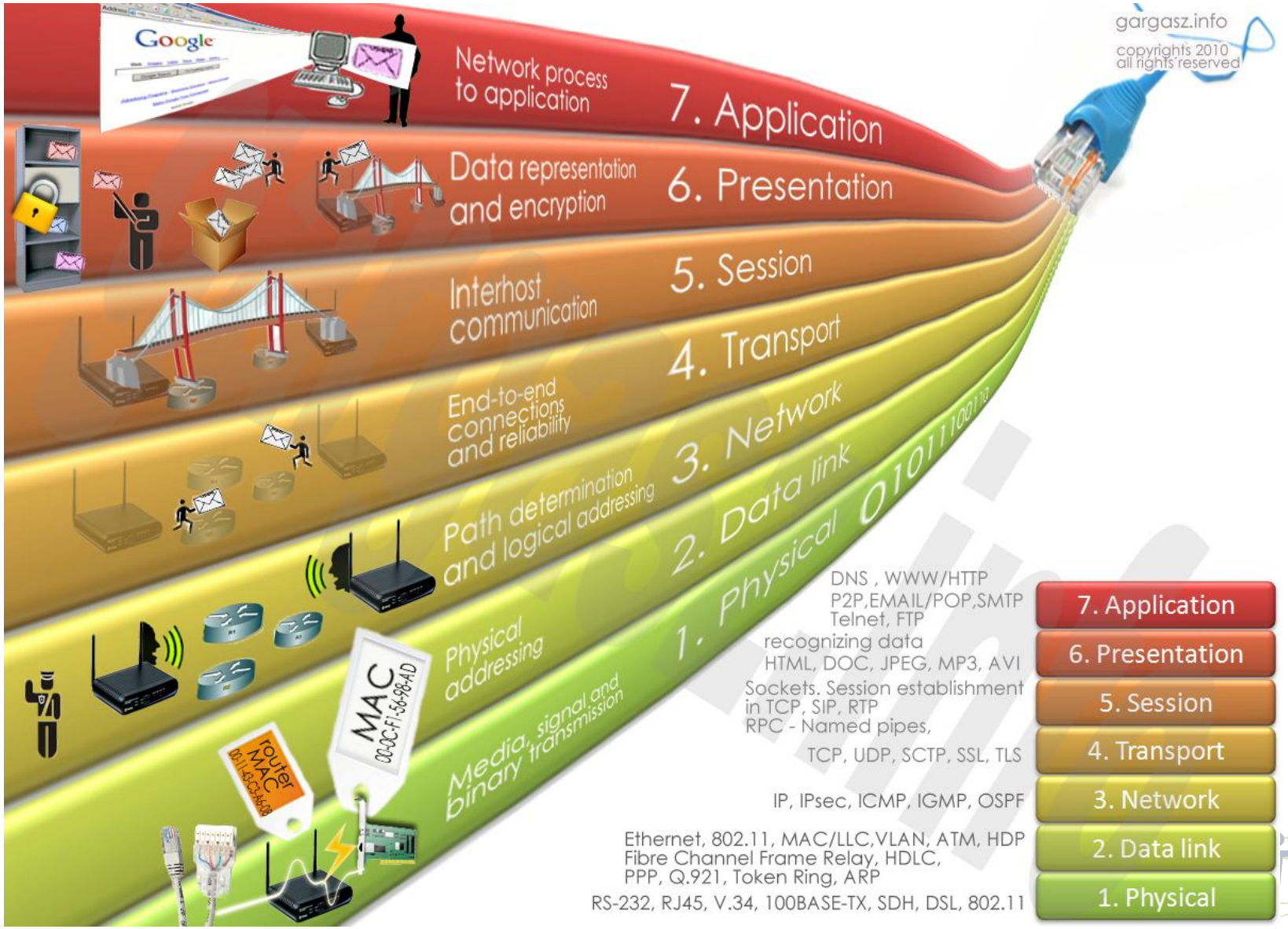
OSI (Open System Interconnection)	TCP/IP (Transmission Control Protocol/ Internet Protocol)
✔ It has 7 layers	✔ It has 5 layers
✔ OSI provides layer functioning and also defines functions of all the layers	✔ TCP/IP model is more based on protocols and protocols are not flexible with other layers
✔ Follows horizontal approach	✔ Follows vertical approach
✔ OSI model has a separate presentation layer	✔ TCP/IP doesn't have a separate presentation layer
✔ OSI model has a problem of fitting the protocols in the model	✔ TCP/IP model does not fit any protocol

Majors between OSI Model and TCP/IP Protocol Layers

OSI Model & TCP/IP Protocol Layer

OSI (Open System Interconnection)	TCP/IP (Transmission Control Protocol/ Internet Protocol)
✔ Network layer of OSI model provide both connection oriented and connectionless service	✔ The Network layer in TCP/IP model provides connectionless service
✔ OSI provides layer functioning and also defines functions of all the layers	✔ TCP/IP model is more based on protocols and protocols are not flexible with other layers
✔ Protocols are hidden in OSI model and are easily replaced as the technology changes	✔ In TCP/IP, replacing protocol is not easy
✔ OSI model defines services, interfaces and protocols very clearly and makes clear distinction between them	✔ In TCP/IP, it is not clearly separated its services, interfaces and protocols
✔ In OSI model the transport layer guarantees the delivery of packets	✔ In TCP/IP model the transport layer does not guarantees delivery of packets

Protocol Layers: Summary



Delay, Loss & Throughput

Delay

- As a packet travels from one node (host or router) to the subsequent node (host or router) along this path, the packet suffers from several types of delays at each node along the path.

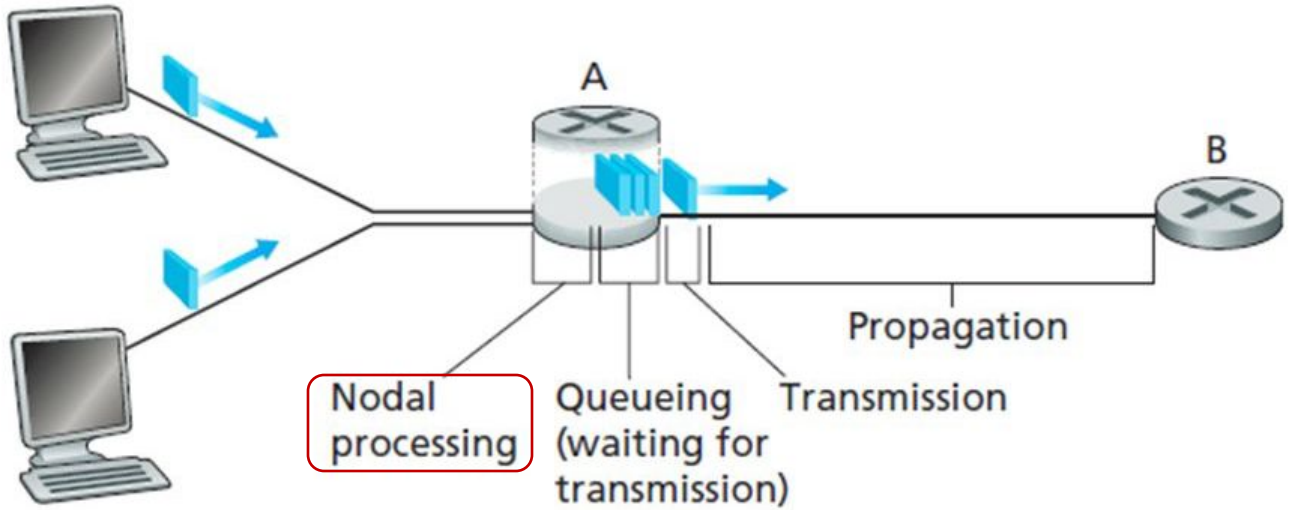
Where

$$d_{nodal} = d_{proc} + d_{queue} + d_{tran} + d_{prop}$$

d_{nodal}	=	**Total Delay**
d_{proc}	=	Processing Delay
d_{queue}	=	Queuing Delay
d_{tran}	=	Transmission Delay
d_{prop}	=	Propagation Delay

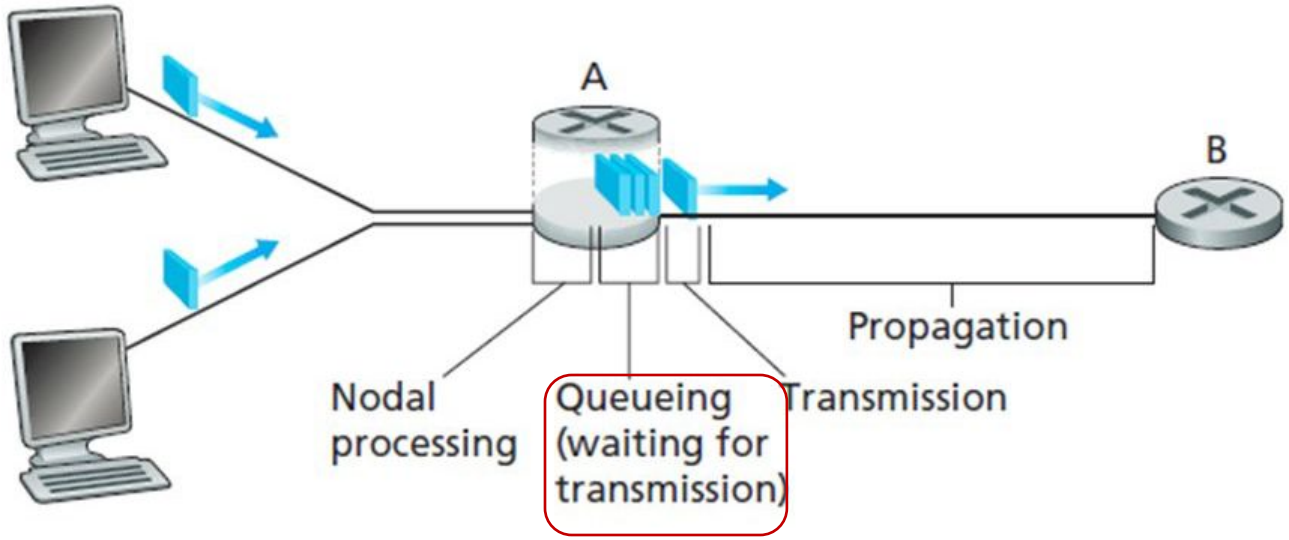
Delay – Cont…

- Processing Delay (d_{proc})
  - The time required to examine the packets header and determine where to direct the packet.
  - To check bit level error
  - Determine output link
  - Delay in terms of microseconds



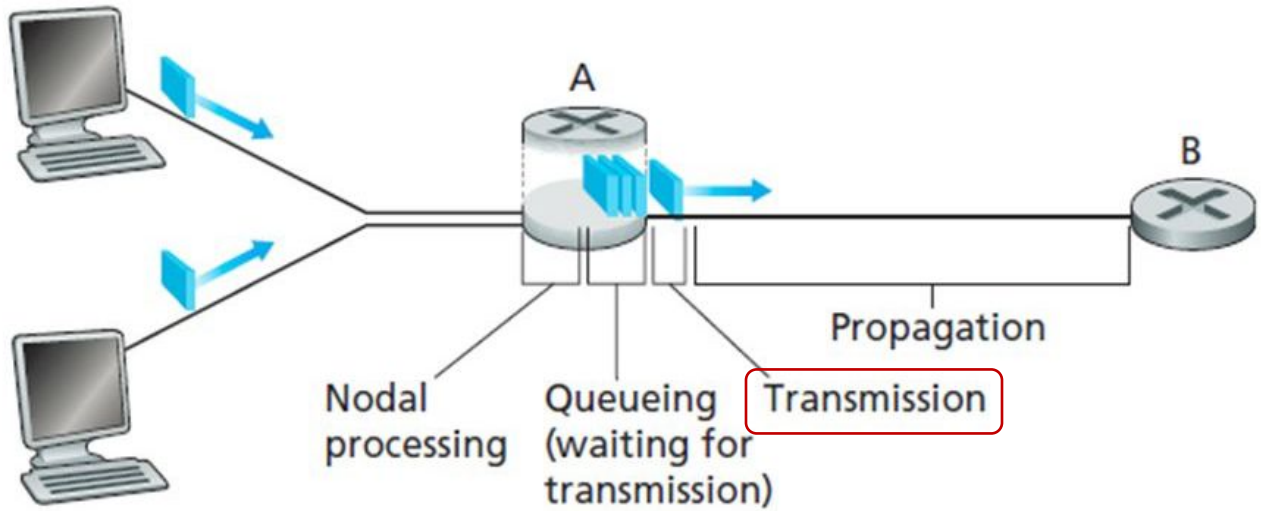
Delay – Cont…

- Queuing Delay (d_{queue})
  - A time to wait at output link for transmission.
  - Depends on congestion level of router.
  - If queue is empty, then delay will be zero.
  - If queue is full (heavy traffic) then delay will be long.
  - Delay in terms of microsecond to millisecond.



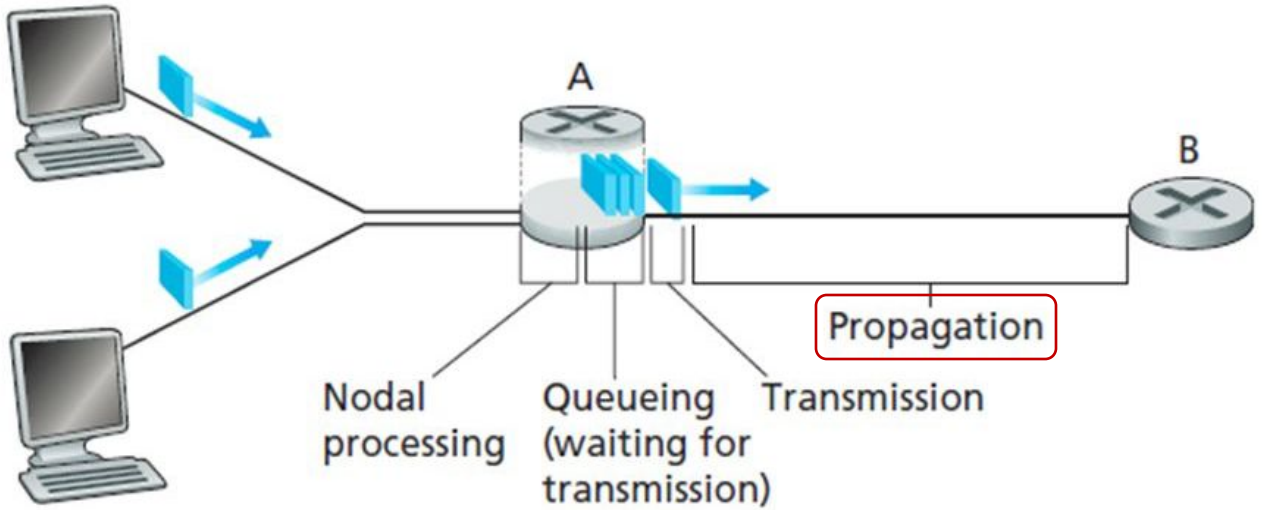
Delay – Cont…

- Transmission Delay ($d_{tran} = L/R$)
  - An amount of time required for the router to transmit the packet.
  - It is depending on packet length(L) and transmission rate(R) of link.



Delay – Cont…

- Propagation Delay ($d_{prop} = d/s$)
  - A time required to propagate from the beginning of the link to router B.
  - Depends on the length of physical medium(d) link and propagation speed(s) of link
  - Delay in terms of millisecond.



Sum

- In this problem, we consider sending real-time voice from Host A to Host B over a packet-switched network (VoIP).
- Host A converts analog voice to a digital 64 kbps bit stream on the fly.
- Host A then groups the bits into 56-byte packets.
- There is one link between Hosts A and B; its transmission rate is 2 Mbps and its propagation delay is 10 msec.
- As soon as Host A gathers a packet, it sends it to Host B. As soon as Host B receives an entire packet, it converts the packet's bits to an analog signal.
- How much time elapses from the time a bit is created (from the original analog signal at Host A) until the bit is decoded (as part of the analog signal at Host B)?

Solution

- Since this is a packet switched network, the data will be transmitted packet by packet. A packet is 56 byte and the analog to digital conversation rate is 64 kbps.
- Thus the preparing time T_p for a packet is (56*8)/(64*1000)= 0.007 s = 7 ms.
- The transition time D_{trans} for a packet is (56*8)/(2*1000*1000) =0.000224 s = 0.224ms.
- T_{prop} = 10ms
- Finally, the total time elapses from the time a bit is create until the bit is decoded is

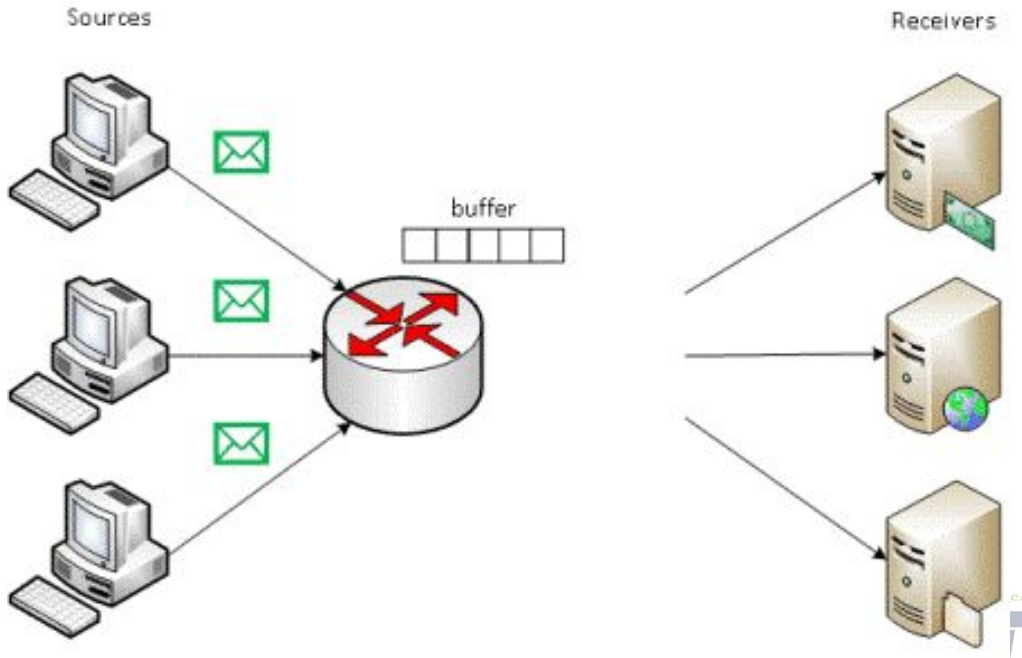
$T_p + D_{trans} + T_{prop}$

= 7+0.224+10

= 17.224 ms

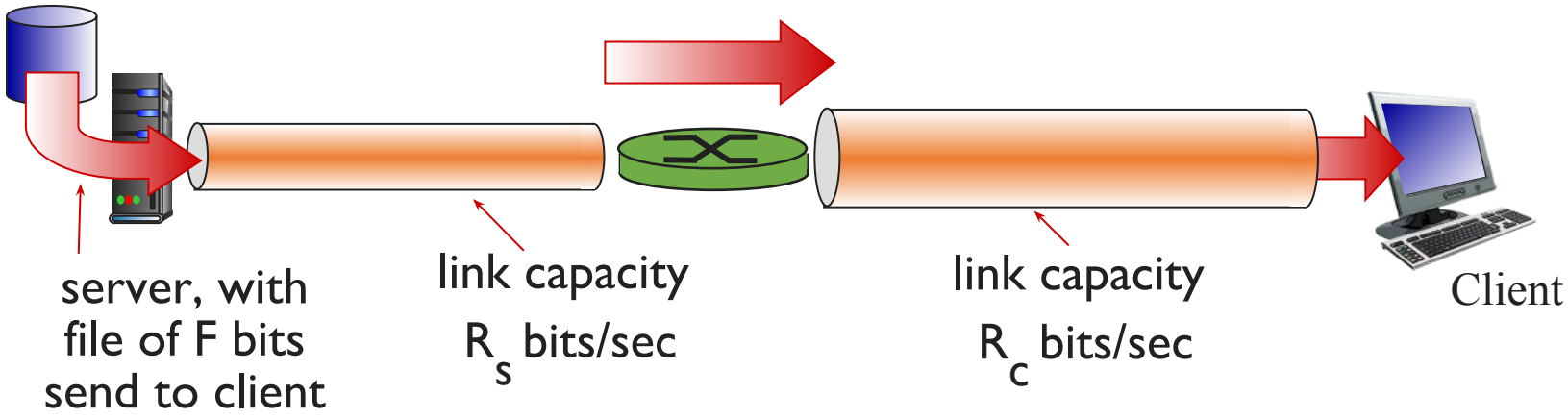
Packet Loss

- Packet loss is the failure of one or more transmitted packets to arrive at their destination.
- The loss of data packets depends on the switch queue/buffer. The loss of data packets increases with the increases in the traffic intensity.
- It affects the performance of the network.



Throughput

- Throughput or Network Throughput is the rate of successful message delivery over a communication channel.
- Throughput is measured in bits(data) per second (bit/s or bps)



History of Computer Networks

- 1961-1972 : The development of Packet Switching
- 1972-1980 : Proprietary Network and Internetworking
- 1980-1990 : A Proliferation of Networks
- 1990s : The Internet Explosion
- Recent Developments…

Outline - Revised

- What is Computer Network? Connected each other
- Advantages of Computer Network
- Applications of Computer Network
- Type of Computer Network LAN, MAN, WAN
- What is Internet? Infinite nos. of connected computers across the world
- What is Protocol? Set of Rules
- The Network Edge Host-end system & edge router
- The Network Core Circuit Switched & Packet Switched
- Transmission Media Guided- Wired & Unguided-Wireless
- Network Topologies Bus, Ring, Star, Mesh, Tree, & Hybrid
- Protocol Layers OSI Layer & TCP/IP Layer
- Delay, Loss & Throughput

Dedicated Faculty, Committed Education
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Thank You

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