Data Communication Network
DAY – 1

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Network Terminologies

•connecting multiple devices (computers) together to share the information group of devices/machines/IP addresses/hosts.

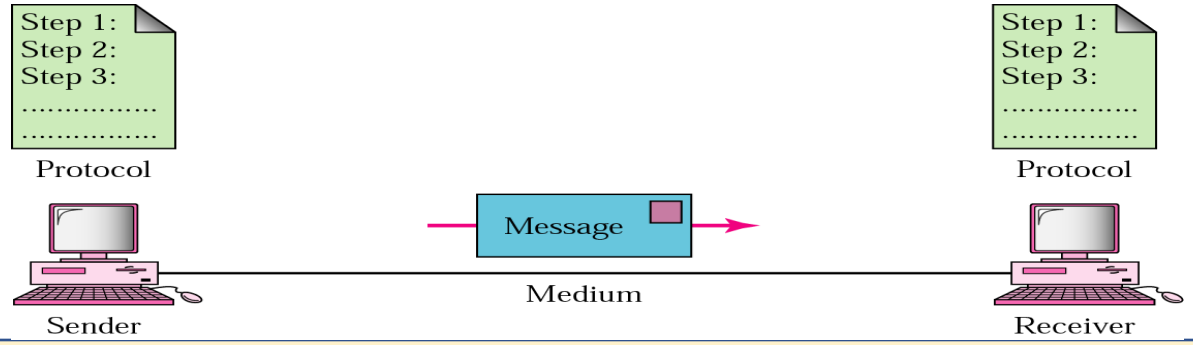
Data

Communication

Network

Computer Network

Components of Data communication



Node

- any device connected to the network(a computer, a printer etc)

Network Interface Card (NIC)

- is the circuit board that is used to connect computers to the network.
- In most cases, this is an *Ethernet* card plugged in a computer's motherboard

The effectiveness of a data communications system depends on four fundamental characteristics:
Delivery, Accuracy , Timeliness , Jitter

Need of Network/ Applications of Network

- **Information Sharing**
- **Enhance communication**
- **Share resources**
- **Facilitate centralized management**
- **Remote computing**

Network Criteria

Performance

- depends on a number of factors, including the number of users, the type of transmission medium, the capabilities of the connected hardware, and the efficiency of the software.
- Measured in terms of Delay and Throughput

Reliability

- is measured by the frequency of failure, the time it takes a link to recover from a failure
- Measured in terms of availability/robustness

Security

- Data protection against corruption/loss of data due to:
  - Errors
  - Malicious users

Network Types

Wired

Medium

- Wire / Cable

Cable Types

- co-axial
  - transfers the data in the form of electrical signals
- CAT Cable / Twisted Pair Cable (STP/UTP)
  - transfers the data in the form of electrical signals
- Fiber Optics
  - transfers the data in the form of light
  - Minimum 10gbps

Types

- LAN , MAN , WAN

- cat1 : - [it was used only for telephony network]
- cat2 : 1 mbps
- cat3 : 10 mbps
- cat4 : 16 mbps
- cat5 : 100 mbps
- cat5e: 125 mbps
- cat6 : 1000 mbps ~ 1 gbps
- cat7 : 10000 mbps ~ 10 gbps
- cat8 : 25000 mbps ~ 25 gbps

Wireless

Medium

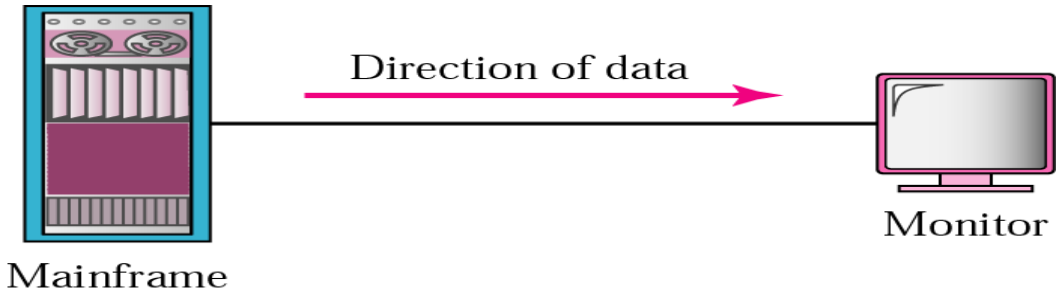
- Air (EM Waves)

Cable Types

- PAN
- WLAN
- WAN (GSM)

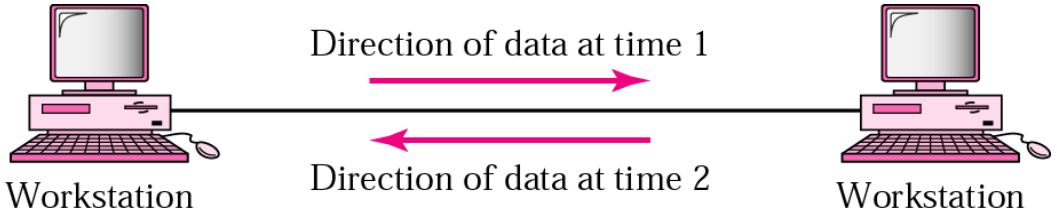
Media (Transmission Medium)

Transmission Modes / Data Flow Direction



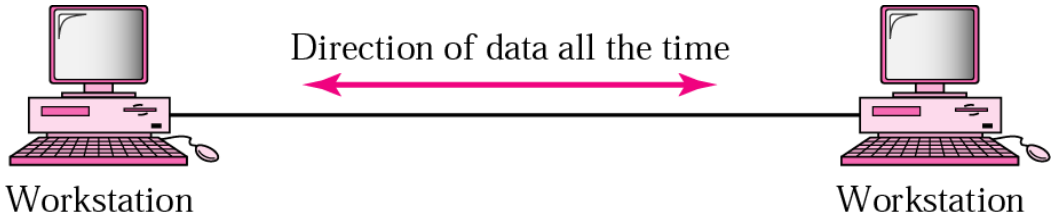
Simplex Mode

- Example: Keyboard and traditional monitors.



Half-Duplex Mode

- each station can both transmit and receive, but not at the same time.
- Example: Walkie- talkie



Full-Duplex Mode

- Example: Telephone Network there is communication between two persons by a telephone line, through which both can talk and listen at the same time.

Transmission Medium

- For any networking to be effective, raw stream of data is to be transmitted from one device to other over some medium.
- Various transmission media can be used for transfer of data.

Types of Transmission Medium

Guided

- Transmitted data travels through cabling system that has a fixed path.
- For example, copper wires, fibre optic wires, etc.

Unguided

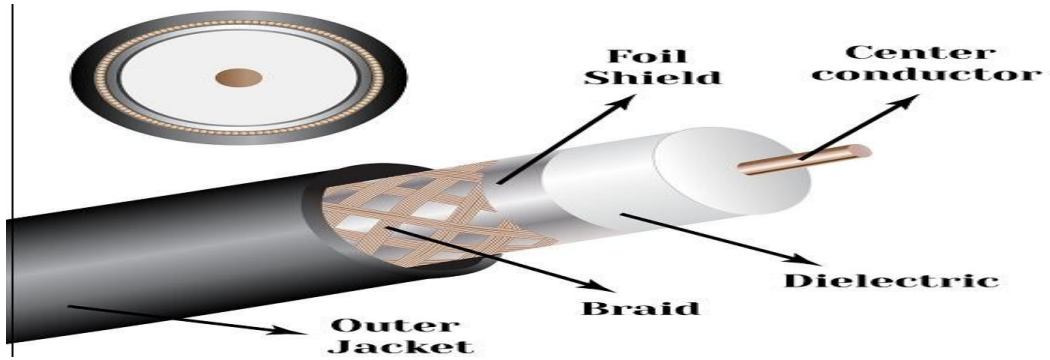
- Transmitted data travels through free space in form of electromagnetic signal.
- For example, radio waves, lasers, etc

Twisted Pair (maximum length of 100 meters)

- Most common wires used for transmitting signals
- To reduce this electromagnetic interference, pair of copper wires are twisted together.
- Shielding twisted pair cable
  - To counter the tendency of twisted pair cables to pick up noise signals, wires are shielded .
  - Such twisted pairs are called **shielded twisted pair (STP) cables**.
- The wires that are not shielded but simply bundled together in a protective sheath are called **unshielded twisted pair (UTP) cables**.

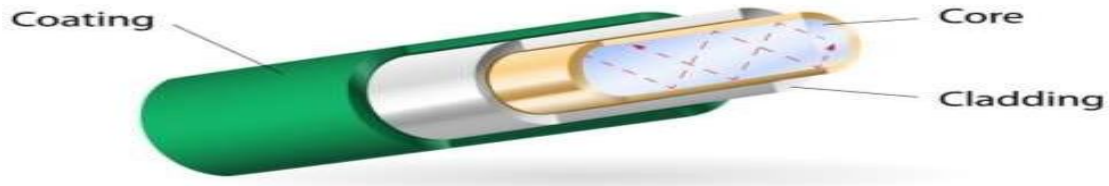
Coaxial Cable

- Coaxial cables are widely used for **cable TV** connections and **LANs**.
- **Coaxial cables** are copper cables with better **shielding** than twisted pair cables.
- Transmitted signals may travel **longer distances** at higher speeds.
  - e.g. 1 to 2 Gbps for 1 Km cable
- Can be used for both analog and digital signals
- Inexpensive as compared to fiber optic cables
- Easy to install and maintain



Optical Fiber

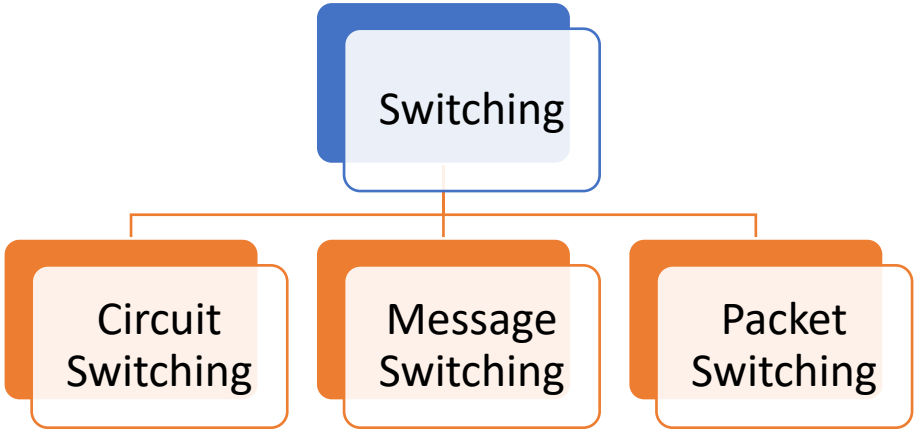
- Thin glass or plastic threads used to transmit data **using light waves** are called **optical fiber**.
- Signals carrying data can travel long distances without weakening
- Immune to electromagnetic interference , Suitable for industrial and noisy areas
- Three Layers:
  - **Core** made of high quality **silica glass** or **plastic**
  - **Cladding** made of high quality **silica glass** or **plastic**, with a lower refractive index than the core
  - Protective outer covering called **buffer**



Switching

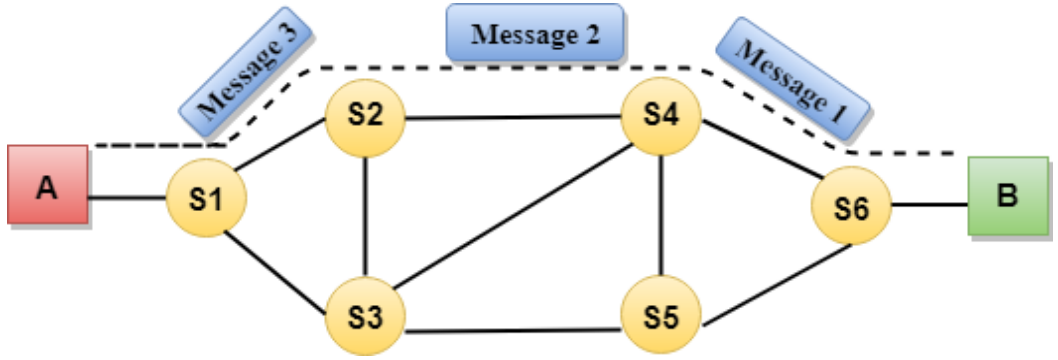
Switching

- In large networks, there can be multiple paths from sender to receiver.
- The switching technique will decide the best route for data transmission.
- Switching technique is used to connect the systems for making one-to-one communication.
- The mechanism for exchange of information between different computer networks and network segments is called switching in Networking.



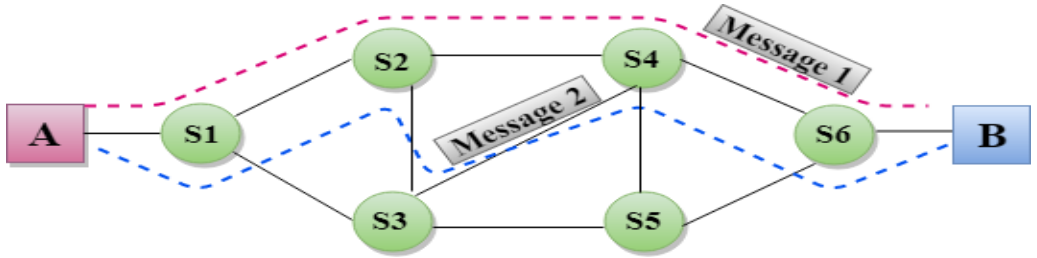
Circuit Switching

- Establishes a dedicated path between sender and receiver.
- once the connection is established then the dedicated path will remain to exist until the connection is terminated.
- Operates in a similar way as the **telephone** works.
- when any user wants to send the data a request signal is sent to the receiver then the receiver sends back the acknowledgment to ensure the availability of the dedicated path. After receiving the acknowledgment, dedicated path transfers the data.
- Three Phases:
  - Circuit Establishment
  - Data Transfer
  - Circuit Disconnect



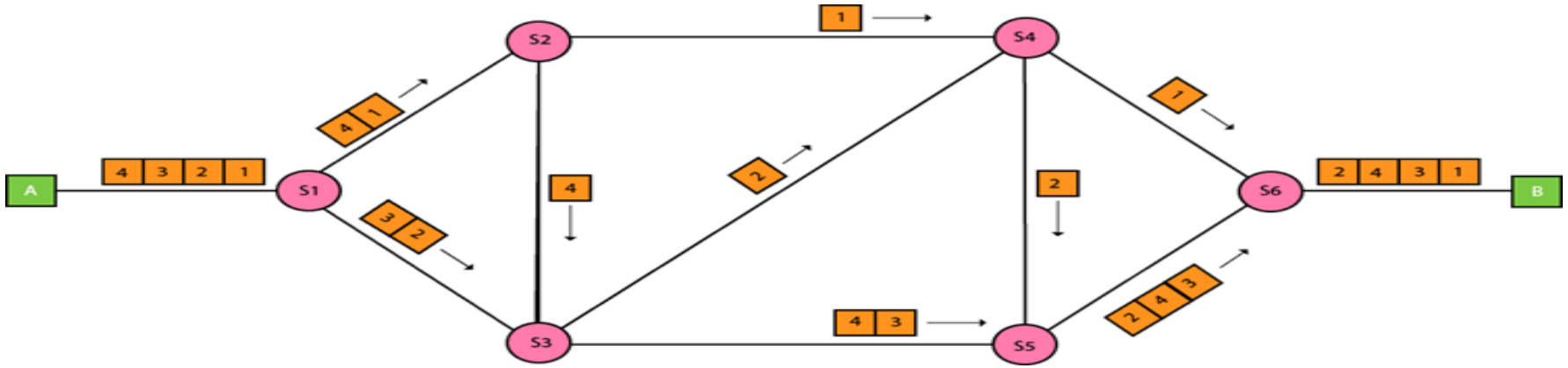
Message Switching

- There is no establishment of a dedicated path between the sender and receiver.
- The destination address is appended to the message.
- provides a dynamic routing as the message is routed through the intermediate nodes based on the information available in the message.
- they can provide the most efficient routes.
- Uses a method of **store and forward network**



Packet Switching

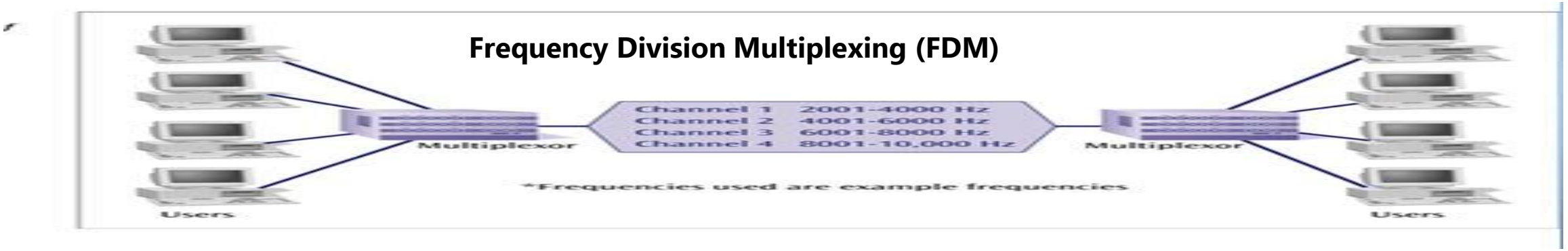
- Message is divided in packets , packets are given a unique number to identify their order at the receiving end.
- Every packet contains some information in its headers such as source address, destination address and sequence number.
- Packets will travel across the network, taking the shortest path as possible.
- All the packets are reassembled at the receiving end in correct order.
- If any packet is missing or corrupted, then the message will be sent to resend the message.
- If the correct order of the packets is reached, then the acknowledgment message will be sent



Multiplexing

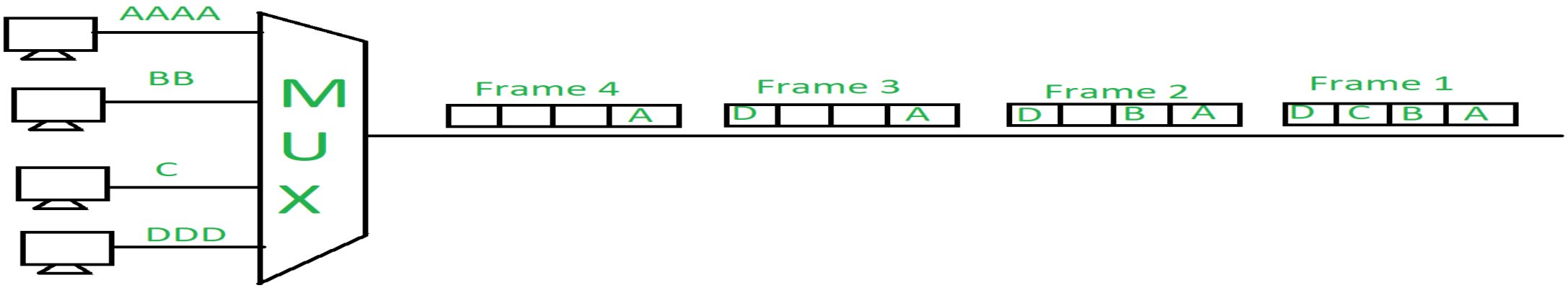
Multiplexing

- A communication channel such as an optical fiber or coaxial cable can carry only one signal at any moment in time. **Wastage of Bandwidth**
- Multiplexing is the process of combining multiple signals into one, in such a manner that each individual signal can be retrieved at the destination.
- **Multiplexing** is used in the cases where the signals of lower bandwidth and the transmitting media is having higher bandwidth.
- Methods of Multiplexing;
  - FDM (Frequency Division Multiplexing)
  - TDM (Time Division Multiplexing)

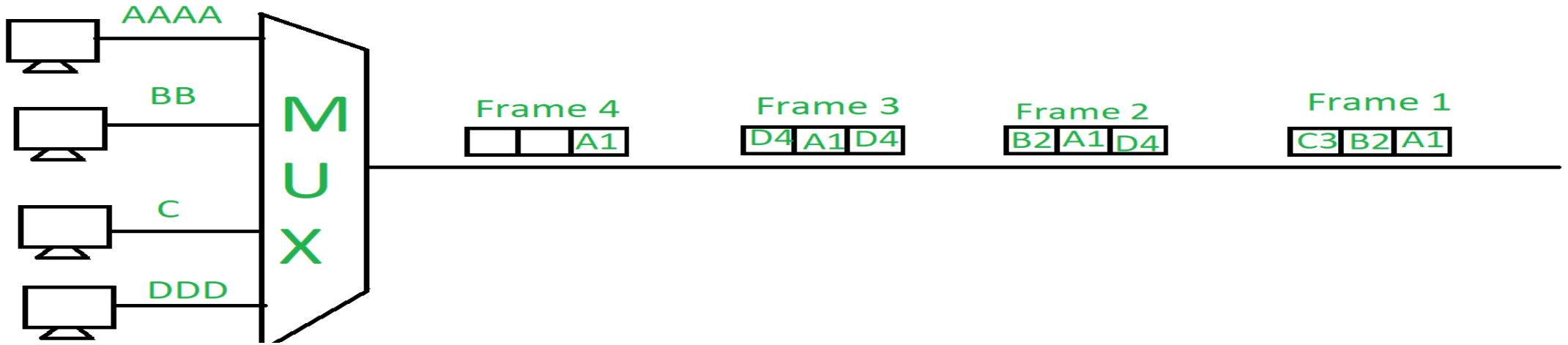


Time Division Multiplexing (TDM)

Synchronous TDM



Asynchronous (or statistical) TDM



TDM VS FDM

	TDM (Time Division Multiplexing.)	FDM(Frequency Division Multiplexing)
1	TDM works with digital signals as well as analog signals.	While FDM works with only analog signals.
2	TDM has low conflict.	While it has high conflict.
3	TDM is efficient.	While it is inefficient.
4	In TDM, time sharing takes place.	While in this, frequency sharing takes place.
5	Here synchronization pulse is necessary.	Here Guard band is necessary.
6	Framing bits (Sync Pulses) are used in TDM at the start of a frame in order to enable synchronization	FDM uses Guard bands to separate the signals and prevent its overlapping

Network Classification

Network Classification

Classification by network geography

- according to the geographical boundaries spanned by the network itself
- LAN, WAN, MAN ,PAN, SAN(Major two are LAN and WAN)

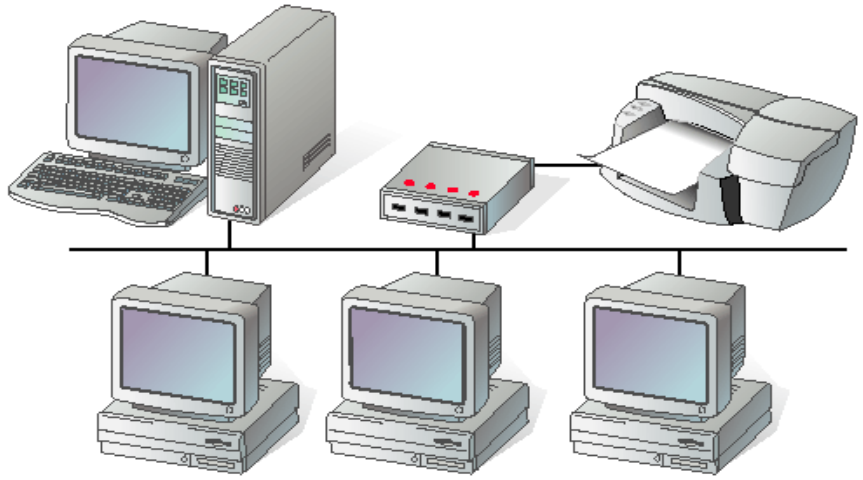
Classification by component roles

- according to the roles that the networked computers play in the network's operation
- Peer-to-peer, server-based, and client-based .

Interprocessor distance	Processors located in same	Example
1 m	Square meter	Personal area network
10 m	Room	Local area network
100 m	Building	
1 km	Campus	
10 km	City	Metropolitan area network
100 km	Country	Wide area network
1000 km	Continent	
10,000 km	Planet	The Internet

LAN (Local Area Network) : Wired Network

- Network in small geographical Area (Room, Building or a Campus)
- **Short distances (100 meters)**
- **Designed to provide local interconnectivity**
- LAN's can either be made wired or wireless. Twisted pair, coax or fiber optic cable can be used in wired LAN's
- a network that is used for communicating among computer devices, usually within an office building or home.



Basic systems people use to set up wired networks

An **Ethernet** system

- uses either a twisted copper-pair or coaxial-based transport system.
- The most commonly used cable for Ethernet is a **category 5 unshielded twisted pair (UTP)** cable

A **phone line**

- simply uses existing phone wiring found in most homes

Broadband systems

- provide cable Internet and use the same type of coaxial cable that gives us cable television

Wired Network Designing

Token Ring (Not used)

- Its copy write by IBM.
- It is a data link technology for local area networks (LANs) in which devices are connected in a star or ring topology.
- It was designed by only IBM PCs with 4mbps they increased upto 16mbps.

Ethernet (Used World wide /Now a days)

- It belongs to IEEE
- Its autonomous
  - 10mbps (Ethernet),
  - 100mbps (fast Ethernet)
  - 1Gbps (Gigabit Ethernet)
  - 10gbps (10 gig Ethernet)
  - 100gbps (100 gig Ethernet)
  - LRE (Long Range Ethernet)

Token Ring

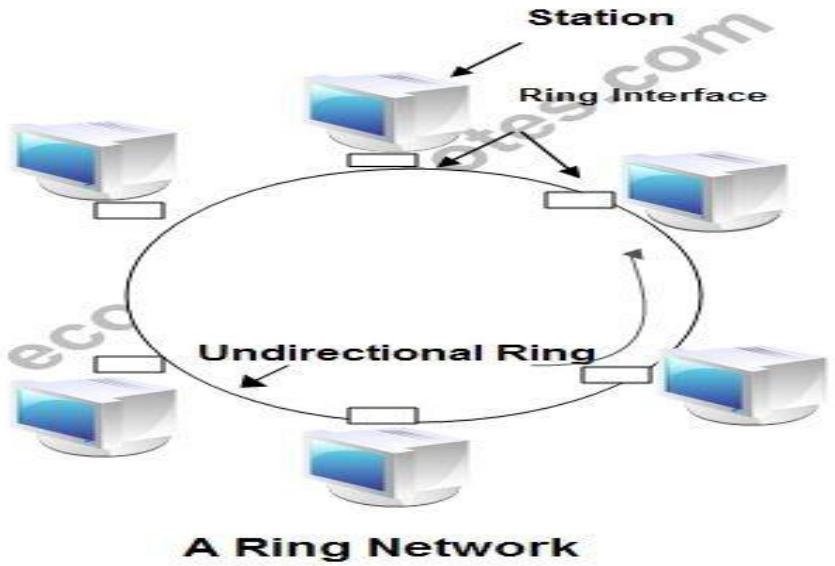
- The token ring LAN process is delineated by the following sequence of events:
  - A token continually circulates inside the toke ring LAN
  - To transmit a message, a node inserts a message and destination address inside an empty token.
  - The token is examined by each successive node.
    The destination node copies the message data and returns the token to the source with the source address and a data receipt message.
  - The source receives the returned token, verifies copied and received data and empties the token.
  - The empty token now changes to circulation mode, and the process continues.

Listen Mode

- The input bits are simply copied to output with a delay of 1-bit time.

Transmit Mode

- The connection between input and output is broken by the interface so that is can insert its own data



Ethernet Transfer speed 10 Mbps, 100 Mbps, or above

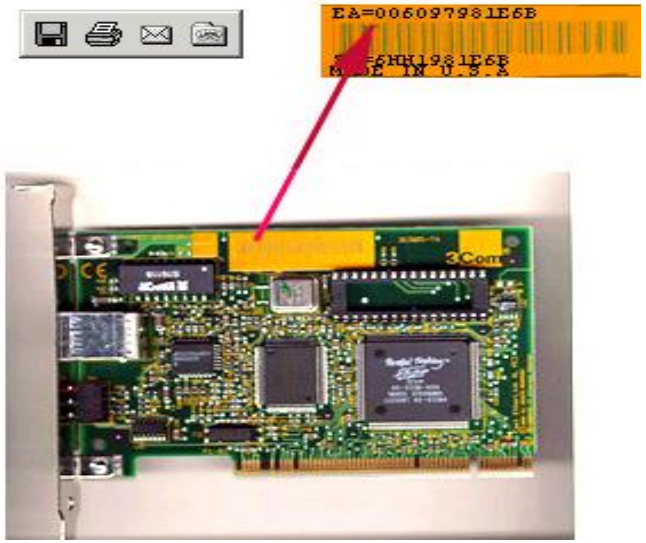
- Ethernet is the dominant cabling and low level data delivery technology used in Local Area Networks (LAN's).
- It was developed by Xerox corp. along with DEC and Intel.
- **Features:**
  1. Ethernet Addresses are 6 bytes(48 bits) long.
  2. Ethernet supports networks built with twisted pair, thin and thick coaxial and fiber optic cabling.
  3. To prevent the loss of data, when two or more devices attempt to send packets at the same time, Ethernet detects collisions.

Ethernet Address/ MAC Address

Example: 47:20:1B:2E:08:EE

- First three bytes from left specify the vendor.
- the last 24 bit should be created uniquely by the company

Cisco	00-00-0C
Dell	20-47-47
Sun	08-00-20
IBM	08-00-5A
Nokia	00-40-43



Ipconfig/all : Ethernet adapter Ethernet(Physical Address)

A network interface card (NIC) / Ethernet Card is a piece of computer hardware designed to allow computers to communicate over a computer network.

Ethernet Frame Format/MAC Frame

Preamble	SFD	Destination MAC	Source MAC	Type	Data and Pad	FCS
7 Bytes	1 Byte	6 Bytes	6 Bytes	2 Bytes	46-1500 Bytes	4 Bytes

Preamble	• informs the receiving system that a frame is starting and enables synchronization. In IEEE 802.3, eighth byte is start of frame (10101011)
SFD (Start Frame Delimiter)	• signifies that the Destination MAC Address field begins with the next byte.
Destination MAC	• identifies the receiving system.
Source MAC	• identifies the sending system.
Type	• defines the type of protocol inside the frame, for example IPv4 or IPv6.
Data and Pad	• contains the payload data. • Padding data is added to meet the minimum length requirement for this field (46 bytes).
FCS (Frame Check Sequence)	• contains a 32-bit Cyclic Redundancy Check (CRC) which allows detection of corrupted data.

How to determine the type of destination addresses

- To find the type of the address, we need to look at the **second hexadecimal digit** from the left. If it is **even**, the address is **unicast.** If it is **odd**, the address is **multicast**.
- ***Define the type of the following destination addresses:***

a) 4A:30:10:21:10:1A

b) 47:20:1B:2E:08:EE

c) FF:FF:FF:FF:FF:FF

Solution:

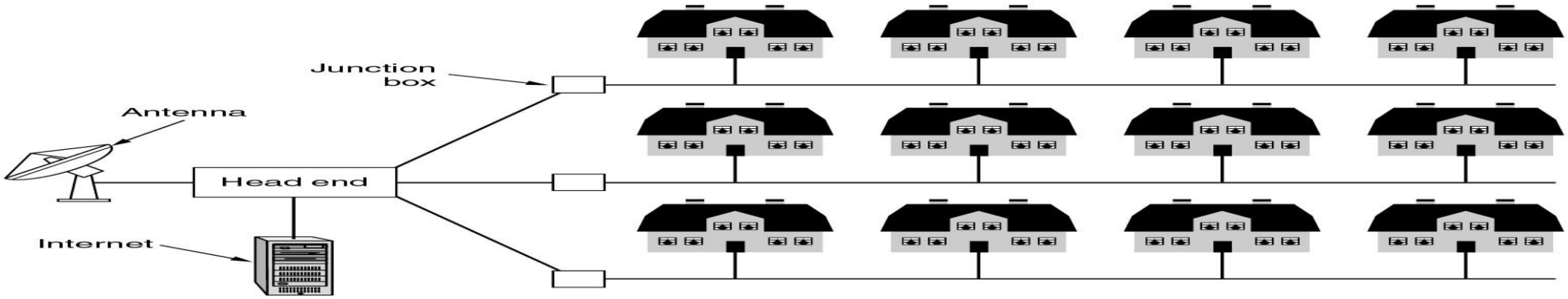
a) This is a unicast address because A in binary is 1010.

b) This is a multicast address because 7 in binary is 0111.

c) This is a broadcast address because all digits are F's.

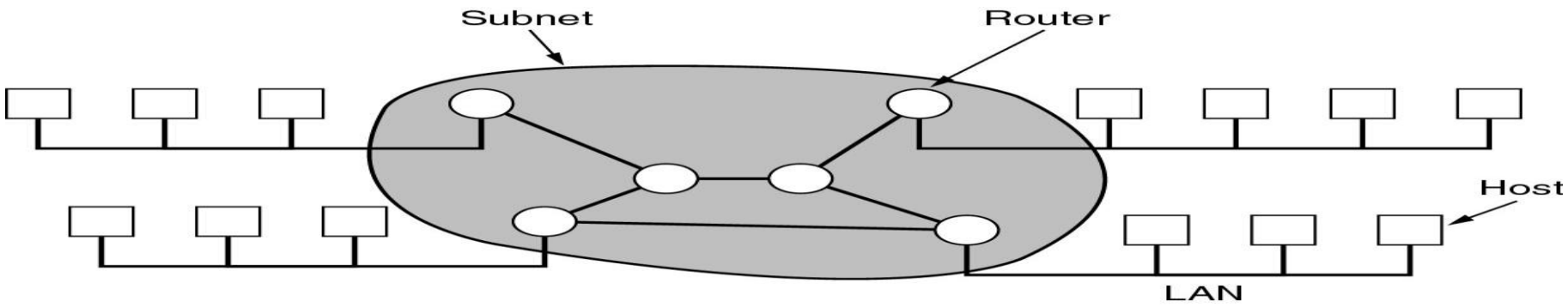
MAN

- A MAN spans the distance of a typical metropolitan city.
- The cost of installation and operation is higher.
- MANs use high-speed connections such as fiber optics to achieve higher speeds.
- Provide connectivity over areas such as a city, a campus
- More than 100m , Designed to handle data communication for multiple organizations in a city and nearby cities as well
- e.g. cable television network



WAN

- Network spread geographically (Country or across Globe)
- WANs consist of two distinct components:
  - transmission lines (copper, fiber, microwave) and switches (electronics, optics)
  - Store-and-forward or packet-switched subnet
- WANs span a larger area than a single city.
- These use long distance telecommunication networks for connection, thereby increasing the cost.
- The Internet is a good example of a WAN.
- More than 1000m long distance, Provide connectivity over large areas



Address Resolution Protocol (ARP)

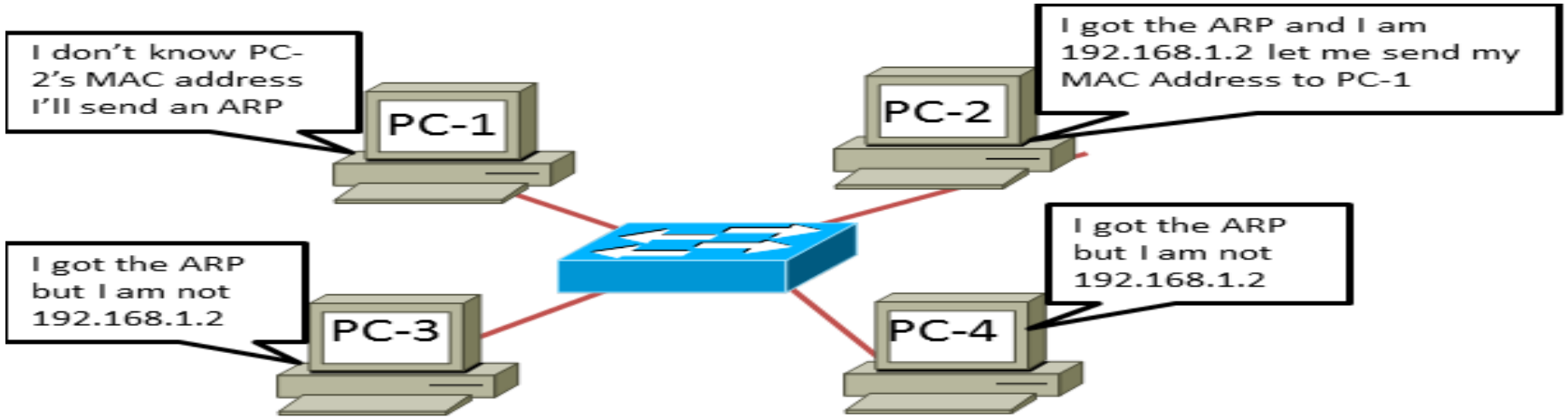
ARP

- Address resolution refers to the process of finding an address of a computer in a network.
- The address is "resolved" using a protocol in which a piece of information is sent by a client process executing on the local computer to a server process executing on a remote computer.
- The address resolution procedure is completed when the client receives a response from the server containing the required address.
- The job of the ARP is essentially to translate 32-bit addresses to 48-bit addresses and vice-versa

ARP

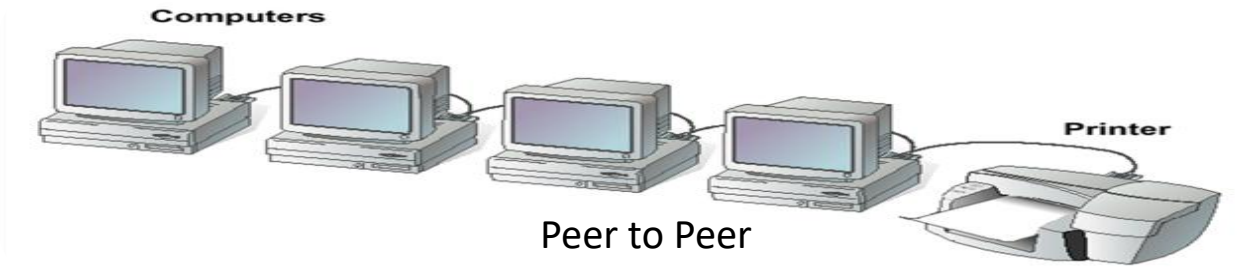
- Step1 : ARP Broadcast
  - Note: Broadcast is received by everyone and processed by everyone.
- Step 2: ARP Reply
- Step 3 : Actual Data Transfer

- Router creates an ARP Request message to be sent to all hosts on the subnet.
- Address resolution protocol message asks “Who has specified IP address ?”
- Passes ARP request to data link layer process for delivery

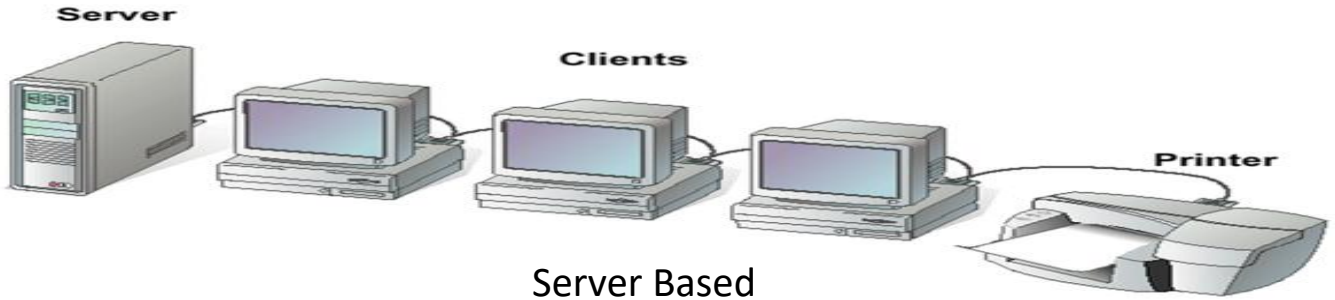


Network Classification by Component Roles

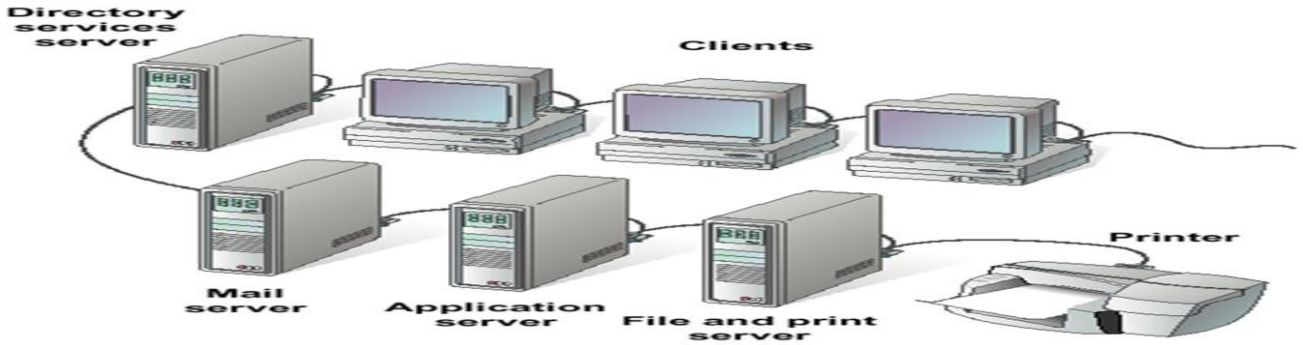
Network Classification by Component Roles



Peer to Peer



Server Based



Client Based

Network Physical Structure

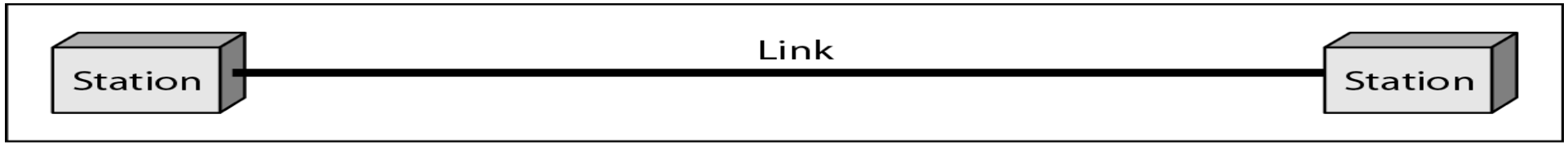
Type of Connection

- Point to Point - single transmitter and receiver
- Multipoint - multiple recipients of single transmission

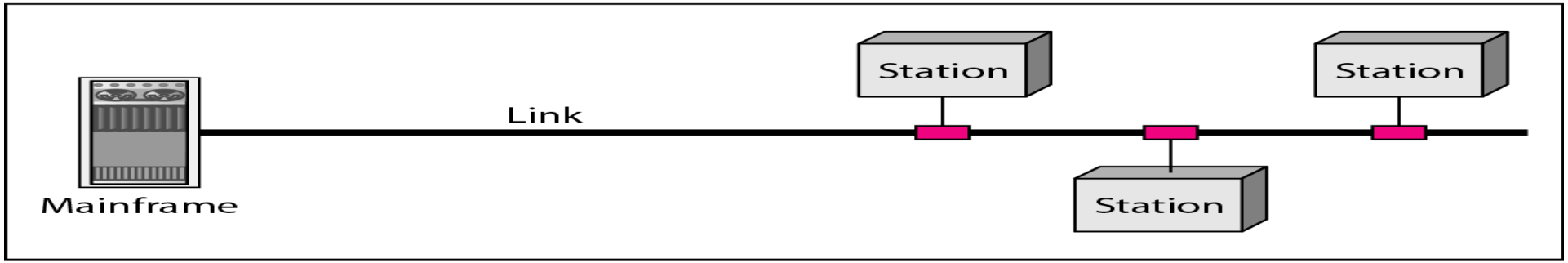
Physical Topology

- Connection of devices
- Refers to the way in which a network is laid out physically
- The geometric representation of the relationship of all the links and linking devices (usually called nodes) to one another.
- **Type of transmission** - unicast, mulitcast, broadcast

Types of Connection



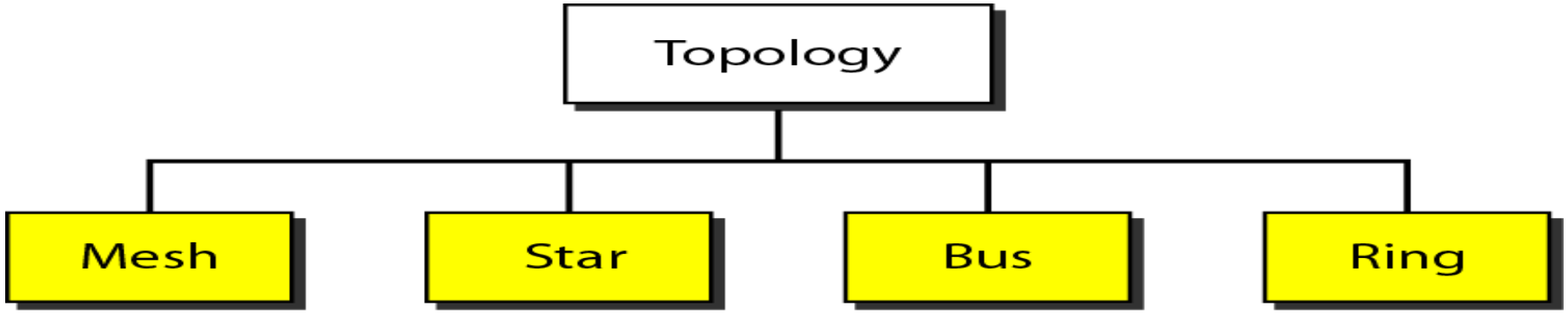
a. Point-to-point



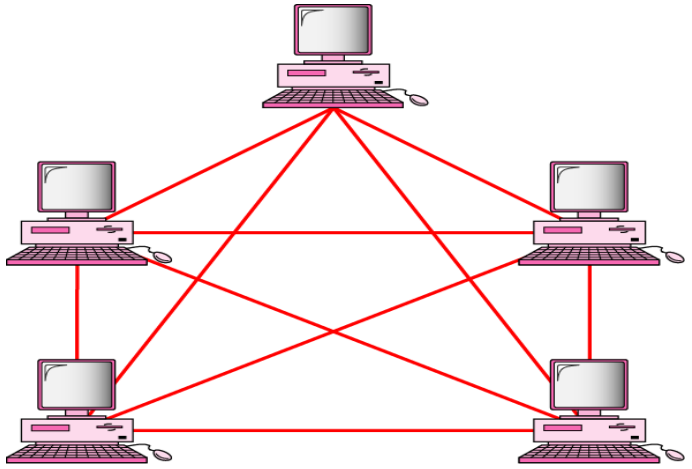
b. Multipoint

Physical Topology

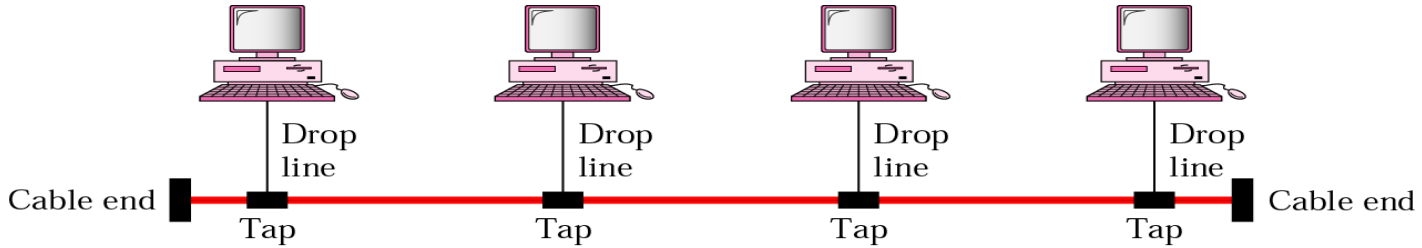
- Topology defines the way hosts are connected to the network
- The network topology defines the way in which computers, printers, and other devices are connected.
- A network topology describes the layout of the wire and devices as well as the paths used by data transmissions.



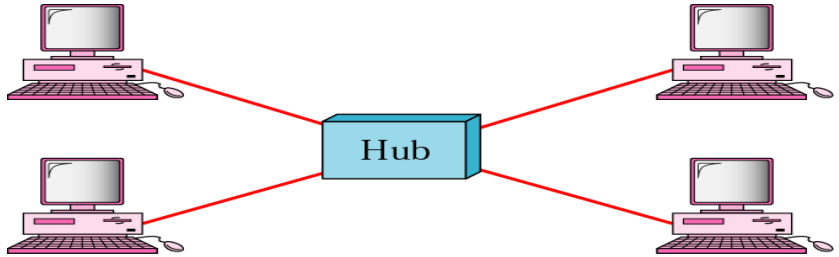
Network Topology



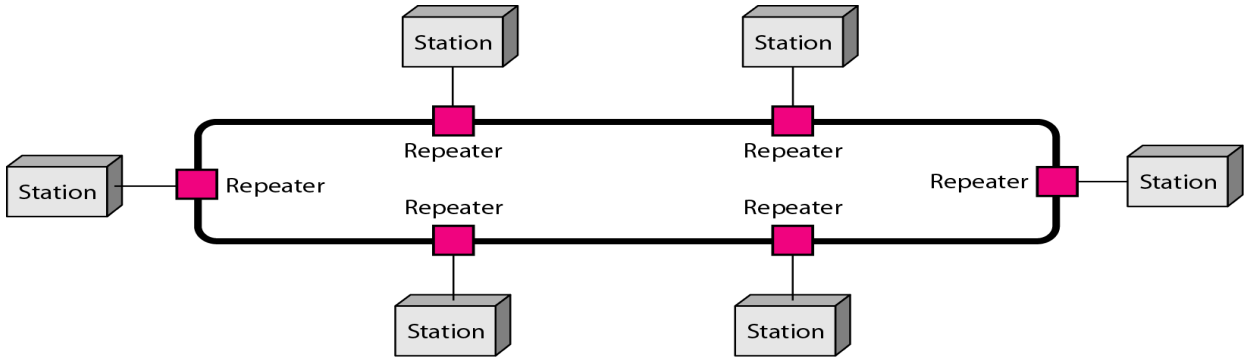
mesh



bus



star



ring

Network Interface Card (NIC)

- Used to connect to the network
- Also known as network card
- Every nic is identified uniquely using its MAC address
- used to
  - sender : convert the data to electrical signals (light)
  - receiver: convert the electrical signals (light) to the data
- Types
  - Onboard: already provided by the motherboard manufacturer
  - external
    - internal: PCI [peripheral component interconnect]
    - external: USB-A, USB-C

Network Devices / Internetworking Devices

Internetworking Devices

- Internetworking devices are products used to connect networks.
- As computer networks grow in size and complexity, so the internetworking devices used to connect them.
  - Hubs
  - Repeaters
  - Bridges
  - Switches
  - Routers
  - Gateways

Hubs

- Hub is used to build a LAN.
- Common connection point for devices in a network.
- It is non intelligent device.
- It does not understand the addressing.
- Hub is Multiport repeater containing multiple ports to interconnect multiple devices
- Hubs regenerate and retime network signals (increases traffic and collision)
- They cannot filter network traffic and they cannot determine best path
- The hub contains multiple ports.
- When a packet arrives at one port, it is copied to the other ports so that all segments of the LAN can see all packets.
  - does not concern about the address
  - concerns with only electrical signals
  - increases the traffic, as they broadcast data to all
  - increases the collision

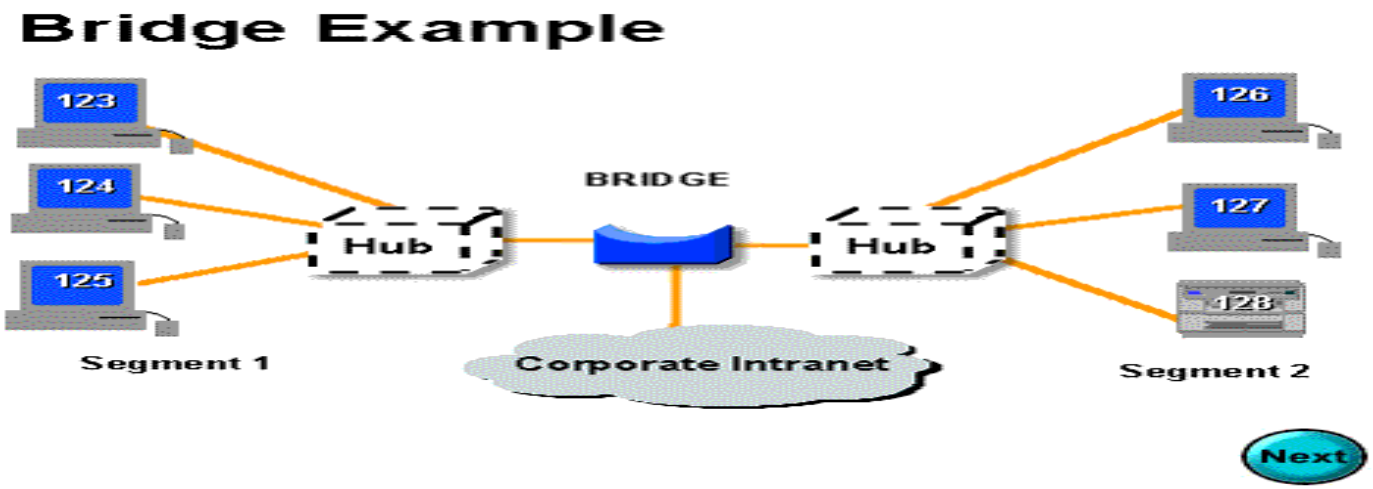
Repeaters

- **Repeaters or hubs work at the OSI physical layer to regenerate the network's signal and resend them to other segments.**
- Its job is to regenerate the signal over the same network before the signal becomes too weak or corrupted so as to extend the length to which the signal can be transmitted over the same network.
- The longer the cable length, the weaker and more deteriorated the signals become as they pass along the networking media.
- Repeaters can be installed along the way to ensure that data packets reach destination.

One way to solve the problems of too much traffic on a network and too many collisions is to use an internetworking device **called a bridge.**

Bridges : Operates at Data Link Layer

- A bridge eliminates unnecessary traffic and minimizes the chances of collisions occurring on a network by dividing it into segments .
- Device that connects and passes packets between two network segments.
- More intelligent than hub- As they analyze incoming packets and forwards (or drops) based on addressing information.(Routing Table is Build to record segment number of address)
- Bridges work best where traffic from one segment of a network to other segments is not too great.



However, when traffic between network segments becomes too heavy, the bridge can become a bottleneck and actually slow down communication.

Switches (Multiport Bridges)

- **Switches operate at the Data Link layer (layer 2) of the OSI model**
- A switch is a device that is used to segment networks into sub networks called subnets. (Used to build LAN)
- **Can interpret address information**
- Uses Addressing Scheme knows as MAC Addressing.
- Switches are capable of inspecting data packets as they are received, determining the source and destination device of that packet, and forwarding it appropriately
- Switch conserves network bandwidth and offers generally better performance than a hub.
- **Switch may Broadcase , unicast or Multicast .**

Learning the MAC Addresses and forwarding to the respective machine is switching.

- Switches have
  - ASIC (Application Specific IC)
  - OS is hardcoded in microprocessor
  - So switches are hardware based.
  - Ports are unlimited

- Bridges have
  - OS is separated
  - So bridges are not used
  - Bridges are software based.
  - Limited Ports (16)

Routers

- Used to build WAN
- Router connect multiple networks and route the packets.
- Uses IP Address to identify every machine uniquely.
- Routers are used to connect two or more networks. For routing to be successful, each network must have a unique network number
- Routers have the ability to make intelligent decisions as to the best path for delivery of data on the network.
- **They use the "logical address" of packets and routing tables to determine the best path for data delivery.**
- To determine the **best path**, routers communicate with each other through **routing protocols**
- The four most common routing protocols:
  - RIP (Routing Information Protocol) for IP
  - OSPF (Open Shortest Path First) for IP
  - EIGRP (Enhanced Interior Gateway Routing Protocol) for IP, IPX, and AppleTalk
  - BGP (Border Gateway Protocol) for IP

Gateways

- Device that connects dissimilar networks.
- Operates at the highest level of abstraction.
- Expands the functionality of routers by performing data translation and protocol conversion.
- Establishes an intelligent connection between a local network and external networks with completely different structures.
- Gateways serve as an entry and exit point for a network as all data must pass through or communicate with the gateway prior to being routed.
- If a network wants to communicate with devices, nodes or networks outside of that boundary, they require the functionality of a gateway.
- A gateway is often characterized as being the combination of a router and a modem.

Thank You