Data Communication & Network

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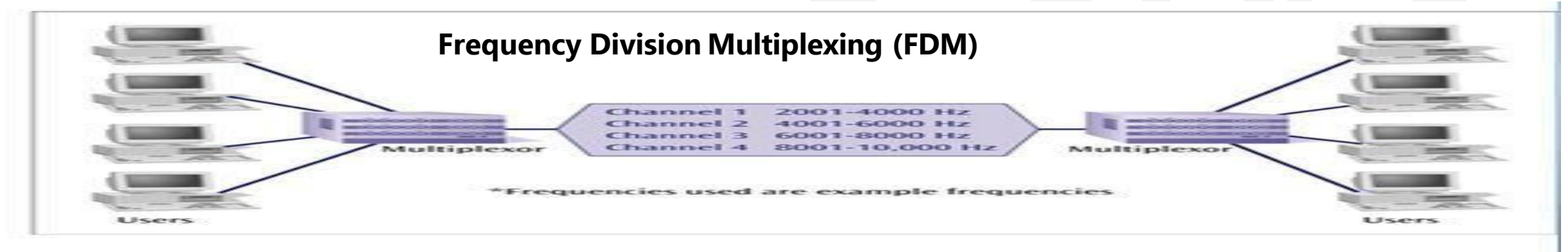**Email: sujata.mohite@sunbeaminfo.com**
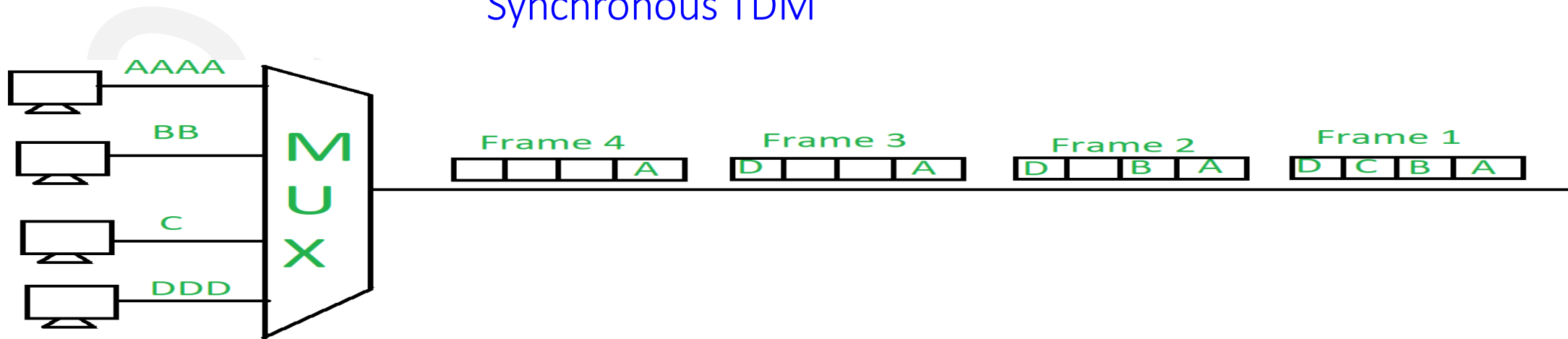
Multiplexing

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)
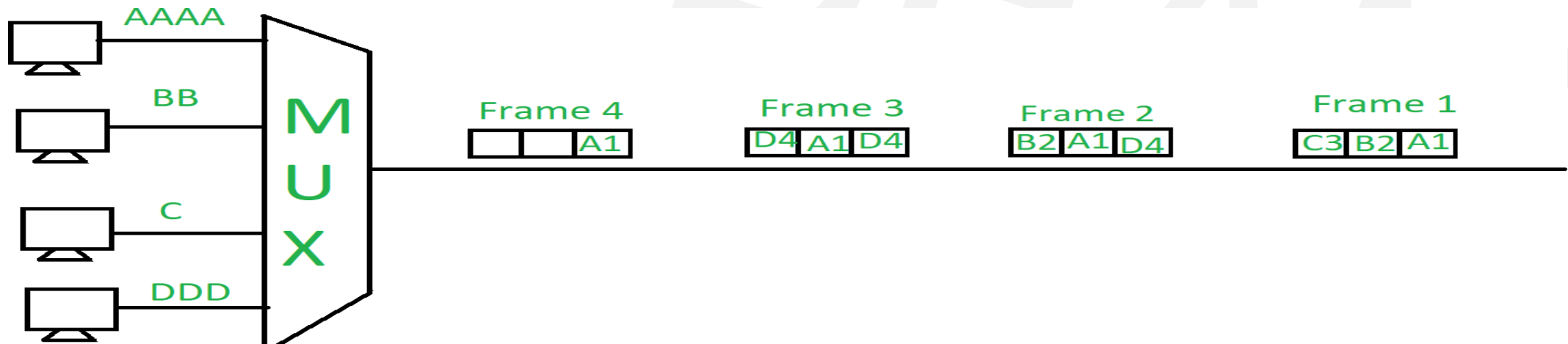 - TDM (Time Division Multiplexing)

Frequency Division Multiplexing (FDM)

Channel 1	2001-4000 Hz
Channel 2	4001-6000 Hz
Channel 3	6001-8000 Hz
Channel 4	8001-10,000 Hz

Multiplexor

*Frequencies used are example frequencies

Users

Multiplexor

Users

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	
100 m	Building	Local area network
1 km	Campus	
10 km	City	Metropolitan area network
100 km	Country	
1000 km	Continent	Wide area network
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.
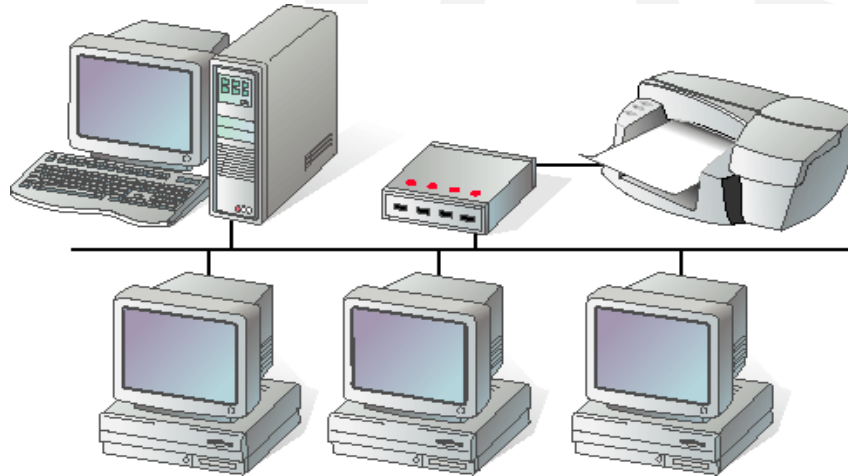
Basic systems people use to set up wired networks

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

Station
Ring Interface
Undirectional Ring
A Ring Network
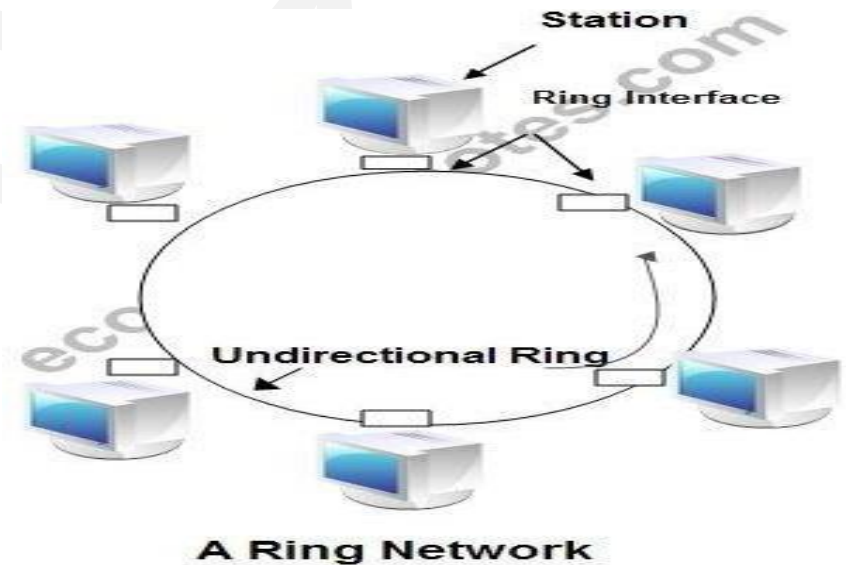
Ethernet Transfer speed 10 Mbps, 100 Mbps, or above

- 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.
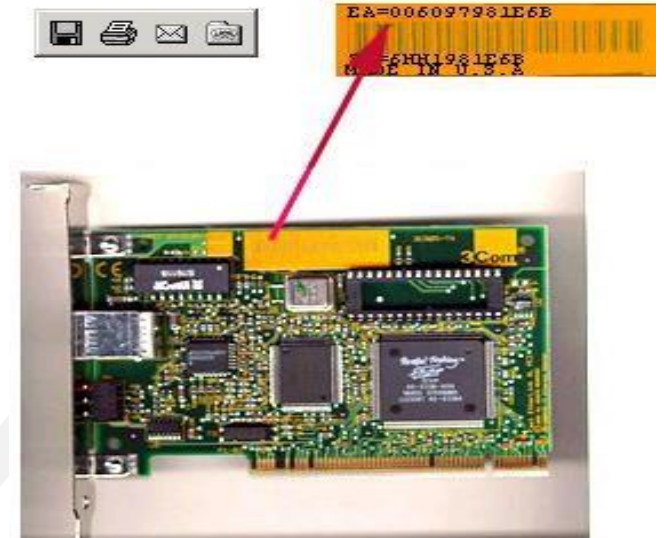
Ethernet Address/ MAC Address

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

- First three bytes from <u>left</u> 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.

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
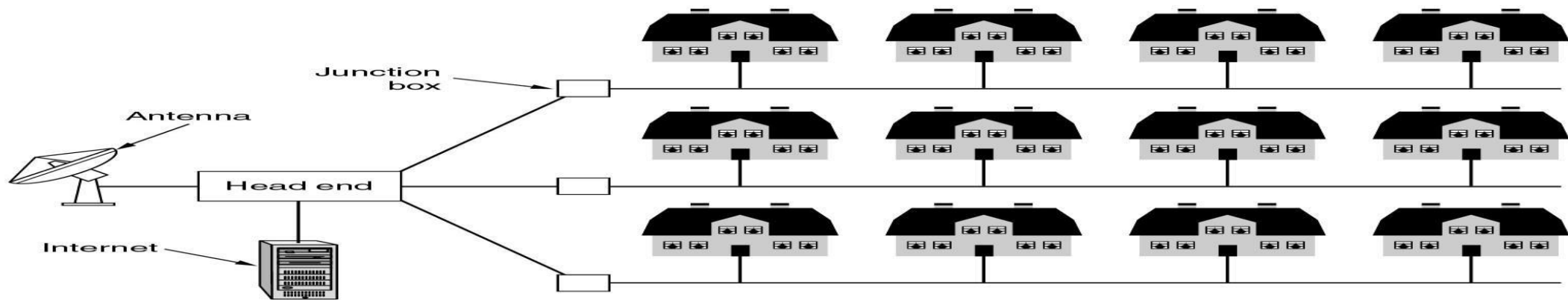
WAN

- 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
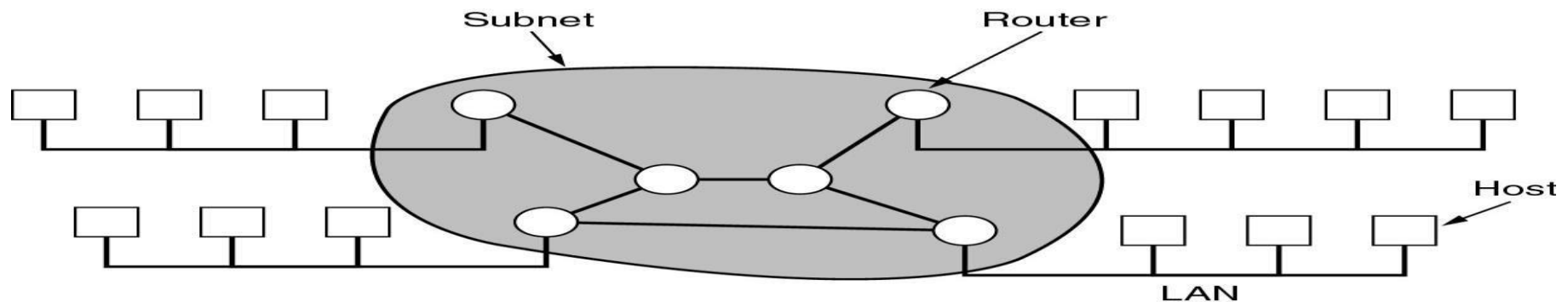
Other Types of Network

CAN (Campus Area Network)
Eg. Sunbeam

PAN(Personal Area Network)
Laptop connected to Bluetooth, speaker, camera , mic etc made up of a wireless modem, a computer or two, phones, printers, tablets, etc., and revolves around one person in one building.
Private Area Network
E.g. One m/c in India (One IP) is connected to other machine in US (Other IP) are connected via Internet / VPN(Virtual Private Network)

SAN(Server Area Network/ System Area Network)
designed to provide high-speed connection in server-to-server applications (cluster environments)
Bank Branches and their transactions are done at centralized Bank server
Storage Area Network
That connects shared pools of storage devices to several servers, they don't rely on a LAN or WAN.
One instance of server is created and kept at each location
Google Drive data (google.co.in/ google.com/google.jp etc)

GAN(Global Area Network)
network composed of different interconnected networks that cover an unlimited geographical area.
used to support mobile number of arbitrary number of wireless LAN (LAN), satellite coverage areas, etc

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
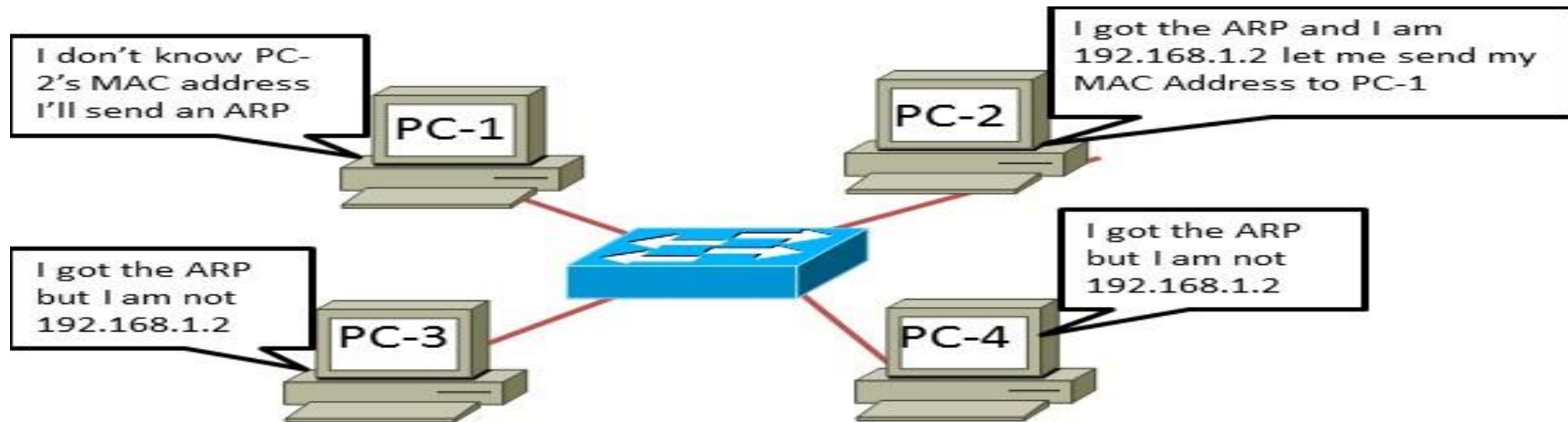
Network Physical Structure

Physical Structure

Type of Connection

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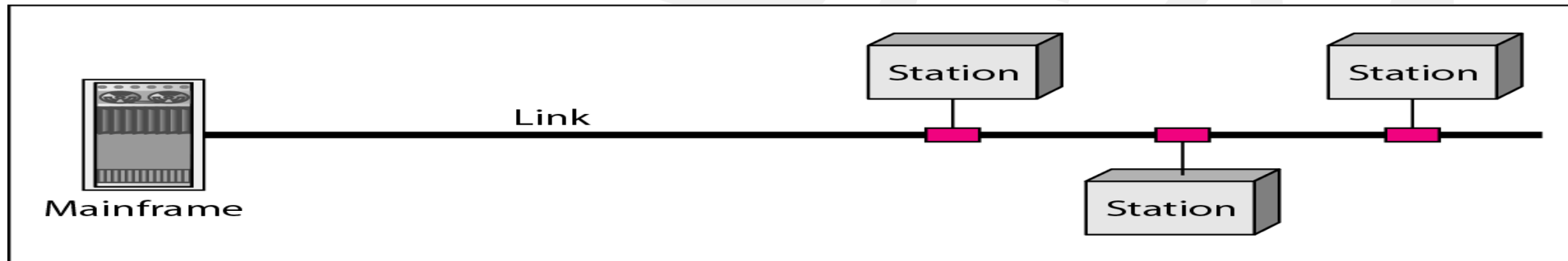
Physical Topology

- 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.
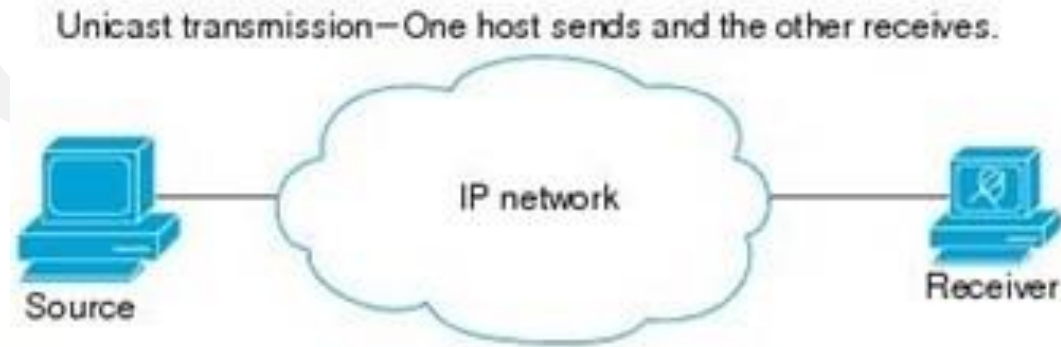
Types of Connection
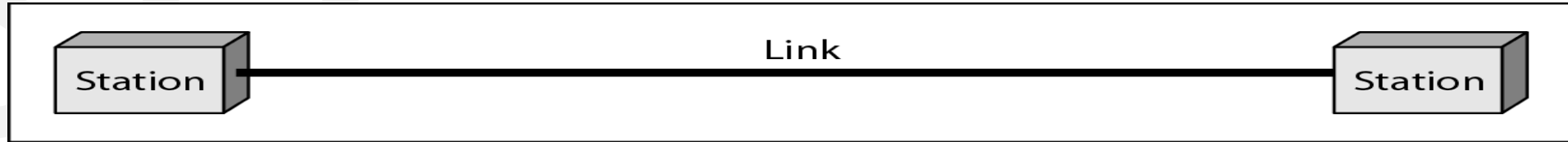
a. Point-to-point

b. Multipoint

Type of transmission

Type of transmission - unicast, multicast, broadcast

1) Unicast Transmission

Unicast transmission—One host sends and the other receives.

Source · IP network · Receiver

- The term unicast refers to "one to one".
- In unicast mode, transmission happens from host to host i.e. one to one. This will not incur any traffic burden on the LAN.
- The devices such as switch uses unicast mode of transmission.
Eg: Phone call between two people

Type of transmission

2)Multicast Transmission

Multicast transmission—One sender to a group of receivers.
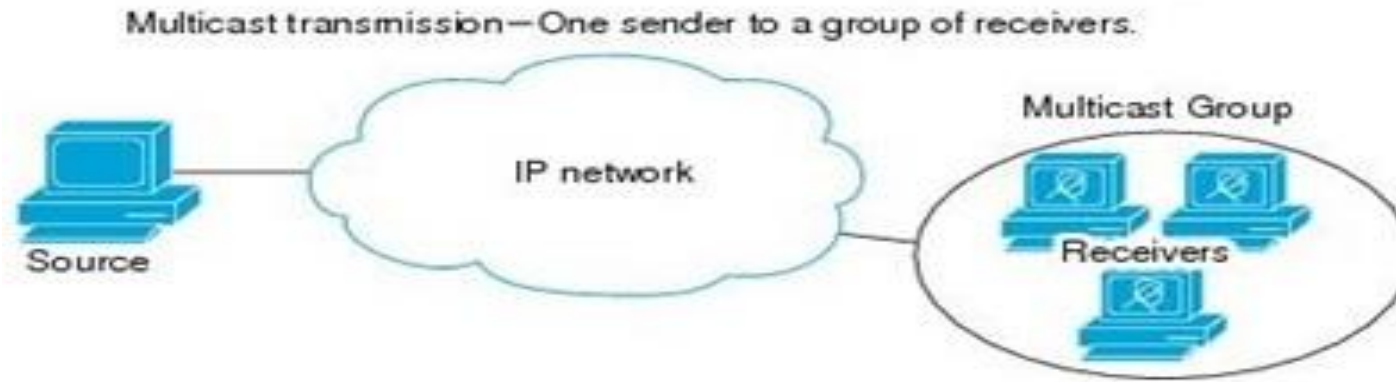
- The term **multicast** refers to "one to selected group of members".
- In multicast mode, transmission happens from one host machine to selected group of host machines.
Eg: giving a group call on WhatsApp or any application.

Type of transmission

3) Broadcast Transmission

Broadcast transmission—One sender to all receivers.

Source

IP network

Receivers
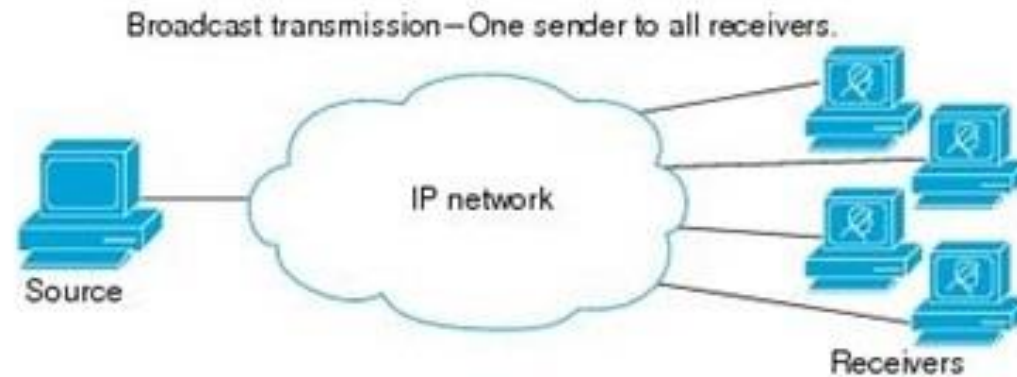
The term **broadcast** refers to "one to all".
• In broadcast mode, transmission happens from one host to all the other hosts connected on the LAN.
The devices such as bridge uses this. The protocol such as ARP implement this, in order to know MAC address for the corresponding IP address of the host machine.
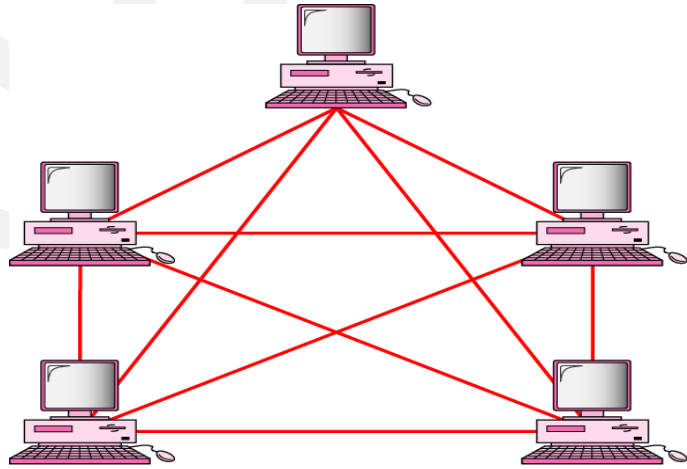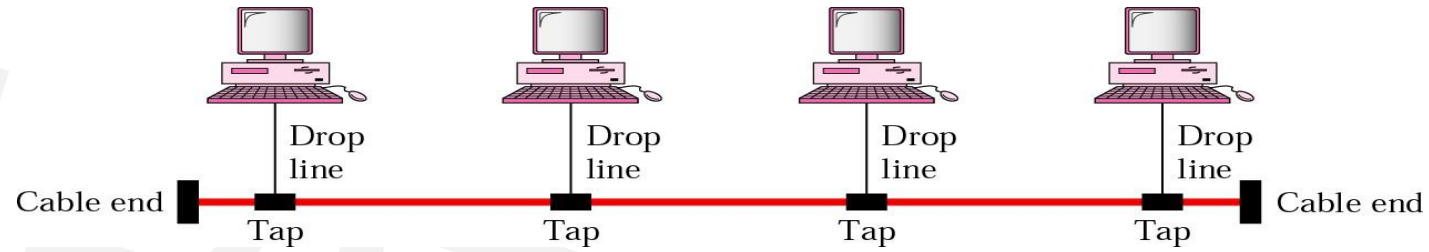
Physical Topology

- 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.
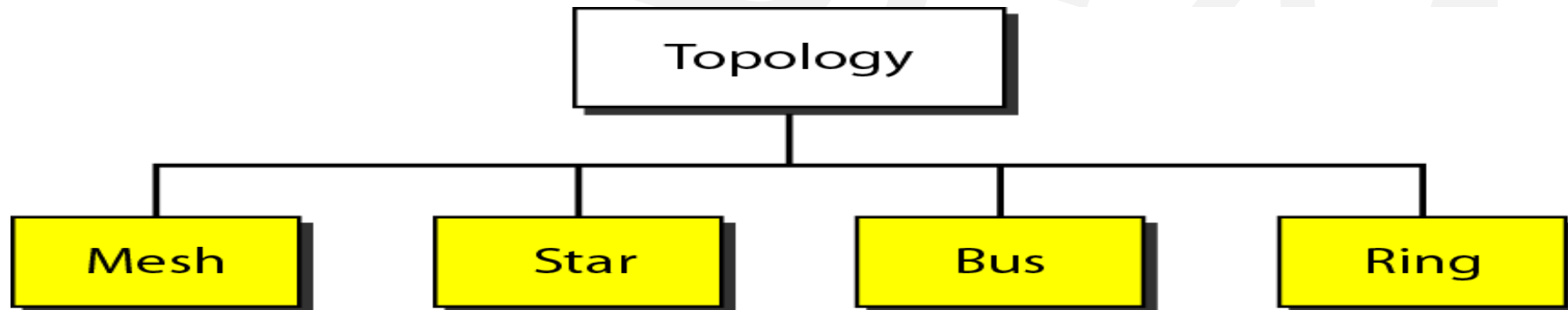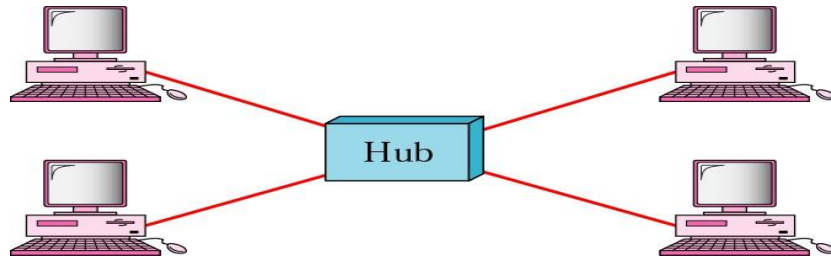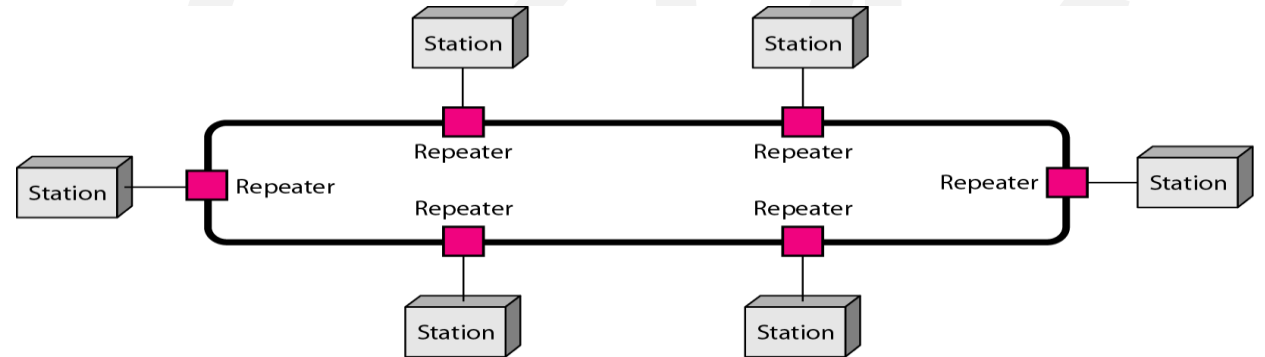
Network Topology

mesh

bus

star

ring

Mesh

- Mesh topology is a type of networking in which all the computers are inter-connected to each other.
- In Mesh Topology, the connections between devices take place randomly.
- The connected nodes can be computers, switches, hubs, or any other devices.
- In this topology, even if one of the connections goes down, it allows other nodes to be distributed.
- This type of topology is very costly.
- It is used for wireless networks, and its connections can be wired or wireless.
- There is a **point-to-point** connection between all nodes in the mesh topology setup.

Bus

- The bus topology is designed in such a way that all the stations are connected through a single cable known as a **backbone cable**.
- Each node is either connected to the backbone cable by drop cable or directly connected to the backbone cable.
- The configuration of a bus topology is quite simpler as compared to other topologies.
- The backbone cable is considered as a **"single lane"** through which the message is broadcast to all the stations.
- In this topology, even if one of the connections goes down, it does not affect whole network but if backbone cable is affected then whole network is affected.
- There is a **multipoint connection** between all nodes.

Star

- Star topology, sometimes known as a star network, is a network topology in which each device is connected to a central hub.
- In this network arrangement, all devices linked to a central network device are displayed as a star.
- In star topology, all connected devices are completely dependent on the central device; the communication through the whole Computer Network fails if the central device gets any problem.
- Each node in this diagram has a direct **point-to-point** link to the central device, yet no single node can communicate directly with the others. Therefore, before reaching the destination, each message has to pass through this central device only.

Ring

- Ring topology is like a bus topology, but with connected ends.
- The node that receives the message from the previous computer will retransmit to the next node.
- The data flows in one direction, i.e., it is **unidirectional**.
- The data flows in a single loop continuously known as an endless loop.
- It has no terminated ends, i.e., each node is connected to other node and having no termination point.
- The data in a ring topology flow in a **clockwise direction**.
- There is a **multipoint connection** between all nodes.
- But each system is connect in point-to-point fashion and if one system goes down then entire network will go down.

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.**

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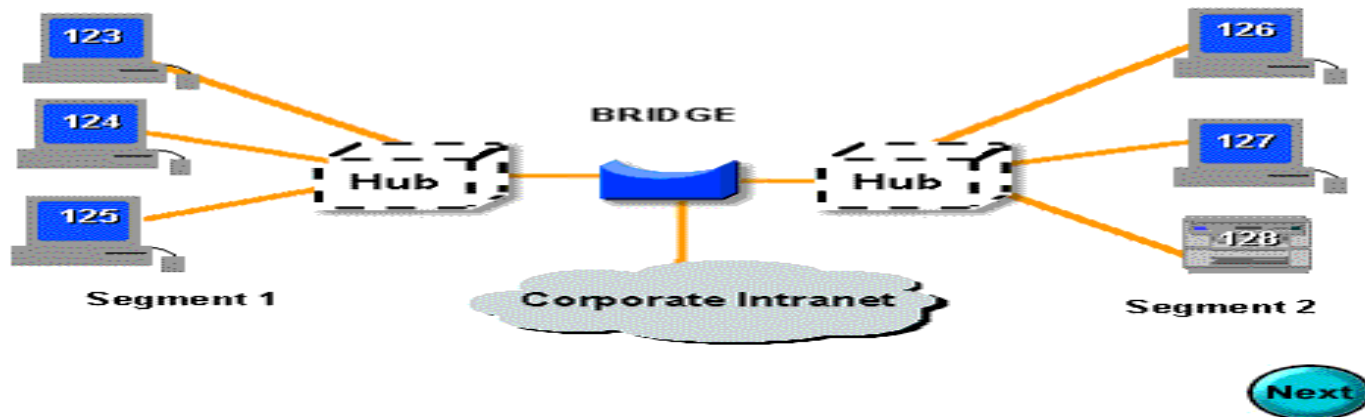
However, when traffic between network segments becomes too heavy, the bridge can become a bottleneck and actually slow down communication.

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
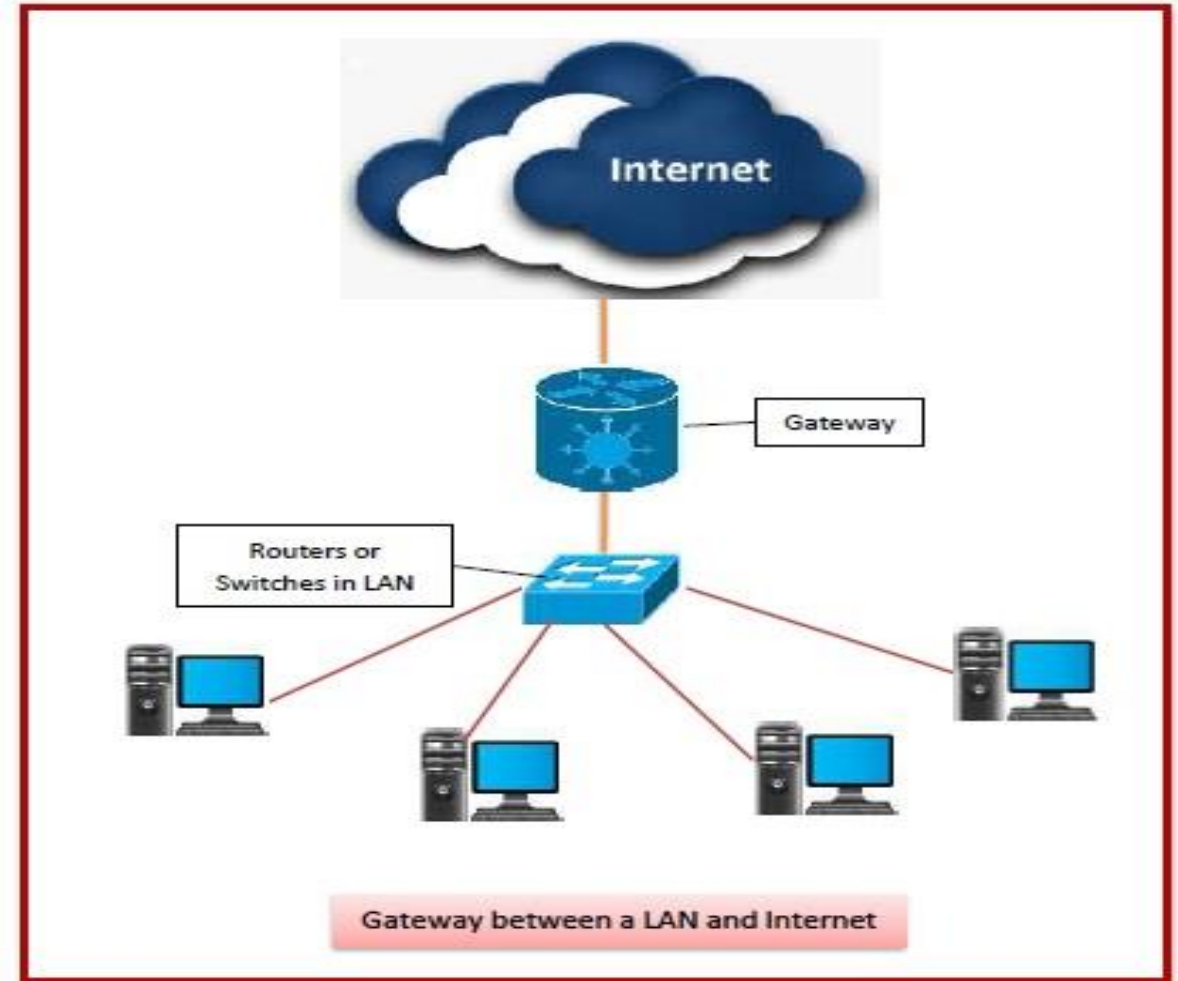   - BGP (Border Gateway Protocol) for IP

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 <u>router</u> and a <u>modem</u>.

Gateways

- A gateway is a network node that forms a passage between two networks operating with different transmission protocols.
- The most common type of gateways, the network gateway operates at layer 3, i.e. network layer of the OSI (open systems interconnection) model.
- However, depending upon the functionality, a gateway can operate at any of the seven layers of OSI model.
- It acts as the entry – exit point for a network since all traffic that flows across the networks should pass through the gateway..

Gateway between a LAN and Internet

Thank You!!