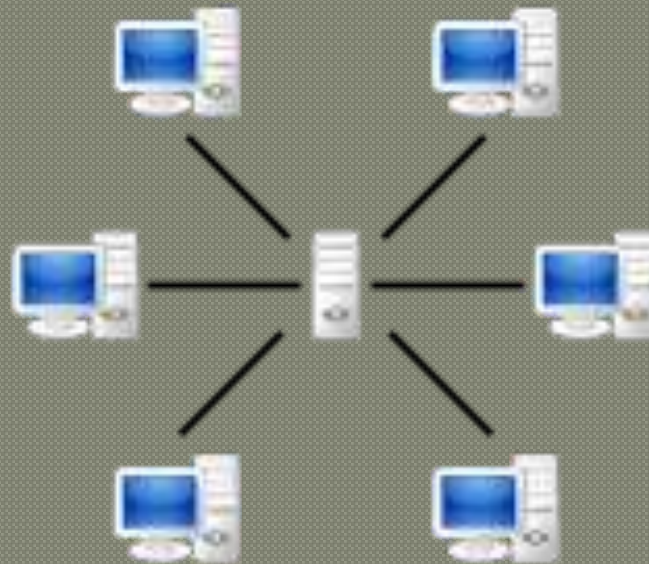


COMPUTER NETWORKING



INTRODUCTION

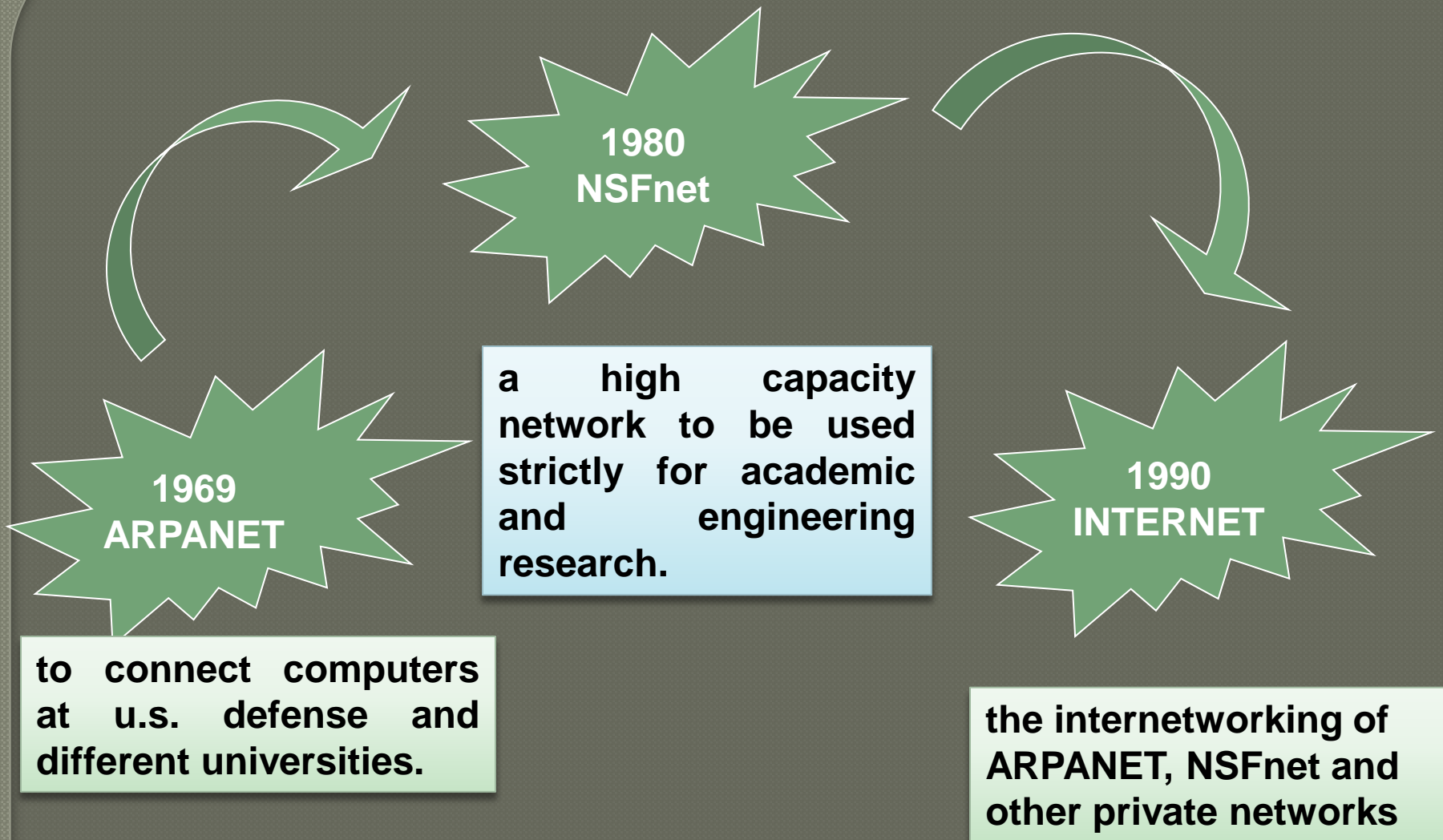
A computer network is a collection of interconnected computers and other devices which are able to communicate with each other. Also defined as - collection of hardware components and computers interconnected by communication channels that allow sharing of resources and information. Where at least one process in one device is able to send/receive data to/from at least one process residing in a remote device, then the two devices are said to be in a network

DISADVANTAGES OF NETWORK

- If network are badly managed, services can become unusable and productivity fails
- If software and files held centrally, it may be impossible to carry out any work if the central server fails.
- File security is more important especially if connected to WAN e.g. protection from viruses
- To handle network of organization you may need specialist staff to run the network

Evolution of Network

- 1969 - First network came into existence
- ARPANET – Advanced Research Project Agency Network
- MID 80'S - NSFNET (National Science Foundation Network)



INTERNET IS THE NETWORK OF NETWORKS.

Internet

- a global computer network providing a variety of information and communication facilities, consisting of interconnected networks using standardized communication protocols
- Network of Networks
- Popularly known as “NET”

Intranet

- Intranet is a local or restricted communications network, especially a private network created using World Wide Web softwares.
- It is managed by any person/ organization
- Intranet user can avail services of Internet whereas Internet user cannot access intranet directly.

Interspace

- Interspace is a client/server software program that allows multiple users to communicate online with real time audio, video and text chat in dynamic 3D environment.
- Online video conferencing is an example of Interspace.

Switching Techniques

- Switching techniques are used for transferring data across network.
- In large network, there might be multiple path linking the sender and receiver. Information may be switched as it travels through various communication channel.
- Three types of Switching techniques
 1. Circuit Switching
 2. Packet Switching
 3. Message Switching

Circuit Switching

- First the complete physical connection between two computers is established and then the data are transmitted from the source computer to the destination
- When a call is placed the switching equipment within the system seeks out a physical copper path all the way from the sender to the receiver.
- It is must to setup an end-to-end connection between computers before any data can be sent.
- The circuit is *terminated* when the connection is closed.
- In circuit switching, resources remain allocated during the full length of a communication, after a circuit is established and until the circuit is terminated and the allocated resources are freed

Packet Switching

- Packet switching introduces the idea of cutting data i.e. at the source entire message is broken in smaller pieces called packets which are transmitted over a network without any resource being allocated.
- Then each packet is transmitted and each packet may follow any rout available and at destination packets may reach in random order.
- At the destination when all packets are received they are merged to form the original message.
- In packet switching all the packets of fixed size are stored in main memory.

Message Switching

- In message Switching, data is first stored by one node then forward to another node to transfer the data to another system.
- In message Switching, data is first stored, then forwarded to the next node
- In Message Switching there is no upper bound on size of packet whereas in Packet Switching each packet is of fixed size.
- In Packet Switching data packets are stored in main memory whereas in Message Switching Message is stored in Hard disk which makes it reducing the access time

Data Communication terminologies

- ◎ Channels
- ◎ **Bandwidth**
 - Hz,
 - KHz
 - MHz
- ◎ Data Transfer Rate
 - bps
 - Kbps
 - Mbps
 - Gbps
 - Tbps

Channels

- Physical medium like cables over which information is exchanged is called channel. Transmission channel may be analog or digital. As the name suggests, analog channels transmit data using analog signals while digital channels transmit data using digital signals
- In popular network terminology, path over which data is sent or received is called data channel. This data channel may be a tangible medium like copper wire cables or broadcast medium like radio waves.

Bandwidth

- Data transfer rates that can be supported by a network is called its bandwidth.
- Bandwidth can be used in two different context with two different measuring values:
 - **BANDWIDTH IN HERTZ**: is the range of frequencies contained in a composite signal or the range of frequencies a channel can pass. It is measured as Hz (Hertz), KHz(Kilo), MHz(Mega)
 - **BANDWITDH IN BITS PER SECOND**: number of bits per second that a channel, link, or network can transmit. It is measures as bps, Kbps, Mbps, etc.

Data Transfer Rate

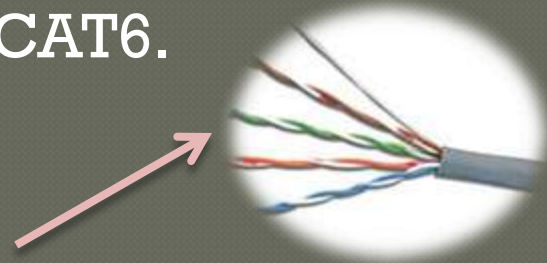
- It defines the number of data elements (bits) sent in 1 second. The unit is bps (bits per second)
- **Kbps (Kilo bits per second)**
- **Mbps (Mega bits per second)**
- **Gbps (Giga bits per second)**
- **Tbps (Tera bits per second)**

Transmission Media

- **Transmission media** is a communication channel that carries the information from the sender to the receiver.
- It is of 2 type:
 - **Wired media**
 - Twisted Pair Cable
 - Co-axial Cable
 - Fiber-Optical Cable
 - **Wireless Media**
 - Radio waves
 - Microwaves
 - Infrared
 - Satellite

Twisted Pair Cable

- used for creating small computer network. It contains four twisted pair covered in an outer shield. These pair are color coded. An RJ-45 is used to connect this cable to a computer. It is available in various forms such as CAT1, CAT2, CAT3, CAT4, CAT5, CAT6.
- Also known as Ethernet Cable
- It is of 2 types:
 - UTP (Unshielded Twisted Pair)
 - STP(Shielded Twisted Pair)



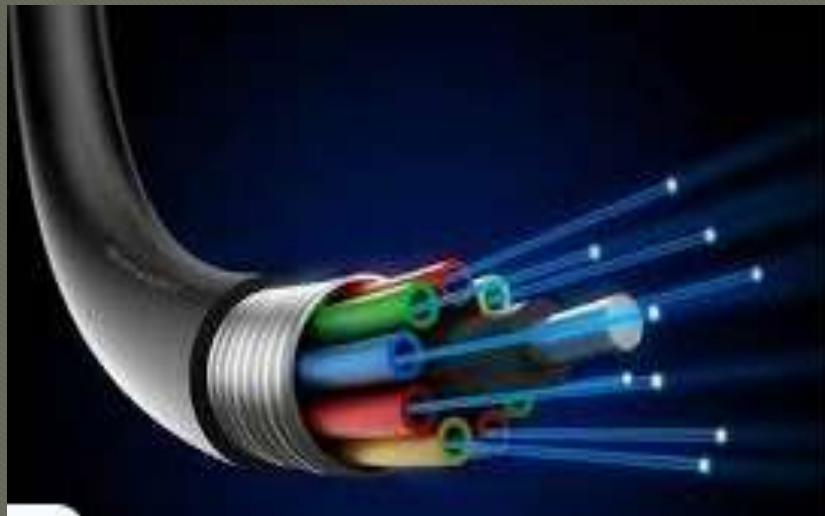
Coaxial Cable

- **Coaxial cable** is a type of copper **cable** specially built with a metal shield and other components engineered to block signal interference. It is primarily used by **cable** TV companies to connect their satellite antenna facilities to customer homes and businesses.



Fiber Optical Cable

- are long, thin strands of glass about thickness of human hair. It is used to transmit data through light signals over long distances. It is capable of transmitting messages modulated onto light waves.



Comparison – Wired media

	Twisted Pair Cable	Coaxial Cable	Optical fiber cable
Data Transfer Rate	10Mbps-10Gbps	100Mbps	>100Gbps
Data Transfer Range	100 m	185-500m	-
Interference susceptibility	More	Less than Ethernet cable	NIL
Cost	Least cost	More than Ethernet	Very Expensive

Wireless computer Network

Electromagnetic waves are used for wireless communication over computer network. Based on their frequencies, electromagnetic waves are categorized into various categories.

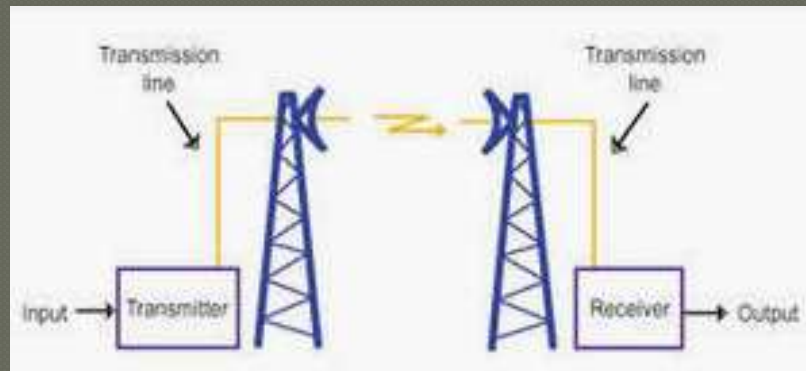
These categories are in increasing order of their frequencies –

Radio Waves < Microwaves < Infra radiation < visible light < ultraviolet radiation < x-rays < gamma rays

Out of these only ***radio waves, microwaves and infrared rays*** are used for wireless communication

Microwave

- Are high frequency waves that can be used to transmit data wirelessly over long distance
- Travels in straight lines and cannot penetrate any solid object, therefore for long distance microwave communication high towers are built and microwave antennas are put on their top.
- It consists of transmitter, receiver and atmosphere
- Used to transmit signals such as mobile phone calls



Radiowave

- Radio waves are used to transmit television and radio programs. Wi-Fi / Bluetooth has become a common word today also used radio wave to transmit data among connected device.
- It is Omni-directional and can penetrate solid objects.



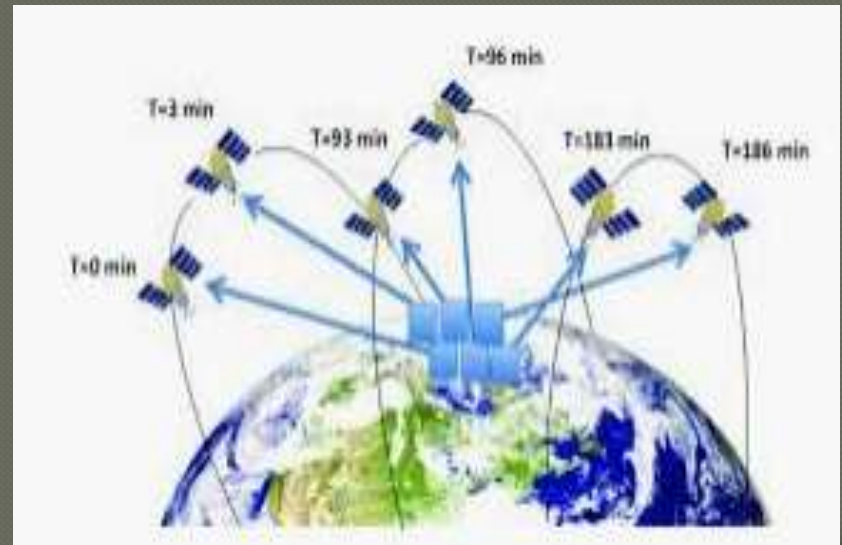
Infrared waves

- Used for short range communication approx. 5-10m
- **Used in cordless mouse, remote controlled devices**
- They do not pass through solid object
- **One advantage of this is that infrared system in one room of building will not interfere with a similar system in adjacent room.**
- It is a line of sight transmission, so information passed to one device is not leaked to another device.



Satellite (Satellite Microwave)

- ✓ Used for very long distance wireless communication.
- ✓ Transmission from earth to a satellite is uplink (frequency range 1.6GHz to 30.0 GHz) and transmission from satellite to earth is known as downlink (frequency range 1.5GHz to 20.0GHz)
- ✓ It covers large area of earth
- ✓ **Expensive**
- ✓ Require legal permissions.



Networking Devices

- ◉ Modem
- ◉ **RJ-45 connector**
- ◉ Ethernet Card (NIC)
- ◉ **Router**
- ◉ Switch
- ◉ **Gateway**
- ◉ Wi-Fi Card

Modem

- Modem is short for "Modulator-Demodulator."
- It is a hardware component that allows a computer or another device, such as a router or switch, to connect to the Internet.
- As we know phone lines work on analog signal while computer works on digital signal, So the role of Modem is to convert Digital signal to Analog so that it can be carried by telephone lines and other side it again convert analog signal to digital form

RJ-45 connector

- The "RJ" in RJ45 stands for "registered jack,"
- Registered Jack 45 (RJ45) is a standard type of physical connector for network cables.
- RJ45 connectors are most commonly seen with Ethernet cables and networks. Modern Ethernet cables feature small plastic plugs on each end that are inserted into the RJ45 jacks of Ethernet devices



Ethernet Card

- It is also known as NIC (Network Interface Card)
- Is a device that is attached to each of the workstations and the server and helps the workstations establish all – important connection with the network.
- It contain RJ-45 slot to connect Ethernet cable with RJ-45 connector.
- Each NIC attached to workstation has a unique number identifying it, known as MAC Address.
- Also known as Network Interface Unit.



Router

- A device that works like a bridge but can handle different protocols is known as router. For example router can link Ethernet and mainframe. It is responsible for forwarding data from one network to different network.
- The main purpose of router is to sorting and distribution of the data packets to their destination based on their IP Address.
- Router uses Logical Address whereas Bridge uses Physical Address

Hub

- is an electronic device that connect several nodes to form a network and redirect the received information to all the connected nodes in a **broadcast mode**.
- Hub is basically used in network to increase the number computer allows them to communicate with each other.
- It is a dumb device i.e. it forward the message to every node connected and create huge network traffic.
- Hubs can be either Passive or Active
 - **Active Hub** : they amplify the signals as it moves from one connected device to another like Repeaters.
 - **Passive Hub**: allows signals to pass from one device to another without any change.



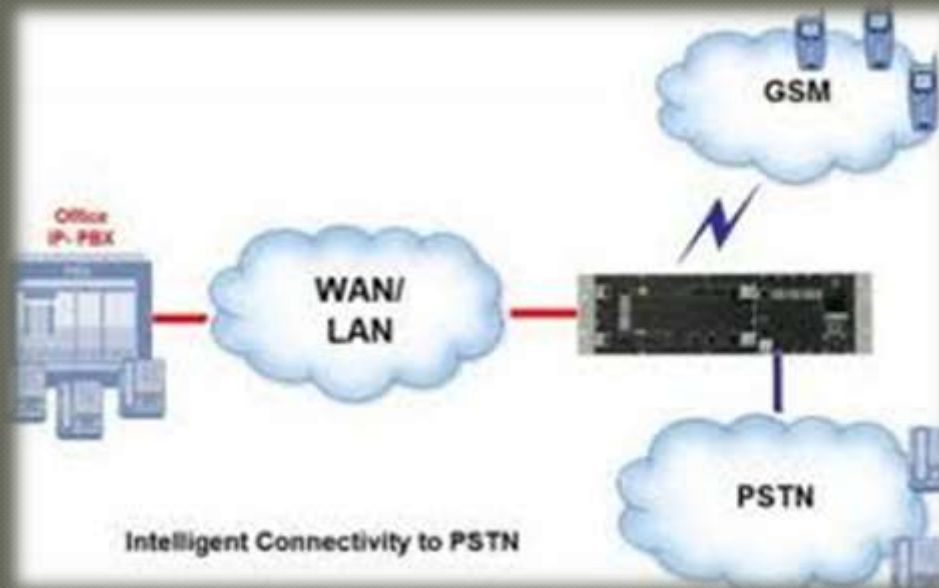
Switch

- It is known as Intelligent HUB
- Is an intelligent device that connect several nodes to form a network and redirect the received information only to the intended node(s)
- Switch stores MAC table, and when any node transmit the data to any node, Switch filters the desired MAC Address of that node and send the data to that node only.



Gateway

- is a device used to connect different type of networks and perform the necessary translation so that the connected networks can communicate properly. Gateway helps to connect different type of network i.e. following different protocols.



Wi-Fi(802.11) Card

- Similar to Ethernet card, but it allows our computer to connect with other device without wire i.e. for wireless connectivity.
- It may be internal or external with built-in wireless radio and antenna. The most common Wi-Fi card used in desktop computer are PCI-Express Wi-Fi card made it fit the PCI-Express card slots on the motherboard.
- It allow to connect our device to hotspot available.
- Advantage is that it allows computer to become part of network without being physically connected through wire and can be placed anywhere.



Network Topologies

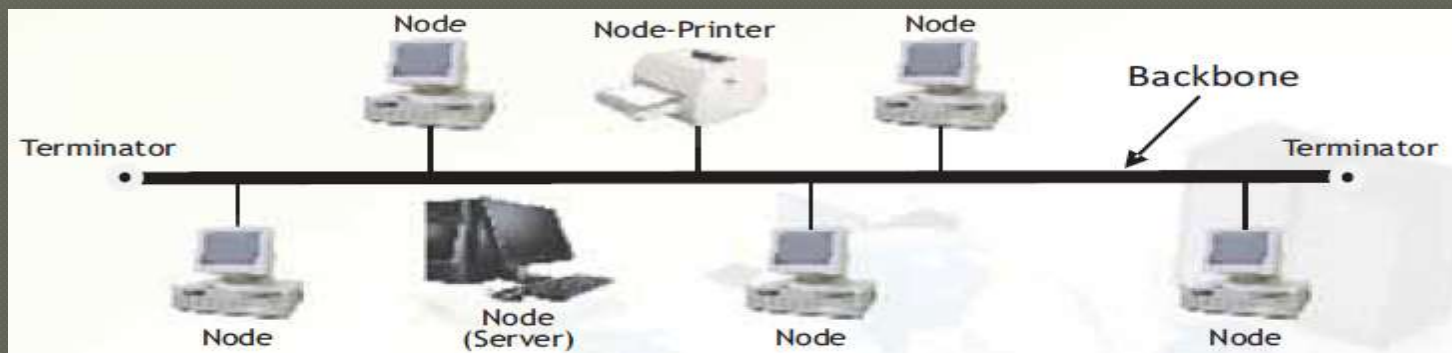
- The way in which the computers/devices are physically interconnected to form a network is called a Topology.
- It can be defined as the arrangement or structure of network.
- *Types of Topologies:*
 - **Bus**
 - **Star**
 - **Tree**
 - *Ring*
 - *Mesh*

Bus Topology

- In bus topology all the nodes are connected to a main cable called backbone.
- If any node has to send some information to any other node, it sends the signal to the backbone. The signal travels through the entire length of the backbone and is received by the node for which it is intended.
- A small device called terminator is attached at each end of the backbone. When the signal reaches the end of backbone, it is absorbed by the terminator and the backbone gets free to carry another signal.

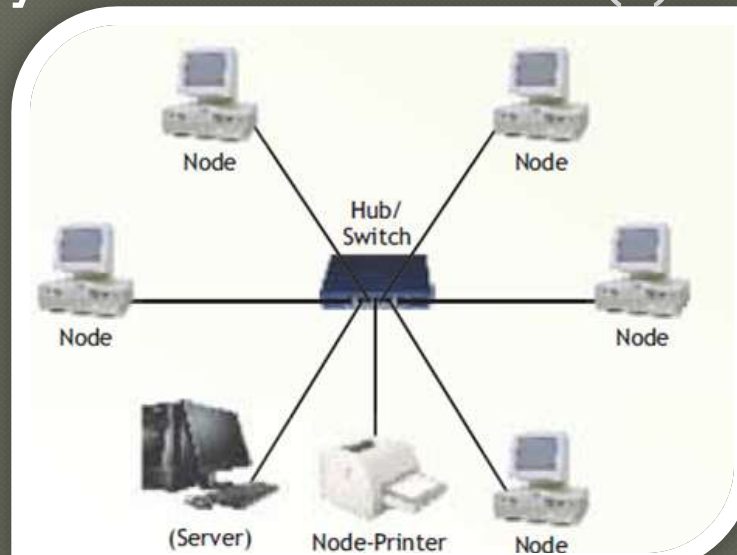
Characteristics – Bus Topology

- It is easy to install.
- It requires less cable length and hence it is cost effective.
- Failure of a node does not affect the network
- In case of cable (backbone) or terminator fault, the entire network breaks down.
- Fault diagnosis is difficult.
- At a time only one node can transmit data.



Star Topology

- In star topology each node is directly connected to a hub/switch.
- If any node has to send some information to any other node, it sends the signal to the hub/switch. This signal is then broadcast (in case of a hub) to all the nodes but is accepted by the intended node(s).

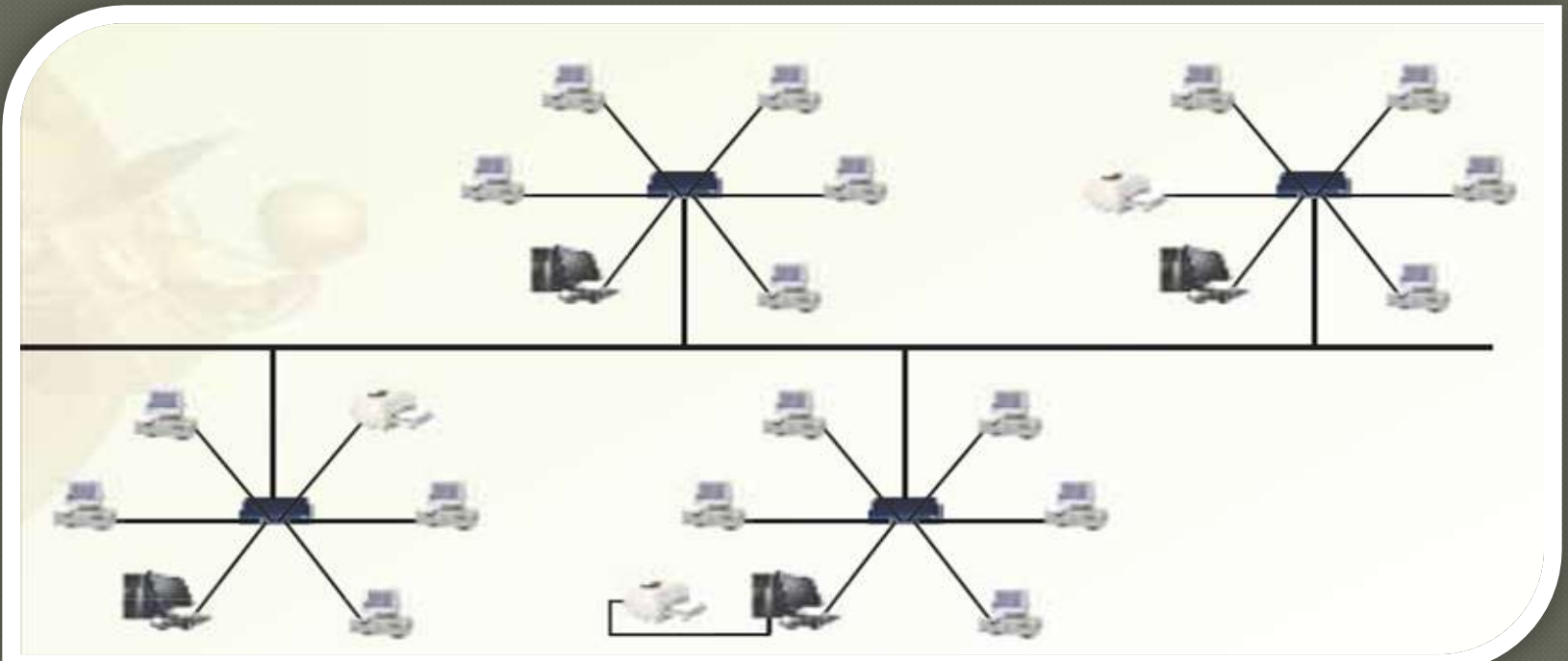


Characteristics – Star Topology

- It is easy to install
- **It is easy to diagnose the fault in Star topology.**
- It is easy to expand depending on the specifications of central hub/switch
- **Failure of hub/switch leads to failure of entire network**
- It requires more cable length as compared to bus topology.

Tree Topology

- Tree topology is a combination of bus and star topologies.
- It is used to combine multiple star topology networks.
- All the stars are connected together like a bus.



Characteristics – Tree Topology

- It offers easy way of network expansion
- Even if one network (star) fails, the other networks remain connected and working.

TYPES OF NETWORK – AREA COVERAGE

- ◎ PAN
- ◎ LAN
- ◎ MAN
- ◎ WAN

PERSONAL AREA NETWORK

- ❖ Network of communicating devices(computer, phone, MP3 etc.)
- ❖ **Cover area of few meters radius**
- ❖ When we transfer songs from one cell phone to another we setup a PAN of two phones
- ❖ **Can be setup using guided or unguided media**

LOCAL AREA NETWORK

- ✓ Network of computing/communication devices in a room, building or campus
- ✓ **Cover area of few kilometer radius(approx. 1 – 10 KM)**
- ✓ Can be setup using wired or wireless media
- ✓ **Managed by single person or organization**
- ✓ Ethernet cable or Wi-Fi is used to establish LAN

METROPOLITAN AREA NETWORK

- ✓ Network of computing/communicating devices within a city.
- ✓ Cover an area of few kilometers to few hundred kilometers radius
- ✓ Network of schools, banks, government offices within a city are example of MAN.
- ✓ It is typically formed by interconnected number of LANs
- ✓ Owned by organization or government.

WIDE AREA NETWORK

- ✓ Network of computing/communication devices crossing the limits of city, country, or continent.
- ✓ **Cover area of over hundreds of kilometer radius**
- ✓ Network of ATMs, BANKs, National or International organization offices spread over a country, continent are example of WAN.
- ✓ **It is usually formed by interconnecting LANs, MANs or may be other WANs.**
- ✓ Best example of WAN is internet

NETWORK PROTOCOLS

- Refers to SET OF RULES
- In Network there are variety of computer connected to each other and data in many ways.
- For interaction among these, some rules are applied like how and when a device can send and receive data, how to send the data packet and how to receive etc. There are many protocols used like:
 - TCP/IP
 - FTP
 - PPP
 - HTTP
 - SMTP
 - POP3

TCP/IP

- Stands for Transmission Control Protocol and Internet Protocol
- **TCP is connection oriented protocol i.e. first the connection between sender and receiver is established through process called handshake (RTS,CTS, ACK etc.)**
- TCP divides the large packets to transmit into smaller data packets called datagrams.
- **At the receiving end it also reassemble the packet for form original message.**
- **IP (INTERNET PROTOCOL) :** responsible for providing address of each computer and performing routing. Each packet is assigned with destination IP address.

FTP

- Stands for File Transfer Protocol
- It allows transferring of files from one system to another like uploading of file from local machine to web server using FTP Client like FileZilla etc.
- FTP offers these advantages:
 - Useful to transfer files from one network to another
 - It is an effective way to get geographically dispersed group to co-operate on a project.
 - It is popular way to update web sites.
- It is not just name of protocol, but also name of program or command by typing ftp followed by another site and press enter.

PPP

- Stands for Point-to-Point Protocol
- Point - to - Point Protocol (PPP) is a communication protocol of the data link layer that is used to transmit multiprotocol data between two directly connected (point-to-point) computers.
- It is a byte - oriented protocol that is widely used in broadband communications having heavy loads and high speeds.

HTTP

- Stands for Hypertext Transfer Protocol
- Used to transfer all files and other data(resources) from one computer to another on the world wide web.
- Client(Browser) send request to Web Server using HTTP protocol and Server respond back to Client using HTTP i.e. Client and server over web communicate using HTTP protocol.
- HTTP is stateless protocol, various technique applied to make HTTP as State full like Cookies.
- See the format of URL:
 - <http://www.google.com>

SMTP

- Stands for Simple Mail Transfer Protocol
- **SMTP** is a set of communication guidelines that allow software to transmit an electronic mail over the internet is called Simple Mail Transfer Protocol.
- It is a program used for sending messages to other computer users based on e-mail addresses
- **Port 25 (non-encrypted, unsecure)**
- **Port 465 (encrypted, secure)**

POP3

- Stands for Post Office Protocol (Version-3.0)
- **POP3** is a client/server protocol in which e-mail is received and held for you by your Internet server.
- Periodically, you (or your client e-mail receiver) check your mail-box on the server and download any mail, probably using **POP3**.
- It also allows to download the received messages on local machine using tool like Outlook so that user can read them even when they are not connected to the Internet.
- Port 110, default POP3 used for unsecured email communication
- Port 995 – the encrypted port used for secured communication using POP3

VoIP

- Voice over Internet Protocol
- It is a protocol that enables voice communication over the Internet through the compression of voice into data packets that can be efficiently transmitted over data network and then convert back into voice at receiving end.
- It uses packet switching (store and forward)
- It is an alternate to traditional telephone network.

Remote Login

- Remote login is a network application that permits a user sitting at a different location to work on a specific program on another program.
- **The user need ID of that computer generated by remote login application.**
- It is done only when both PC are connected to Internet.
- **Mainly used by customer support system to do some installation, setting on client computer.**
- The main programs are:
 - Telnet
 - AnyDesk
 - Team Viewer

Telnet

- Telnet is one of the earliest remote login protocols on the Internet.
- Telnet is a user command and an underlying TCP/IP protocol for accessing remote computers.
- Through Telnet, an administrator or another user can access someone else's computer remotely. On the Web, HTTP and FTP protocols allow you to request specific files from remote computers, but not to actually be logged on as a user of that computer.
- With Telnet, you log on as a regular user with whatever privileges you may have been granted to the specific application and data on that computer.

Wireless/Mobile Communication Protocol

- Mobile communication protocols use multiplexing to send information. Multiplexing is a method to combine multiple digital or analog signals into one signal over the data channel.
- This ensures optimum utilization of expensive resource and time. At the destination these signals are de-multiplexed to recover individual signals.



Wireless/Mobile Communication Protocol

- **GSM**
 - (Global System for Mobile Communication)
- **CDMA**
 - **Code Division Multiple Access**
- **WLL**
 - Wireless Local Loop

Global System for Mobile Communication (GSM)

- It is one of the most widely used digital wireless telephony system.
- **It was developed in Europe in 1980s**
- Now it is an international standard in Europe, Australia, Asia and Africa.
- **Any GSM handset with a SIM card can be used in any country that uses this standard. Every SIM card has a unique identification number.**
- GSM uses TDMA (Time Division Multiple Access) to support up to eight calls simultaneously. It also uses encryption to make the data more secure.

GPRS

- It stands for General Packet Radio Services.
- It is a packet based wireless communication technology that charges users based on the volume of data they send rather than the time duration for which they are using the service.
- GPRS is the mobile communication protocol used by second (2G) and third generation (3G) of mobile telephony). Its speed upto 56kbps to 114kbps, however the actual speed may vary depending on network traffic.

Wireless Local Loop(WLL)

- It is wireless local telephone service that can be provided in homes or offices.
- The subscribers connect to their local exchange instead of the central exchange wirelessly.
- A data is transferred over very short range, it is more secure than wired network.
- WLL system consists of user handset and a base station. The base station is connected to the central exchange as well as antenna.
- The antenna transmits to and receives call from users through microwave links

Code Division Multiple Access

- It was first used by the British military during world war II.
- After the war its use spread to civilian areas due to high service quality.
- As each user gets the entire spectrum all the time, voice quality is very high.
- CDMA phones were not using the SIM card, it comes with built in technology.
- In India CDMA technology was used by Tata Docomo and Reliance, but now its services are stopped and only GSM network is working.

Mobile Communication Technologies

- The popular network nowadays is Mobile phone Network. It is cellular based network which gave mobile phone name “cell phone”. Popular mobile technologies:
 - 1G
 - 2G
 - 3G
 - 4G
 - 5G

First Generation (1G)

- Used for voice calls as analog signal
- **No data was transmitted**
- Technology used as AMPS (Advanced Mobile Phone System)
- **An AMP was a voice-only network operating on 800MHz.**
- Speed upto 2.4 kbps
- **Poor voice quality**
- Large phone with limited battery life
- **No data security**

Second Generation (2G)

- In this generation, few features like simple text messaging were added.
- New services such as text messaging, packet data(for MMS and internet access), called ID and also introduced SIM (Subscriber Identify Module) card.
- Data transfer rate upto 64kbps
- Disadvantage was low network range, slow data rates.
- To overcome these two problems two new network – CDMA and EDGE (Enhanced Data Rate for GSM evolution) were introduced.

Third Generation(3G)

- In this generation Web browsing, email, video conferencing, video downloading, picture sharing and other smartphone technologies were introduced.
- Devices are called smartphones
- Fast communication, data speed between 144kbps to 2Mbps
- High quality voice transmission
- Supported multimedia(playing music, viewing videos, video calls etc)
- Mobile TC, Mobile internet

Fourth Generation(4G)

- The speed of this generation is from 100 Mbps to 1Gbps
- **Based on LTE-Advanced (Long Term Evolution)**
- Voice as VoIP (Voice over Internet Protocol (VoLTE))
- **Better Video calling than 3G, Video conferencing etc.**

Fifth Generation(5G)

- It is yet to be implemented in India which promises superfast data transfer rate upto 20Gbps along with energy saving.

Mobile Processor

- Brain of Smartphone
- Mobile processor receives commands, makes instant calculations, plays audio/video, stores information and sends signals throughout the device.
- Mobile processor has majorly two sub-processor:
 - Communication Processing Unit
 - Application Processing Unit
- Popular Mobile processors are:
 - Qualcomm Snapdragon 865
 - Apple A13 Bionic
 - Samsung Exynos 990 etc.

Communication Processing Unit

- It is responsible for making and receiving phone calls on a mobile handset. It works with 2 subunits:-
 - RF Transceiver
 - Audio Subsystem
- **RF Transceiver** : responsible for connecting SIM card to base station through radio signals. Its uses networks like 3G/4G/LTE etc.
- **Audio subsystem** : responsible for converting the voice signals(analog) to digital signals. The audio subsystem receives voice input through in-built mic and can produce audio output and send it to in-built speaker.

Application Processing Unit

- It is responsible for performing operations like making calculations, playing music, internet surfing, playing videos, connecting to other device, chat, screenshot, making videos, saving data etc.

Chat Protocol

- Popular Chat protocols are:
 - IRC
 - XMPP
- IRC (Internet Relay Chat) : IRC (Instant Relay Chat) is a chat protocol that has been around since 1988. It is a simple protocol and is quick to parse on the server side, requiring little resources. IRC does not require any user authentication, only that the connecting username must be unique in a channel.
- XMPP (Extensible Messaging and Presence Protocol): it is based on XML. It requires each user must have registered unique IDs. WhatsApp, Facebook, Google Talk chat is using this protocol. Its features are User Identity, Multiple logins, Persistent message, Popularity, Personal Message

Video Conferencing

- The H.323 protocol is one of the most widely deployed protocols in video conferencing.
- Video conferencing is a technology by means of which two or more parties situated in different geographical locations can watch and converse with each other by means of two-way transmission of video and audio data in near real-time.

Wi-Fi (802.11x protocol)

- **WIRELESS FIDELITY** : protocols allows devices to connect to the internet without a direct line from your Device to ISP (Internet Service provider). **Its maximum coverage area is 100 meters.** Transmission speed upto 54 mbps. **It is mostly used in LAN Application.** It uses Radio wave spectrum
- **Wi-Fi HOTSPOT** : a hotspot is a venue that offers Wi-Fi access. We can share out internet through Wi-Fi hotspot. We can set Hotspot with or without password. With mobile we can connect upto 10 devices with hotspot (However it depends upto type of device)

Wi-Max(802.16y protocol)

- ◉ Stands for wireless inter-operability for Microwave access.
- ◉ Wi-Max is used in MAN Applications
- ◉ Wi-Max network range to max 90kms
- ◉ Wi-Max transmission speed can be upto 70mbps