1.1 COMPUTER NETWORK

INTRODUCTION TO NETWORKING

Network is the collection of computer, software and hardware that are all connected to each other to help their work together. A network connects computers by means of cabling system (or wireless media), specialized software and devices that manage data traffic. A network enables users to share files and resources such as printer as well as send message electrically to each other.

Computer network falls under two types

1) Client server network
2) P2P (peer-to-peer) network

- **Client Server Network**

Each client is assigned as account name and password that is verified by an authentication service. The authentication service guards access to the network. With the centralization of user accounts, security and access control, server based networks simplify the administration of large network.

The concentration of network resources such as files, printers and applications on servers also makes it easier to backup and maintain the data. Resource can be located on specialized dedicated servers for easier access.

Advantages

- Easier to administer when the network is large.
- All data can be backed up on one central location.

Disadvantages

- Requires expensive, more powerful hardware for the server machines.
- Has a single point of failure user data is unavailable when the server is down.
- Requires expensive specialized network administrative and operational software.
- Requires a professional administrator.

- **Peer-to-Peer Network**

Network computers act as equal partners, or peers. Each computer can take on the client function or the server function.

Suppose computer A may request for a file from computer B, which then sends file to computer A. In this case, computer A acts like the client and computer B as server.

At a later time, their role may be reserved; individual users control their own resources.

The users may decide to share certain files with other users. The users may also require passwords before they allow others to access their resources. Since individual users make these decisions, there is no central point of control or administration in the network.

When a computer acts as a server, the user of that machine may experience reduced performance as the machine server the requests made by other system.

Advantages

- Less expensive to implement.
- Doesn't require additional specialized network administration software.
- Doesn't require a dedicated network administrator.

Disadvantages

- Less secure.
- Doesn't scale well to large networks, and administration becomes unmanageable.
- Each must be trained to perform administrative tasks.
- All machines sharing resources negatively impact the performance.

COMPUTER NETWORK AND ITS USES

A computer network is a telecommunications network which allows computers to exchange data. It is a collection of computers and other devices (nodes) that use a common network protocol to share information and resources with each other over a network medium. The network medium may be copper wire, fiber optics, microwave, infrared or even communication satellites.

Uses of Computer Networks

Business Applications

- **Resource sharing:-** Computer Network is used in Resource sharing. The Same Device in a network can be accessed by the different computer which is connected to the same network like the printer, fax, scanner, etc.

- **Information sharing:-** Information sharing is the exchange of data between various organizations, people, and technologies. Different information and data can be shared like the file, videos, etc.

- **Communication medium:-** Computer Network is widely used in communication like chatting, video chatting, emails ,etc.

- **E-commerce:-** Computer Network is also used in E-commerce where users can pay bills, transfer cash, buy good, etc using the computer.

Home Applications

- **Access to remote information:-** Computer Network facilitates users to access information that is distant away by staying at home remotely.

- **Person-to-person communication:-** Users can use Computer Network in their home to communicate with other peoples by telephone, video chat, etc.

- **Interactive entertainment:-** Computer Network is used in multiplayer gaming. It is also used in social networking sites like facebook, twitter, etc to connect people.

Mobile Users

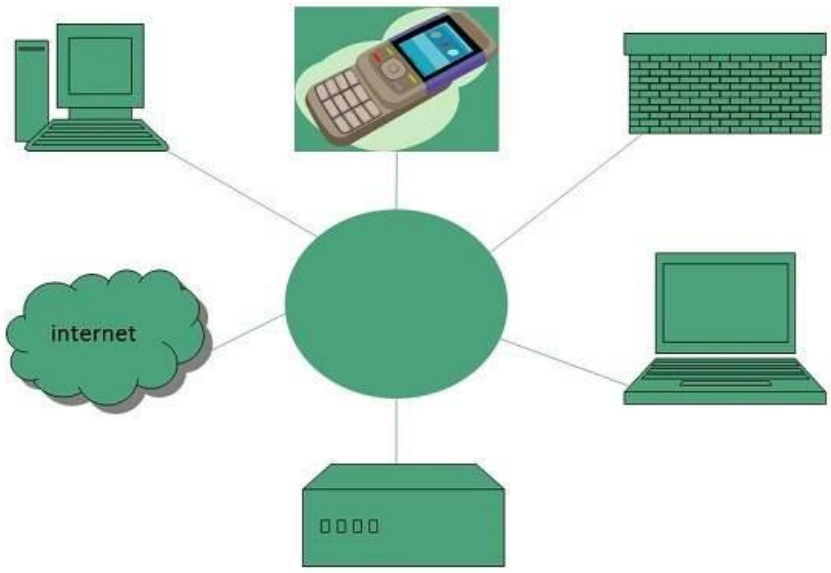
Computer Network is used in the mobile device like telephone, Smartphone, tablets, etc for communication, the internet, file sharing, etc.

INTERNET, EVOLUTION OF INTERNET AND ITS APPLICATION

Internet

Internet is defined as an Information super Highway, to access information over the web. However, It can be defined in many ways as follows:

- Internet is a world-wide global system of interconnected computer networks.
- Internet uses the standard Internet Protocol (TCP/IP).
- Every computer in internet is identified by a unique IP address.
- IP Address is a unique set of numbers (such as 110.22.33.114) which identifies a computer location.
- A special computer DNS (Domain Name Server) is used to give name to the IP Address so that user can locate a computer by a name.
- For example, a DNS server will resolve a name **http://www.tutorialspoint.com** to a particular IP address to uniquely identify the computer on which this website is hosted.
- Internet is accessible to every user all over the world.



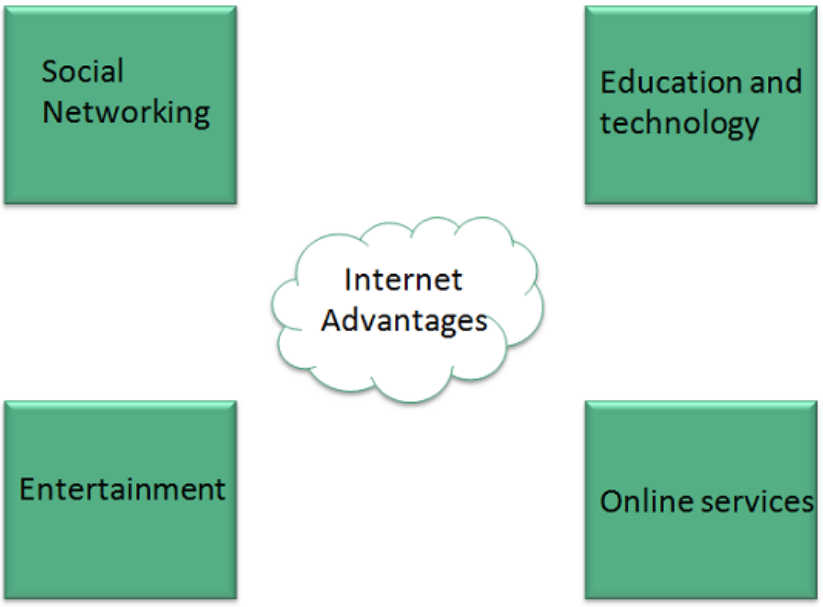
Evolution

The concept of Internet was originated in 1969 and has undergone several technological & Infrastructural changes as discussed below:

- The origin of Internet devised from the concept of **Advanced Research Project Agency Network (ARPANET).**
- **ARPANET** was developed by United States Department of Defense.
- Basic purpose of ARPANET was to provide communication among the various bodies of government.
- Initially, there were only four nodes, formally called **Hosts.**
- In 1972, the **ARPANET** spread over the globe with 23 nodes located at different countries and thus became known as **Internet.**
- By the time, with invention of new technologies such as TCP/IP protocols, DNS, WWW, browsers, scripting languages etc.,Internet provided a medium to publish and access information over the web.

Advantages

Internet covers almost every aspect of life, one can think of. Here, we will discuss some of the advantages of Internet:

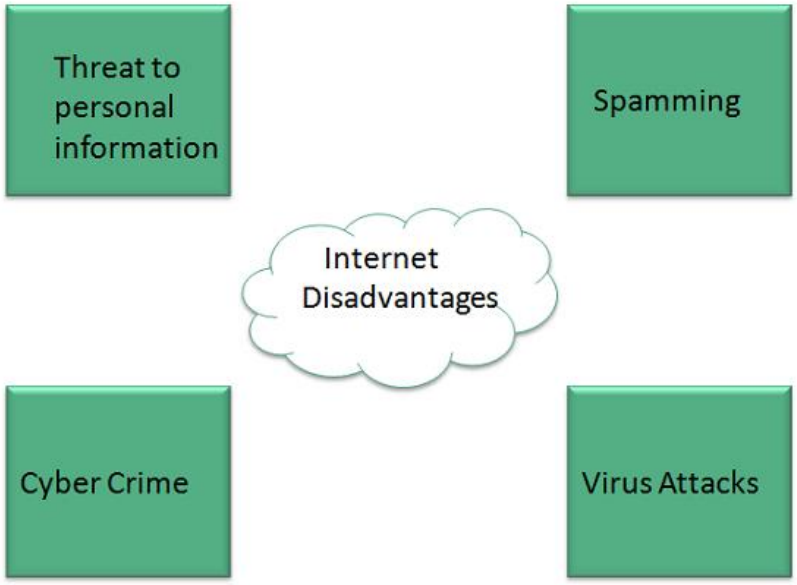


- Internet allows us to communicate with the people sitting at remote locations. There are various apps available on the wed that uses Internet as a medium for communication. One can find various social networking sites such as:
    - Facebook
    - Twitter
    - Yahoo
    - Google+
    - Flickr
    - Orkut
- One can surf for any kind of information over the internet. Information regarding various topics such as Technology, Health & Science, Social Studies, Geographical Information, Information Technology, Products etc can be surfed with help of a search engine.
- Apart from communication and source of information, internet also serves a medium for entertainment. Following are the various modes for entertainment over internet.
    - Online Television
    - Online Games
    - Songs
    - Videos
    - Social Networking Apps
- Internet allows us to use many services like:
    - Internet Banking
    - Matrimonial Services
    - Online Shopping
    - Online Ticket Booking
    - Online Bill Payment
    - Data Sharing
    - E-mail

- Internet provides concept of **electronic commerce**, that allows the business deals to be conducted on electronic systems

Disadvantages

However, Internet has proved to be a powerful source of information in almost every field, yet there exists many disadvantages discussed below:



- There are always chances to loose personal information such as name, address, credit card number. Therefore, one should be very careful while sharing such information. One should use credit cards only through authenticated sites.
- Another disadvantage is the **Spamming**. Spamming corresponds to the unwanted e-mails in bulk. These e-mails serve no purpose and lead to obstruction of entire system.
- **Virus** can easily be spread to the computers connected to internet. Such virus attacks may cause your system to crash or your important data may get deleted.
- Also a biggest threat on internet is pornography. There are many pornographic sites that can be found, letting your children to use internet which indirectly affects the children healthy mental life.
- There are various websites that do not provide the authenticated information. This leads to misconception among many people.

ADVANTAGES AND DISADVANTAGES OF COMPUTER NETWORK

- **Advantages**

1. File Sharing

The major advantage of a computer network is that it allows file sharing and remote file access. A person sitting at one work station that is connected to a network can easily see files present on another workstation provided he/she is authorized to do so.

If the files are stored on server and all of its clients share that storage capacity, then it becomes easier to make a file available to multiple users.

2. Resource Sharing

For example, if there are twelve examples in an organization, each having their own computers, they will require twelve modems and twelve printers if they go to use resources at the same time. A computer network on the other hand provides cheaper alternative by the provision of resources sharing. All computers can be interconnected using a network and just one modem and printer can efficiently provides the services to all twelve users.

3. Inexpensive Set-Up

Shared resources mean reduction in hardware costs. Shared files means reduction in memory requirements, which indirectly means reduction in file storage expenses.

4. Flexible Handling

A user can log on to the computer anywhere on the network and access his/her files. This offers flexibility to the user as to where he/she should be during the course of his/her routine.

5. Increased Storage Capacity

A standalone computer might fall short of storage memory, but when many computers are on a network the memory of different computers can be used in such a case.

- **Disadvantages**

1. Security

If a computer is on a network, a hacker can get unauthorized access by using different tools. In case of big organizations, various security software need to be used to prevent theft of any confidential and classified data.

2. Virus Attack

If even one computer on a network gets affected by a virus, there is a possible threat for the other systems getting affected too. Viruses can spread on a network easily, because of inter-connectivity of workstations.

3. Lack Of Robustness

If the main file server of computer network breaks down, the entire system becomes useless.

4. Need Of Expert Handler

The technical skills and know-how required to operate and administer a computer network is considerably high.

5. Lack Of Independence

Since most computers have a centralized server and dependent clients, the clients/users lack any freedom whatsoever.

NETWORK EDGE

- **End System**

→ End system are also referred to as host because they host (ie, run) application program such as a web browser program, a web server program, an email reader program.

→ Host are further divided into two categories:

- Clients
- Servers

→ Informally, clients tend to be desktop and mobile pc's and so on, whereas servers tend to be more powerful machine that stores and distribute web pages, stream video so on.

- **Clients and Servers**

→ A client is a program running on one end system that requests and receive a service from a server running on other end system.

→ Not all internet applications are client-server model; they are also peer-to-peer model like Bit Torrent and eMute.

CONNECTION ORIENTED AND CONNECTIONLESS SERVICES

These are the two services given by the layers to layers above them. These services are :

1. Connection Oriented Service
2. Connectionless Services

Connection Oriented Services

There is a sequence of operation to be followed by the users of connection oriented service. These are:

1. Connection is established
2. Information is sent
3. Connection is released

In connection oriented service we have to establish a connection before starting the communication. When connection is established we send the message or the information and then we release the connection.

Connection oriented service is more reliable than connectionless service. We can send the message in connection oriented service if there is an error at the receivers end. Example of connection oriented is TCP (Transmission Control Protocol) protocol.

Connection Less Services

It is similar to the postal services, as it carries the full address where the message (letter) is to be carried. Each message is routed independently from source to destination. The order of message sent can be different from the order received.

In connectionless the data is transferred in one direction from source to destination without checking that destination is still there or not or if it prepared to accept the message. Authentication is not needed in this. Example of Connectionless service is UDP (User Datagram Protocol) protocol.

Difference between Connection oriented service and Connectionless service

1. In connection oriented service authentication is needed while connectionless service does not need any authentication.
2. Connection oriented protocol makes a connection and checks whether message is received or not and sends again if an error occurs connectionless service protocol does not guarantees a delivery.
3. Connection oriented service is more reliable than connectionless service.
4. Connection oriented service interface is stream based and connectionless is message based.

NETWORK CORE

→ It means the approach to moving data through a network of links and switches.

→ There are two types:

- Circuit Switching
- Packet Switching

→ In **circuit switched network**, the resources needed along a path (buffer, link transmission rate) to provide for communication between the end systems are reserved for the duration of the communication session between the end systems.

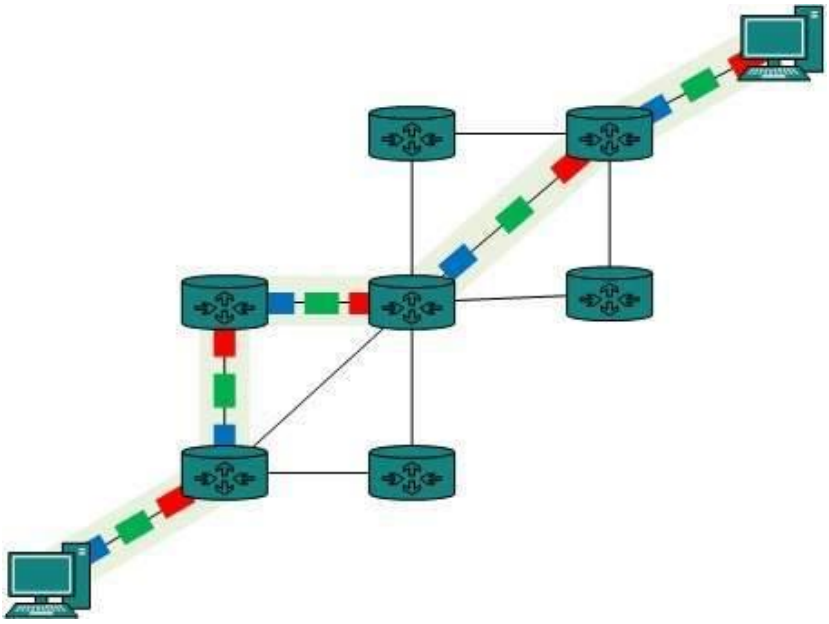
→ It reserves a constant transmission rate in the network's links for the duration of the communication. Since bandwidth has been reserved for this sender-to-receiver. Connection, the sender can transfer the data to the receiver at the guaranteed constant rate.

When two nodes communicate with each other over a dedicated communication path, it is called circuit switching. There 'is a need of pre-specified route from which data will travels and no

other data is permitted. In circuit switching, to transfer the data, circuit must be established so that the data transfer can take place.

Circuits can be permanent or temporary. Applications which use circuit switching may have to go through three phases:

- Establish a circuit
- Transfer the data
- Disconnect the circuit

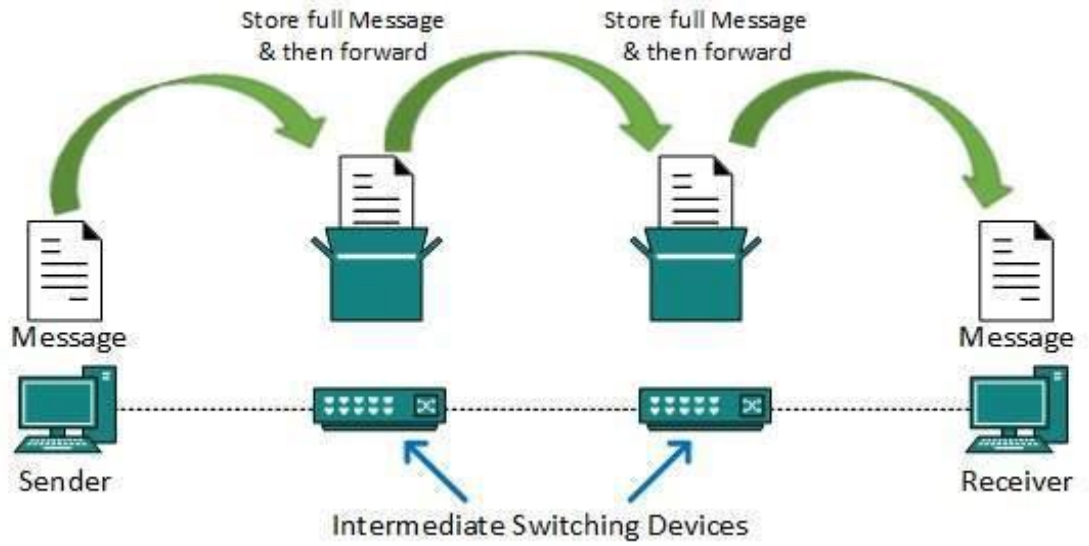


Circuit switching was designed for voice applications. Telephone is the best suitable example of circuit switching. Before a user can make a call, a virtual path between caller and callee is established over the network.

Message Switching

This technique was somewhere in middle of circuit switching and packet switching. In message switching, the whole message is treated as a data unit and is switching / transferred in its entirety.

A switch working on message switching, first receives the whole message and buffers it until there are resources available to transfer it to the next hop. If the next hop is not having enough resource to



accommodate large size message, the message is stored and switch waits.

This technique was considered substitute to circuit switching. As in circuit switching the whole path is blocked for two entities only. Message switching is replaced by packet switching. Message switching has the following drawbacks:

- Every switch in transit path needs enough storage to accommodate entire message.
- Because of store-and-forward technique and waits included until resources are available, message switching is very slow.
- Message switching was not a solution for streaming media and real-time applications.

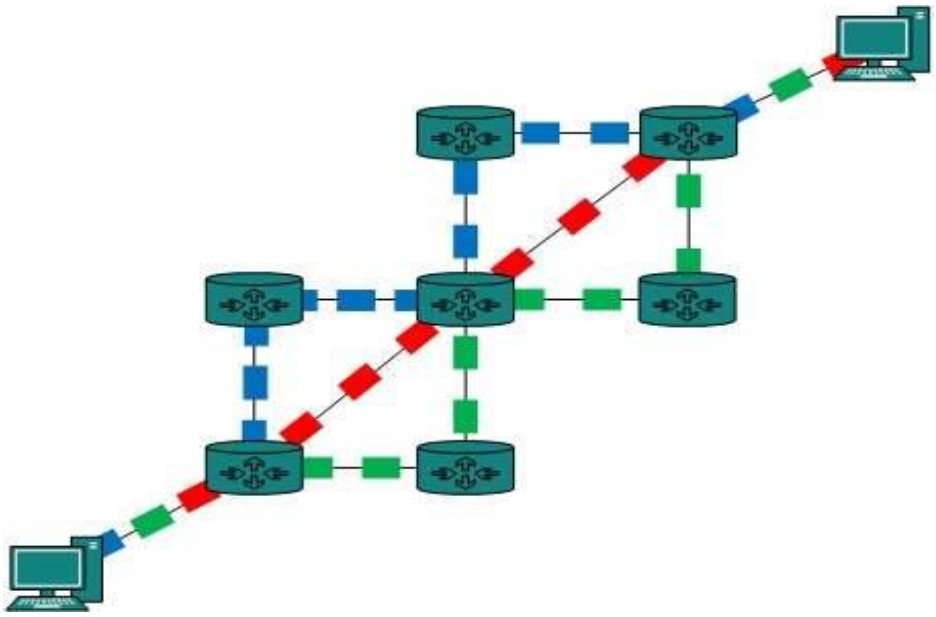
→ In **packet switched network**, the resources are not reserved for a sessions message use the resources on demand, and as a consequence may have to wait (i.e. queue) for access to a communication link.

→ The packet is sent into the network without reserving and bandwidth if one of the links is busy because other packets need to be transmitted over the link at the same time, our packet will have to wait in a buffer at the sending side of the transmission link, and suffer a delay.

→ Shortcomings of message switching gave birth to an idea of packet switching. The entire message is broken down into smaller chunks called packets. The switching information is added in the header of each packet and transmitted independently.

→ It is easier for intermediate networking devices to store small size packets and they do not

take much resources either on carrier path or in the internal memory of switches.



There are two approaches in packet switched network

1. **Datagram Network**
   - Any network that forwards the packets according to the destination address is called a datagram network.
   - The routers in the internet forwards packets according to the destination address. Hence, internet is datagram network.
2. **Virtual Circuit Network**
   - Any network that forwards the packets according to virtual circuit identifier (fixed route) is called a virtual circuit network.
   - Preplanned route established before packets sent.
   - Examples are X25, Frame relay, ATM technologies.

NETWORK ACCESS

1. **Dial-Up**

→ Accessing the internet over ordinary analog telephone lines using a dial-up modem.

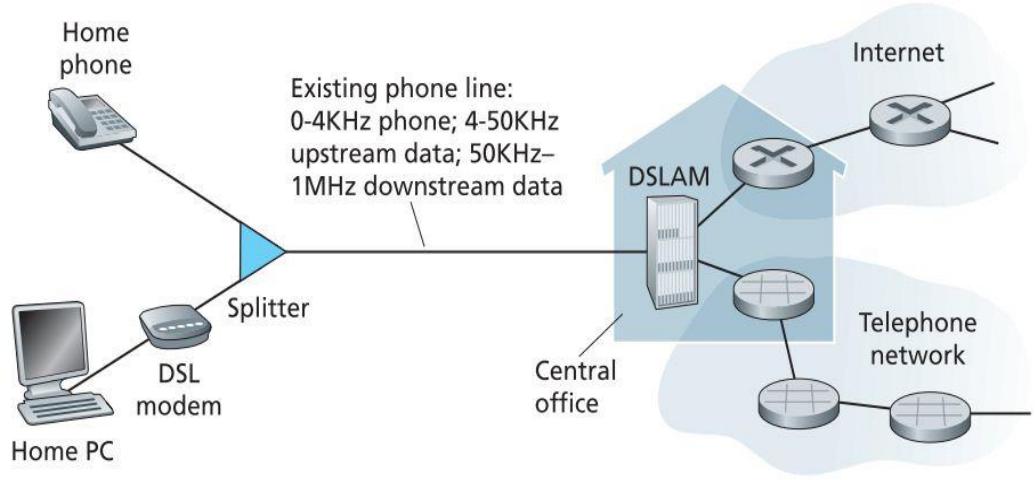
→ The term "dial-up" is used because the user software actually dials an ISP's phone number and makes a traditional phone connection with the ISP.

→ Two major drawbacks:

- Extremely slow, maximum 50 kbps.
- Cannot use phone line while accessing internet.

2. **DSL (Digital Subscriber Line)**

→ DSL internet is accessed from the same company that provides it wired local phone access.



→ Advantages:

a) High data rate (download 1-2 mbps, upload 128 kbps-1mbps)
b) Users can simultaneously talk on the phone and access internet.

3) Cable

→ Cable internet access make the use of cable TV company's existing infrastructure

→ Both the fiber and co-axial cable are employed, it is also called hybrid fiber coax (HFC)

→ Requires cable modem, which connects to the home PC through Ethernet port.

4) Wireless Network

Wireless networks are computer networks that are not connected by cables of any kind. The use of a wireless network enables enterprises to avoid the costly process of introducing cables into buildings or as a connection between different equipment locations. The basis of wireless systems are radio waves, an implementation that takes place at the physical level of network structure.

There are four main types of wireless networks:

- Wireless Local Area Network (LAN): Links two or more devices using a wireless distribution method, providing a connection through access points to the wider Internet.
- Wireless Metropolitan Area Networks (MAN): Connects several wireless LANs.
- Wireless Wide Area Network (WAN): Covers large areas such as neighboring towns and cities.
- Wireless Personal Area Network (PAN): Interconnects devices in a short span, generally within a person's reach.

→ Wireless LAN (Wi-Fi)
IEEE 802.11

→ Wide Area Wireless Access e.g.:- 3G, GPRS.

→ WiMAX

→ Intel WiMAX 2009

→ k/a IEEE 802.16 is a long distance derivation of the 802.11 WiFi protocol speed 5-10 Mbps.

Hybrid Fiber Coaxial

A hybrid fiber coaxial (HFC) network is a telecommunication technology in which optical fiber cable and coaxial cable are used in different portions of a network to carry broadband content (such as video, data, and voice). Using HFC, a local CATV company installs fiber optic cable from the cable head-end (distribution center) to serving nodes located close to business and residential users and from these nodes uses coaxial cable to individual businesses and homes. An advantage of HFC is that some of the characteristics of fiber optic cable (high bandwidth and low noise and interference susceptibility) can be brought close to the user without having to replace the existing coaxial cable that is installed all the way to the home and business.

TRANSMISSION MEDIA

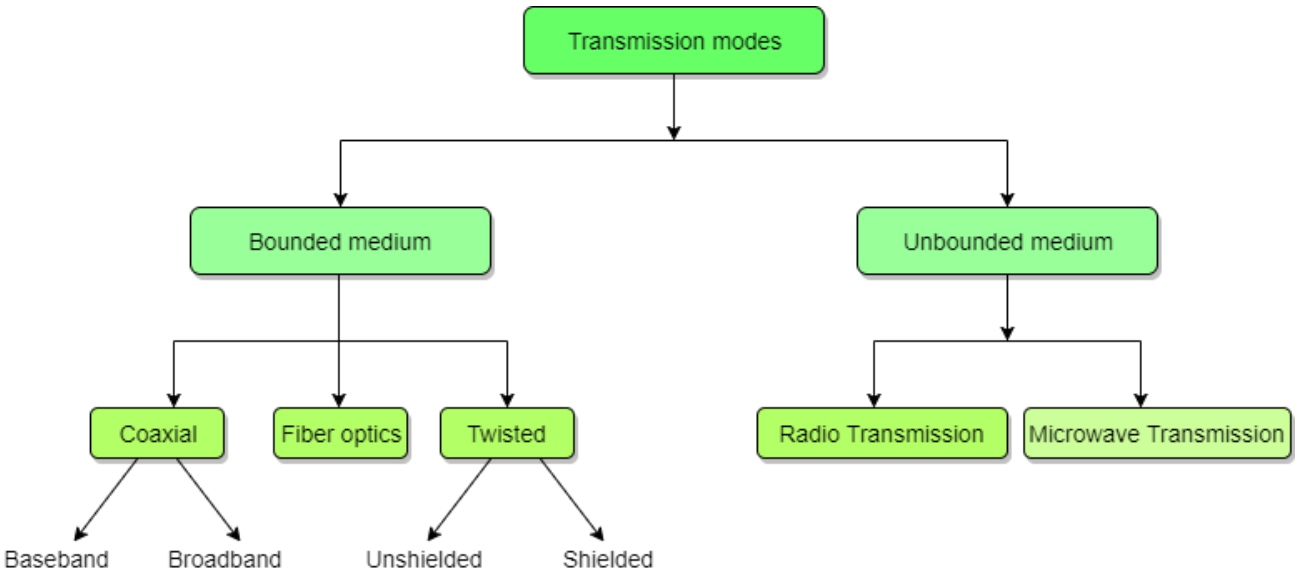
Data is represented by computers and other telecommunication devices using signals. Signals are transmitted in the form of electromagnetic energy from one device to another. Electromagnetic signals travel through vacuum, air or other transmission mediums to move from one point to another (from sender to receiver).

Electromagnetic energy (includes electrical and magnetic fields) consists of power, voice, visible light, radio waves, ultraviolet light, gamma rays etc.

Transmission medium is the means through which we send our data from one place to another.

Factors to be considered while selecting a Transmission Medium

1. Transmission Rate
2. Cost and Ease of Installation
3. Resistance to Environmental Conditions
4. Distances



Bounded/Guided Transmission Media

Guided media, which are those that provide a conduit from one device to another, include **Twisted-Pair Cable**, **Coaxial Cable**, and **Fibre-Optic Cable**.

A signal travelling along any of these media is directed and contained by the physical limits of the medium. Twisted-pair and coaxial cable use metallic (copper) conductors that accept and transport signals in the form of electric current. **Optical fibre** is a cable that accepts and transports signals in the form of light.

Twisted Pair Cable

This cable is the most commonly used and is cheaper than others. It is lightweight, cheap, can be installed easily, and they support many different types of network. Some important points :

- Its frequency range is 0 to 3.5 kHz.
- Typical attenuation is 0.2 dB/Km @ 1kHz.
- Typical delay is 50 µs/km.
- Repeater spacing is 2km.

A twisted pair consists of two conductors (normally copper), each with its own plastic insulation, twisted together. One of these wires is used to carry signals to the receiver, and the other is used only as ground reference. The receiver uses the difference between the two. In addition to the signal sent by the sender on one of the wires, interference(noise) and crosstalk may affect both wires and create unwanted signals. If the two wires are parallel, the effect of these unwanted

signals is not the same in both wires because they are at different locations relative to the noise or crosstalk sources. This results in a difference at the receiver.

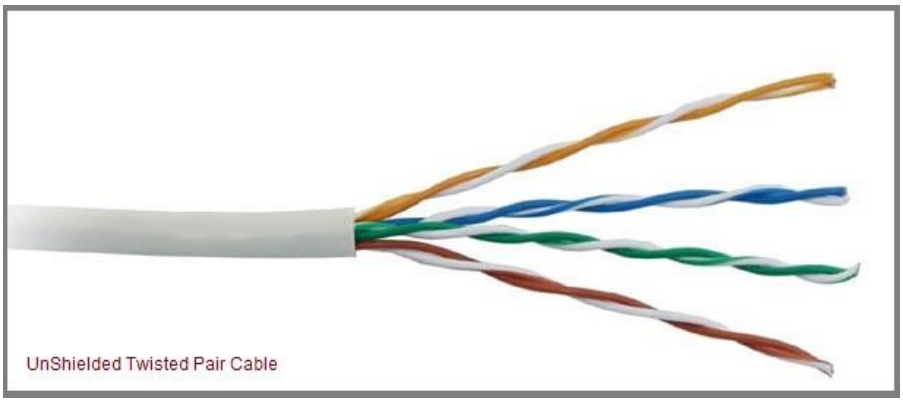
Twisted Pair is of two types:

- **Unshielded Twisted Pair (UTP)**
- **Shielded Twisted Pair (STP)**

Unshielded Twisted Pair Cable

It is the most common type of telecommunication when compared with Shielded Twisted Pair Cable which consists of two conductors usually copper, each with its own colour plastic insulator. Identification is the reason behind coloured plastic insulation.

UTP cables consist of 2 or 4 pairs of twisted cable.



Advantages

- Installation is easy
- Flexible
- Cheap
- It has high speed capacity,
- 100 meter limit
- Higher grades of UTP are used in LAN technologies like Ethernet.

It consists of two insulating copper wires (1mm thick). The wires are twisted together in a helical form to reduce electrical interference from similar pair.

Disadvantages

- Bandwidth is low when compared with Coaxial Cable

- Provides less protection from interference.

Shielded Twisted Pair Cable

This cable has a metal foil or braided-mesh covering which encases each pair of insulated conductors. Electromagnetic noise penetration is prevented by metal casing. Shielding also eliminates crosstalk .

It has same attenuation as unshielded twisted pair. It is faster the unshielded and coaxial cable. It is more expensive than coaxial and unshielded twisted pair.

Advantages

- Easy to install
- Performance is adequate
- Can be used for Analog or Digital transmission
- Increases the signalling rate
- Higher capacity than unshielded twisted pair
- Eliminates crosstalk

Disadvantages

- Difficult to manufacture
- Heavy

Applications

- In telephone lines to provide voice and data channels. The DSL lines that are used by the telephone companies to provide high-data-rate connections also use the high-bandwidth capability of unshielded twisted-pair cables.
- Local Area Network, such as 10Base-T and 100Base-T, also use twisted-pair cables.

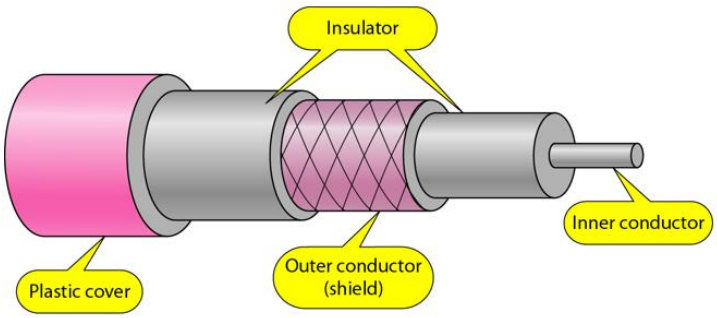
Coaxial Cable

Coaxial is called by this name because it contains two conductors that are parallel to each other. Copper is used in this as centre conductor which can be a solid wire or a standard one. It is surrounded by PVC installation, a sheath which is encased in an outer conductor of metal foil, barid or both.

Outer metallic wrapping is used as a shield against noise and as the second conductor which completes the circuit. The outer conductor is also encased in an insulating sheath. The outermost part is the plastic cover which protects the whole cable.

Here the most common coaxial standards.

- 50-Ohm RG-7 or RG-11 : used with thick Ethernet.
- 50-Ohm RG-58 : used with thin Ethernet
- 75-Ohm RG-59 : used with cable television
- 93-Ohm RG-62 : used with ARCNET.



There are two types of Coaxial cables :

Thicknet:

0.38 inch in diameter

Also called 10b5 cable, wgich means speed 10 and signal can be strong upto 500m.

Thinnet

0.25 inch in diameter

Similar to the material commonly used in cable TV

Also called 10b2 cable, means 10 mbps and can carry upto 200m before being weak.

Advantages

- Bandwidth is high
- Used in long distance telephone lines.
- Transmits digital signals at a very high rate of 10Mbps.
- Much higher noise immunity
- Data transmission without distortion.
- The can span to longer distance at higher speeds as they have better shielding when compared to twisted pair cable

Disadvantages

- Single cable failure can fail the entire network.
- Difficult to install and expensive when compared with twisted pair.
- If the shield is imperfect, it can lead to grounded loop.

Applications

- Coaxial cable was widely used in analog telephone networks, where a single coaxial network could carry 10,000 voice signals.

- Cable TV networks also use coaxial cables. In the traditional cable TV network, the entire network used coaxial cable. Cable TV uses RG-59 coaxial cable.
- In traditional Ethernet LANs. Because of it high bandwidth, and consequence high data rate, coaxial cable was chosen for digital transmission in early Ethernet LANs. The 10Base-2, or Thin Ethernet, uses RG-58 coaxial cable with BNC connectors to transmit data at 10Mbps with a range of 185 m.

Fiber Optic Cable

These are similar to coaxial cable. It uses electric signals to transmit data. At the centre is the glass core through which light propagates.

In multimode fibres, the core is 50microns, and In single mode fibres, the thickness is 8 to 10 microns.

The core in fiber optic cable is surrounded by glass cladding with lower index of refraction as compared to core to keep all the light in core. This is covered with a thin plastic jacket to protect the cladding. The fibers are grouped together in bundles protected by an outer shield.

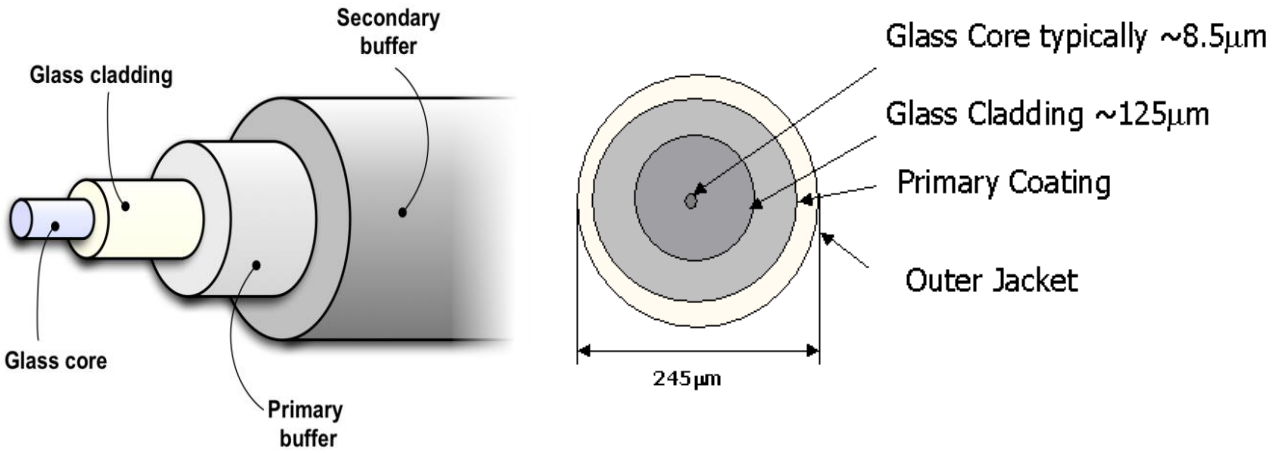
Fiber optic cable has bandwidth more than **2 gbps (Gigabytes per Second)**

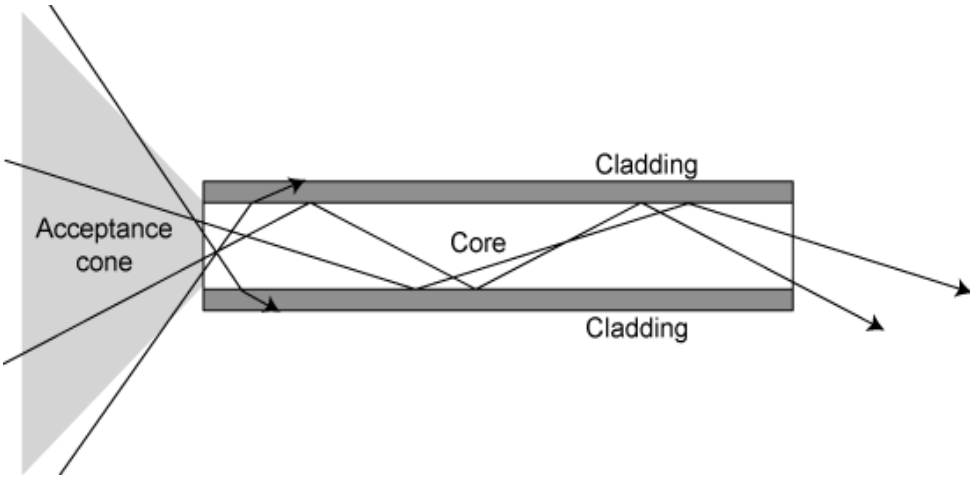
Advantages :

- Provides high quality transmission of signals at very high speed.
- These are not affected by electromagnetic interference, so noise and distortion is very less.
- Used for both analog and digital signals.

Disadvantages :

- It is expensive
- Difficult to install.
- Maintenance is expensive and difficult.
- Do not allow complete routing of light signals.



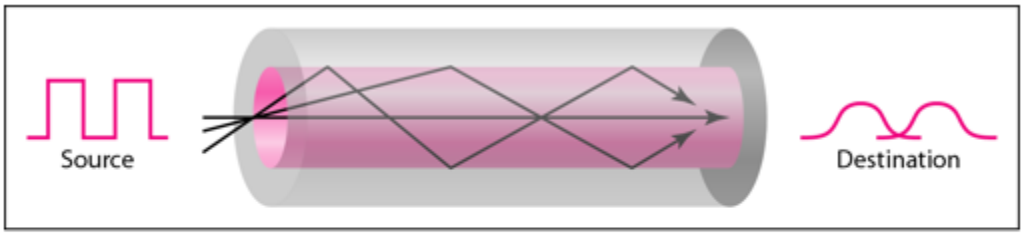


Propagation Modes

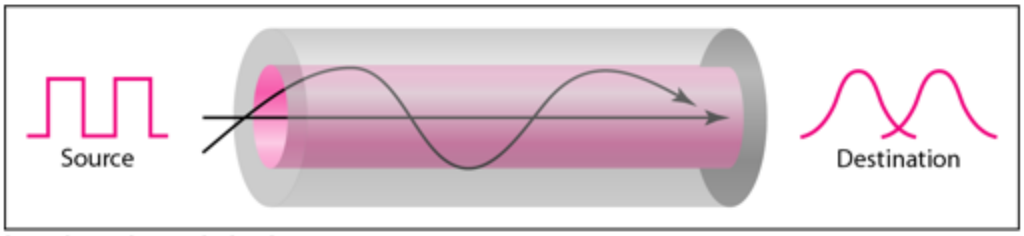
Current technology supports two modes(**Multimode** and **Single mode**) for propagating light along optical channels, each requiring fibre with different physical characteristics

Multimode

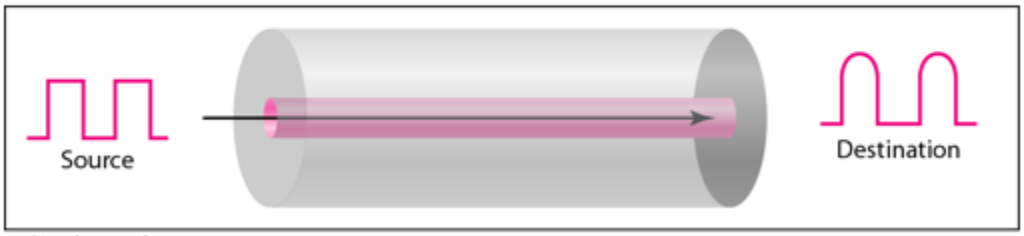
Multimode is so named because multiple beams from a light source move through the core in different paths. How these beams move within the cable depends on the structure of the core as shown in the below figure.



a. Multimode, step index



b. Multimode, graded index



c. Single mode

Single Mode

Single mode uses step-index fibre and a highly focused source of light that limits beams to a small range of angles, all close to the horizontal. The single-mode fibre itself is manufactured with a much smaller diameter than that of multimode fibre, and with substantially lower density. The decrease in density results in a critical angle that is close enough to 90 degree to make the propagation of beams almost horizontal.

Applications

- Often found in backbone networks because its wide bandwidth is cost-effective.
- Some cable TV companies use a combination of optical fibre and coaxial cable thus creating a hybrid network.
- Local-area Networks such as 100Base-FX network and 1000Base-X also use fibre-optic cable.

UnBounded/UnGuided Transmission Media

Unguided medium transport electromagnetic waves without using a physical conductor. This type of communication is often referred to as wireless communication. Signals are normally broadcast through free space and thus are available to anyone who has a device capable of receiving them.

We can divide wireless transmission into three broad groups:

1. Radio waves
2. Micro waves
3. Satellite

Radio Waves

Electromagnetic waves ranging in frequencies between 3 KHz and 1 GHz are normally called radio waves.

Radio waves are omnidirectional. When an antenna transmits radio waves, they are propagated in all directions. This means that the sending and receiving antennas do not have to be aligned. A sending antenna send waves that can be received by any receiving antenna. The omnidirectional property has disadvantage, too. The radio waves transmitted by one antenna are susceptible to interference by another antenna that may send signal suing the same frequency or band.

Radio waves, particularly with those of low and medium frequencies, can penetrate walls. This characteristic can be both an advantage and a disadvantage. It is an advantage because, an AM radio can receive signals inside a building. It is a disadvantage because we cannot isolate a communication to just inside or outside a building.

Omnidirectional Antenna

Radio waves use omnidirectional antennas that send out signals in all directions.

Applications

- The omnidirectional characteristics of radio waves make them useful for multicasting in which there is one sender but many receivers.
- AM and FM radio, television, maritime radio, cordless phones, and paging are examples of multicasting.

Micro Waves

Electromagnetic waves having frequencies between 1 and 300 GHz are called micro waves. Micro waves are unidirectional. When an antenna transmits microwaves, they can be narrowly focused. This means that the sending and receiving antennas need to be aligned. The unidirectional property has an obvious advantage. A pair of antennas can be aligned without interfering with another pair of aligned antennas.

The following describes some characteristics of microwaves propagation:

- Microwave propagation is line-of-sight. Since the towers with the mounted antennas need to be in direct sight of each other, towers that are far apart need to be very tall.
- Very high-frequency microwaves cannot penetrate walls. This characteristic can be a disadvantage if receivers are inside the buildings.
- The microwave band is relatively wide, almost 299 GHz. Therefore, wider sub-bands can be assigned and a high date rate is possible.
- Use of certain portions of the band requires permission from authorities.

Unidirectional Antenna

Microwaves need unidirectional antennas that send out signals in one direction. Two types of antennas are used for microwave communications: **Parabolic Dish** and **Horn**.

Applications

Microwaves, due to their unidirectional properties, are very useful when unicast(one-to-one) communication is needed between the sender and the receiver. They are used in cellular phones, satellite networks and wireless LANs.

There are 2 types of Microwave Transmission :

1. Terrestrial Microwave
2. Satellite Microwave

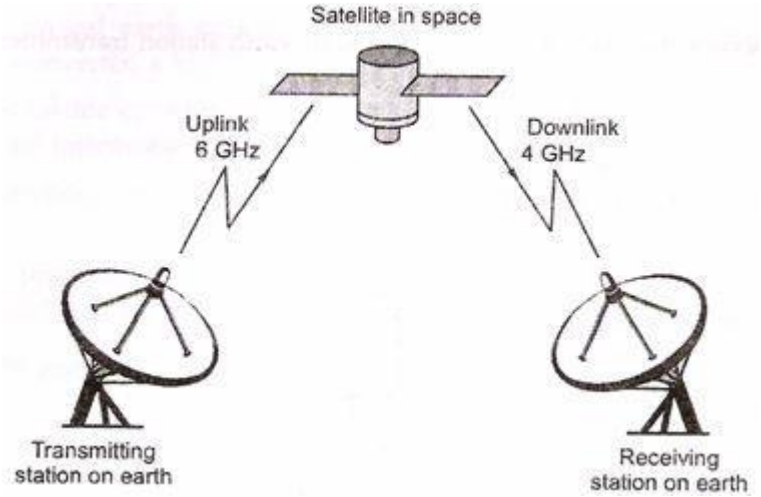
Advantages of Microwave Transmission

- Used for long distance telephone communication

- Carries 1000's of voice channels at the same time

Disadvantages of Microwave Transmission

- It is Very costly
  - The concept of satellite based networks is to transmit and receive signals from ground stations. The purpose of satellite communication is to use it for video transmission and sharing. In simple words a satellite is a device which revolves around the earth either for collecting useful information or for helping transfer of information.



  - LEO os called Low earth orbit, MEO is called Medium Earth Orbit and GEO is called Geostationary orbit. LEO are about 500 Km to 1500 Km above the earth, so the delay is very small and the losses is small too. MEO are installed at 5000 to 12000 km above the earth and generally used for navigation communications like GPS. GEO is about 35800 Km above the equator, the delay and losses are greater, but the advantages is more coverage (it covers 40% of the earth) and there no need to track the satellite, so the earth terminal is cheaper.

- ***Geo-Stationary Earth Orbit***
- These satellites have almost a distance of 36,000 km to the earth.
- E.g. All radio and TV, whether satellite etc, are launched in this orbit.
- **Advantages of Geo-Stationary Earth Orbit**
- 1.It is possible to cover almost all parts of the earth with just 3 geo satellites.

- 2.Antennas need not be adjusted every now and then but can be fixed permanently.
- 3.The life-time of a GEO satellite is quite high usually around 15 years.

- **Disadvantages of Geo-Stationary Earth Orbit**
- 1. Larger antennas are required for northern/southern regions of the earth.
- 2. High buildings in a city limit the transmission quality.
- 3. High transmission power is required.
- 4. These satellites cannot be used for small mobile phones.
- 5. Fixing a satellite at Geo stationary orbit is very expensive.
-

- ***Medium Earth Orbit***
- Satellite at different orbits operates at different heights. The MEO satellite operates at about 5000 to 12000 km away from the earth's surface.
- These orbits have moderate number of satellites.

- **Advantages of Medium Earth Orbit**
- 1. Compared to LEO system, MEO requires only a dozen satellites.
- 2 Simple in design.
- 3. Requires very few handovers.

- **Disadvantages of Medium Earth Orbit**
- 1. Satellites require higher transmission power.
- 2.Special antennas are required.

- ***Low Earth Orbit***
- LEO satellites operate at a distance of about 500-1500 km.

- **Advantages of Low Earth Orbit**
- 1.The antennas can have low transmission power of about 1 watt.
- 2.The delay of packets is relatively low.
- 3. Useful for smaller foot prints.

- **Disadvantages of Low Earth Orbit**
- 1 If global coverage is required, it requires at least 50-200 satellites in this orbit.
- 2. Special handover mechanisms are required.

- 3. These satellites involve complex design.
- 4.Very short life: Time of 5-8 years. Assuming 48 satellites with a life-time of 8 years each, a new satellite is needed every 2 months.
- 5. Data packets should be routed from satellite to satellite.

Advantages of Satellite Microwave :

- Transmitting station can receive back its own transmission and check whether the satellite has transmitted information correctly.
- A single microwave relay station which is visible from any point.

ISPS AND INTERNET BACKBONES

An Internet backbone refers to one of the principal data routes between large, strategically interconnected networks and core routers on the Internet. An Internet backbone is a very high-speed data transmission line that provides networking facilities to relatively small but high-speed Internet service providers all around the world.

Internet backbones are the largest data connections on the Internet. They require high-speed bandwidth connections and high-performance servers/routers. Backbone networks are primarily owned by commercial, educational, government and military entities because they provide a consistent way for Internet service providers (ISPs) to keep and maintain online information in a secure manner.

We saw earlier that end systems (user PCs, PDAs, Web servers, mail servers, and so on) connect into the Internet via an access network. Recall that the access network may be a wired or wireless local area network (for example, in a company, school, or library) or may be a residential ISP (for example, AOL or MSN) that is reached via dial-up modem, cable modem, or DSL. But connecting end users and content providers into access networks is only a small piece of solving the puzzle of connecting the hundreds of millions of users and hundreds of thousands of networks that make up the Internet. The Internet is a network of networks—understanding this phrase is the key to solving this puzzle.

In the public Internet, access networks situated at the edge of the Internet are connected to the rest of the Internet through a tiered hierarchy of ISPs, as shown in Figure 1.12 (Figure 1.12 Interconnection of ISPs). Access ISPs (for example, residential ISPs such as AOL, and company ISPs using LANs) are at the bottom of this hierarchy. At the very top of the hierarchy is a

relatively small number of so-called tier-1 ISPs. In many ways, a tier-1 ISP is the same as any network—it has links and routers and is connected to other networks. In other ways, however, tier-1 ISPs are special. Their link speeds are often 622 Mbps or higher, with the larger tier-1 ISPs having links in the 2.5 to 10 Gbps range; their routers must consequently be able to forward packets at extremely high rates. Tier-1 ISPs are also characterized by being:

- Directly connected to each of the other tier-1 ISPs
- Connected to a large number of tier-2 ISPs and other customer networks
- International in coverage

Tier-1 ISPs are also known as Internet backbone networks. These include Sprint, MCI (previously UUNet/WorldCom), AT&T, Level3 (which acquired Genuity), Qwest, and Cable & Wireless. In mid-2002, WorldCom was by far the largest tier-1 ISP—more than twice as big as its nearest rival according to several measures of size [Teleography 2002]. Interestingly, no group officially sanctions tier-1 status; as the saying goes—if you have to ask if you are a member of a group, you're probably not.

A tier-2 ISP typically has regional or national coverage, and (importantly) connects to only a few of the tier-1 ISPs . Thus, in order to reach a large portion of the global Internet, a tier-2 ISP needs to route traffic through one of the tier-1 ISPs to which it is connected. A tier-2 ISP is said to be a customer of the tier-1 ISPs to which it is connected, and the tier-1 ISP is said to be a provider to its customer. Many large companies and institutions connect their enterprise's network directly into a tier-1 or tier-2 ISP, thus becoming a customer of that ISP. A provider ISP charges its customer ISP a fee, which typically depends on the transmission rate of the link connecting the two. A tier-2 network may also choose to connect directly to other tier-2 networks, in which case traffic can flow between the two tier-2 networks without having to pass through a tier-1 network. Below the tier-2 ISPs are the lower-tier ISPs, which connect to the larger Internet via one or more tier-2 ISPs. At the bottom of the hierarchy are the access ISPs. Further complicating matters, some tier-1 providers are also tier-2 providers (that is, vertically integrated), selling Internet access directly to end users and content providers, as well as to lower-tier ISPs. When two ISPs are directly connected to each other, they are said to peer with each other. An interesting study [Subramanian 2002] seeks to define the Internet's tiered structure more precisely by studying the Internet's topology in terms of customer-provider and peer-peer relationships.

Within an ISP's network, the points at which the ISP connect to other ISPs (whether below, above, or at the same level in the hierarchy) are known as Points of Presence (POPs). A POP is simply a group of one or more routers in the ISP's network at which routers in other ISPs or in the networks belonging to the ISP's customers can connect. A tier-1 provider typically has many

POPs scattered across different geographical locations in its network, with multiple customer networks and other ISPs connecting into each POP. For a customer network to connect to a provider's POP, the customer typically leases a high-speed link from a third-party telecommunications provider and directly connects one of its routers to a router at the provider's POP. Two tier-1 ISPs can also peer with each other by connecting together a pair of POPs, one from each of the two ISPs. Furthermore, two ISPs may have multiple peering points connecting with each other at two or more pairs of POPs.

In summary, the topology of the Internet is complex, consisting of dozens of tier-1 and tier-2 ISPs and thousands of lower-tier ISPs. The ISPs are diverse in their coverage, with some spanning multiple continents and oceans, and others limited to narrow regions of the world. The lower-tier ISPs connect to the higher-tier ISPs, and the higher-tier ISPs interconnect at (typically) private peering points and NAPs. Users and content providers are customers of lower-tier ISPs, and lower-tier ISPs are customers of higher-tier ISPs.