What is a network?

A network is a **set of devices** (often referred to as *nodes)* **connected by communication links**. A node can be a computer, printer, or any other device capable of sending and/or receiving data generated by other nodes on the network.

Distributed Processing

Most networks use distributed processing, in which a **task is divided among multiple computers**. Instead of one single large machine being responsible for all aspects of a process, separate computers (usually a personal computer or workstation) handle a job.

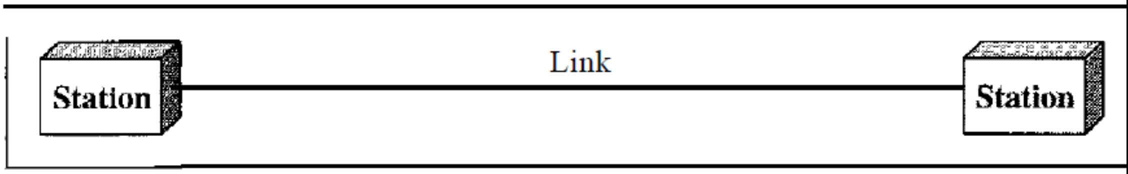
Network Critaria

A network must be able to meet a certain number of criteria.

- **Performance**: Performance can be measured in many ways, including transit time and response time. Transit time is the amount of time required for a message to travel from one device to another. Response time is the elapsed time between an inquiry and a response. The performance of a network depends on a number of factors, including the number of users, the type of transmission medium, the capabilities of the connected hardware, and the efficiency of the software. Performance is often evaluated by two networking metrics: throughput and delay. We often need more throughput and less delay. However, these two criteria are often contradictory. If we try to send more data to the network, we may increase throughput but we increase the delay because of traffic congestion in the network.(**network throughput** is the average rate of *successful* message delivery over a communication channel)
- **Reliability**: In addition to accuracy of delivery, network reliability is measured by the frequency of failure, the time it takes a link to recover from a failure, and the network's robustness in a catastrophe.
- **Security**: Network security issues include protecting data from unauthorized access, protecting data from damage and development, and implementing policies and procedures for recovery from breaches and data losses.

Type of Connection:

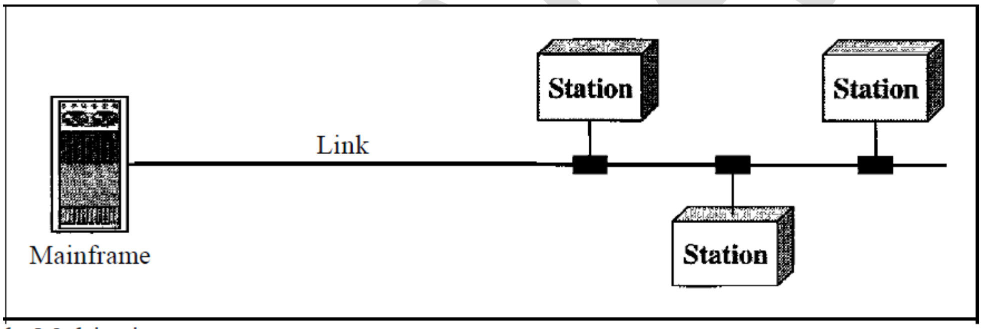
- **Point to point:**



a. Point-to-point

A point-to-point connection provides a **dedicated link between two devices**. The entire link is reserved for transmission between those two devices. Most point-to-point connections use an actual length of wire or cable to connect the two ends, but other options, such as microwave or satellite links, are also possible. When you change television channels by infrared remote control, you are establishing a point-to-point connection between the remote control and the television's control system.

- **Multipoint:**



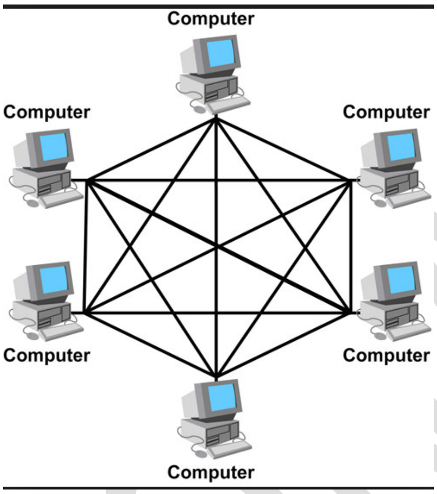
b. Multipoint

A multipoint (also called multidrop) connection is one in which **more than two specific devices share a single link** (see Figure). In a multipoint environment, the capacity of the channel is shared, either spatially or temporally. If several devices can use the link simultaneously, it is a *spatially shared* connection. If users must take turns, it is a *timeshared* connection.

Network Topology

Definition: The way in which a network is laid out physically, its a graphical representation.

Mesh Topology:



- Dedicated Point to Point link(connection) between devices
- Each node is connected to every node
- n(n-1)/2 = no of cables to connect
- n-1 = no of ports per device
- Advantages
  - Dedicated link so data is carried on separate line, eliminates traffic prob
  - Robust, one breakdown does not break the whole network
  - Security, as data travels on specific lines
  - Fault identification and fault isolation
- **Disadvantages**
  - Expensive
  - Difficult to implement
  - Complicated design
- Implemented as a backbone to connect key computers

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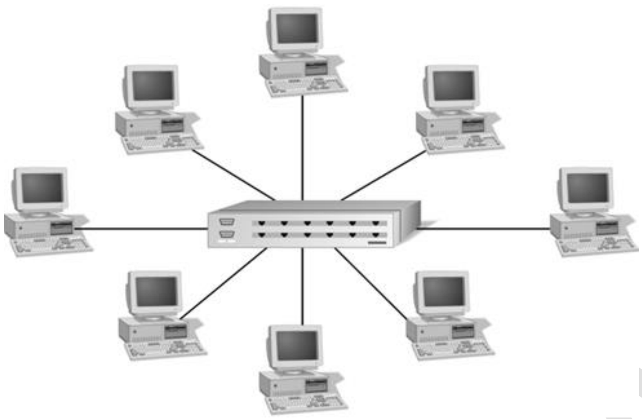
Star Topology

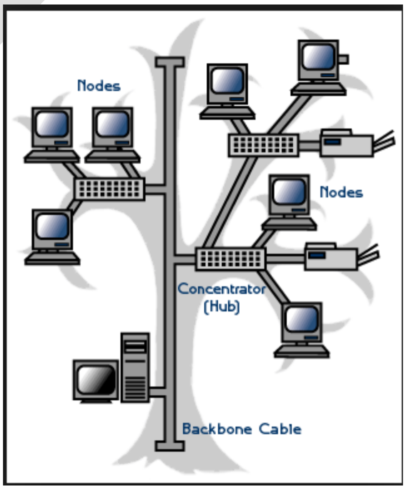
- Every node on the network is connected through a central device



  - Any single cable connects only two devices
  - Cabling problems affect two nodes at most
  - Requires more cabling than ring or bus networks
  - More fault-tolerant
  - Easily moved, isolated, or interconnected with other networks
  - Scalable
  - Supports max of 1024 addressable nodes on logical network
  - Less Expensive
  - Easy to Install
  - Most popular - Wide variety of equipment available

Tree Topology

Tree Topology is a variation of Star.



- A tree topology includes multiple star topologies, which involve a variety of single nodes connected to a central node. Central hub is connected to secondary hub

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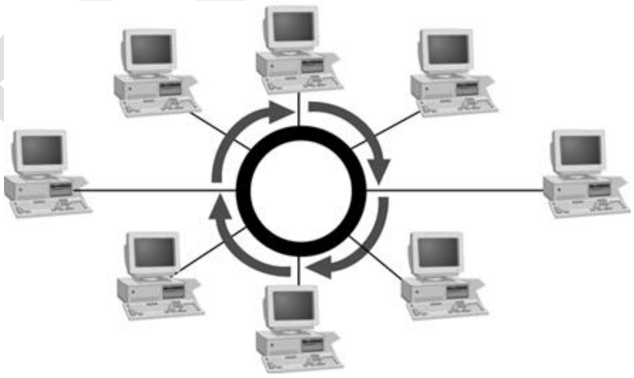
- Secondary hub contains repeater feature
- Advantages
    - can connect more nodes
    - can increase the distance signal can travel
- Cable TV network is a god example

Bus Topology

- Single cable connects all network nodes without intervening connectivity devices
- Devices share responsibility for getting data from one point to another
- Terminators stop signals after reaching end of wire prevent signal bounce
- Inexpensive, not very scalable
- Difficult to troubleshoot, not fault-tolerant
- Advantages
    - Works well for small networks
    - Relatively inexpensive to implement
    - Easy to add to it
- Disadvantages
    - Congestion in network

Ring Topology



- Each node is connected to the two nearest nodes so the entire network forms a circle.
- One method for passing data on ring networks is **token passing**
- Each workstation transmits data, every device contains repeater, which passes data for another devices by regenerating the bits
- Advantages
    - Easy to install and reconfigure
    - making changes is easy
    - good fault isolation
    - Well-suited for transmitting signals over long distances on a LAN

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    - Handles high-volume network traffic
    - Enables reliable communication
- Disadvantages
    - Expensive
    - Requires more cable and network equipment at the start
    - Not used as widely as bus topology
    - Fewer equipment options
    - Fewer options for expansion to high-speed communication

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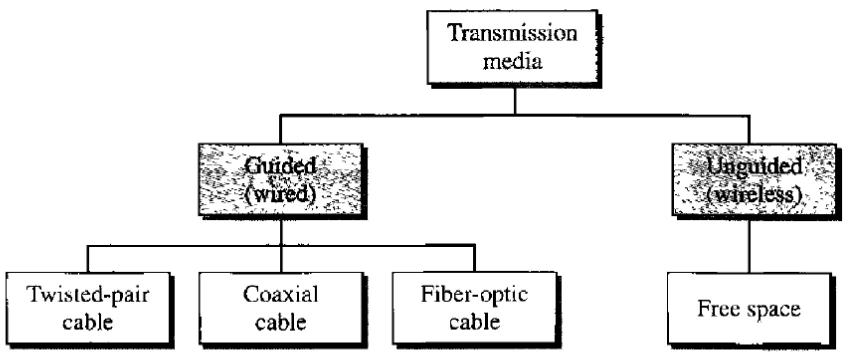
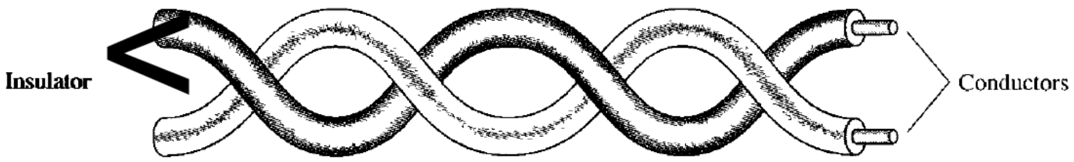
TYPES OF CHANNELS OR TRANSMISSION MEDIUM

- A transmission **medium** can be broadly defined as anything that can carry information from a source to a destination.
- The transmission medium is usually free space, metallic cable, or fiber-optic cable.
- The information is usually a signal that is the result of a conversion of data from another form.
- The use of long-distance communication using electric signals started with the invention of the telegraph by Morse in the 19th century.
- Extending the range of the human voice became possible when the telephone was invented in 1869.
- Wireless communication started in 1895 when Hertz was able to send highfrequency signals. Later, Marconi devised a method to send telegraph-type messages over the Atlantic Ocean.

Classes of transmission media



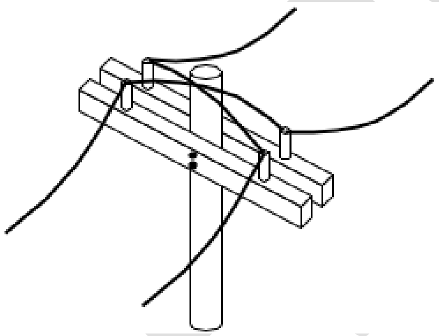
1. Twisted Pair



Twisted pair cabling is a type of wiring in which two conductors of a single circuit are twisted together for the purposes of canceling out electromagnetic interference (EMI) from external sources; for instance, electromagnetic radiation from unshielded twisted pair (UTP) cables, and crosstalk between neighboring pairs. It was invented by Alexander Graham Bell.

Electromagnetic interference is disturbance that affects an electrical circuit due to either electromagnetic induction or electromagnetic radiation emitted from an external source.

History



Wire transposition on top of pole

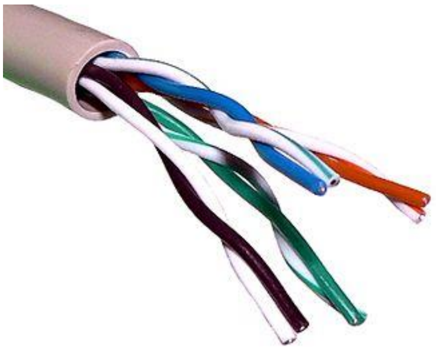
The earliest telephones used telegraph lines, or open-wire single-wire earth return circuits. In the 1880s electric trams were installed in many cities, which induced noise into these circuits. Lawsuits being unavailing, the telephone companies converted to balanced circuits, which had the incidental benefit of reducing attenuation, hence increasing range.

As electrical power distribution became more commonplace, this measure proved inadequate. Two wires, strung on either side of cross bars on utility poles, shared the route with electrical power lines. Within a few years, the growing use of electricity again brought an increase of interference, so engineers devised a method called wire transposition, to cancel out the interference.

In wire transposition, the wires exchange position once every several poles. In this way, the two wires would receive similar EMI from power lines. This represented an early implementation of twisting, with a twist rate of about four twists per kilometer, or six per mile. Such open-wire balanced lines with periodic transpositions still survive today in some rural areas.

Twisted pair cables were invented by Alexander Graham Bell in 1881. By 1900, the entire American telephone line network was either twisted pair or open wire with transposition to guard against interference. Today, most of the millions of kilometres of twisted pairs in the world are outdoor landlines, owned by telephone companies, used for voice service, and only handled or even seen by telephone workers.

Unshielded twisted pair (UTP)



Unshielded twisted pair cable with different twist rates

UTP cables are found in many Ethernet networks and telephone systems. For indoor telephone applications, UTP is often grouped into sets of 25 pairs according to a standard 25-pair color code originally developed by AT&T Corporation. A typical subset of these colors (white/blue, blue/white, white/orange, orange/white) shows up in most UTP cables. The cables are typically made with copper wires with the colored insulation typically made from an insulator such as polyurethane and the total package covered in a polyurethane jacket.

For urban outdoor telephone cables containing hundreds or thousands of pairs, the cable is divided into smaller but identical bundles. Each bundle consists of twisted pairs that have different twist rates. The bundles are in turn twisted

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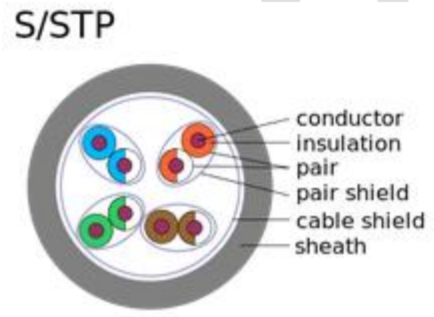
together to make up the cable. Pairs having the same twist rate within the cable can still experience some degree of crosstalk. Wire pairs are selected carefully to minimize crosstalk within a large cable.

UTP cable is also the most common cable used in computer networking. Modern Ethernet, the most common data networking standard, can use UTP cables. Twisted pair cabling is often used in data networks for short and medium length connections because of its relatively lower costs compared to optical fiber and coaxial cable.

UTP is also finding increasing use in video applications, primarily in security cameras.

Cable shielding

S/UTP cable format



S/STP cable format

Twisted pair cables are often shielded in an attempt to prevent electromagnetic interference. Because the shielding is made of metal, it may also serve as a ground. Usually a shielded or a screened twisted pair cable has a special grounding wire added called a drain wire which is electrically connected to the shield or screen. The drain wire simplifies connection to ground at the connectors.

This shielding can be applied to individual pairs, or to the collection of pairs. When shielding is applied to the collection of pairs, this is referred to as screening. Shielding provides an electric conductive barrier to attenuate electromagnetic waves external to the shield and provides conduction path by which induced currents can be circulated and returned to the source, via ground reference connection.

S/STP cable is both individually shielded and also has an outer metal shielding covering the entire group of shielded copper pairs.

This type of cabling offers the best protection from interference from external sources and also eliminates.

Advantages

- It is a thin, flexible cable that is easy to string between walls.
- More lines can be run through the same wiring ducts.
- Electrical noise going into or coming from the cable can be prevented.
- Cross-talk is minimized.

Disadvantages

- Twisted pair's susceptibility to electromagnetic interference greatly depends on the pair twisting schemes (usually patented by the manufacturers) staying intact during the installation. As a result, twisted pair cables usually have stringent requirements for maximum pulling tension as well as minimum bend radius. This relative fragility of twisted pair cables makes the installation practices an important part of ensuring the cable's performance.
- In video applications that send information across multiple parallel signal wires, twisted pair cabling can introduce signaling delays known as skew which results in subtle color defects and ghosting due to the image components not aligning correctly when recombined in the display device.

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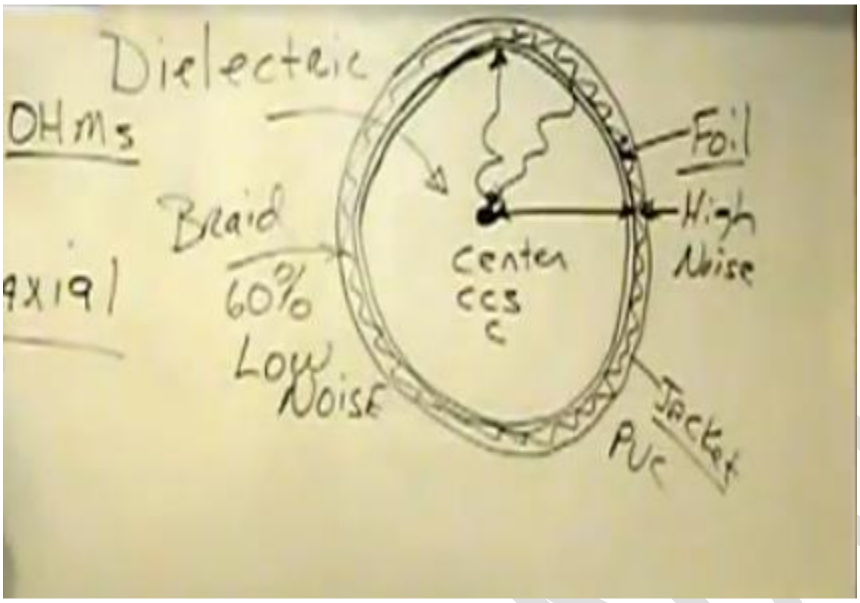
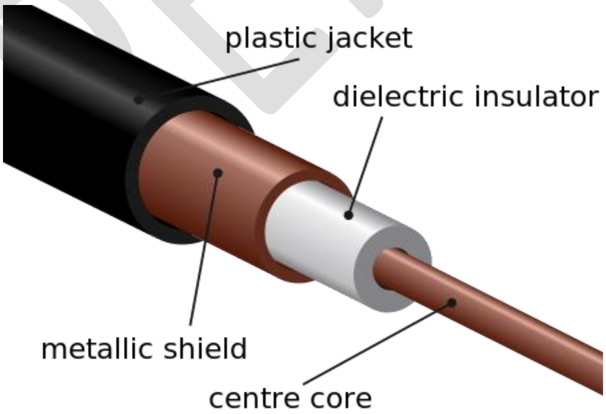
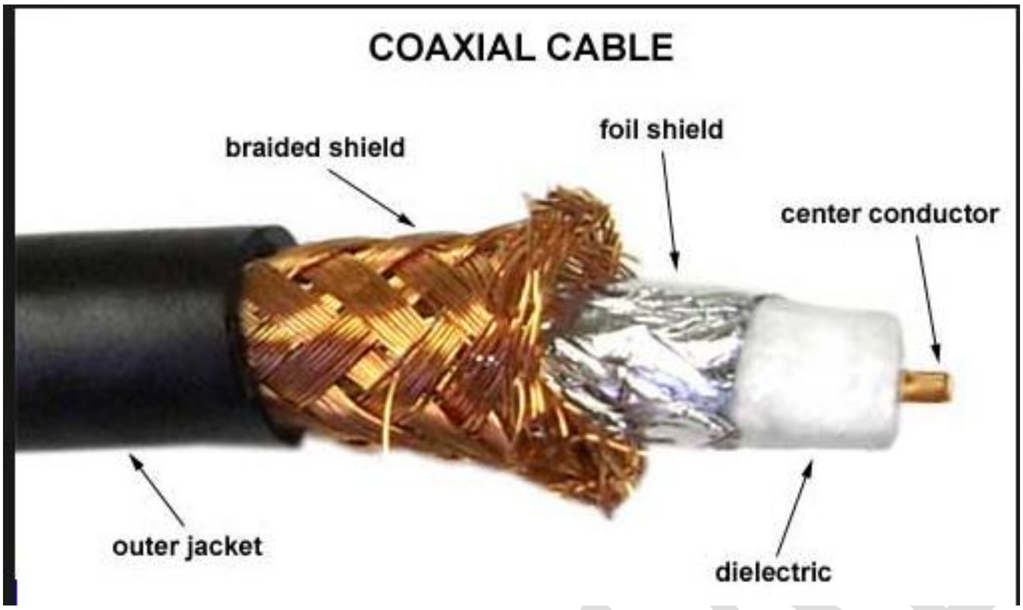
2. Coaxial cable (coax)



It is a type of cable that has an **inner conductor** surrounded by a tubular **insulating layer**, surrounded by a tubular **conducting shield**. Many coaxial cables also have an insulating outer sheath or jacket. The term coaxial comes from the inner conductor and the outer shield sharing a geometric axis. Coaxial cable was invented by English engineer and mathematician Oliver Heaviside, who patented the design in 1880. Coaxial cable differs from other shielded cable used for carrying lower-frequency signals, such as audio signals, in that the dimensions of the cable are controlled to give a precise, constant conductor spacing, which is needed for it to function efficiently as a radio frequency transmission line.



Coaxial cable cut-away



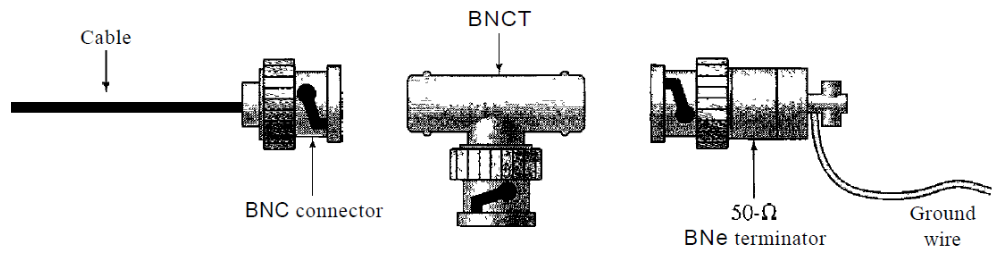
- Coaxial cable conducts electrical signal using an inner conductor (usually a solid copper, stranded copper or copper plated steel wire)
- The wire is typically surrounded by an insulating layer and all enclosed by a shield, typically one to four layers of woven metallic braid and metallic tape.
- The cable is protected by an outer insulating jacket.
- The shield is kept at ground potential and a voltage is applied to the center conductor to carry electrical signals.
- The advantage of coaxial design is that electric and magnetic fields are confined to the dielectric with little leakage outside the shield.
- Electric and magnetic fields outside the cable are largely kept from causing interference to signals inside the cable.
- Larger diameter cables and cables with multiple shields have less leakage.
- This property makes coaxial cable a good choice for carrying weak signals that cannot tolerate interference from the environment or for higher electrical signals that must not be allowed to radiate or couple into adjacent structures or circuits.

Applications

- Common applications of coaxial cable include
  - video and CATV distribution
  - RF and microwave transmission
  - computer and instrumentation data connections.

Connectors

- The ends of coaxial cables usually terminate with connectors.



- Coaxial connectors are designed to maintain a coaxial form across the connection and have the same impedance (measure of the opposition that a circuit presents to a current when a voltage is applied.) as the attached cable.

- Connectors are usually plated with high-conductivity metals such as silver or tarnish-resistant gold.
- To connect coaxial cable to devices, we need coaxial connectors.
- The most common type of connector used today is the Bayone-Neill-Concelman (BNe) connector.
- The three popular types of these connectors:
  - BNC connector: used to connect the end of the cable to a device
  - BNC T connector: used in Ethernet networks to branch out to a connection to a computer or other device.
  - BNC terminator. used at the end of the cable to prevent the reflection of the signal

.Problems

- Signal Leakage: Signal leakage can be severe if there is poor contact at the interface to connectors at either end of the cable or if there is a break in the shield.
- Ground Loop: A **ground loop** usually refers to a current, almost always unwanted, in a conductor connecting two points that are supposed to be at the same potential, but are actually at different

potentials. Ground loops created by improperly designed or improperly installed equipment are a major cause of noise and interference in audio and video systems.

Categories of coaxial cables

Category	*Impedance*	*Use*
RG-59	75 Ω	Cable TV
RG-58	50 Ω	Thin Ethernet
RG-11	50 Ω	Thick Ethernet

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3. Optical Fiber

An optical fiber cable

An **optical fiber** is a flexible, transparent fiber **made of high quality extruded glass (silica) or plastic**, slightly thicker than a human hair. It can function as a waveguide, or “light pipe”, to transmit light between the two ends of the fiber.

Field of study and design is called Fiber Optics. **Fibers are used instead of metal wires because signals travel along them with less loss and are also immune to electromagnetic interference.**

Optical fibers typically include a transparent core surrounded by a transparent cladding material with a lower index of refraction. Light is kept in the core by total internal reflection. This causes the fiber to act as a waveguide.

Fibers that support many propagation paths or transverse modes are calledFor short distance application, such as a network in an office building, fiber-optic cabling can save space in cable ducts. This is because a single fiber can carry much more data than electrical cables such as standard category 5 Ethernet cabling, which typically runs at 100 Mbit/s or 1 Gbit/s speeds. multi-mode fibers (MMF), while those that only support a single mode are called single-mode fibers (SMF).

Multi-mode fibers generally have a wider core diameter, and are used for short-distance communication links and for applications where high power must be transmitted. Single-mode fibers are used for most communication links longer than 1,000 meters (3,300 ft).

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Application

Optical fiber can be used as a medium for telecommunication and computer networking because it is flexible and can be bundled as cables. It is especially advantageous for long-distance communications, because light propagates through the fiber with little attenuation compared to electrical cables. This allows long distances to be spanned with few repeaters.

The per-channel light signals propagating in the fiber have been modulated at rates as high as 111 gigabits per second (GBPS) by NTT, although 10 or 40 Gbit/s is typical in deployed systems. In June 2013, researchers demonstrated transmission of 400 GBPS.

For short distance application, such as a network in an office building, fiber-optic cabling can save space in cable ducts. This is because a single fiber can carry much more data than electrical cables such as standard category 5 Ethernet cabling, which typically runs at 100 Mbit/s or 1 Gbit/s speeds.

Fiber is also immune to electrical interference; there is no cross-talk between signals in different cables, and no pickup of environmental noise.

Wiretapping (in this case, fiber tapping) is more difficult compared to electrical connections, and there are concentric dual core fibers that are said to be tap-proof.

Advantages of Optical Fiber over Conventional Copper System

1. **Broad Bandwidth**
Broadband communication is very much possible over fiber optics which means that audio signal, video signal, microwave signal, text and data from computers can be modulated over light carrier wave and demodulated by optical receiver at the other end. It is possible to transmit around 3,000,000 full-duplex voice or 90,000 TV channels over one optical fiber.

2. **Immunity to Electromagnetic Interference**
Optical fiber cables carry the information over light waves which travel in the fibers due to the properties of the fiber materials, similar to the light traveling in free space. The light waves (one form of electromagnetic radiation) are unaffected by other electromagnetic

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radiation nearby. The optical fiber is electrically non-conductive, so it does not act as an antenna to pick up electromagnetic signals which may be present nearby. So the information traveling inside the optical fiber cables is immune to electromagnetic interference eg. radio transmitters, power cables adjacent to the fiber cables, or even electromagnetic pulses generated by nuclear devices.

3. **Low attenuation loss over long distances**
There are various optical windows in the optical fiber cable at which the attenuation loss is found to be comparatively low and so transmitter and receiver devices are developed and used in these low attenuation region. Due to low attenuation of 0.2dB/km in optical fiber cables, it is possible to achieve long distance communication efficiently over information capacity rate of 1 Tbit/s.

4. **Electrical Insulator**
Optical fibers are made and drawn from silica glass which is nonconductor of electricity and so there are no ground loops and leakage of any type of current. Optical fibers are thus laid down along with high voltage cables on the electricity poles due to its electrical insulator behavior.

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Unguided Media

- Unguided media transport electromagnetic waves without using a physical conductor.
- Signals are normally broadcast through free space or air
- available to anyone who has a device capable of receiving them
- Unguided signals can travel from the source to destination in several ways:
    - ground propagation
    - sky propagation
    - line-of-sight propagation

- Ground propagation
    - Radio waves travel through the lowest portion of the atmosphere, hugging the earth.
    - These low-frequency signals emanate in all directions from the transmitting antenna and follow the curvature of the planet.
    - Distance depends on the amount of power in the signal: The greater the power, the greater the distance.

Ground propagation
(below 2 MHz)

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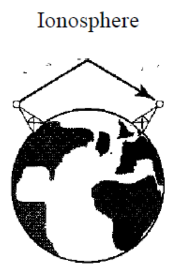
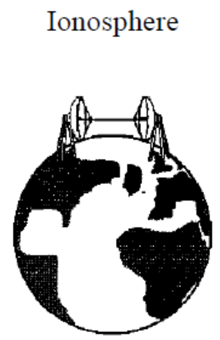
- Sky propagation
    - Higher-frequency radio waves radiate upward into the ionosphere (the layer of atmosphere where particles exist as ions) where they are reflected back to earth.
    - This type of transmission allows for greater distances with lower output power.



Sky propagation
(2-30 MHz)

- Line-of-sight propagation
    - Very high-frequency signals are transmitted in straight lines directly from antenna to antenna.
    - Antennas must be directional, facing each other and either tall enough or close enough together not to be affected by the curvature of the earth.

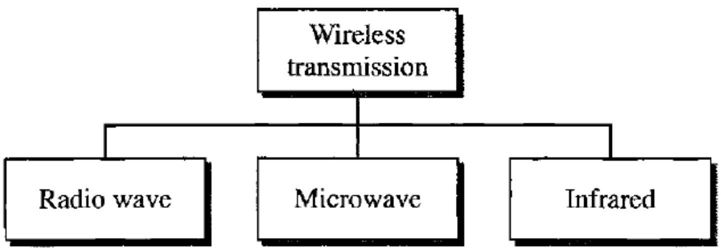


Line-af-sight propagation
(above 30 MHz)

The section of the **electromagnetic spectrum** defined as radio waves and microwaves is divided into eight ranges, called ***bands***, each regulated by government authorities. These bands are rated from *very low frequency* (VLF) to *extremely highfrequency* (EHF).

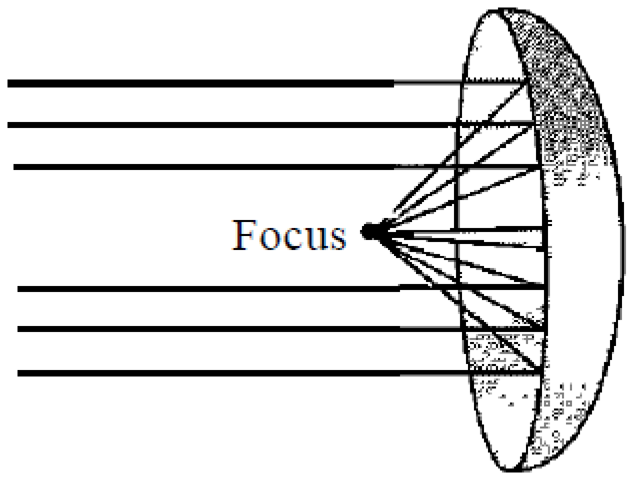
Band	*Range*	*Propagation*	*Application*
VLF (very low frequency)	3-30 kHz	Ground	Long-range radio navigation
LF (low frequency)	30-300 kHz	Ground	Radio beacons and navigational locators
MF (middle frequency)	300 kHz-3 MHz	Sky	AM radio
HF (high frequency)	3-30 MHz	Sky	Citizens band (CB), ship/aircraft communication
VHF (very high frequency)	30-300 MHz	Sky and line-of-sight	VHF TV, FM radio
UHF (ultrahigh frequency)	300 MHz-3 GHz	Line-of-sight	UHF TV, cellular phones, paging, satellite
SHF (superhigh frequency)	3-30 GHz	Line-of-sight	Satellite communication
EHF (extremely high frequency)	30-300 GHz	Line-of-sight	Radar, satellite

Wireless transmission waves



Microwave Communication System

- frequencies between 1 and 300 GHz
- unidirectional
- 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. The curvature of the earth as well as other blocking obstacles does not allow two short towers to communicate by using microwaves. Repeaters are often needed for long distance communication.
- Very high-frequency microwaves cannot penetrate walls. This characteristic can be a disadvantage if receivers are inside buildings.
- The microwave band is relatively wide, almost 299 GHz. Therefore wider sub bands can be assigned, and a high data rate is possible
- Use of certain portions of the band requires permission from authorities.
- Microwaves need unidirectional antennas that send out signals in one direction.
- Two types of antennas are used for microwave communications:
    - The parabolic dish- A parabolic dish antenna is based on the geometry of a parabola: Every line parallel to the line of symmetry (line of sight) reflects off the curve at angles such that all the lines intersect in a common point called the focus. The parabolic dish works as a funnel, catching a wide range of waves and directing them to a common point. In this way, more of the signal is recovered than would be possible with a single-point receiver.



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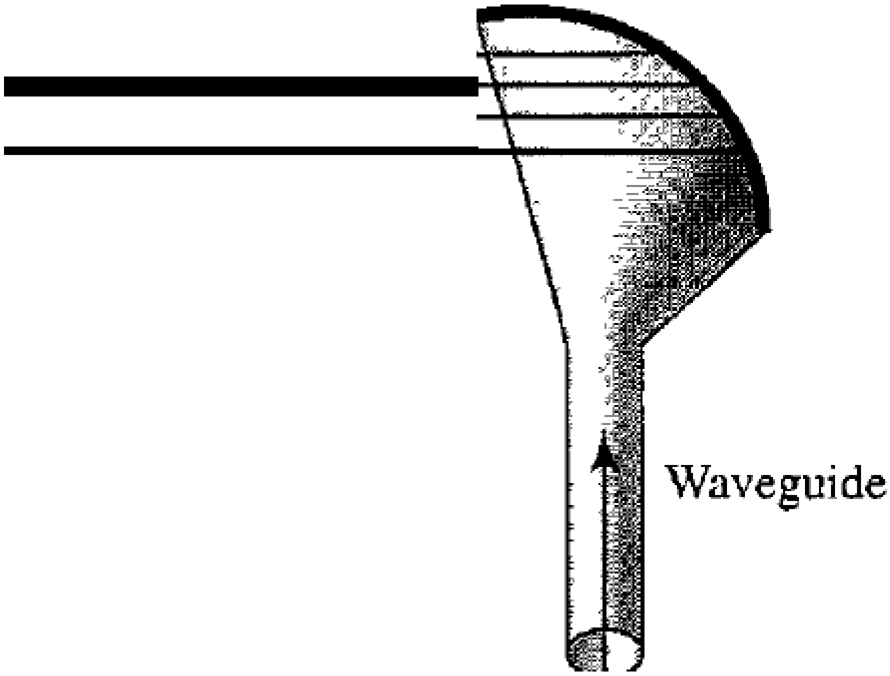
- The horn antenna- Outgoing transmissions are broadcast through a horn aimed at the dish. The microwaves hit the dish and are deflected outward in a reversal of the receipt path. A horn antenna looks like a gigantic scoop. Outgoing transmissions are broadcast up a stem (resembling a handle) and deflected outward in a series of narrow parallel beams by the curved head. Received transmissions are collected by the scooped shape of the horn, in a manner similar to the parabolic dish, and are deflected down into the stem.

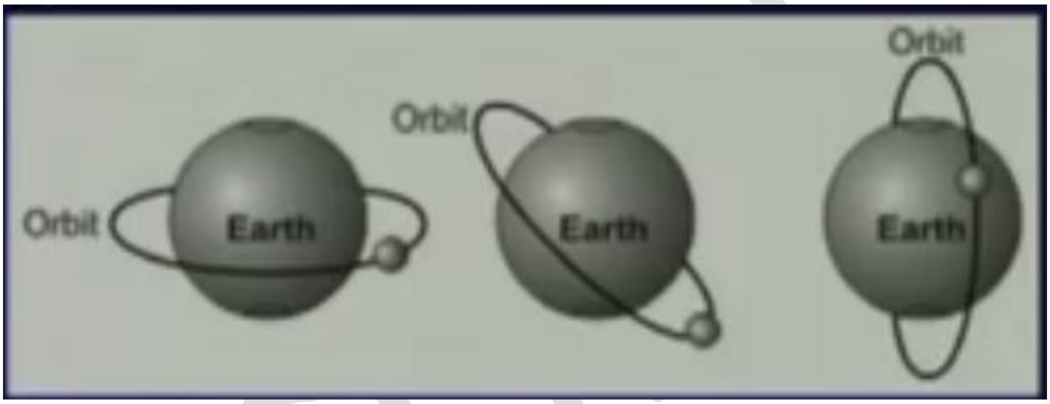


- Applications:
  - Microwaves, due to their unidirectional properties, are very useful when unicast (one-to-one) communication is needed between the sender and the receiver. They are used in cellular phones, satellite networks, and wireless LANs.

SATELLITE COMMUNICATIONS

Three basic types of orbits in which satellites rotate around the earth:

1. Equatorial
2. Inclined
3. Polar

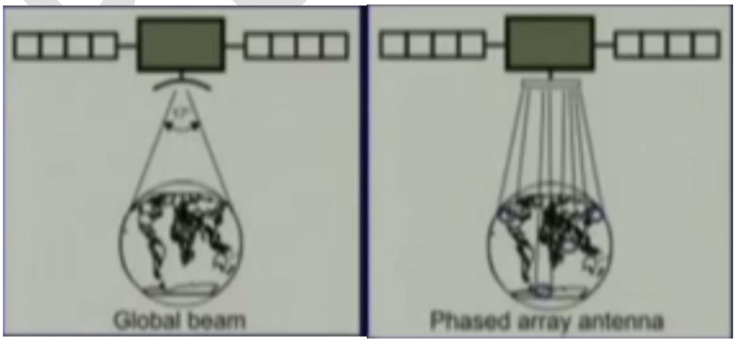


Time required to make a complete trip around the earth is known as period. It is determined by Kepler's law of period,

$$T^2 = (4\pi^2/GM)r^3$$

Where T is the period, G is the gravitational Constant, M is the mass of the central body and r is the radius.

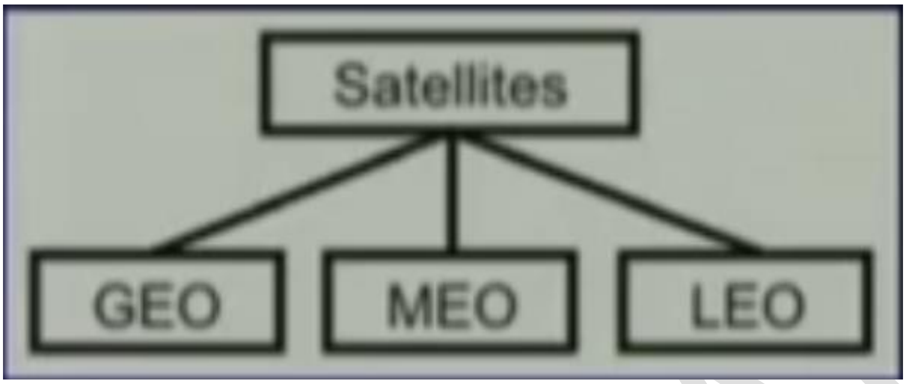
Footprint:

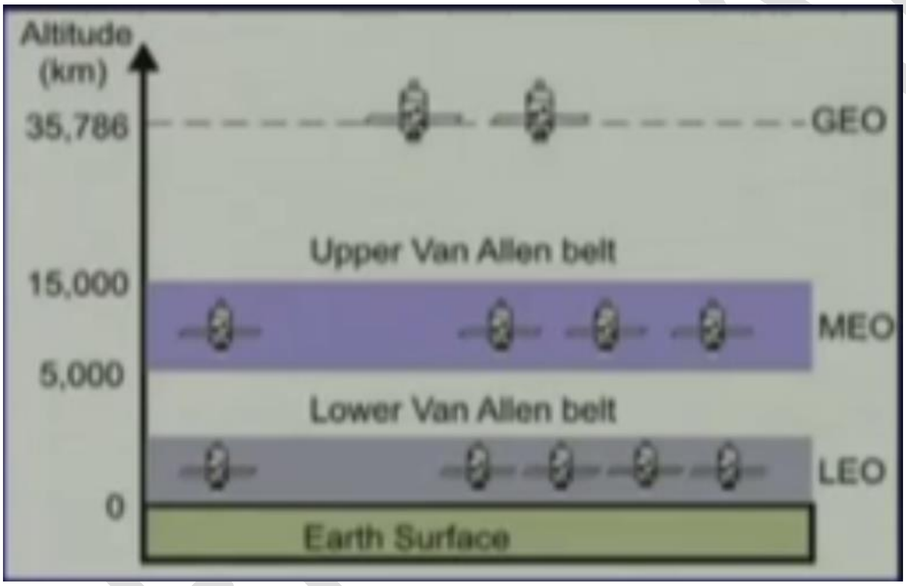


- Signals from a satellite are normally aimed at a specific area called the Footprint.
- Power is maximum at the centre of the footprint.
- It decreases as the point moves away from the footprint centre.

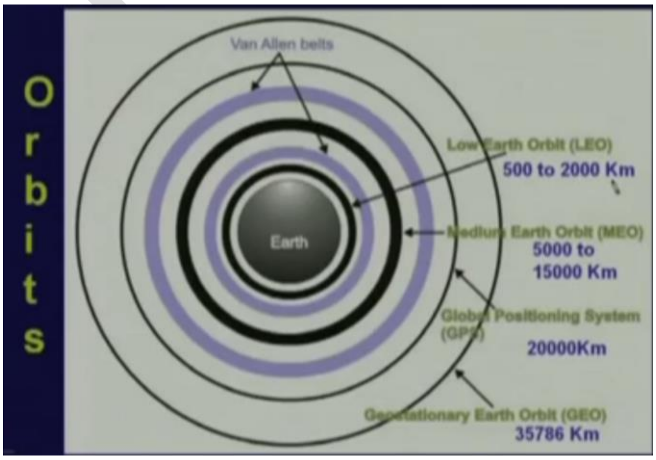
- The amount of time a beam is pointed to a given area is known as Dwell Time.

Categories of Satellites





Satellites are placed in such a way that they are not destroyed by the high energy charged particles present in the two Van Allen Belts.



Microwave bands for satellite communications

Band	Downlink Frequency (GHz)	Uplink Frequency (GHz)	Bandwidth (MHz)	Comments
L	1.5	1.6	15	• Easiest to implement for marine satellite systems. • Not much L-Band bandwidth available. • Requires less sophisticated and less expensive equipment
S	1.9	2.2	70	• used by weather radar, surface ship radar, and some communications satellites, especially those used by NASA to communicate with the Space Shuttle and the International Space Station.
C	4	6	500	• uses large (2.4- 3.7 meter) antennas • These are the large white domes that you see on top of the cruise ships and commercial vessels • Typically used by large ships that traverse the oceans on a regular basis and require uninterrupted, dedicated, always on connectivity as they move from region to region.
Ku	11	14	500	• most commonly used for satellite TV • used for most VSAT systems on yachts and ships today. • much more bandwidth available in Ku -Band and it is therefore less expensive that C or L-band. • The main disadvantage of Ku-Band is rain fade. The wavelength of rain drops coincides with the wavelength of Ku-Band causing the signal to be attenuated during rain showers. This can be overcome by transmitting extra power but this of course comes with a cost as well.
Ka	20	30	3500	• It is an extremely high frequency requiring great pointing accuracy and sophisticated equipment. Like Ku-band it is susceptible to rain fade. • commonly used for high definition satellite TV. • also used today for terrestrial VSAT services • Ka-Band bandwidth is plentiful and once implemented should be quite inexpensive

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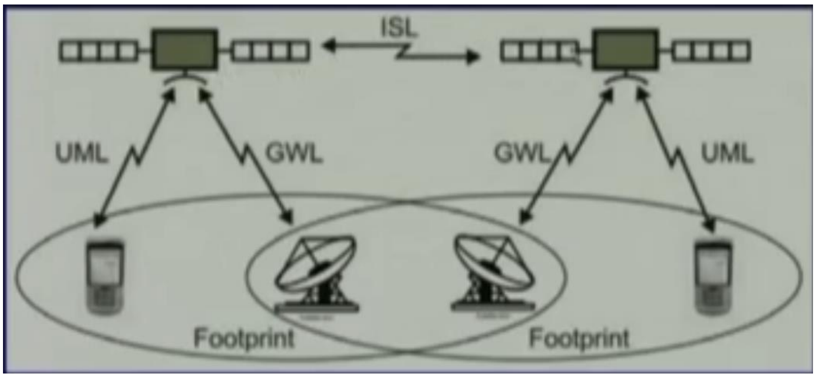
				compared to Ku-Band.

Low Earth Orbit (LEO) Satellites

- A constellation of satellites that work together as a network.
- Orbits: Polar (When satellites rotate on polar orbits, the earth are turning beneath them. That's why during 24 hours a satellite can cover the whole surface. Satellites at higher altitude (Equatorial orbit) will orbit more slowly as the circumference of the orbit is greater and gravitational pull is lower.)
- Altitude: 500 to 2000 KM (850)
- Period: 90 to 120 Min (100)
- Speed: 20,000 to 25,000 KM/H
- Footprint: 8000 KM Diameter
- How do they work?
- 

    -
        - ISL(Intersatellite Link)

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- GWL(Gateway Link)
- UML(User Mobile Link)

LEO Categories:

1. Little LEO (Below 1GHz)
2. Big LEO (1-3 GHz) (IRIDIUM Project)
3. Broadband LEO (Teledesic Project)

IRIDIUM PROJECT

- Project started by Motorola in 1990
- To provide worldwide voice and data communication service using handheld devices
- It took 8 years to materialize using 66 satellites
- They are placed in 6 different orbits at an altitude of 750 KM (11 satellites/orbit)
- Each satellite has 48 spot beams(total 3168 beams)

TELEDESIC SYSTEM

- Project started by Craig McCaw and Bill Gates in 1990
- To provide high speed internet
- 288 satellites were placed in 12 polar orbits (24 s/o)
- Altitude 1350 KM
- Communication using Ka band
    - ISL: 8 neighboring satellites
    - GWL: between a satellite and a gateway
    - UML: Between a user and a satellite
- Data rates: 155 mbps uplink to 1.2 gbps downlink

Medium Earth Orbit (MEO) Satellites

- These satellites are positioned in between two Van Allen belts.
- MEO satellites cover more earth area than LEOs
- Orbits: Inclined (mostly)

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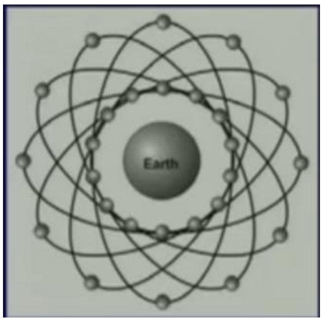
- 

- Altitude: around 10,000-12,000 KM or sometimes at around 18,000KM
- Period: 6-8 Hrs.
- GPS (Global Positioning System) Satellites
  - It is an Artificial Satellite based navigation system
  - It comprises a network of minimum 24 satellites (currently 31 satellites are deployed) hovering at an altitude of 20,000 KMs (Period 12 Hrs) (2 rotation per day) (Inclination 55 degrees)
  - Originally intended for military use but since 1980 it is available for civilian usage
  - It allows land, sea and airborne users to measure their position, velocity and time using a GPS receiver.
  - A GPS receiver's job is to locate four or more of these satellites, figure out the distance to each, and use this information to deduce its own location. This operation is based on a simple mathematical principle called **trilateration**.
  - It works in any weather condition, 24 hrs a day
  - Positioning is accurate to 15 meters
  - 

Geostationary Earth Orbit (GEO) Satellites

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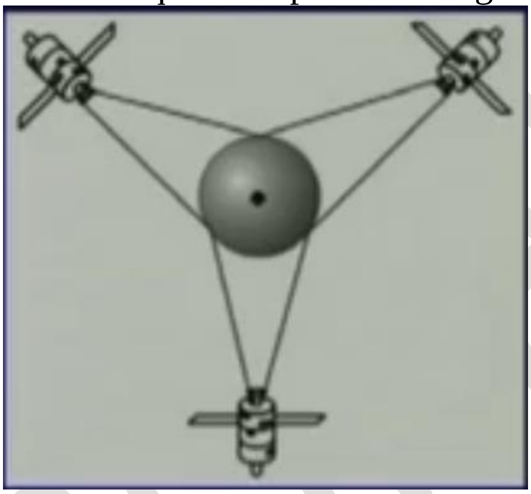
- To facilitate constant communication, the satellite must move at the same speed as earth: such satellites are GeoSynchronous Satellites.
- However, If such satellites are placed in equatorial orbit then they are called Geostationary (GEO) Satellites.
- Altitude: 35786 Km
- Period: 24 Hrs
- Orbit: Equatorial
- Only 3 satellites are required to provide full global coverage



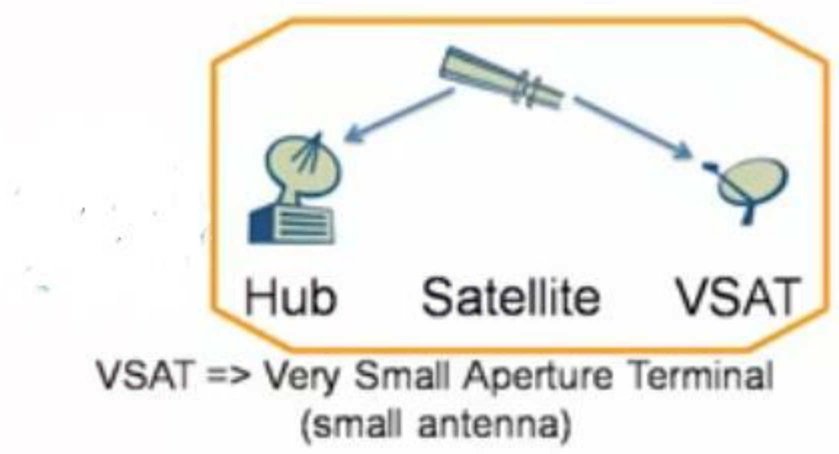
- VSAT is the best example of GEO satellites.
- Applications: Communication, DTH TV, Radio Broadcasting, Navigation and Signal Intelligence
- *Good to Know: The Indian National Satellite (INSAT) system which are placed in Geo-stationary orbits is one of the largest domestic communication satellite systems in Asia-Pacific region. Established in 1983 with commissioning of INSAT-1B, it initiated a major revolution in India's communications sector and sustained the same later. INSAT space segment consists of 24 satellites out of which 10 are in service (INSAT-3A, INSAT-4B, INSAT-3C, INSAT-3E, KALPANA-1, INSAT-4A, INSAT-4CR,GSAT-8, GSAT-12 and GSAT-10). Recently, on 26/7/203 INSAT 3D was launched. INSAT-3D is an advanced weather satellite of India configured with improved Imaging System and Atmospheric Sounder. INSAT-3D is designed for enhanced meteorological observations, monitoring of land and ocean surfaces, generating vertical profile of the atmosphere in terms of temperature and humidity for weather forecasting and disaster warning.*
- ***How Do Objects Stay in Orbit?***

  A moving object will continue moving unless something pushes or pulls on it. This statement is called Newton's first law of motion.

Without gravity, a satellite would fly off into space. With gravity, a satellite is constantly pulled back toward Earth. This tug-of-war keeps the satellite in orbit. Height is how far up something is. Objects at different heights move at different speeds in orbit. The space station is about 200 miles above Earth. At that height, the station must move about 17,500 miles per hour. It takes the space station about 90 minutes to go around Earth. The moon is much higher, about 250,000 miles from Earth. It takes the moon about 28 days to orbit Earth, going about 2,200 miles per hour. Earth takes a year to orbit the sun. Pluto takes about 248 Earth years.

Very Small Aperture Terminal (VSAT)

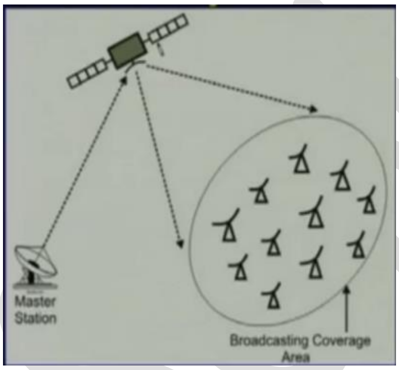
- Developed to make access to the satellite more affordable and without any intermediate distribution hierarchy
- Name refers to the size of antenna



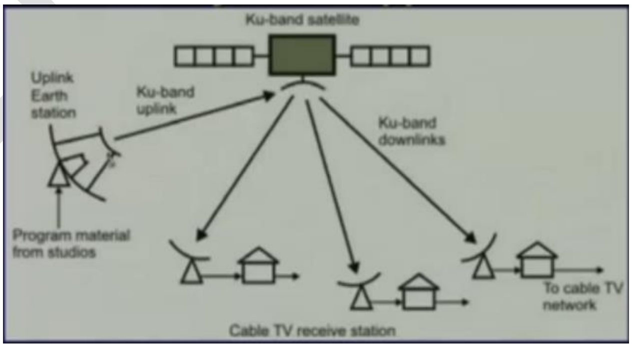
- VSAT generally operates in Ku band with antenna diameter from 0.74 meter up to 2.4 meters and transmitting low power at 1-2 watts (Since the size of terminal is small and it operates at low power, It can be easily implemented for domestic usage.)
- VSAT consists of:
    - Outdoor Unit (Reflector and Transceiver)
    - Cable (Coaxial)
    - Indoor unit (to connect devices to the outdoor unit)
- VSAT key components
    - Satellite
    - Central Hub or Gateway station
    - Remote Station

- Internet or corporate network

- Implementation:
  - One Way



    - Used in the broadcast satellite service (BSS)
    - Simplex Communication
    - Satellite is used as a relay in sky



    - Cable TV broadcast and DTH Service
  - Two Way: All the traffic is routed through Central Hub

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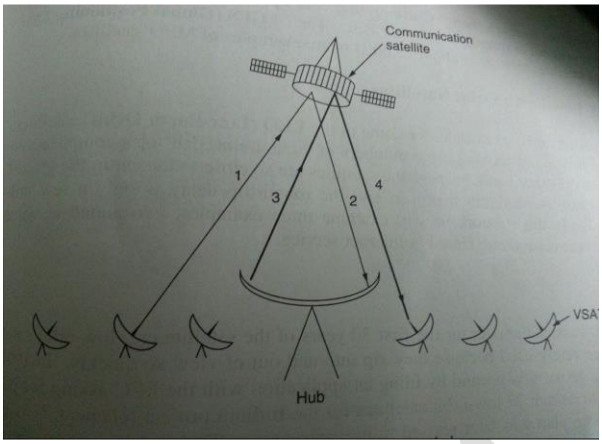
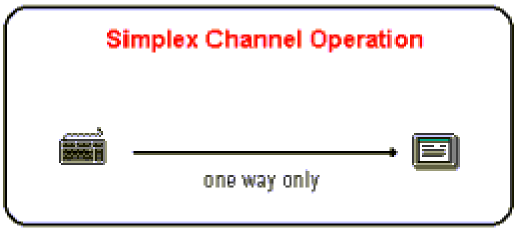


- Application:
    - High availability
    - Quick implementation for long range network
    - Delivery of extra capacity on same is quick

Modes of Transmission (Channel Operation) (Networking) (Communication)

Simplex

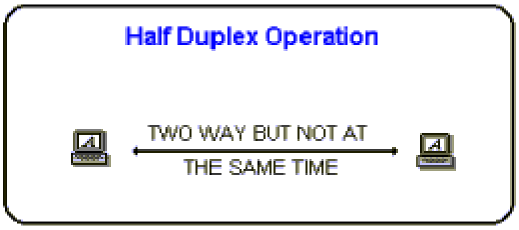
Data in a simplex channel is always one way. Simplex channels are not often used because it is not possible to send back error or control signals to the transmit end.



It's like a one way street. An example of simplex is Television, or Radio.

Half Duplex

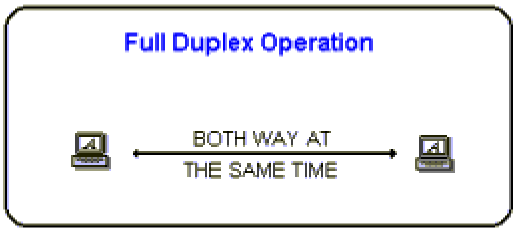
A half-duplex channel can send and receive, but not at the same time. It's like a one-lane bridge where two-way traffic must give way in order to cross. Only one end transmits at a time, the other end receives. In addition, it is possible to perform error detection and request the sender to retransmit information that arrived corrupted.



Another example of half-duplex is Walkie-Talkie using which Police communicate to each other, and when they want the other person to speak, they say "over". This is because only one person can talk at a time.

Full Duplex

Data can travel in both directions simultaneously. There is no need to switch from transmit to receive mode like in half duplex. It's like a two lane bridge on a two-lane highway. Example: Mobile Phones



Of course, in the world of data communications, full duplex allows both way communications simultaneously.

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