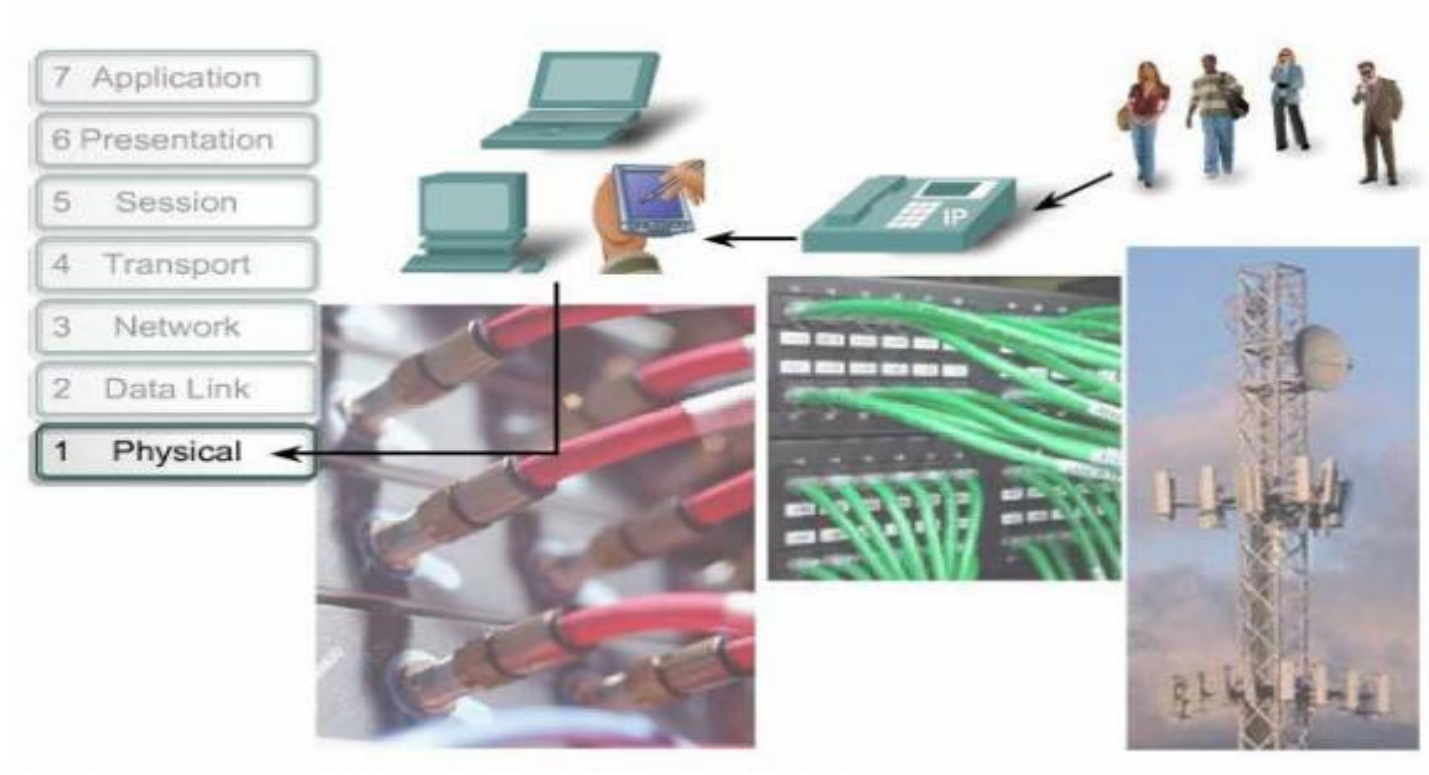
Chapter 2

Physical Layer-Transmission Media

Introduction-The Physical Layer

- Physical layer in the OSI

Foundation on which other Layer Build.

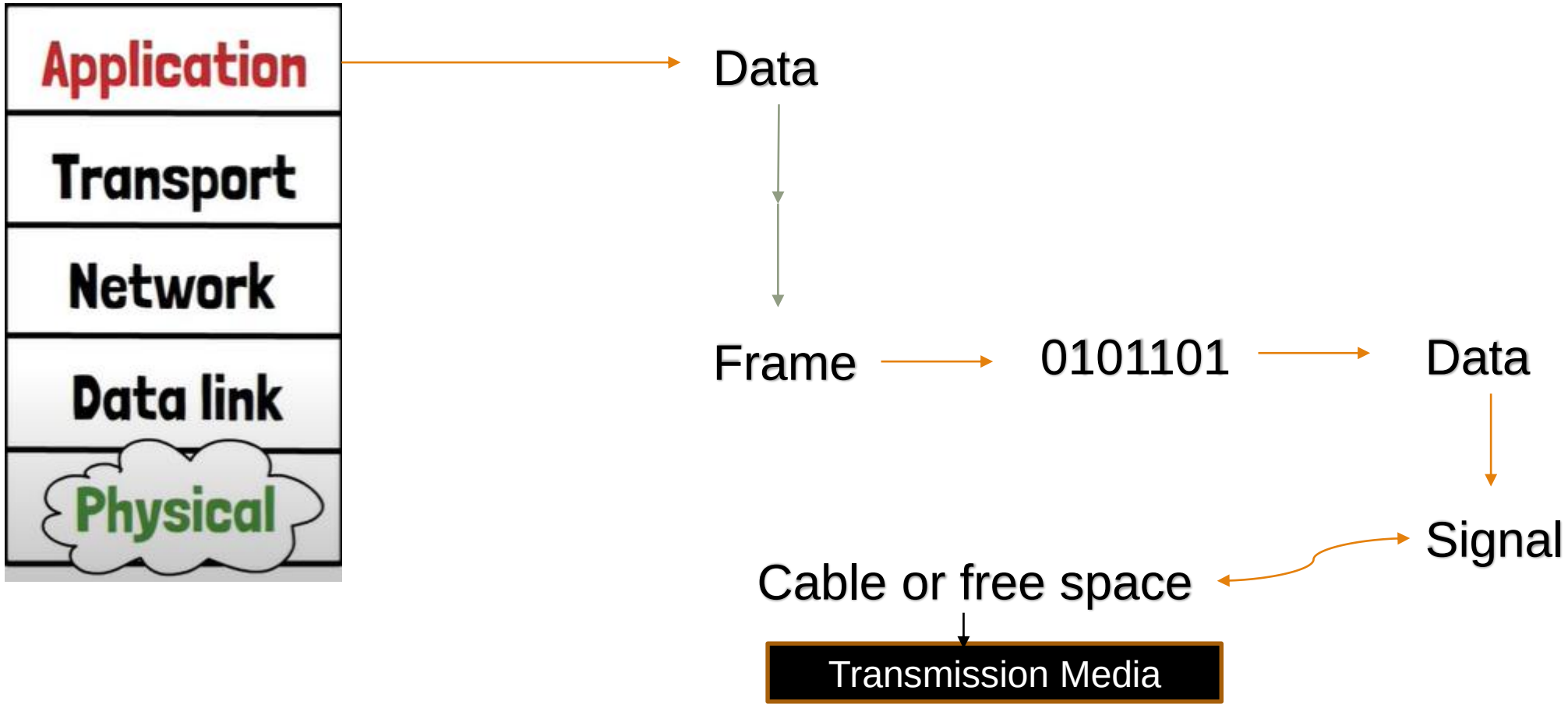


Physical Layer

- Physical layer in the OSI model plays the role of interacting with actual hardware and signaling mechanism.
- Physical layer is the only layer of OSI network model which actually deals with the physical connectivity of two different stations.
- This layer defines the hardware equipment, cabling, wiring, frequencies, binary signals etc.
- Physical layer provides its services to Data-link layer. Data-link layer hands over frames to physical layer. Physical layer converts them to electrical pulses, which represent binary data. The binary data is then sent over the wired or wireless media.

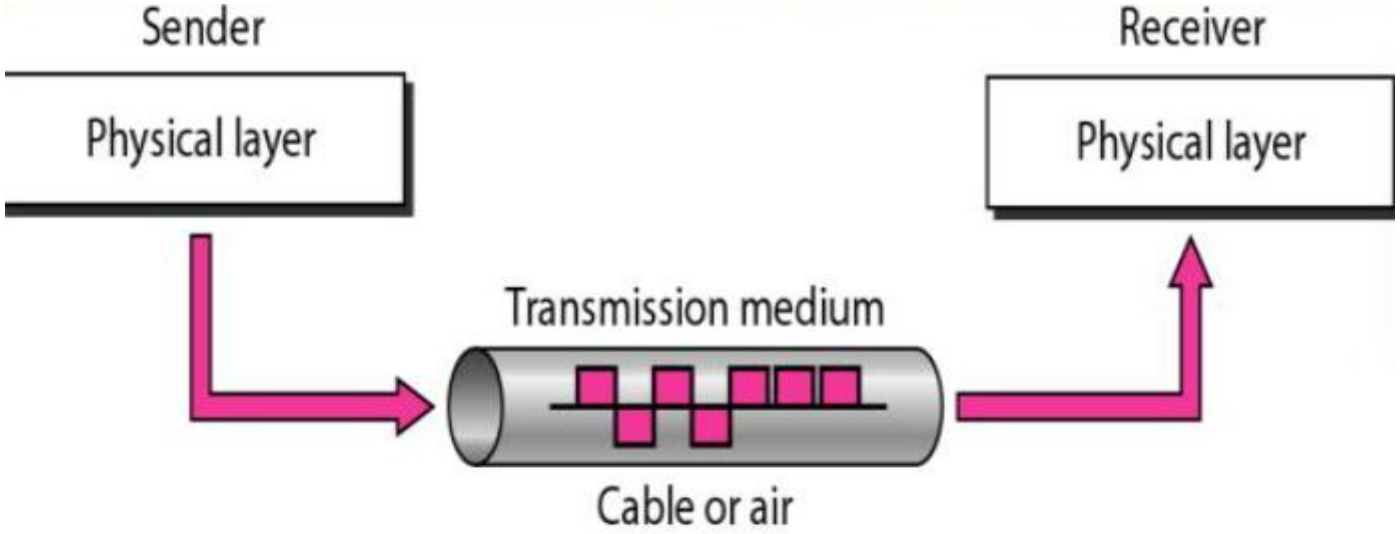
Data and Signal

- TCP/IP Protocol suit



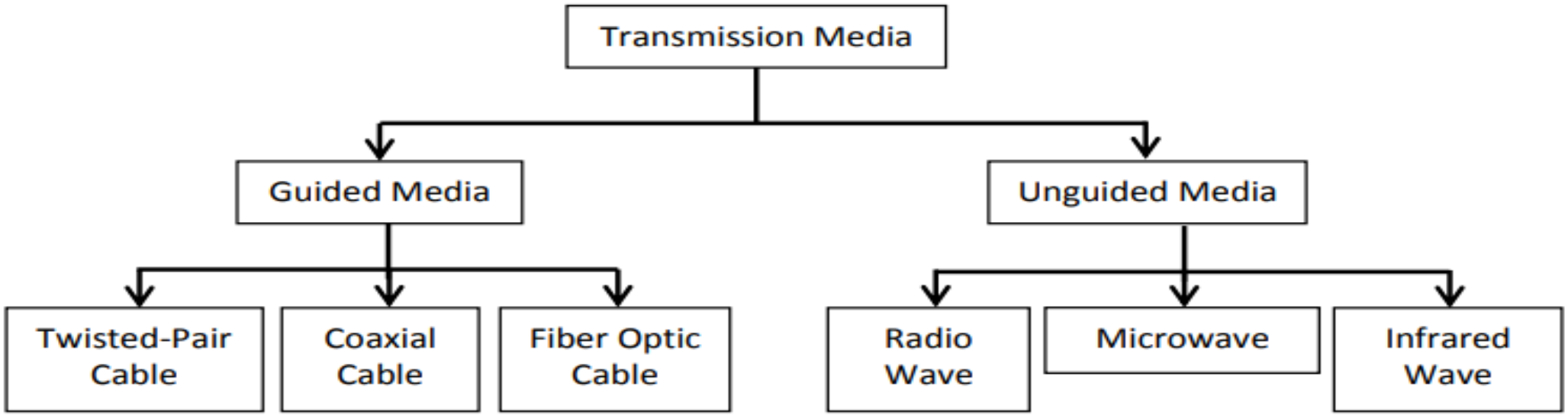
Transmission Media

- A transmission **medium** can be broadly defined as anything that can carry information from a source to a destination.
- Ex: Air, truck,
- In data communications the transmission medium is more specific
- Ex: free space, metallic cable, fiber optic cable.



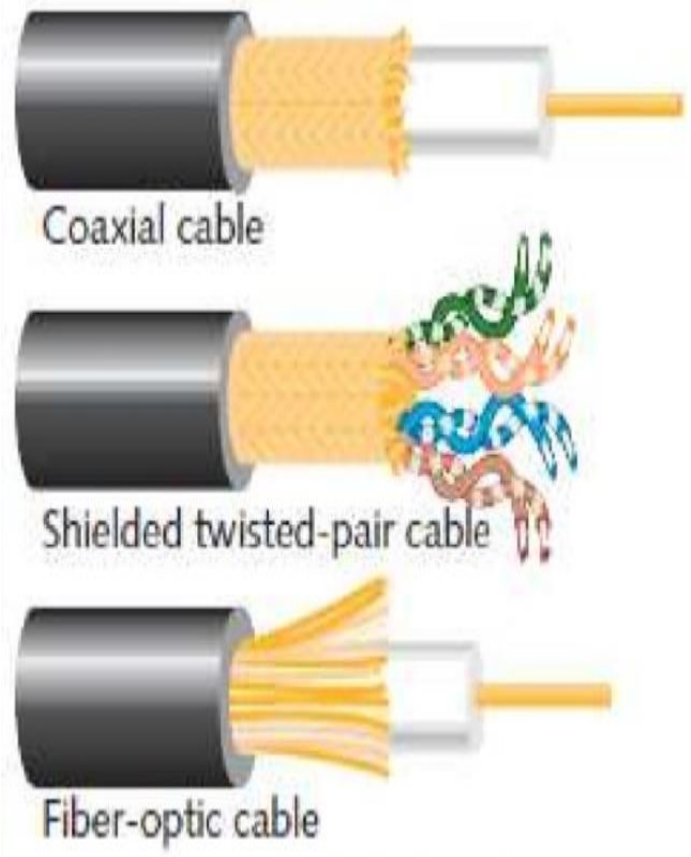
Transmission Media

- A transmission media can be defined as anything that can carry information from a source to a destination.
- On the basis of transmission of data, the transmission media can be classified into two categories:
    1. Guided (Physical) transmission media
    2. Unguided (Wireless) transmission media



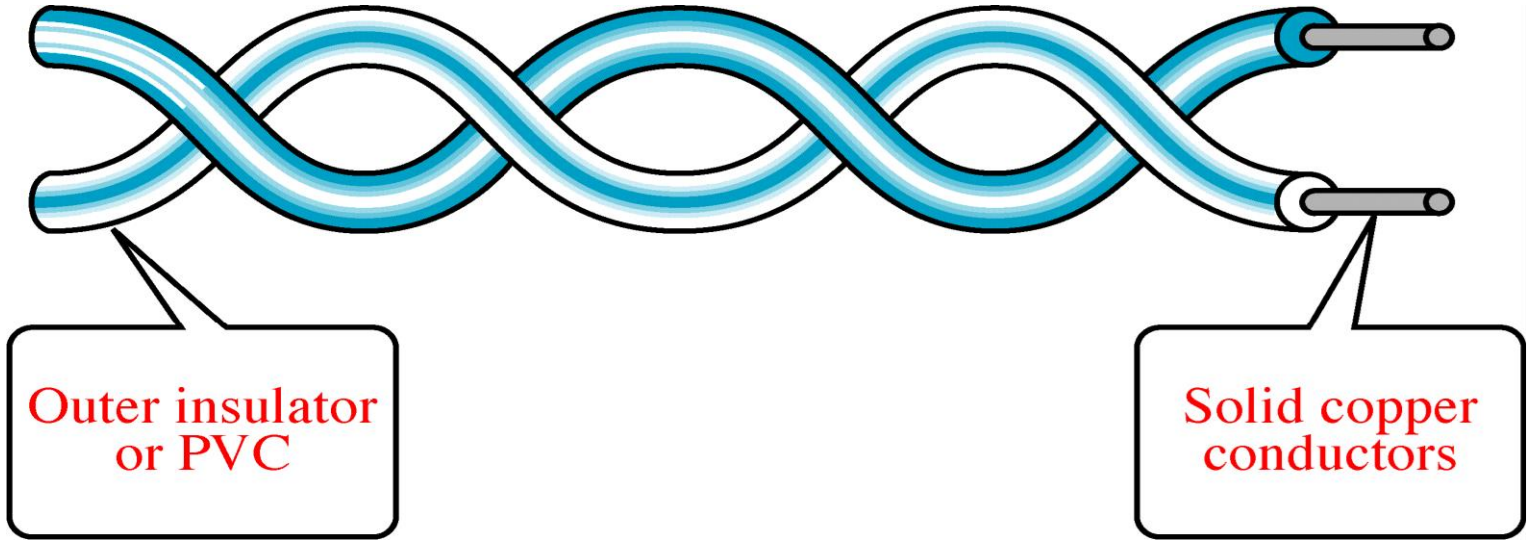
Guided Media

- It Provides a conduit from one device to another, include twisted pair, coaxial and fiber optic cable.
- A signal traveling 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 fiber is a cable that accepts and transports signals in the form of light.

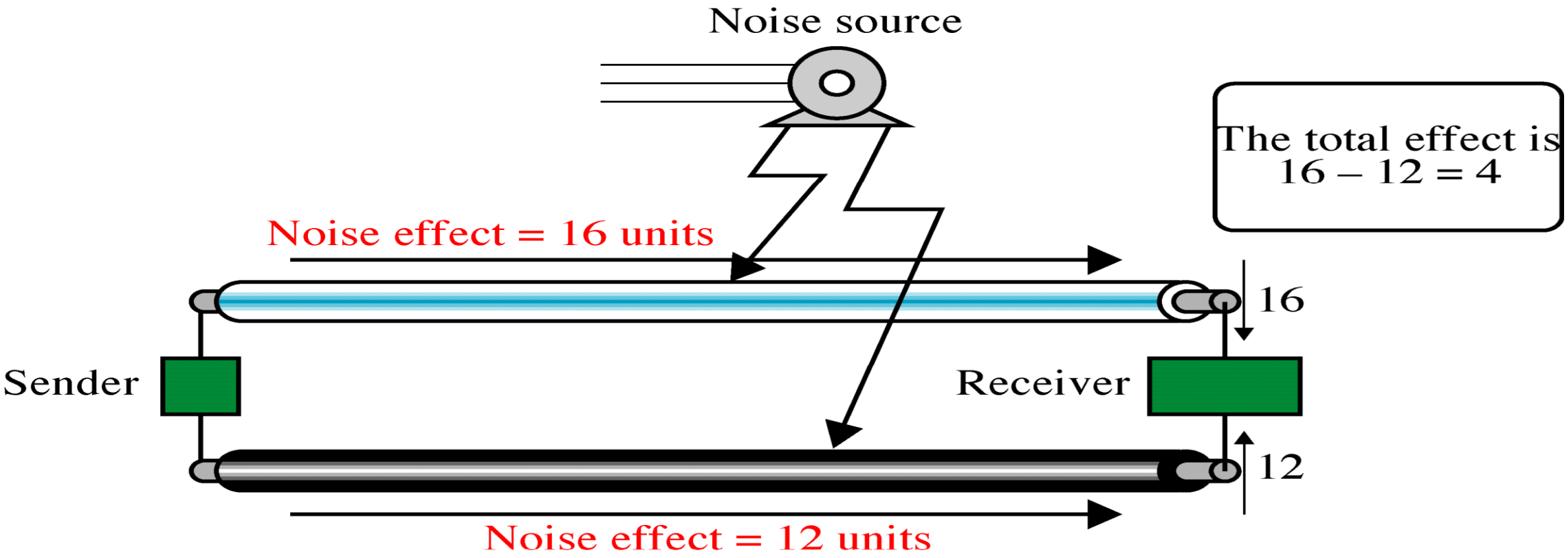


Twisted-Pair Cable

- One wires is used to carry signals and other used as a ground reference.
- Why the two wire twist together?
- Why not in parallel?



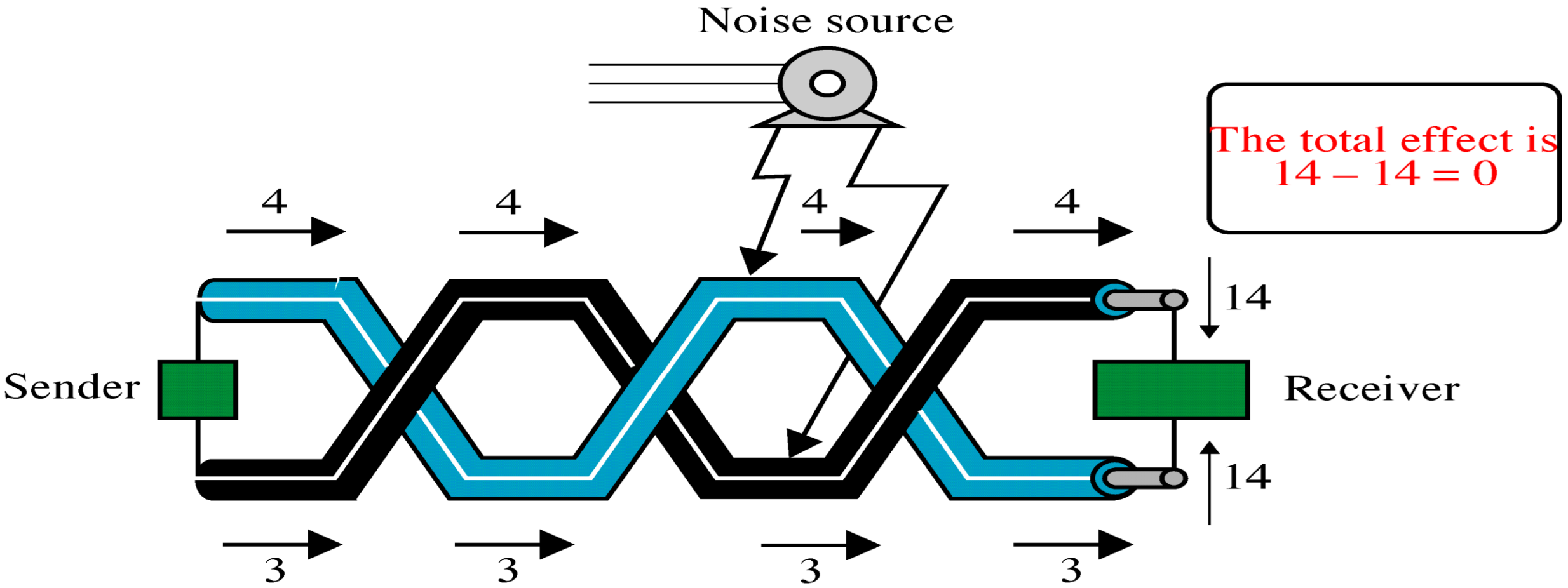
Effect of Noise on Parallel Lines



Effect of Noise on Parallel Lines

- Here receiver uses the difference between two
- In addition to the signal send by the sender one of wire interference noise and crosstalk may affect both wire and create unwanted signals.

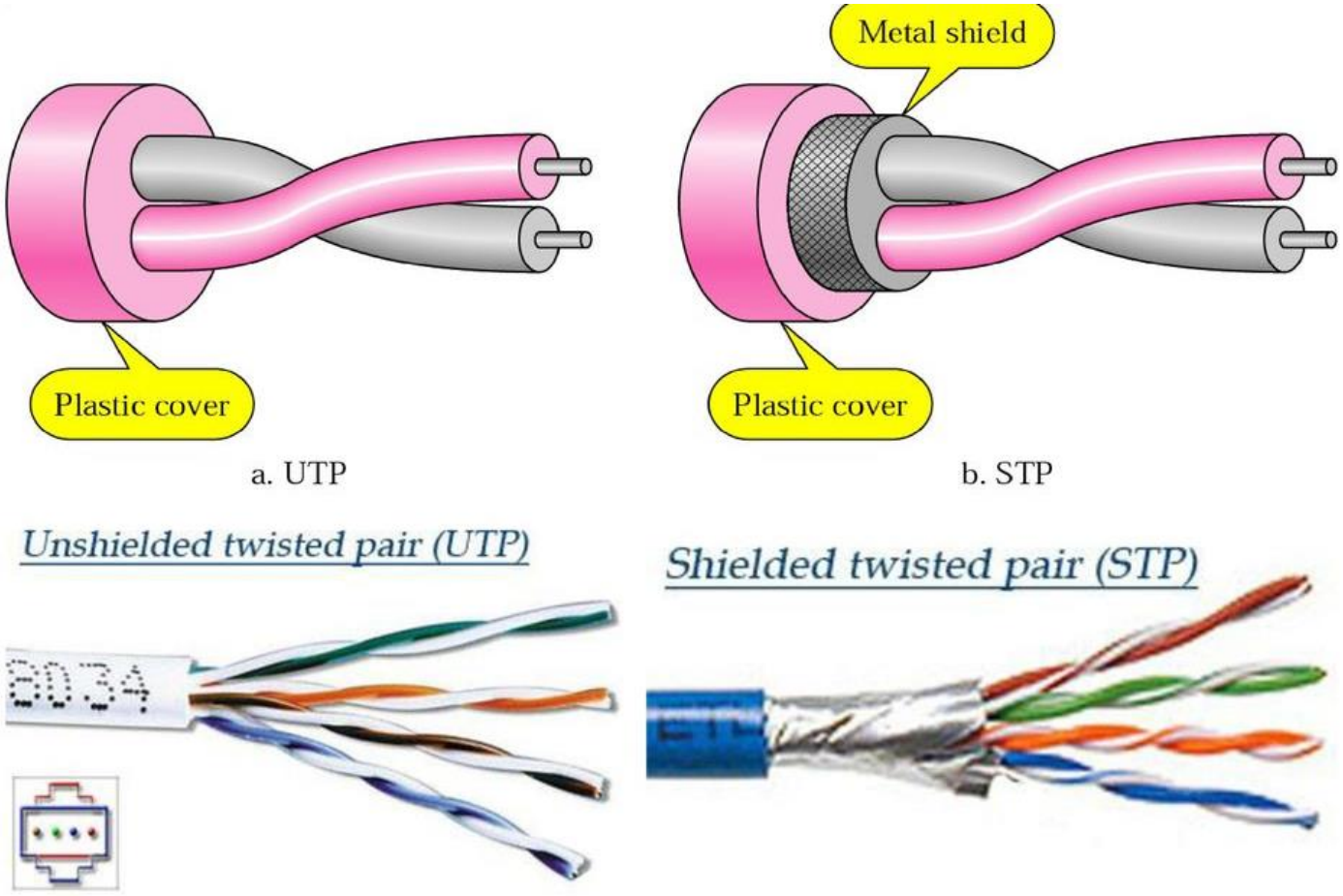
Noise on Twisted pair Line



Noise on Twisted pair Line

- Here in one twist , one wire is closer to the noise source and other is farther, in next twist reverse is true.
- In twist both the wire are equally effected by noise(crosstalk).
- So the difference created at receiver side is zero(we can say negligible)
- So from above, clear that the no. of twist per unit length has some effect on quality of cable.

Twisted-Pair Cable- UTP and STP

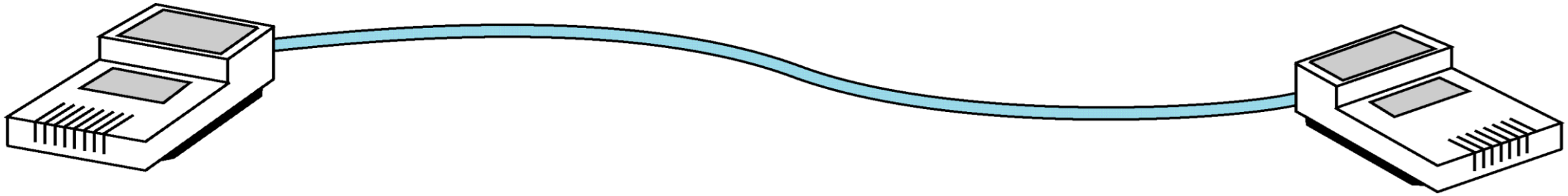


- STP has metal foil, that improves the quality of cable by preventing the penetration of noise or crosstalk
- STP is expensive

Categories of UTP Cables

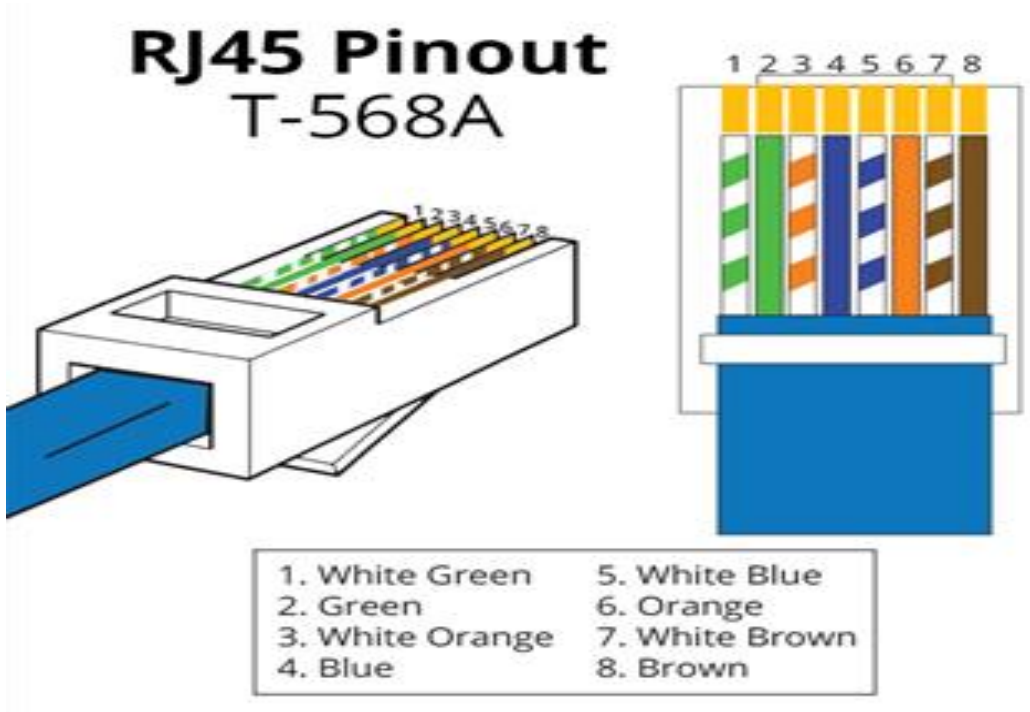
Category	*Specification*	*Data Rate (Mbps)*	*Use*
1	Unshielded twisted-pair used in telephone	< 0.1	Telephone
2	Unshielded twisted-pair originally used in T-lines	2	T-1lines
3	Improved CAT 2 used in LANs	10	LANs
4	Improved CAT 3 used in Token Ring networks	20	LANs
5	Cable wire is normally 24 AWG with a jacket and outside sheath	100	LANs
SE	An extension to category 5 that includes extra features to minimize the crosstalk and electromagnetic interference	125	LANs
6	A new category with matched components coming from the same manufacturer. The cable must be tested at a 200-Mbps data rate.	200	LANs
7	Sometimes called SSTP (shielded screen twisted-pair). Each pair is individually wrapped in a helical metallic foil followed by a metallic foil shield in addition to the outside sheath. The shield decreases the effect of crosstalk: and increases the data rate.	600	LANs

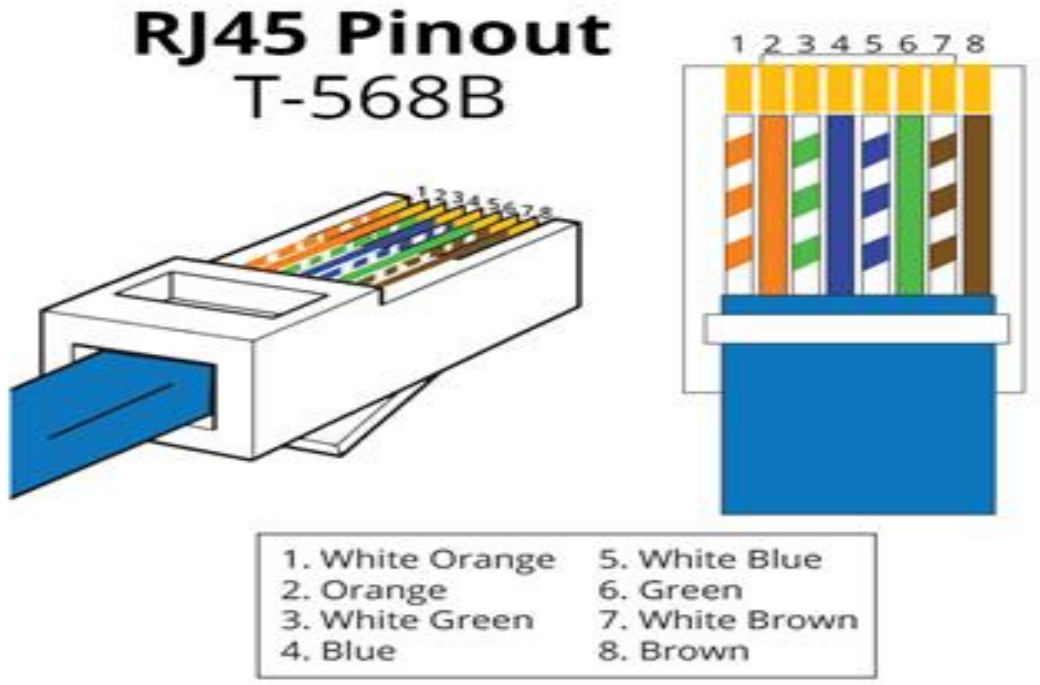
Twisted-pair cable Connectors



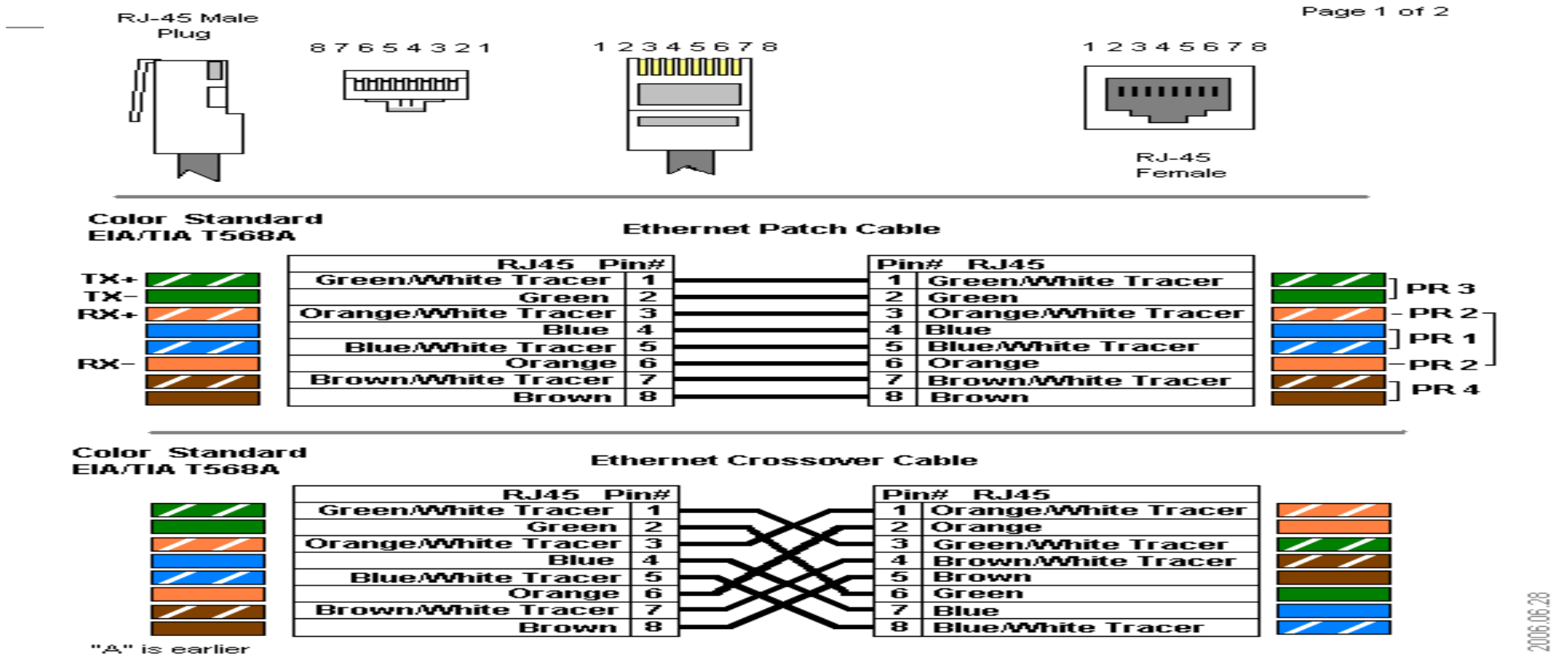
- RJ-45
- RJ stands for registered jack

PINOUT


RJ45 Pinout
T-568A
1 2 3 4 5 6 7 8
1. White Green
2. Green
3. White Orange
4. Blue
5. White Blue
6. Orange
7. White Brown
8. Brown


RJ45 Pinout
T-568B
1 2 3 4 5 6 7 8
1. White Orange
2. Orange
3. White Green
4. Blue
5. White Blue
6. Green
7. White Brown
8. Brown

Patch and Cross cable



Applications

- Used in telephone lines to provide voice and data
- In Local area network
- 10Base-T
- 100Base-T

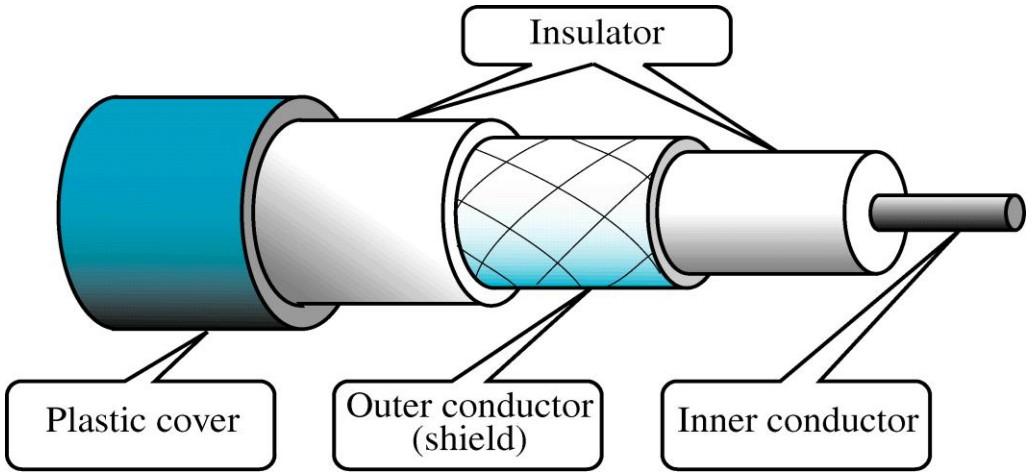
Advantages:

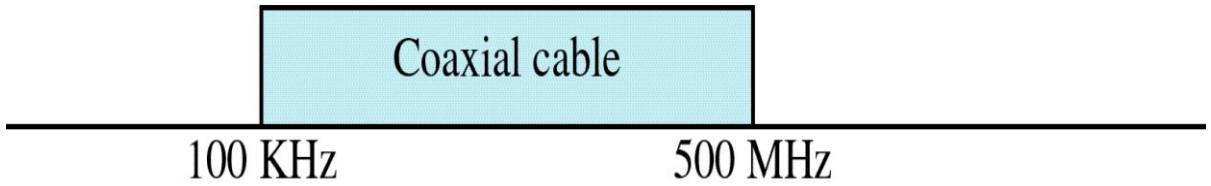
- Twisted pair cable are oldest and most popular cable all over the world.
- Trained personnel easily available.
- Least expensive for short distances.
- Entire network does not go down if a part of network is damage.
- Easy to install and maintain.
- Low weight.

Disadvantages:

- Signal can not travel long distance without repeaters due to attenuation.
- High error rate for distance greater than 100m
- Very thin and hence break easily.
- Low bandwidth

Coaxial Cable





- coax has a central core conductor of solid or stranded wire(usually copper) enclosed in an insulating sheath, which is, in turn, encased in an outer conductor of metal foil, braid, or a combination of the two which completes the circuit.
- This outer conductor is also enclosed in an insulating sheath, and the whole cable is protected by a plastic cover.
- (HZ=BIT/SECOND)

Coaxial Cable

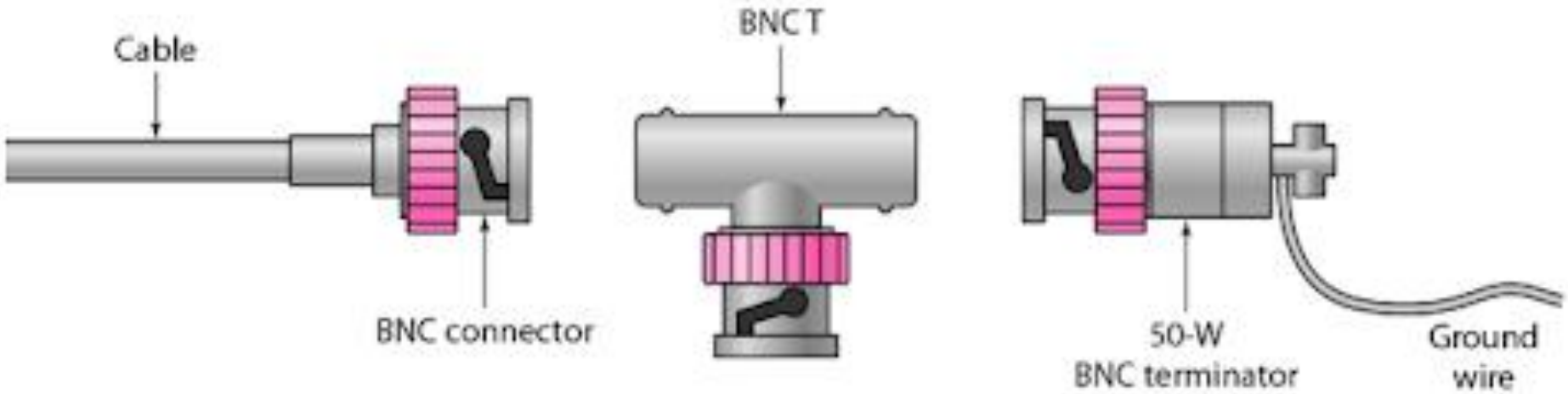
Coaxial Cable Standards

- Each Radio government(RG) ratings denotes unique set of physical specifications.

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

Coaxial Cable Connectors:

- Bayone-Neill-Concelman (BNC).
- BNC connector,
- BNC T connector
- BNC terminator



Coaxial Cable Connectors:

- The BNC connector is used to connect the end of the cable to a device, such as a TV set.
- The BNC T connector is used in Ethernet networks to branch out to a connection to a computer or other device
- The BNC terminator is used at the end of the cable to prevent the reflection of the signal.

BNC Connector

BNC T

BNC Terminator

Coaxial Cable Application

- Analog cable TV.
- Telephone network:
- Single coaxial carry 10000 voice signals.
- Digital data upto 600Mbps.
- 10 Base 2 (Thin Ethernet) RG-58 coaxial cable with BNC connector - 10Mbps -185 m
- 10Base 5(Thick Ethernet) RG-11 -10Mbps -500m.

Advantages of Coaxial Cable

- Excellent noise immunity
- Signal can travel longer distance at higher speed (1 to 2Gbps in 1 km)
- Inexpensive cmp to fiber optics.
- Easy to install and maintain.

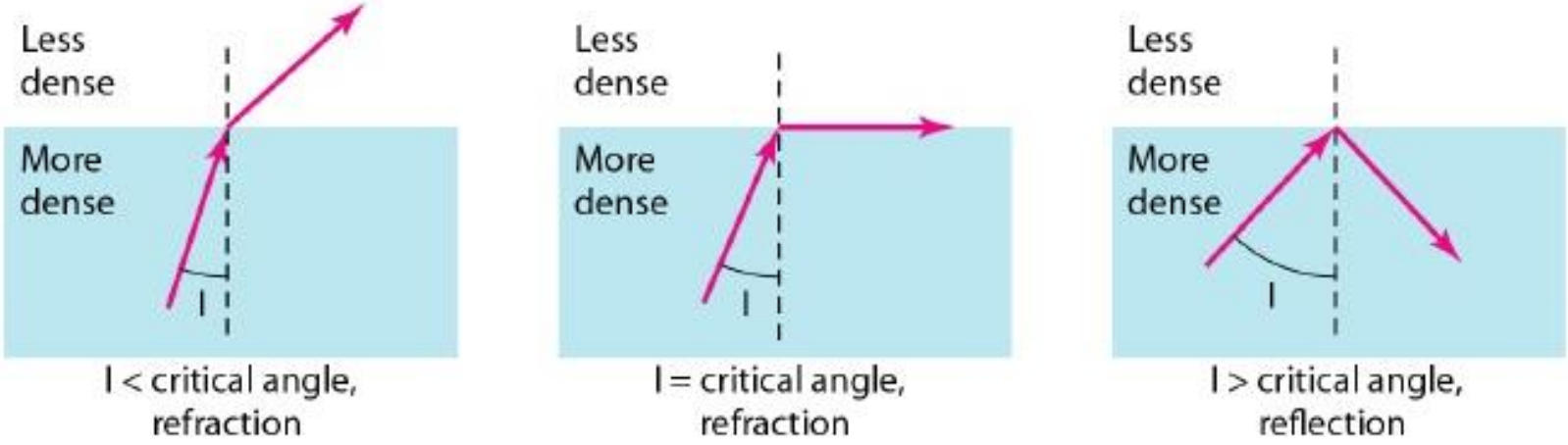
Disadvantages of Coaxial Cable

Not compatible with twisted pair cable.

Expensive as compare to twisted pair cable.

Optical fiber

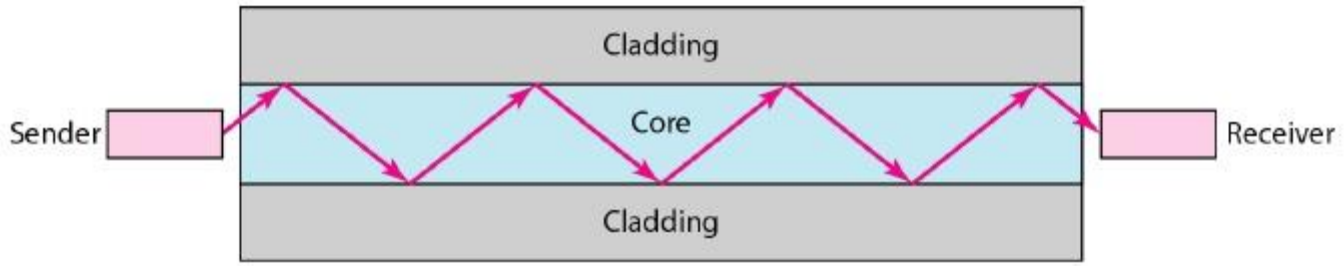
- Made up of glass or plastic
- Transmit Signal in form of light
- Nature of light
- Optical fibers use reflection to guide light through channel.



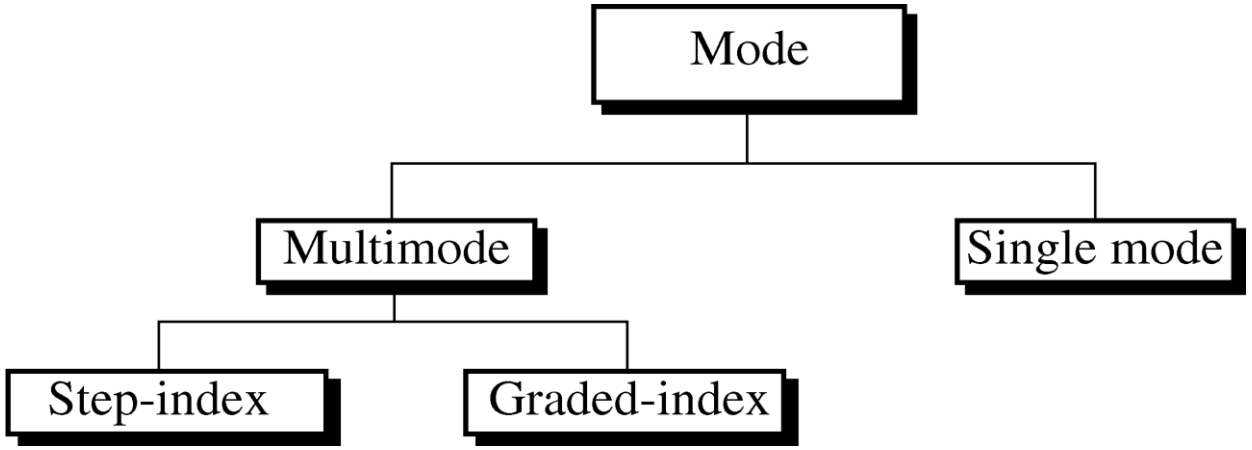
Angle of incidence : angle the ray makes with the line perpendicular to the interface between the substances

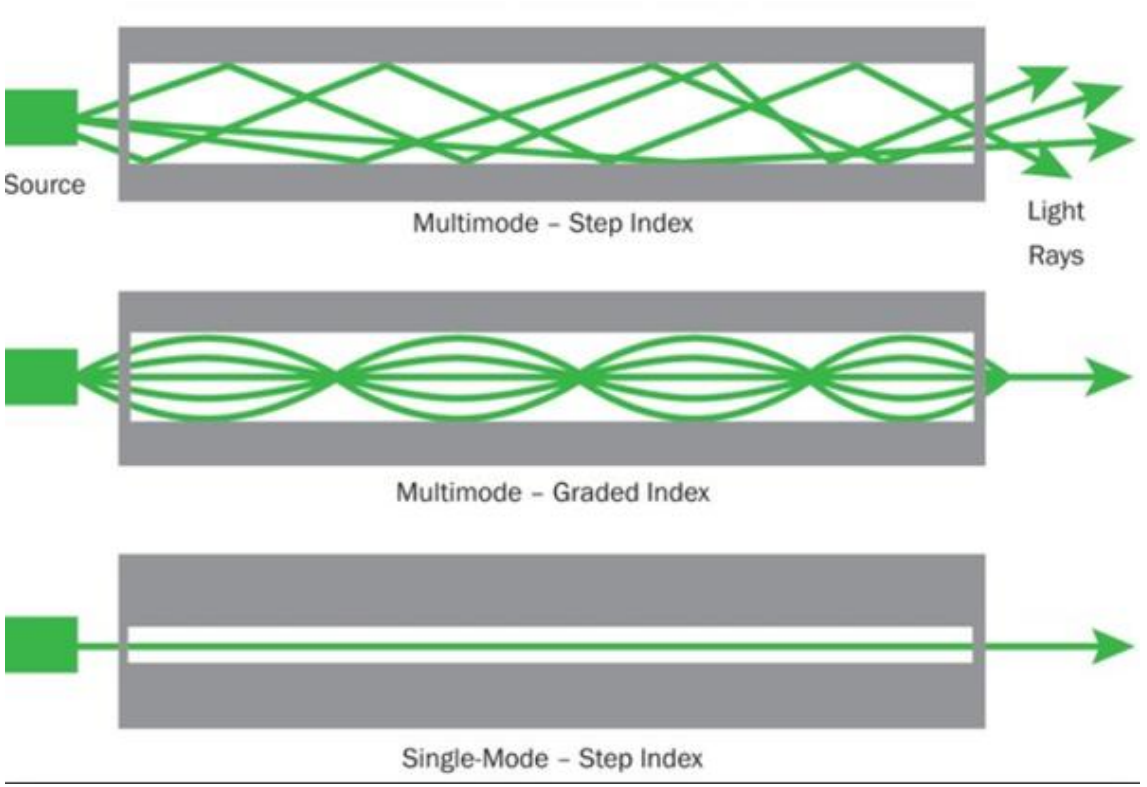
Optical fiber

- Optical fibers use reflection to guide light though a channel
- A glass core is surrounded by cladding of plastic
- Difference in density of the two materials must be such that a beam of light moving though the core is reflected off the cladding instead of being refracted into it

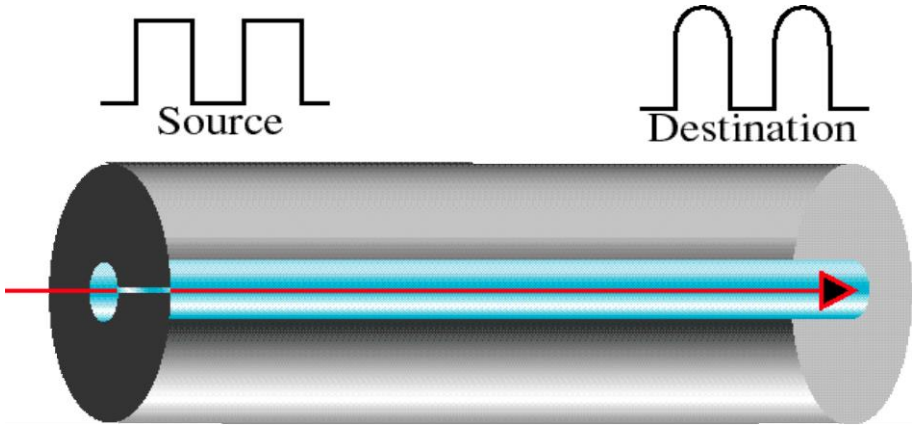


Optical fiber – Propagation modes



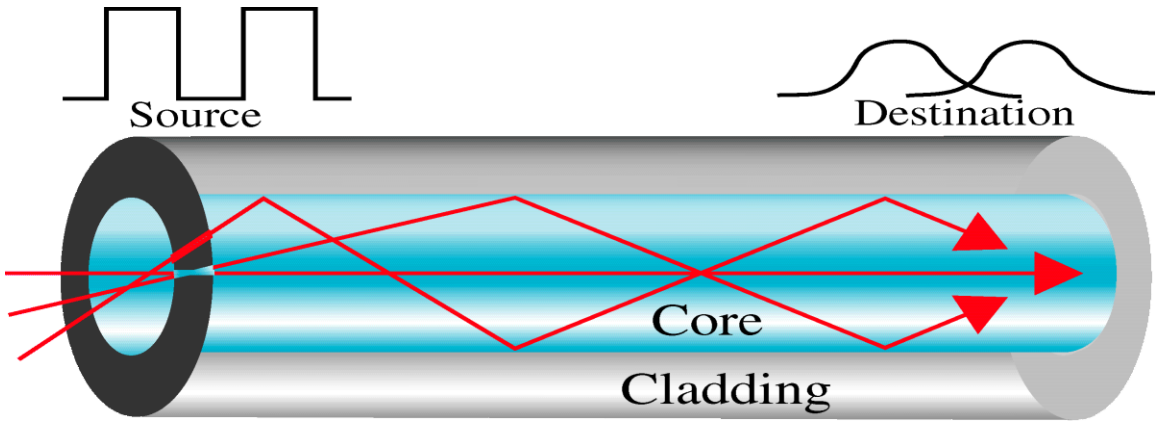


Single Mode



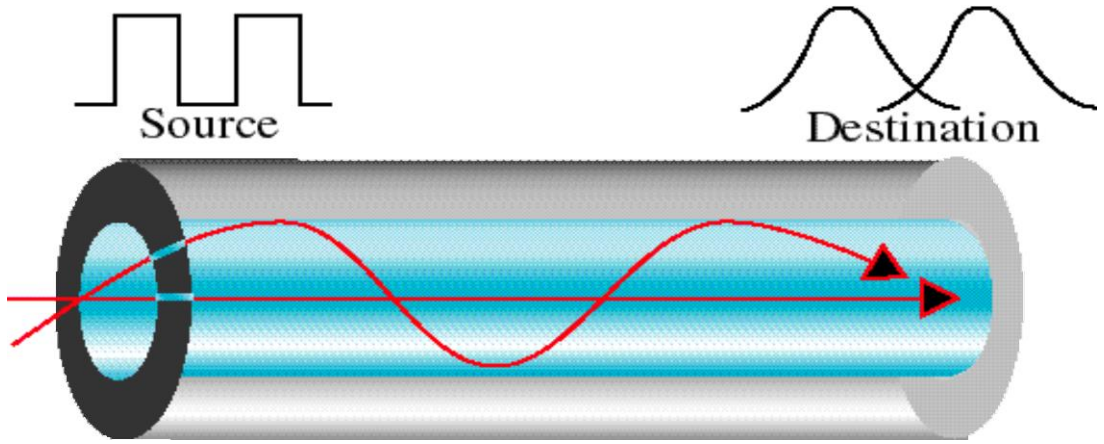
- Source of light that limits beams to a small range of angles, all close to the horizontal.
- Much smaller diameter - 8 to 12 micrometer.
- Critical angle that is close to 90
- Used for long distance communication.

Multimode Step-Index



- The density of the core remains constant from the center to the edges
- Light entering the fiber at different angle of incident will go through different path.
- Distortion of the signal.(Time to reach output of fiber is different)

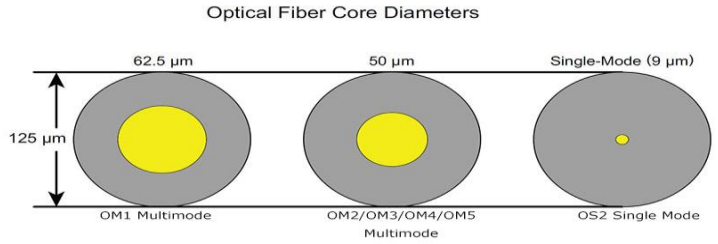
Multimode Graded-Index



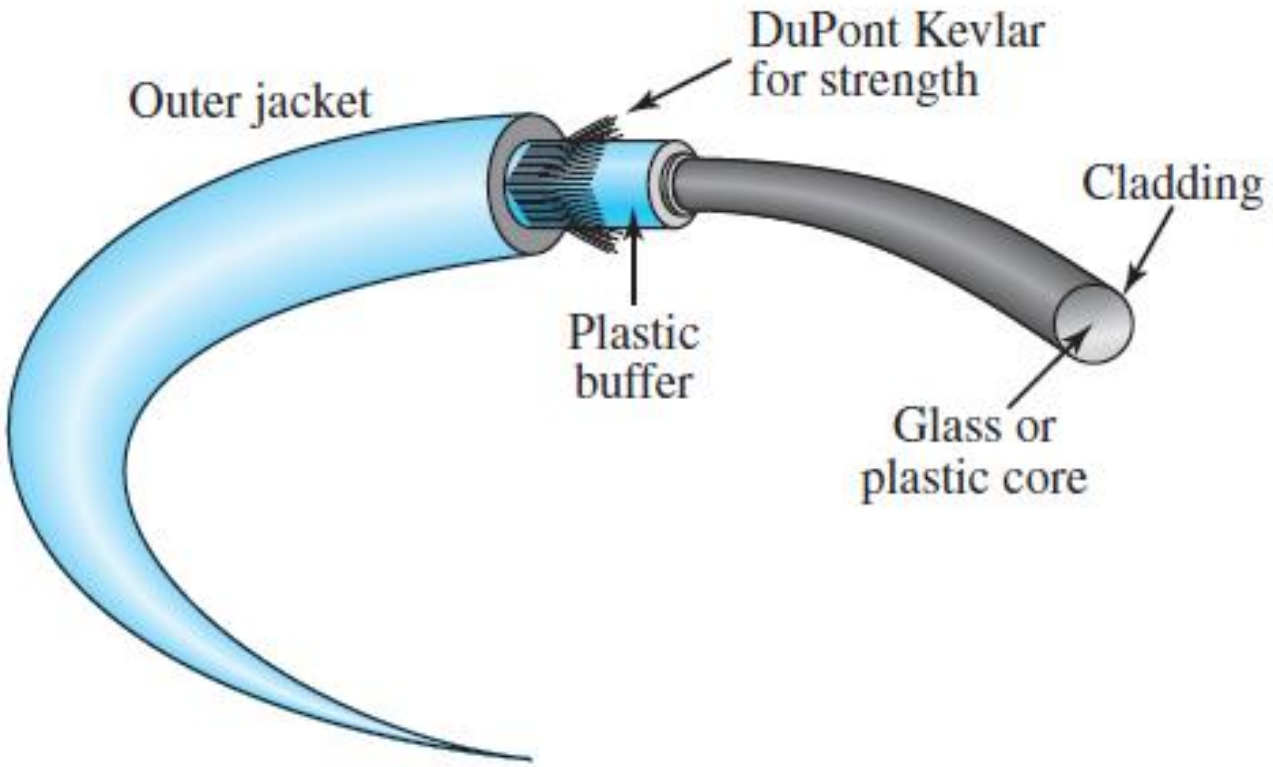
- The word index here refers to the index of refraction
- Density is highest at the center of the core and decreases gradually to its lowest at the edge

Fiber size

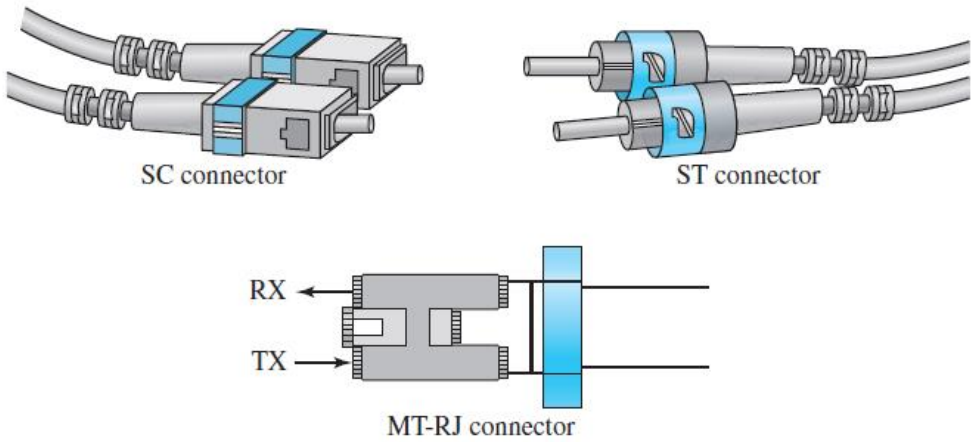
Type	*Core (µm)*	*Cladding (µm)*	*Mode*
501125	50.0	125	Multimode, graded index
62.51125	62.5	125	Multimode, graded index
100/125	100.0	125	Multimode, graded index
7/125	7.0	125	Single mode



Fiber Cable Composition



Fiber-cable connector



- The subscriber channel (SC) connector is used for cable TV

  It uses a push/pull locking system.
- The straight-tip (ST) connector is used for connecting cable to networking devices. It uses a bayonet locking system and is more reliable than SC.
- MT-RJ is a connector that is the same size as RJ45

Optical fiber Application

- Use in backbone network
- 45mbps to 9.6gbps speed using single wavelength transmission.
- SONET network
- Cable TV use hybrid network

Advantages:

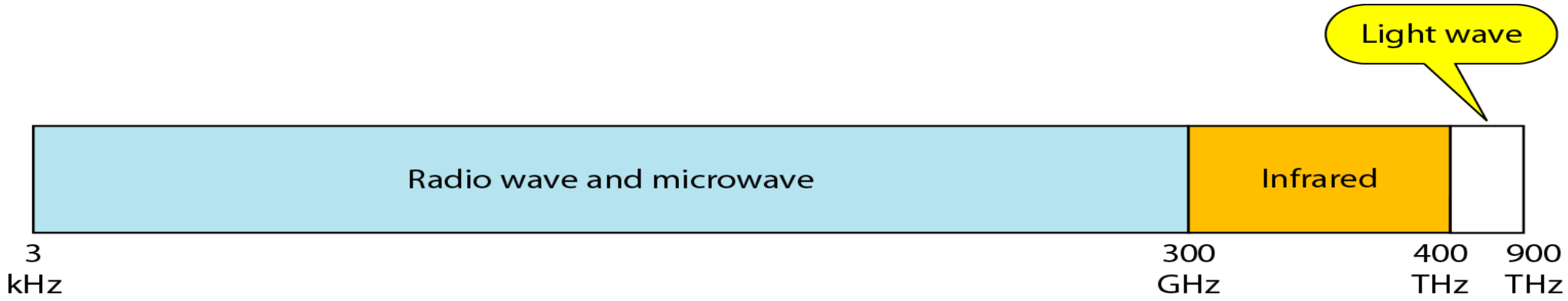
- Higher bandwidth
- Less signal attenuation
- Fiber-optic transmission distance is significantly greater than that of other guided media.
- A signal can run for 50 km without requiring regeneration.
- Immunity to electromagnetic interference
- Resistance to corrosive materials. Glass is more resistant to corrosive materials than copper
- Light weight. Fiber-optic cables are much lighter than copper cables.
- Greater immunity to tapping.

Disadvantages

- *Installation and maintenance:* Fiber-optic cable is a relatively new technology. Its installation and maintenance require expertise that is not yet available everywhere.
- *Unidirectional light propagation:* Propagation of light is unidirectional. If we need bidirectional communication, two fibers are needed.
- *Cost :* The cable and the interfaces are relatively more expensive than those of other guided media

Unguided Media

Unguided media transport electromagnetic waves without using a physical conductor. This type of communication is often referred to as wireless communication.



Electromagnetic spectrum for wireless communication

Propagation methods

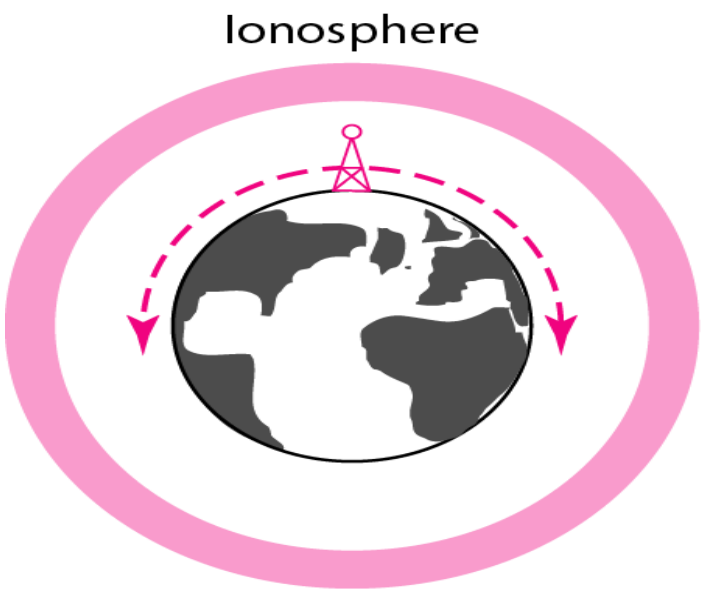
Unguided signals can travel from the source to destination in several ways

- **Ground propagation:** travel though lowest portion, signals emanate in all directions

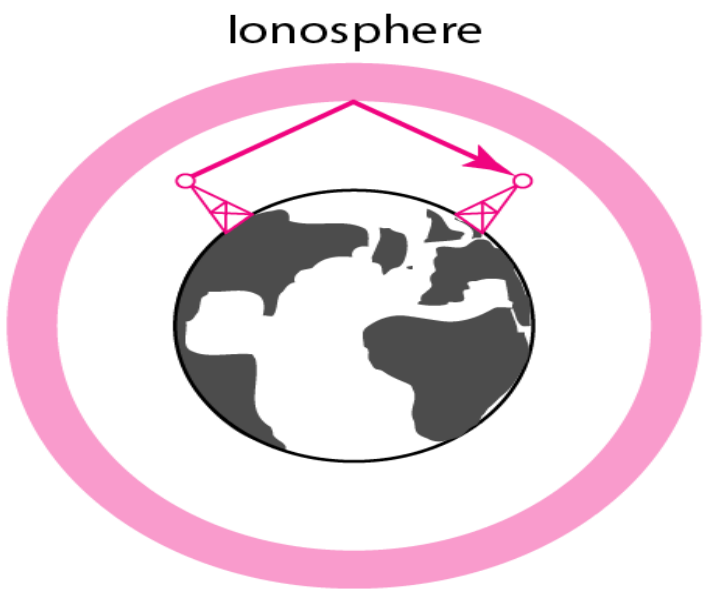
- **Sky propagation:** higher-frequency radio waves radiate upward into the ionosphere where they are reflected back to earth. This type of transmission allows for greater distances with lower output power.

- **Line – of – sight propagation:** very high frequency signals are transmitted in straight lines directly from antenna to antenna

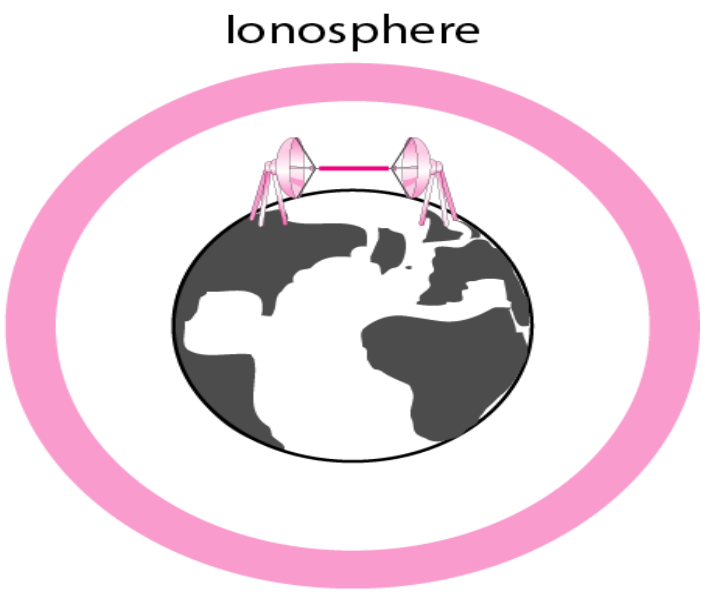
Propagation methods



Ground propagation
(below 2 MHz)



Sky propagation
(2–30 MHz)

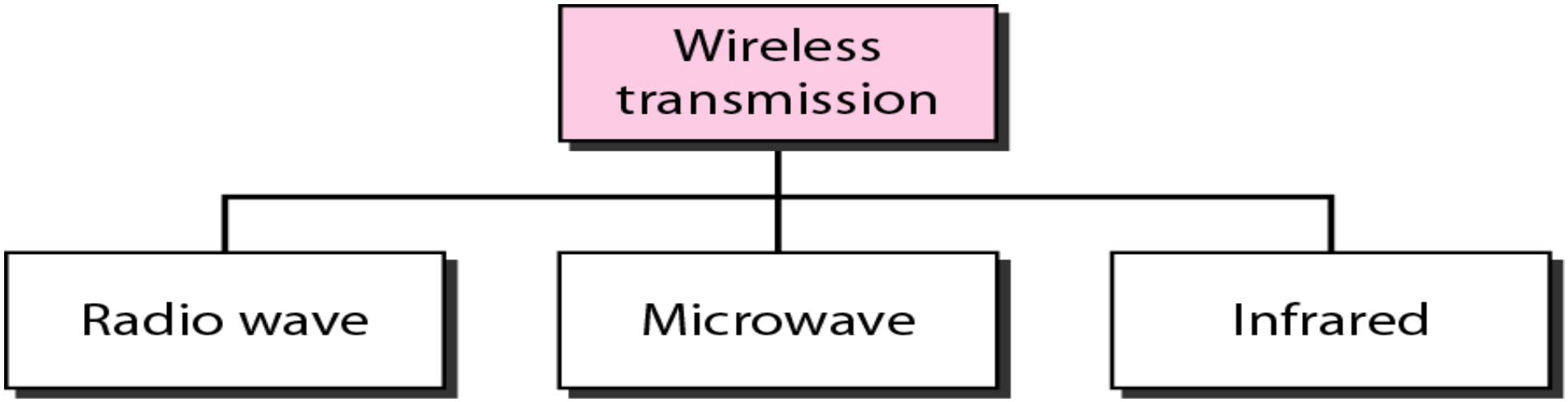


Line-of-sight propagation
(above 30 MHz)

Electromagnetic spectrum Bands

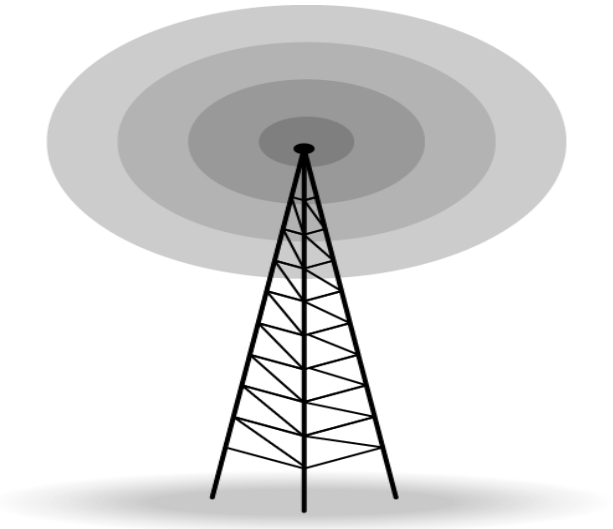
Band	*Range*	*Propagation*	*Application*
VLF (very low frequency)	3–30 kHz	Ground	Long-range radio navigation
LF (low frequency)	30–300 kHz	Ground	Radio beacons and navigational locators
MF (middle frequency)	300 kHz–3 MHz	Sky	AM radio
HF (high frequency)	3–30 MHz	Sky	Citizens band (CB), ship/aircraft 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



Radio Waves

- Electromagnetic waves ranging in frequencies between 3kHz and 1GHz
- Omnidirectional antenna
- When antenna transmits radio waves, they are propagated in all directions
- No aligned
- Signal may interference by another antenna
- It can penetrate walls
- Used for multicasting, AM and FM radio, cordless

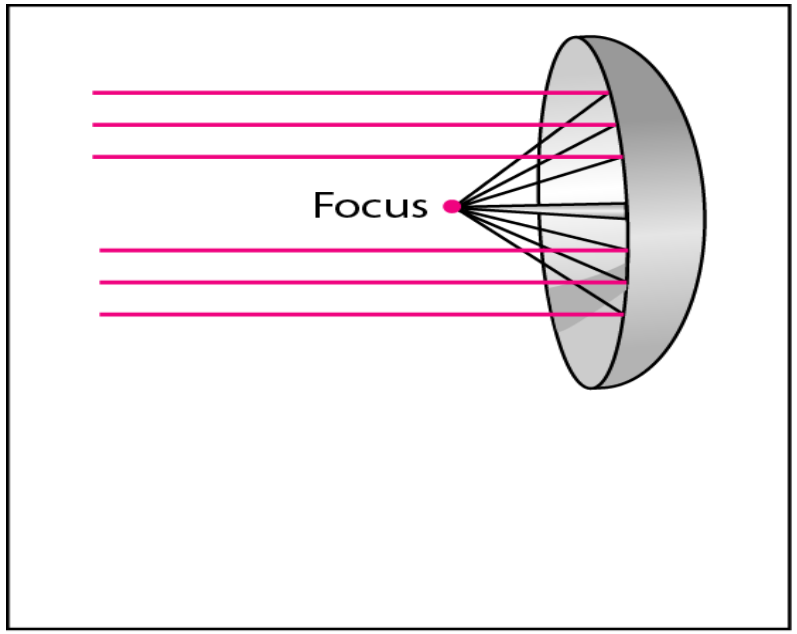


Micro Waves

- Electromagnetic waves ranging in frequencies between 1GHz – 300 GHz
- Microwaves are unidirectional
- Sending and receiving antennas need to be aligned
- Microwave propagation is line-of-sight.
- Very High frequency microwaves can not penetrate walls
- Wider sub bands can be assigned, high data rate possible
- Use of certain portions of the band requires permission from authorities

Unidirectional antennas

- Two types of antennas: parabolic dish and horn

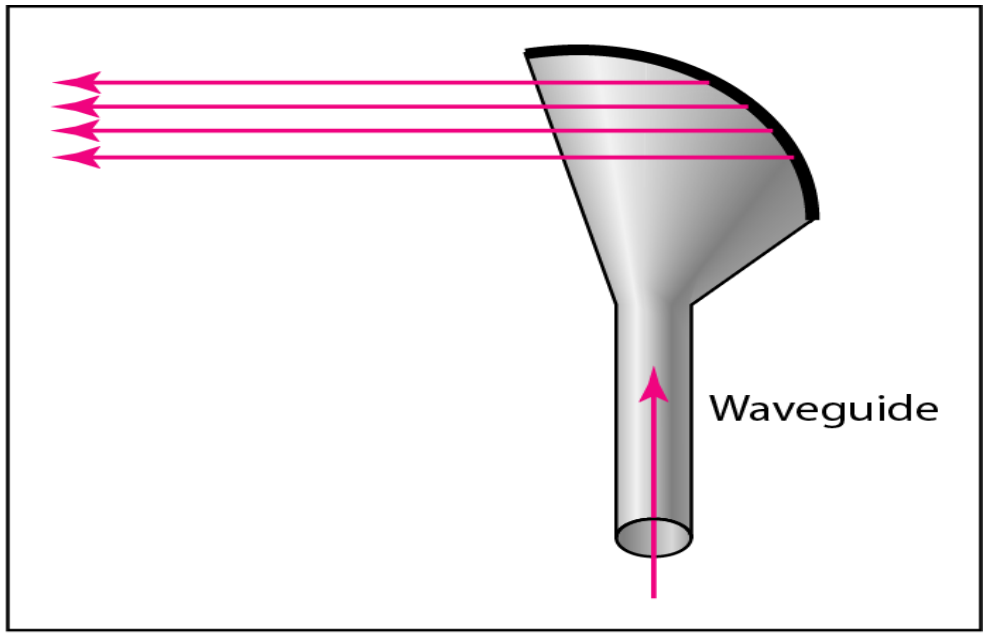


a. Dish antenna

Dish Antenna

- Every line parallel to the line of symmetry reflects off the curve at angles such that all line intersect in a common point called the focus.
- Work as funnel
- Catch wide range of waves and directing them in common point.
- More signal is recovered

Unidirectional antennas

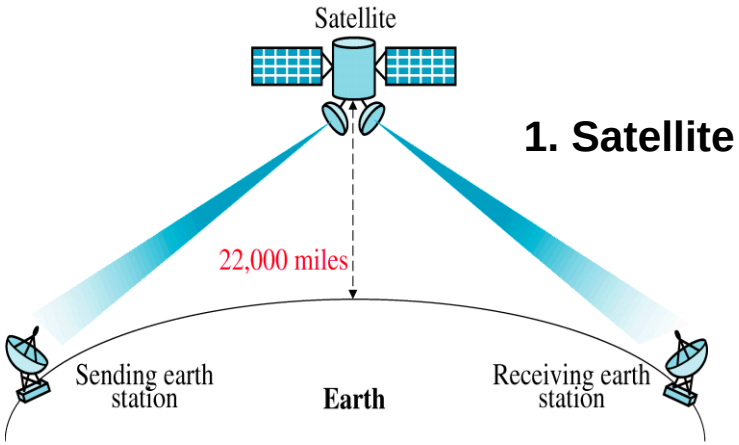


b. Horn antenna

Horn Antenna

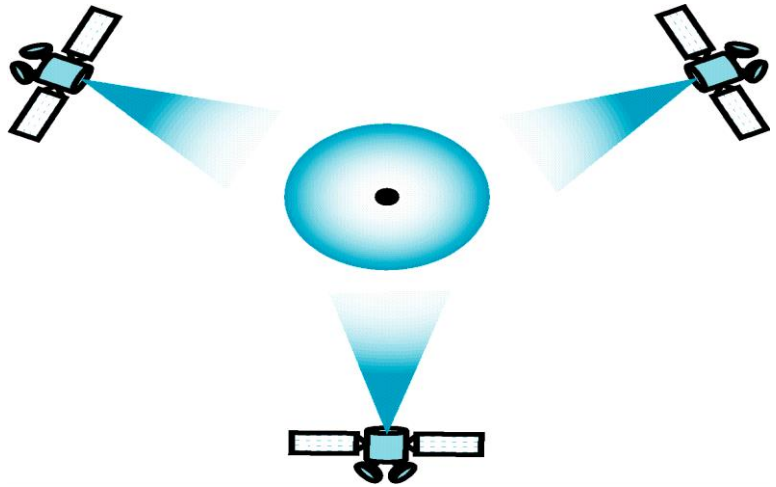
- Looks like gigantic scoop
- Outgoing transmissions deflected outward in series of narrow parallel beams by curved head.

Microwave Applications

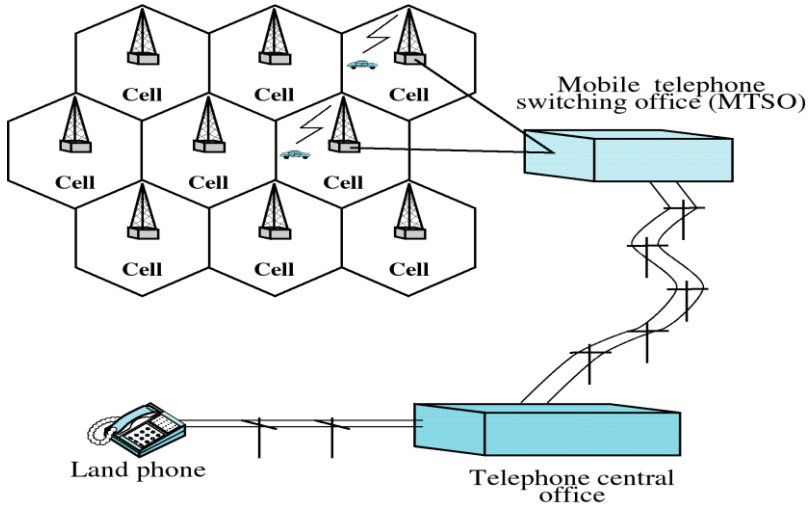


1. Satellite Communication

2. GEO



3. Cellular system



Infrared

- 300GHz to 400GHz
- Wavelength: 1mm to 770 nm
- Used for short range communication
- High frequency
- Can not penetrate wall
- Infrared remote control
- Useless for long communication
- Can not use outside the building

Infrared- Application

- 400THz-Infrared signals can be used for short-range communication in a closed area using line-of-sight propagation
- Excellent potential for data transmission.
- IrDA(Infrared Data Association)
- Keyboard, mice, PCs and printer.
- Infrared signals defined by IrDA transmit through line of sight, the IrDA port on the keyboard needs to point to the PC for transmission to occur.
- 75kbps to 4Mbps.

Selection of Transmission Media

Factors:

- Transmission Rate
- Cost and ease of Installation
- Resistance to environmental condition
- Distance between sender and receiver

QUESTIONS?

1) State the types of Guided media.
2) What is the effect of twisting the wires in UTP Cables.
3) What is the advantages of using shielding?
4) Compare the guided transmission media.
5) Explain the difference between UTP and STP.
6) Explain optical fiber propagation mode in detail.
7) State advantages of optical fiber cable.
8) State the three ways of wireless transmission media.
9) Write a note on: microwave communication.
10) State and discuss various types of connectors.

THANK YOU