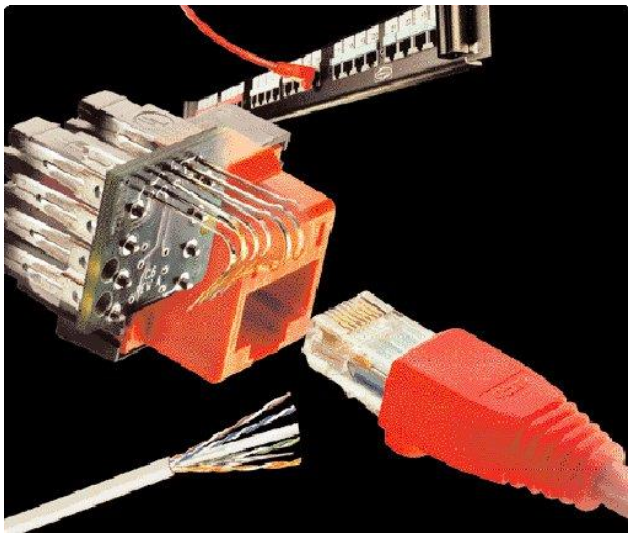
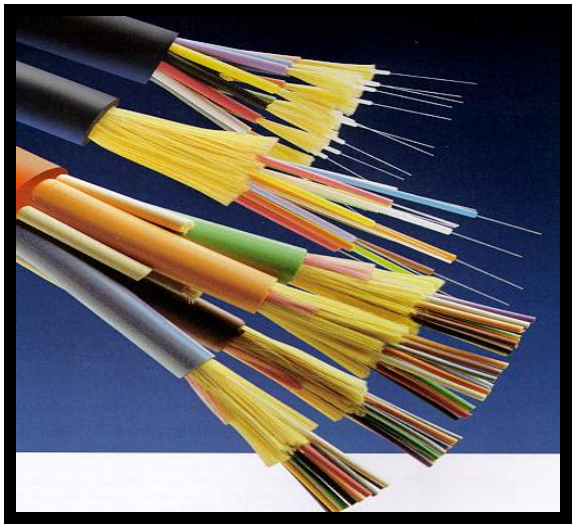
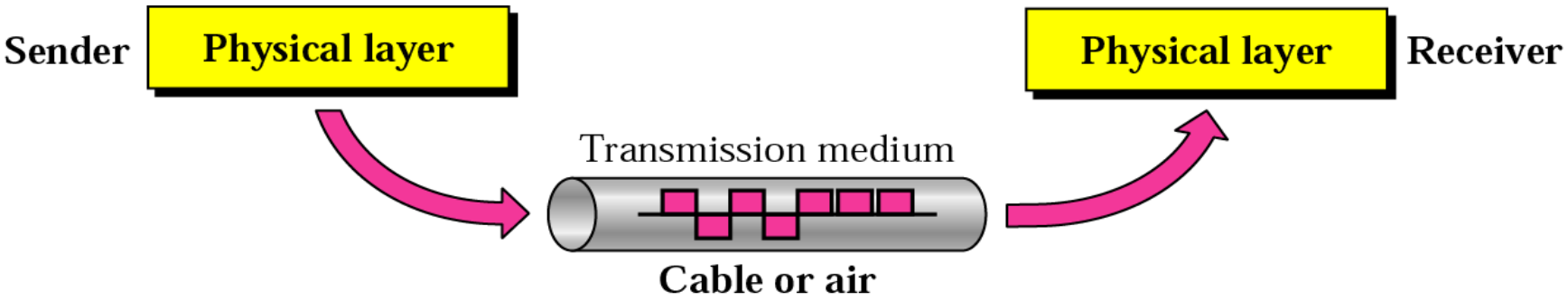
PHYSICAL MEDIA

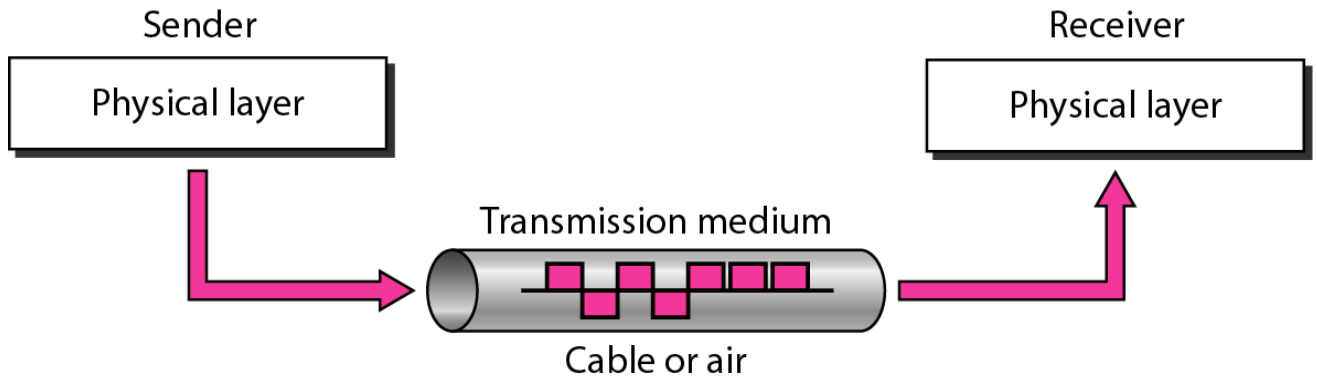


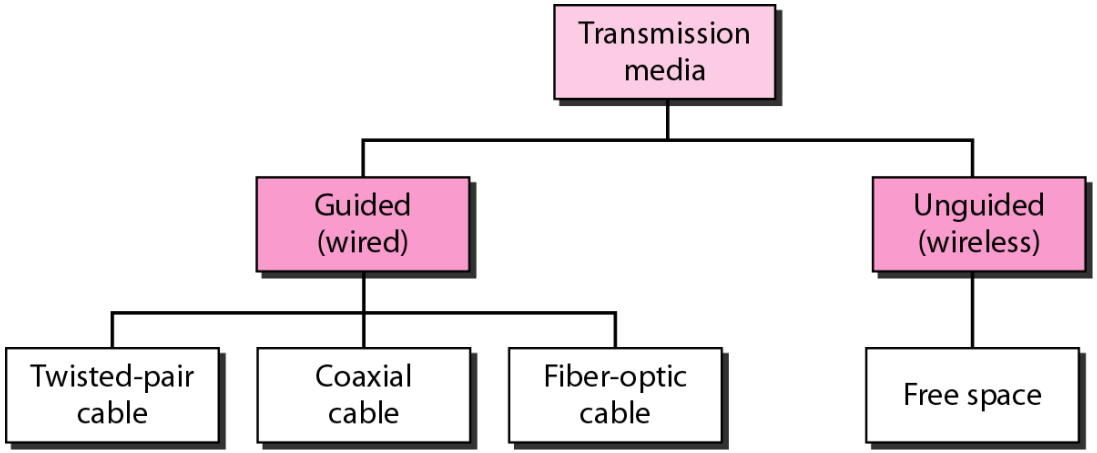


Physical Media



Physical Media



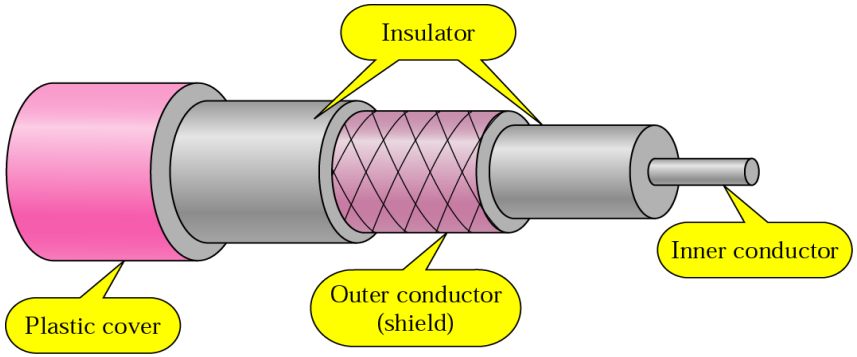


Physical Media

- **Copper**
  - Coaxial Cable - Thick or Thin
  - Unshielded Twisted Pair - CAT 3,4,5,5e&6
- **Optical Fiber**
  - Multimode
  - Singlemode
- **Wireless**
  - Short Range
  - Medium Range (Line of Sight)
  - Satellite

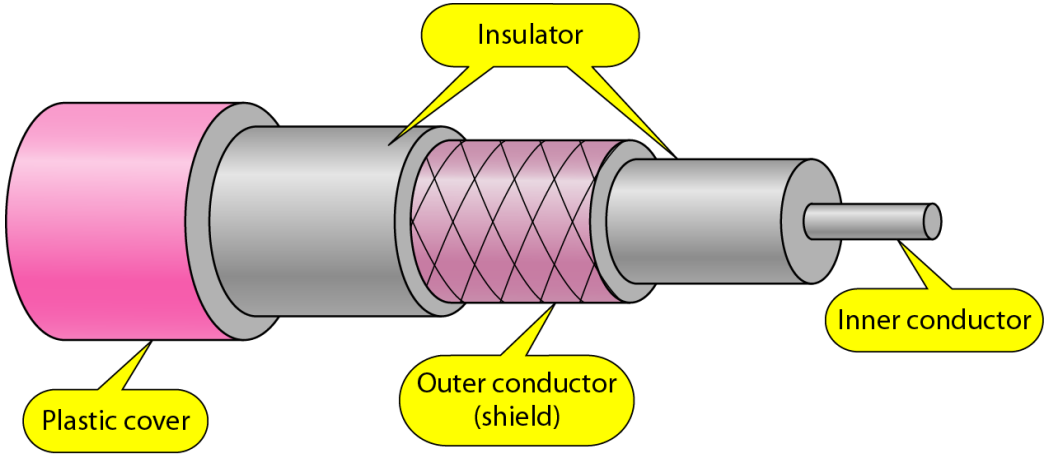
Copper Media: Coaxial Cable

- Coaxial cable is a copper-cored cable surrounded by a heavy shielding and is used to connect computers in a network.
- Outer conductor shields the inner conductor from picking up stray signal from the air.
- High bandwidth but lossy channel.
- Repeater is used to regenerate the weakened signals.



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

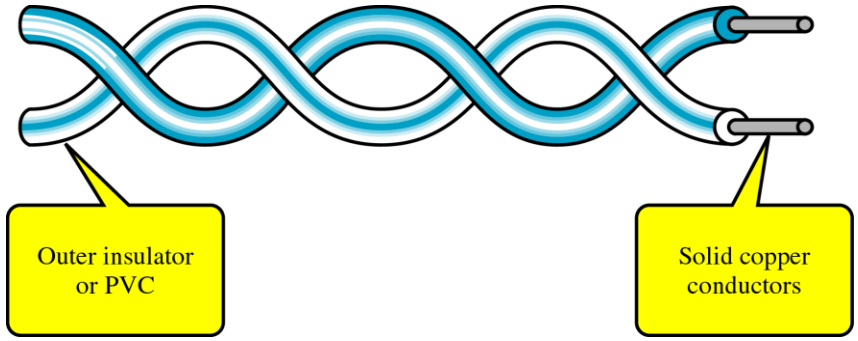
Copper Media: Coaxial Cable



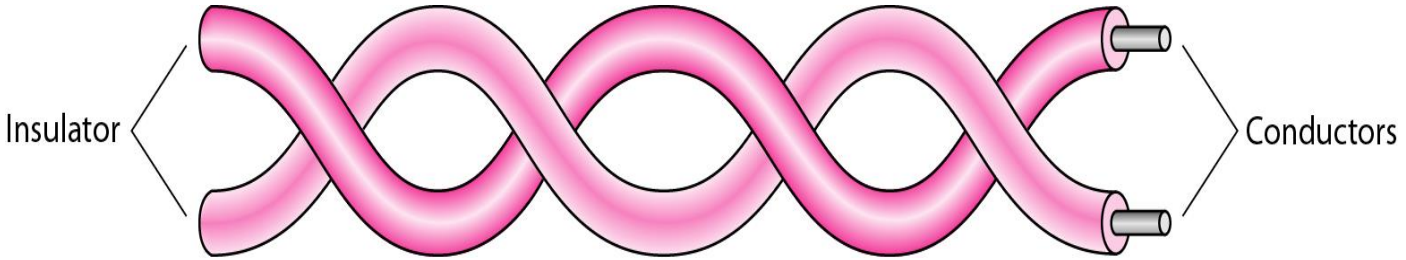
Category	*Impedance*	*Use*
RG-59	75 Ω	Cable TV
RG-58	50 Ω	Thin Ethernet
RG-11	50 Ω	Thick Ethernet

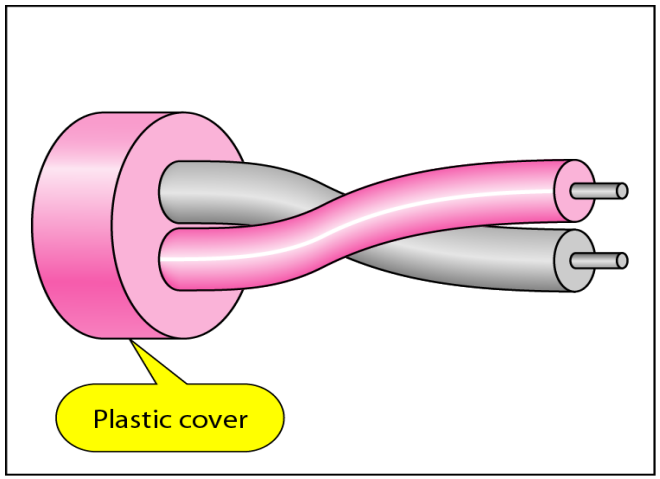
Copper Media: Twisted Pair

- Twisted-pair is a type of cabling that is used for telephone communications and most modern Ethernet networks.
- A pair of wires forms a circuit that can transmit data. The pairs are twisted to provide protection against crosstalk, the noise generated by adjacent pairs.
- There are two basic types, shielded twisted-pair (STP) and unshielded twisted-pair (UTP).

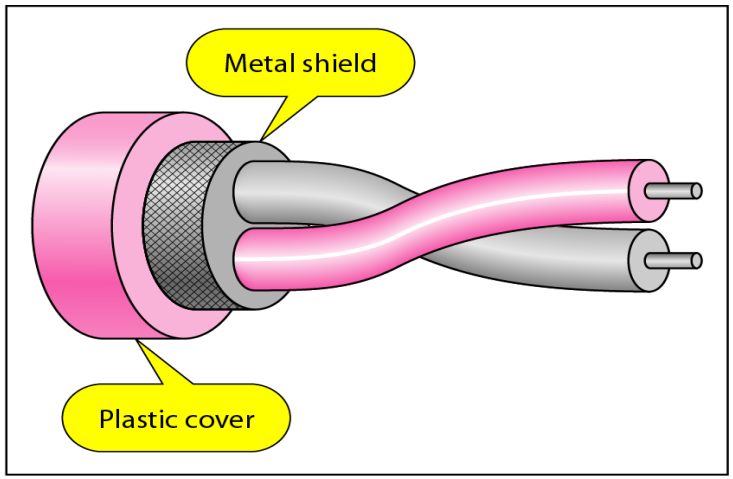


Copper Media: Twisted Pair



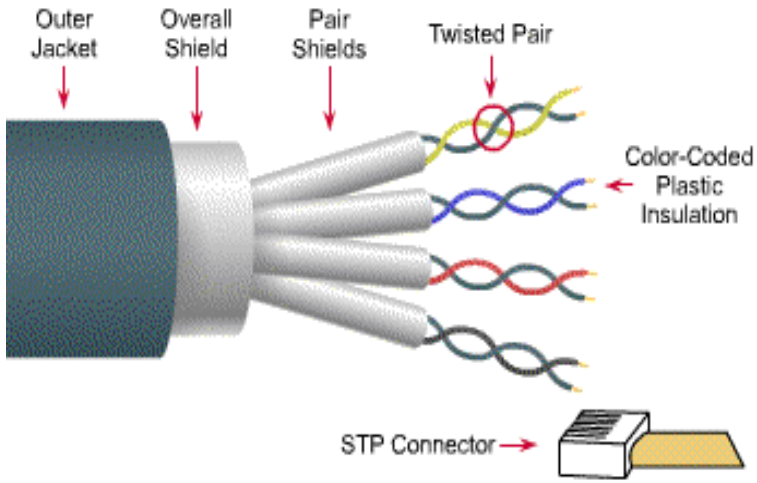


a. UTP



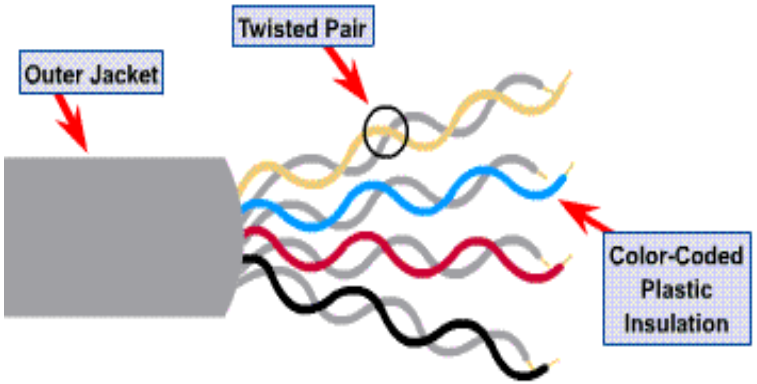
b. STP

Shielded Twisted Pair (STP)



- Speed and throughput: 10-100 Mbps
- Cost per node: Moderately expensive
- Media and connector size: Medium to Large
- Maximum cable length: 100m (short)

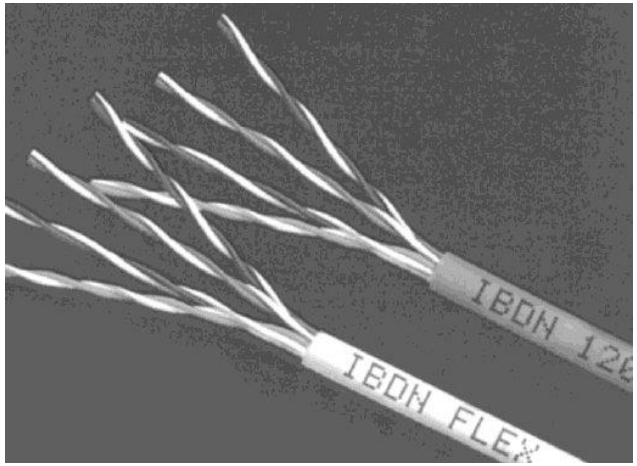
Unshielded Twisted Pair (UTP)

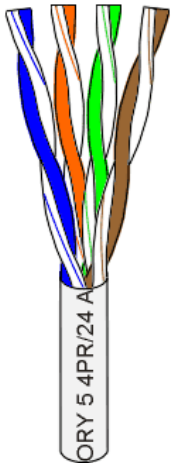


- Speed and throughput: 10-100 Mbps
- Cost per node: Least Expensive
- Media and connector size: Small
- Maximum cable length: 100m (short)

Unshielded Twisted Pair (UTP)

- Consists of 4 pairs (8 wires) of insulated copper wires typically about 1 mm thick.
- The wires are twisted together in a helical form.
- Twisting reduces the interference between pairs of wires.
- High bandwidth and High attenuation channel.
- Flexible and cheap cable.
- Category rating based on number of twists per inch and the material used
- CAT 3, CAT 4, CAT 5, Enhanced CAT 5 and now CAT 6.





Categories of UTP

- UTP comes in several categories that are based on the number of twists in the wires, the diameter of the wires and the material used in the wires.
- Category 3 is the wiring used primarily for telephone connections.
- Category 5e and Category 6 are currently the most common Ethernet cables used.

Categories of UTP: CAT 3

- Bandwidth 16 Mhz
- 11.5 dB Attenuation
- 100 ohms Impedance
- Used in voice applications and 10baseT (10Mbps) Ethernet

Categories of UTP: CAT 4

- 20 MHz Bandwidth
- 7.5 dB Attenuation
- 100 ohms Impedance
- Used in 10baseT (10Mbps) Ethernet

Categories of UTP: CAT 5

- 100 MHz Bandwidth
- 24.0 dB Attenuation
- 100 ohms Impedance
- Used for high-speed data transmission
- Used in 10BaseT (10 Mbps) Ethernet & Fast Ethernet (100 Mbps)

Categories of UTP: CAT 5e

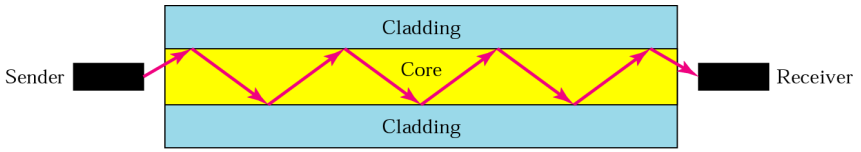
- 150 MHz Bandwidth
- 24.0 dB Attenuation
- 100 ohms Impedance
- Transmits high-speed data
- Used in Fast Ethernet (100 Mbps), Gigabit Ethernet (1000 Mbps) & 155 Mbps ATM

Categories of UTP: CAT 6

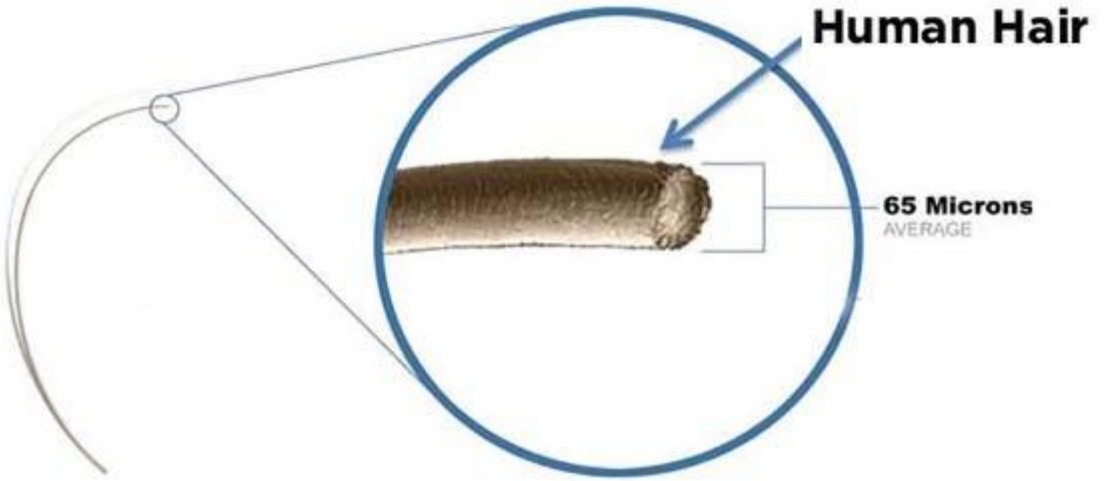
- 250 MHz Bandwidth
- 19.8 dB Attenuation
- 100 ohms Impedance
- Transmits high-speed data
- Used in Gigabit Ethernet (1000 Mbps) & 10 Gig Ethernet (10000 Mbps)

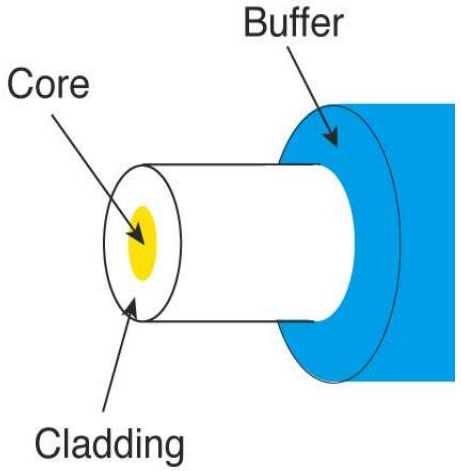
Fiber Media

- Optical fibers use light to send information through the optical medium.
- It uses the principal of total internal reflection.
- Modulated light transmissions are used to transmit the signal.



Fiber Technology

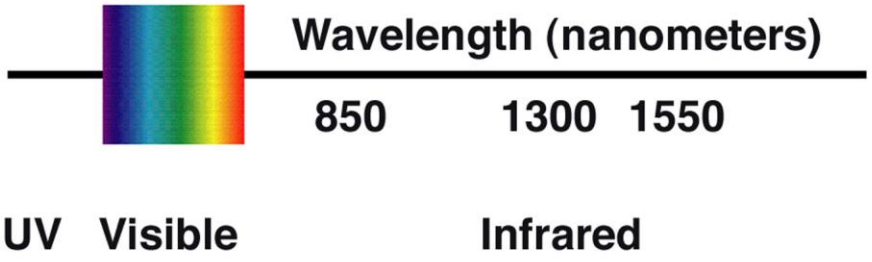




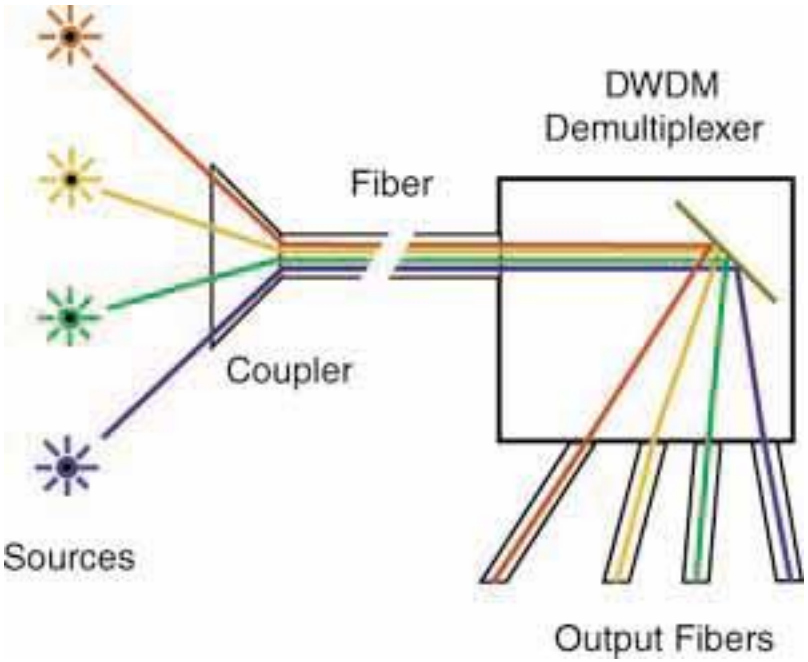
A glass optical fiber is about twice the size of a human hair.

Light Used In Fiber Optics

- Fiber optic systems transmit using infrared light, invisible to the human eye, because it goes further in the optical fiber at those wavelengths.

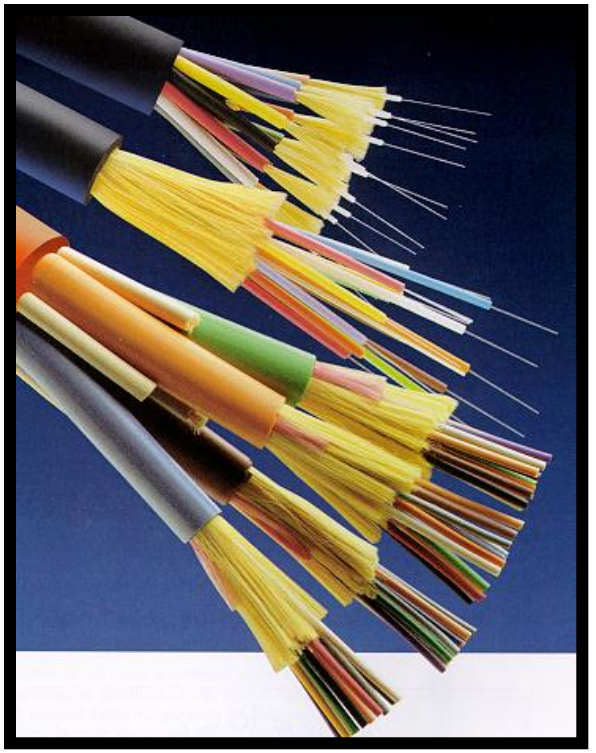


Wavelength-Division Multiplexing Allows Transmitting Multiple Signals



Fiber Optic Cable

- Protects the fibers wherever they are installed
- May have 1 to >1000 fibers



What are optical fibers

- Thin strands of pure glass
- Carry data over long distances
- At very high speeds
- Fiber can be bent or twisted

Fiber optic technology

- Sources
- Transmission medium
- Detectors

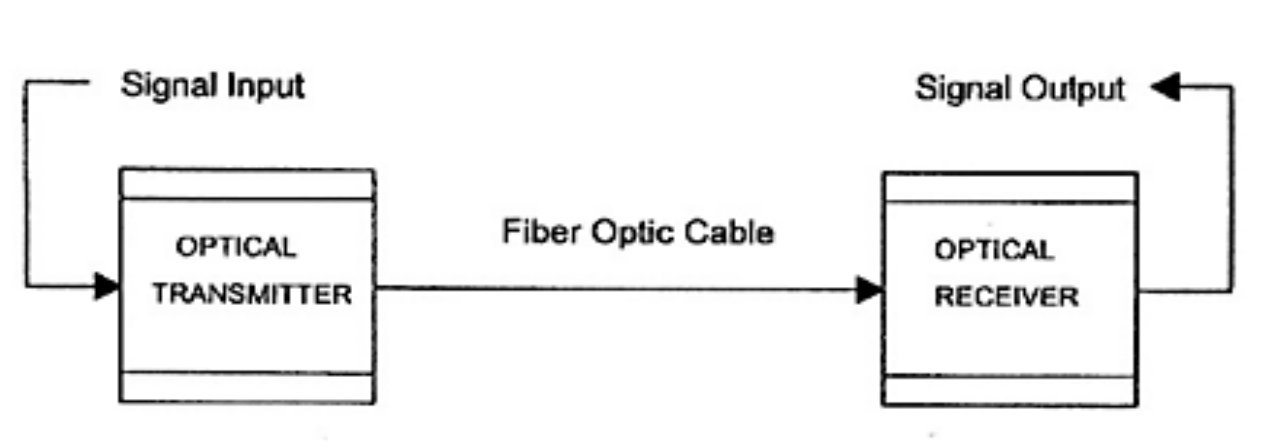
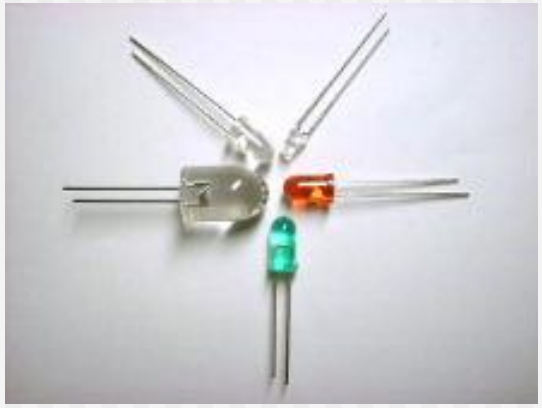
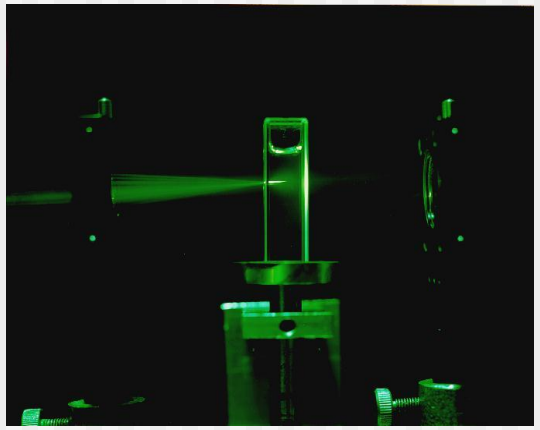


Fig: The fiber optic communication system

Sources of light

- Light emitting diodes
- Lasers



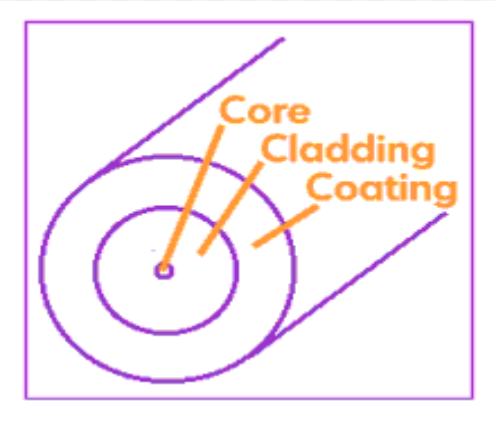


Sources

- Modulate electrical signals into optical signals
- Mostly modulate at 850nm, 1300nm and 1550 nm
- Lasers give high intensity, high frequency light
- LEDs are economical

Transmission medium

- Optical fiber is replacing copper
- Light is used as the carrier of information
- Much higher data rate



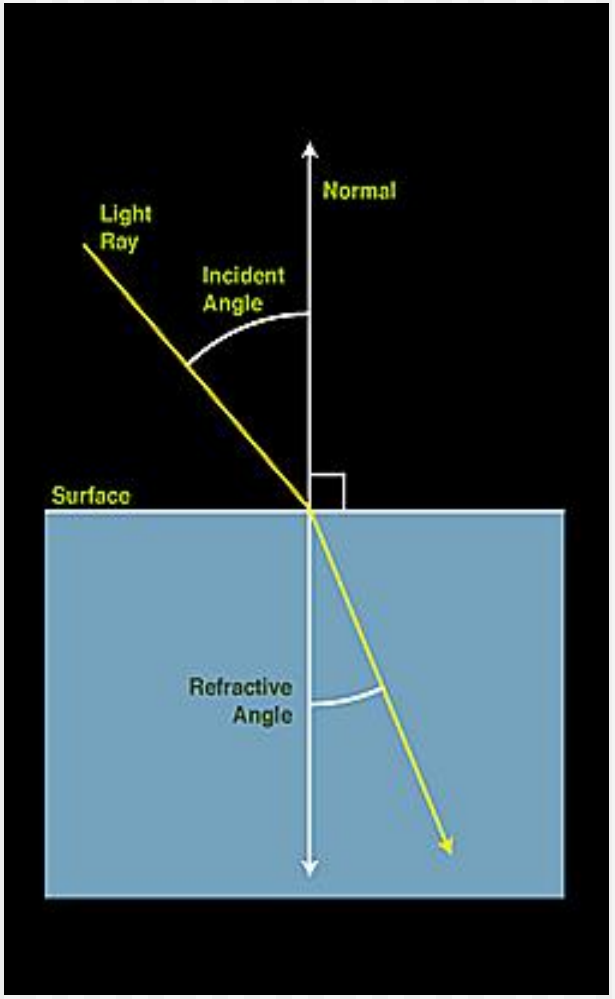
The optical fiber

Physics of optical fibers

- Index of refraction of material : ratio of speed of light in vacuum to speed of light in medium
- Refraction of light : bending of light as it travels from one media to another

Refraction of light

- Speed of light changes as it across the boundary of two media
- Angles w.r.t normal



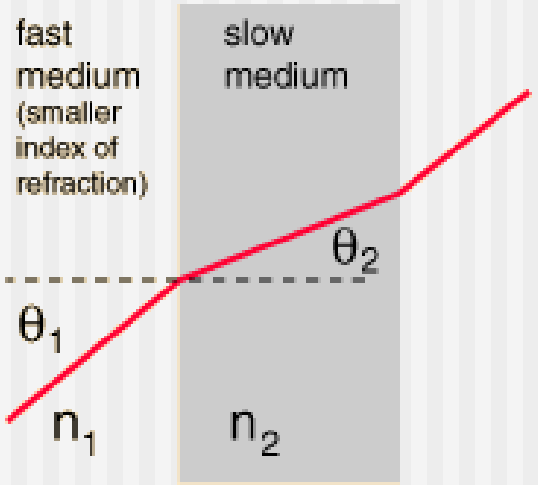
Refraction Indices

- Vacuum…….1.00000 (exactly)
- Air ……1.00029
- Alcohol ……1.329
- Diamond …… 2.417
- Glass …….. 1.5
- Ice ……. 1.309
- Sodium Chloride (Salt) …. 1.544
- Sugar Solution (80%) …….. 1.49
- Water (20 C) …….. 1.333

Snell's Law

Snell's Law

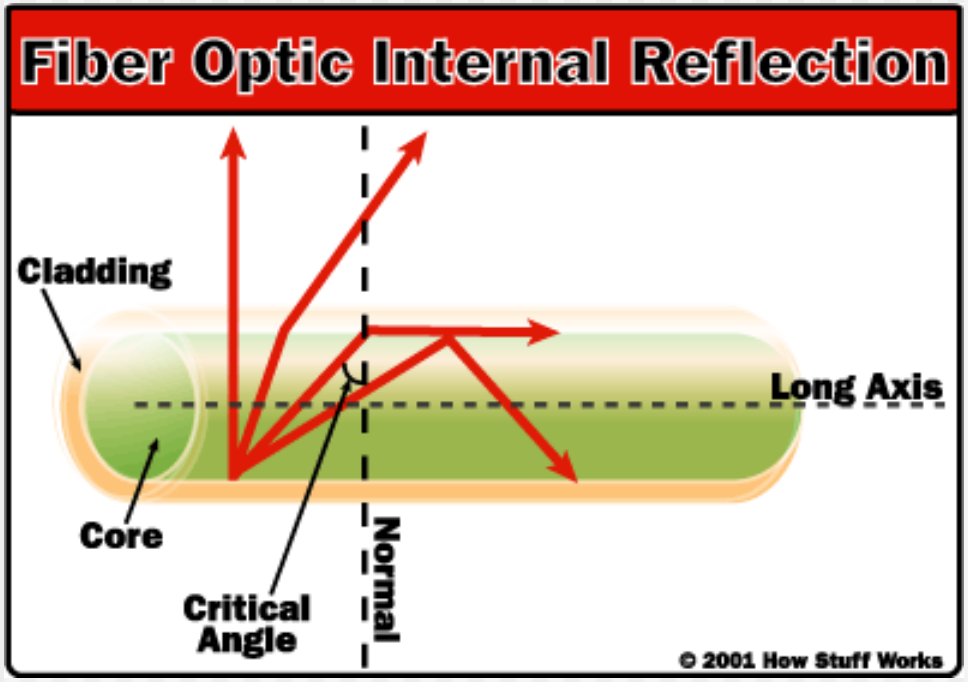
$$\frac{n_1}{n_2} = \frac{\sin\theta_2}{\sin\theta_1}$$



- Critical angle: Angle of incidence at which angle of refraction = 90^0

Total internal reflection

- Trapping light in the fiber



Fibers can be bent!!

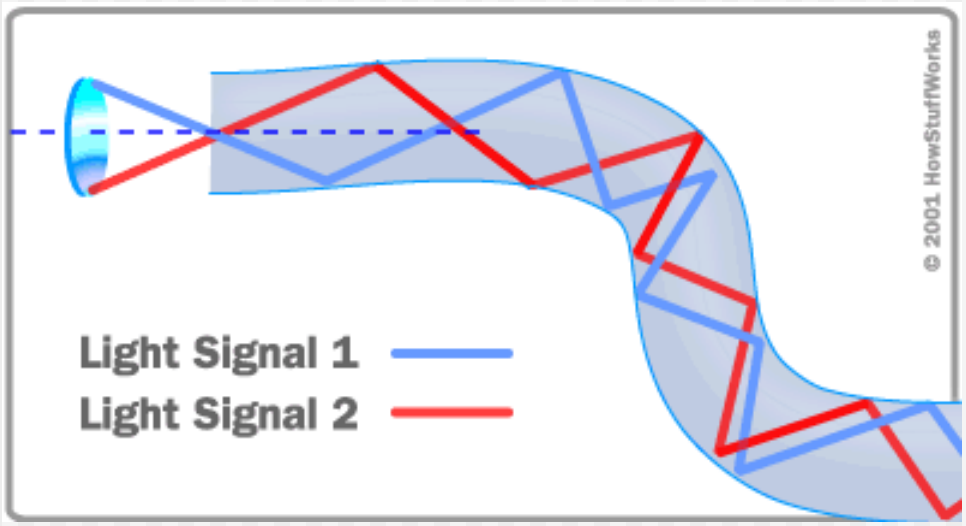


Fig: Illustration of total internal reflection

Types of optical fibers

- Single mode
  - only one signal can be transmitted
  - use of single frequency
- Multi mode
  - Several signals can be transmitted
  - Several frequencies used to modulate the signal

Splices and Connectors

- To connect to fibers mechanically or by fusion
- Lot of signal loss possible
- Very accurate alignment necessary
- Most important cost factor
- Now being replaced by optical amplifiers

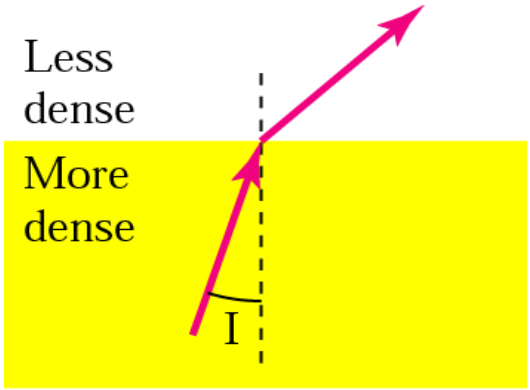
Optical Receivers

- Must be very sensitive
- Capable of picking up and amplifying signals of nanowatts
- Photodiodes and phototransistors
- These devices get ‘turned ON’ by light
- Produce photocurrent

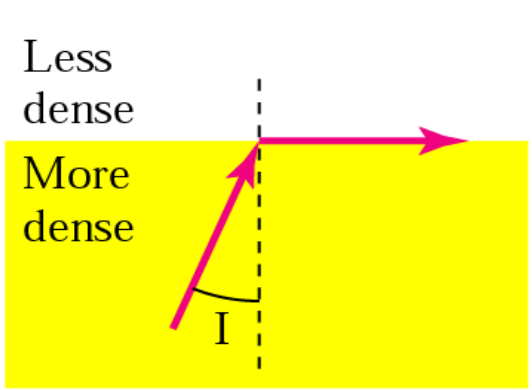
Advantages of optical fibers

- Can carry much more information
- Much higher data rates
- Much longer distances than co-axial cables
- Immune to electromagnetic noise
- Light in weight
- Unaffected by atmospheric agents

Total Internal Reflection



I < critical angle,
refraction



I = critical angle,
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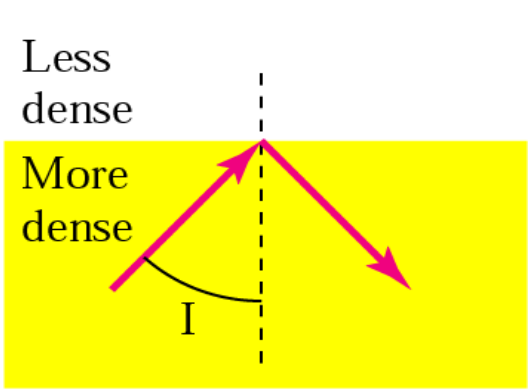


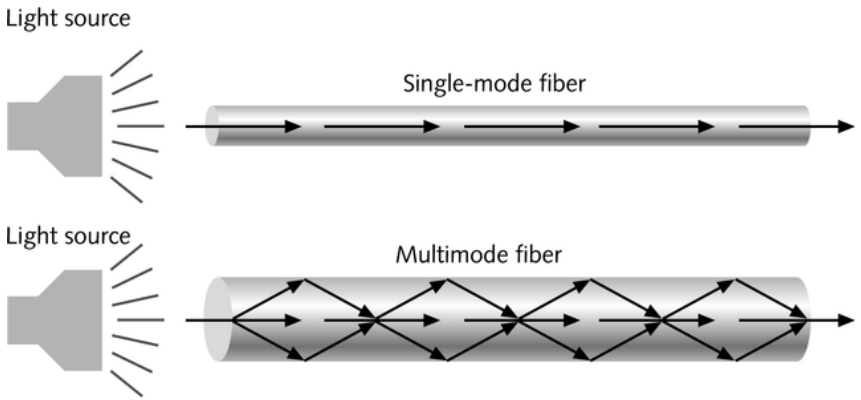
I > critical angle,
reflection

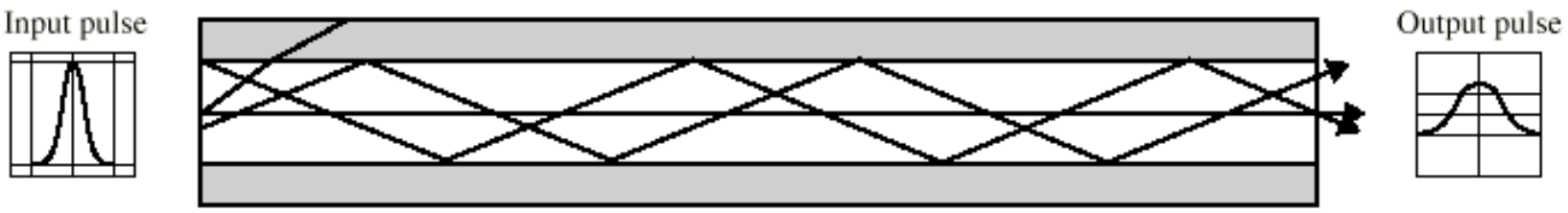
Fiber Media

- **Light travels through the optical media by the way of total internal reflection.**
- **Modulation scheme used is intensity modulation.**
- **Two types of Fiber media :**
  - Multimode
  - Singlemode
- **Multimode Fiber can support less bandwidth than Singlemode Fiber.**
- **Singlemode Fiber has a very small core and carry only one beam of light. It can support Gbps data rates over > 100 Km without using repeaters.**

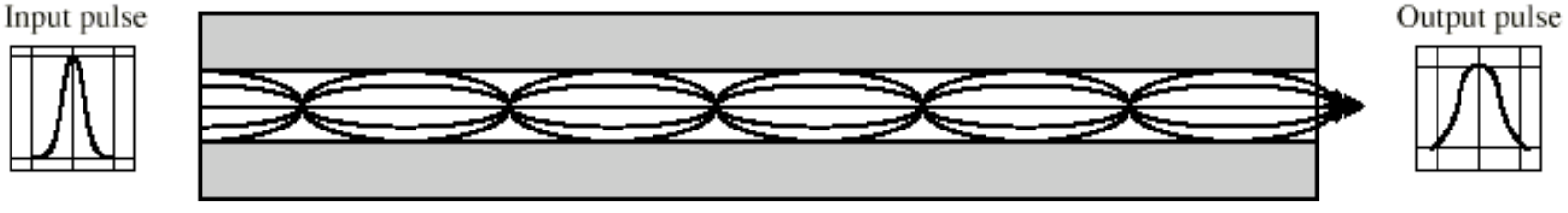
Single and Multimode Fiber

- **Single-mode fiber**
  - Carries light pulses along single path
  - Uses Laser Light Source
- **Multimode fiber**
  - Many pulses of light generated by LED travel at different angles





(a) Step-index multimode



(b) Graded-index multimode

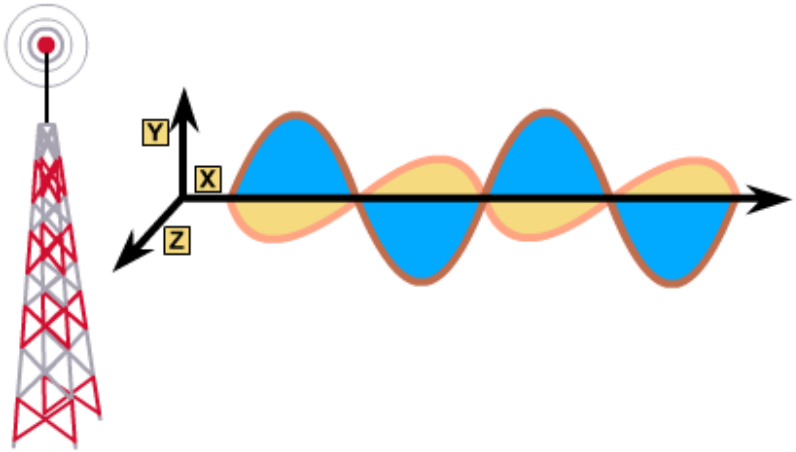
(c) Single mode

Fiber Media

- The bandwidth of the fiber is limited due to the dispersion effect.
- Distance Bandwidth product of a fiber is almost a constant.
- Fiber optic cables consist of multiple fibers packed inside protective covering.
- 62.5/125 µm (850/1310 nm) multimode fiber
- 50/125 µm (850/1310 nm) multimode fiber
- 10 µm (1310 nm) single-mode fiber

Wireless Media

- Very useful in difficult terrain where cable laying is not possible.
- Provides mobility to communication nodes.
- Right of way and cable laying costs can be reduced.
- Susceptible to rain, atmospheric variations and Objects in transmission path.



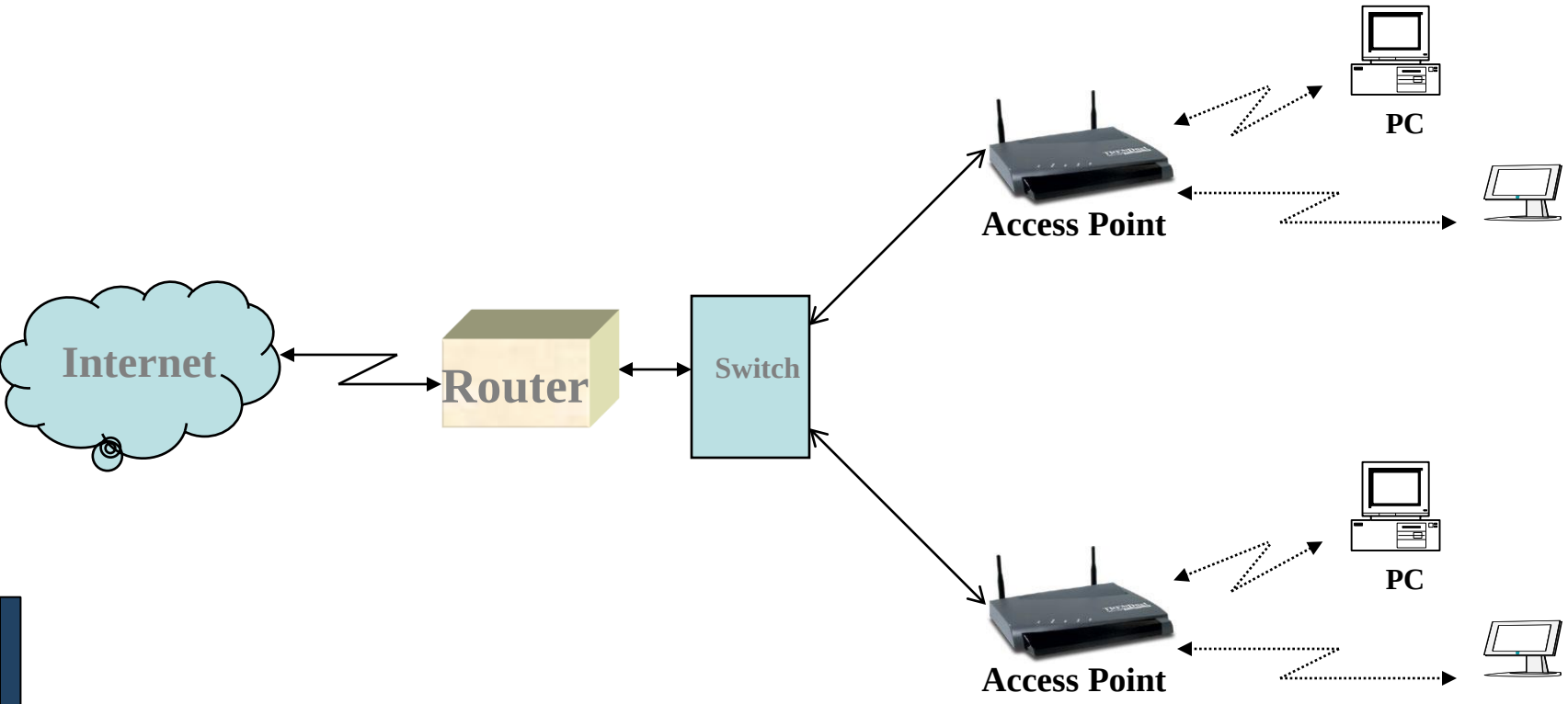
Wireless Media

- Indoor : 10 – 50m : BlueTooth, WLAN
- Short range Outdoor : 50 – 200m: WLAN
- Mid Range Outdoor : 200m – 5 Km : GSM, CDMA, WLAN Point-to-Point, Wi-Max
- Long Range Outdoor : 5 Km – 100 Km : Microwave Point-to-Point
- Long Distance Communication : Across Continents : Satellite Communication

Frequency Bands

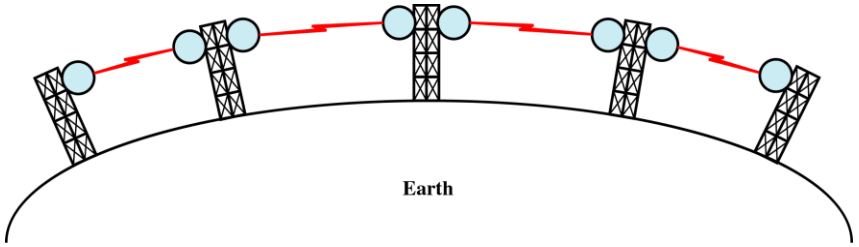
Band	Range	Propagation	Application
VLF	3–30 KHz	Ground	Long-range radio navigation
LF	30–300 KHz	Ground	Radio beacons and navigational locators
MF	300 KHz–3 MHz	Sky	AM radio
HF	3–30 MHz	Sky	Citizens band (CB), ship/aircraft communication
VHF	30–300 MHz	Sky and line-of-sight	VHF TV, FM radio
UHF	300 MHz–3 GHz	Line-of-sight	UHF TV, cellular phones, paging, satellite
SHF	3–30 GHz	Line-of-sight	Satellite communication
EHF	30–300 GHz	Line-of-sight	Long-range radio navigation

Wireless LAN



Terrestrial Microwave

- Microwaves do not follow the curvature of earth
- Line-of-Sight transmission
- Height allows the signal to travel farther
- Two frequencies for two way communication
- Repeater is used to increase the distance Hop-by-Hop



Satellite Communication