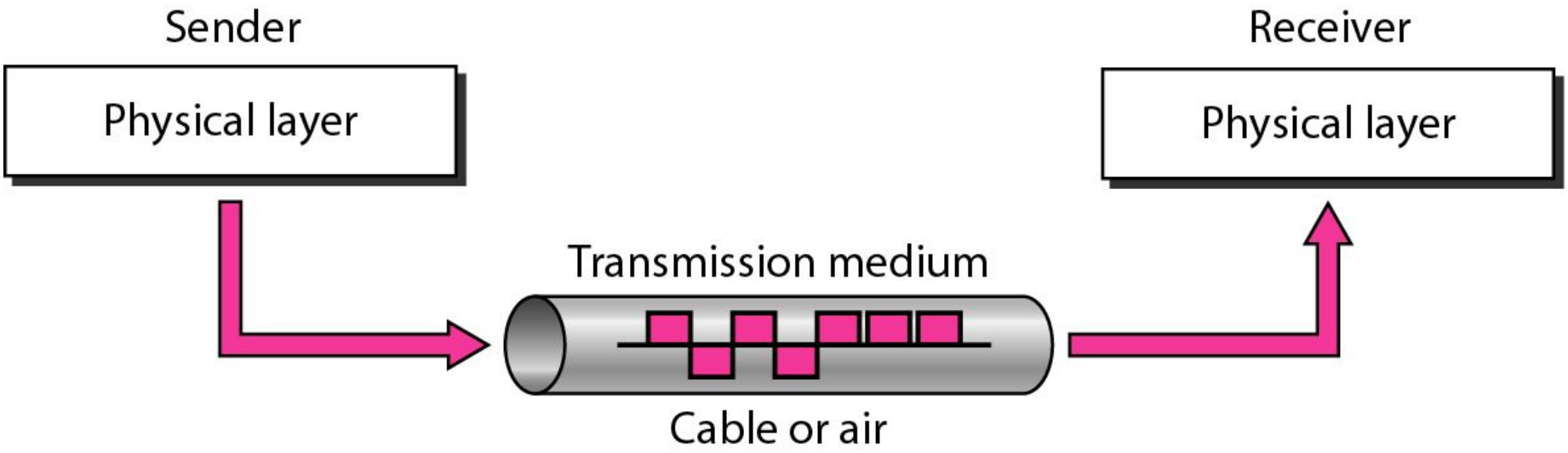
CSE 311: Communication Engineering

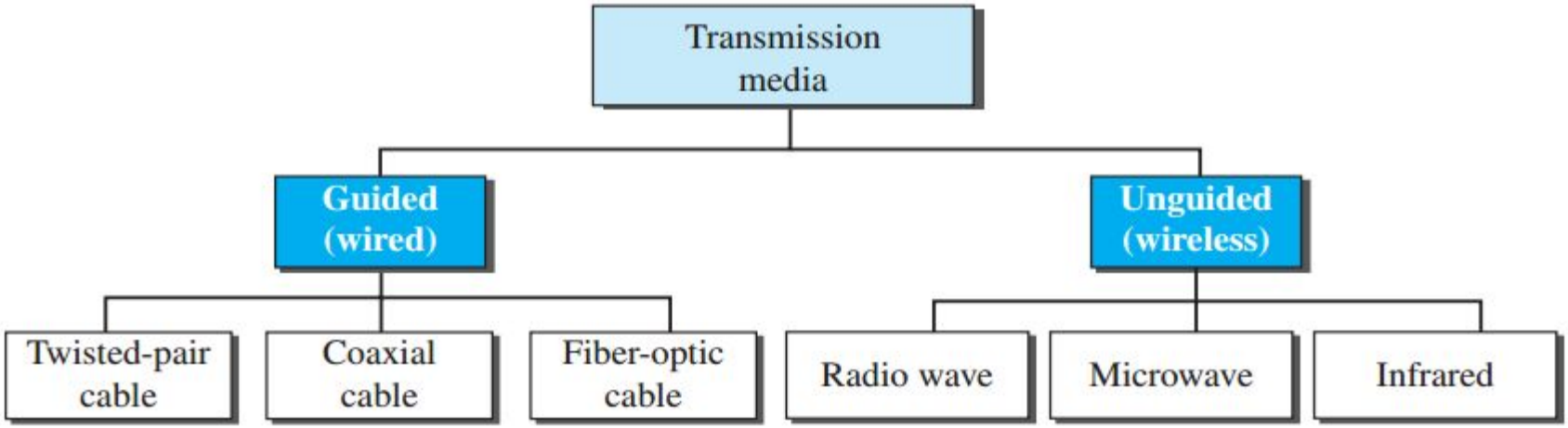
Lecture 3: Transmission Media

Physical Layer



- A transmission medium can be broadly defined as anything that can carry information from a source to a destination

Classes of Transmission Media

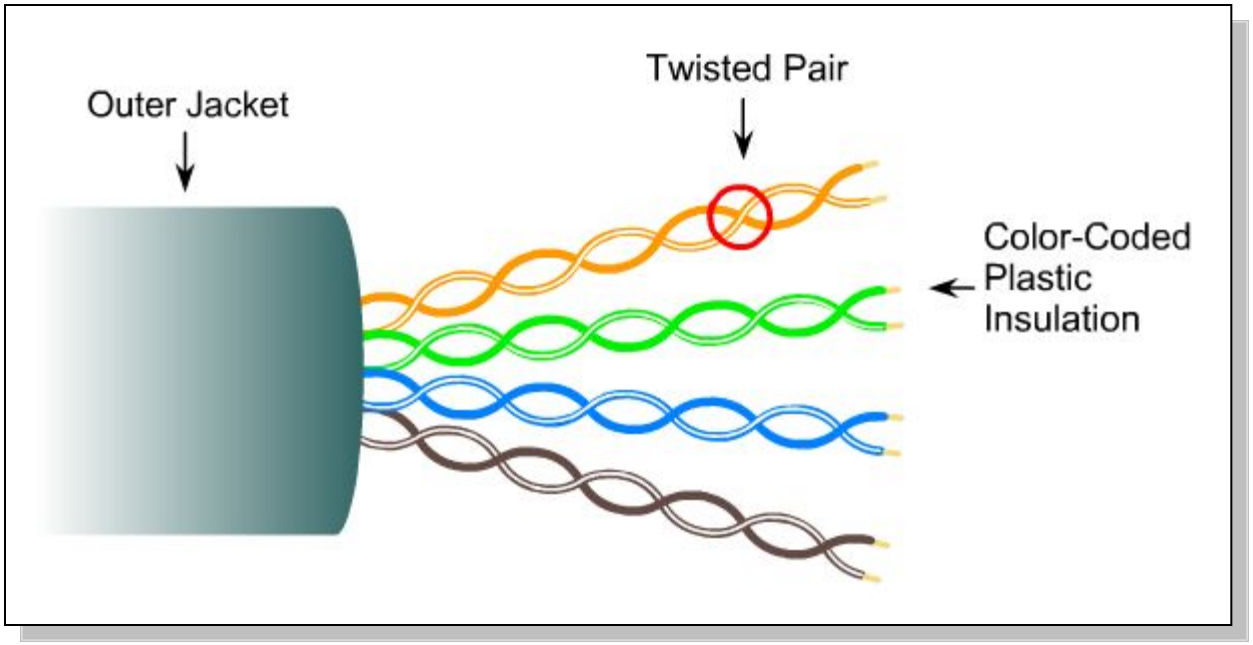


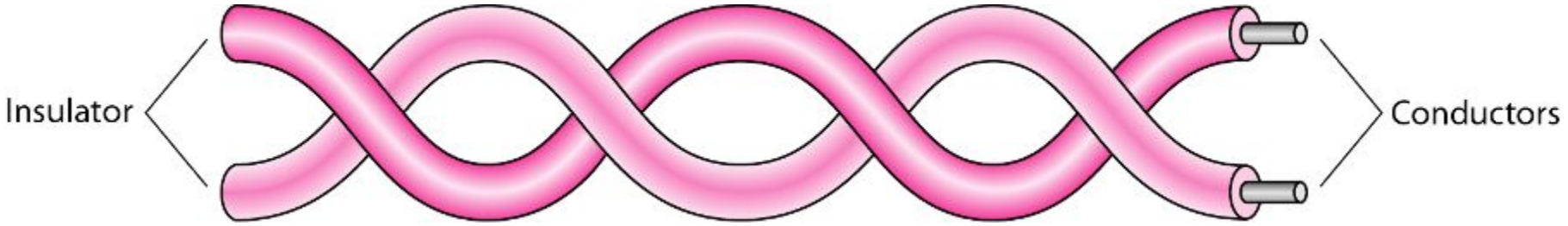
Guided Media : Copper Media

- Provide a conduit from one device to another
- Include
  - Twisted-pair cables
  - Coaxial cables
  - Fiber-optic cables

- 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.

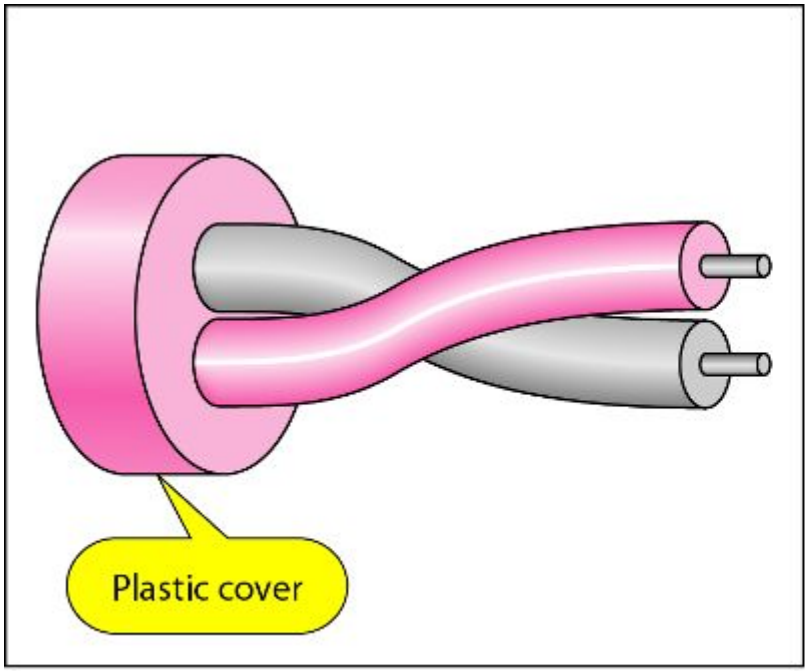
Twisted-Pair Cable





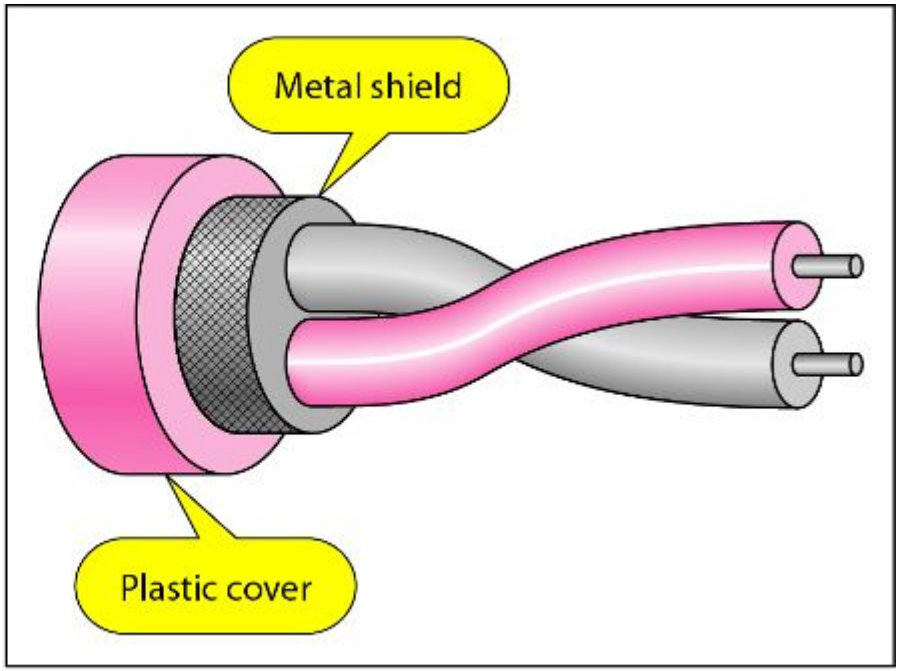
UTP and STP Cables

UTP is the most common



a. UTP

STP introduced by IBM

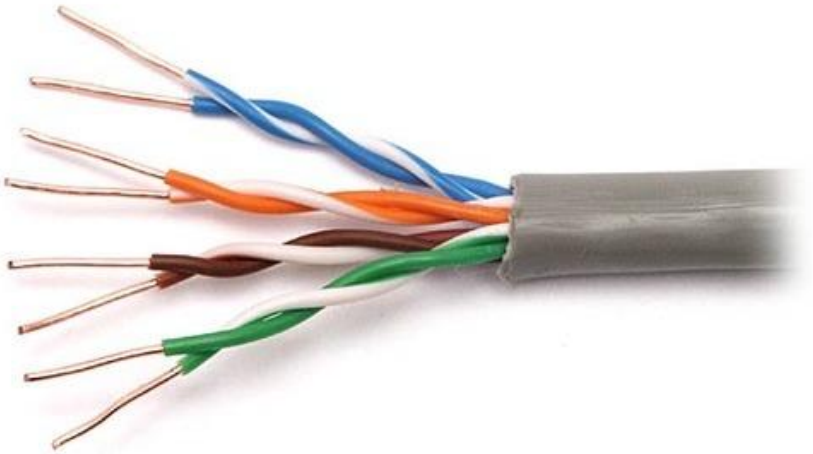


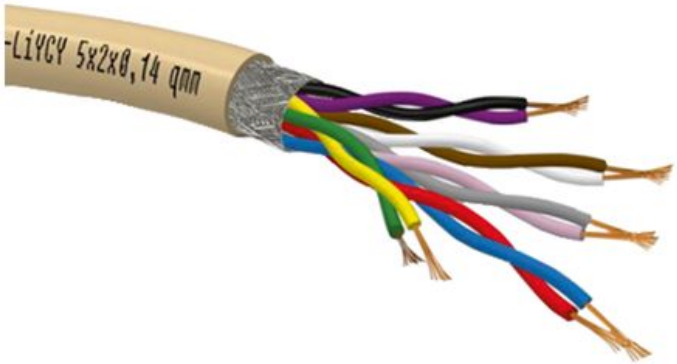
b. STP

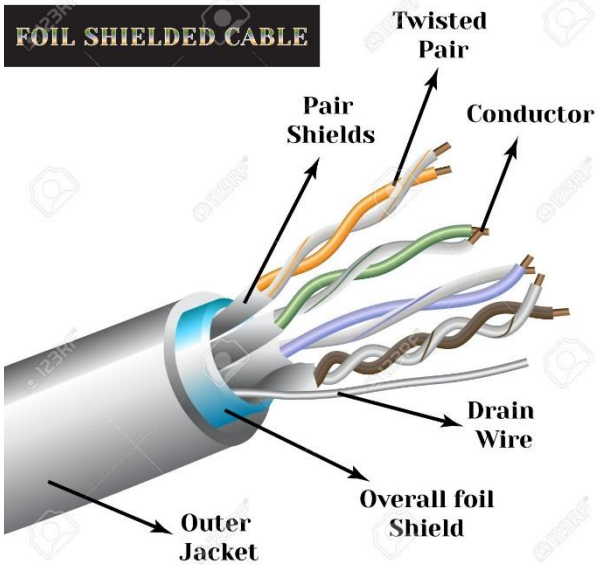
UTP – Unshielded Twisted Pair

STP –Shielded Twisted Pair

UTP and STP



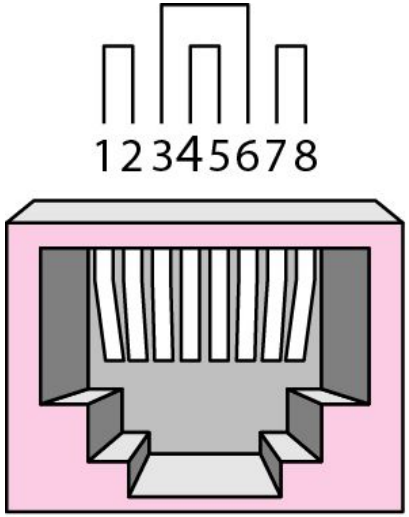

-LiYCY 5x2x0,14 qmm


FOIL SHIELDED CABLE
Twisted Pair
Pair Shields
Conductor
Drain Wire
Overall foil Shield
Outer Jacket

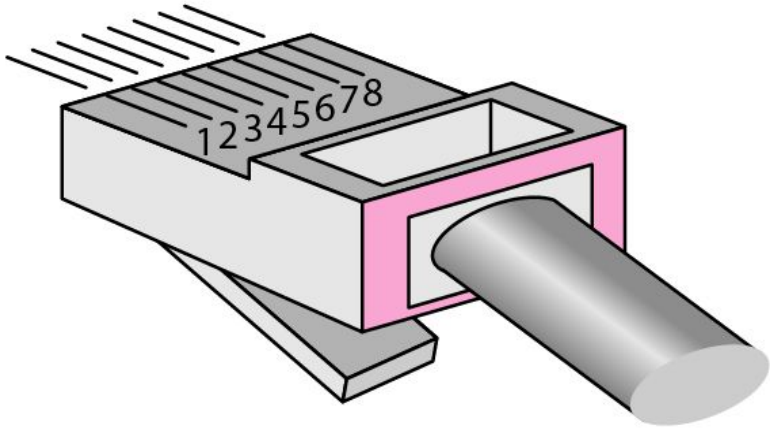
Categories of UTP/STP Cables

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-1 lines
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
5E	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

UTP Connectors



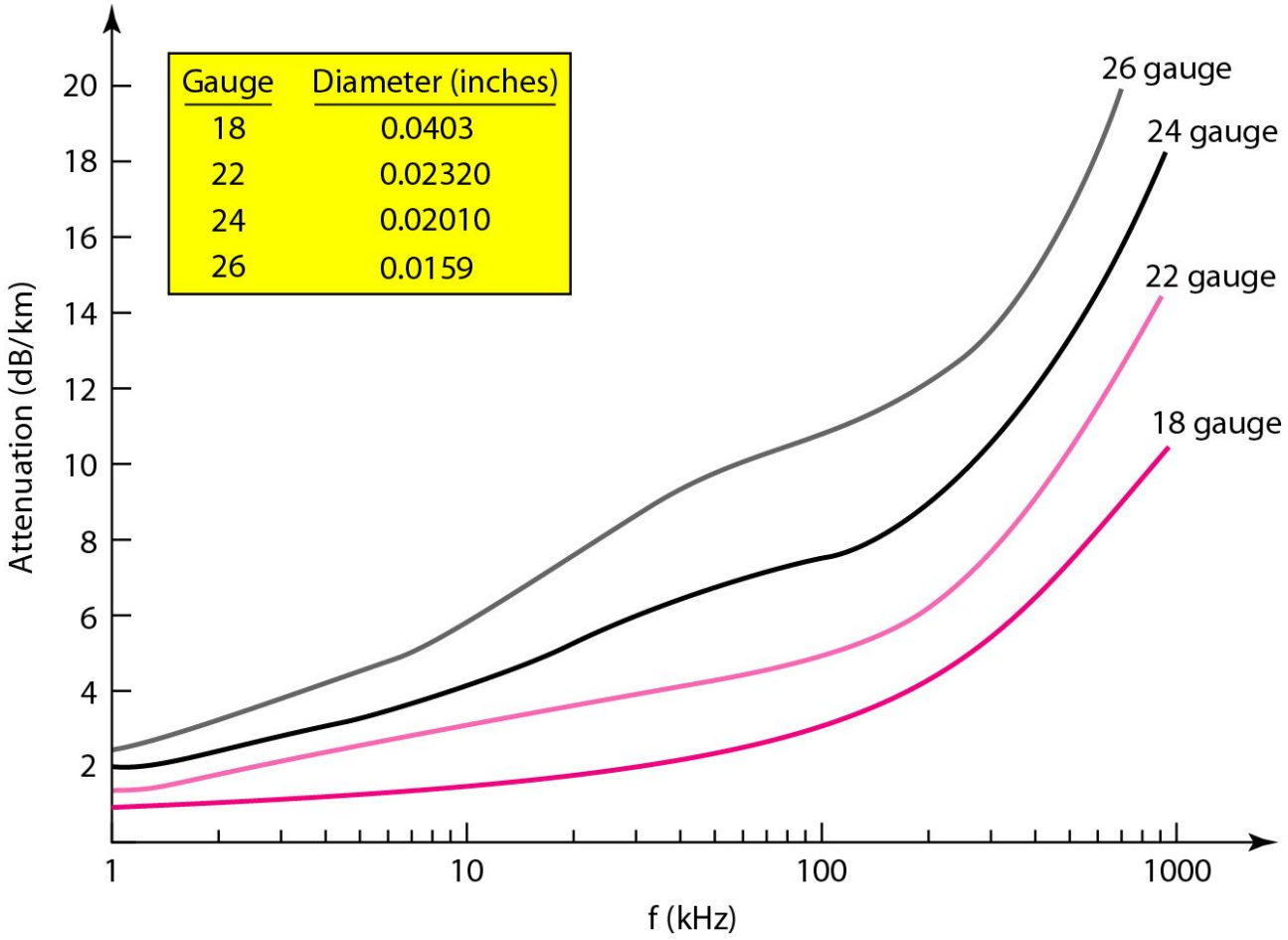
RJ-45 Female



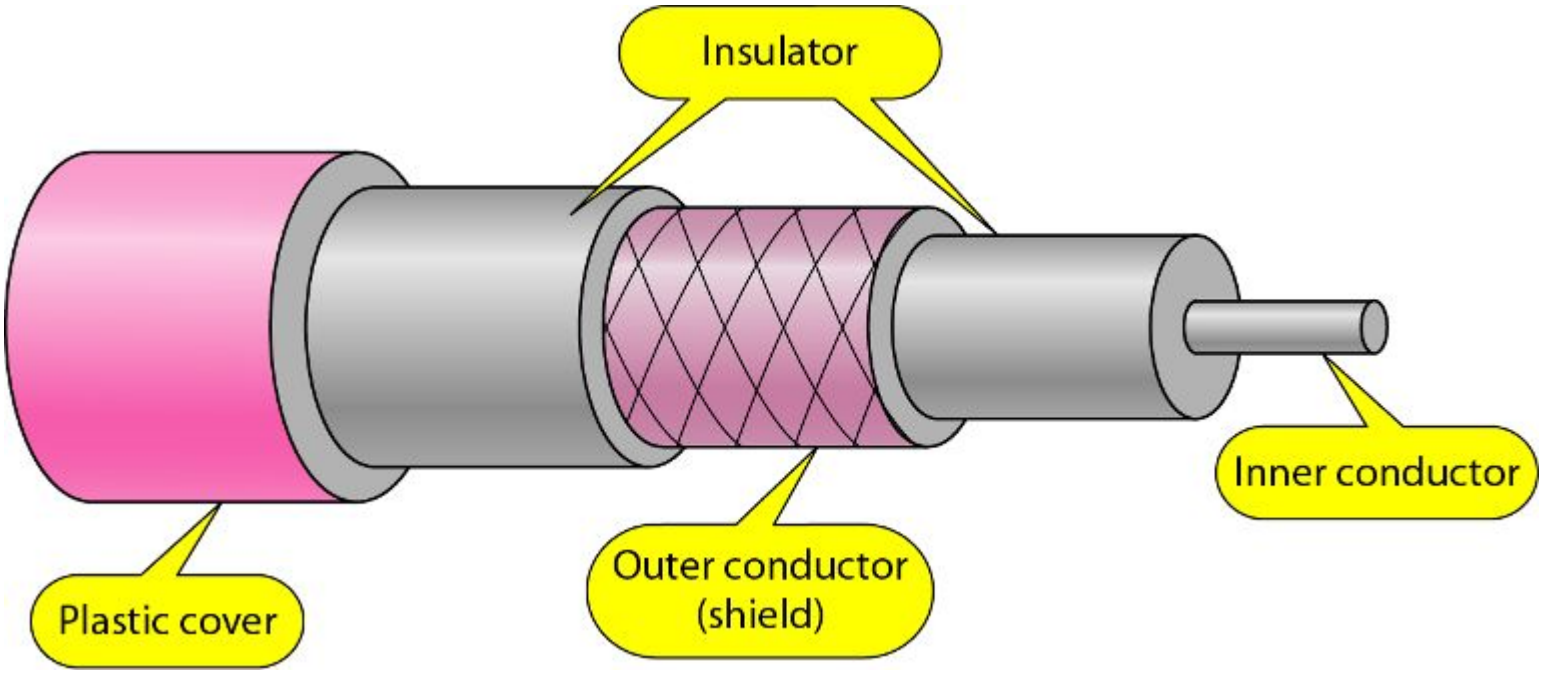
RJ-45 Male

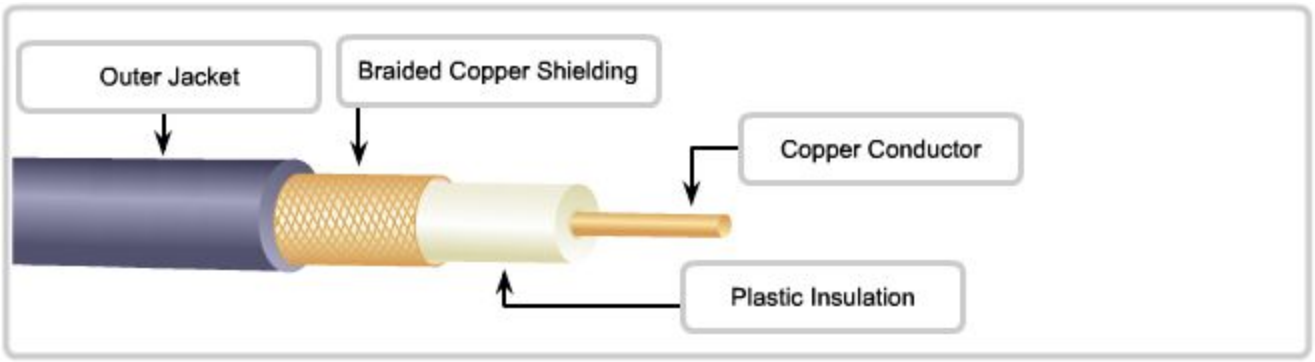
RJ – Registered Jack

UTP Performance



Coaxial Cable





Coaxial Cable

Categories of Coaxial Cables

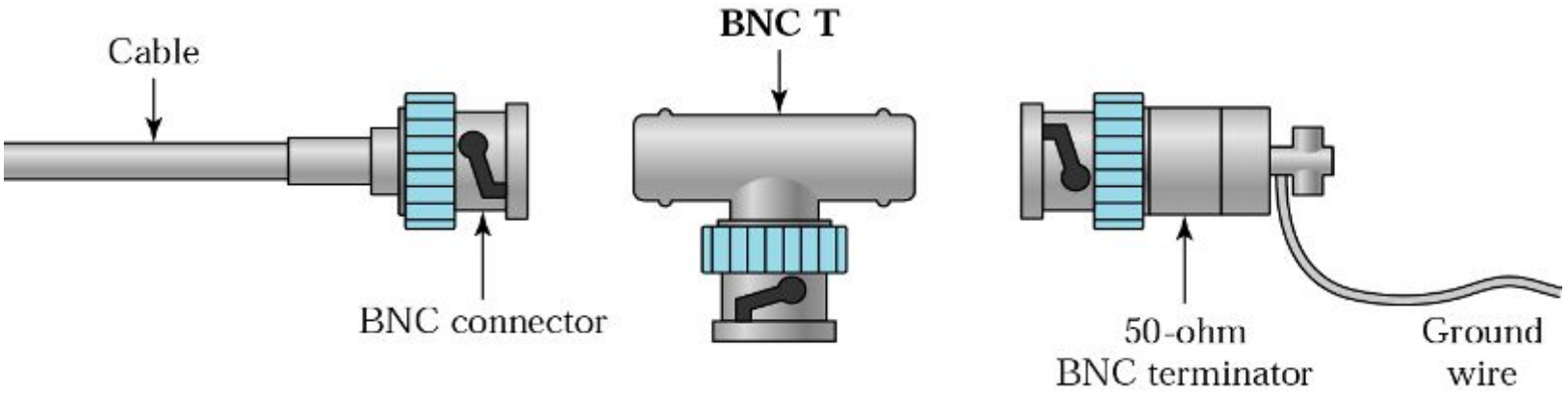
Category	*Impedance*	*Use*
RG-59	75 Ω	Cable TV
RG-58	50 Ω	Thin Ethernet
RG-11	50 Ω	Thick Ethernet

RG – Radio Government

- Each RG number defines a unique set of physical specifications, including the wire gauge of the inner conductor, the thickness and type of the inner insulator, the construction of the shield, and the size and type of the outer casing.

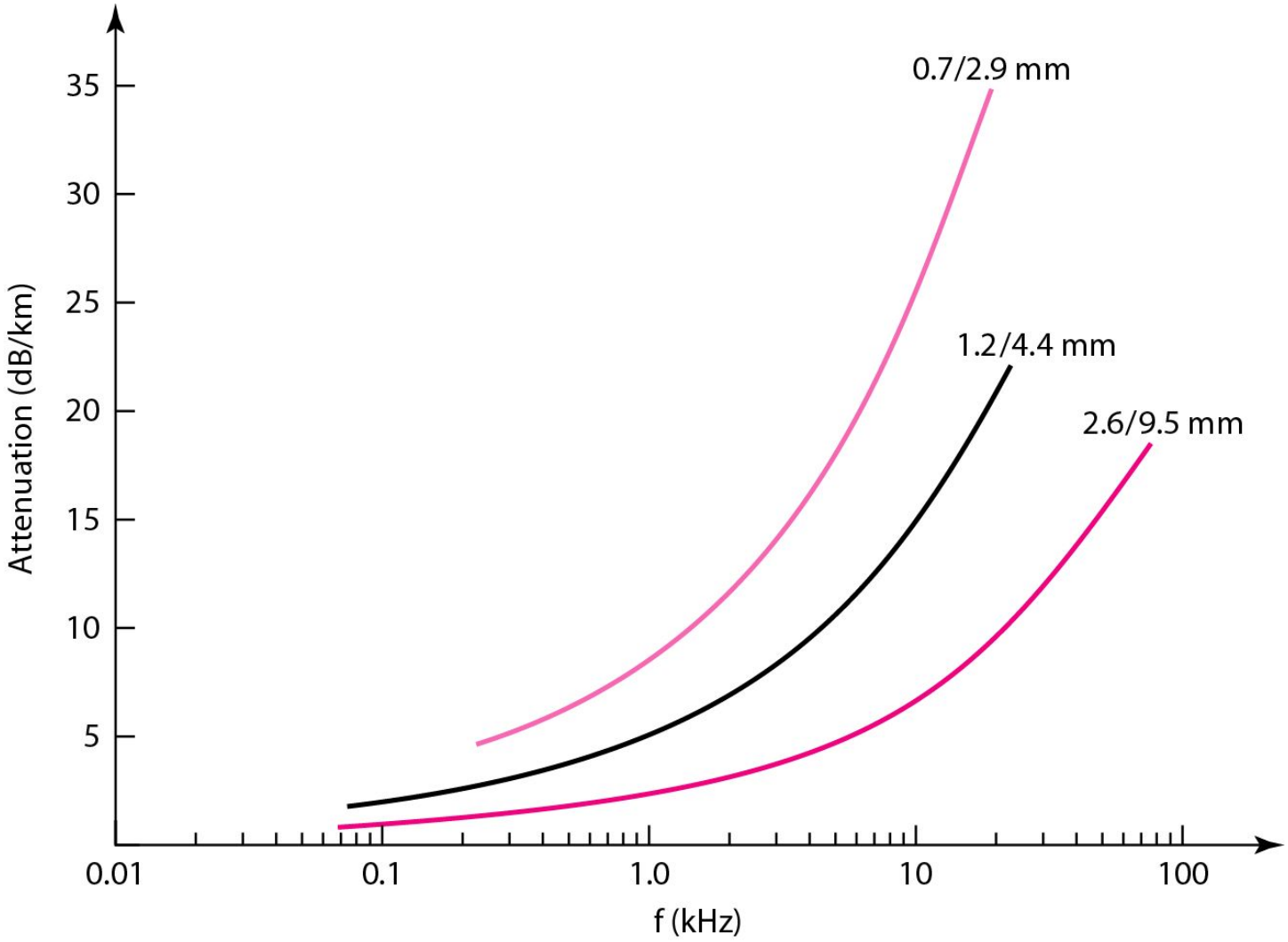
BNC Connectors

- **B**ayonet **N**etwork **C**onnector
  - aka. Bayonet Neil-Concelman
- Used with coaxial cables



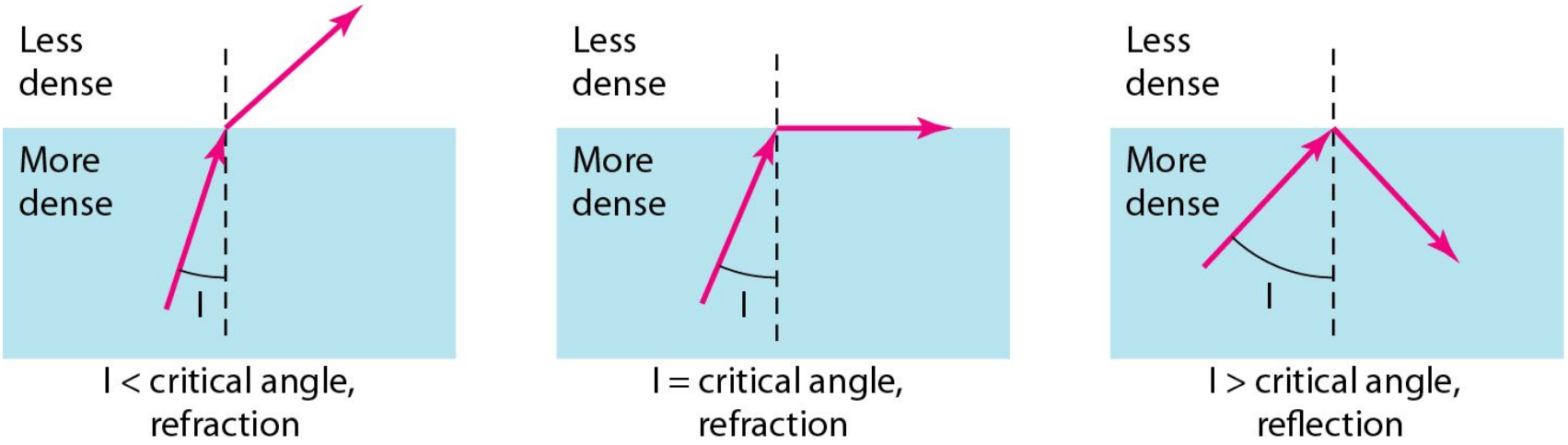
- BNC connector at the end of the cable to a device, e.g. TV set.
- BNC T connector Ethernet networks to branch out to a connection to a computer or other device.
- BNC terminator at the end of the cable to prevent the reflection of the signal.

Performance of Coaxial Cables



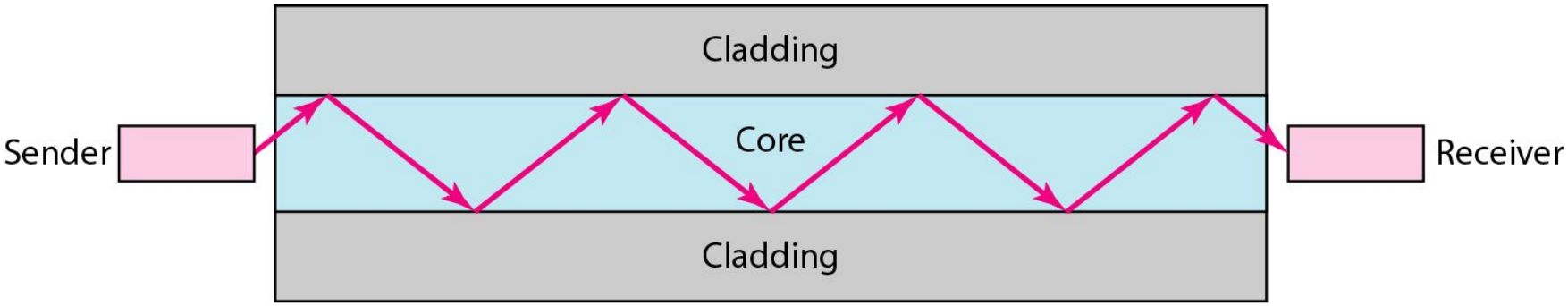
Guided Media: *Optical Media*

- Optical Fiber
  - A fiber-optic cable is made of glass or plastic and transmits signals in the form of light
  - Based on physics of light

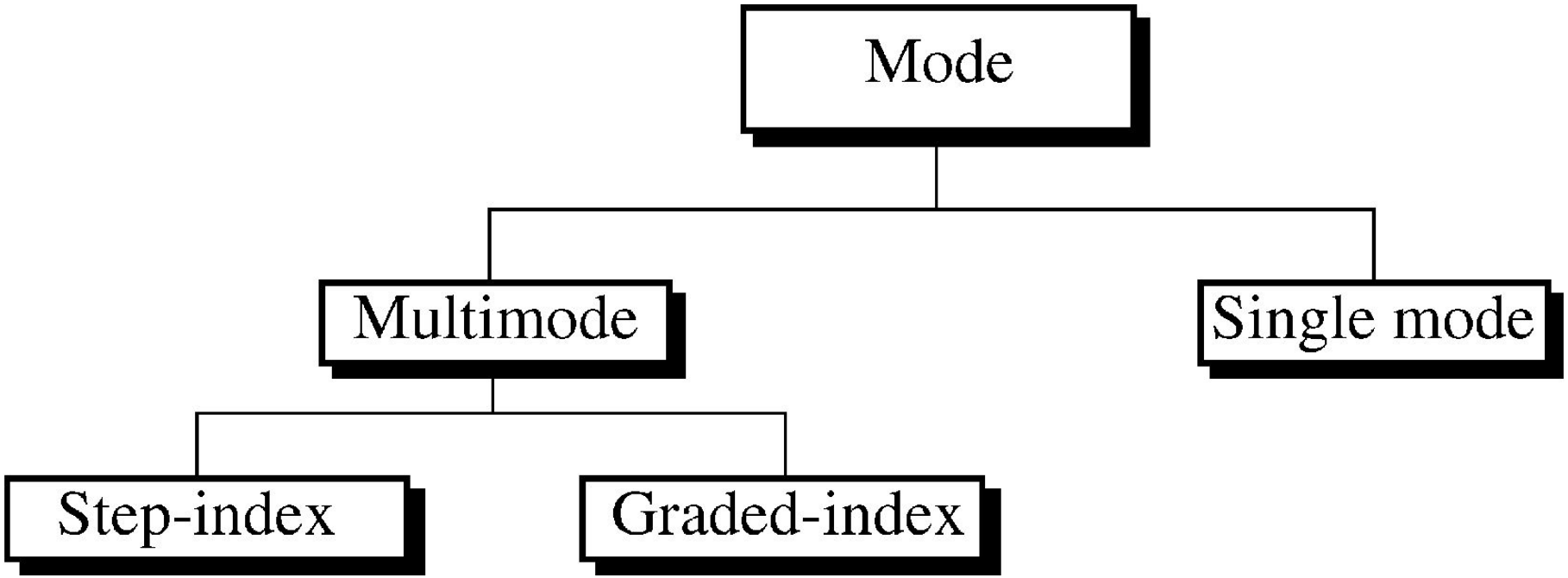


Optical Fiber

- Use reflection to guide light through a channel.
- A glass or plastic core is surrounded by a *Cladding* of less dense glass or plastic.
- The difference in density of the two materials must be such that a beam of light moving through the core is reflected off the cladding instead of being refracted into it.



Propagation Modes

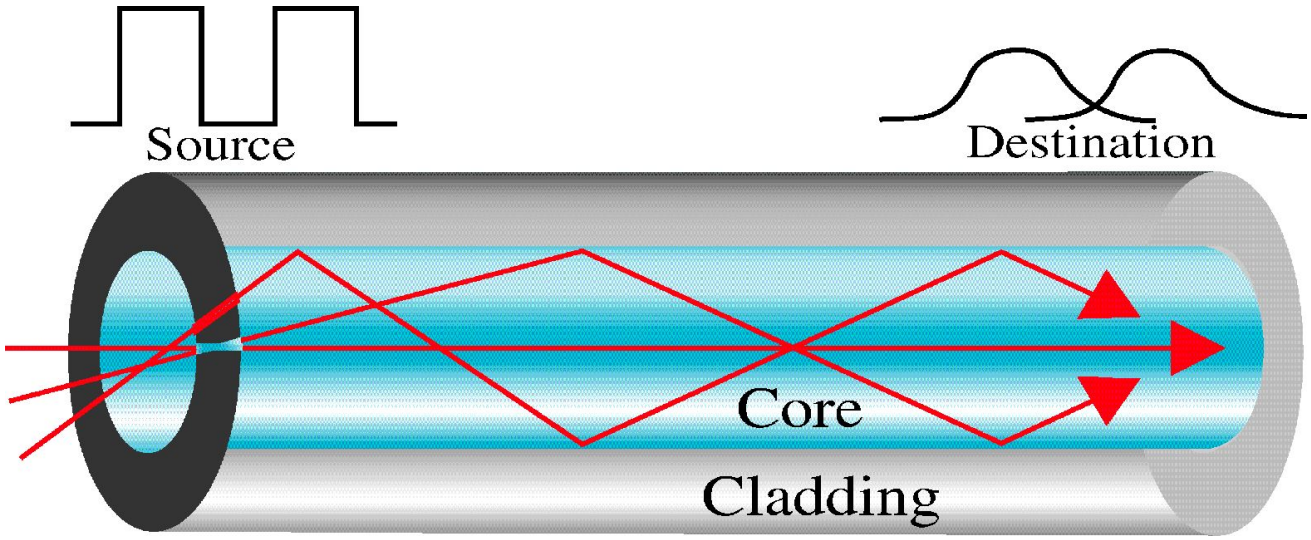


Multimode

- Multimode - 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.

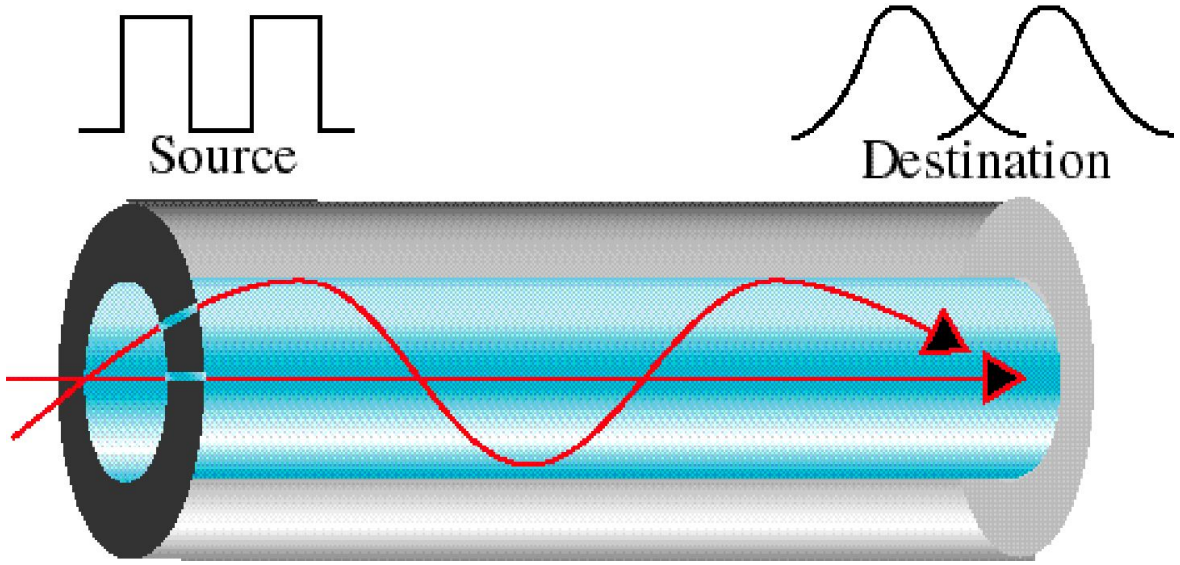
Multimode: Step index

- The density of the core remains constant from the center to the edges.
- The term step-index refers to the suddenness of the change, which contributes to the distortion of the signal as it passes through the fiber.



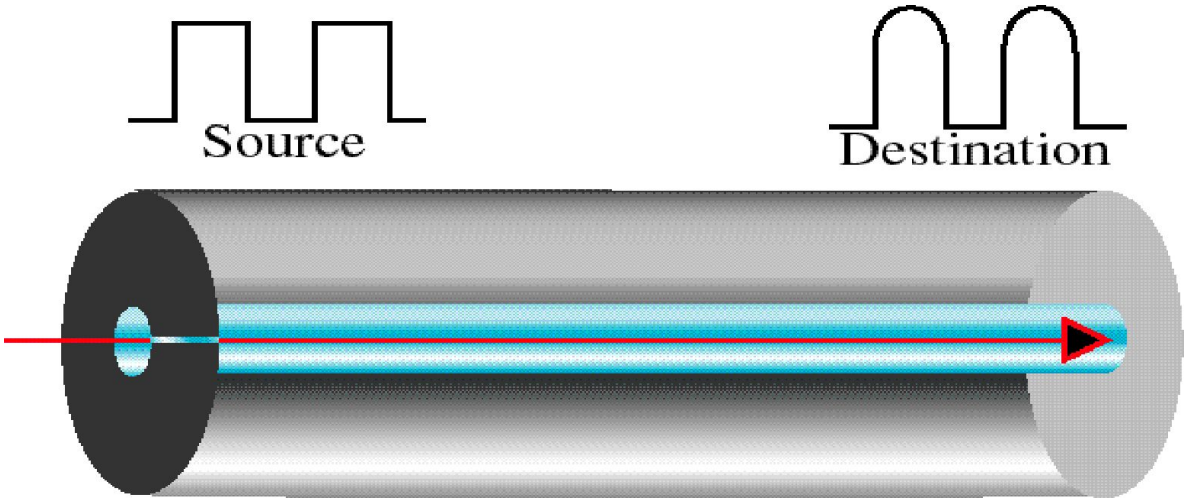
Multimode: Graded index

- A graded index fiber is one with varying densities.
- Density is highest at the center of the core and decreases gradually to its lowest at the edge.
- This decreases the distortion of the signal through the cable.



Single Mode

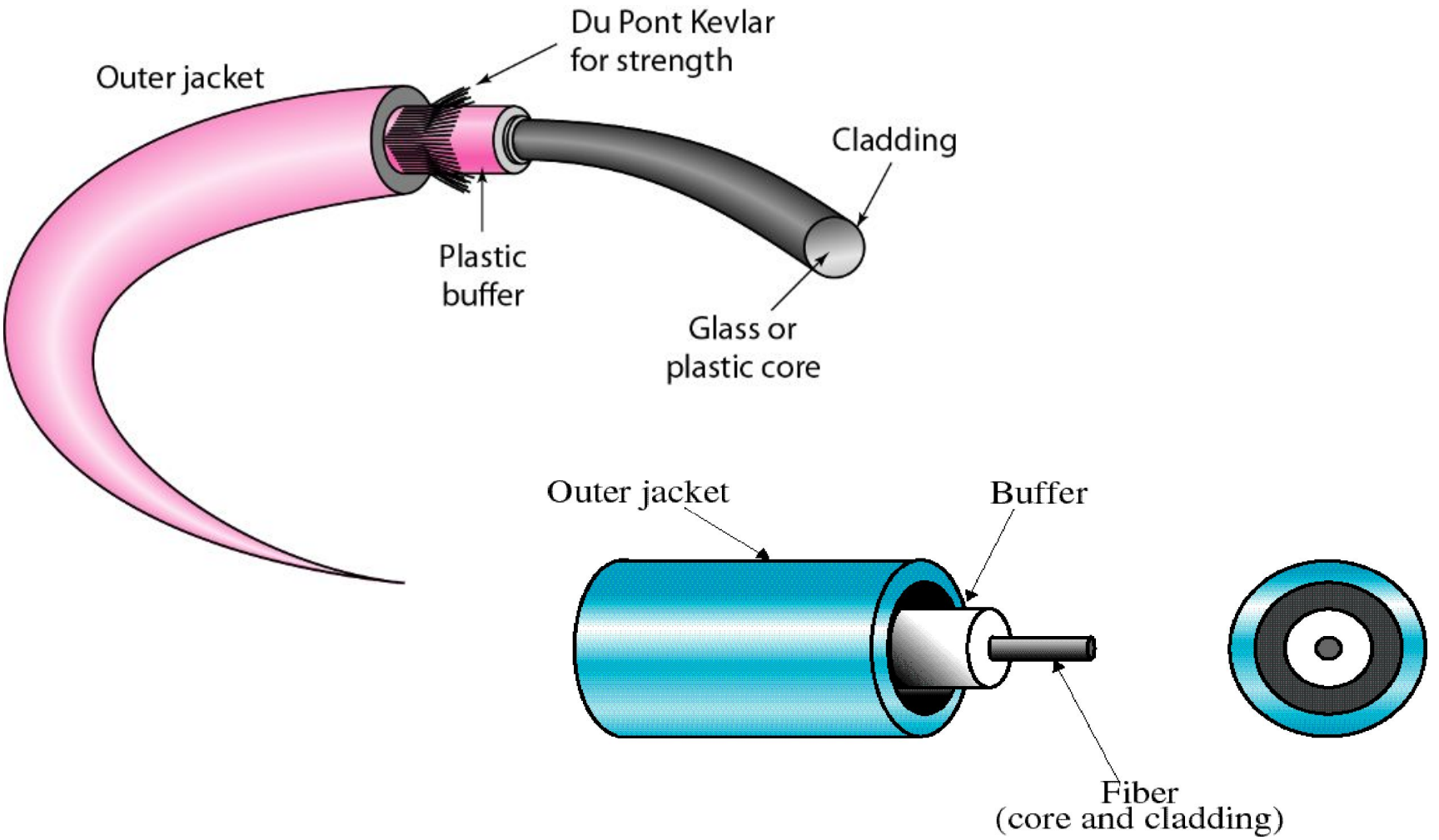
- Uses step-index fiber and a highly focused source of light that limits beams to a small range of angles, all close to the horizontal.
- Much smaller diameter than that of multimode fiber.
- Substantially lower density.
- The decrease in density results in a critical angle that is close enough to 90°to make the propagation of beams almost horizontal.



Fiber Types

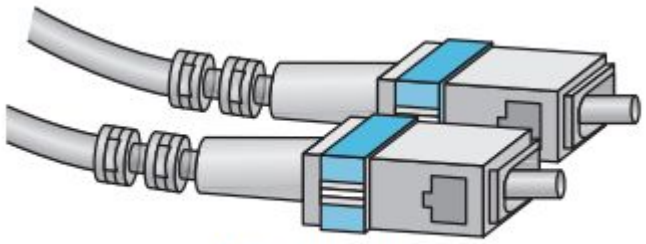
Type	*Core (μm)*	*Cladding (μm)*	*Mode*
50/125	50.0	125	Multimode, graded index
62.5/125	62.5	125	Multimode, graded index
100/125	100.0	125	Multimode, graded index
7/125	7.0	125	Single mode

Fiber Construction



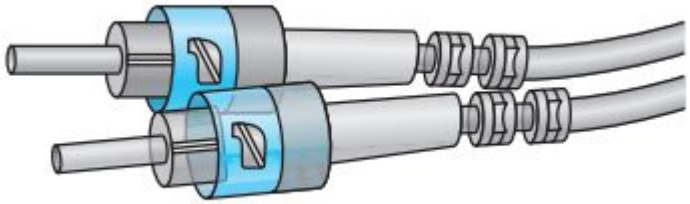
Fiber-Optic Cable Connectors

- Subscriber channel (SC) –
  - Cable TV.
  - push/pull locking system.



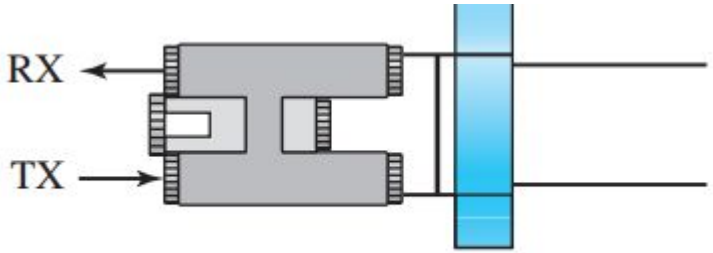
SC connector

- Straight-Tip (ST) connector –
  - Networking devices.
  - Bayonet locking system and
  - More reliable than SC.



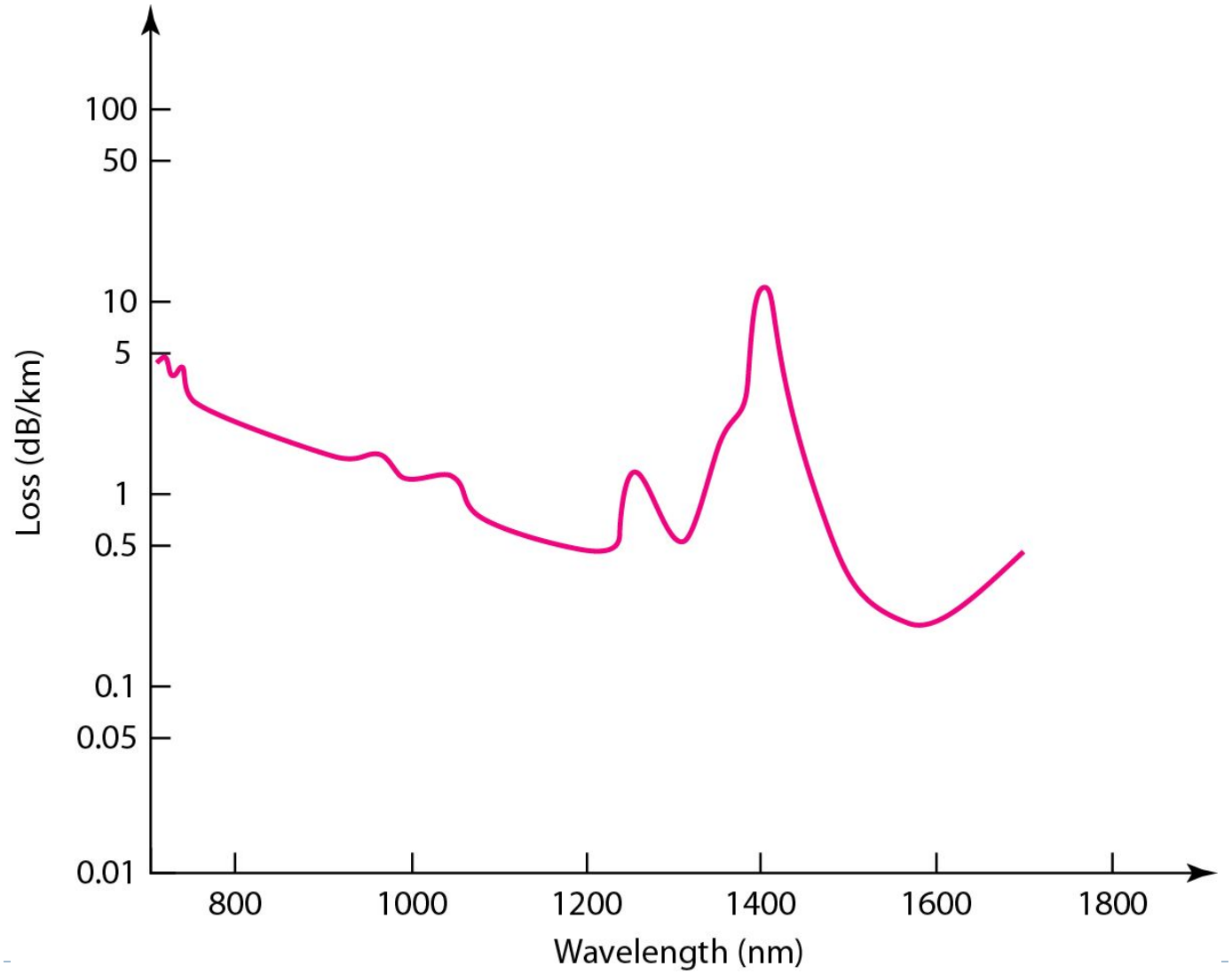
ST connector

- MT-RJ
  - Same size as RJ45.



MT-RJ connector

Optical Fiber Performance



Advantages of Optical Fiber

- **Higher bandwidth**. Can support dramatically higher bandwidths (and data rates) than twisted-pair or coaxial cable.
- **Less signal attenuation**. A signal can run for 50 km without requiring regeneration; whereas, repeaters are needed in every 5 km for coaxial or twisted-pair cable.
- **Immunity to electromagnetic interference**. Cannot effect.
- **Resistance to corrosive materials**. Glass is more resistant to corrosive materials than copper.
- **Light weight**. Much lighter than copper cables.
- **Greater immunity to tapping**. Fiber-optic cables are more immune to tapping than copper cables. Copper cables create antenna effects that can easily be tapped.

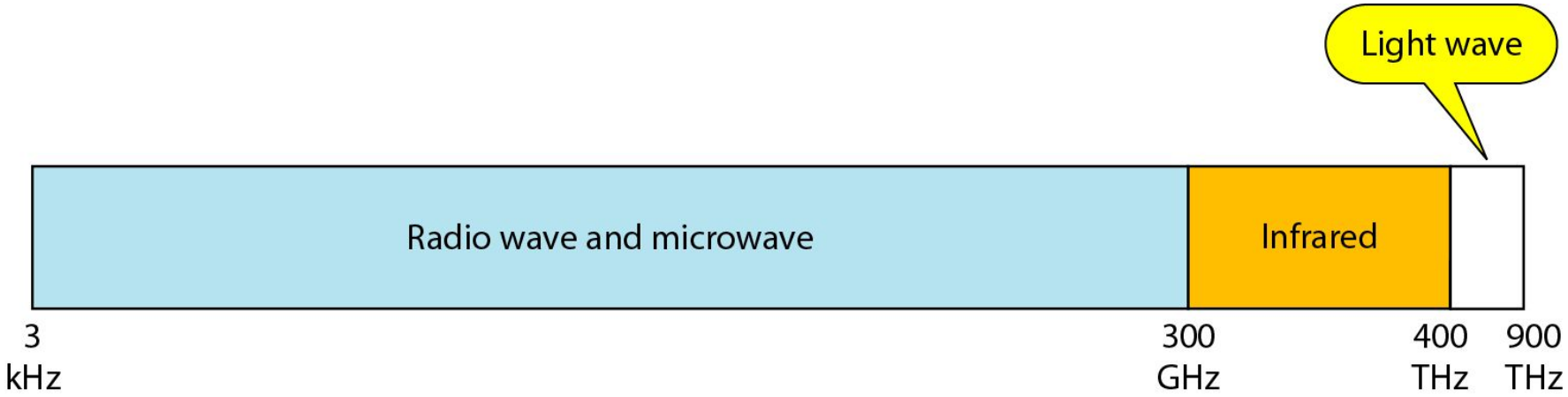
Disadvantages of Optical Fiber

- **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. If the demand for bandwidth is not high, often the use of optical fiber cannot be justified.

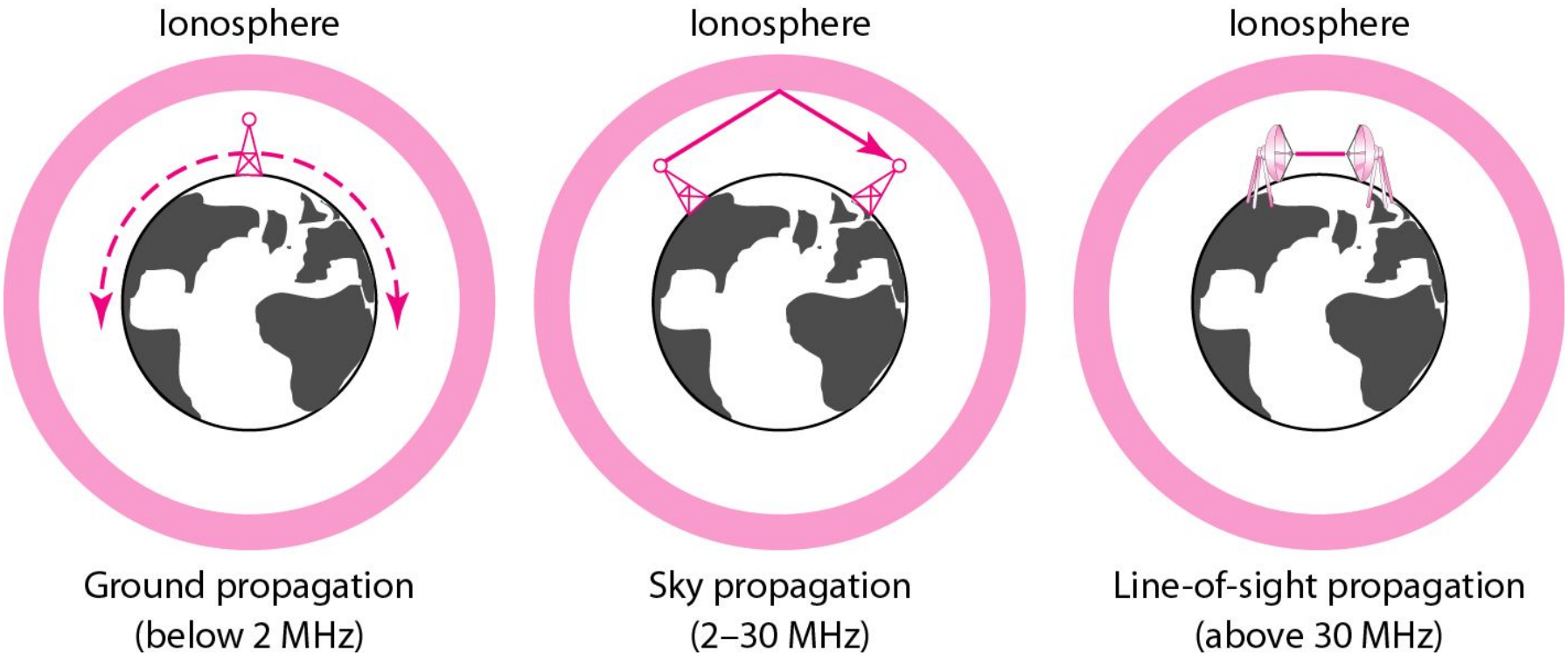
Unguided Media: Wireless

- Transport electromagnetic waves without using a physical conductor
  - Radio Waves
  - Microwaves
  - Infrared
- Often referred to as wireless communication

Electromagnetic Spectrum



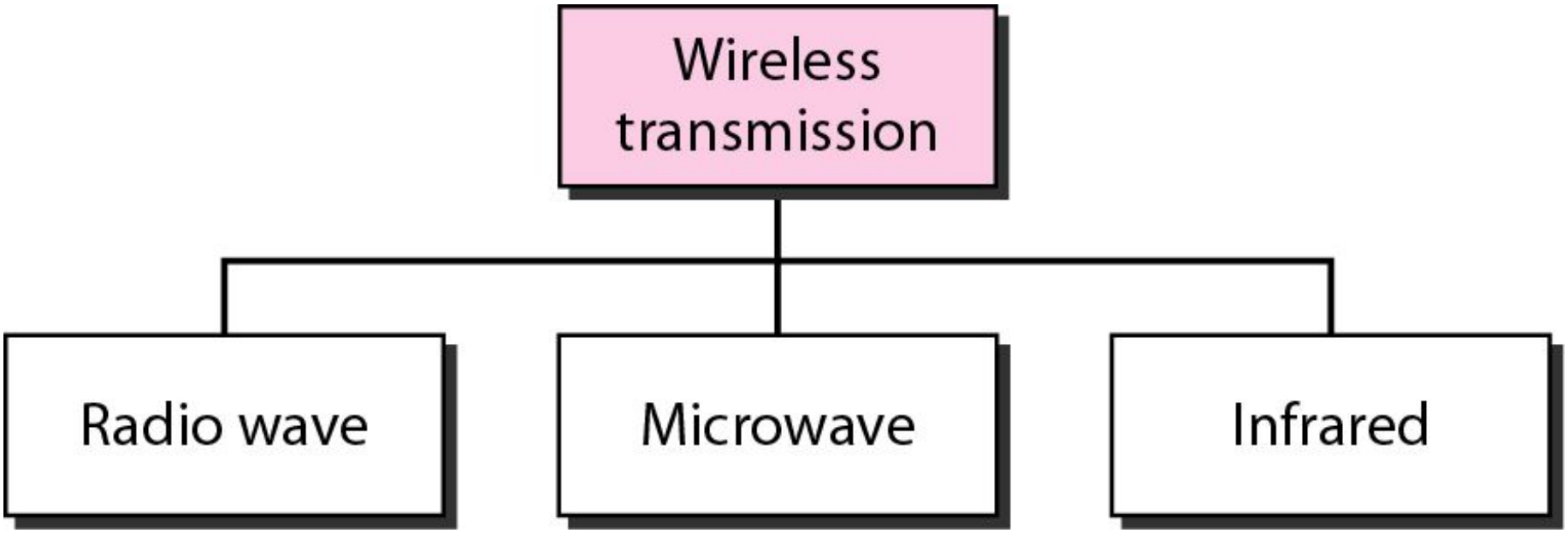
Propagation Methods



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



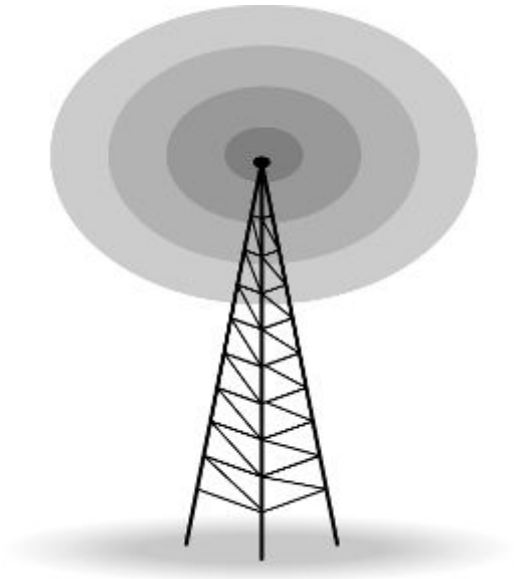
used for multicast/broadcast communications, such as radio and television

used for unicast communication such as cellular telephones, satellite networks,
and wireless LANs

used for short-range communication in a closed area using line-of-sight propagation

Radio Waves

- Electromagnetic waves ranging in frequencies between 3 kHz and 1 GHz are normally called radio waves.
- Radio waves are omnidirectional – propagated in all directions.
- Propagate in the sky mode, can travel long distances.
- Radio waves are used for multicast communications, such as radio and television, and paging systems.

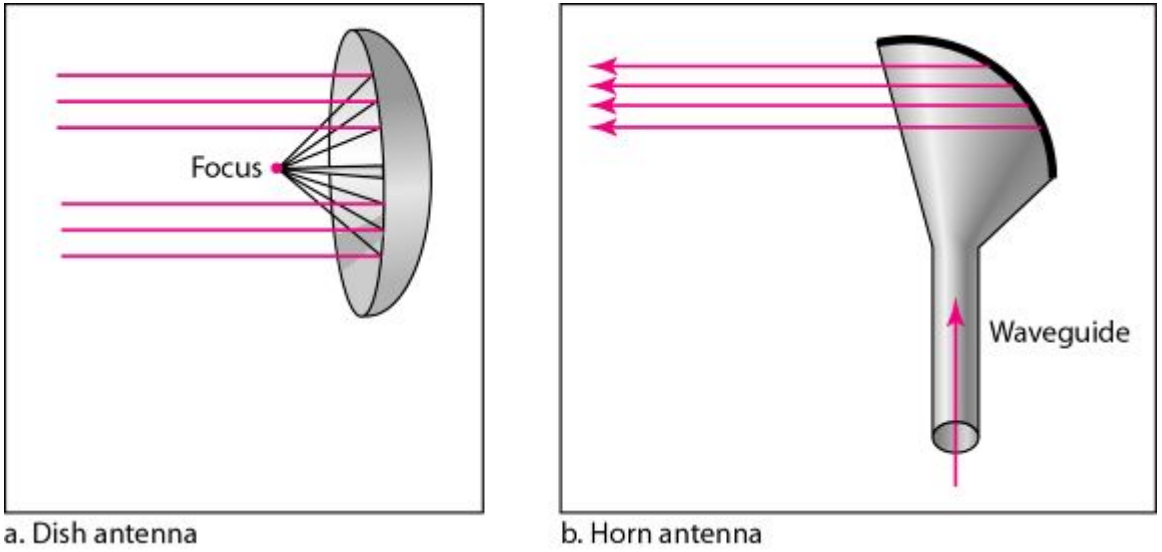


Omni-directional Antenna

Microwaves

- Electromagnetic waves ranging in frequencies between 1 and 300 GHz are called microwaves.
- Microwaves are unidirectional.
- Microwave propagation is line-of-sight.
- Very high-frequency microwaves cannot penetrate walls. This characteristic can be a disadvantage if receivers are inside buildings.
- Use of certain portions of the band requires permission from authorities.
- Used for unicast communication such as cellular telephones, satellite networks, and wireless LANs.

Unidirectional Antennas



a. Dish antenna

b. Horn antenna

Unidirectional Antennas

Infrared

- Electromagnetic waves ranging in frequencies between 300 GHz and 400 THz are called infrared.
- Cannot penetrate walls.
- Infrared propagation is line-of-sight.
- Can be used for short range communication.
- The Infrared Data Association (IrDA), an association for sponsoring the use of infrared waves, has established standards for using these signals for communication between devices such as keyboards, mice, PCs, and printers.
- For example, some manufacturers provide a special port called the IrDA port that allows a wireless keyboard to communicate with a PC.
- The standard originally defined a data rate of 75 kbps for a distance up to 8 m.
- The recent standard defines a data rate of 4 Mbps.

A number of slides modified from Chaiporn Jaikaeo and borrowed from Forouzan's book website
A few Pictures collected from internet