Data Communications and Networking Fourth Edition

Forouzan

Chapter 7

Transmission Media

Partially Edited and
Presented by
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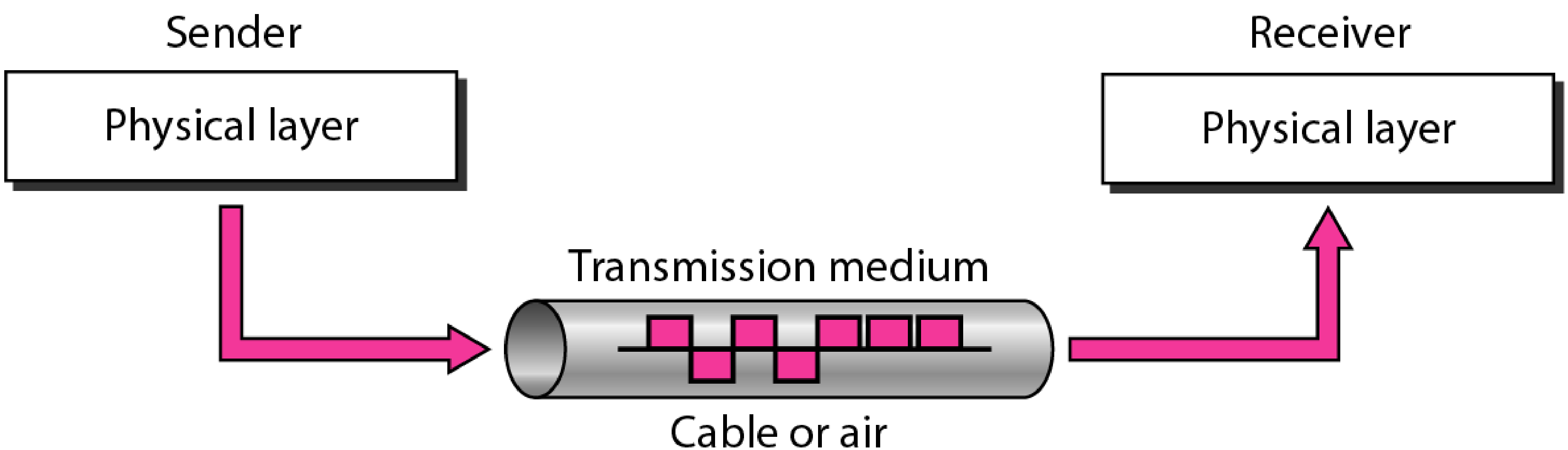
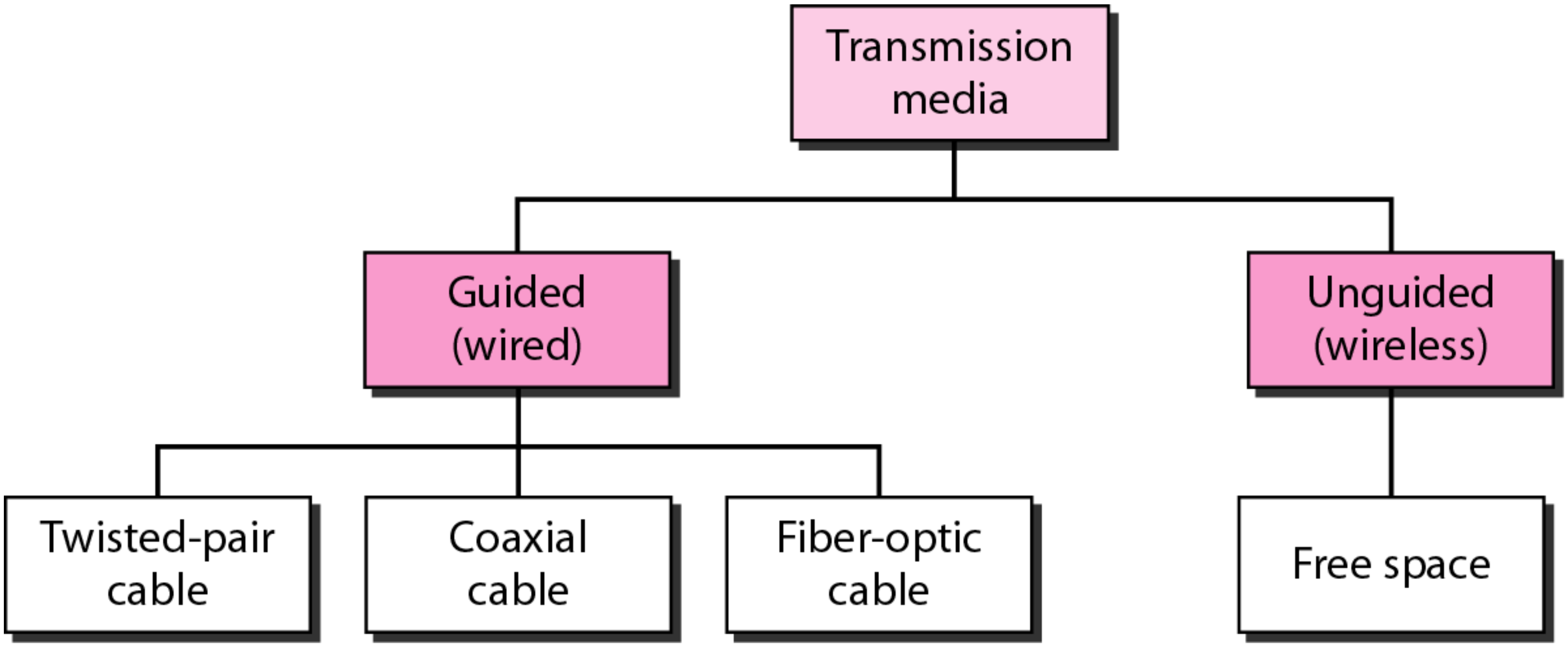
Figure 7.1 *Transmission medium and physical layer*



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

Figure 7.2 *Classes of transmission media*



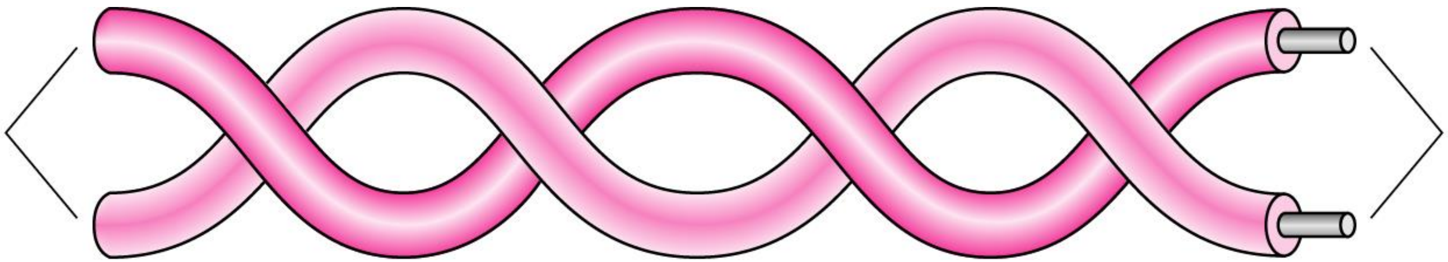
7-1 GUIDED MEDIA

Guided media, which are those that provide a conduit from one device to another, include twisted-pair cable, coaxial cable, and fiber-optic cable.

Topics discussed in this section:

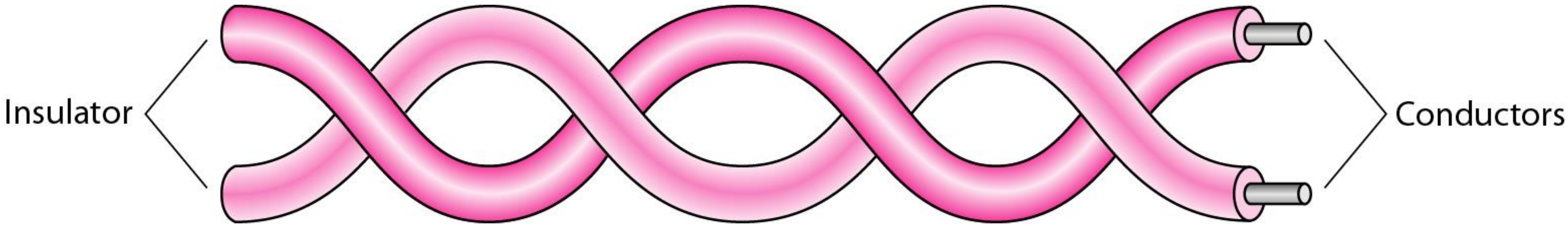
Twisted-Pair Cable
Coaxial Cable
Fiber-Optic Cable

Figure 7.3 *Twisted-pair cable*



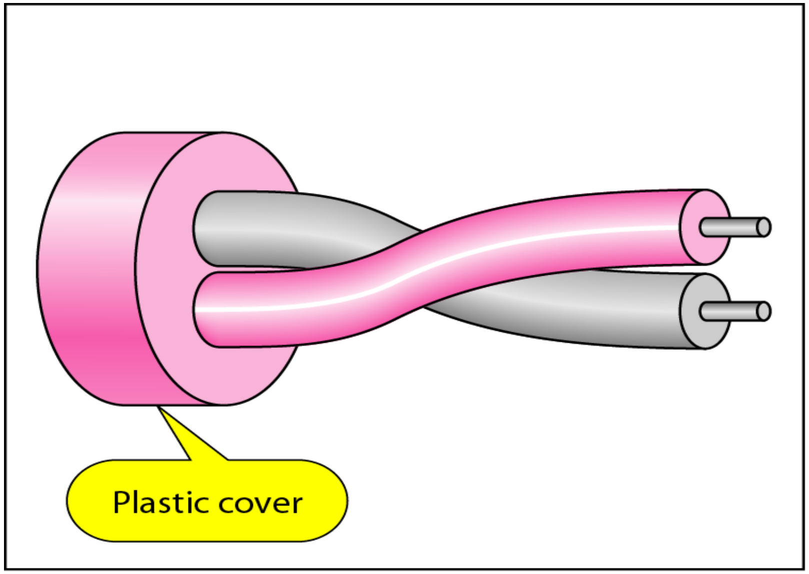
- A twisted pair cable consists of two conductors (usually coppers), covering plastic insulation and twisted togather
- In twisted pair cable, one wire is used to carry signals to the receiver and
- Other is used as a ground reference
- The receiver uses the difference bertween the two wires
- Ex. Telephone lines used to provide voice and data channels

Figure 7.3 *Twisted-pair cable*

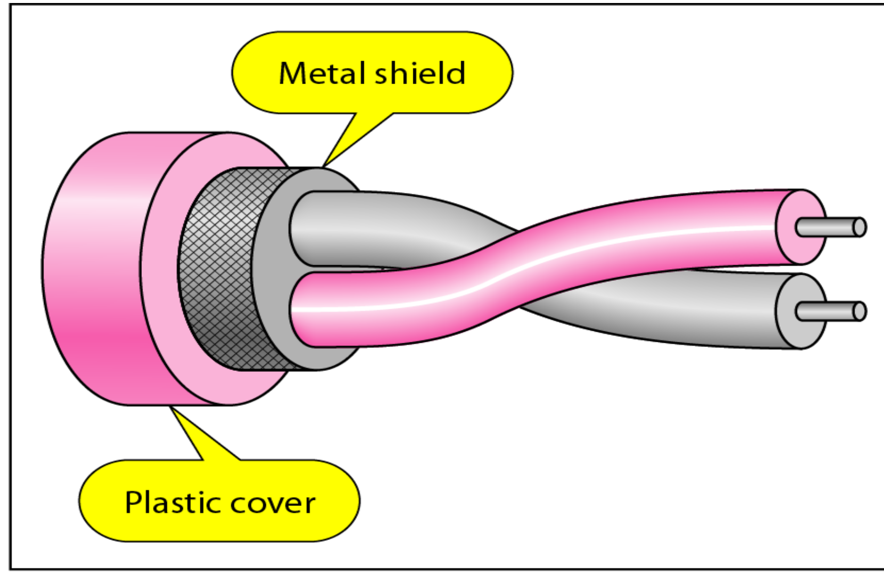


- Advantages
  - These cables are cost-effective and easy to install owing to their compact size.
  - They are generally used for short-distance transmission of both voice and data.
  - It is less costly as compared to other types of cables.
- Disadvantages
  - The connection established using UTP is not secure.
  - They are efficient only for a distance up to 100 meters and have to be installed in pieces of up to 100 meters.
  - These cables have limited bandwidth.

Unshielded TP vs Shielded TP cables



a. UTP



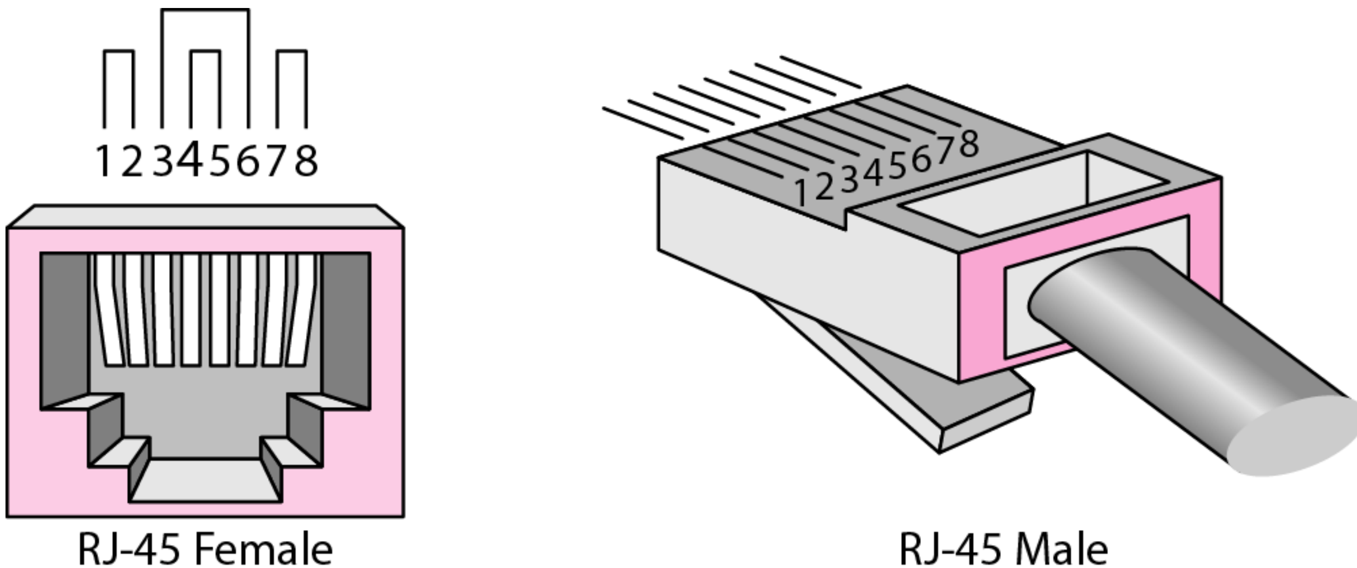
b. STP

- Most common twisted pair(TP) cable is unshielded TP(UTP) cable
- IBM introduced shielded TP(STP) cable
- STP has a metal foil covering each pair of insulated conductors

Electronic Industries Association(EIA) introduce seven categories of unshielded twisted-pair 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

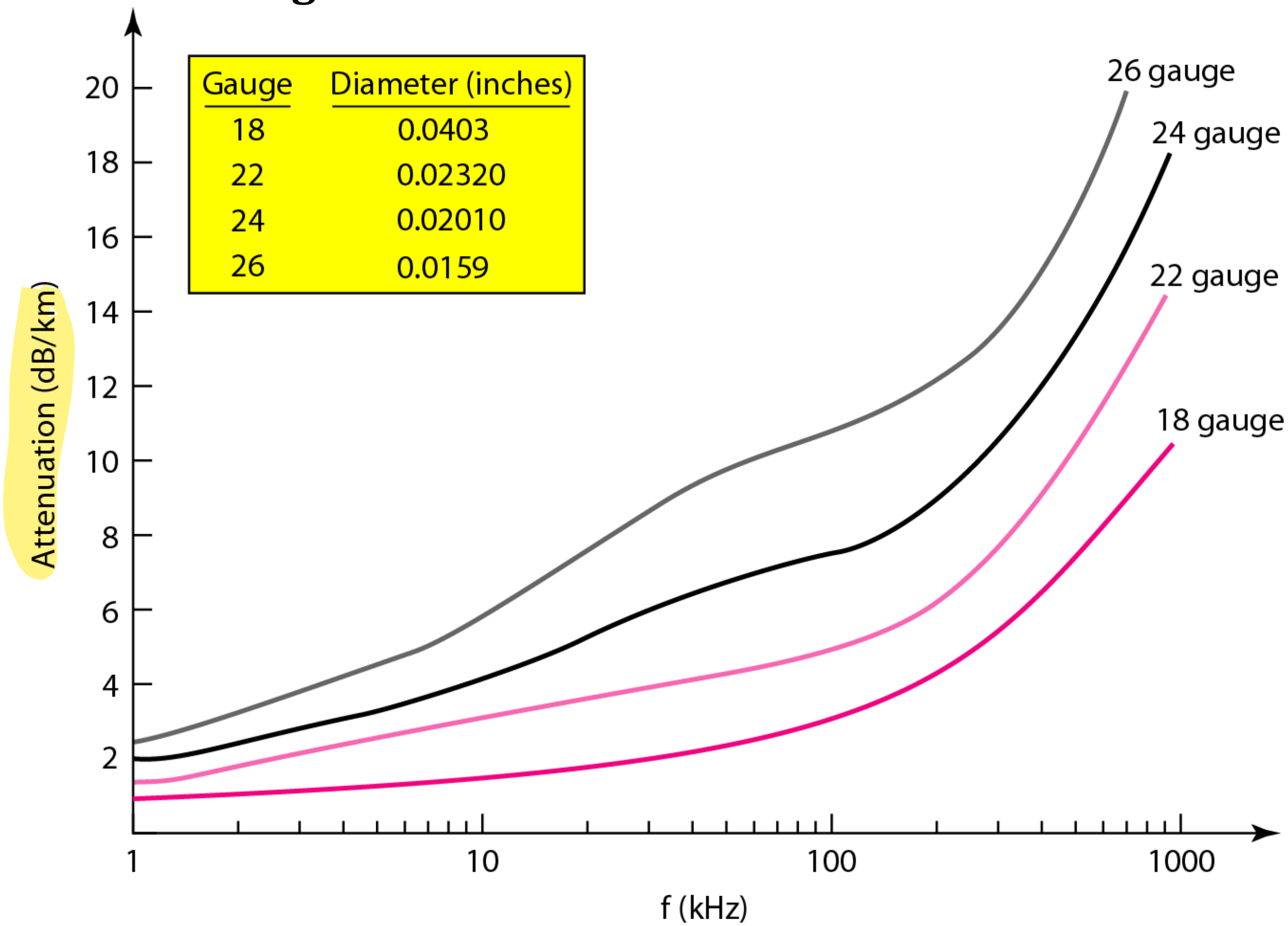
Figure 7.5 ***UTP connector***



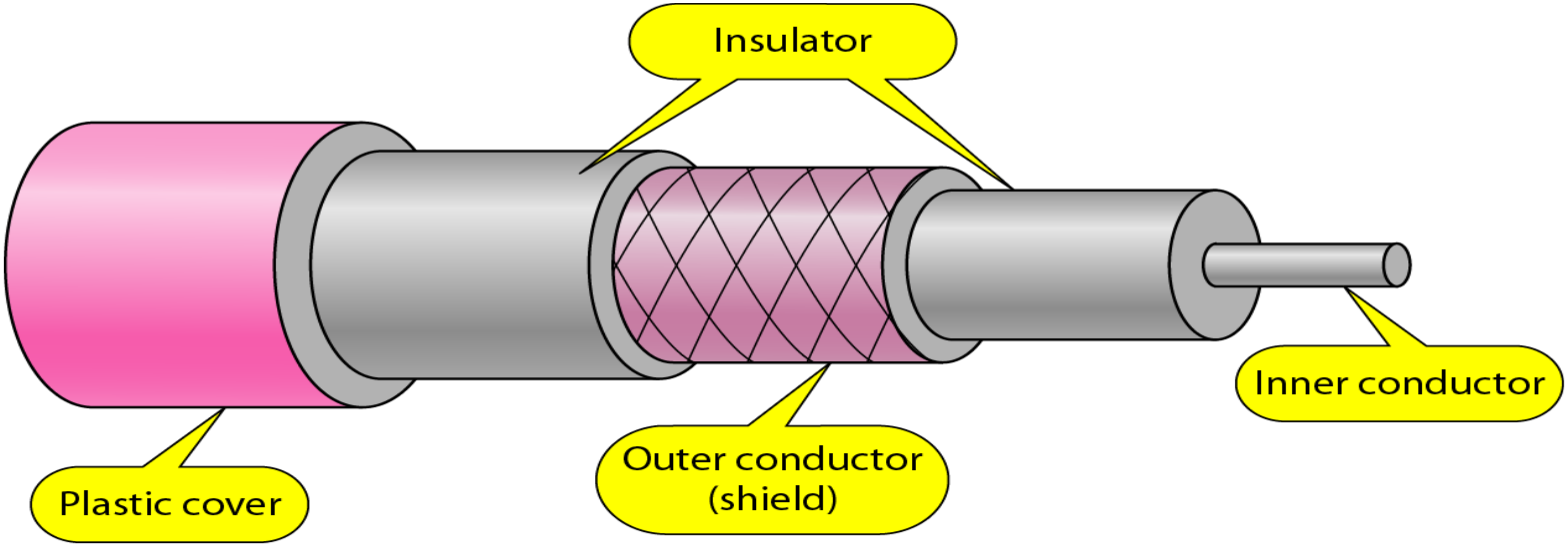
- Most common UTP connector is RJ45 connector
- RJ stands for registered jack
- RJ connector can be inserted only one way

Figure 7.6 *UTP performance*

Gauge is a measure of the thickness of the wire



Coaxial cable



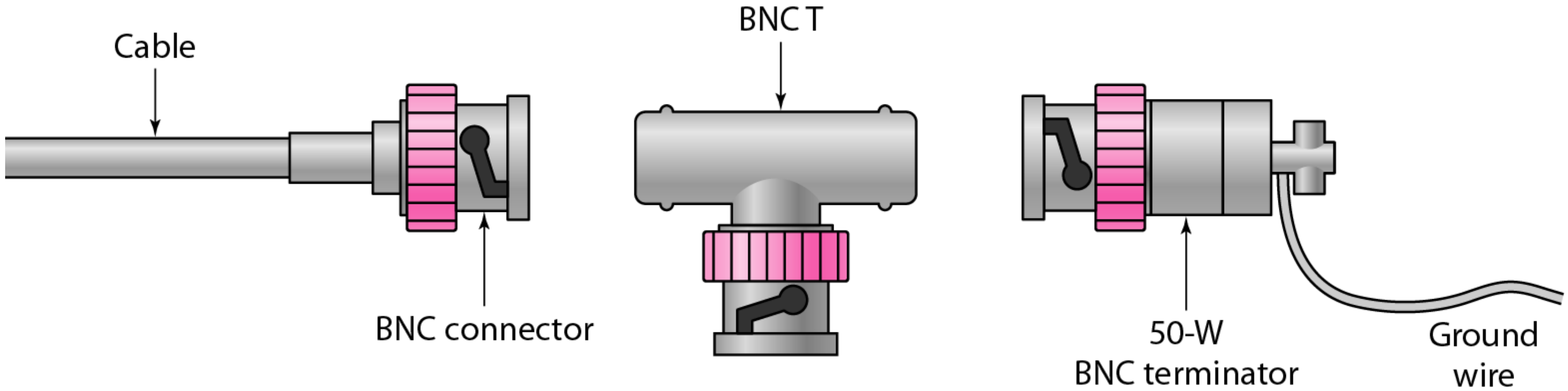
- Carries signal of higher frequency range as 600 Hz ~ 2000Hz
- Has a central core conductor made usually of copper enclosed in an insulating sheath
- The outer conductor serves both as a sheild against noise and as a second conductor
- The outer conductor also enclosed in an insulating sheath
- The whole cable is protected by a plastic cover.

Table 7.2 ***Categories of coaxial cables***

Category	*Impedance*	*Use*	
RG-59	75 Ω	Cable TV	
RG-58	50 Ω	Thin Ethernet	10base2
RG-11	50 Ω	Thick Ethernet	10base5

- Coaxial cables are classified by **radio government (RG)** ratings.
- Each RG number has a unique set of physical specifications including the wire gauge of the inner conductor, the thickness and type of inner insulator, construction and size and type of outer casing.

Figure 7.8 *BNC connectors*

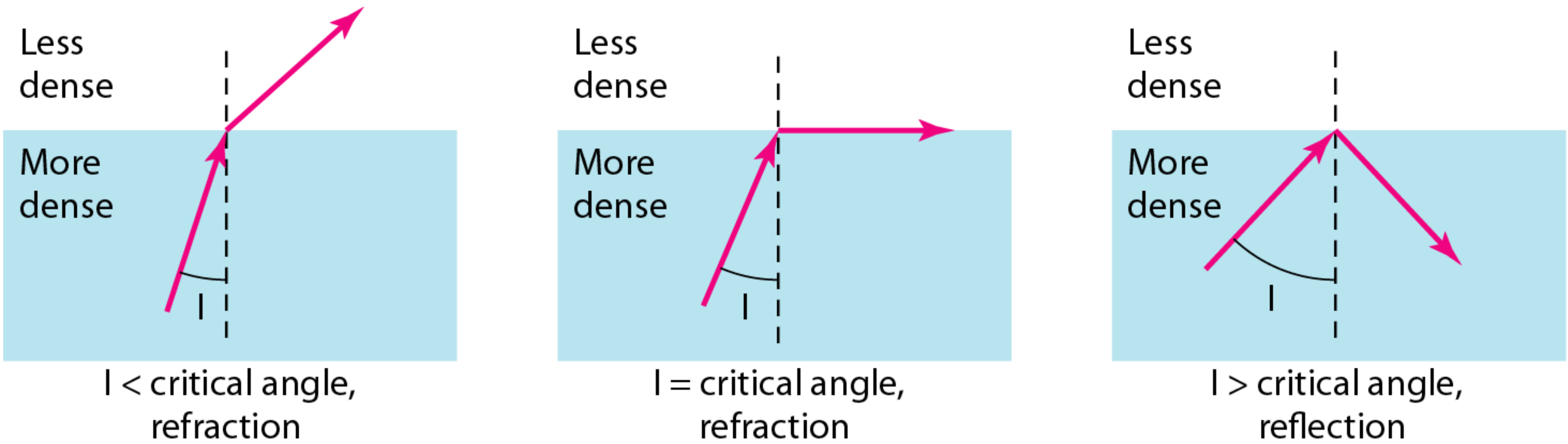


- The most common type of coaxial cable connector is **Bayone-Neill-Concelman (BNC)** connector
- The BNC connector is used to connect the end of the cable to a device such a TV set.
- The BNC T connector is used in Ethernet networks
- The BNC terminator is used at the end of the cable to prevent the reflection of the signal.

Coaxial Cable applications

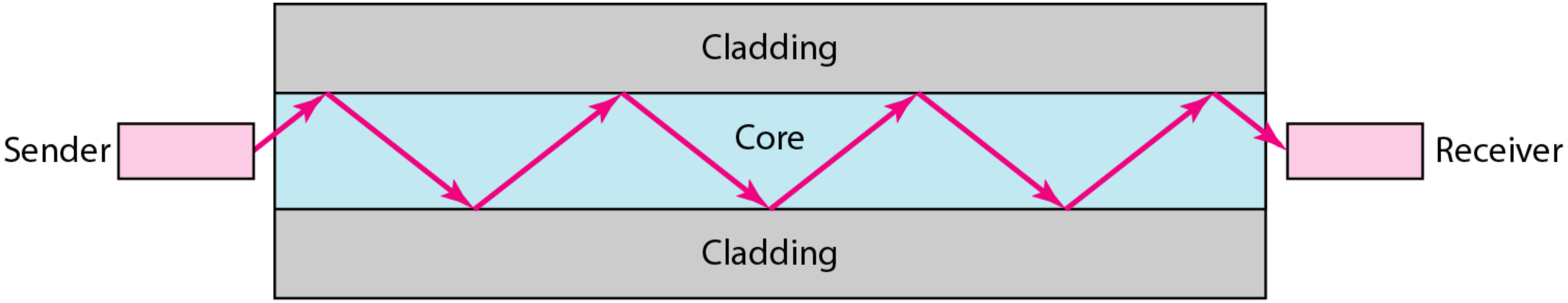
- Widely used in analog telephone networks and carry up to 10000 voice signals
- Later used in digital telephone networks and carry up to 600 Mbps digital data.
- Also used in cable TV network.
- Hybrid network also used coaxial cable
- Industrial Ethernet LANs also used coaxial cable
- Now a days replaced by Fiber optic cable.

Fiber optic Bending of light ray



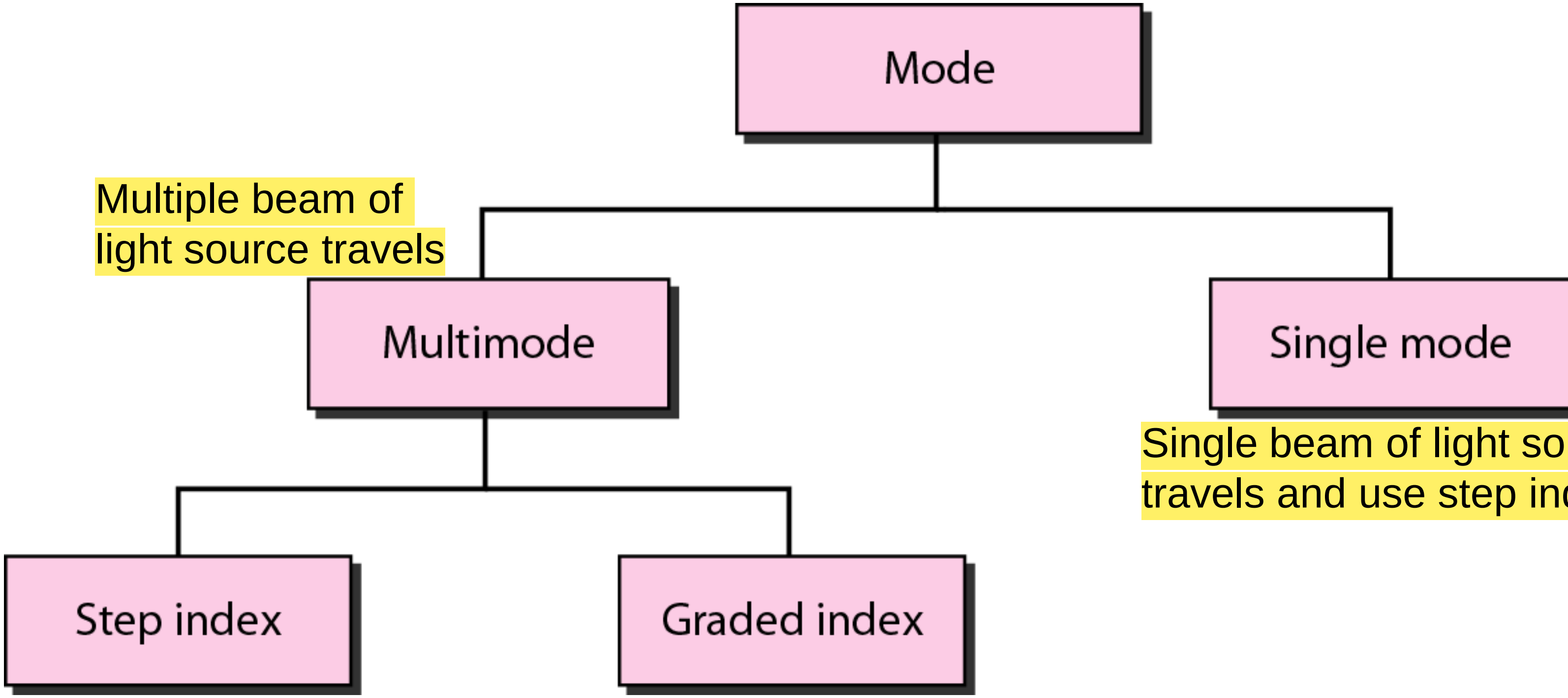
- If angle of incidence I, is **less than** the critical angle, the light ray **refracts and moves closer to the surface**
- If angle of incidence I, is **equal** to the critical angle, the light ray **bends along the interface**
- If angle of incidence I, **is greater** than the critical angle, the light ray reflects and travels back to the denser medium.

Optical Fiber



- A fiber optic cable made of glass or plastic and transmit signal in the form of light.
- Optical fibers use reflection of light to guide through a channel
- A higher dense glass or plastic core is surrounded by a cladding of less dense glass or plastic.
- The difference in density must ensure to light reflection into core from cladding instead of being refracted.

Figure 7.12 *Propagation modes*



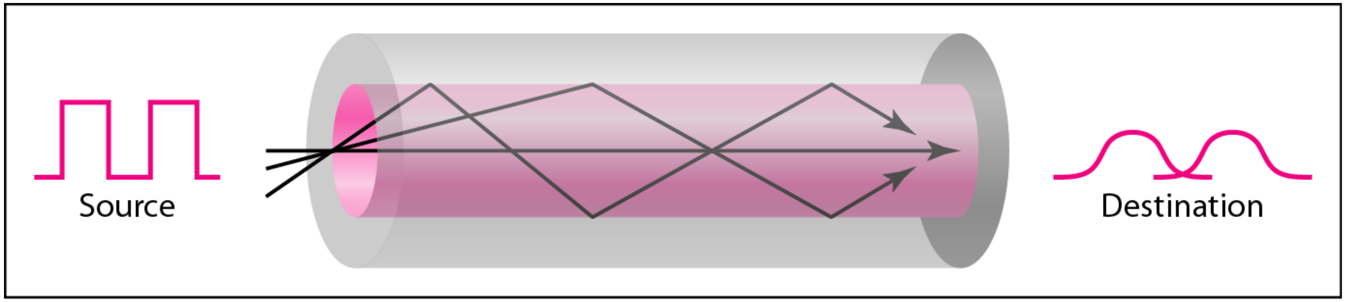
Multiple beam of light source travels

Single beam of light source travels and use step index fiber

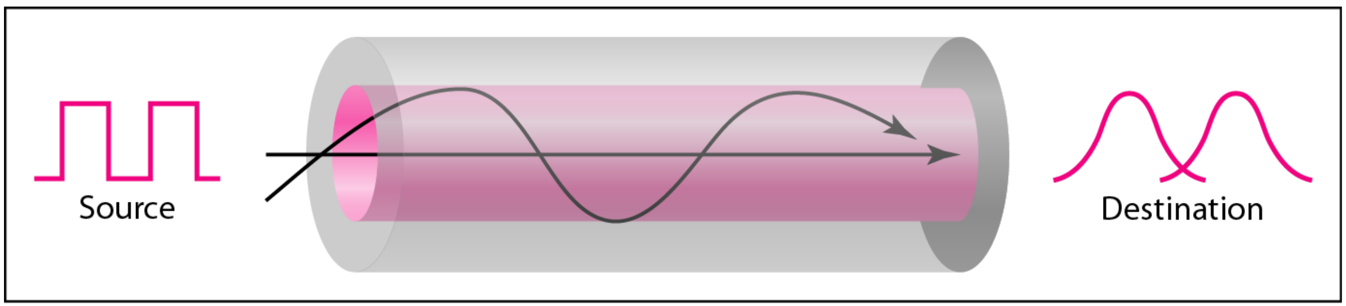
1. Density of core remain constant from center to edges

Density of core varying and highest at the center and gradually lowest at the edges

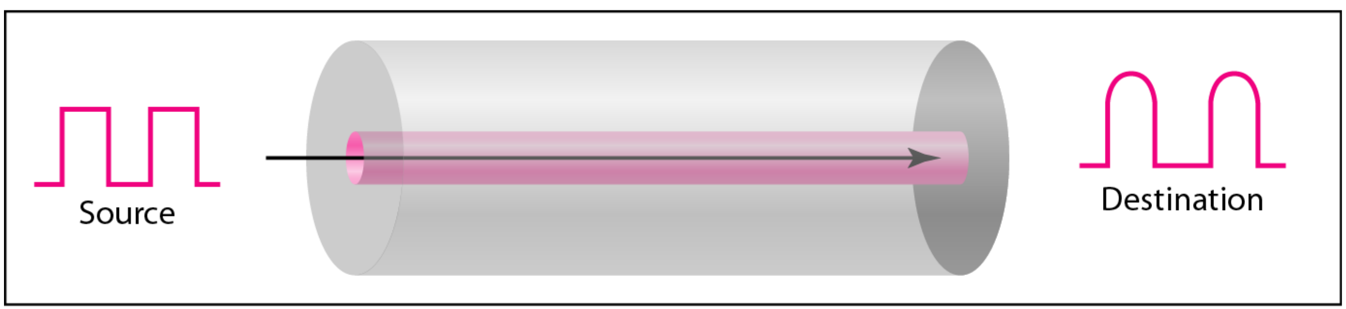
Figure 7.13 *Modes*



a. Multimode, step index



b. Multimode, graded index



c. Single mode

Fiber optic Types

- Optical fibers are defined by the ratio of the diameter of their core to the diameter of their cladding and expressed in micrometers.

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

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Comparison among Fiber optic Types

Feature	50/125 µm	62.5/125 µm	100/125 µm
Core Size	Smaller	Medium	Larger
Bandwidth	☑ High (~500+ MHz·km)	~160–200 MHz·km	✕ Low
Modal Dispersion	☑ Low (better for high-speed)	Moderate	✕ High
Max Data Rate	☑ Up to 10 Gbps and beyond	Up to 1 Gbps	Limited
Distance (GbE)	☑ Long (~600–1000 m)	Medium (~275 m)	✕ Short (~100 m or less)
Light Coupling	✕ Harder	☑ Easier	☑ Very Easy
Legacy Support	✕ Less common in older systems	☑ Common in legacy systems	☑ Used in older equipment
Standards	☑ OM2 / OM3 / OM4 / OM5	OM1	Legacy / Obsolete
Industry Preference	☑ Preferred for modern networks	✕ Phasing out	✕ Obsolete

Figure 7.14 *Fiber construction*

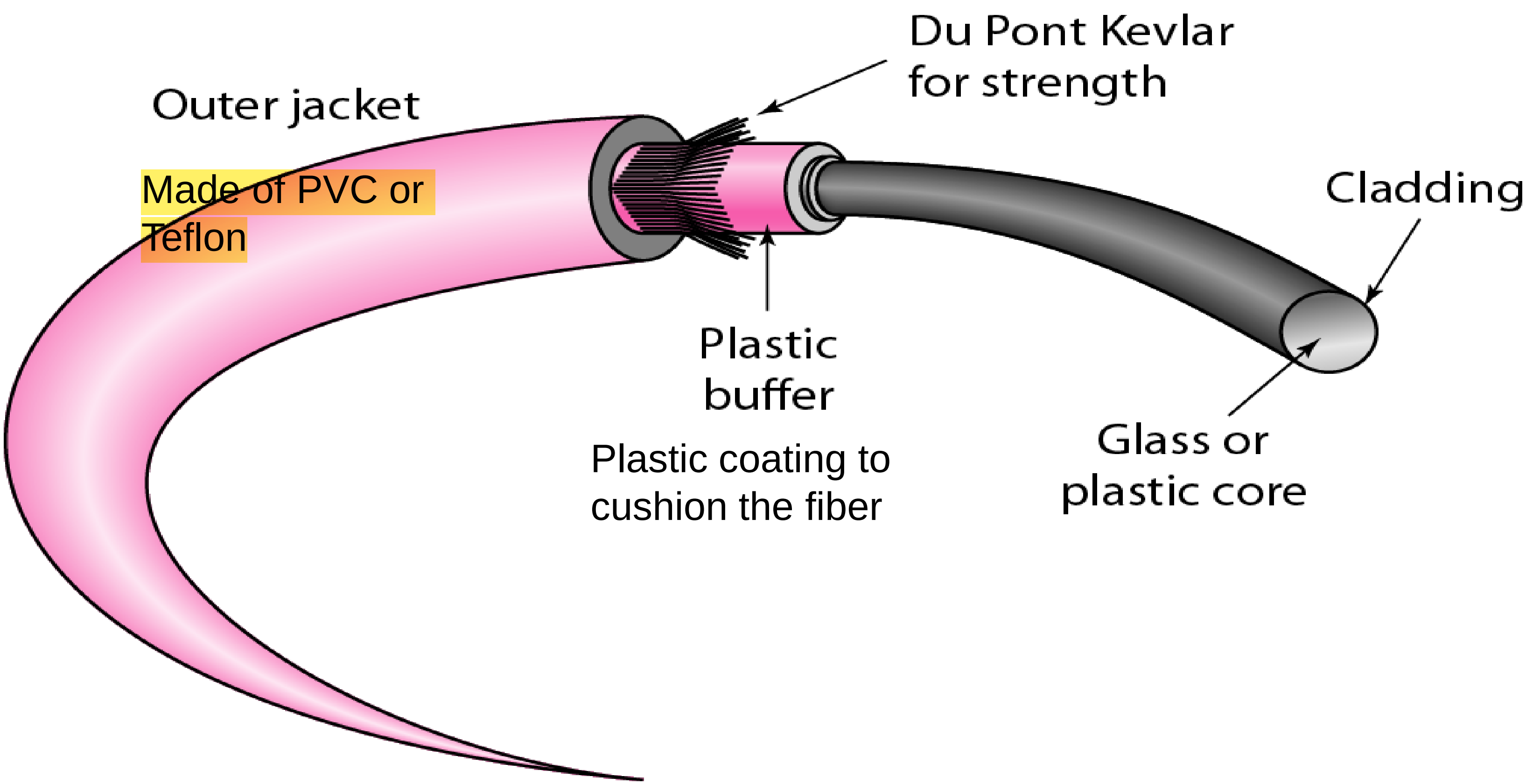
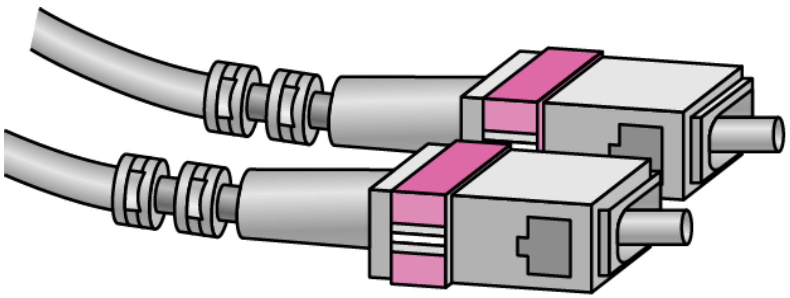
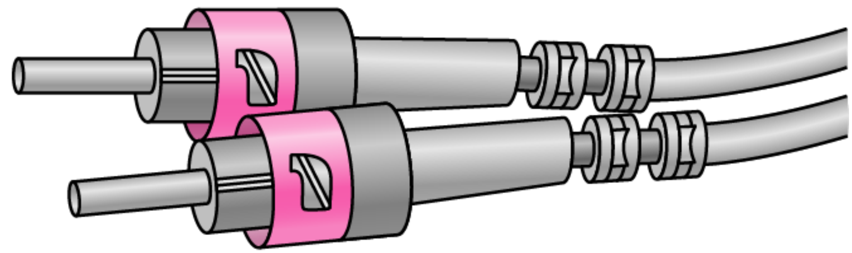


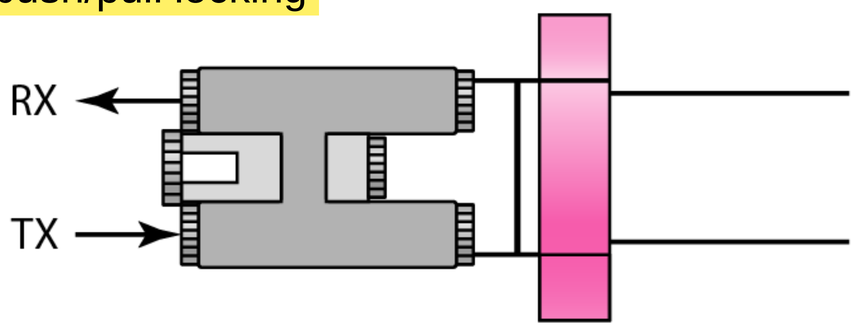
Figure 7.15 *Fiber-optic cable connectors*

Straight-tip (ST) connector is used for connecting cable to networking device and used a bayonet locking system





Subscriber Channel (SC) connector is used for cable TV and used a push/pull locking system



Mechanical Transfer Registered Jack(MT-RJ) is a small size connection as RJ45 connector and used in small size device as commercial workstation, router, modems, and other device

7-2 UNGUIDED MEDIA: WIRELESS

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

Topics discussed in this section:

Radio Waves
Microwaves
Infrared

Figure 7.17 *Electromagnetic spectrum for wireless communication*

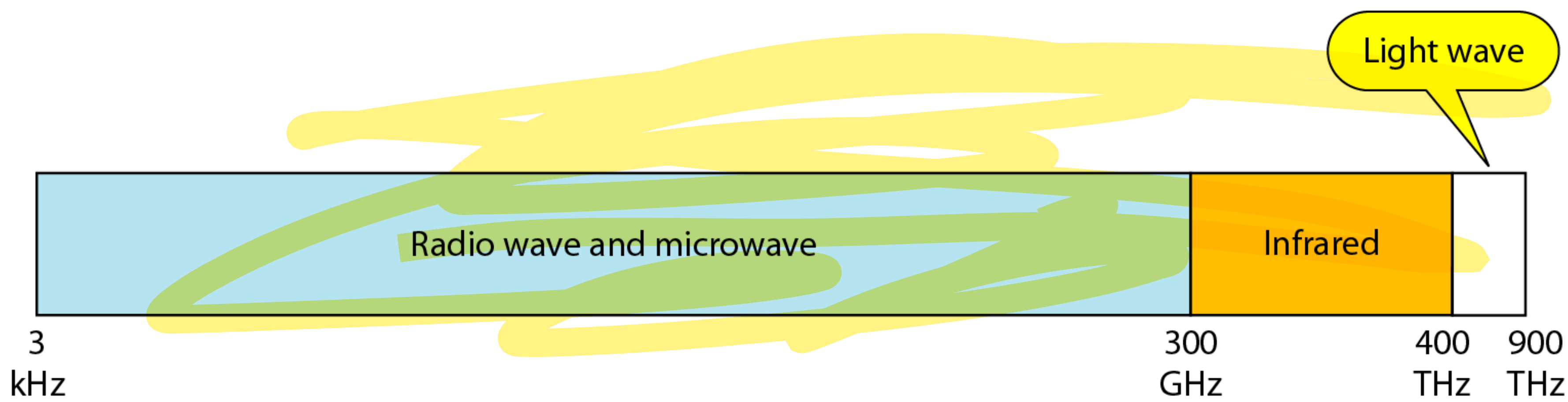
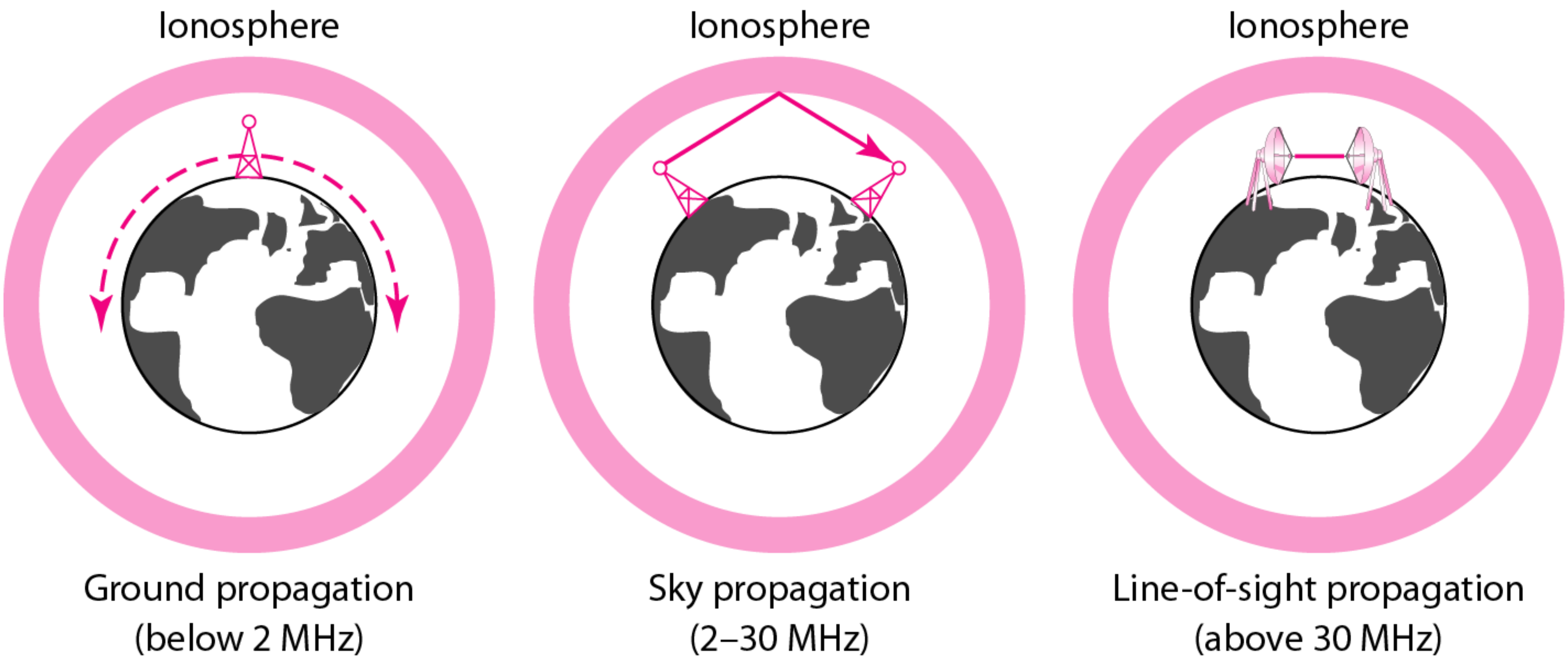


Figure 7.18 *Propagation methods*



1. Radio wave travels through the lowest portion of the atmosphere.
2. Travel distance depends on the power

1. Very high frequency signals are transmitted in straight lines directly from antenna to antenna.

1. Higher frequency radio waves radiate upward into the ionosphere and reflected back to the earth
2. Allows for greater distance and lower output power

Table 7.4 *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

Comparison among ground, sky, and Line of sight propagation

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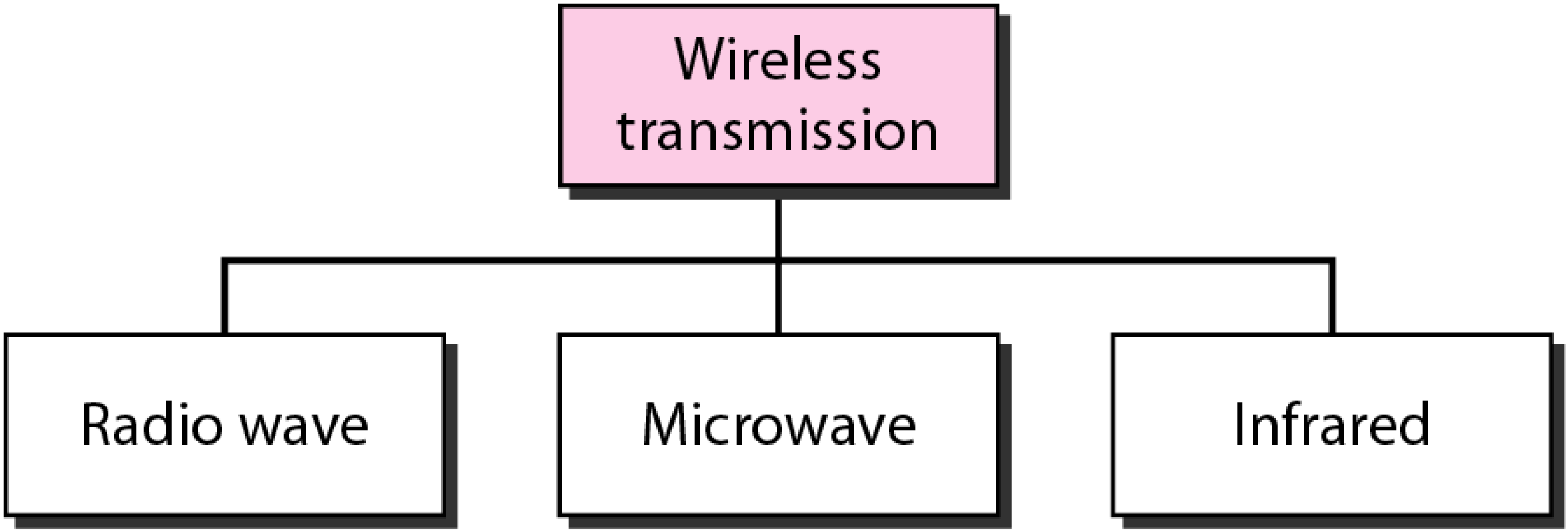
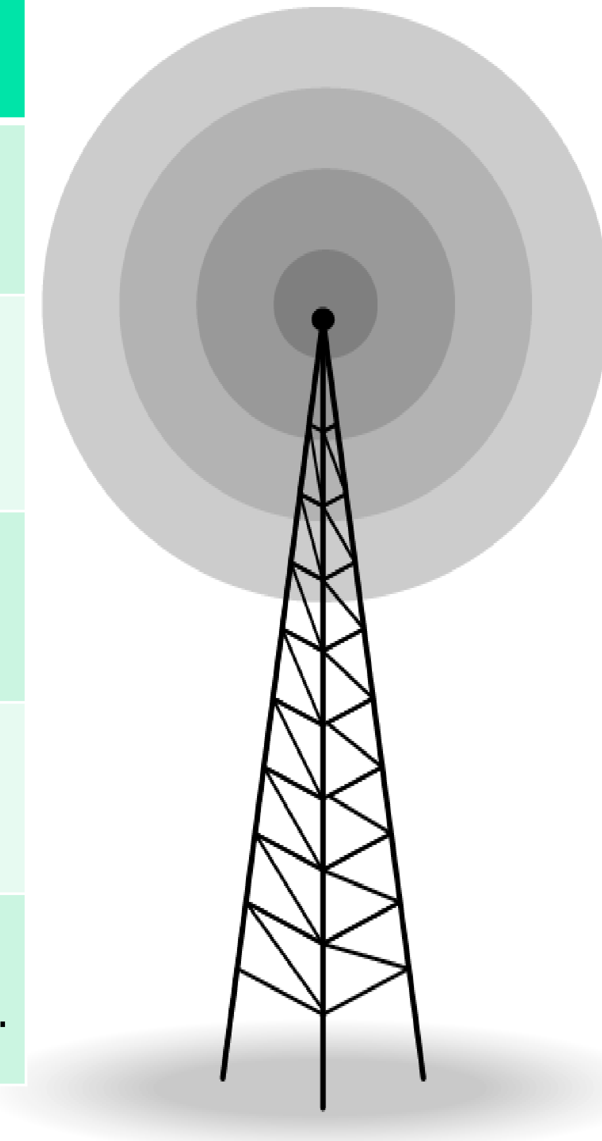
Feature	Ground Propagation	Sky Propagation	Line of Sight (LOS) Propagation
Definition	Radio waves travel close to the Earth's surface	Radio waves reflected/refracted by the ionosphere	Direct straight-line path between transmitter and receiver
Frequency Range	Typically low frequencies (up to ~2 MHz)	Medium frequencies (~2 MHz to 30 MHz)	High frequencies (above ~30 MHz)
Distance Coverage	Limited to moderate distances (tens to hundreds of km)	Very long distances (thousands of km)	Short to moderate distances (line of sight range)
Propagation Mechanism	Surface wave follows Earth's curvature	Skywave reflects from ionosphere layers	Direct wave travels unobstructed in straight path
Signal Reliability	Affected by terrain, ground conductivity	Variable; depends on ionospheric conditions	Highly reliable if unobstructed
Applications	AM radio broadcasting, maritime communication	Long-distance HF radio, amateur radio	TV, FM radio, satellite, microwave links
Advantages	Can reach beyond horizon due to diffraction	Enables global communication without satellites	Low delay, high bandwidth, clear reception
Disadvantages	Attenuation due to ground losses	Signal affected by time of day and solar activity	Limited by Earth's curvature and obstacles

Figure 7.19 *Wireless transmission waves*



Omnidirectional antenna

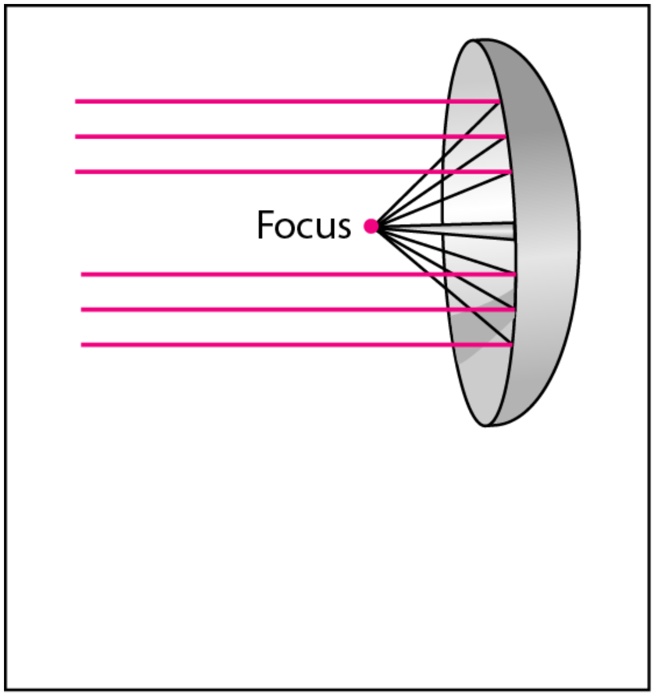
Characteristics	Description
Radiation Pattern:	Emits radio waves equally in all horizontal directions (360° around the antenna).
Coverage:	Provides broad, uniform coverage in the horizontal plane, but limited vertical coverage.
Common Use:	Ideal for environments where signals must reach devices in all directions, such as Wi-Fi routers, mobile base stations, and walkie-talkies.
Design Types:	Examples include dipole antennas, ground-plane antennas, and vertical whip antennas.
Applications:	Suitable for broadcasting, mobile communication, and any scenario needing wide-area coverage without direction bias.



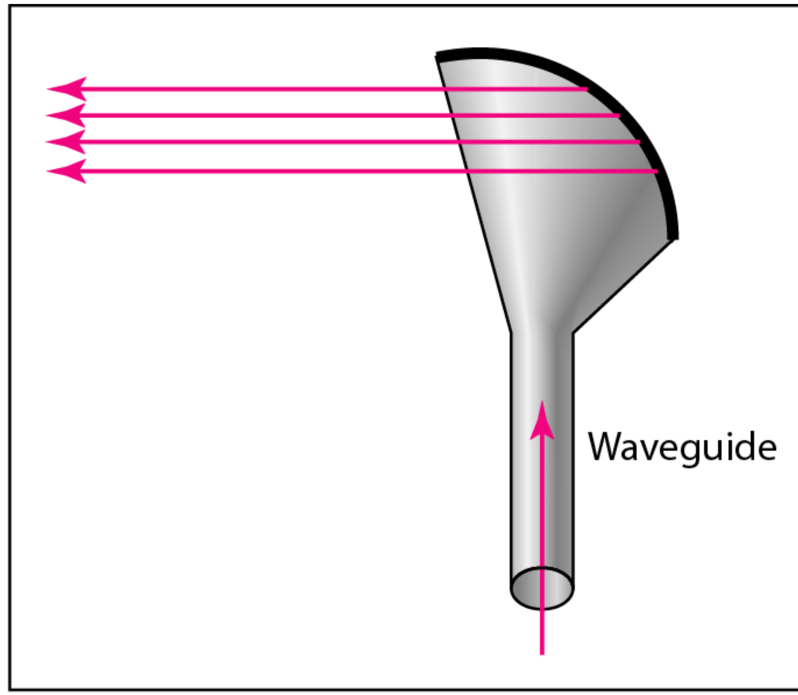
Note

Radio waves are used for multicast communications, such as radio and television, and paging systems.

Figure 7.21 *Unidirectional antennas*

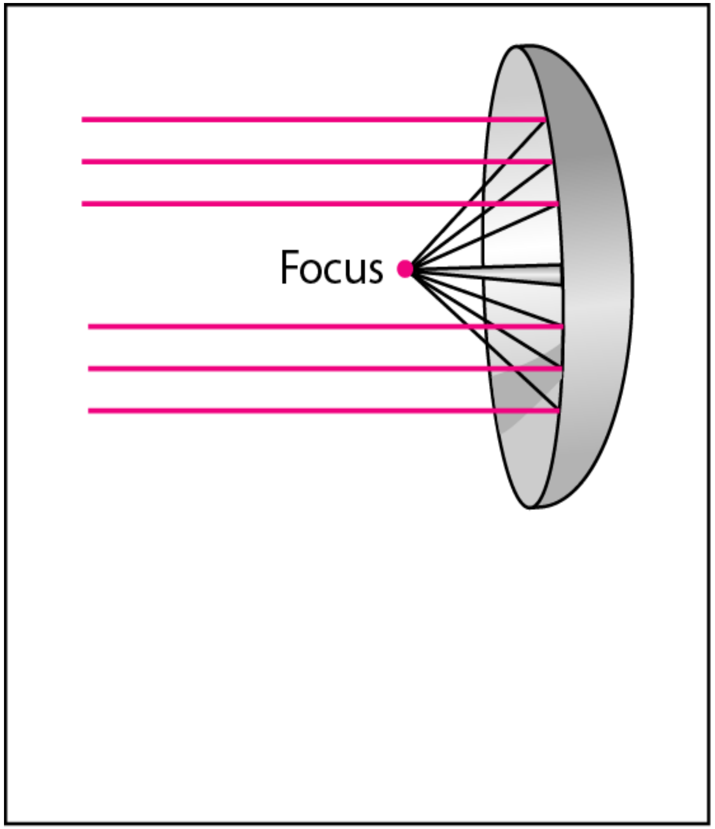


a. Dish antenna



b. Horn antenna

Figure 7.21 *Unidirectional antennas*



a. Dish antenna

- Microwave needs unidirectional antenna that send out signal in one direction.
- A parabolic dish antenna receives every line in such way that all incoming straight lint reflects back to a common point called focus point.
- It acts as a funnel catching a wide range of waves and directing to acommon point.

Figure 7.21 *Unidirectional antennas*

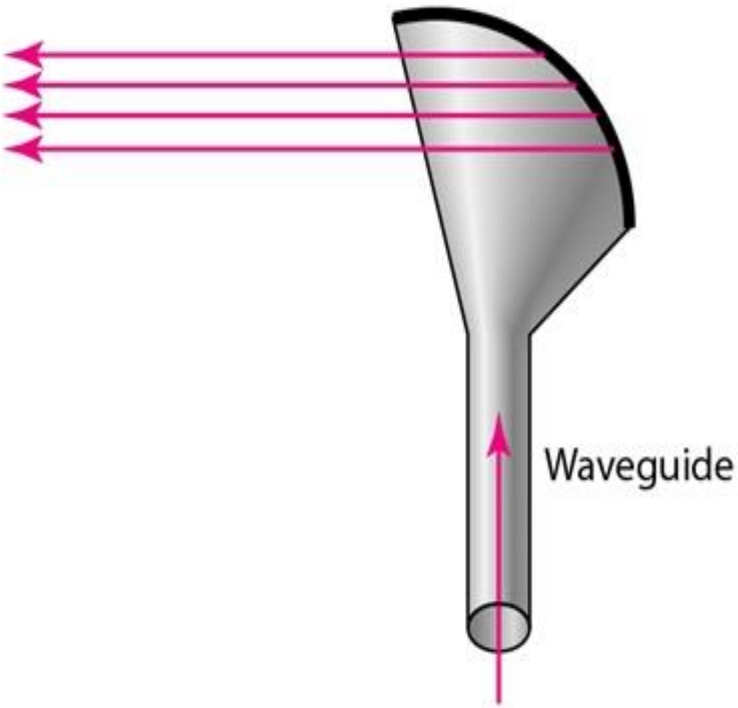


Fig. Horn antenna

- Consists of a flared metal waveguide shaped like a horn to direct radio waves into a beam.
- Radiates or receives microwave signals by gradually transitioning from a waveguide to free space, reducing reflection and increasing gain.
- Commonly used in microwave frequencies, typically from 1 GHz to 40 GHz.
- Used in radar systems, satellite communication, and as feed horns for parabolic dish antennas.

Note

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

Note

Infrared signals can be used for short-range communication in a closed area using line-of-sight propagation.

THANK YOU.