Computer Networks (CS30006)

Spring Semester (2021-2022)

Transmission Media

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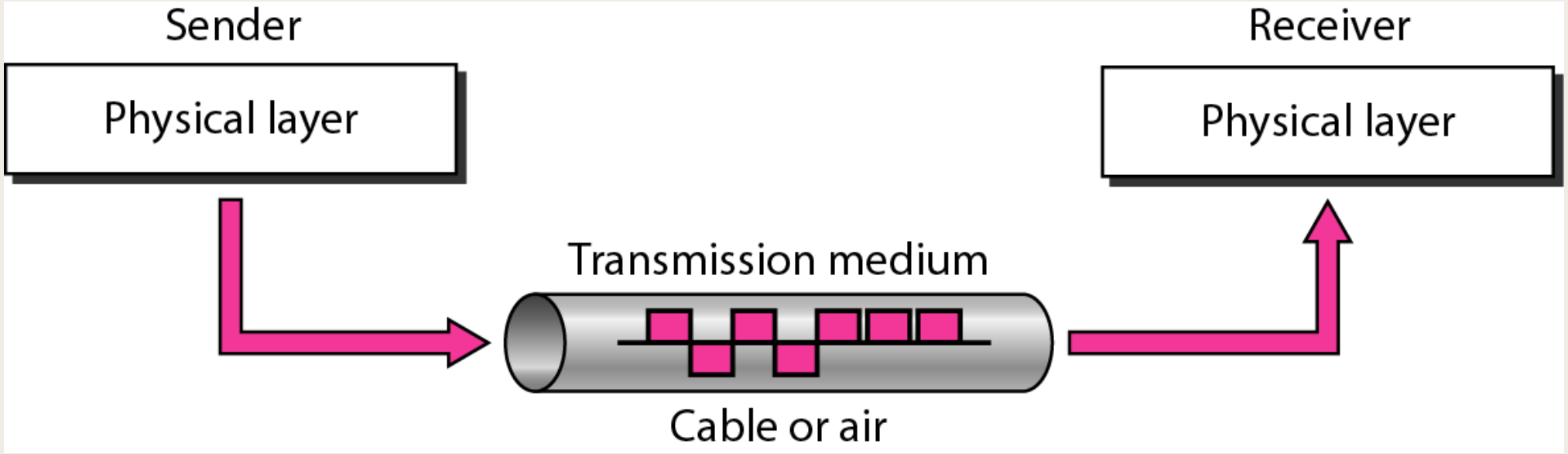
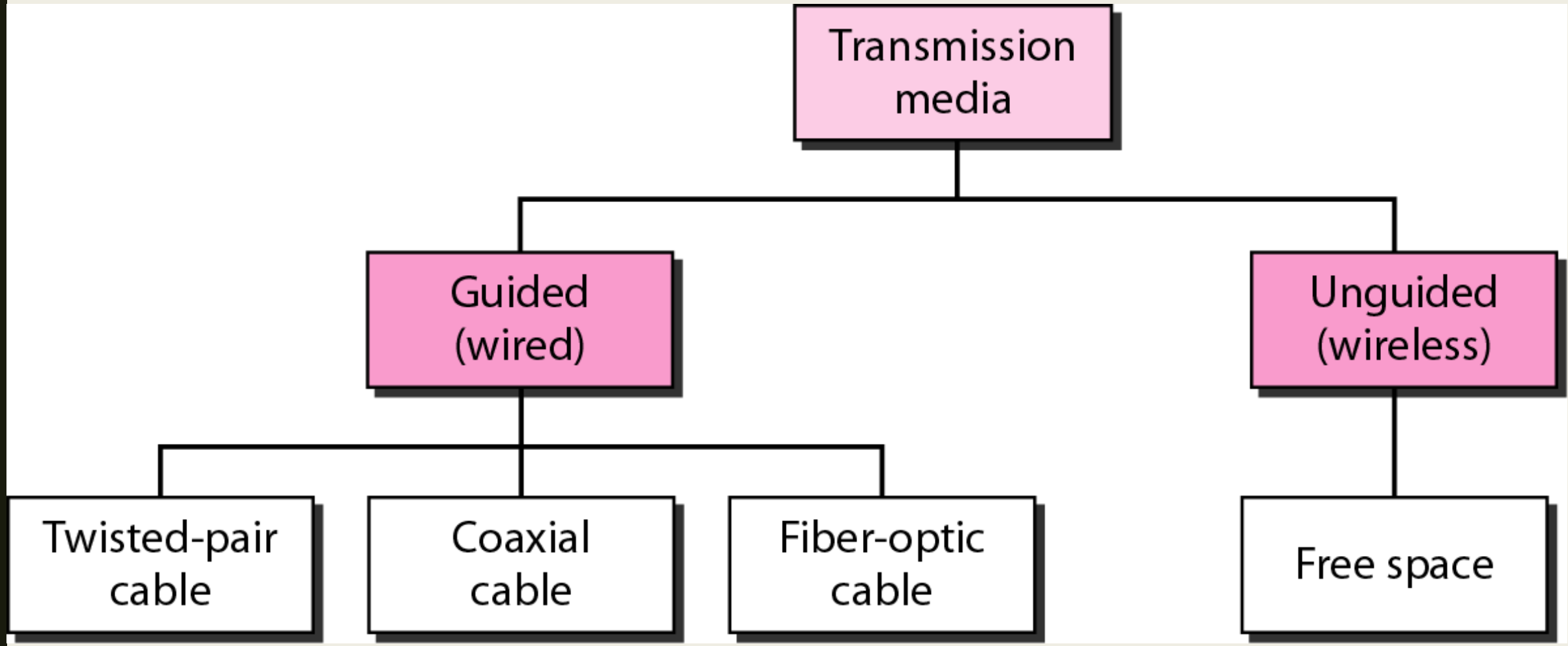
Transmission Medium

- 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.



Source: B. A. Forouzan, " Data Communications and Networking ," *McGraw-Hill Forouzan Networking Series*,5E.

Types of Transmission Medium



Source: B. A. Forouzan, " Data Communications and Networking ," *McGraw-Hill Forouzan Networking Series*,5E.

Guided Transmission Medium

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

- A signal traveling along any of these media is directed and contained by the physical limits of the medium.

	Frequency Range	Typical Attenuation	Typical Delay	Repeater Spacing
Twisted pair (with loading)	0 to 3.5 kHz	0.2 dB/km @ 1 kHz	50 μs/km	2 km
Twisted pairs (multi-pair)	0 to 1 MHz	0.7 dB/km @ 1 kHz	5 μs/km	2 km
Coaxial cable	0 to 500 MHz	7 dB/km @ 10 MHz	4 μs/km	1 to 9 km
Optical fiber	186 to 370 THz	0.2 to 0.5 dB/km	5 μs/km	40 km

Source: B. A. Forouzan, " Data Communications and Networking ," *McGraw-Hill Forouzan Networking Series*,5E.

Twisted Pair Cable

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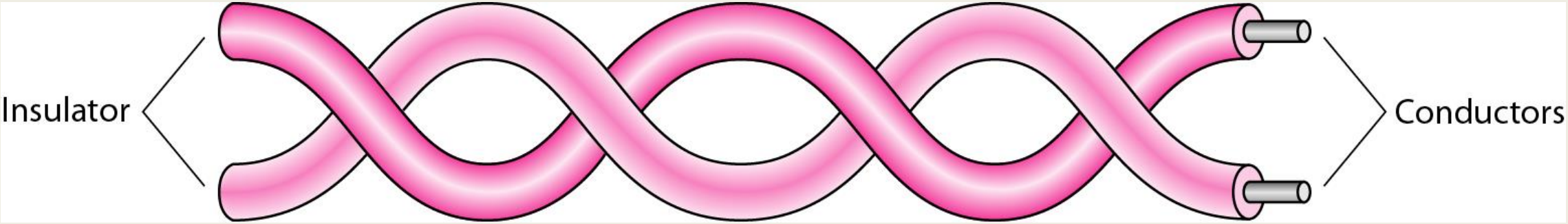


Source: B. A. Forouzan, " Data Communications and Networking ," *McGraw-Hill Forouzan Networking Series*,5E.

Characteristics of Twisted Pair Cable

Analog

- Amplifiers every 5km to 6km

Digital

- Use either analog or digital signals
- Repeater every 2km or 3km

Limited distance
Limited bandwidth (1MHz)
Limited data rate (100MHz)
Susceptible to interference and noise

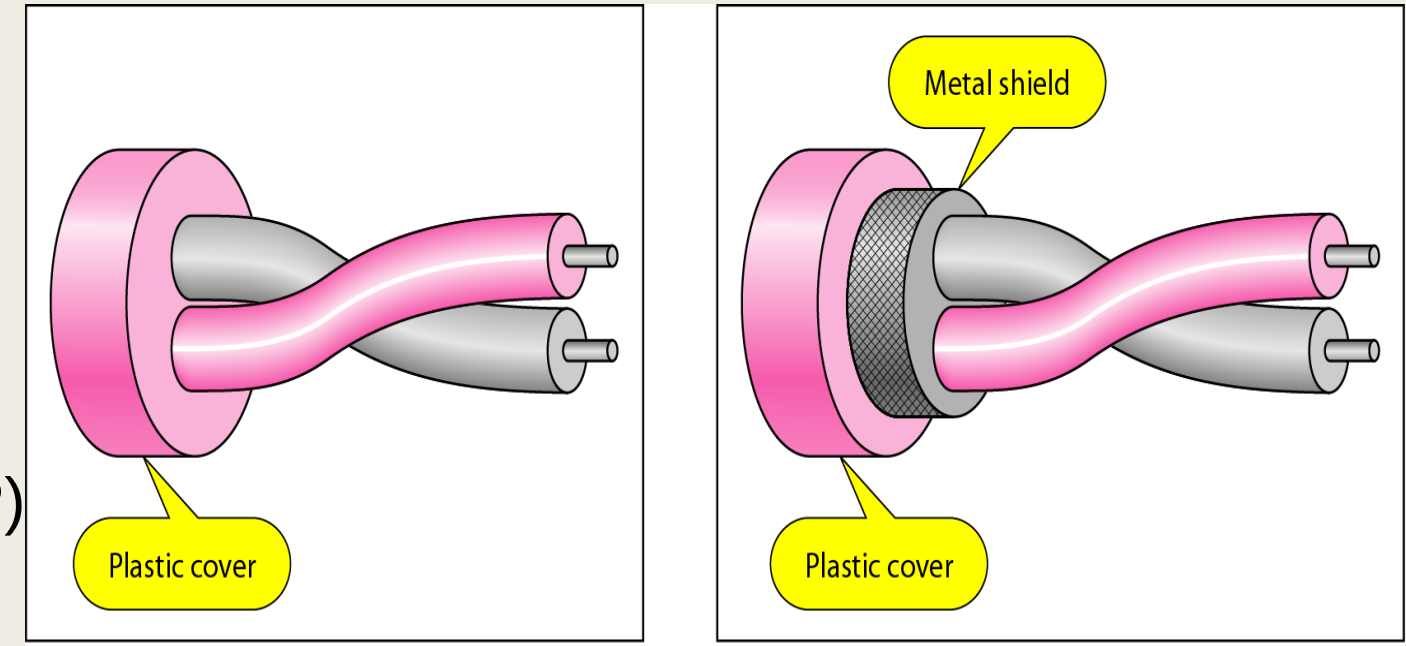
Types of Twisted Pair Cable

Unshielded Twisted Pair Cable (UTP)

- Ordinary telephone wire
- Cheapest
- Easiest to install
- Suffers from external EM interference

Shielded Twisted Pair Cable (STP)

- Metal braid or sheathing that reduces interference
- More expensive
- Harder to handle (thick, heavy)



a. UTP b. STP

Source: B. A. Forouzan, " Data Communications and Networking ," *McGraw-Hill Forouzan Networking Series*,5E.

Types of Twisted Pair Cable

	Attenuation (dB per 100 m)			Near-end Crosstalk (dB)		
Frequency (MHz)	**Category 3 UTP**	**Category 5 UTP**	**150-ohm STP**	**Category 3 UTP**	**Category 5 UTP**	**150-ohm STP**
1	2.6	2.0	1.1	41	62	58
4	5.6	4.1	2.2	32	53	58
16	13.1	8.2	4.4	23	44	50.4
25	—	10.4	6.2	—	41	47.5
100	—	22.0	12.3	—	32	38.5
300	—	—	21.4	—	—	31.3

Source: B. A. Forouzan, " Data Communications and Networking ," *McGraw-Hill Forouzan Networking Series*,5E.

Categories of UTP

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

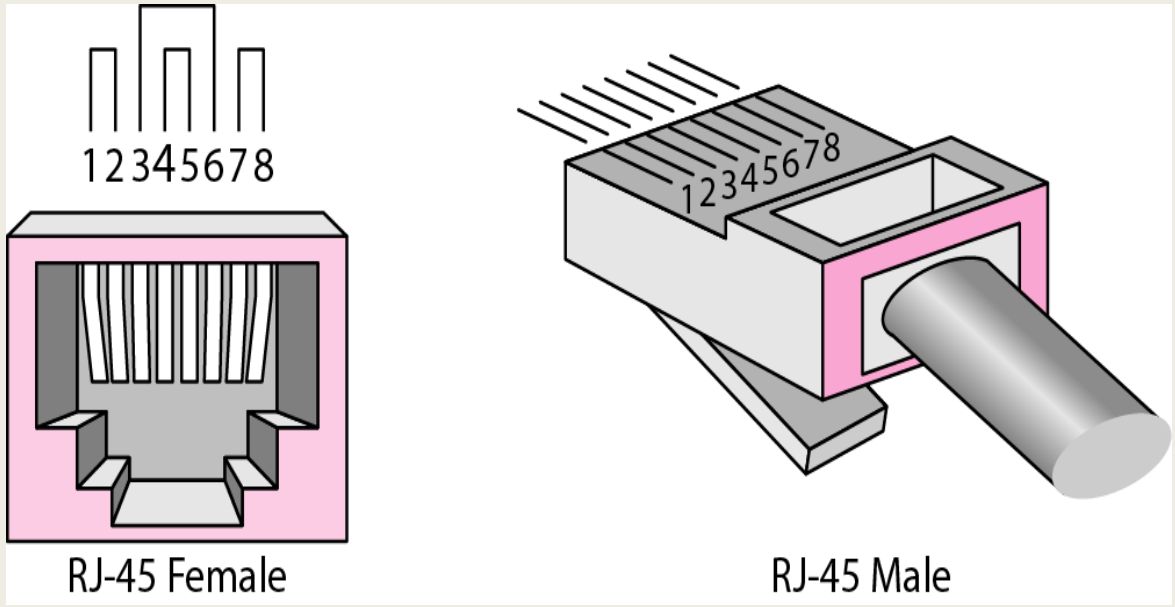
Source: B. A. Forouzan, " Data Communications and Networking ," *McGraw-Hill Forouzan Networking Series*,5E.

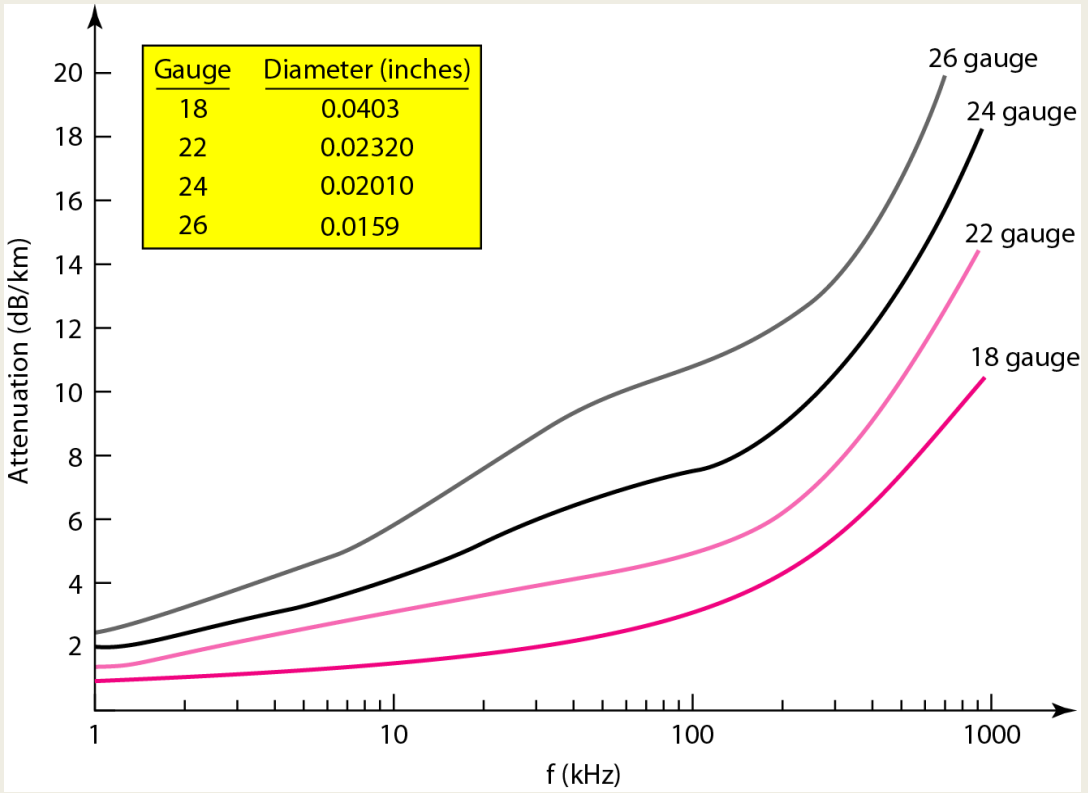
Categories of UTP

Category	Standard Bandwidth	Max Data Rate	Shielding
Cat5e	100MHz (up to 350)	1000Mbps	UTP or STP
Cat6	250MHz (up to 550)	1000Mbps	UTP or STP
Cat6A	500MHz (up to 550)	10Gbps	UTP or STP
Cat7	600MHz	10Gbps	Shielded only
Cat8	2000MHz	25Gbps or 40Gbps	Shielded only

Source: [Online] Link: http://www.cablek.com/technical-reference/cat-5---5e--6--6a---7--8-standards

UTP Connectors





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Advantages of Twisted Pair Cable

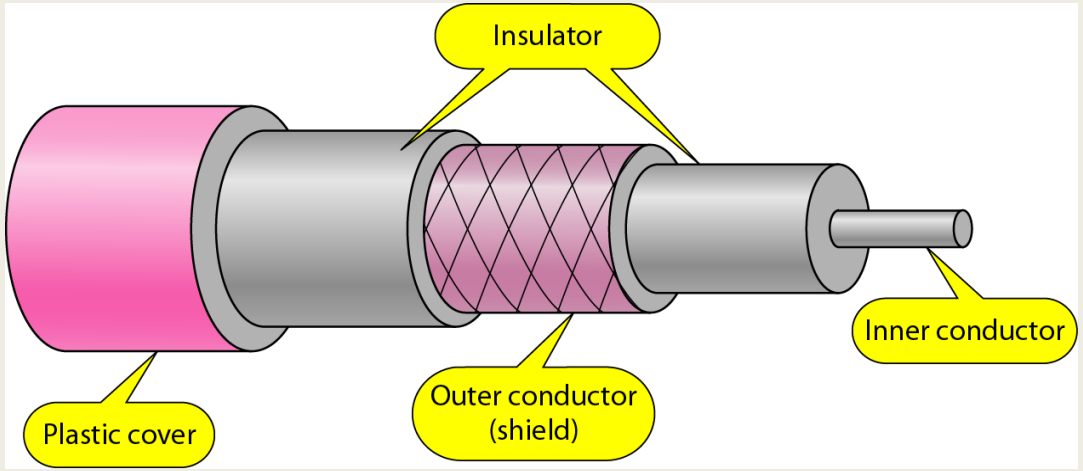
- It is often used to carry both analog and digital data.
- It's relatively easy to implement and terminate.
- It is the smallest amount expensive media of transmission for brief distances.
- If portion of a twisted pair cable is broken it doesn't affect the whole network.
- Less vulnerable to electrical interference caused by nearby equipment or wires.
- It causes interference themselves.
- Best performance in short distances.
- High-cost performance

Disadvantages of Twisted Pair Cable

- It results signal distortion.
- Attenuation is very high.
- It supports 10 mbps upto a distance of 100 meters on a 10BASE-T which are considered to be low bandwidth.
- It provides poor security and is relatively easy to tap.
- As they a thin so can be easily broken.
- Low durability (must be maintained regularly).
- Susceptible to electromagnetic interference (EMI).

Coaxial Cable

- Coaxial cable (or coax) carries signals of higher frequency ranges than those in twisted pair cable, in part because the two media are constructed quite differently.



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

Source: B. A. Forouzan, " Data Communications and Networking ," *McGraw-Hill Forouzan Networking Series*,5E.

Characteristics of Coaxial Cable

Analog

- Amplifiers every few km
- Closer if higher frequency
- Up to 500MHz

Digital

- Repeater every 1km
- Closer for higher data rates

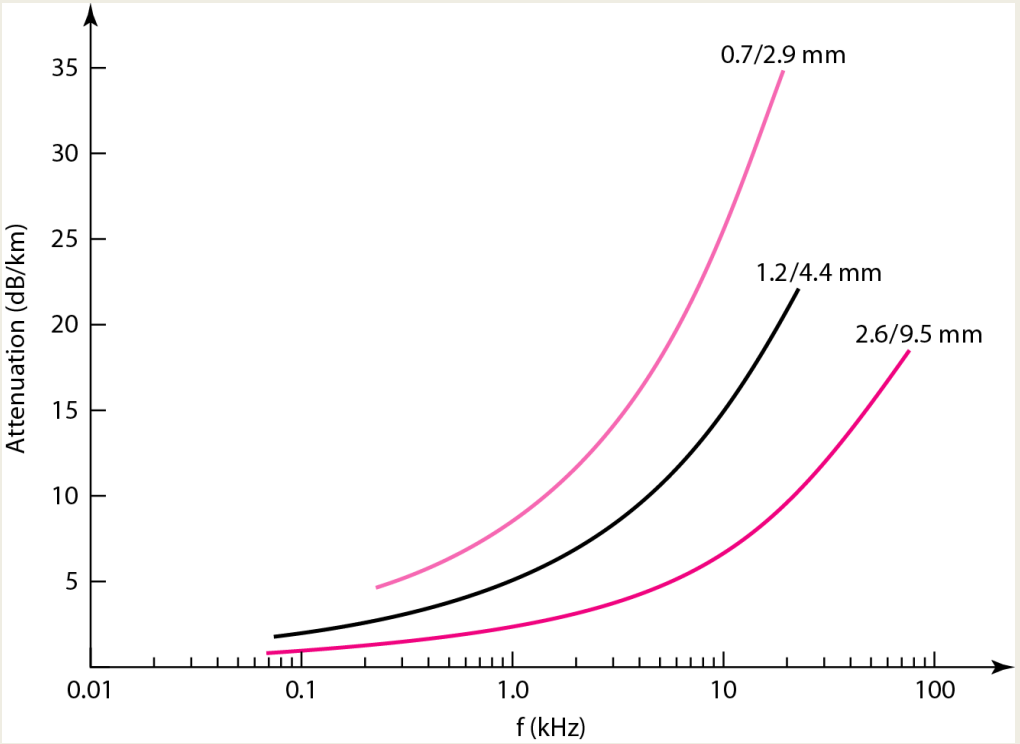


Fig.: Performance of Coaxial Cable

Source: B. A. Forouzan, " Data Communications and Networking ," *McGraw-Hill Forouzan Networking Series*,5E.

Pros and Cons of Coaxial Cable

Pros

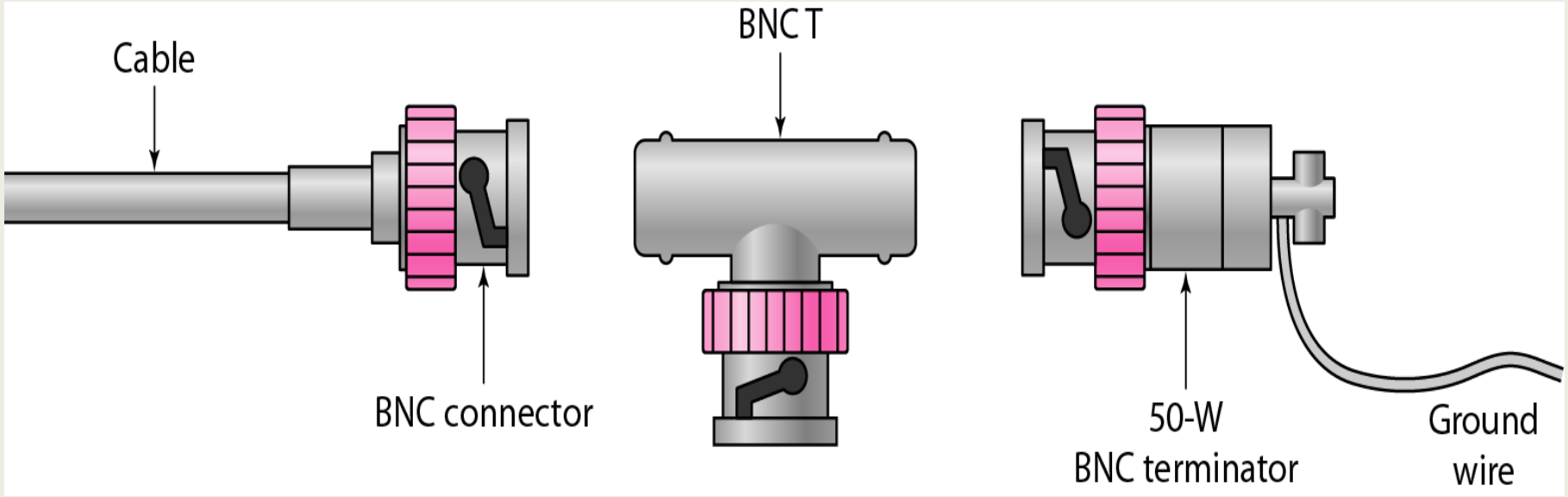
- Coaxial cable is very durable.
- Best performance in short-distance transmission.

Cons

- Long-distance signal loss is serious
- Signal leakage at the connection
- Speed fluctuation under heavy use

Coaxial Cable Connectors

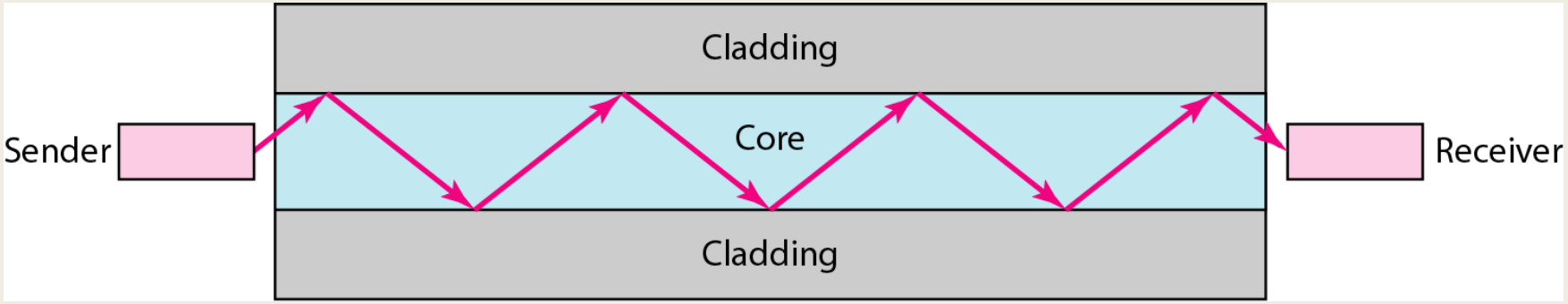
- Used to connect the end of the cable to a device, such as a TV set.
- The BNC connector is used in Ethernet networks to branch out to a connection to a computer or other device.
- The BNC terminator is used at the end of the cable to prevent the reflection of the signal.



Source: B. A. Forouzan, " Data Communications and Networking ," *McGraw-Hill Forouzan Networking Series*,5E.

Fiber Optics

- Greater capacity
- Data rates of hundreds of Gbps
- Smaller size & weight
- Lower attenuation
- Electromagnetic isolation
- Greater repeater spacing



Source: B. A. Forouzan, " Data Communications and Networking ," *McGraw-Hill Forouzan Networking Series*,5E.

Characteristics of Fiber Optics

Act as wave guide for 10^{14} to 10^{15} Hz

- Portions of infrared and visible spectrum

Light Emitting Diode (LED)

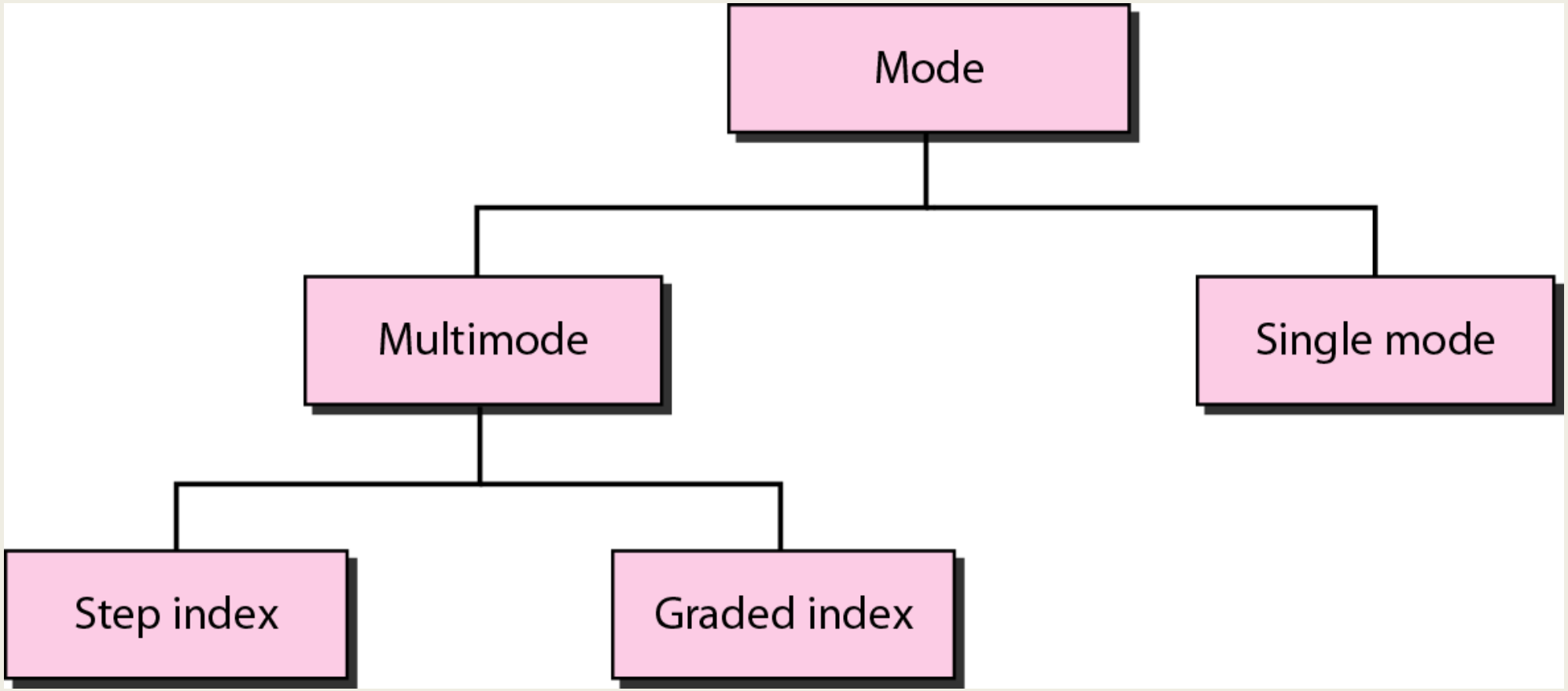
- Cheaper
- Wider operating temp range
- Last longer

Injection Laser Diode (ILD)

- More efficient
- Greater data rate

Wavelength Division Multiplexing

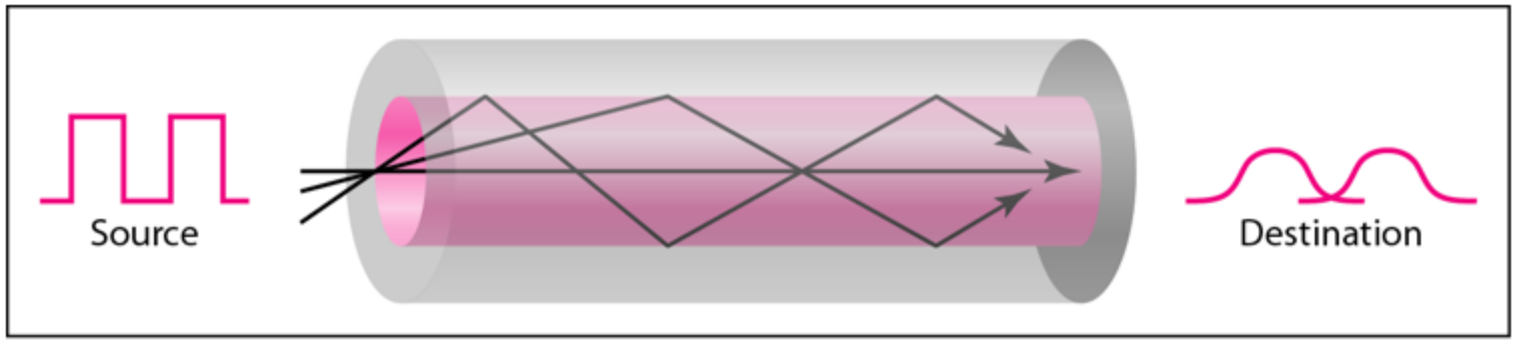
Propagation modes of Fiber Optics



Source: B. A. Forouzan, " Data Communications and Networking ," *McGraw-Hill Forouzan Networking Series*,5E.

Multi-mode, Step Index

- Multiple beams from a light source move through the core in different paths.
- In multimode step-index fiber, the density of the core remains constant from the center to the edges.
- A beam of light moves through this constant density in a straight line until it reaches the interface of the core and the cladding.
- At the interface, there is an abrupt change due to a lower density; this alters the angle of the beam's motion.
- The term *step index* refers to the suddenness of this change, which contributes to the distortion of the signal as it passes through the fiber

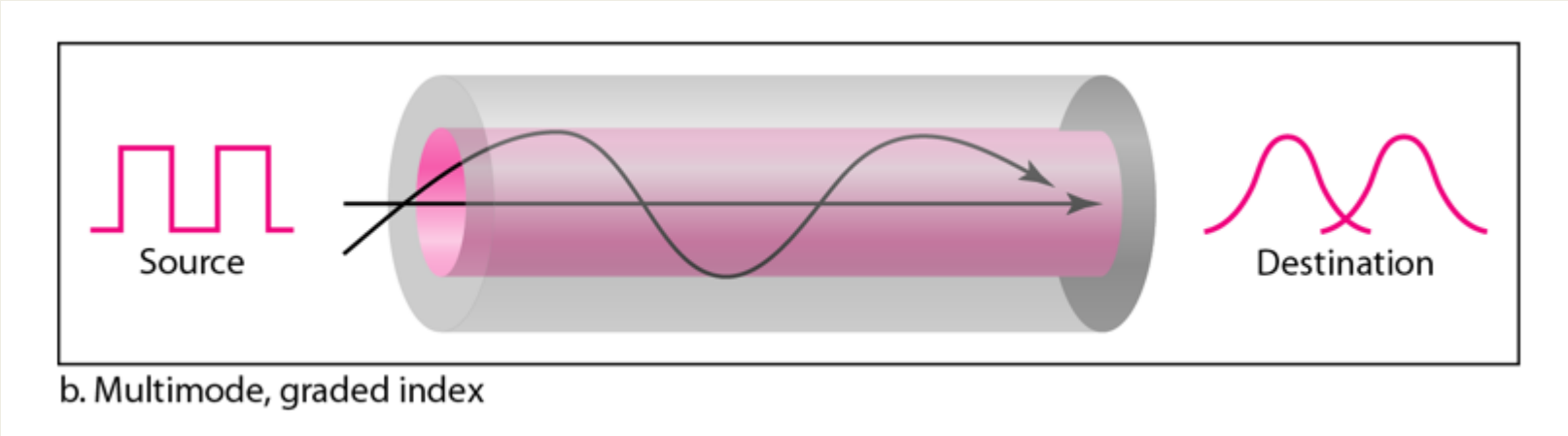


a. Multimode, step index

Source: B. A. Forouzan, " Data Communications and Networking ," *McGraw-Hill Forouzan Networking Series*,5E.

Multi-mode, Graded Index

- Having varying densities.
- Density is highest at the center of the core and decreases gradually to its lowest at the edge.

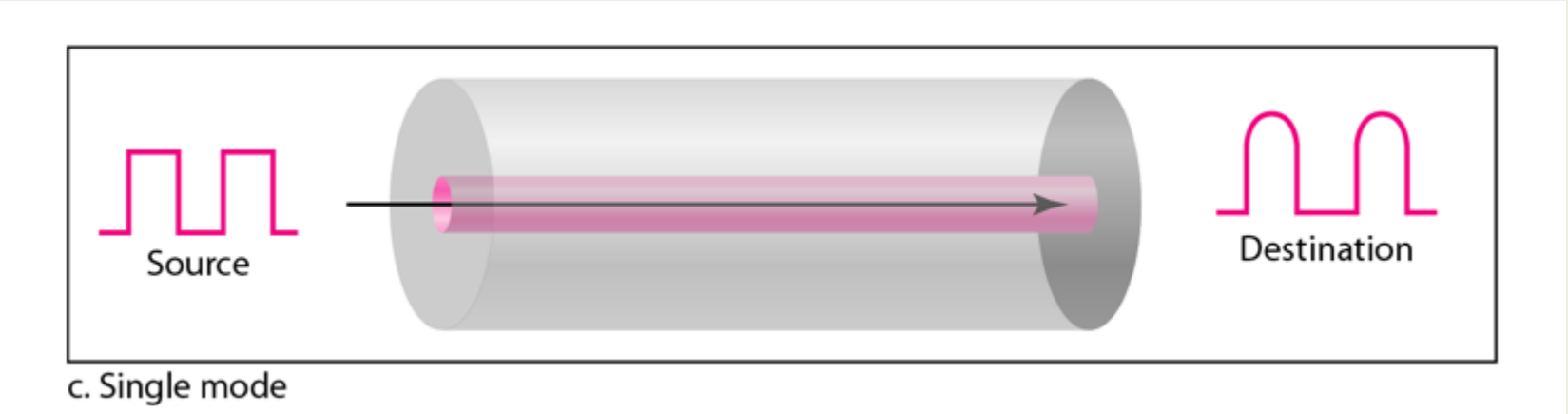


b. Multimode, graded index

https://docs.google.com/viewer?a=v&pid=sites&srcid=ZGVmYXVsdGRvbWFpbnxlZWJhaHJpYTV8Z3g6MjE2MzY2MjcxMGU3MmQ4Nw

Single mode

- 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.
- Manufactured with a much smaller diameter than that of multimode fiber.
- Lower density.



c. Single mode

Source: B. A. Forouzan, " Data Communications and Networking ," *McGraw-Hill Forouzan Networking Series*,5E.

Types of Fibers

Optical fibers are defined by the ratio of the diameter of their core to the diameter of their cladding, both 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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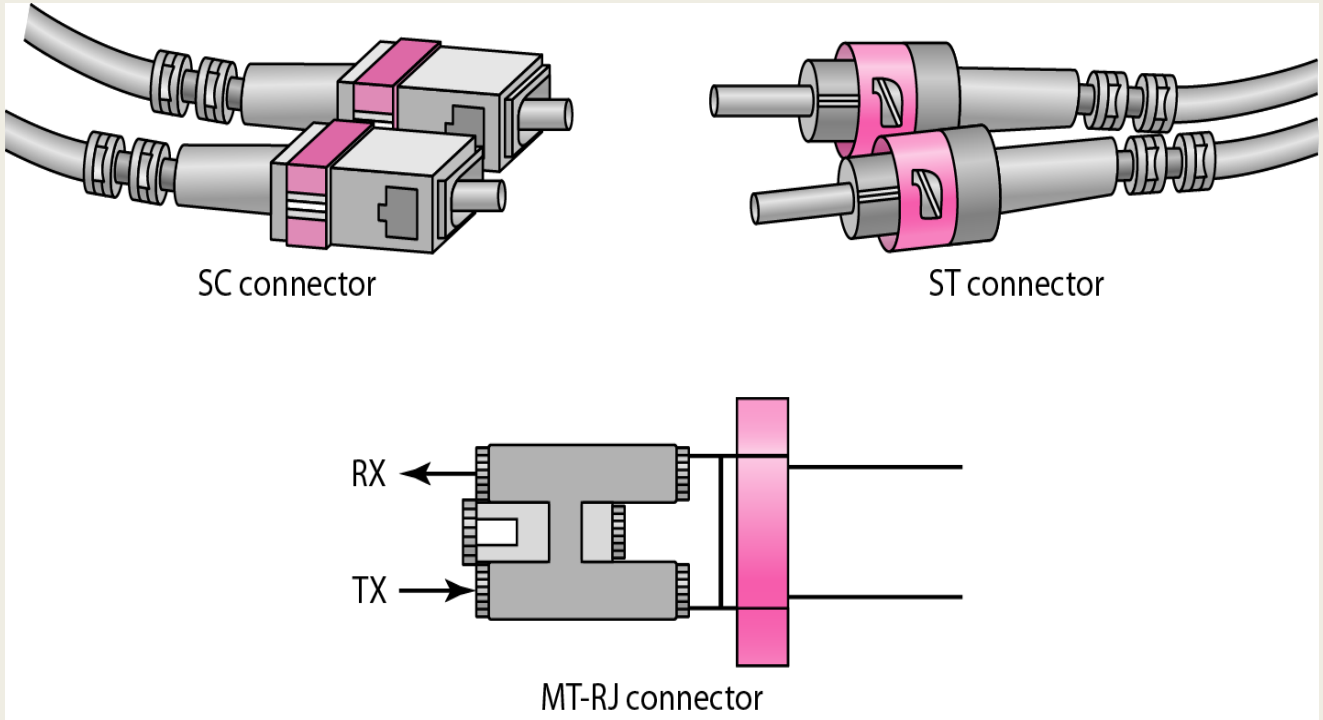
Fiber Cable Connector

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.



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Unguided Media

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

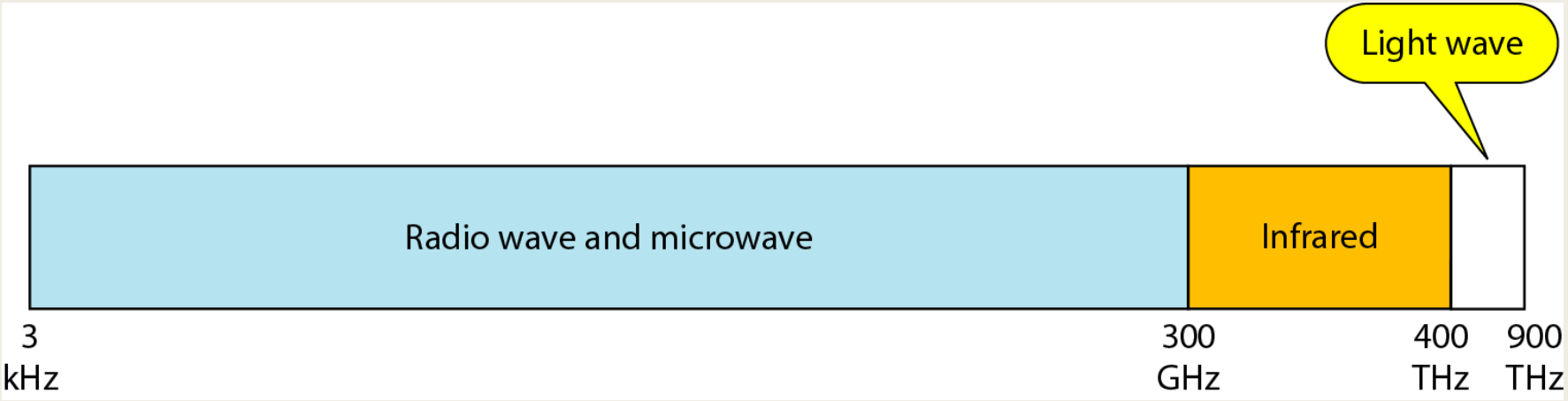

Fig. :Electromagnetic spectrum for wireless communication

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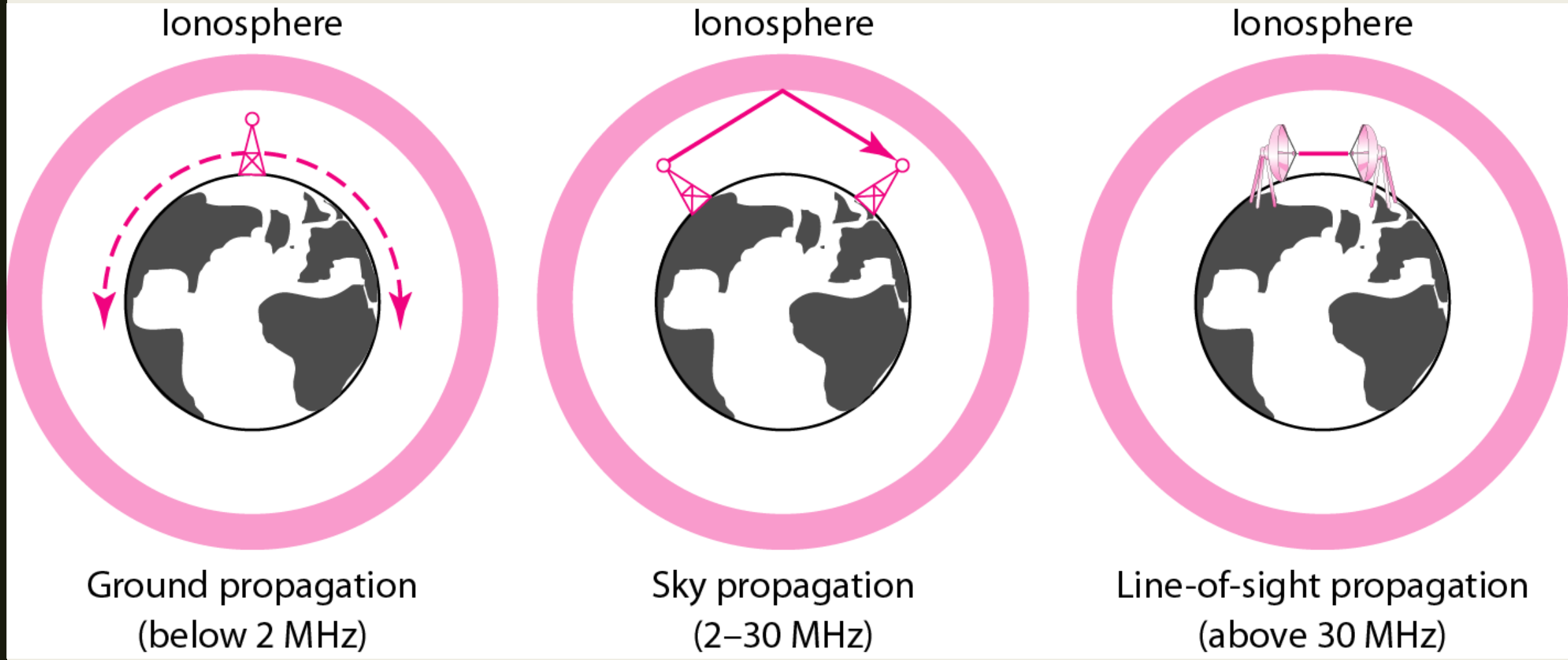
Propagation Methods



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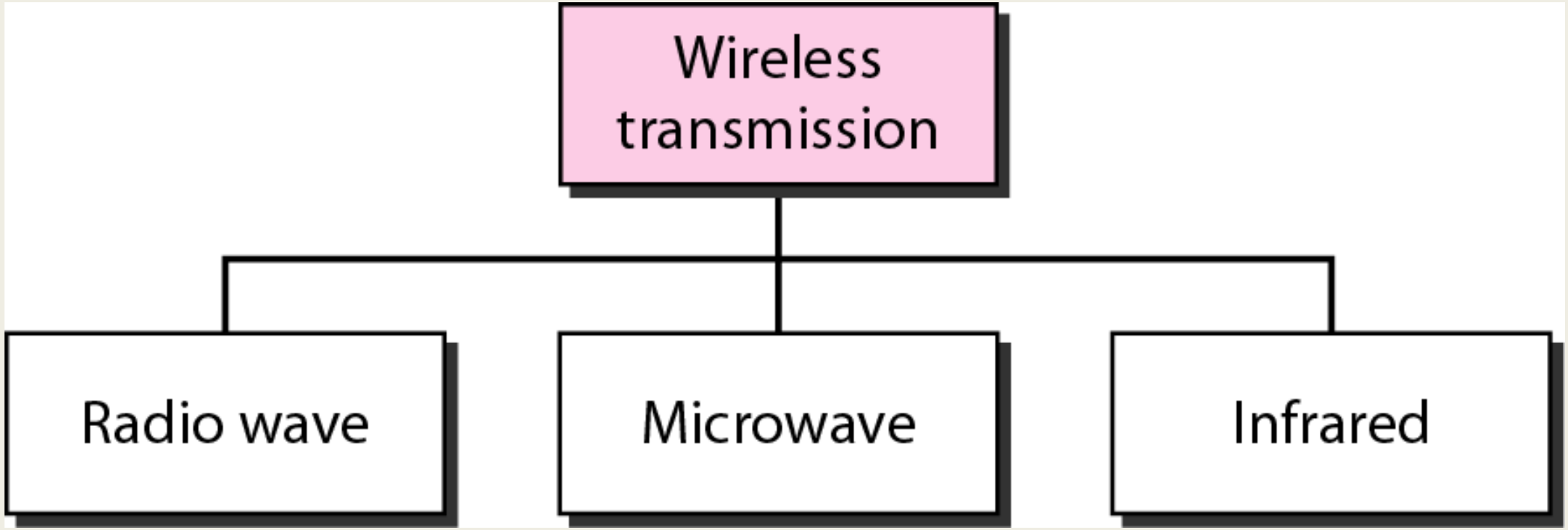
Bands

The section of the electromagnetic spectrum defined as radio waves and microwaves is divided into eight ranges, called *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

https://docs.google.com/viewer?a=v&pid=sites&srcid=ZGVmYXVsdGRvbWFpbnxlZWJhaHJpYTV8Z3g6MjE2MzY2MjcxMGU3MmQ4Nw

Wireless Transmission Waves



Source: B. A. Forouzan, " Data Communications and Networking ," *McGraw-Hill Forouzan Networking Series*,5E.

Radio Waves

- Radio waves are a type of electromagnetic radiation with wavelengths in the electromagnetic spectrum longer than infrared radiation.
- Radio waves are generated artificially by transmitters and received by radio receivers, using antennas.
- They can penetrate through walls.
- Use omni directional antennas

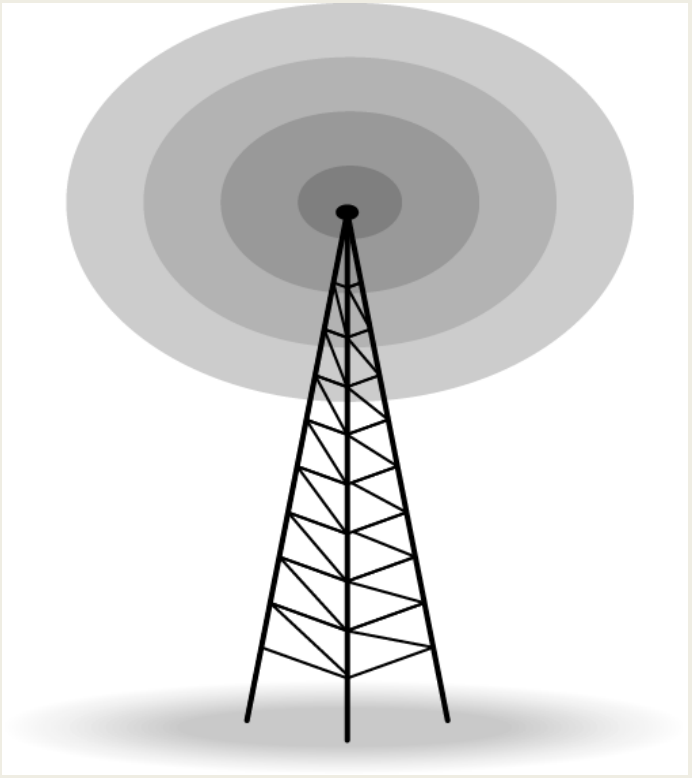


Fig. Omnidirectional antenna

Source: B. A. Forouzan, " Data Communications and Networking ," *McGraw-Hill Forouzan Networking Series*,5E.

Microwaves

- Microwaves are used for unicast communication such as cellular telephones, satellite networks, and wireless LANs.
- Higher frequency ranges cannot penetrate walls.
- Use directional antennas - point to point line of sight communications.

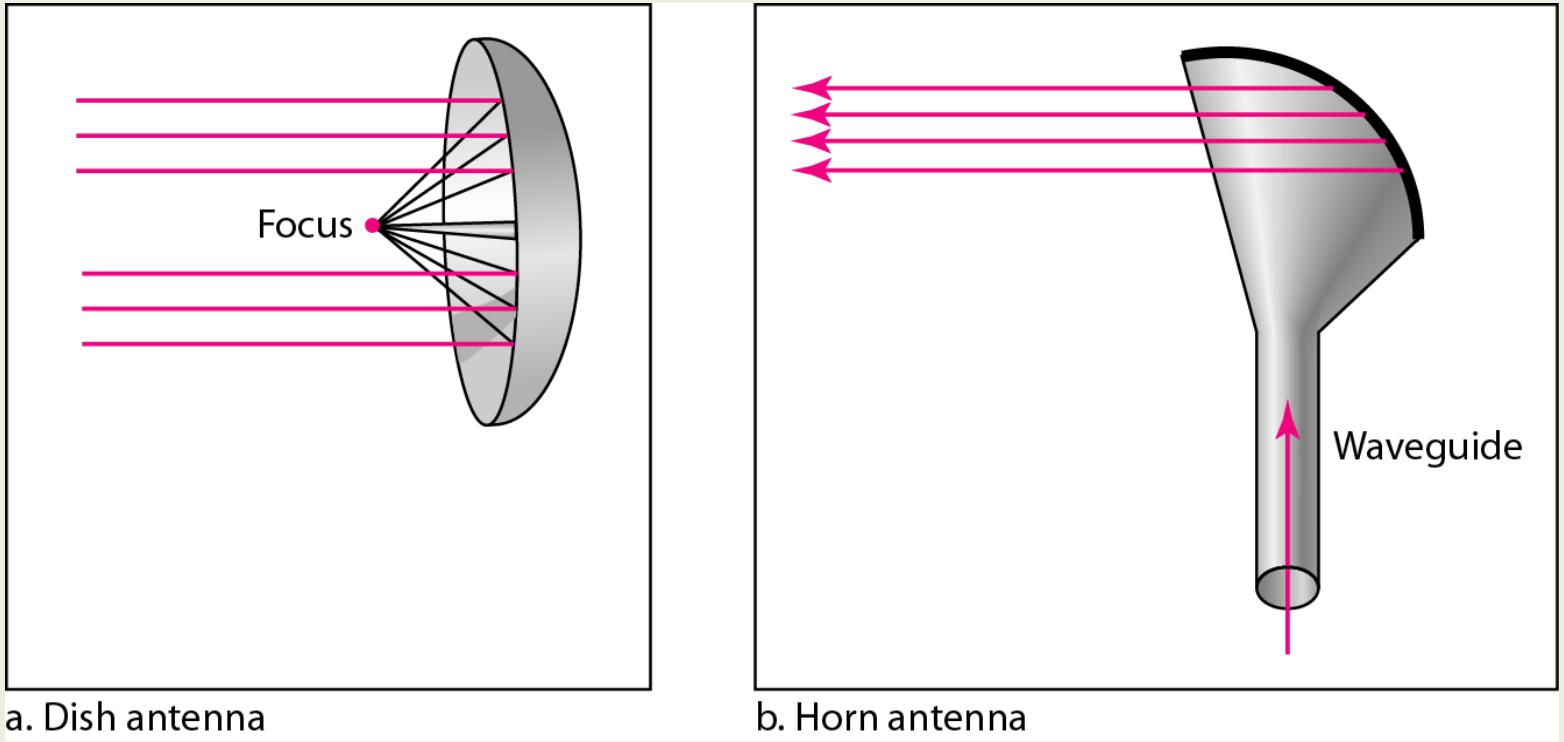


Fig. Unidirectional antenna

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Infrared Signals

- Infrared waves, with frequencies from 300 GHz to 400 THz (wavelengths from 1 mm to 770 nm), can be used for short-range communication.
- Infrared waves, having high frequencies, cannot penetrate walls.
- This advantageous characteristic prevents interference between one system and another
- Infrared signals can be used for short-range communication in a closed area using line-of-sight propagation.

Thank You!!!