Communication Networks

Week-3 and Week-4

Transmission Media

Guided Media

Twisted Pair, Shielded ,Unshielded ,10BaseT ,Connectors Coaxial, Thin net, Thick net ,BNC, Terminators

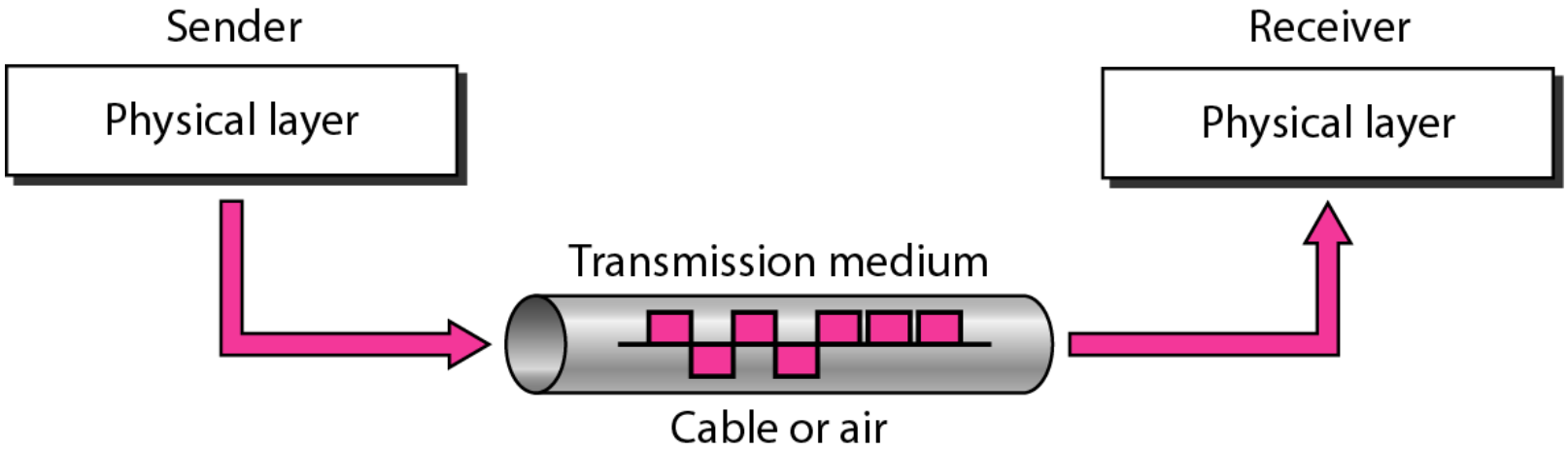
Transport Layer

Fiber Optic –Step Index, Graded Index

Wireless, Frequency Spectrum ,VF to EHF TCP/IP Stack, DOD Model, protocols

Transmission media

- Transmission media are located below the physical layer
- Computers use signals to represent data.
- Signals are transmitted in form of electromagnetic energy.



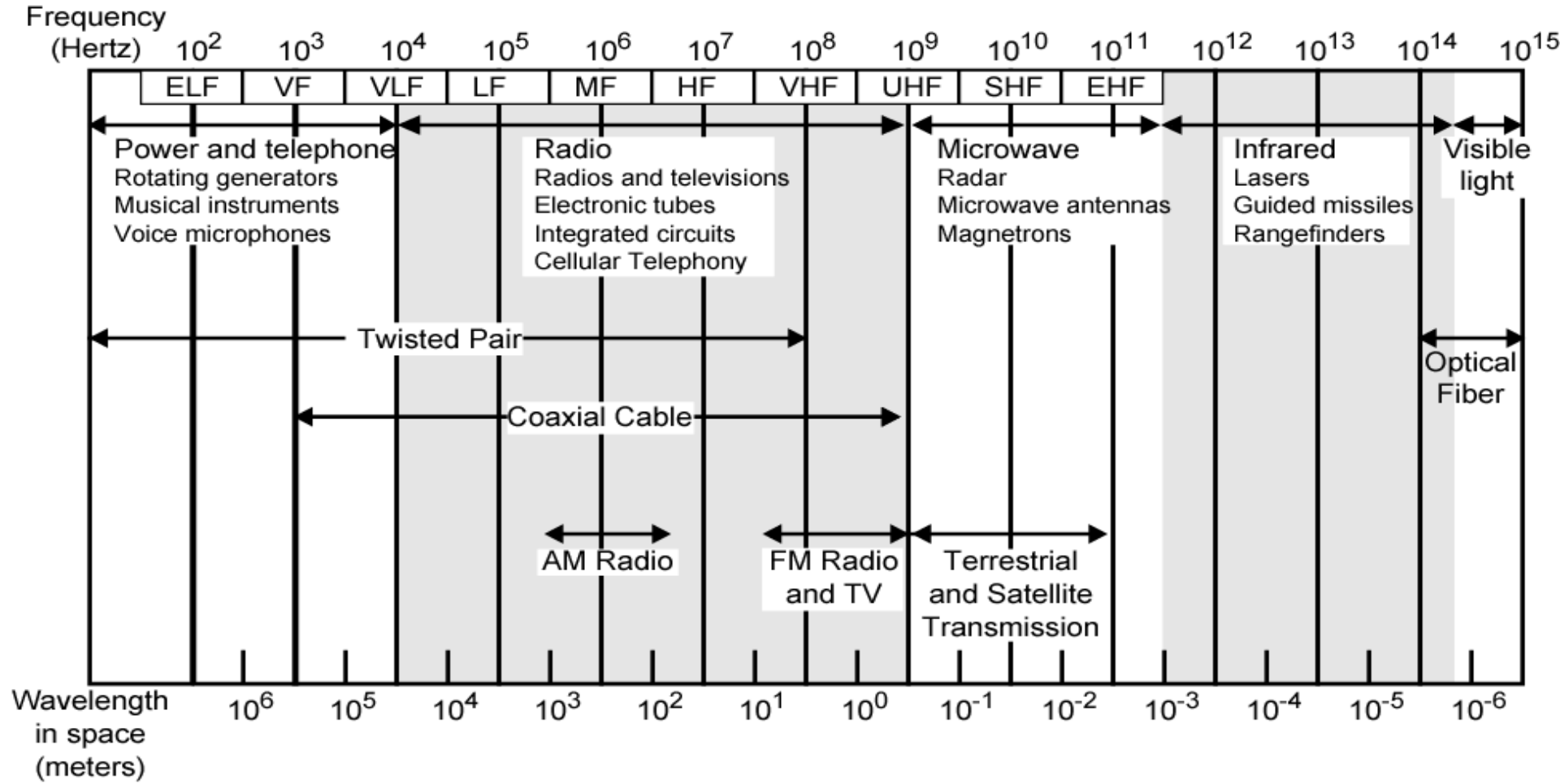
Overview

- Guided – wire
- Unguided - wireless
- For guided: the **medium** is more important
- For unguided: the **bandwidth** produced by the antenna is more important
- Key concerns are ***data rate*** and ***distance***

Basic concepts

- Spectrum
  - range of frequencies contained in signal
- Absolute bandwidth
  - width of spectrum
- Effective bandwidth
  - Often just *bandwidth*
  - *Narrow band of frequencies* containing most of the *energy*

Electromagnetic Spectrum



ELF = Extremely low frequency
VF = Voice frequency
VLF = Very low frequency
LF = Low frequency
MF = Medium frequency
HF = High frequency
VHF = Very high frequency
UHF = Ultrahigh frequency
SHF = Superhigh frequency
EHF = Extremely high frequency

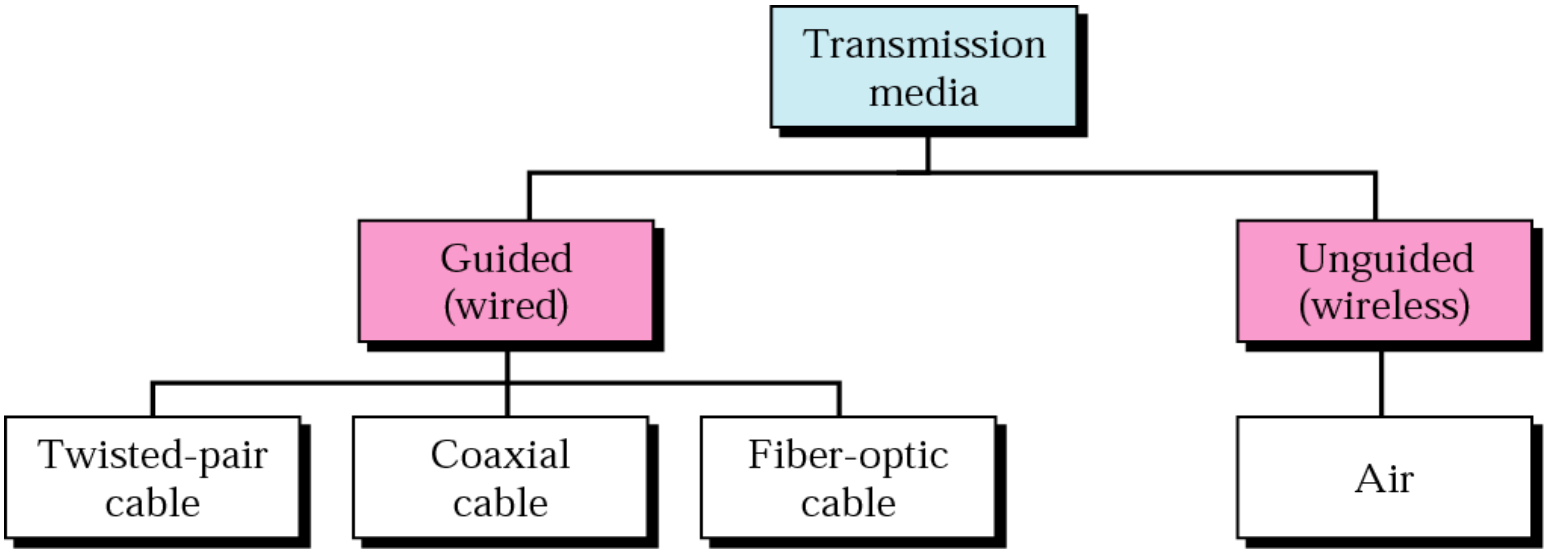
Data Rate and Bandwidth

- Any transmission system has a limited band of frequencies
- This limits the data rate that can be carried

Design Factors

- Bandwidth
  - Higher bandwidth gives higher data rate
- Transmission impairments
  - Attenuation
- Interference
- Number of receivers

Classes of transmission media

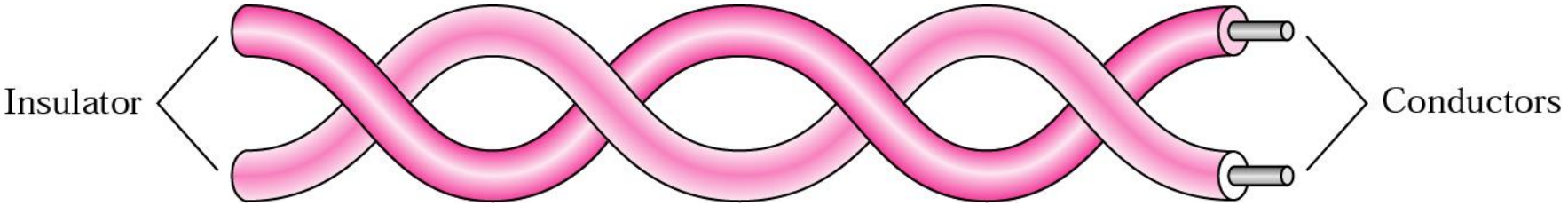


Guided Media

- Twisted-Pair Cable
- Coaxial Cable
- Fiber-Optic Cable

Twisted pair

- One of the wires carries signal, the other is used only as a ground reference.
- The receiver uses the difference b/w the two levels.
- Twisting increases the probability that both wires are effected by the noise in the same manner, thus the difference at the receiver remains same.
- Therefore, number of twists per unit length determines the quality of the cable.



Twisted Pair - Applications

- Most common medium
- Telephone network
- Within buildings
- For local area networks (LAN)

Twisted Pair - Pros and Cons

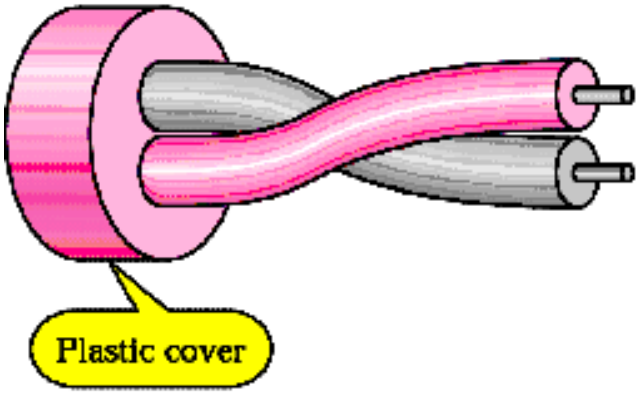
- Cheap
- Easy to work with
- Low data rate
- Short range

Twisted Pair - Transmission Characteristics

- Analog - amplifiers every 5km to 6km
- Digital - repeater every 2km or 3km
- Limited distance
- Limited bandwidth
- Limited data rate
- Susceptible to interference and noise

Unshielded Twisted Pair (UTP)

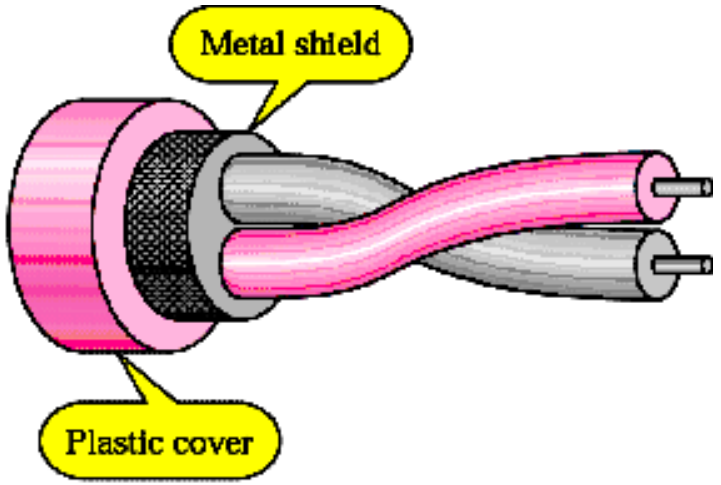
- Ordinary telephone wire
- Cheapest
- Easiest to install
- Suffers from external EM interference



a. UTP

Shielded Twisted Pair (STP)

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



b. STP

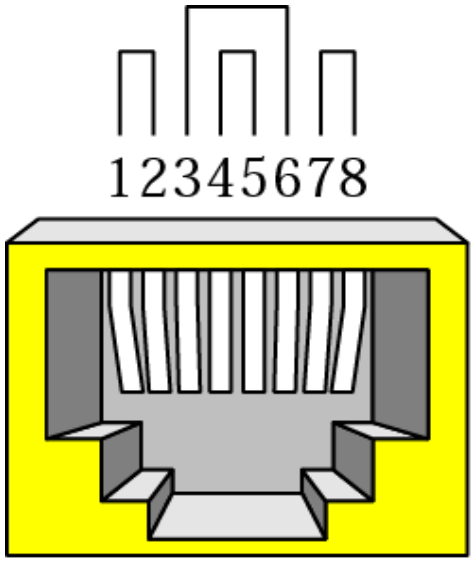
UTP Categories

- Cat 3
  - up to 16MHz
  - Voice grade found in most offices
  - Twist length of 7.5 cm to 10 cm
- Cat 4
  - up to 20 MHz
- Cat 5
  - up to 100MHz
  - Commonly pre-installed in new office buildings
  - Twist length 0.6 cm to 0.85 cm
- Cat 6
- Cat 7

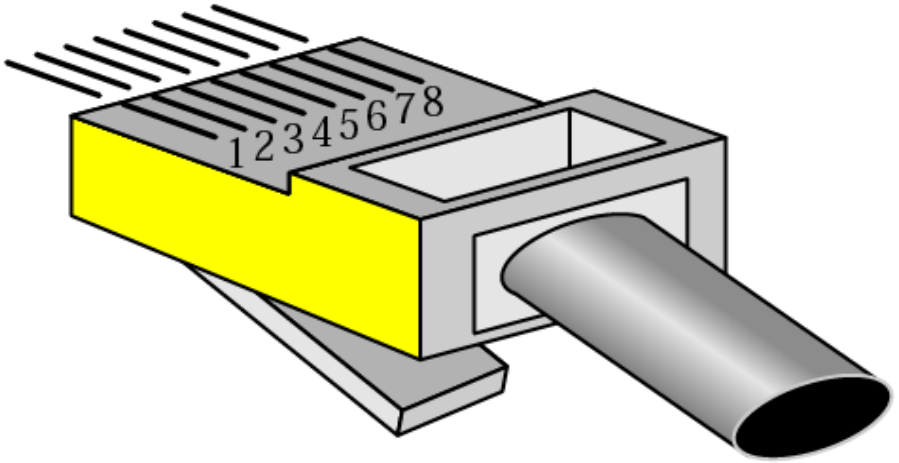
UTP Categories

Category	Bandwidth	Data Rate	Digital/Analog	Use
1	very low	< 100 kbps	Analog	Telephone
2	< 2 MHz	2 Mbps	Analog/digital	T-1 lines
3	16 MHz	10 Mbps	Digital	LANs
4	20 MHz	20 Mbps	Digital	LANs
5	100 MHz	100 Mbps	Digital	LANs
6	200 MHz	200 Mbps	Digital	LANs
7	600 MHz	600 Mbps	Digital	LANs

UTP connector



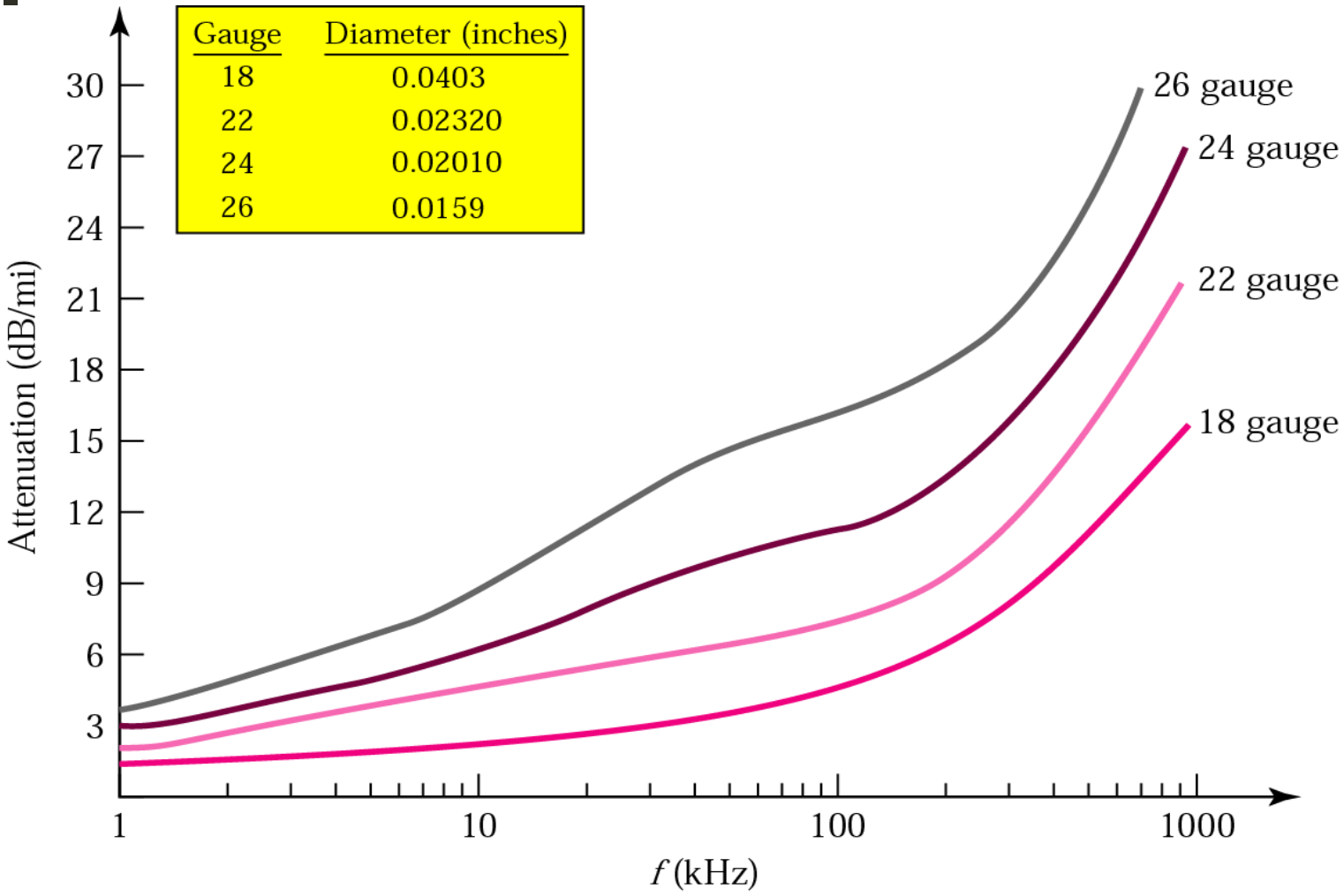
RJ-45 Female



RJ-45 Male

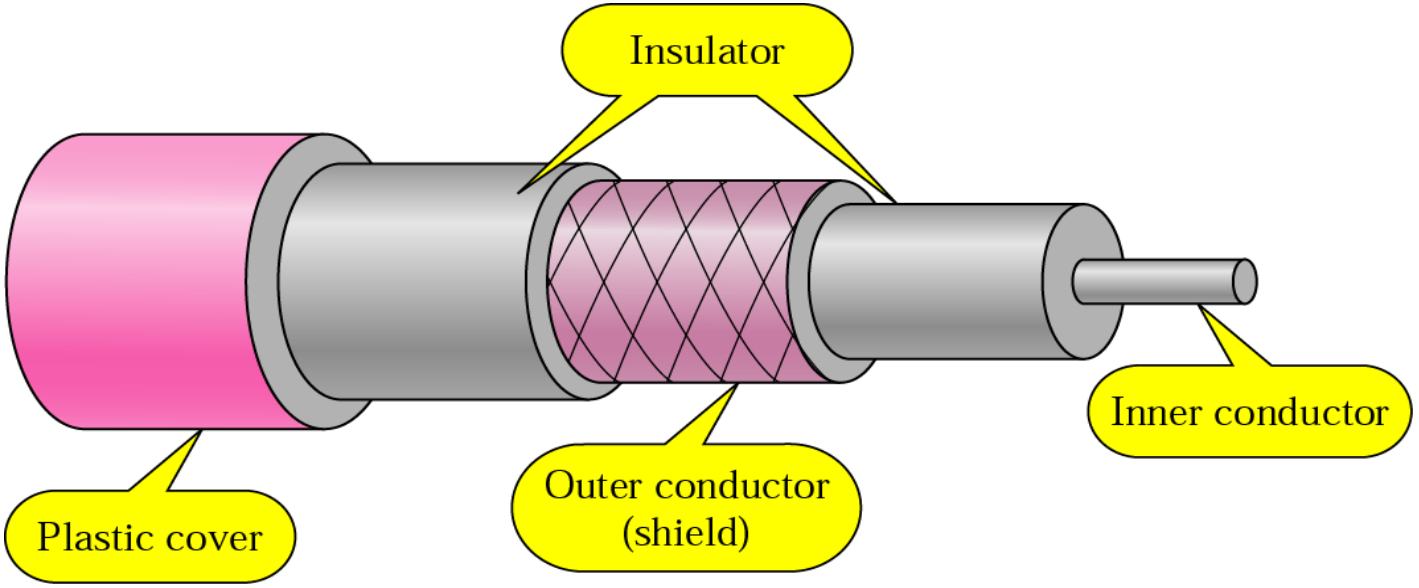
UTP performance

Gauge	Diameter (inches)
18	0.0403
22	0.02320
24	0.02010
26	0.0159



Coaxial cable

- Inner conductor is a solid wire
- Outer conductor serves both as a shield against noise and a second conductor



Coaxial Cable Applications

- Most versatile medium
- Television distribution
- Long distance telephone transmission
  - Can carry 10,000 voice calls simultaneously
- Short distance computer systems links
- Local area networks

Coaxial Cable - Transmission Characteristics

- Analog
  - Amplifiers every few km
  - Closer if higher frequency
  - Up to 500MHz
- Digital
  - Repeater every 1km
  - Closer for higher data rates

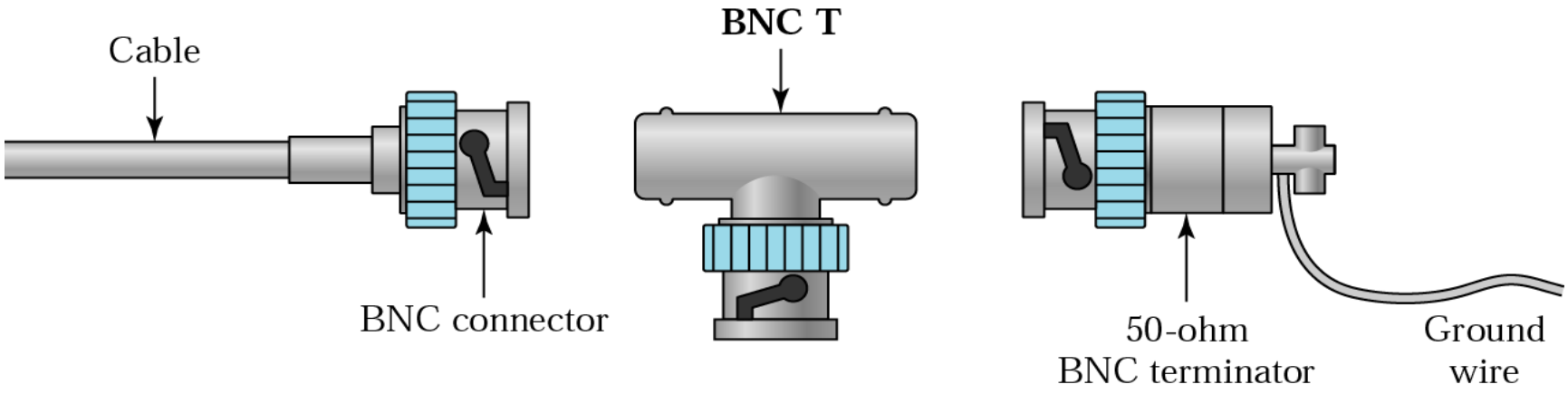
Categories of coaxial cables

- Coaxial are categorized by their Radio Government (RG) ratings

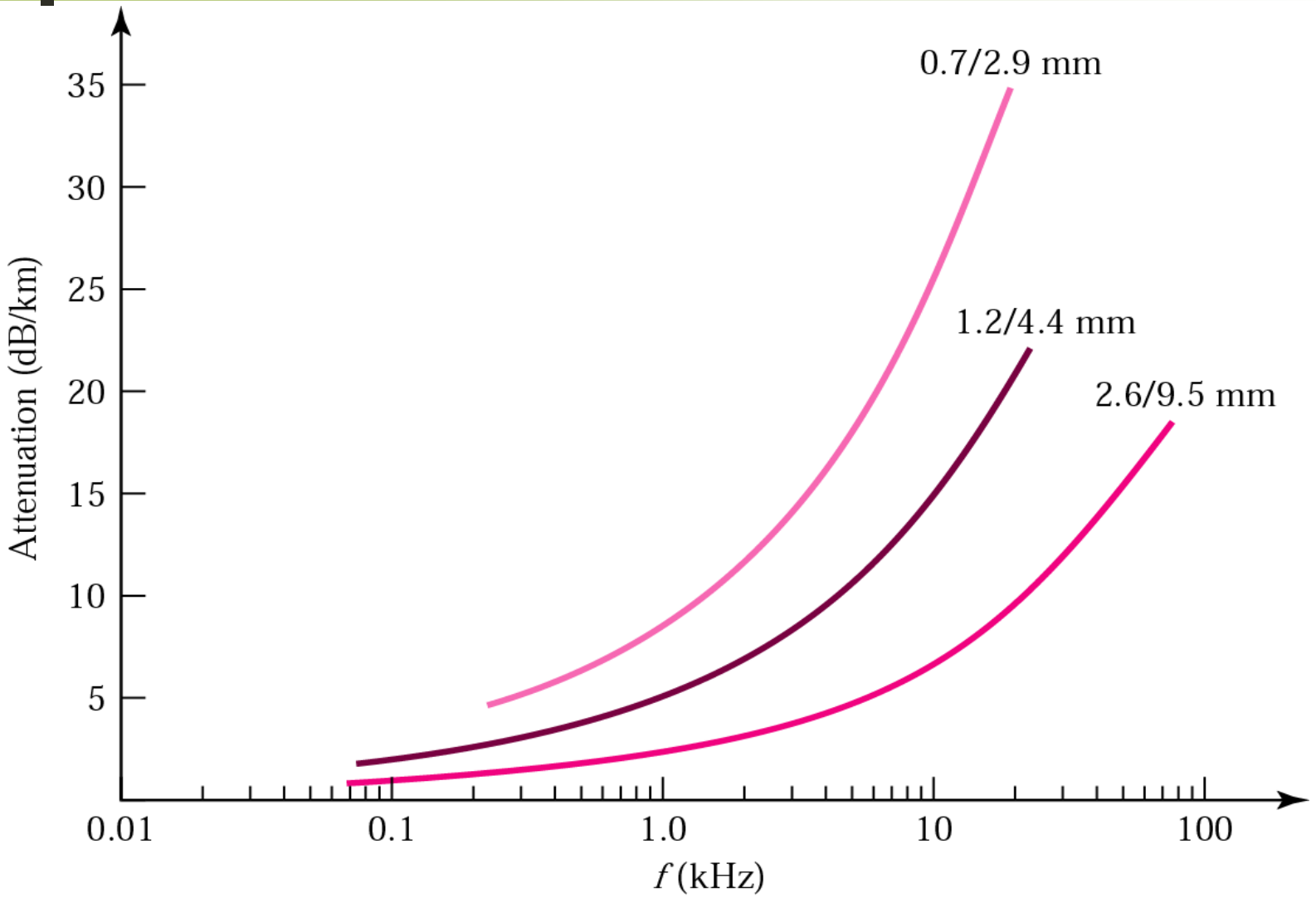
Category	Impedance	Use	Specs
RG-59	75 Ω	Cable TV	
RG-58	50 Ω	Thin Ethernet	10Base2 (10 Mbps / 185m)
RG-11	50 Ω	Thick Ethernet	10Base5 (10 Mbps / 500m)

BNC connectors

- BNC = Bayone-Neill- Concelman
- BNC Connector is used to connect the end of the cable to a device
- BNC T is used in networks to branch out a cable for connection to a computer or other device
- BNC Terminator is used at the end of the cable to prevent the reflection of signal.

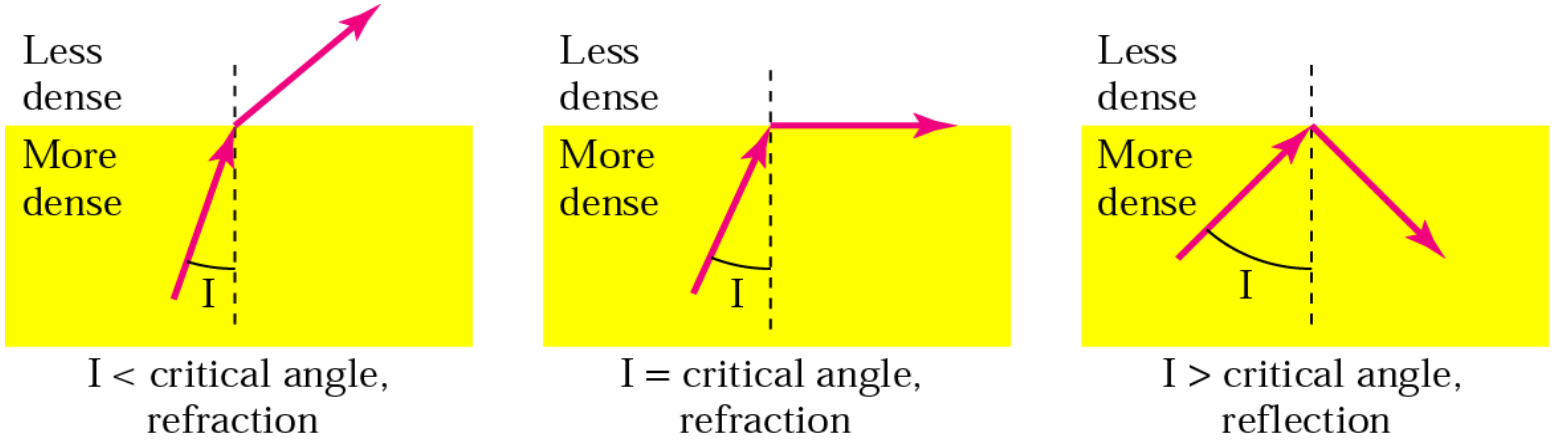


Coaxial performance



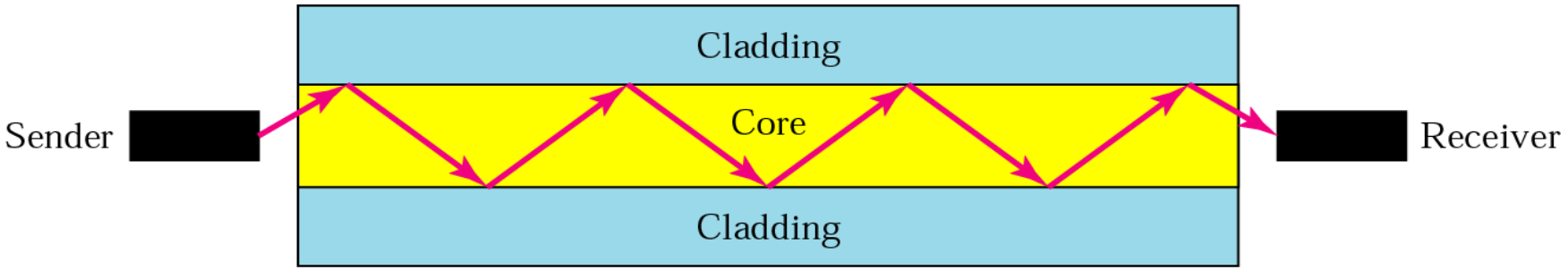
Bending of light ray

- Angle of Incidence (I): the angle the ray makes with the line perpendicular to the interface between the two substances
- Critical Angle: the angle of incidence which provides an angle of refraction of 90-degrees



Optical fiber

- Uses reflection to guide light through a channel
- Core is of glass or plastic surrounded by Cladding
- Cladding is of less dense glass or plastic



Optical Fiber - Benefits

- Greater capacity
  - Data rates of hundreds of Gbps
- Smaller size & weight
- Lower attenuation
- Electromagnetic isolation
- Greater repeater spacing
  - 10s of km at least

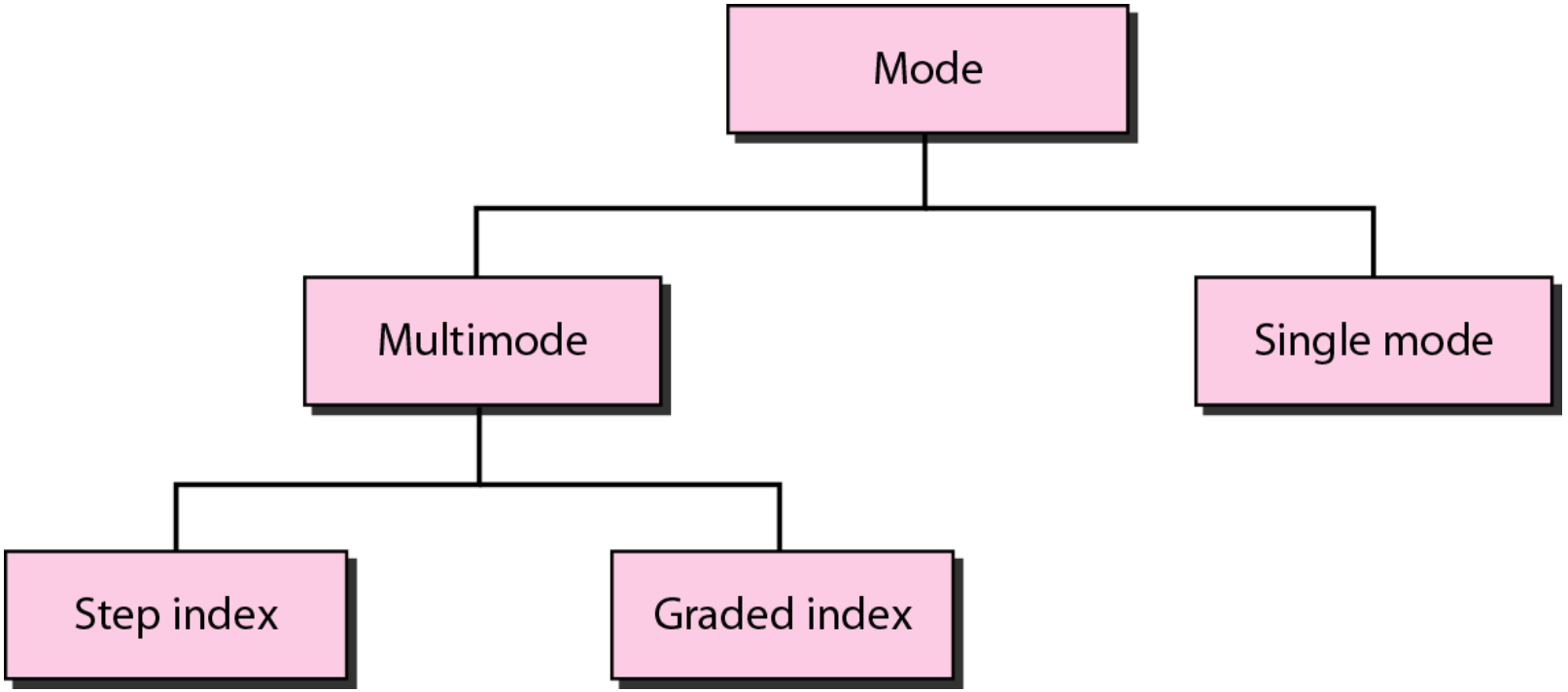
Optical Fiber - Applications

- Long-haul trunks
- Metropolitan trunks
- Rural exchange trunks
- Subscriber loops
- LANs

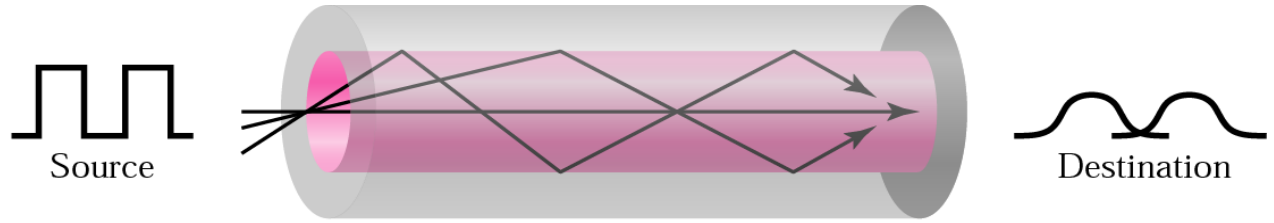
Optical Fiber - Transmission Characteristics

- 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

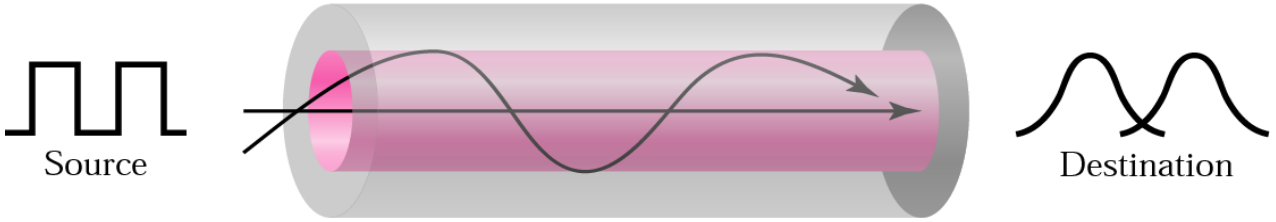
Fiber-optic propagation modes



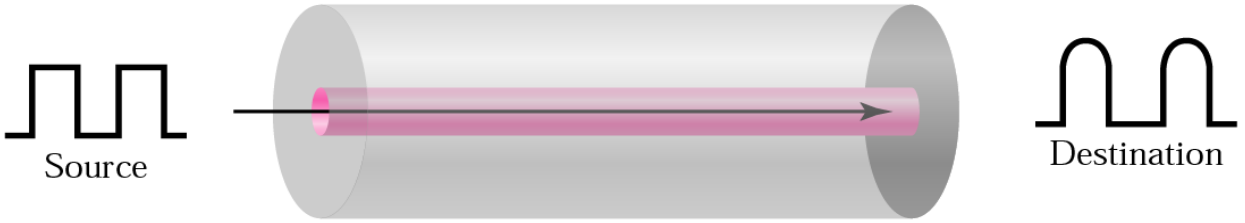
Fiber-optic propagation modes



a. Multimode, step-index

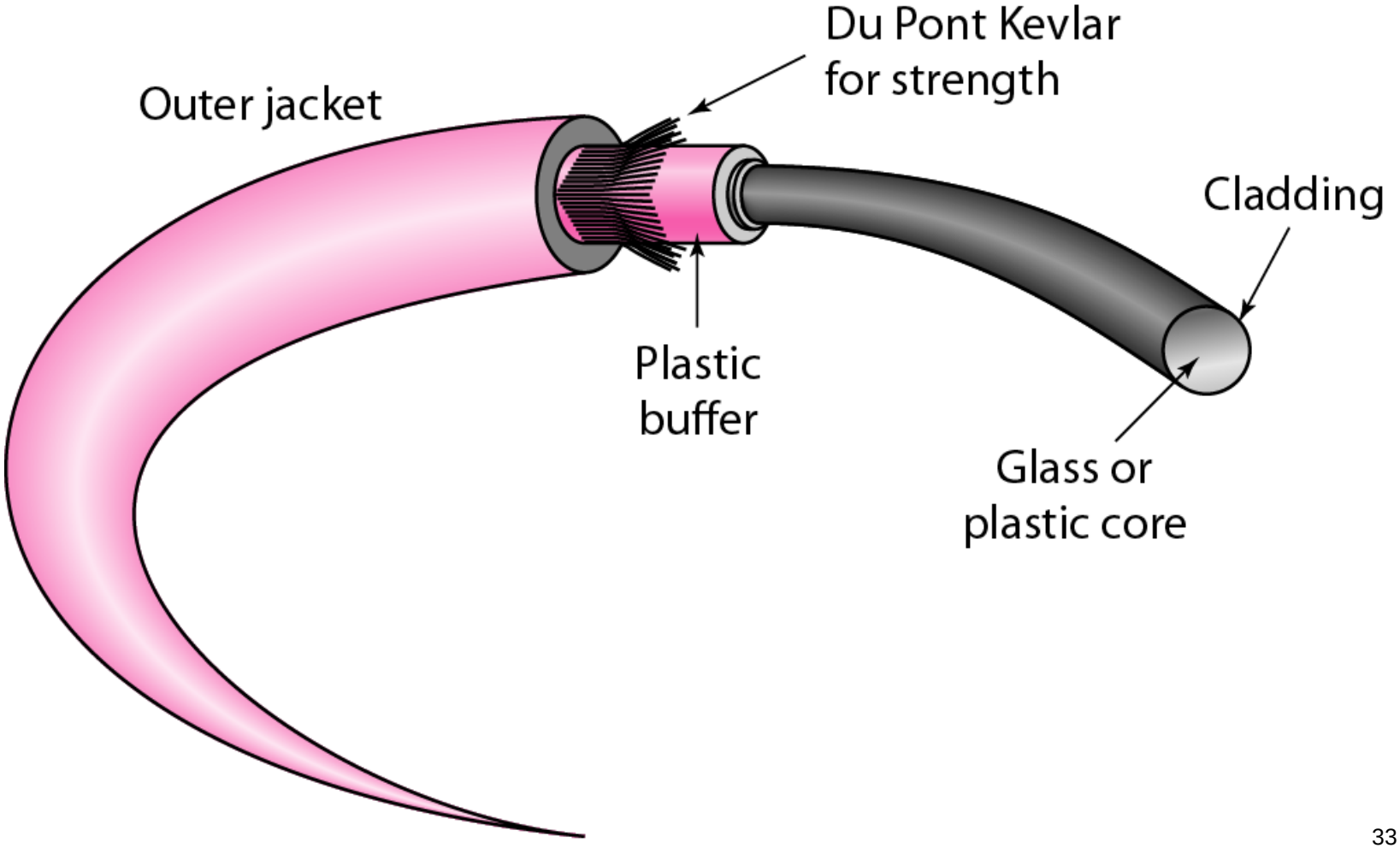


b. Multimode, graded-index



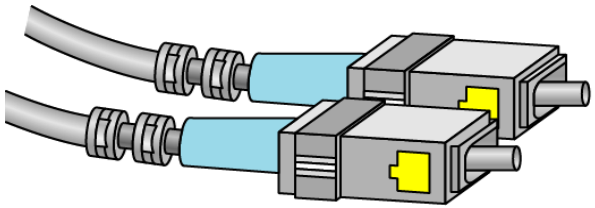
c. Single-mode

Fiber construction

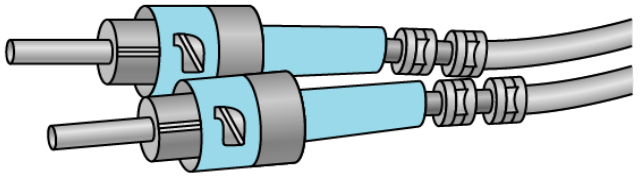


Fiber-optic cable connectors

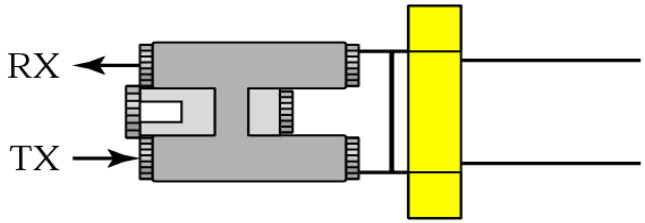
- Subscriber Channel (SC) is used in ***cable TV***
- Straight-Tip (ST) is used for connecting cable to ***networking devices***
- MT-RJ is a new connector with the ***same size of RJ45***



SC connector

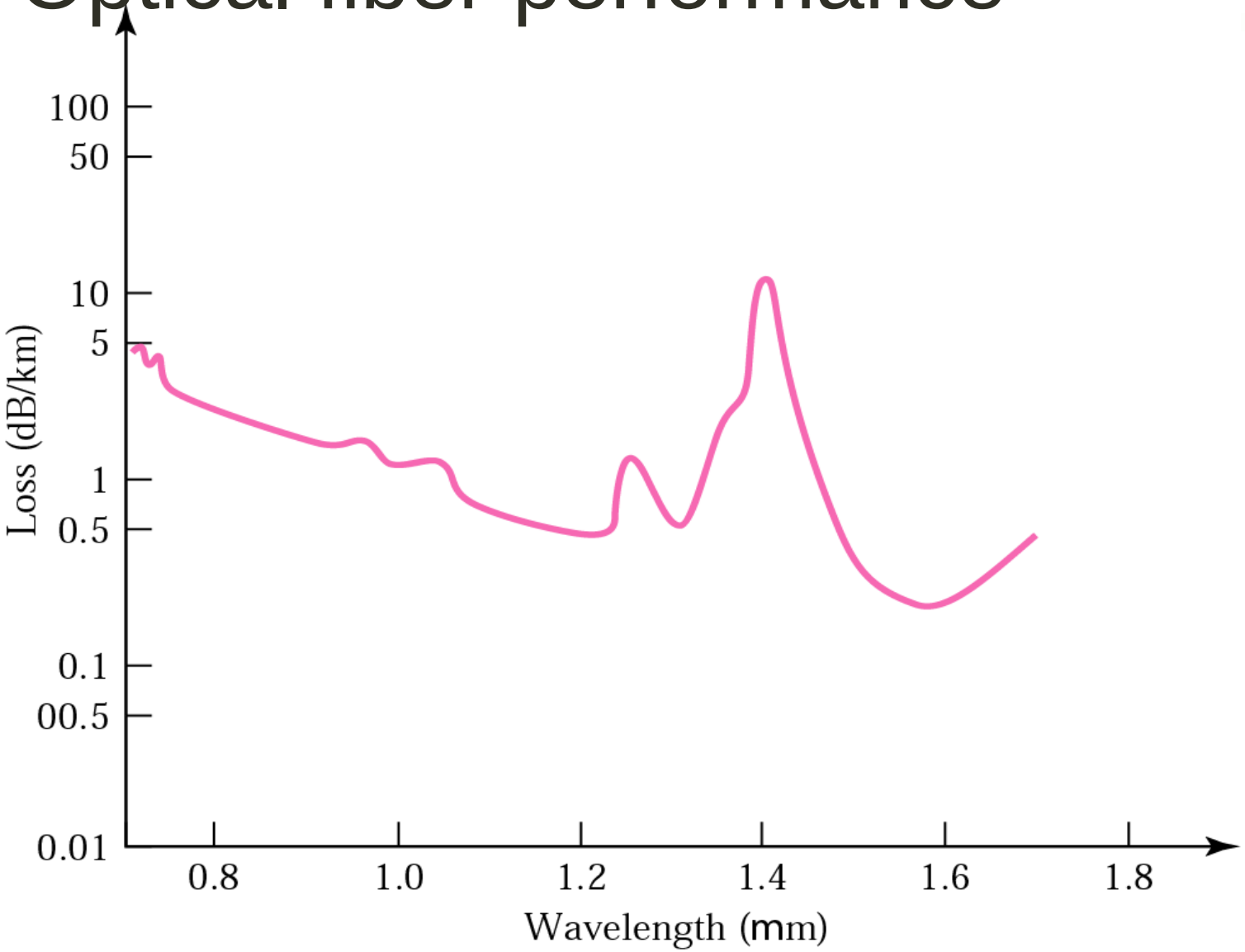


ST connector

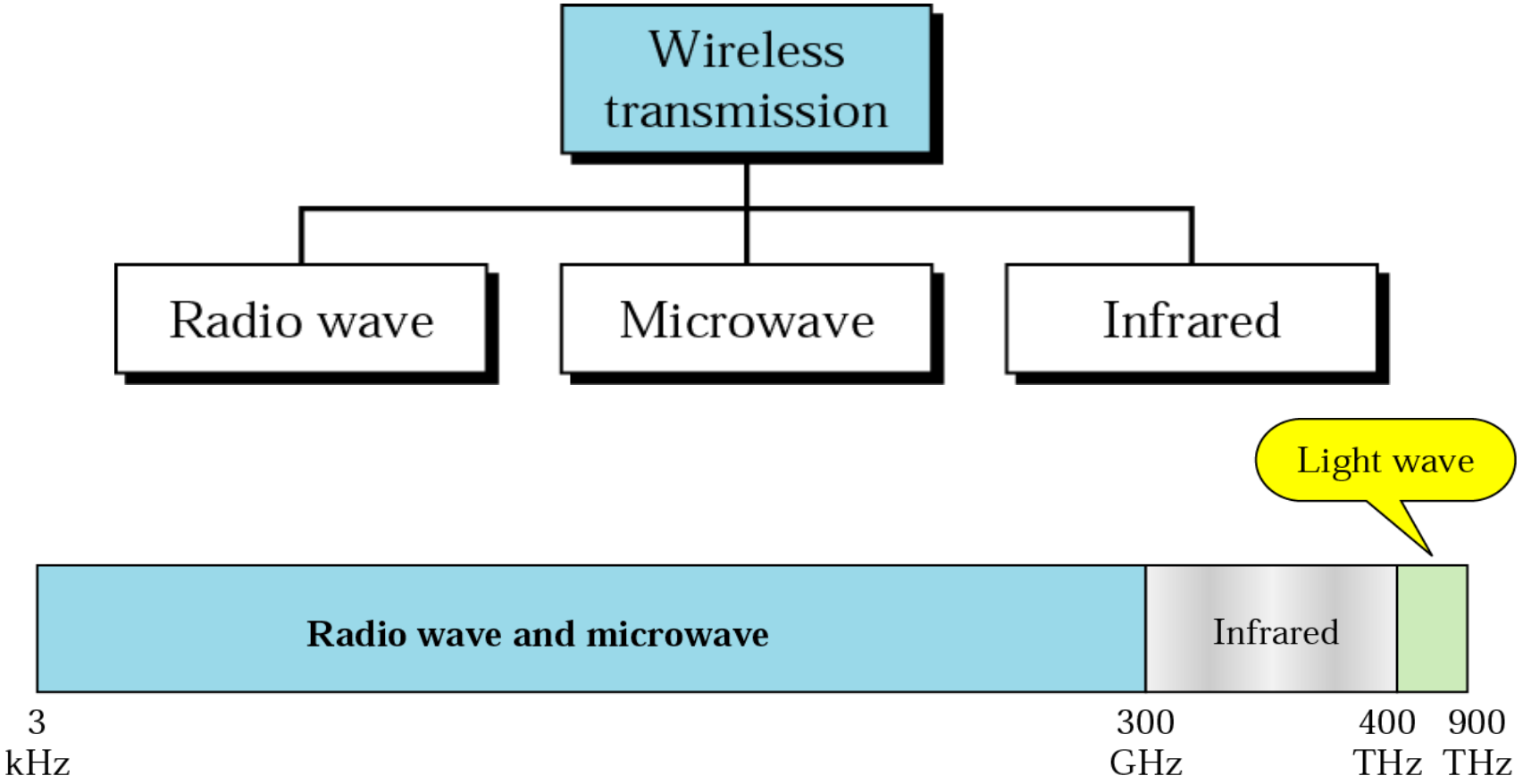


MT-RJ connector

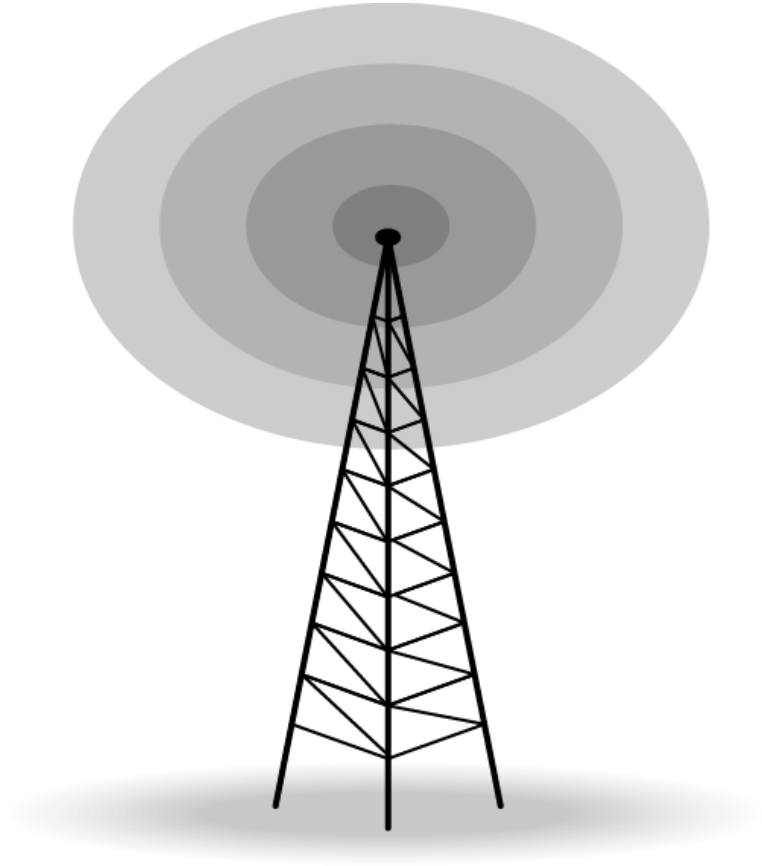
Optical fiber performance



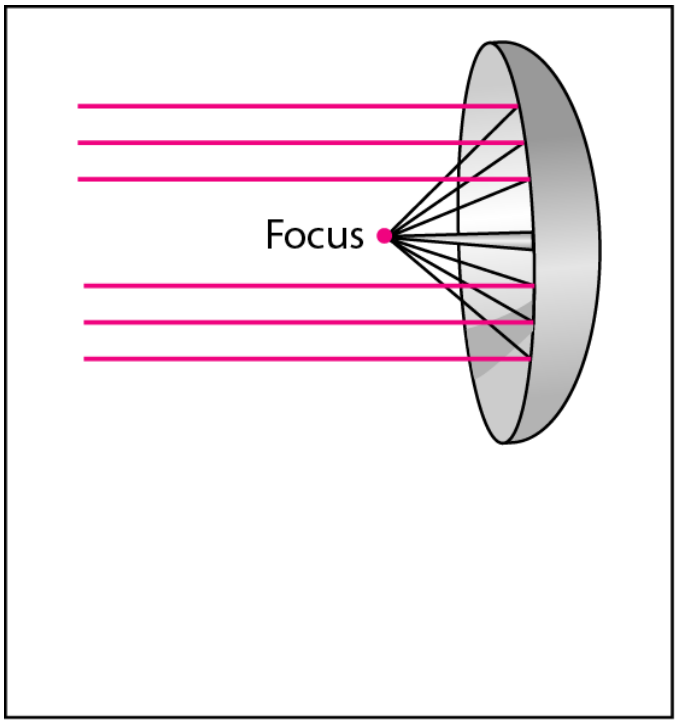
Wireless Transmission



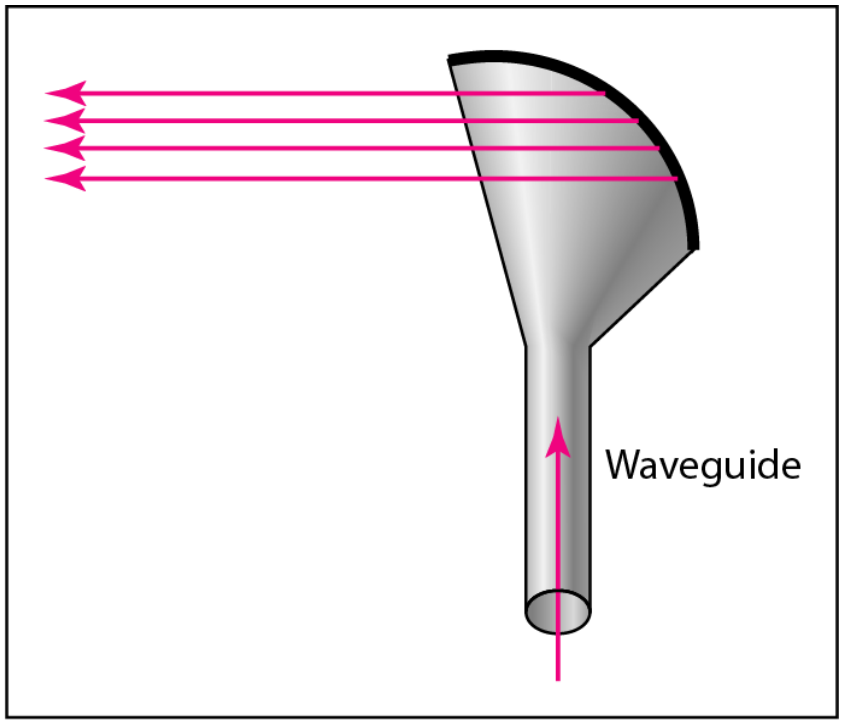
Omnidirectional Antenna



Unidirectional Antennas



a. Dish antenna



b. Horn antenna

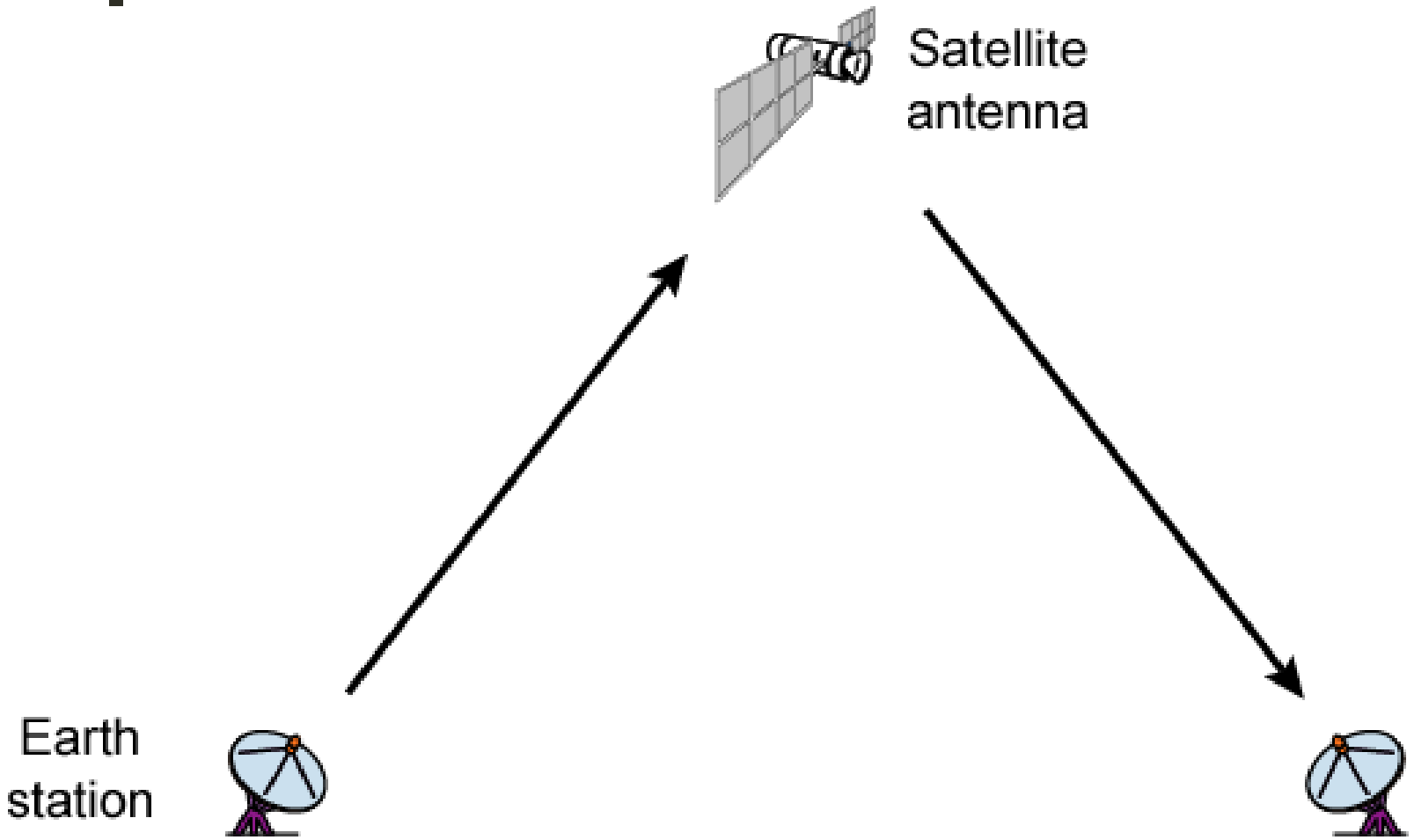
Wireless Transmission Frequencies

- 30MHz to 1GHz
  - Omni directional
  - Broadcast radio
- 2GHz to 40GHz
  - Microwave
  - Highly directional
  - Point to point
  - Satellite
- 3×10^{11} to 2×10^{14}
  - Infrared
  - Local

Satellite Microwave

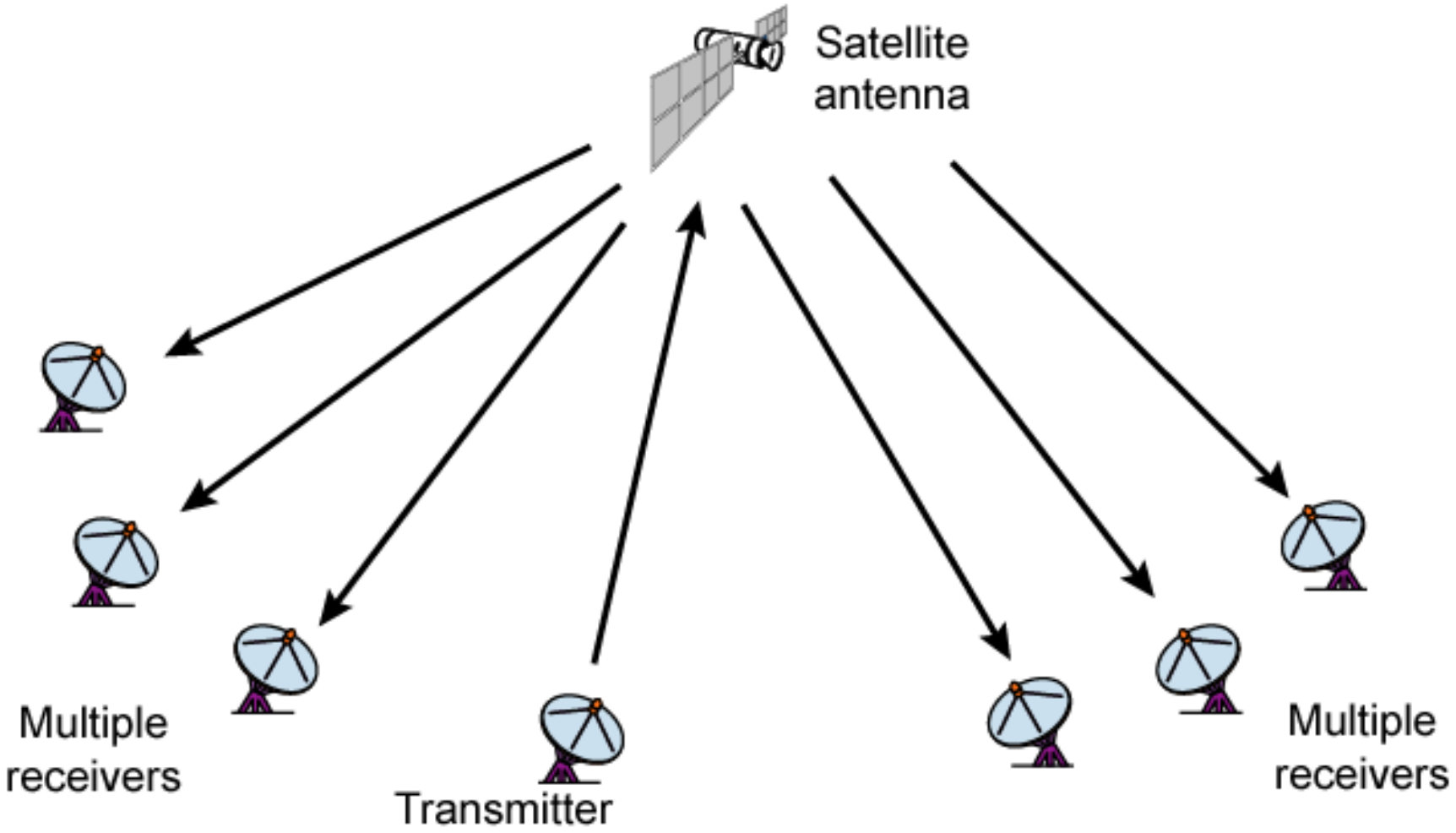
- Satellite is relay station
- Satellite receives on one frequency, amplifies or repeats signal and transmits on another frequency
- Requires geo-stationary orbit
  - Height of 35,784km
- Television
- Long distance telephone
- Private business networks

Satellite Point to Point Link



(a) Point-to-point link

Satellite Broadcast Link



(b) Broadcast link

Terrestrial Microwave

- Parabolic dish
- Focused beam
- Line of sight
- Long haul telecommunications
- Higher frequencies give higher data rates

Broadcast Radio

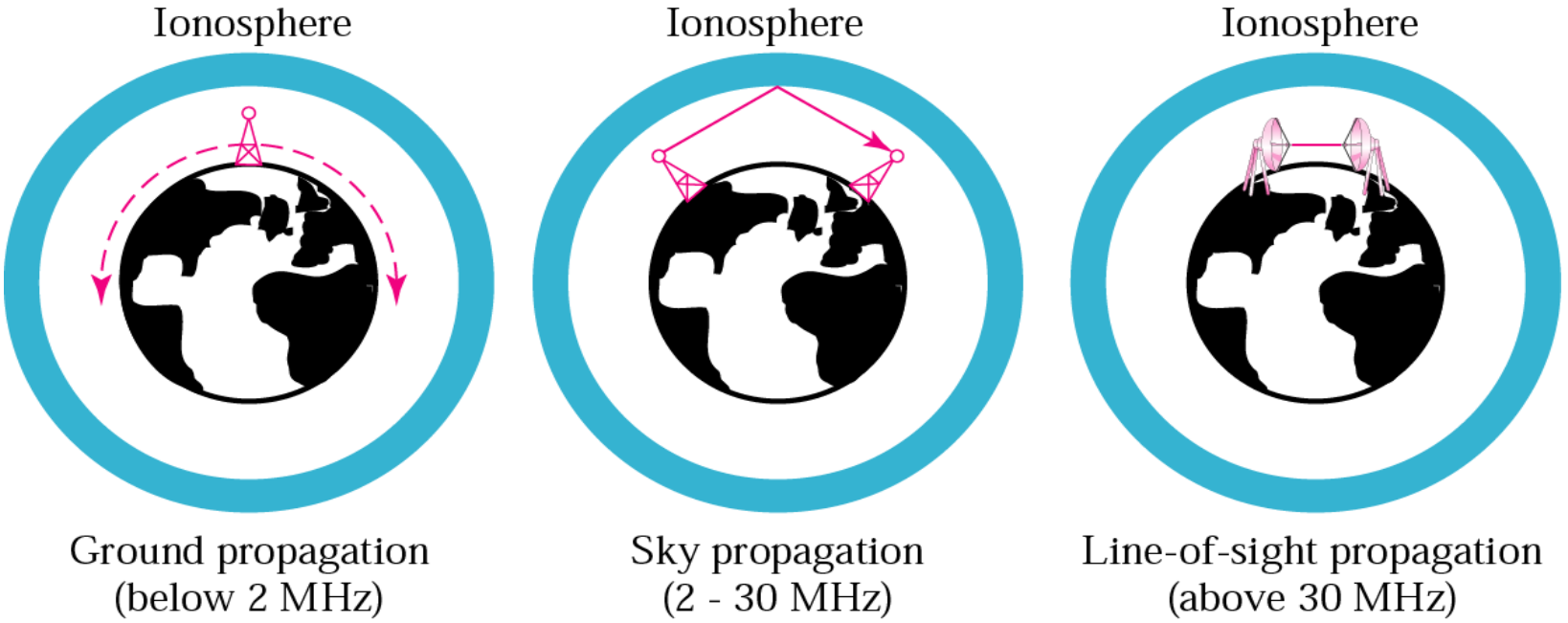
- Omnidirectional
- FM radio
- UHF and VHF television
- Suffers from multipath interference
  - Reflections

Infrared

- Modulate noncoherent infrared light
- Line of sight (or reflection)
- Blocked by walls
- e.g. TV remote control, IRD port
- **Note:** An **integrated receiver/decoder** (**IRD**) is an electronic device used to pick up a radio-frequency signal and convert digital information transmitted in it.

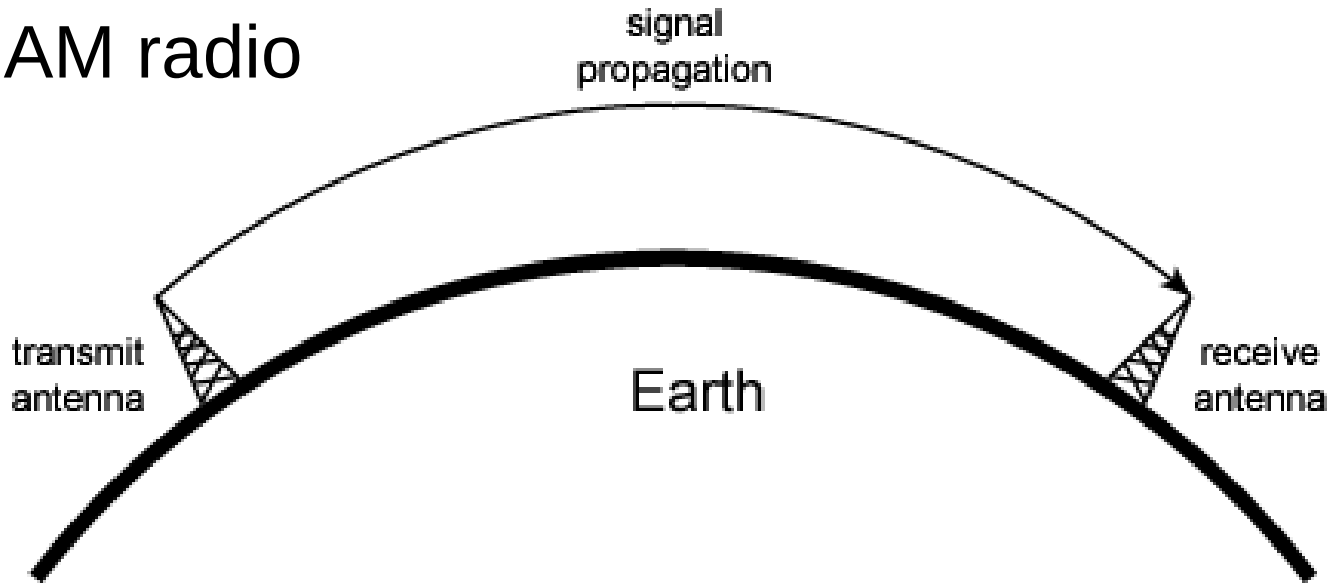
Wireless Propagation

- Signal travels along three routes
  - Ground wave
  - Sky wave
  - Line of sight



Ground Wave Propagation

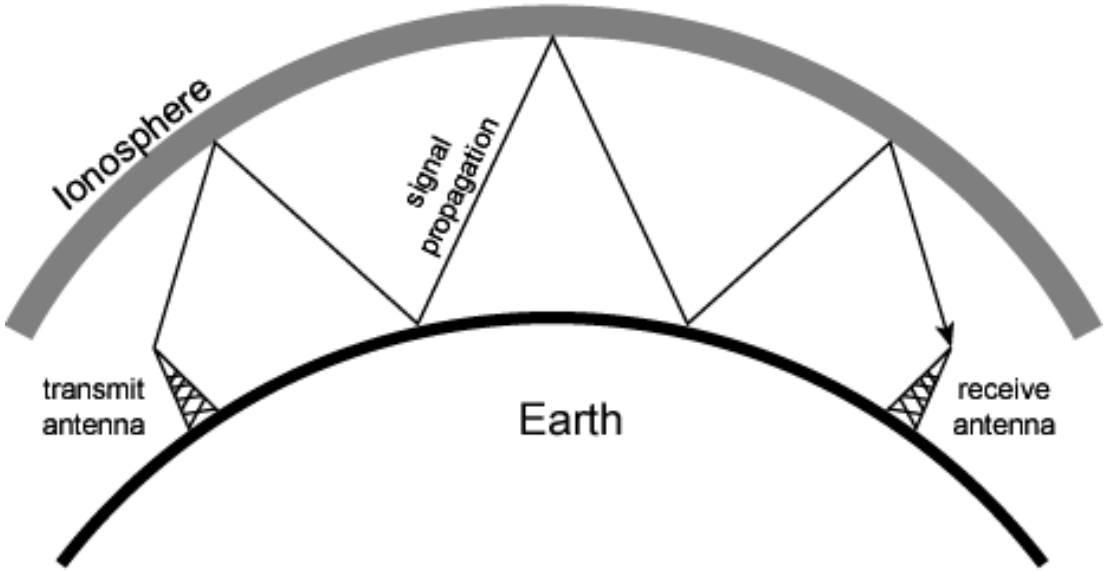
- Follows contour of earth
- Up to 2MHz
- AM radio



(a) Ground-wave propagation (below 2 MHz)

Sky Wave Propagation

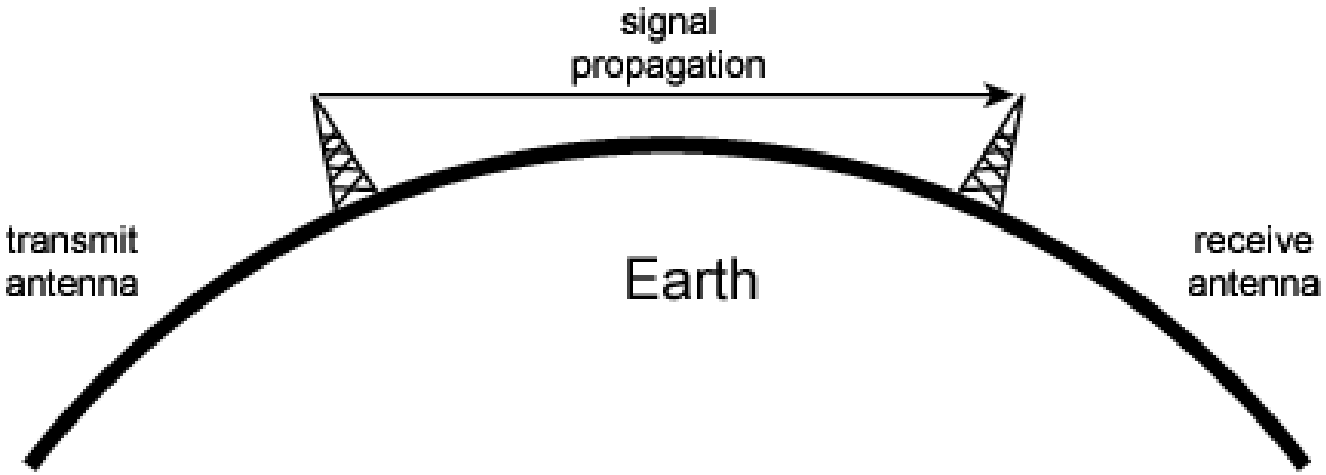
- Amateur radio, BBC world service, Voice of America
- Signal reflected from ionosphere layer of upper atmosphere
- (Actually refracted)



(b) Sky-wave propagation (2 to 30 MHz)

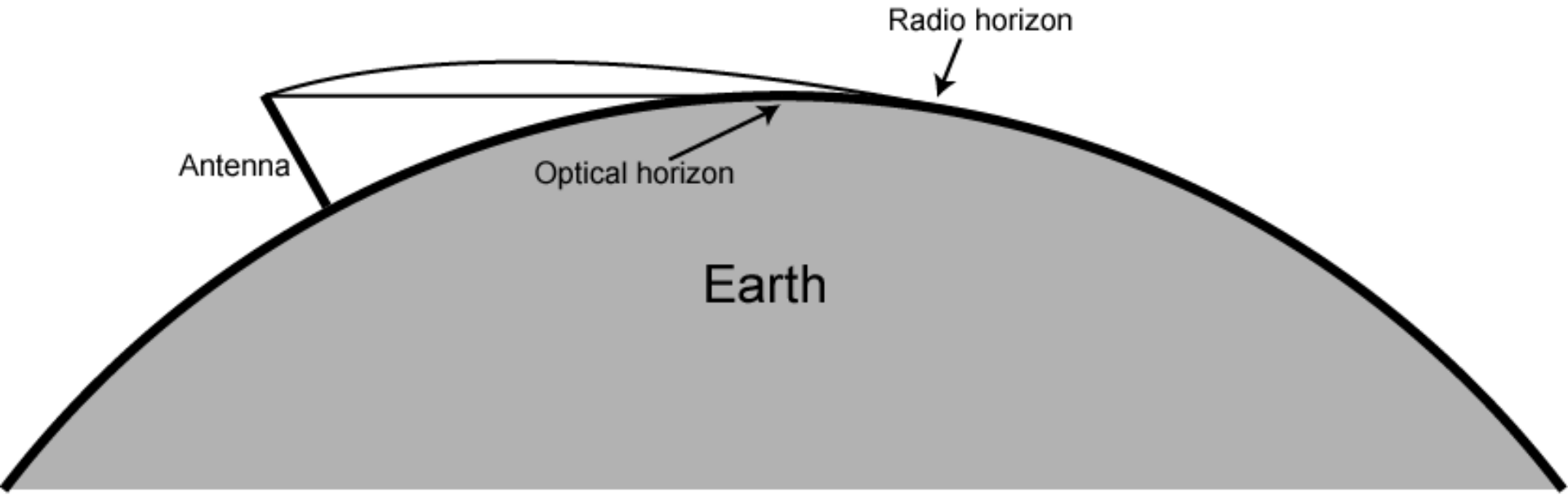
Line of Sight Propagation

- Above 30Mhz
- May be further than optical line of sight due to refraction



(c) Line-of-sight (LOS) propagation (above 30 MHz)

Optical and Radio Horizons



Refraction

- Velocity of electromagnetic wave is a function of density of material
  - ~3 x 10^8 m/s in vacuum, less in anything else
- As wave moves from one medium to another, its speed changes
  - Causes bending of direction of wave at boundary
  - Towards more dense medium

Refraction

- Index of refraction (refractive index) is
  - Sin(angle of incidence)/sin(angle of refraction)
  - Varies with wavelength
- May cause sudden change of direction at transition between media
- May cause gradual bending if medium density is varying
  - Density of atmosphere decreases with height
  - Results in bending towards earth of radio waves

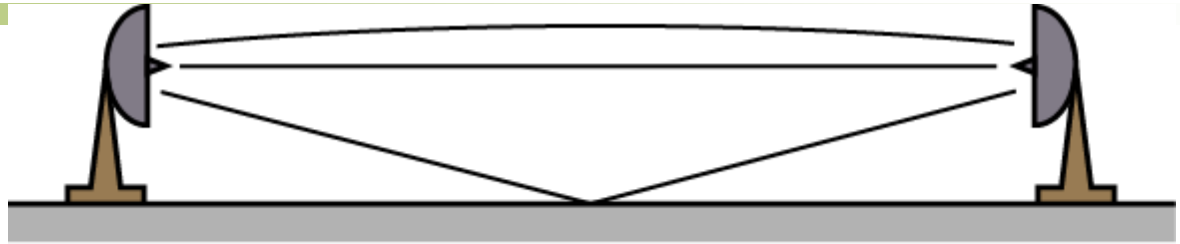
Line of Sight Transmission

- Free space loss
  - Signal disperses with distance
  - Greater for lower frequencies (longer wavelengths)
- Atmospheric Absorption
  - Water vapour and oxygen absorb radio signals
  - Water greatest at 22GHz, less below 15GHz
  - Oxygen greater at 60GHz, less below 30GHz
  - Rain and fog scatter radio waves

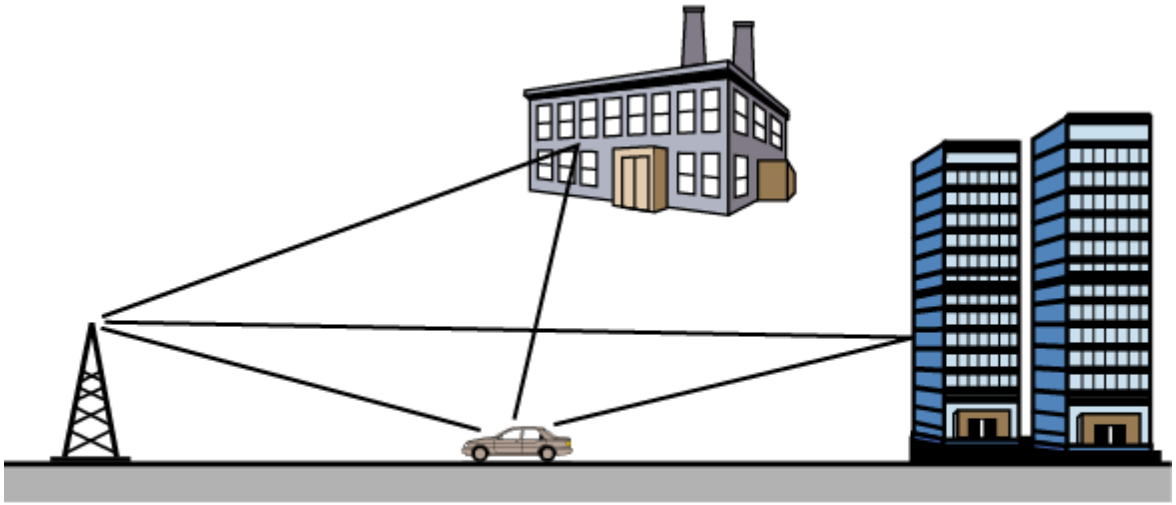
Line of Sight Transmission

- Multipath
  - Better to get line of sight if possible
  - Signal can be reflected causing multiple copies to be received
  - May be no direct signal at all
  - May reinforce or cancel direct signal
- Refraction
  - May result in partial or total loss of signal at receiver

Multipath Interference



(a) Microwave line of sight



(b) Mobile radio