Guided and Unguided Transmission media

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Aim of the session

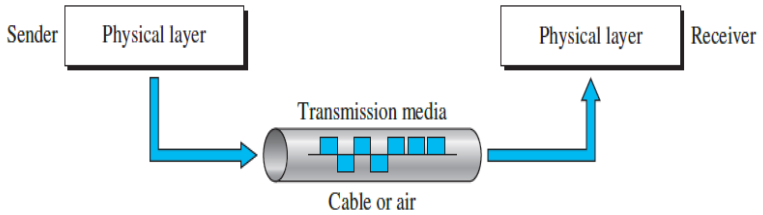
Explain the guided and unguided transmission media

Learning Outcomes

Understand and describe Guided and Unguided Transmission media

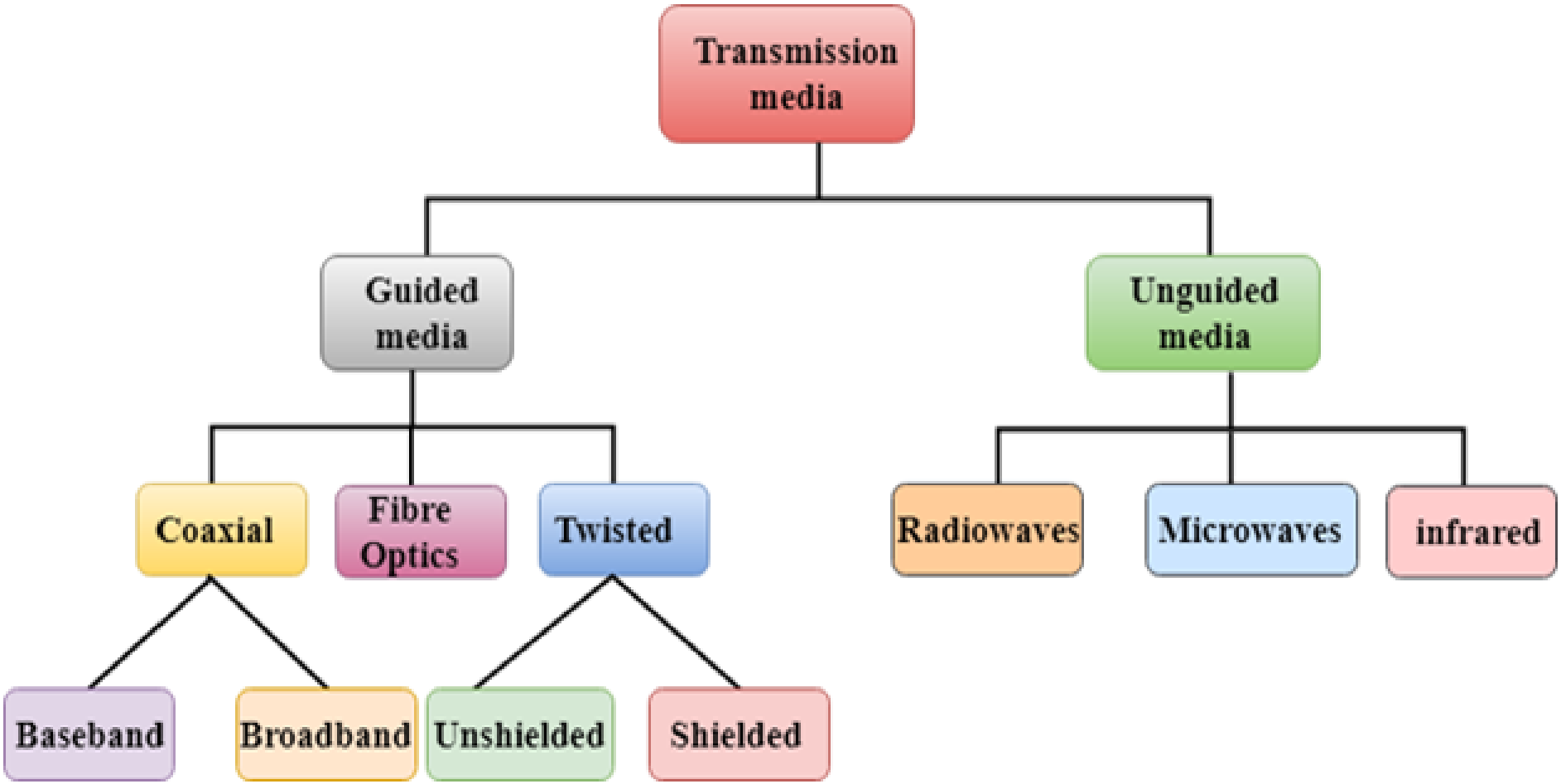
Physical Layer

- The physical layer is the foundation on which the network is built.
- Transmission media are actually located below the physical layer and are directly controlled by the physical layer



- The properties of different kinds of physical channels determine the performance (e.g., throughput, latency, and error rate)

Transmission Media classification



Guided Media

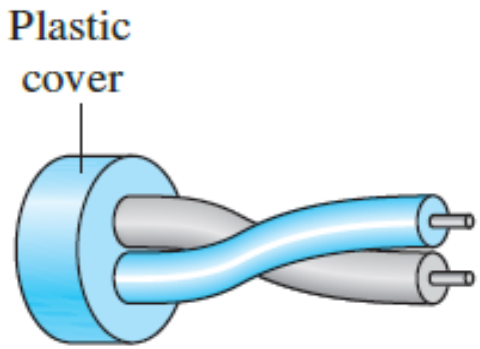
- The most common guided transmission media are copper cable (in the form of coaxial cable or twisted pair) and fiber optics
- Each type of guided transmission media has its own set of trade-offs in terms of frequency, bandwidth, delay, cost, and ease of installation and maintenance.

Twisted-pair cable

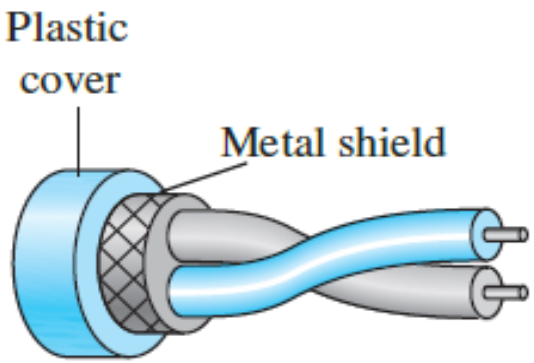
- A twisted pair consists of two insulated copper wires, typically about 1 mm thick.
- The wires are twisted together in a helical form
- A signal is usually carried as the difference in voltage between the two wires in the pair
- Transmitting the signal as the difference between the two voltage levels provides better immunity to external noise
- Applications: Telephone system, LANs in office
- Telephone companies to provide high-data-rate connections using high-bandwidth capable unshielded twisted-pair cables
- Twisted- pair cables now deployed in many buildings is called Category 5e cabling (**Cat 5e**)

Twisted-pair cable

UTP: Unshielded Twisted Pair.
STP: Shielded Twisted Pair.
Shielding reduces the susceptibility to external interference and crosstalk.



a. UTP



b. STP

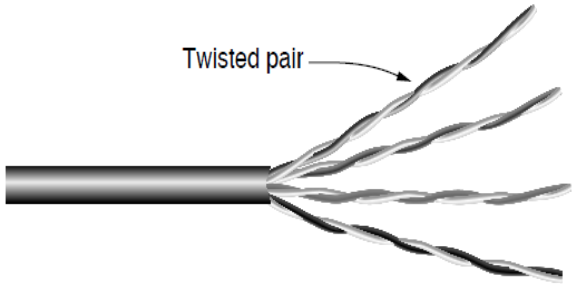


Figure: Category 5e UTP cable with four twisted pairs

- 100-Mbps Ethernet uses two (out of the four) pairs, one pair for each direction
- 1-Gbps Ethernet uses all four pairs in both directions simultaneously

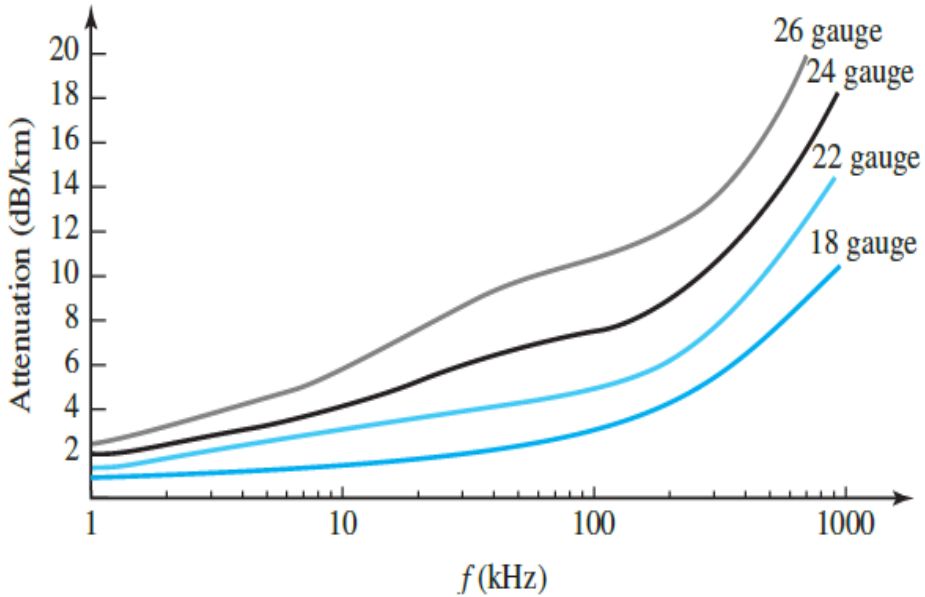
Twisted-pair

Advantages

- Installation is easy
- Can carry both analog and digital data
- Cheaper than other transmission media

Disadvantages

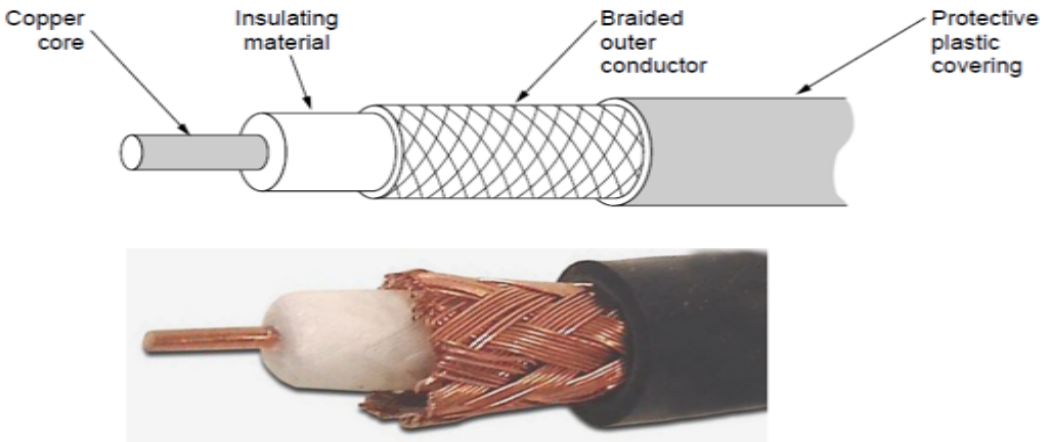
- Poor security
- Supports only lower bandwidth



- Attenuation increases with frequencies above 100 kHz
- Gauge is a measure of the thickness of the wire

Coaxial Cable

Coaxial cable (or coax) carries signals of higher frequency ranges than those in twisted-pair cable



Coaxial cable consists of

- a stiff copper wire as the core
- Core is surrounded by insulating material
- The insulator is encased by a cylindrical conductor-Braided mesh
- The outer conductor is covered in a protective plastic sheath.

Coaxial Cable

- The construction and shielding of the coaxial cable give it a good combination of high bandwidth and excellent noise immunity
- Cables have a bandwidth of up to 6 GHz
- Coax is still widely used for cable television and high speed internet in metropolitan area networks
- A single television program might occupy approximately 3.5 MHz
- Advantage: The electromagnetic field carrying the signal exists only in the space between the inner and outer conductors.
- This allows coaxial cable runs to be installed next to metal objects

Coaxial Cable

- **Baseband Coaxial cable**:
  - Use the entire bandwidth for the transmission of a single signal
  - The characteristic impedance of 50Ω (RG-8,RG-58)
- **Broadband Coaxial cable**:
  - Use the bandwidth for transmission of multiple signals.
  - characteristic impedance of 75Ω (RG-6,RG-59)
- Advantages
  - High speed data transmission
  - It has better shielding as compared to twisted pair cable
  - Supports high bandwidth
- Disadvantage
  - More expensive than twisted pair cable

Fiber-Optic cable

An optical transmission system has three key components: the light source, the **transmission medium**, and the detector.

- Transmission medium is an ultra-thin fiber of glass
- Transmits signals in the form of light
- Conventionally, a pulse of light indicates a 1 bit and the absence of light indicates a 0 bit.
- When a light ray passes from fused silica (glass) to air—the ray is refracted (bent) at the silica/air boundary
- For angles of incidence above a certain critical angle, the light is refracted back into the silica
- Light ray incident at or above the critical angle is trapped inside the fiber and can propagate for many kilometers with virtually no loss

Fiber-Optic cable

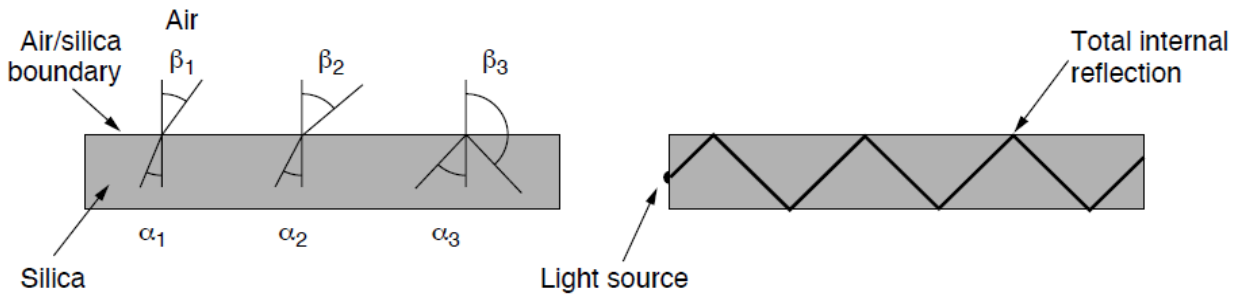
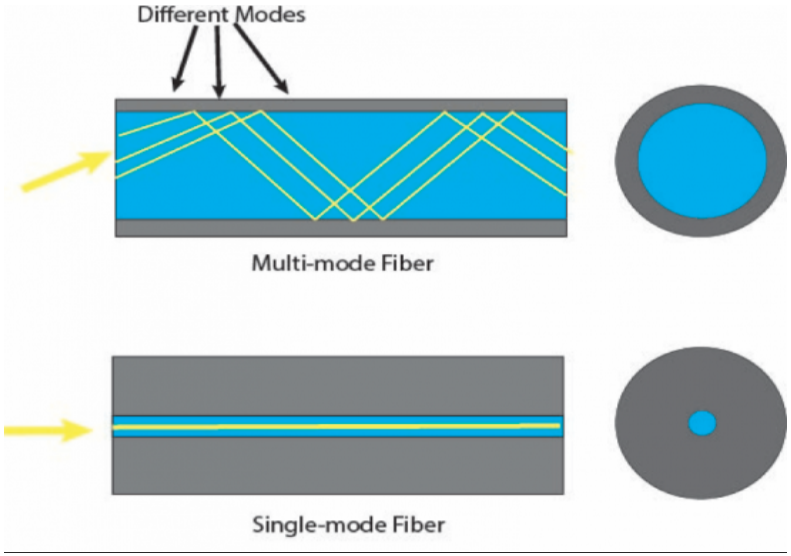
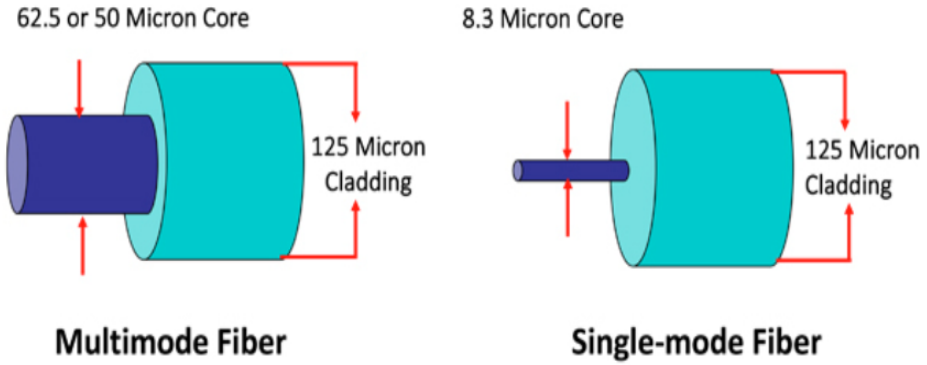
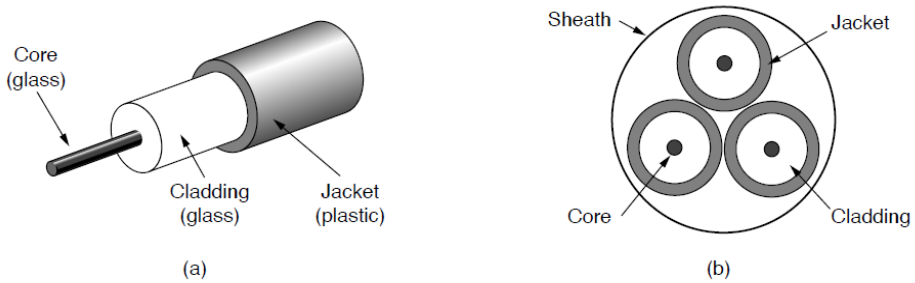


Figure: Total internal reflection

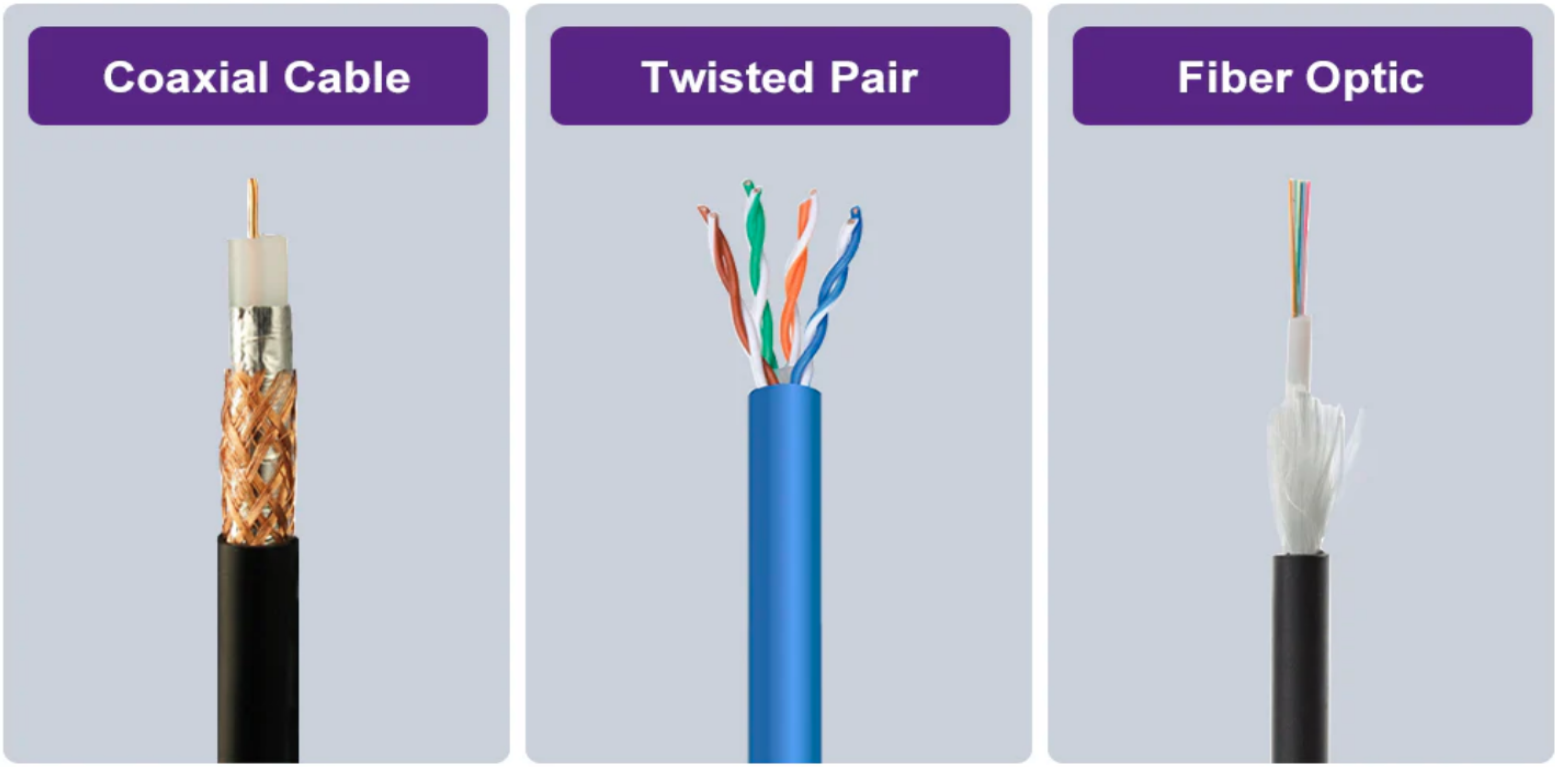




Fiber-Optic cable



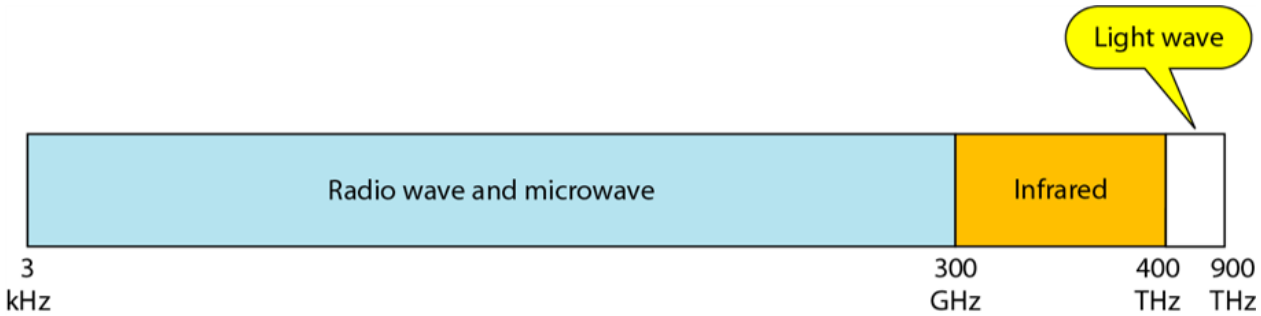
- Single-mode
  - Single-mode fibers are more expensive but are widely used for longer distances
  - Single-mode fibers can transmit data at 100 Gbps for 100 km without amplification
- Multimode fiber
  - Used for transmissions of up to about 15 km
  - Bandwidth of multimode fiber becomes more limited as distance increases.
- Advantages: High bandwidth, High speed, Longer range, Reliable


Coaxial Cable
Twisted Pair
Fiber Optic

Unguided Media

Unguided media transport electromagnetic waves without using a physical conductor.

- This type of communication is often referred to as wireless communication
- Signals are normally broadcast through free space



Unguided transmission is classified into three categories :

- Radio Waves
- Microwaves
- Infrared

Radio Waves

- Electromagnetic waves ranging in frequencies between 3 kHz and 1 GHz are normally called radio waves
- Radio waves are omnidirectional $\Longrightarrow$ Sending and receiving antennas do not have to be aligned
- Disadvantage of omnidirectional property: Radio waves are susceptible to interference by another Tx antenna using the same frequency

Radio Waves

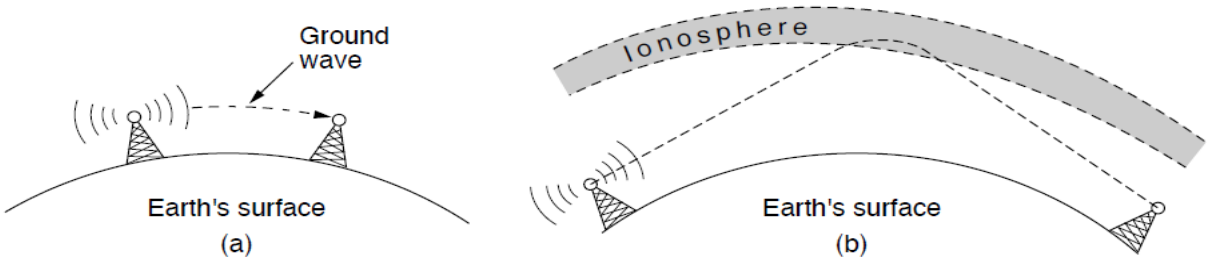
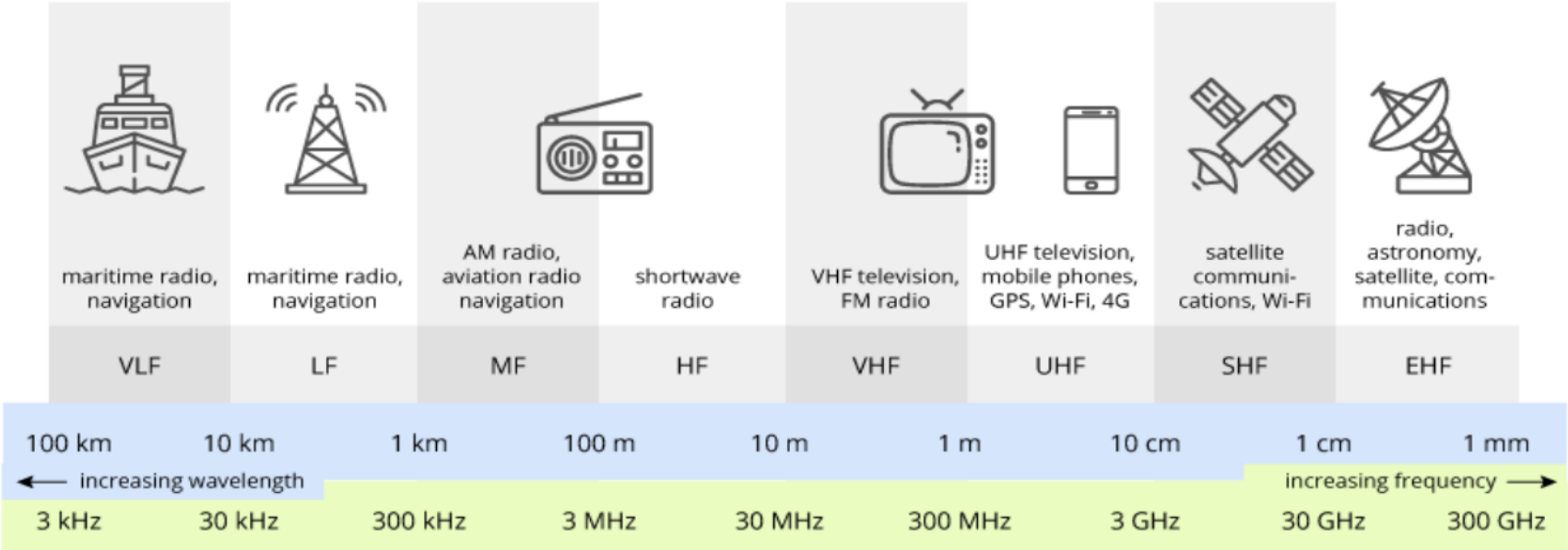


Figure: (a)VLF, LF, and MF bands, radio waves follow the curvature (b)HF band, they bounce off the ionosphere



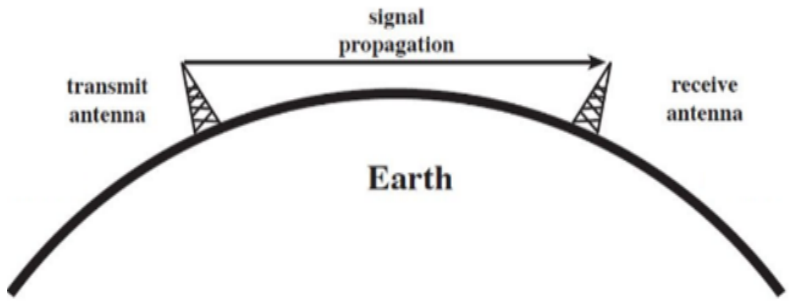
Radio Waves

- Advantages
  - Radio waves cover a large area, and they can penetrate the walls.
    - AM radio can receive signals inside a building
  - Radio transmission is mainly used for wide area networks
    - Mobile cellular networks
- Disadvantages
  - Communication cannot be isolated to just inside or outside a building.
  - Radio wave band is relatively narrow compared to microwave
    - Low bandwidth leads to low data rate for digital communications

Microwaves

- Electromagnetic waves having frequencies between 1 and 300 GHz are called microwaves.
- Before fiber optics, for decades these microwaves formed the heart of the long-distance telephone transmission system.
- Microwaves are unidirectional-Hence repeaters are needed periodically
- The sending and receiving antennas need to be aligned
- Unlike radio waves at lower frequencies, microwaves do not pass through buildings well.
- Some wav es may be refracted off low-lying atmospheric layers and may take slightly longer to arrive than the direct waves.
- The delayed waves may arrive out of phase with the direct wave and thus cancel the signal: **Multipath fading**

Microwaves



- Characteristics of microwave propagation
  - Microwave propagation is in line of sight
    - Towers with the mounted antennas need to be in direct sight of each other
  - Very-high-frequency microwaves cannot penetrate walls
    - Disadvantage if receivers are inside buildings
  - Microwave band is relatively wide: almost 299 GHz
    - High data rate is possible
- Applications:
  - Widely used for long-distance telephone communication, mobile phones, television distribution
  - Used in places where there is a severe shortage of spectrum has developed.

Infrared

- 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. Therefore, the infrared communication in one room cannot be interrupted by the nearby rooms.
- Security of infrared systems against eavesdropping is better than that of radio systems
- No government license is needed to operate an infrared system, in contrast to radio systems

Acknowledge various sources for the images.
Thankyou