



TA: Xifan Zheng

Email: [zhengxifan0403@gmail.com](mailto:zhengxifan0403@gmail.com) 

# Welcome to CPSC 441!



# Outline

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- Guided media
  - twisted pair wires
  - coaxial cables
  - optical fiber
- Unguided media
  - terrestrial microwave
  - satellite microwave
  - broadcast radio
  - infrared

# The physical layer

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- Converts bit streams into electrical or optical (electromagnetic) signals that can transfer information from one part of the network to another over a transmission medium
- An electromagnetic wave propagates through vacuum at a speed of  $c=3 \times 10^8$  m/s and at smaller speeds in other materials.



# Classes of Transmission Media

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- **Conducted or guided media**
  - use a conductor such as **a wire or a fiber optic cable** to move the signal from sender to receiver
- **Wireless or unguided media**
  - use **radio waves** of different frequencies and do not need a wire or cable conductor to transmit signals



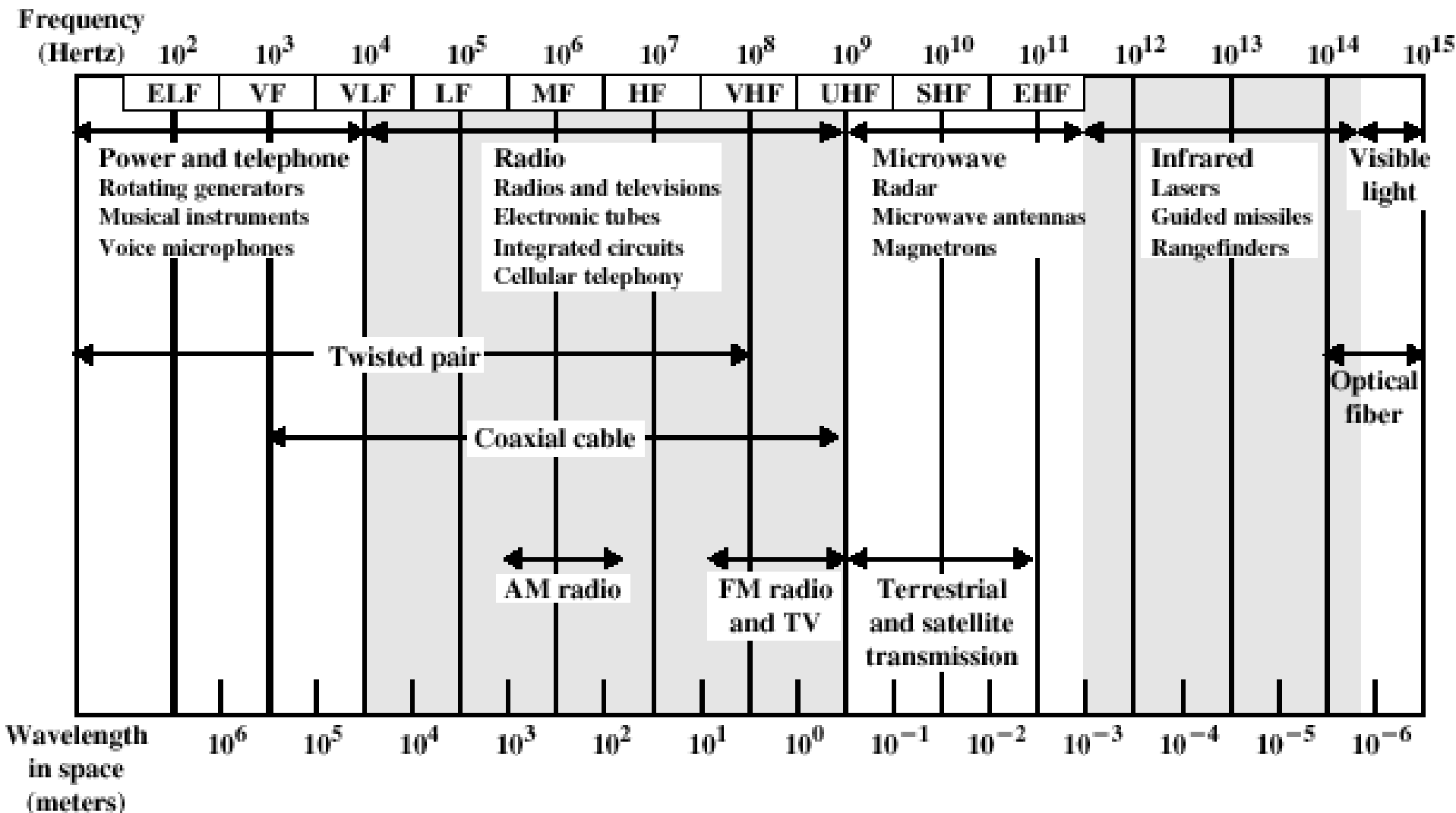
# Design Factors for Transmission Media

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- **Bandwidth:** All other factors remaining constant, the greater the band-width of a signal, the higher the data rate that can be achieved.
- **Transmission impairments.** Limit the distance a signal can travel.
- **Interference:** Competing signals in overlapping frequency bands can distort or wipe out a signal.
- **Number of receivers:** Each attachment introduces some attenuation and distortion, limiting distance and/or data rate.



# Electromagnetic Spectrum for Transmission Media



# Guided Transmission Media

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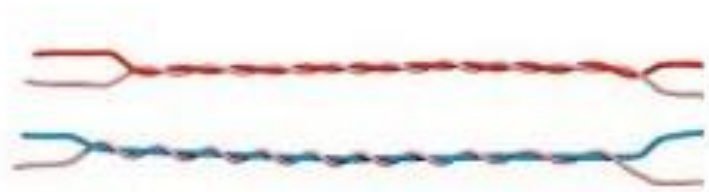
- Transmission capacity depends on the distance and on whether the medium is point-to-point or multipoint
- Examples
  - twisted pair wires
  - coaxial cables
  - optical fiber



# Common transmission media



UTP



STP



Coaxial Cables



# Twisted Pair Wires

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- Consists of **two insulated copper wires** arranged in **a regular spiral pattern** to **minimize the electromagnetic interference** between adjacent pairs
- Often used at customer facilities and also over distances to carry voice as well as data communications
- Low frequency transmission medium



# Types of Twisted Pair

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- STP (shielded twisted pair)
  - the pair is wrapped with metallic foil or braid to insulate the pair from electromagnetic interference
- UTP (unshielded twisted pair)
  - each wire is insulated with plastic wrap, but the pair is encased in an outer covering



# Ratings of Twisted Pair

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- Category 3 UTP
  - data rates of up to 16mbps are achievable
- Category 5 UTP
  - data rates of up to 100mbps are achievable
  - more tightly twisted than Category 3 cables
  - more expensive, but better performance
- STP
  - More expensive, harder to work with

# Twisted Pair Advantages

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- Inexpensive and readily available
- Flexible and light weight
- Easy to work with and install



# Twisted Pair Disadvantages

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- Susceptibility to interference and noise
- Attenuation problem
  - For analog, repeaters needed every 5-6km
  - For digital, repeaters needed every 2-3km
- Relatively low bandwidth (3000Hz)



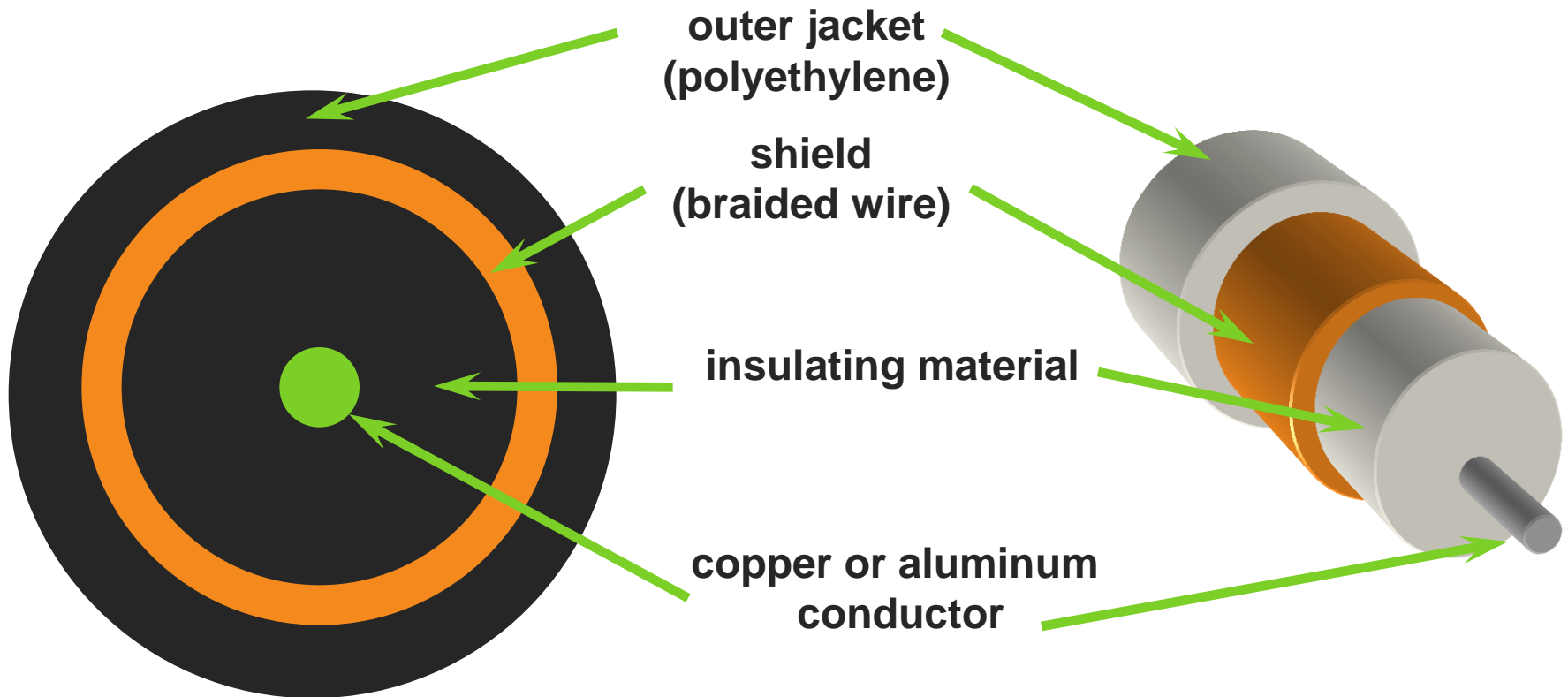
# Coaxial Cable (or Coax)

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- Used for cable television, LANs, telephony
- Has an inner conductor surrounded by a braided mesh
- Both conductors share a common center axial, hence the term “co-axial”



# Coax Layers



# Coax Advantages

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- Higher bandwidth
  - 400 to 600Mhz
  - up to 10,800 voice conversations
- Can be tapped easily (pros and cons)
- **Much less susceptible to interference than twisted pair**



# Coax Disadvantages

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- High attenuation rate makes it expensive over long distance
- Bulky



# Fiber Optic Cable

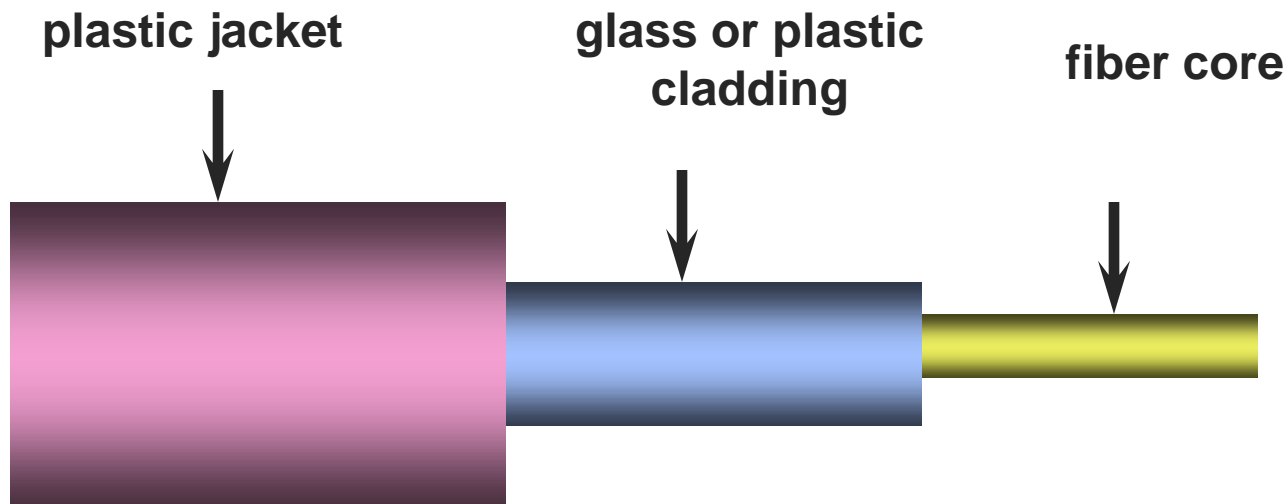
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- Relatively new transmission medium used by telephone companies in place of long-distance trunk lines
- Also used by private companies in implementing local data communications networks
- Require a light source with injection laser diode (ILD) or light-emitting diodes (LED)



# Fiber Optic Layers

- Made of glass or plastic
- consists of three concentric sections



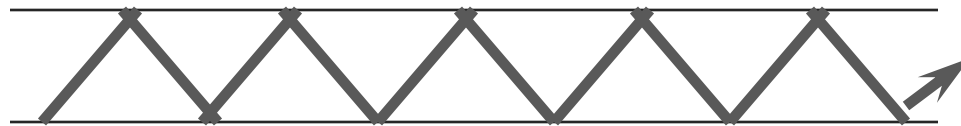
# Fiber Optic Types

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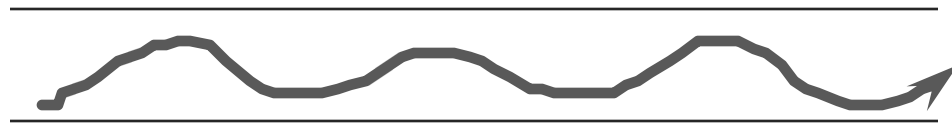
- multimode step-index fiber
  - the reflective walls of the fiber move the light pulses to the receiver
- multimode graded-index fiber
  - acts to refract the light toward the center of the fiber by variations in the density
- single mode fiber
  - the light is guided down the center of an extremely narrow core



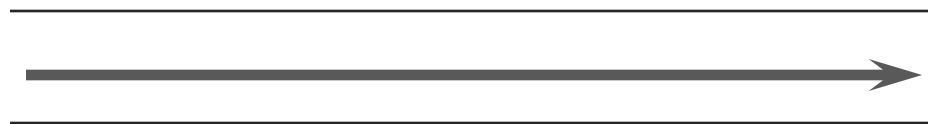
# Fiber Optic Signals



**fiber optic multimode  
step-index**



**fiber optic multimode  
graded-index**



**fiber optic single mode**



# Fiber Optic Advantages

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- greater capacity (bandwidth of up to 2 Gbps)
- smaller size and lighter weight
- lower attenuation
- immunity to environmental interference
- highly secure due to tap difficulty and lack of signal radiation



# Fiber Optic Disadvantages

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- expensive over short distance
- requires highly skilled installers
- adding additional nodes is difficult



# Wireless (Unguided Media) Transmission

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- transmission and reception are achieved by means of an antenna
- directional
  - transmitting antenna puts out focused beam
  - transmitter and receiver must be aligned
- omnidirectional
  - signal spreads out in all directions
  - can be received by many antennas



# Wireless Examples

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- terrestrial microwave
- satellite microwave
- broadcast radio
- infrared



# Terrestrial Microwave

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- used for **long-distance** telephone service
- uses **radio frequency spectrum**, from 2 to 40 Ghz
- parabolic dish transmitter, mounted high
- used by common carriers as well as private networks
- requires **unobstructed line of sight** between source and receiver
- curvature of the earth requires stations (repeaters) **~30 miles apart**



# Terrestrial Microwave Applications

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- Close-circuit Television
- Long-distance telephone transmission



# Terrestrial Microwave Transmission Disadvantages

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- line of sight requirement
- expensive towers and repeaters
- subject to interference such as passing airplanes and rain



- a microwave relay station in space
- can relay signals over long distances
- geostationary satellites
  - remain above the equator at a height of 22,300 miles (geosynchronous orbit)
  - travel around the earth in exactly the time the earth takes to rotate



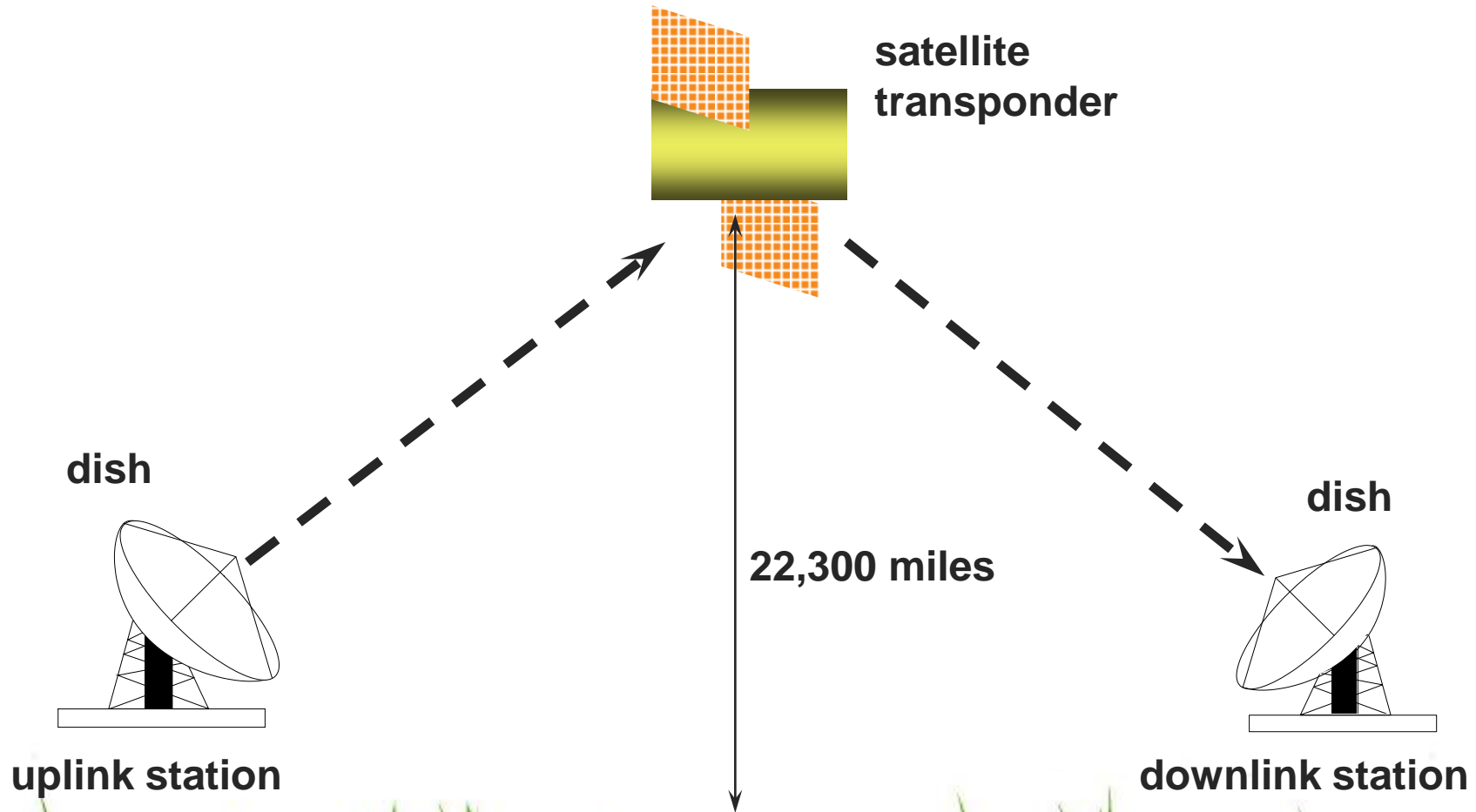
# Satellite Transmission Links

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- earth stations communicate by sending signals to the satellite on an uplink
- the satellite then repeats those signals on a downlink
- the broadcast nature of the downlink makes it attractive for services such as the distribution of television programming



# Satellite Transmission Process



# Satellite Transmission Applications

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- television distribution
  - a network provides programming from a central location
  - direct broadcast satellite (DBS)
- long-distance telephone transmission
  - high-usage international trunks
- private business networks



# Principal Satellite Transmission Bands

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- C band: 4(downlink) - 6(uplink) GHz
  - the first to be designated
- Ku band: 12(downlink) -14(uplink) GHz
  - rain interference is the major problem
- Ka band: 19(downlink) - 29(uplink) GHz
  - equipment needed to use the band is still very expensive



# Fiber vs Satellite

**Table 7.6** A Comparison of Optical Fiber and Satellite Transmission

Characteristic	Optical Fiber	Satellite
Bandwidth	Theoretical limit of 1 terahertz; currently 1–10 GHz	Typical transponder has a bandwidth of 36–72 MHz
Immunity to interference	Immune to electromagnetic interference	Subject to interference from various sources, including microwave
Security	Difficult to tap without detection	Signals must be encrypted for security
Multipoint capability	Primarily a point-to-point medium	Point-to-multipoint communications easily implemented
Flexibility	Difficult to reconfigure to meet changing demand	Easy to reconfigure
Connectivity to customer site	Local loop required	With antenna installed on customer premises, local loop not required



# Radio

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- radio is omnidirectional and microwave is directional
- Radio is a general term often used to encompass frequencies in the range 3 kHz to 300 GHz.
- Mobile telephony occupies several frequency bands just under 1 GHz.



# Infrared

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- Uses transmitters/receivers (transceivers) that modulate noncoherent infrared light.
- Transceivers must be within line of sight of each other (directly or via reflection ).
- Unlike microwaves, infrared does not penetrate walls.
- Use mainly to send information between laptop without the need of antennas or for TV remote control.



# Conclusion

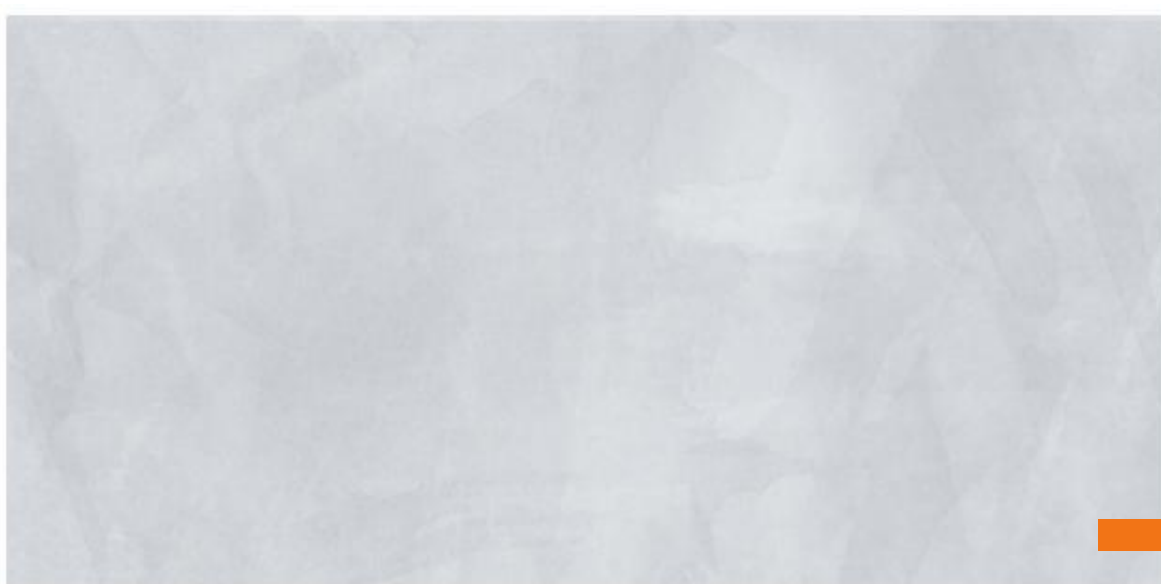
## Media Selection

### Guided Media

Media	Network Type	Cost	Transmission Distance	Security	Error Rates	Speed
Twisted Pair	LAN	Low	Short	Good	Low	Low-high
Coaxial Cable	LAN	Mod.	Short-Mod	Good	Low	Low-high
Fiber Optics	any	High	Mod.-long	V. Good	V.Low	High-V.High

### Radiated Media

Media	Network Type	Cost	Transmission Distance	Security	Error Rates	Speed
Radio	LAN	Low	Short	Poor	Mod	Low
Infrared	LAN, BN	Low	Short	Poor	Mod	Low
Microwave	WAN	Mod	Long	Poor	Low-Mod	Mod
Satellite	WAN	Mod	Long	Poor	Low-Mod	Mod



**Thanks for attending!**

