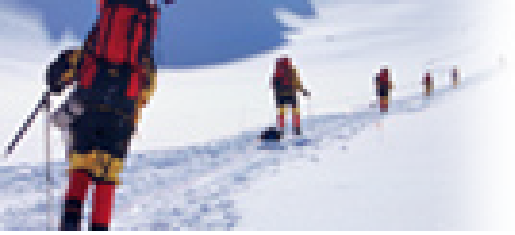
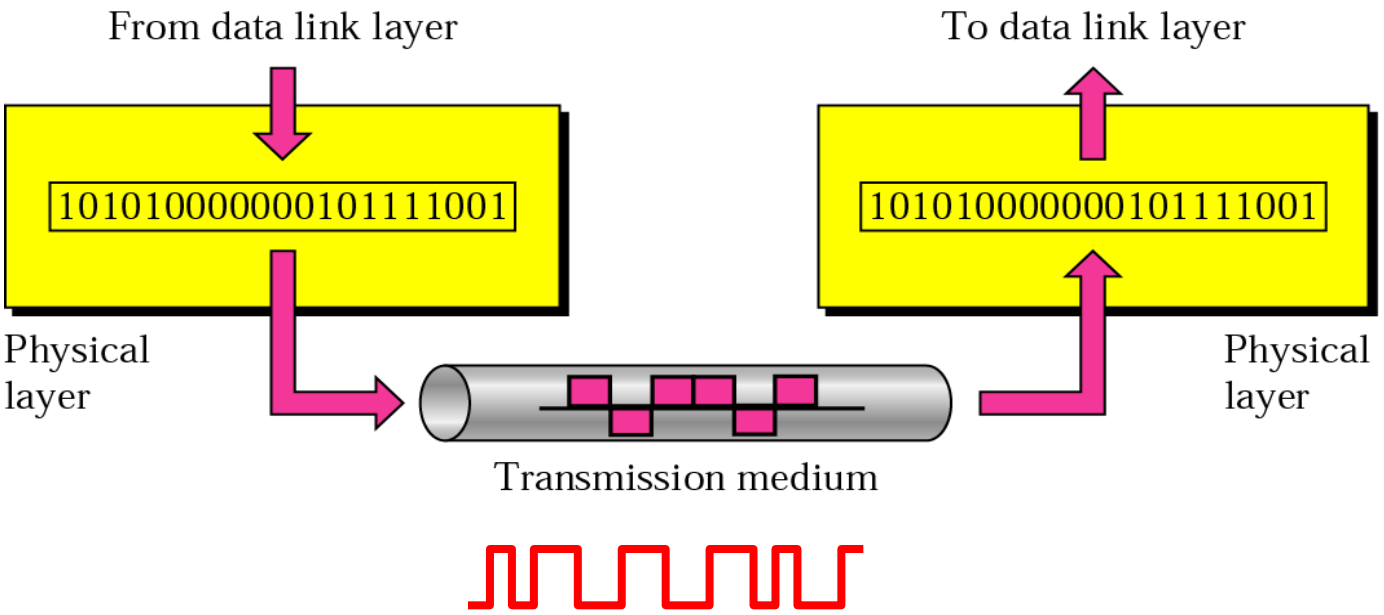


Chapter 7

Transmission Media

Review of Signals



	Analog signal	Digital signal
Analog Data	**AM, FM**	**PCM & Video using codecs**
Digital Data	**ASK, FSK, PSK, QAM**	**LAN Cable Standards (bi-phase, Manchester)**

What we do in this lecture!

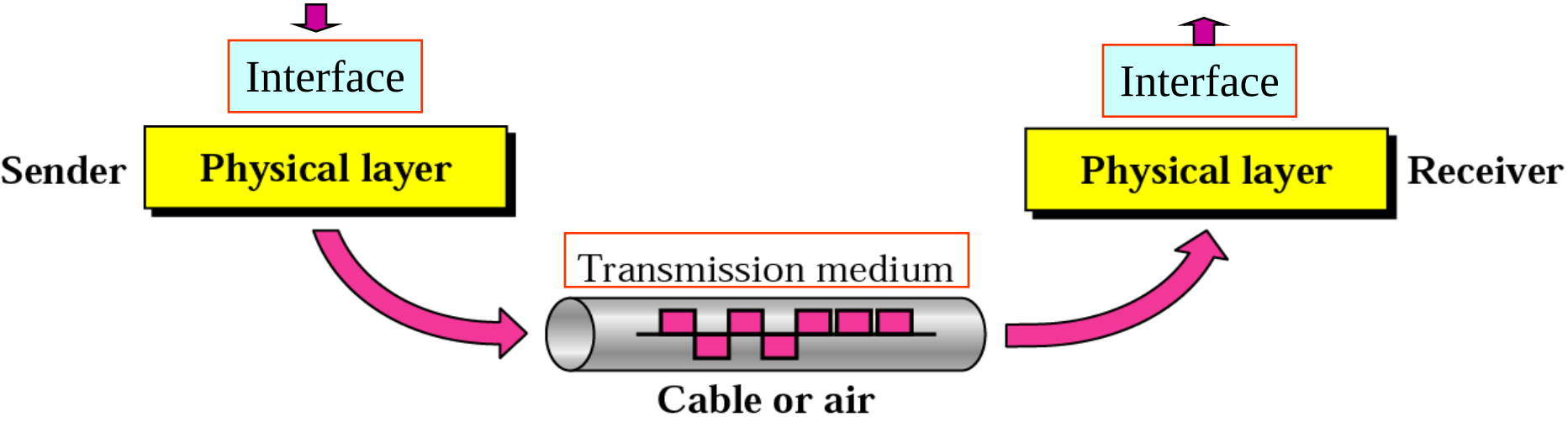
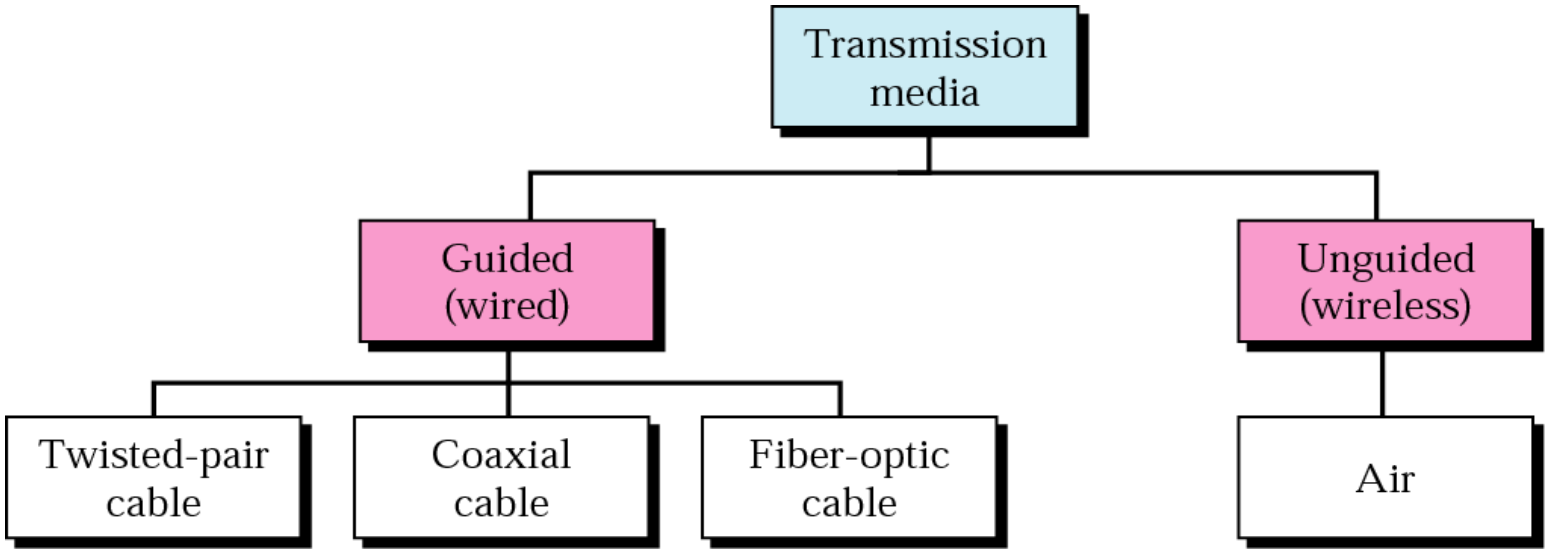


Figure 7.1 **Transmission medium and physical Interface**

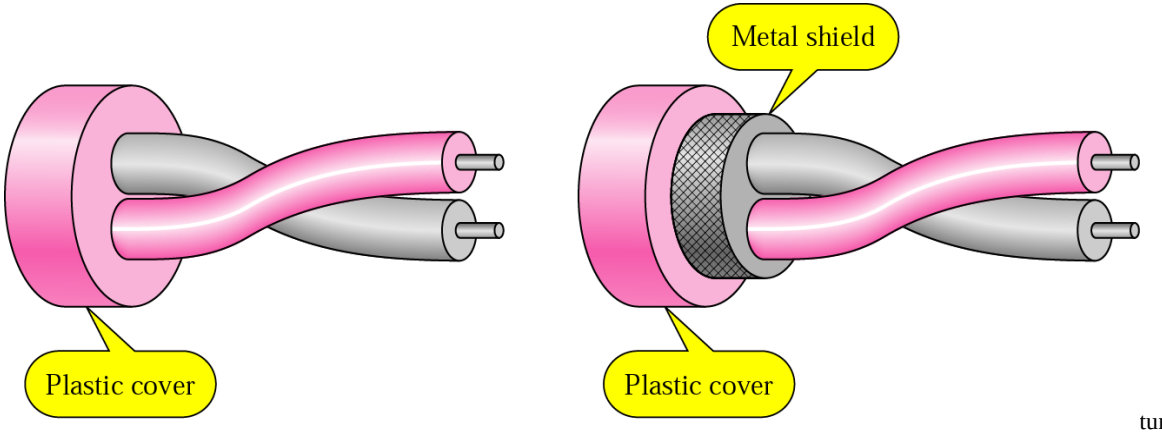
Transmission Media



- Medium**: the physical matter that carries the transmission.**
  - **With** Guided media **the transmission flows along a physical guide. The three main types of guided media: twisted pair wiring, coaxial cable and optical fiber cable.**
  - **With** Wireless media **there is no wave guide and the transmission just flows through the air (or space). The main forms of wireless communications are radio, infrared, microwave, and satellite communications.**

Twisted-pair Cable

- **Can carry both voice and data**
- **Often used in buildings for LAN and PBX station connections**
  - **Also used in telco outside plant (local loops)**
- **Analog**
  - **Amplifiers every 5km to 6km**
- **Digital**
  - **Use either analog or digital signals**
  - **repeater every 2km or 3km**
- **Categories**
  - Unshielded**: most common type of telecommunication medium**
  - Shielded**: has a metal foil or braided-mesh covering that encases each pair of insulated conductors (See Figure 7.4)**



a. UTP b. STP

Cable Categories

- **The EIA (Electronic Industries Association) has developed the following categories with 1 (the lowest quality) and 5:**
  - Category 1**: used in telephone system; is fine for voice but not adequate for all but low-speed data communication**
  - Category 2**: suitable for voice and data transmission up to 4Mbps**
  - Category 3**: required to have 3 twists per foot can be used for data transmission up to 10Mbps; most standard cable for telephone now**
  - Category 4**: possible transmission rate to 16Mbps**
  - Category 5**: used for data transmission up to 100Mbps**

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 (draft)	200 MHz	200 Mbps	Digital	LANs
7 (draft)	600 MHz	600 Mbps	Digital	LANs

Advantages of UTP and UTP connectors

- **Advantages:**
  - **Cost: cheap**
  - **Ease of use: flexible and easy to install**
- **Higher grades of UTP are used in many LANs technologies (Ethernet and Token Ring)**
- **Connected to devices via a type of snap-in plug (see Figure 7.9)**

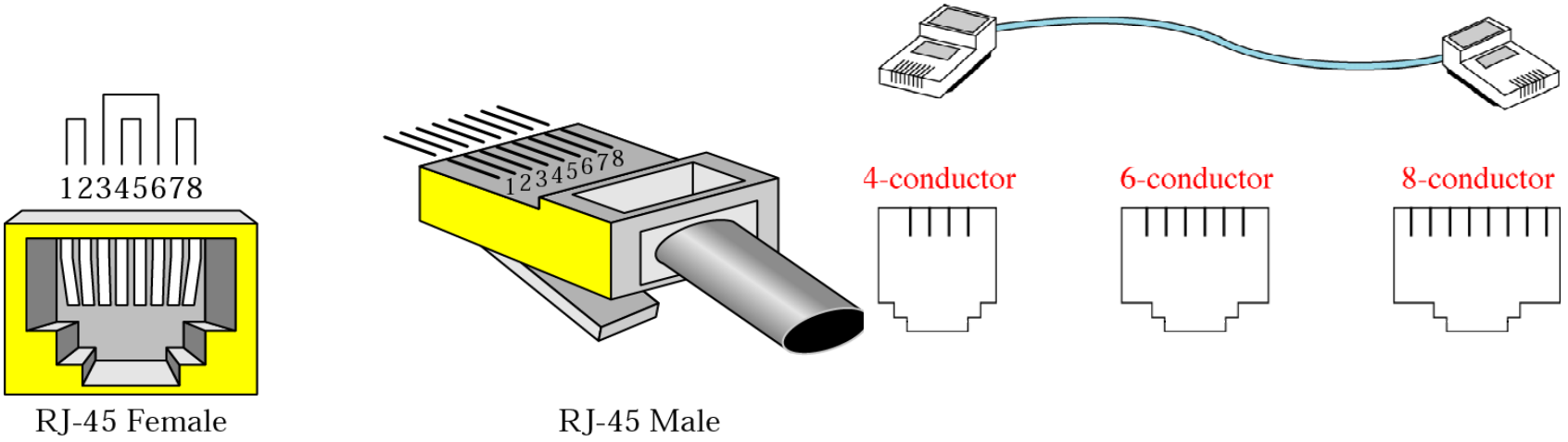
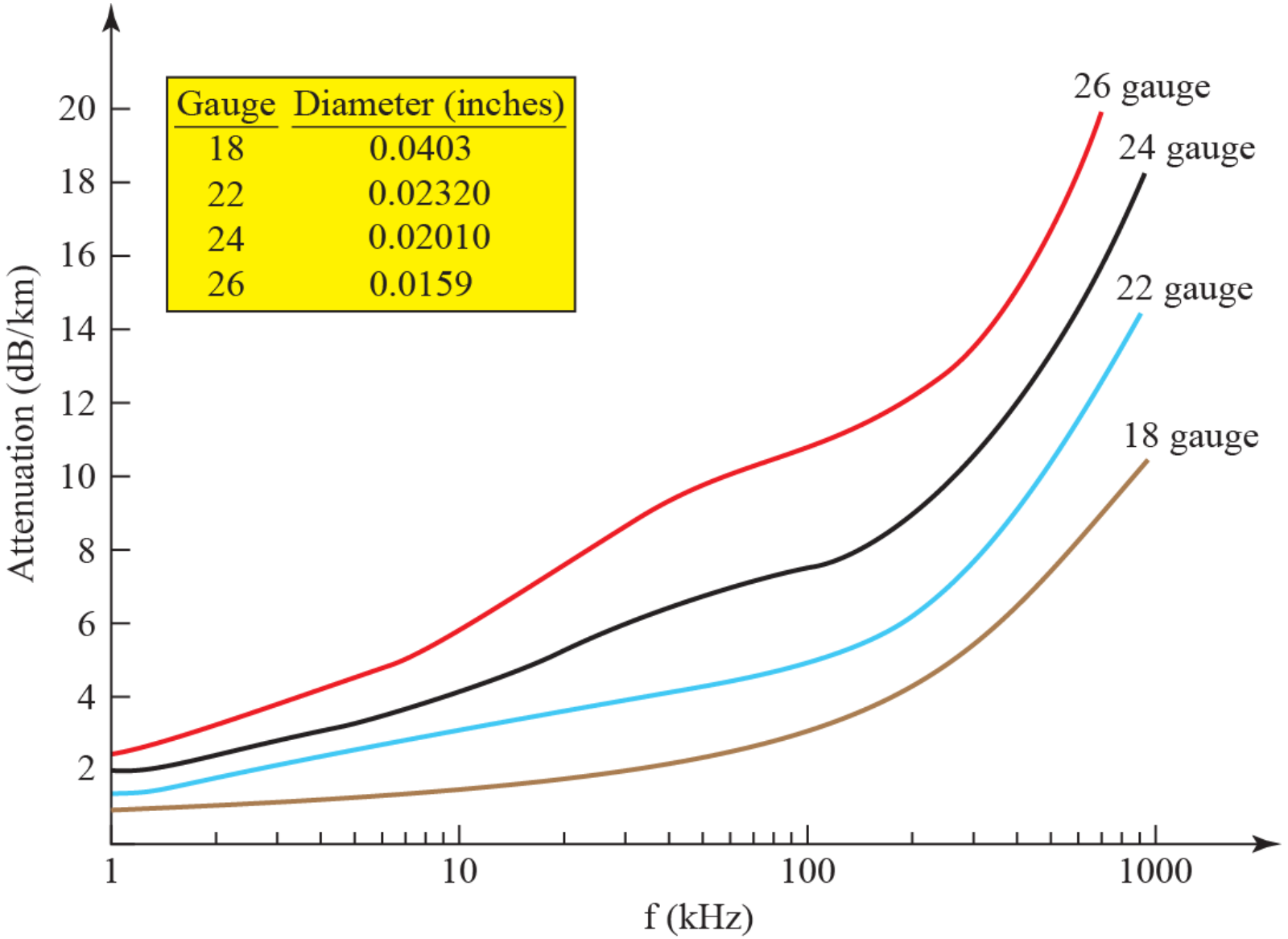


Figure 7.6: UTP Performance



Coaxial Cable

- **Can carry higher frequency ranges than twisted pair cable (Coaxial: 100KHz to 500MHz; Twister pair: 100Hz to 5MHz**

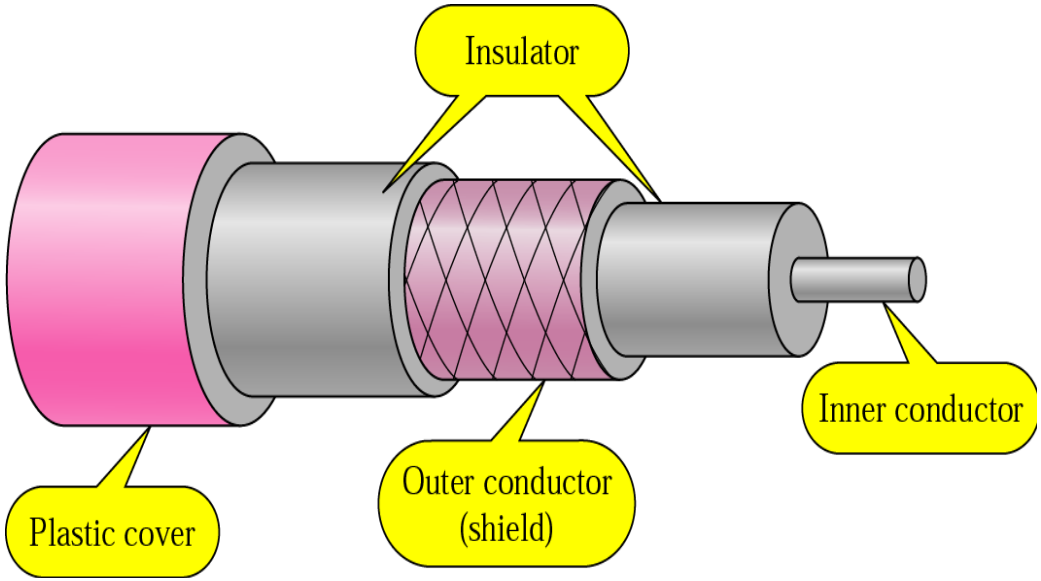


Table 7.2 *Categories of coaxial cables*

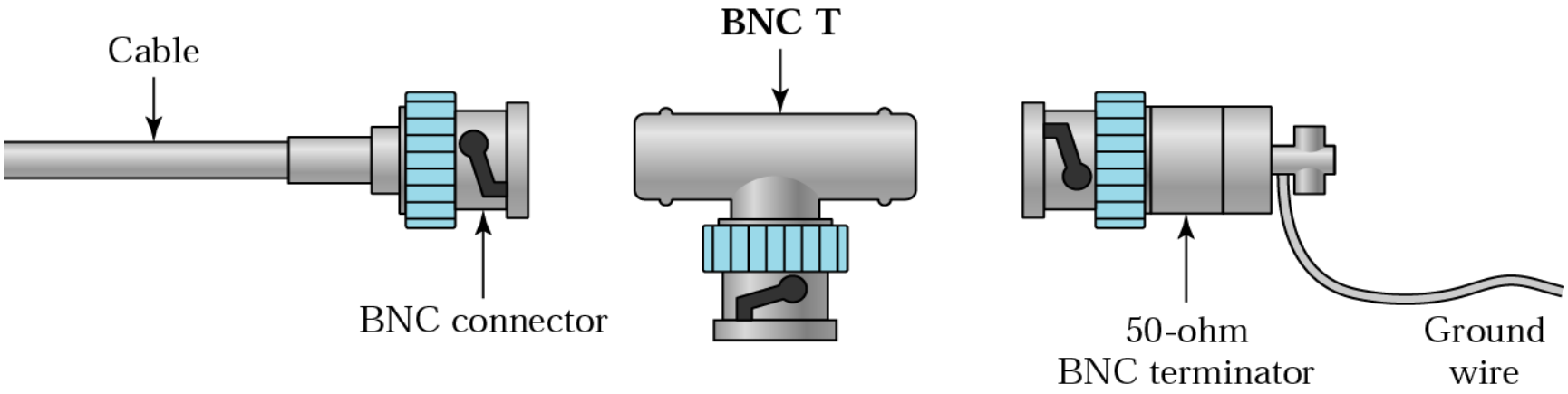
Category	*Impedance*	*Use*
RG-59	75 Ω	Cable TV
RG-58	50 Ω	Thin Ethernet
RG-11	50 Ω	Thick Ethernet

Coaxial Cable Connectors

- **Barrel connectors:**
  - **Bayonet network connector (BNC) is the most popular, which pushes on and locks into place with a half turn**
  - **Other types includes screw on, push on without locking**
  - **Are familiar from cable TV and VCR hookups**

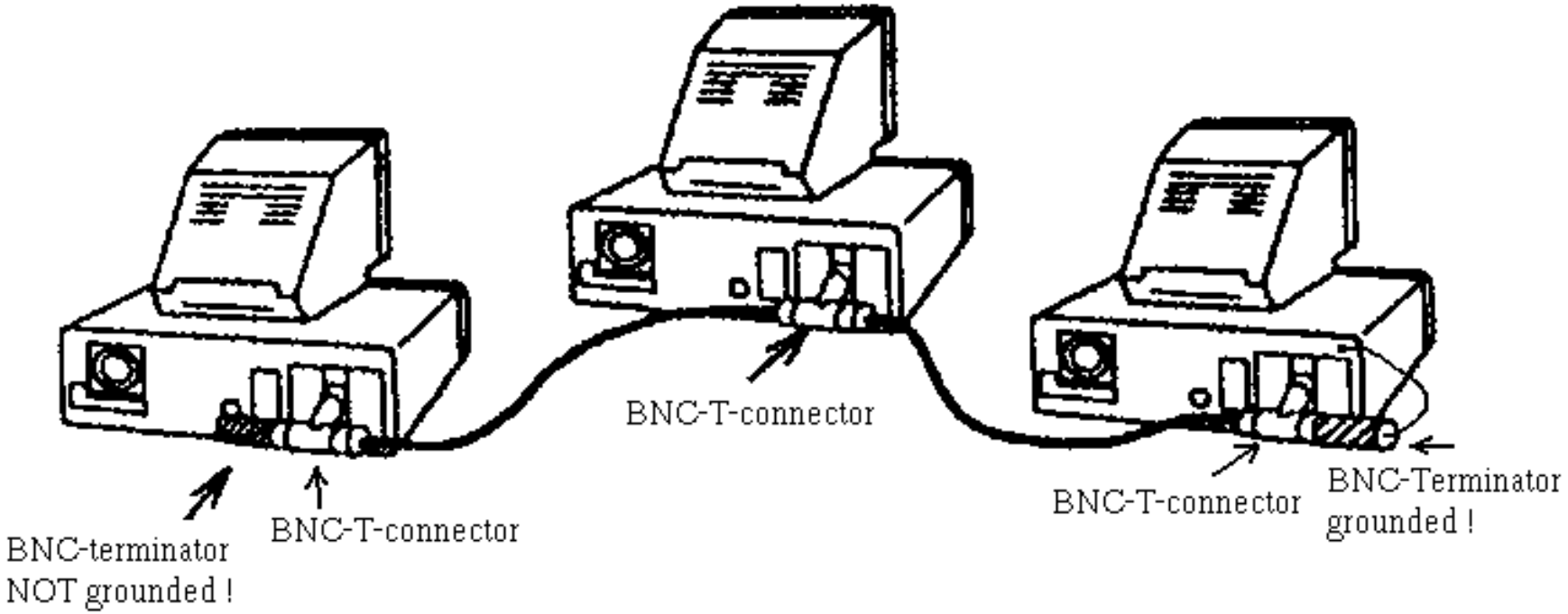
Coaxial – T-connector and Terminators

- **T-connectors used in Ethernet that allows a secondary cable or cables to branch off from a main line**



- **Terminator is used to prevent the reflection**

Coaxial Cable Connection

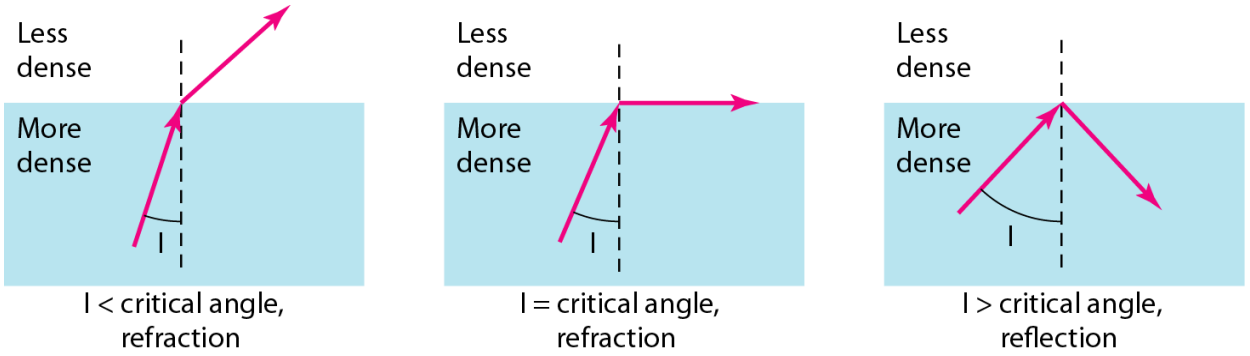


Transmission Characteristics

- **Analog**
  - **Amplifiers every few km**
  - **Closer if higher frequency**
  - **Up to 500MHz**
- **Digital**
  - **Repeater every 1km**
  - **Closer for higher data rates**
- **Less susceptible to interference and crosstalk than twisted pair**

Optical Fiber

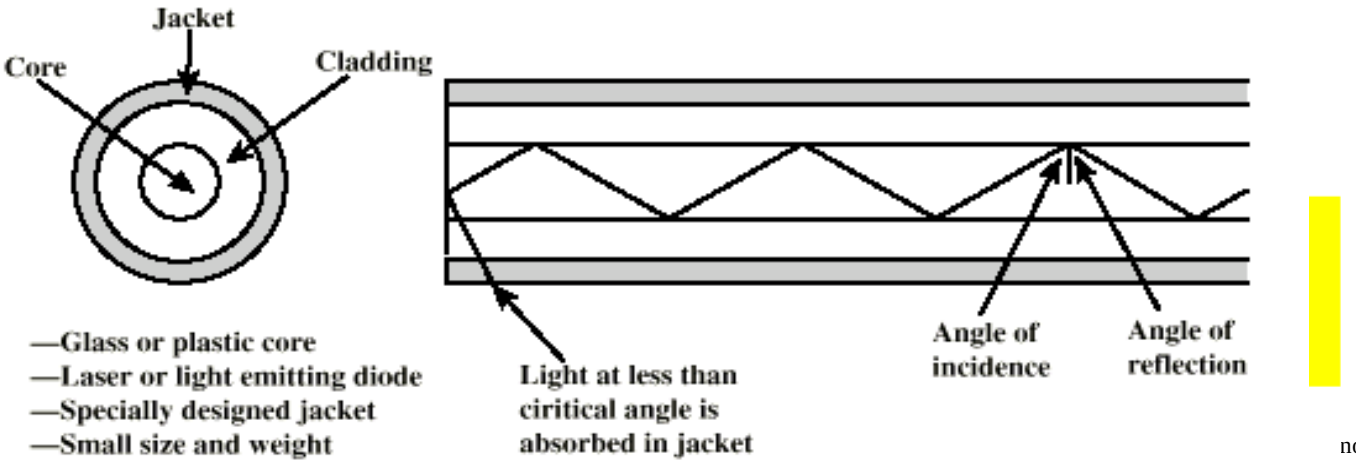
- **Is made of glass or plastic and transmits signals in the form of light.**
- **To understand the transmission, several aspects of the nature of the light need to be examine:**
  - **Refraction**
  - **Reflection**
  -



- **Lights travels fastest in a vacuum: 300000 kilometers/second; speed of light depends of the density of the medium (higher density transmit light slower)**

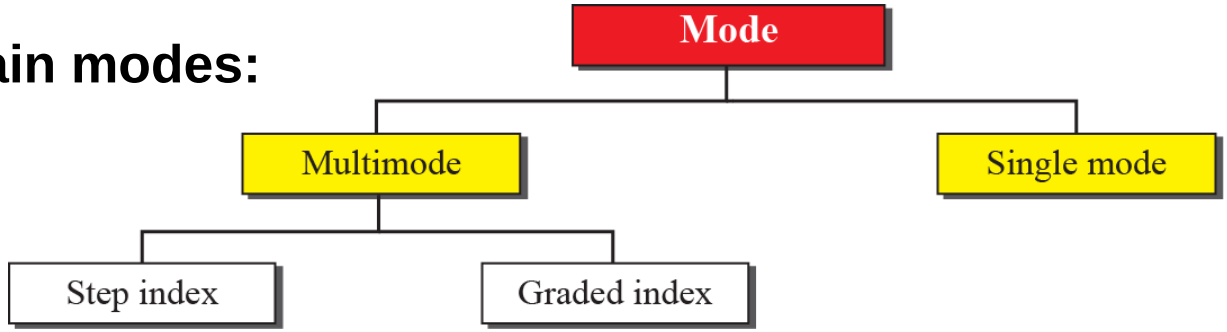
The nature of light

- Refraction (굴절)**:**
  - **When the light travels another substance, speed and direction changes (see Figure 7.13)**
  - **Fiber optic technology takes advantages of this properties to control the propagation of light**
- Reflection (반사)**:**
  - **When light cannot passes into the less dense medium Optical fibers uses reflection to guide light through a channel**



Propagation Modes

- **There are two main modes:**



  - Multimode**:**
    - multiple beams from a light source move through the core in different paths
    - is cheap, but the signal spreads out over short distances (up to ~500m).
  - 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 horizontal (see Figure 7.19)
    - is expensive because difficult to manufacture, but signal can be sent over many kilometers without spreading

Figure 7.14 *Fiber construction*

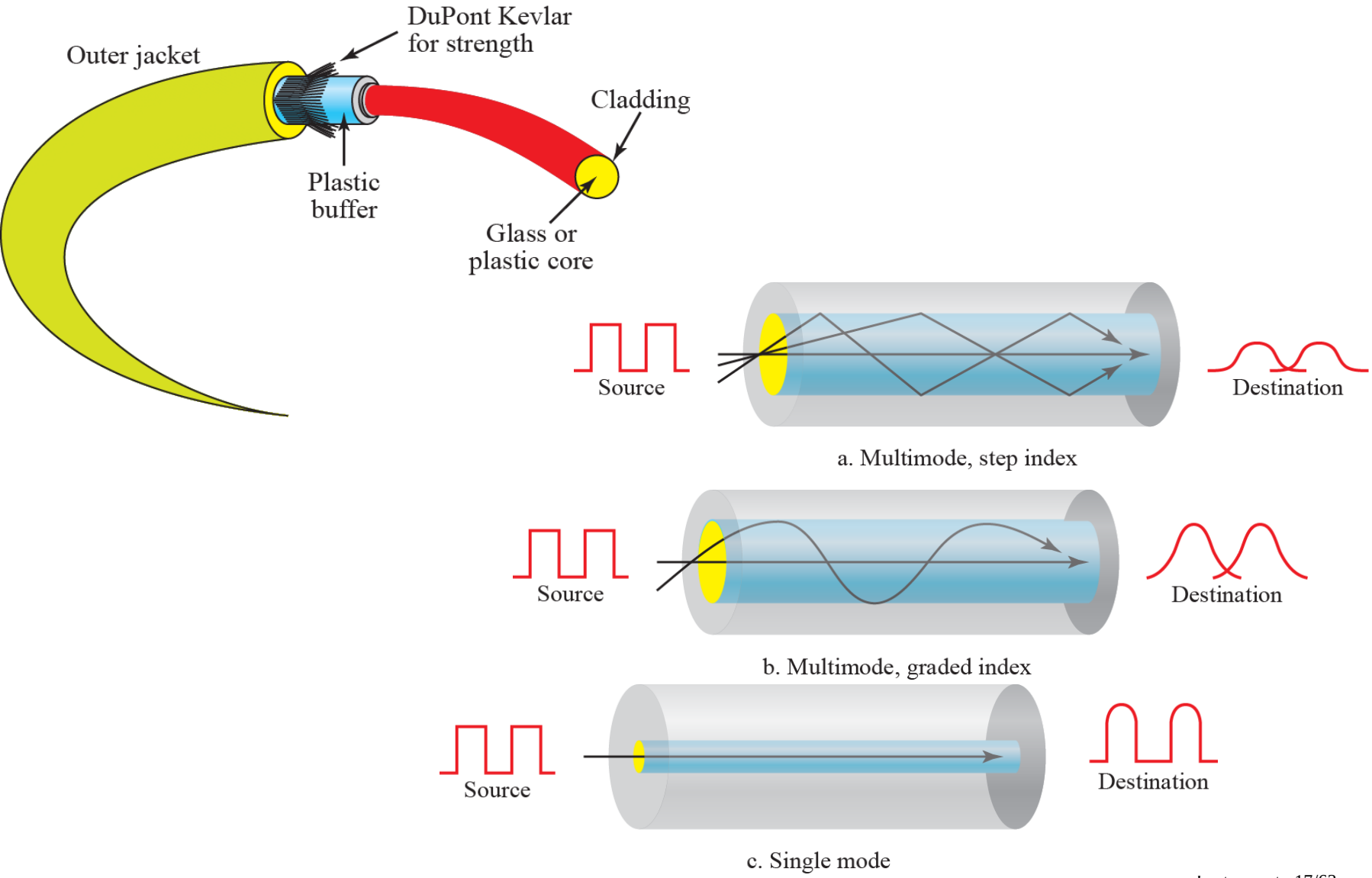
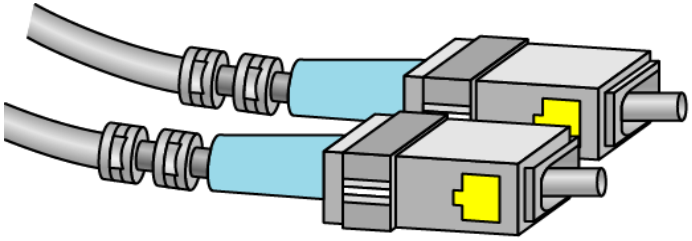
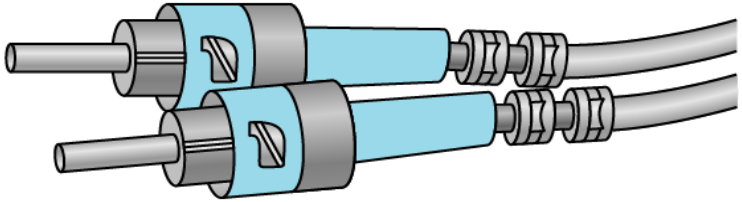


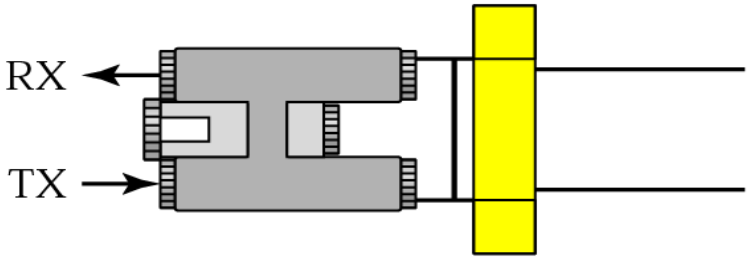
Figure 7.15 *Fiber-optic cable connectors*



SC connector

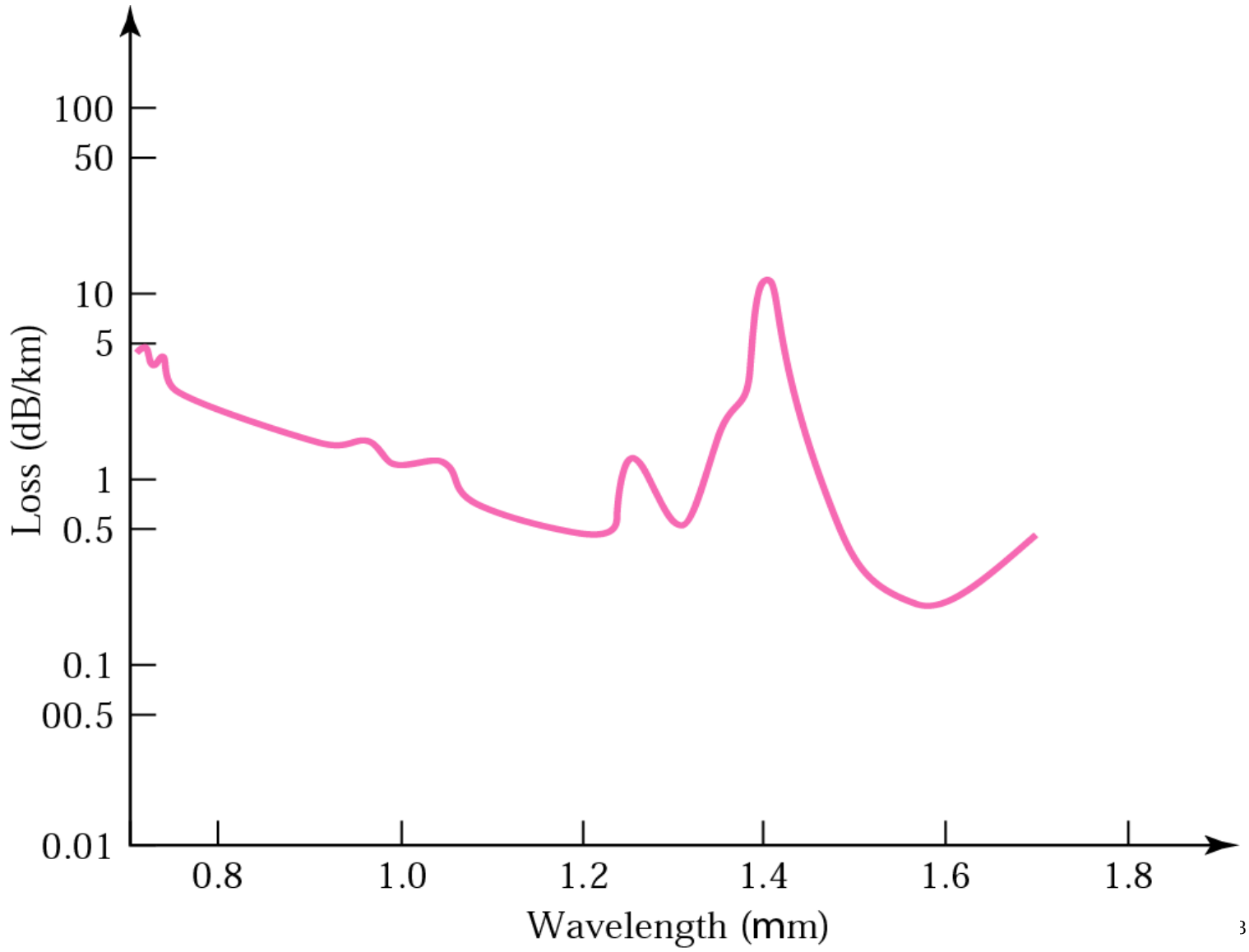


ST connector



MT-RJ connector

Figure 7.16 *Optical fiber performance*



Advantages and disadvantages

- **Advantages:**
  - **Higher bandwidth**
  - **Less signal attenuation**
  - **Less interference**
  - **Resistance to corrosive materials**
  - **Light weight**
  - **More immune to tapping**
- **Disadvantages**
  - **Expensive to install**

Application

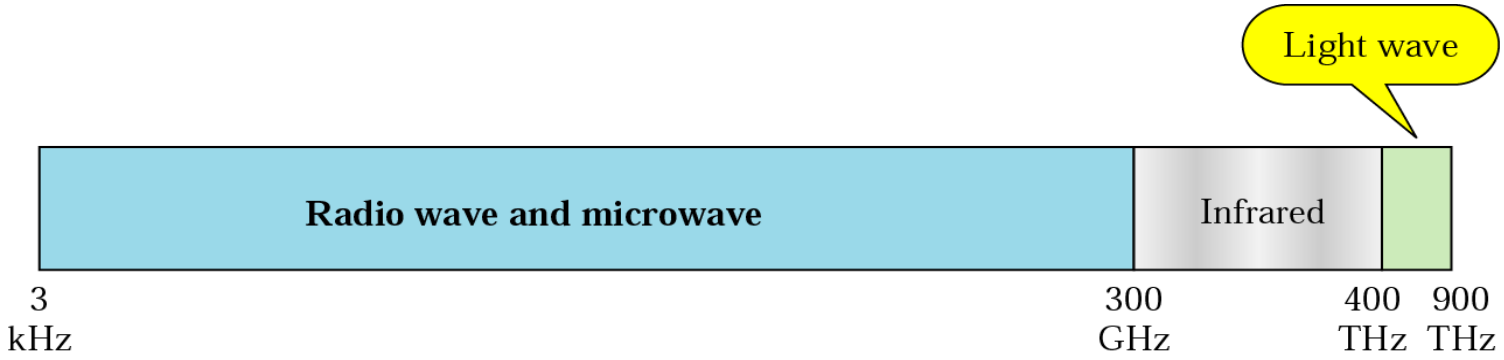
- **Long-haul trunks**
- **Metropolitan trunks**
- **Rural exchange trunks**
- **Subscriber loops**
- **LANs**
- **Other**
  - **Backbone networks**
  - **TV distribution**

Summary - Guided transmission media summary

Type	Advantage	Disadvantage
Twisted Pair Wire	Very inexpensive Easy to install Already installed in many locations	Doesn't pass high frequencies well
Coaxial cable	Shielded Fairly inexpensive Moderately high bandwidth	Bulky and somewhat inflexible
Fiber optic cable	Transmission unaffected by noise Very high bandwidth Great repeater spacing	Expensive to install

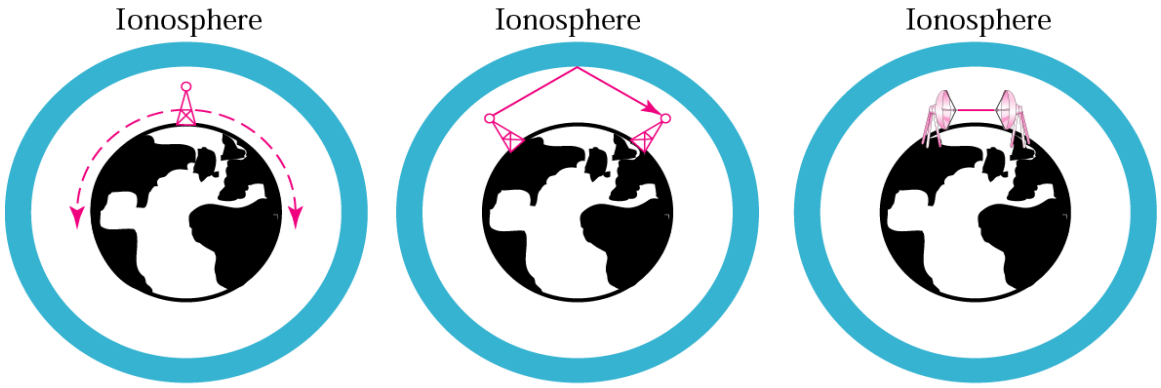
Wireless Transmission - Unguided Media

- Radio: **wireless transmission of electrical waves. Includes AM and FM radio bands. Microwave is also a form of radio transmission.**
- Microwave: **high frequency form of radio with extremely short wavelength (1 cm to 1 m). Often used for long distance, terrestrial transmissions and cellular telephones. Requires line-of-sight.**
- Infrared: **"invisible" light waves whose frequency is below that of red light. Requires line of sight and are generally subject to interference from heavy rain. Used in remote control units (e.g., TV).**
- **lightwave**



Radio Transmission

- **The properties of radio waves are frequency dependent:**
  - low frequencies – **ground wave propagation**
    - radio waves pass through obstacles well
    - power of signal falls off sharply over distance
  - high frequencies - **Sky Wave Propagation & line of sight**
    - radio waves tend to travel in straight lines
    - bounce off obstacles
    - absorbed by rain



Ground propagation (below 2 MHz)

Sky propagation (2 - 30 MHz)

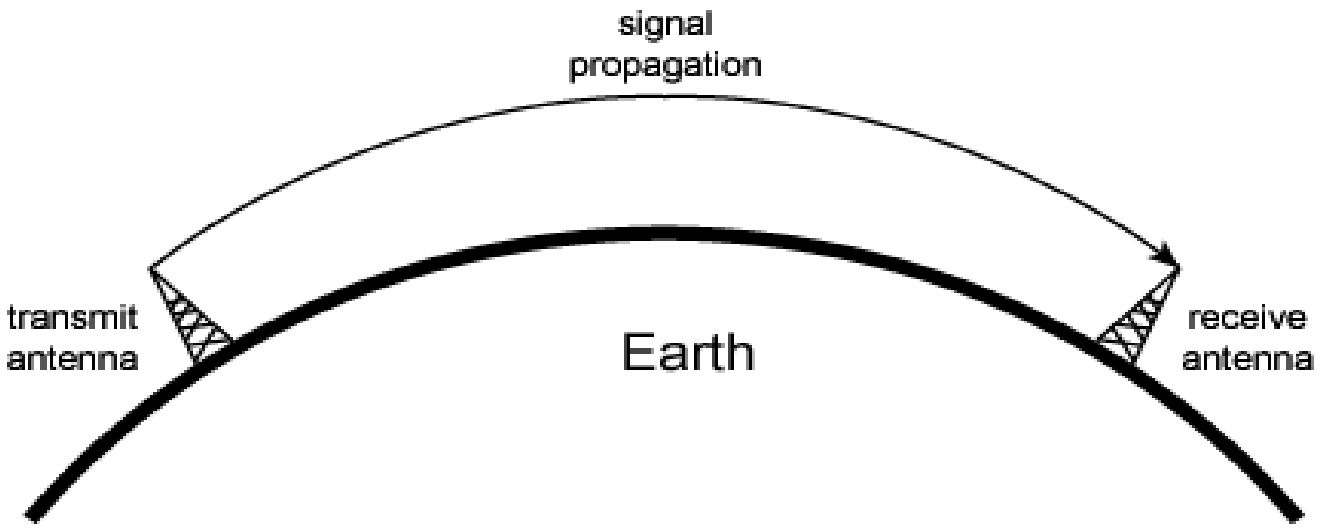
Line-of-sight propagation (above 30 MHz)

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

Ground Wave Propagation

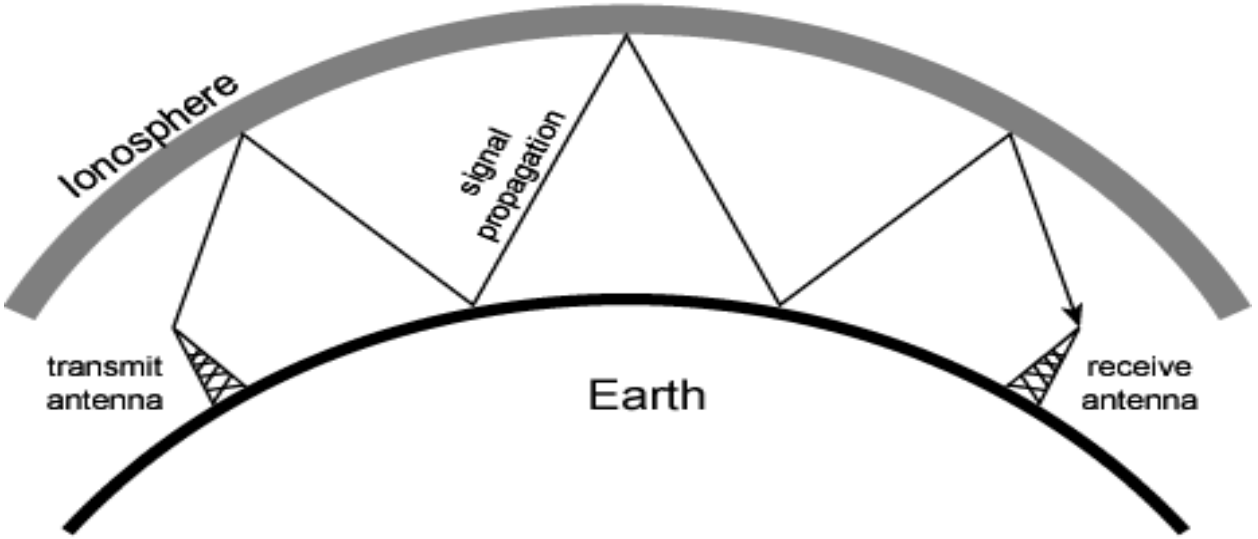
- Follows contour of earth
- Up to 2MHz
- AM radio



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

Sky Wave Propagation

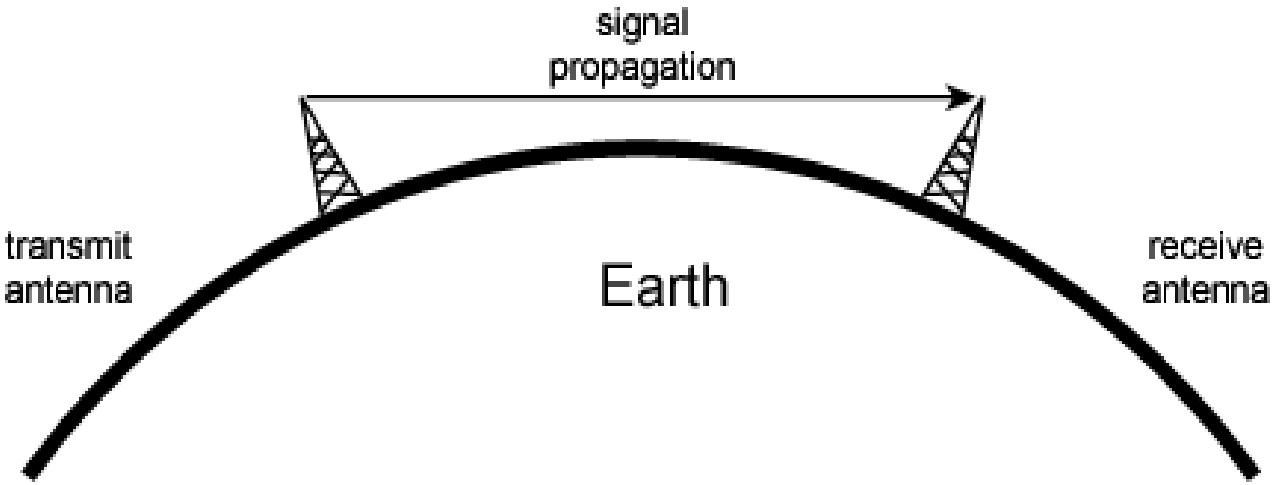
- Signal reflected from ionosphere layer of upper atmosphere
- Amateur radio, BBC world service, Voice of America
- (Actually refracted)



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

Line-of-Sight

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

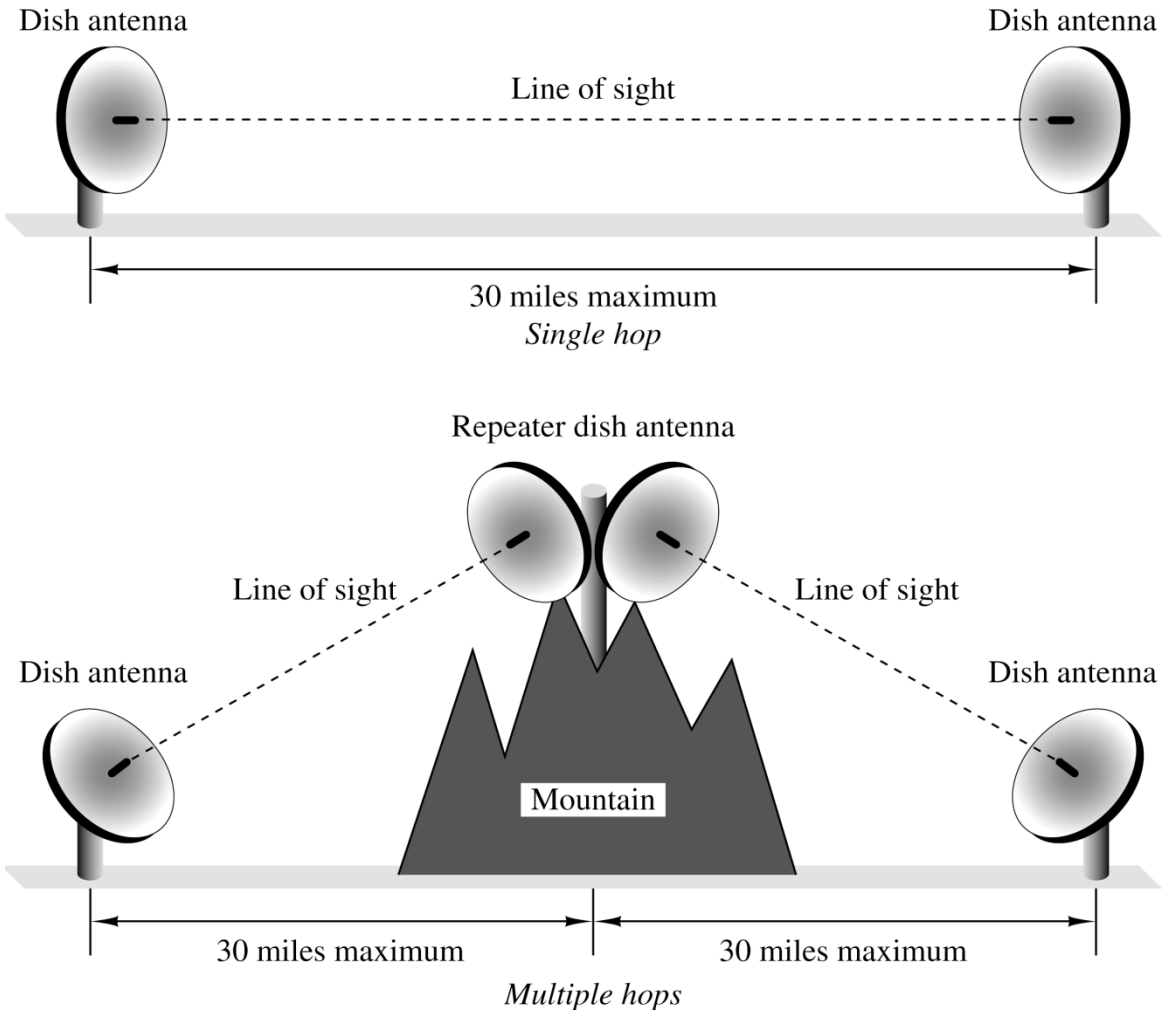


(c) Line-of-sight (LOS) propagation (above 30 MHz)

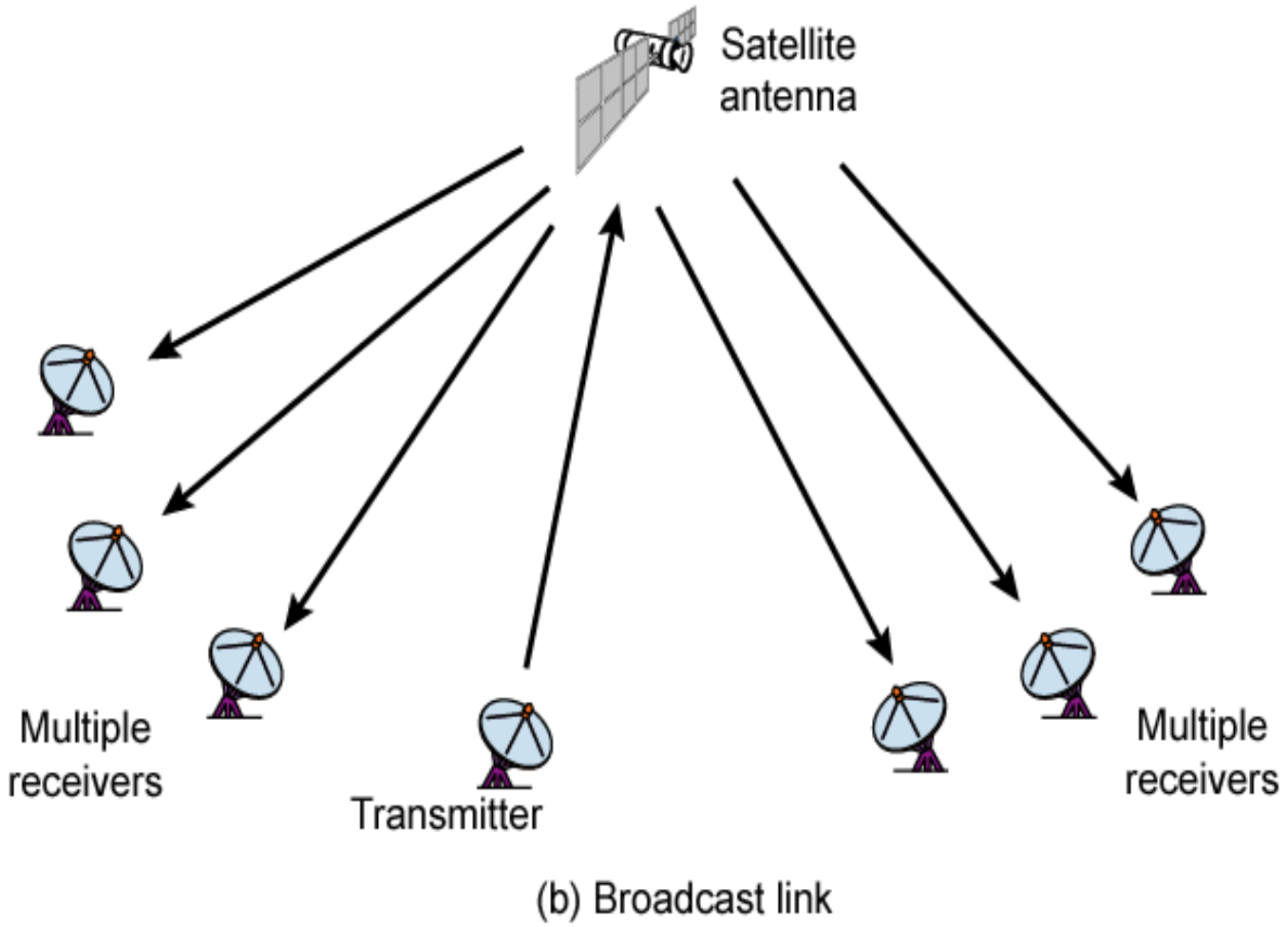
Microwave Transmission

- frequency above 100 MHz
- the waves travel in straight lines
- can be narrowly focused into a small beams
- higher signal to noise ratio
- transmitters and receivers must be accurately aligned
- low interference with adjacent beams
- Ex
  - Terrestrial Microwave
  - Satellite

Terrestrial Microwave



Satellite Broadcast Link



(b) Broadcast link

Satellite

- Satellite is a relay station
- Satellite receives on one frequency, amplifies or repeats signal and transmits on another frequency
- GEO (geosynchronous-earth orbit) satellites
  - Height of 22,230 miles
  - Requires 3 GEO satellites
- LEO (low – earth orbit) satellites
  - A few hundred miles above the earth
  - Require more 66 LEO satellites
- MEO (medium-earth orbit) satellites
  - 6434 miles above the earth
  - Require 12 MEO satellites
- Advantage: cheaper over long distances than fiber optics or twisted pair
- Problem:
  - susceptible to noise and interference caused by a variety of sources
  - Security risk

Infra-red and Millimetre Waves

- short-range communication (VCR remotes
- relatively directional
- cheap
- do not pass through solid objects
- will not interfere with a similar system in adjacent rooms
- better security against eavesdroppers
- possible to use as wireless connection to fixed LANs or other wireless machines

Antenna

- Electrical conductor (or system of..) used to radiate electromagnetic energy or collect electromagnetic energy
- Transmission
  - Electrical energy is converted into electromagnetic energy by antenna
  - Radiated into surrounding environment
- Reception
  - Electromagnetic energy impinging on antenna
  - Converted to electrical energy
  - Fed to receiver
- Same antenna often used for both

Radiation Pattern

- **Power radiated in all directions**
- **Not same performance in all directions**
- **Isotropic antenna is (theoretical) point in space**
  - **Radiates in all directions equally**
  - **Gives spherical radiation pattern**

Omnidirectional antennas

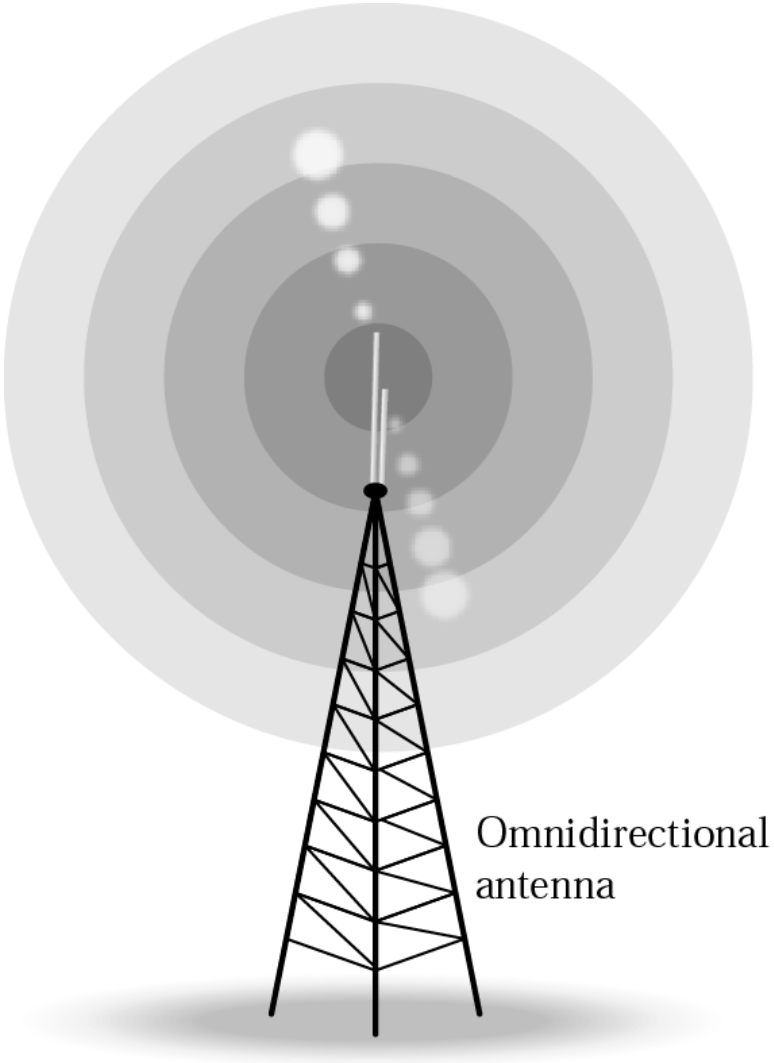
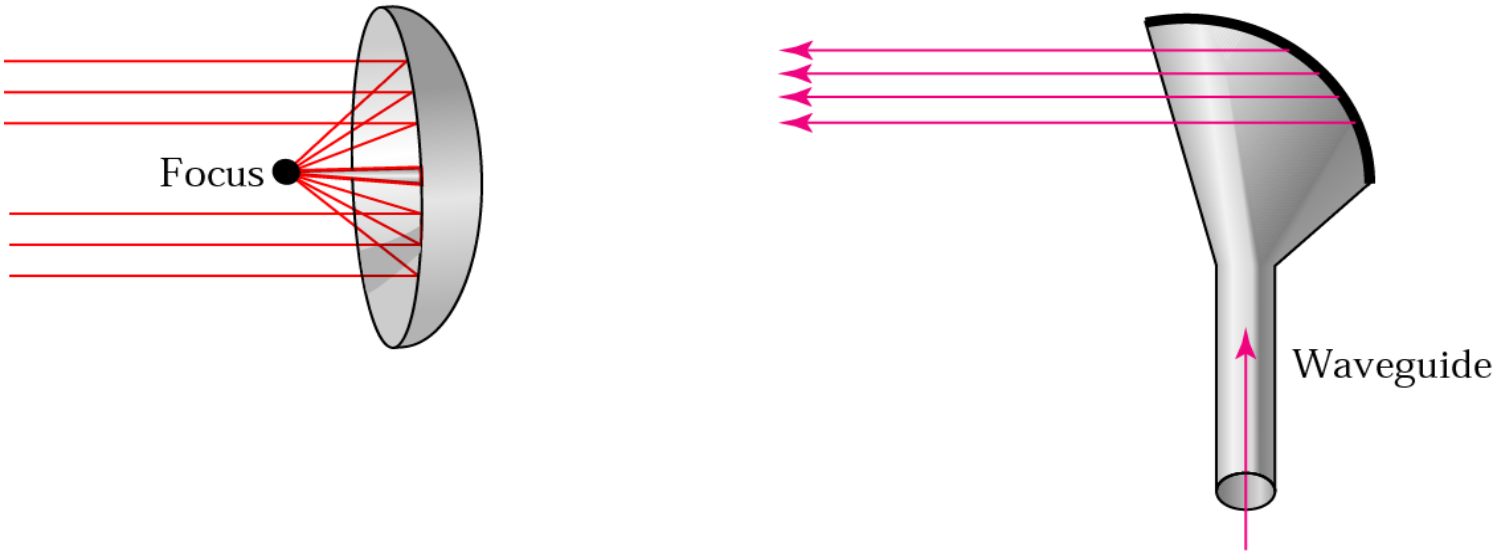


Figure 7.21 *Unidirectional antennas*



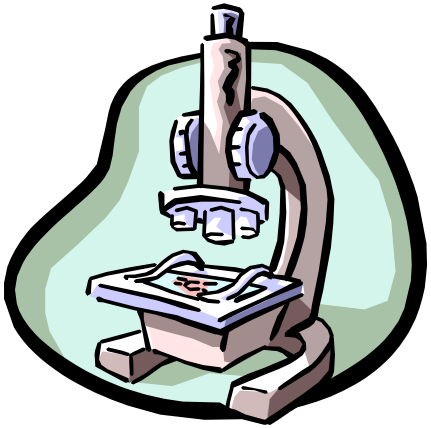
a. Dish antenna

b. Horn antenna

Media Selection depends on many factors including:

- Type of network
- Cost
- Transmission distance
- Security
- Error rates
- Transmission speeds

Questions



- **Research questions for Lecture 3:**

1. **What is transmission impairment? Describe the three types of impairment usually occur.**

2. **What is DSL and ADSL?**