Week 4 – Transmission Media Types
Ethernet in Depth

Figure 7.1 *Transmission medium and physical layer*

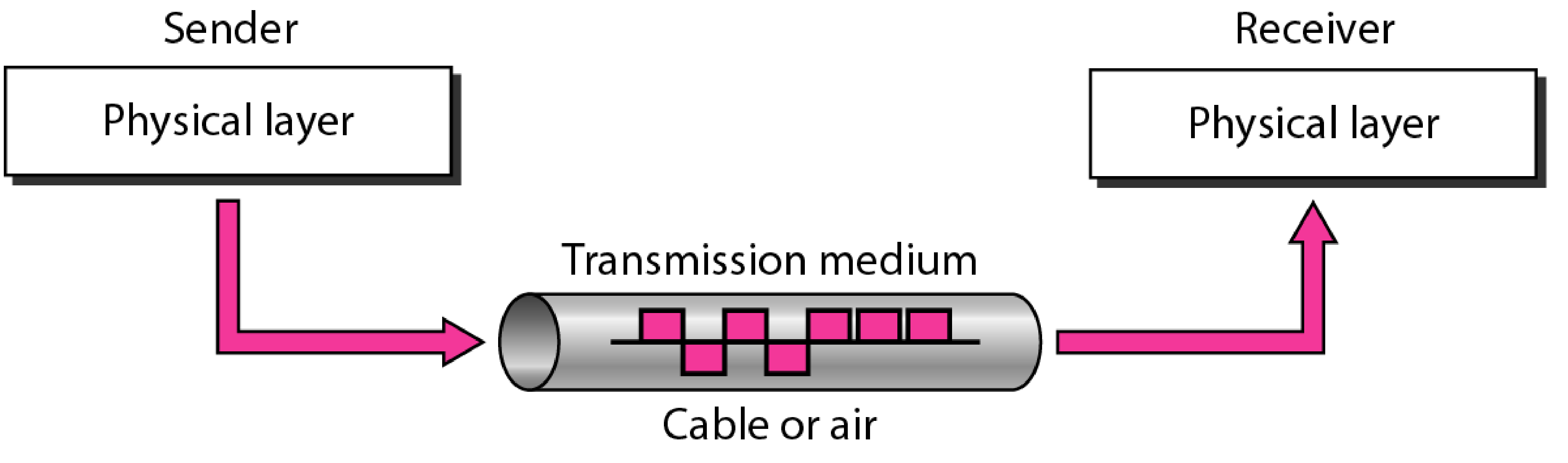
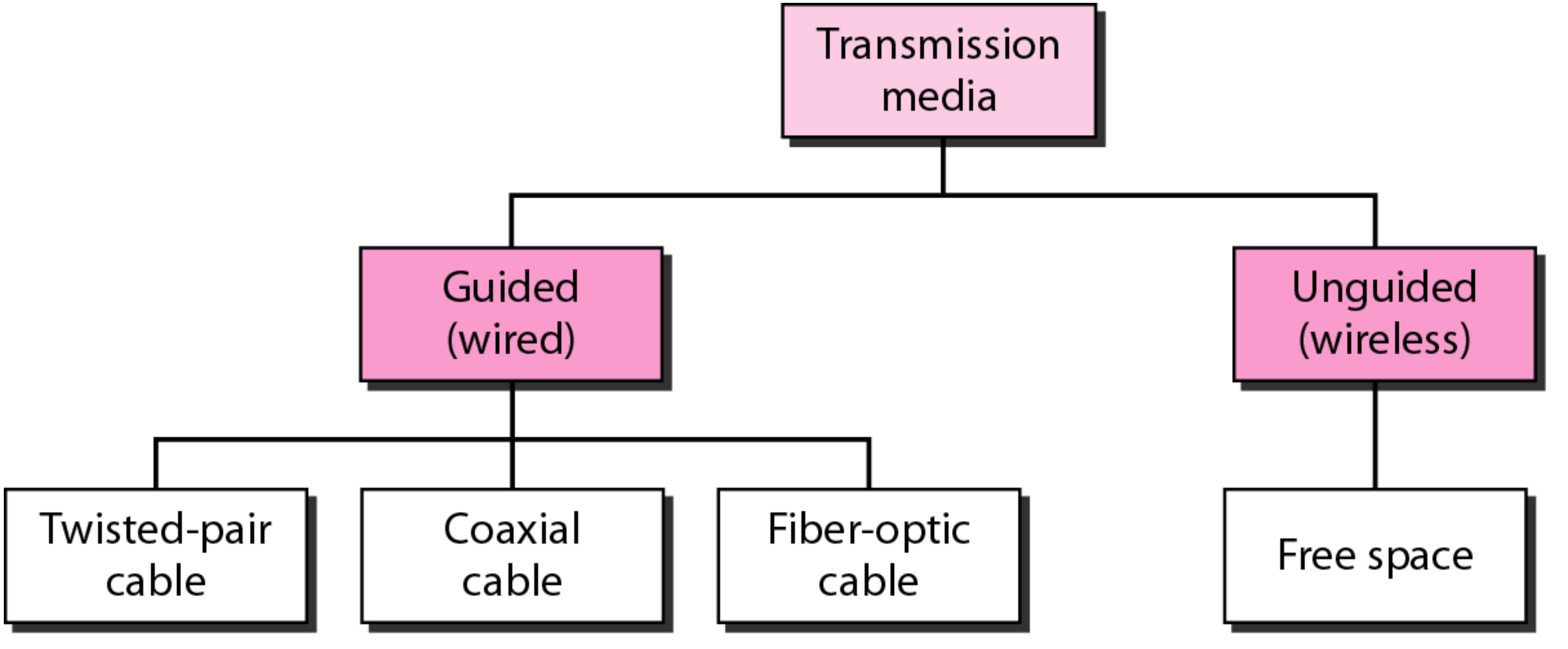


Figure 7.2 ***Classes of transmission media***



7-1 GUIDED MEDIA

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

Topics discussed in this section:

Twisted-Pair Cable
Coaxial Cable
Fiber-Optic Cable

Figure 7.3 *Twisted-pair cable*

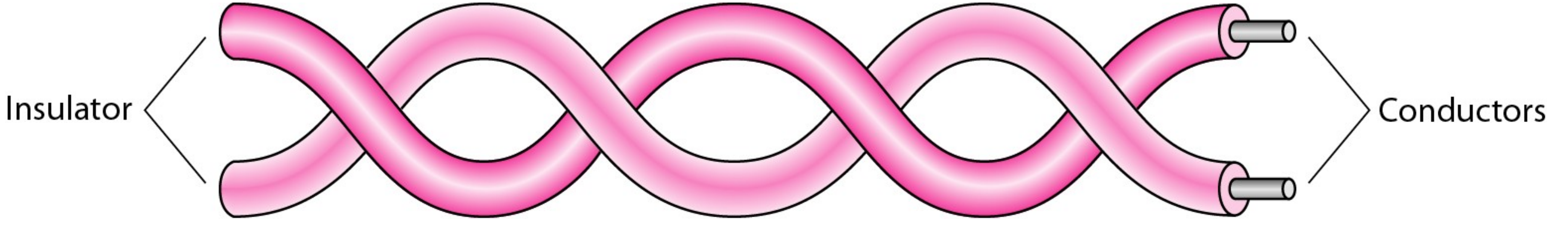


Figure 7.4 *UTP and STP cables*

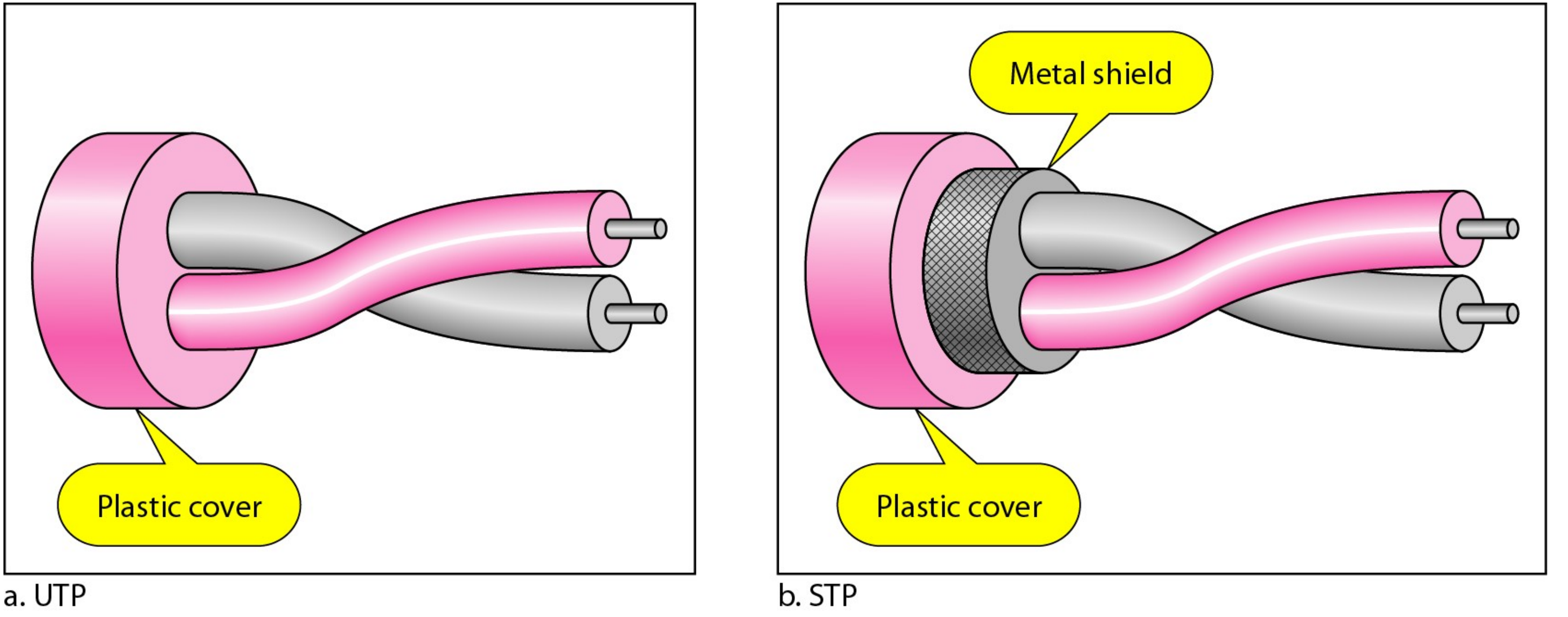


Table 7.1 ***Categories of unshielded twisted-pair cables***

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

Figure 7.5 *UTP connector*

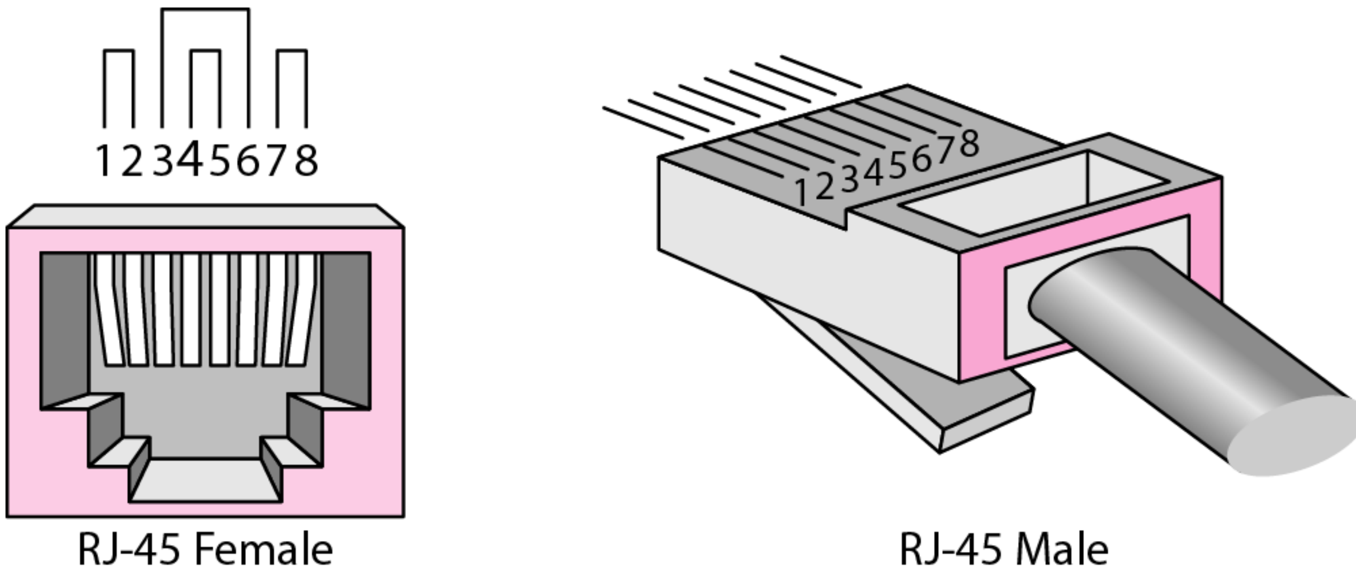
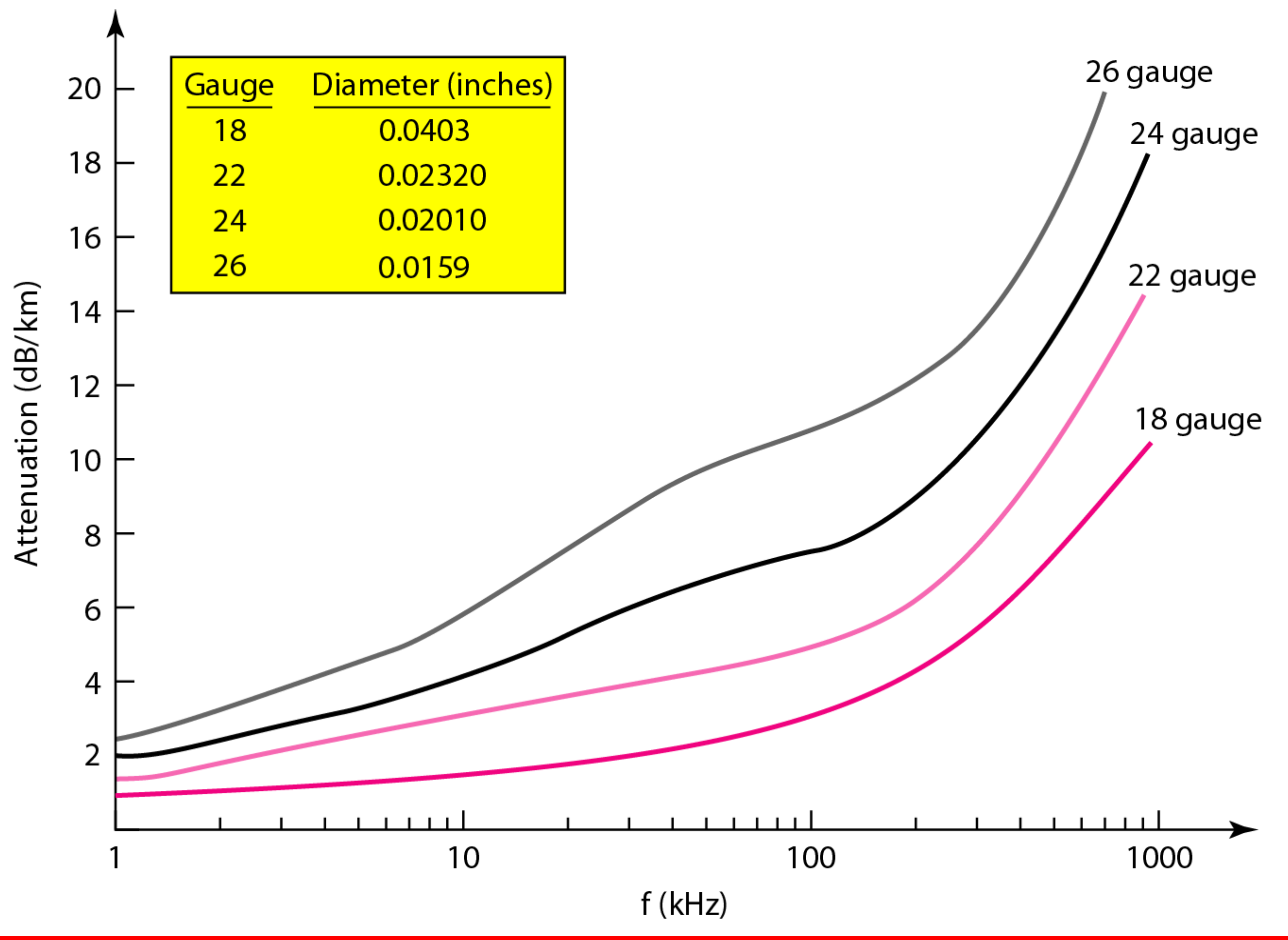


Figure 7.6 *UTP performance*



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

Figure 7.7 ***Coaxial cable***

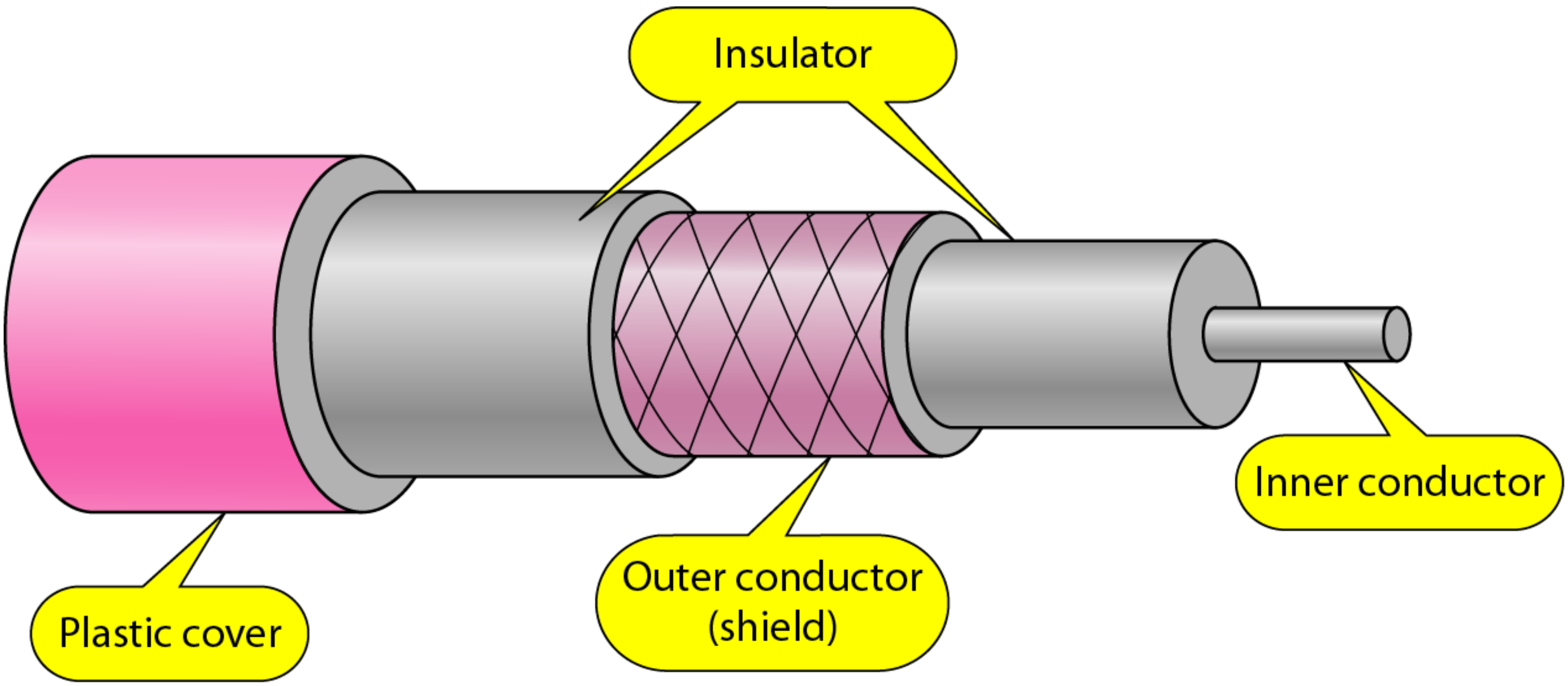


Table 7.2 ***Categories of coaxial cables***

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

Figure 7.8 *BNC connectors*

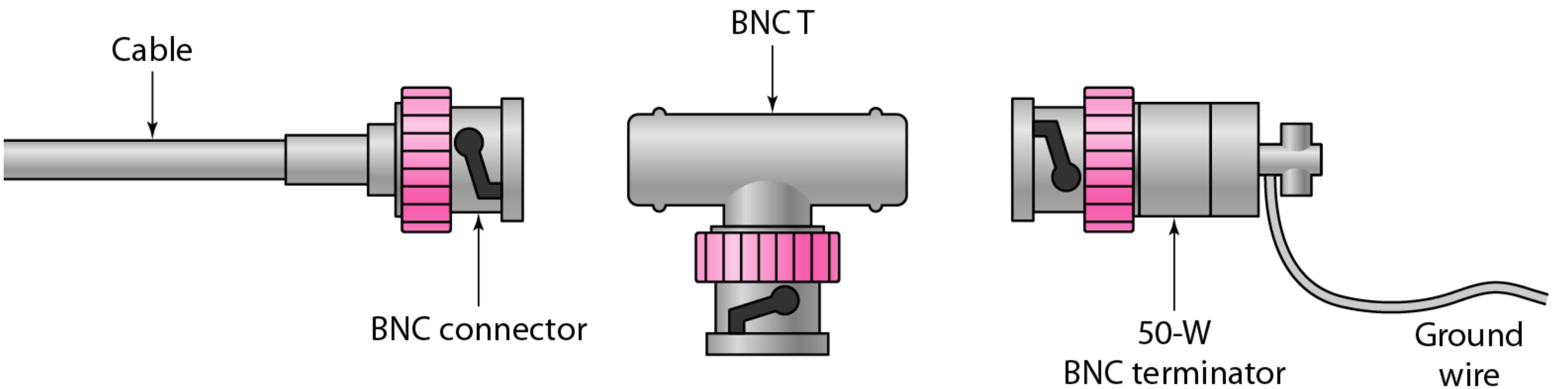


Figure 7.9 *Coaxial cable performance*

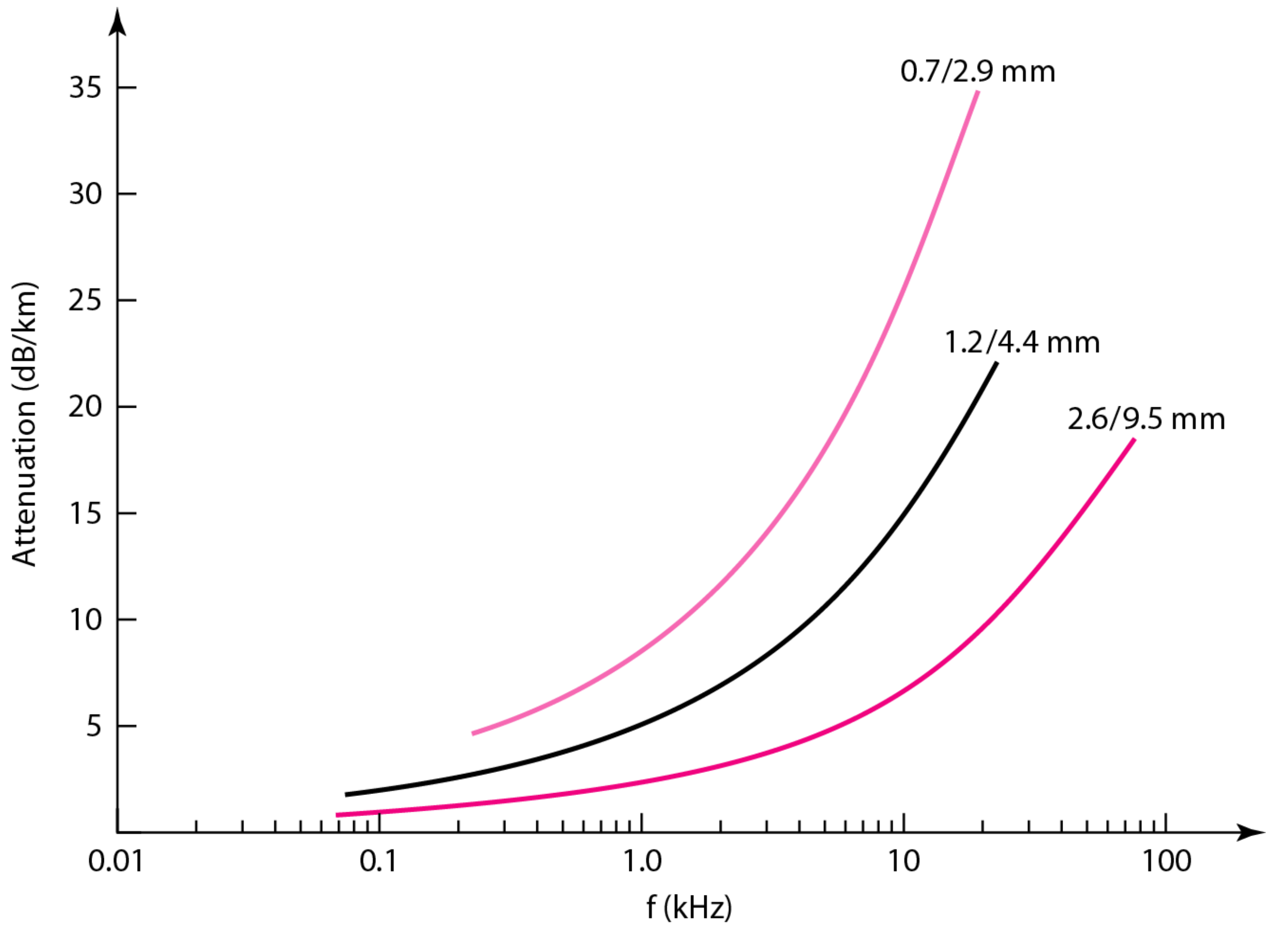


Figure 7.10 Fiber optics: *Bending of light ray*

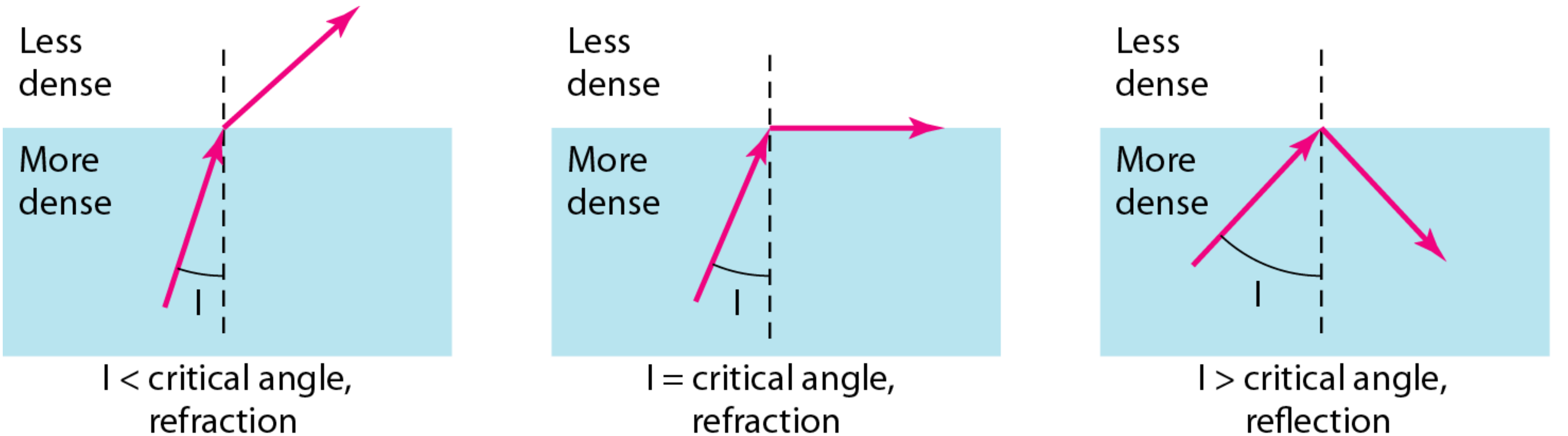


Figure 7.11 ***Optical fiber***

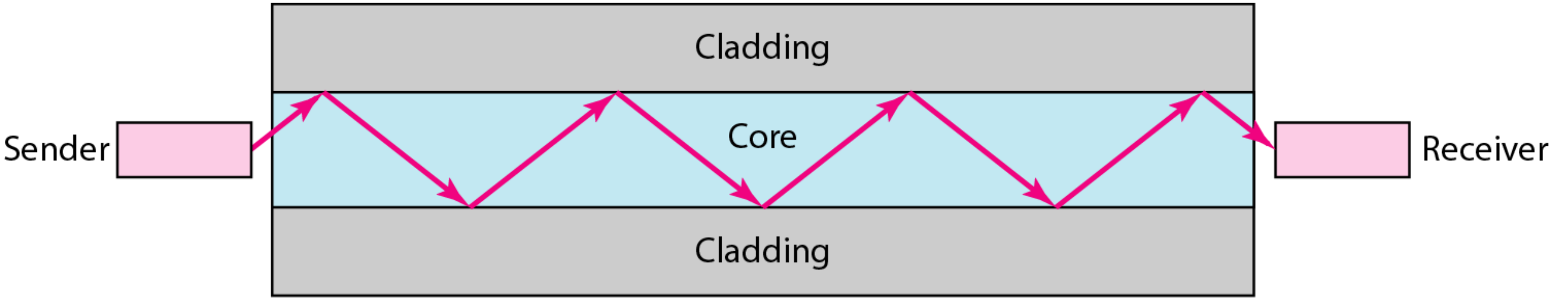


Figure 7.12 *Propagation modes*

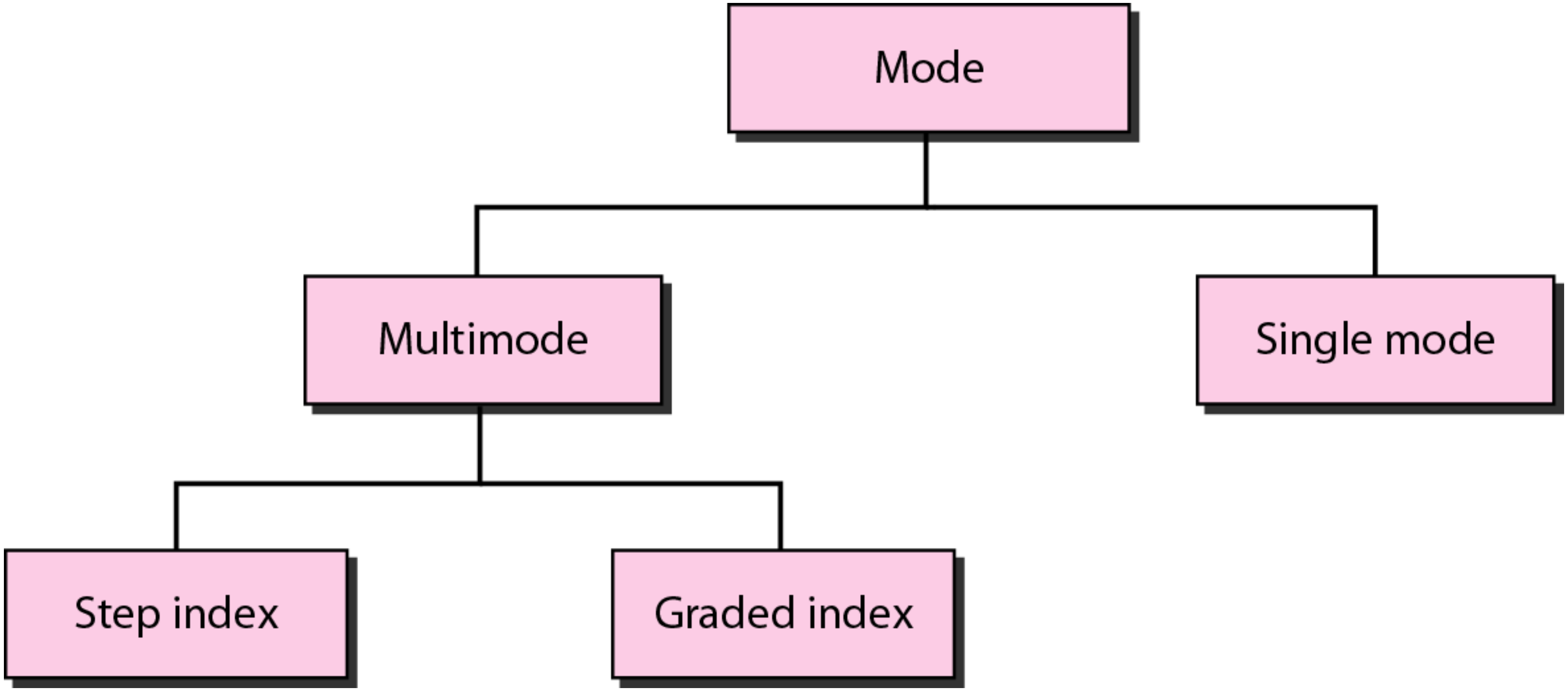
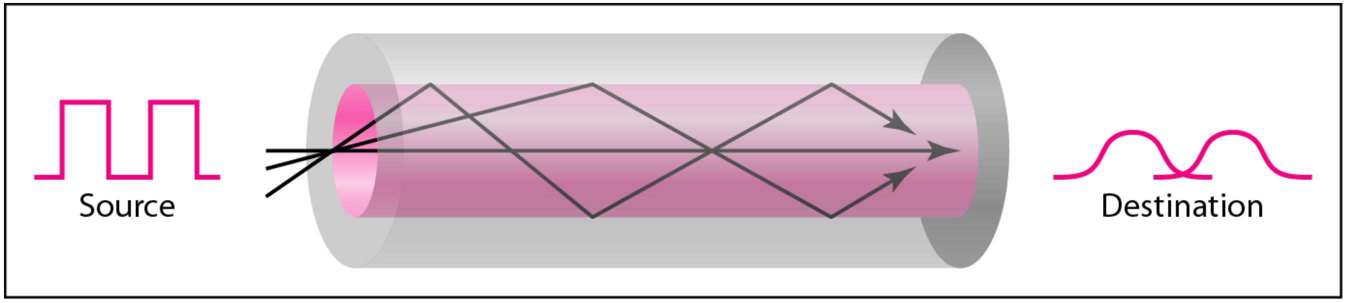
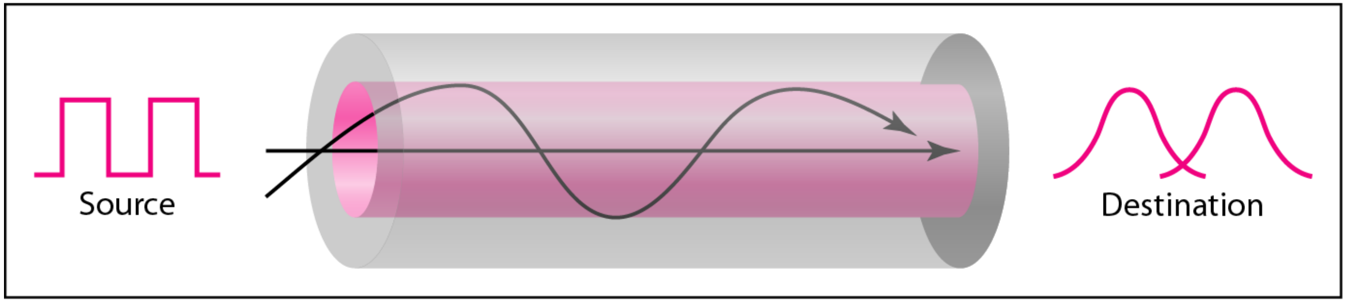


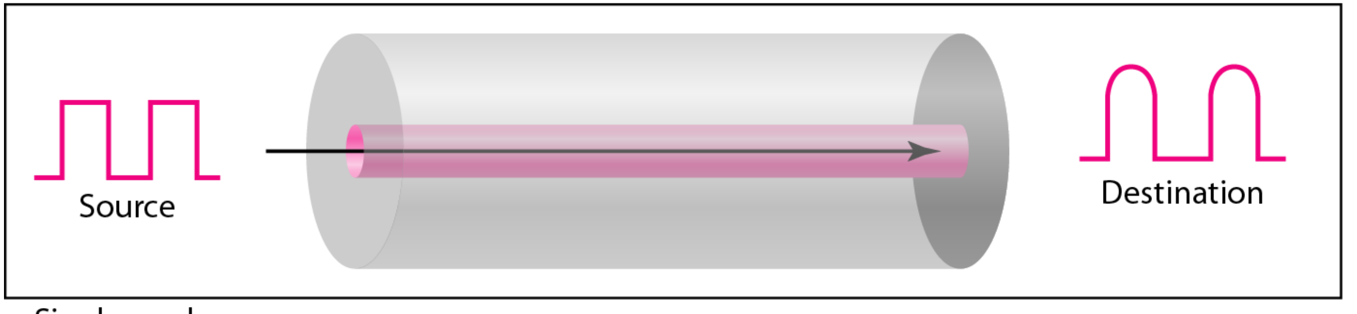
Figure 7.13 *Modes*



a. Multimode, step index



b. Multimode, graded index



c. Single mode

Table 7.3 ***Fiber types***

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

Figure 7.14 ***Fiber construction***

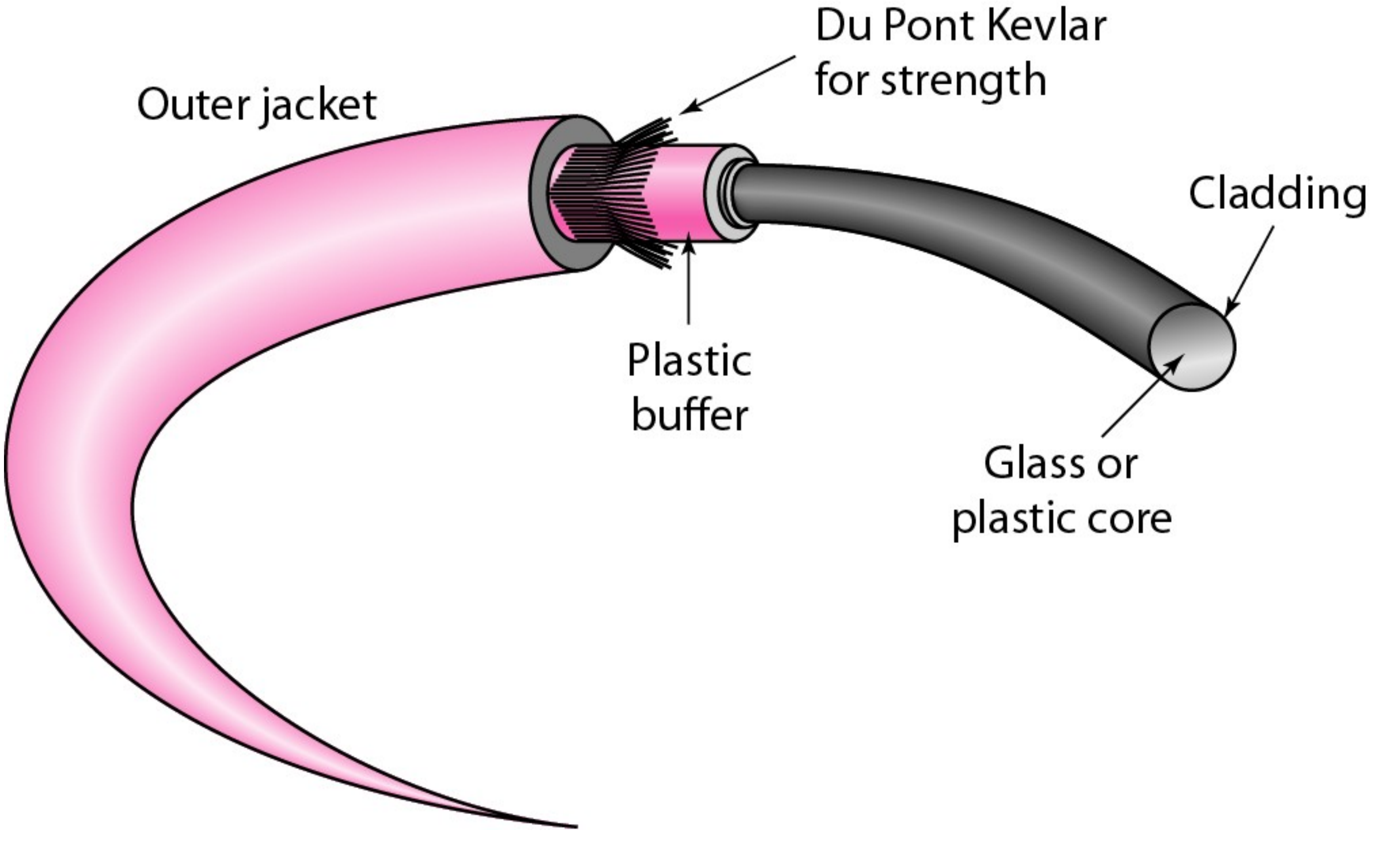


Figure 7.15 ***Fiber-optic cable connectors***

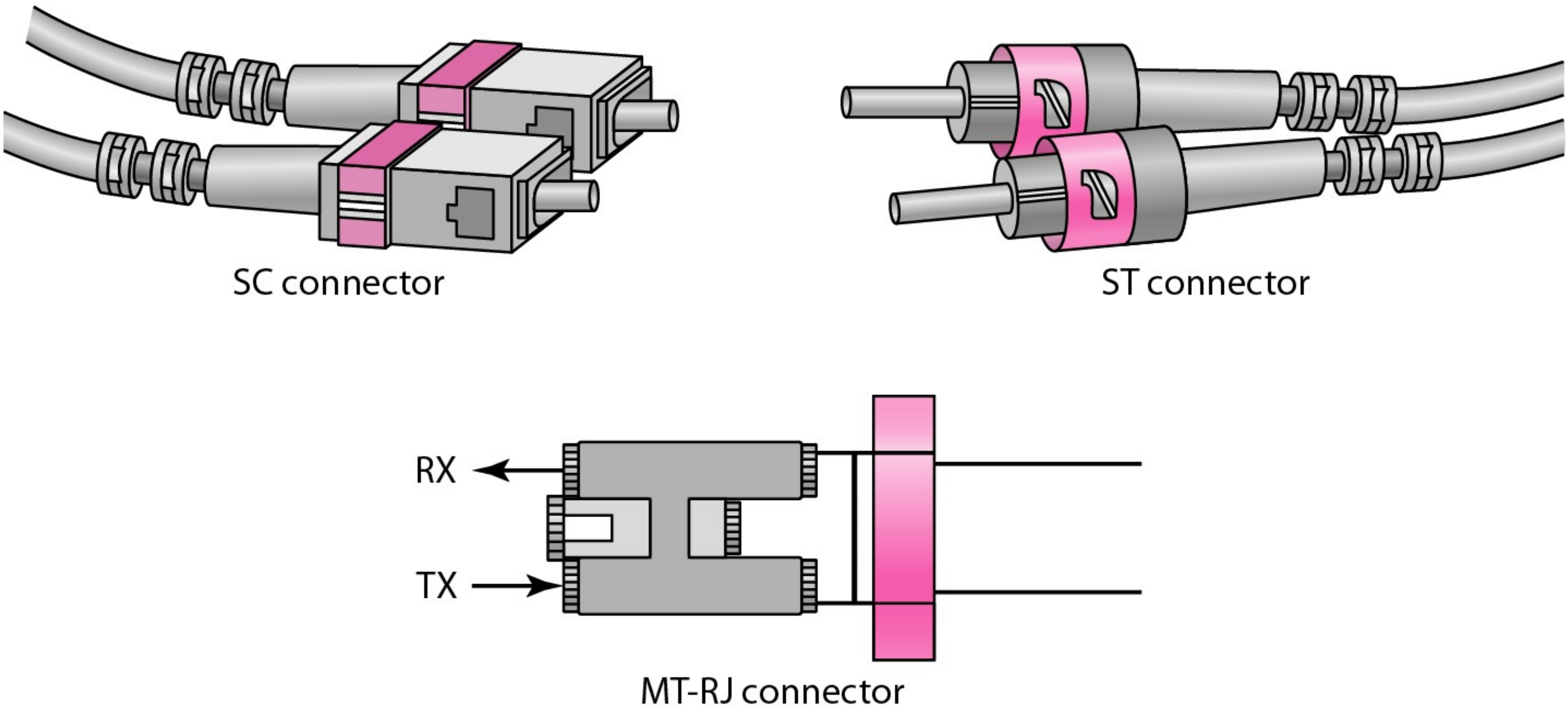
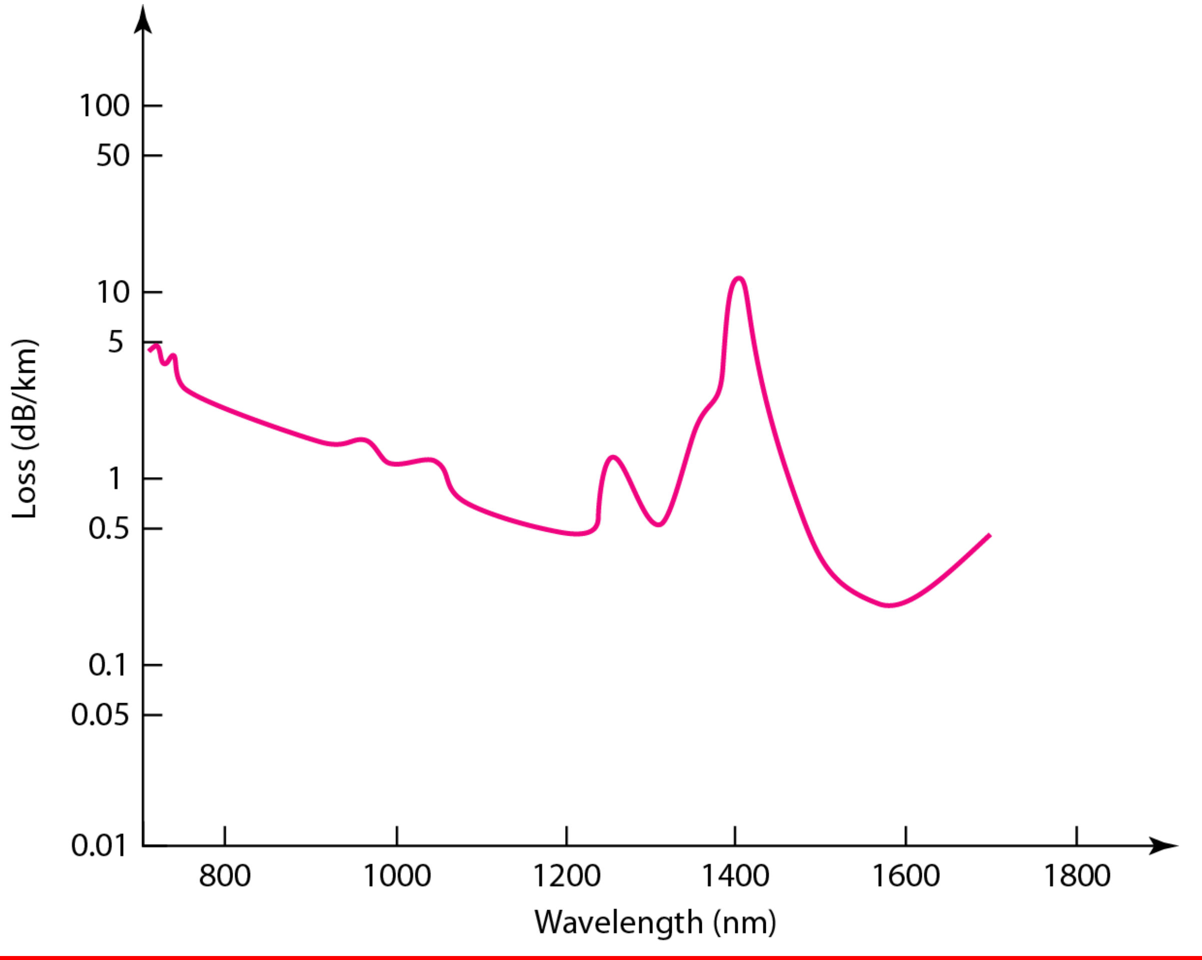


Figure 7.16 *Optical fiber performance*



7-2 UNGUIDED MEDIA: WIRELESS

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

Topics discussed in this section:

Radio Waves
Microwaves
Infrared

Figure 7.17 *Electromagnetic spectrum for wireless communication*

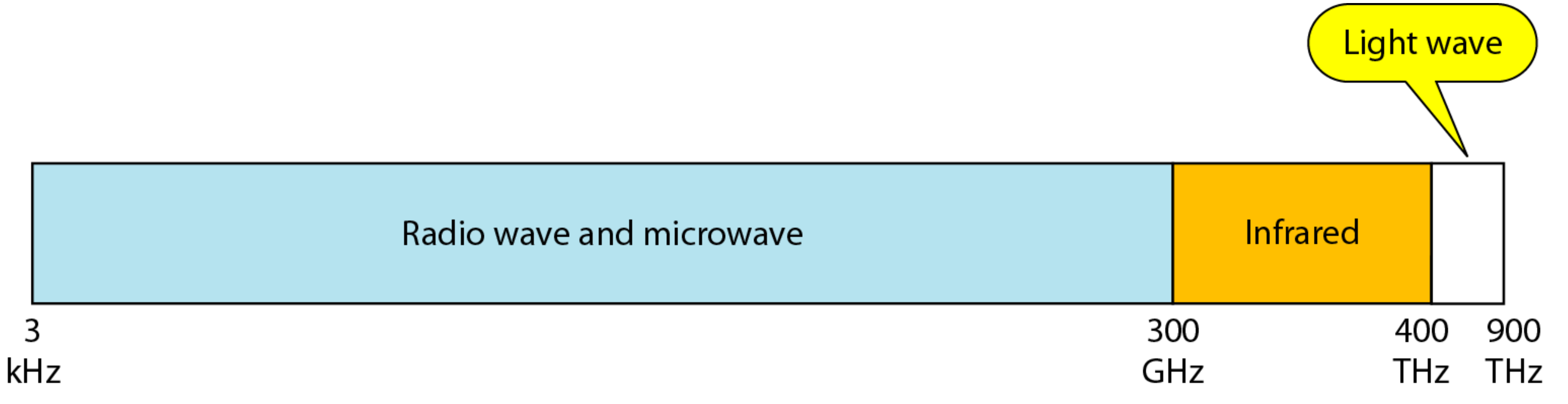


Figure 7.18 *Propagation methods*

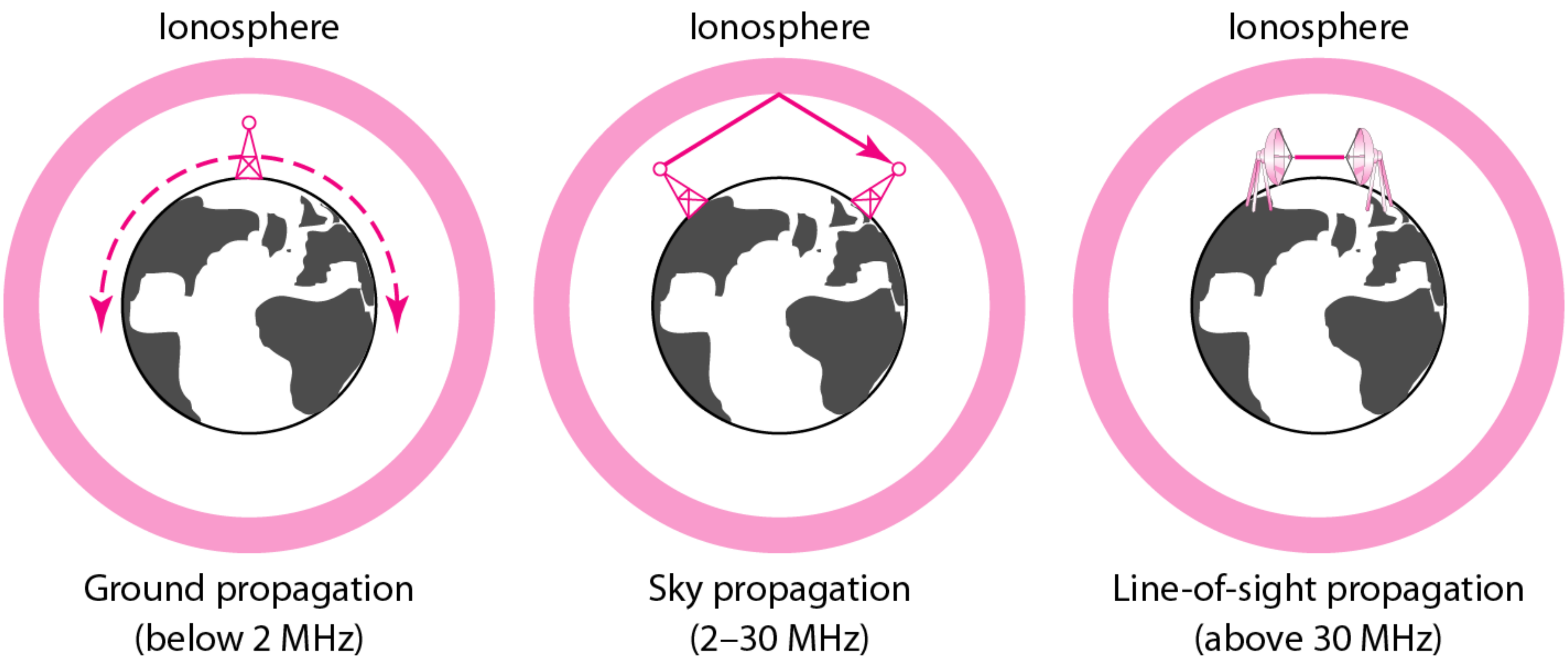
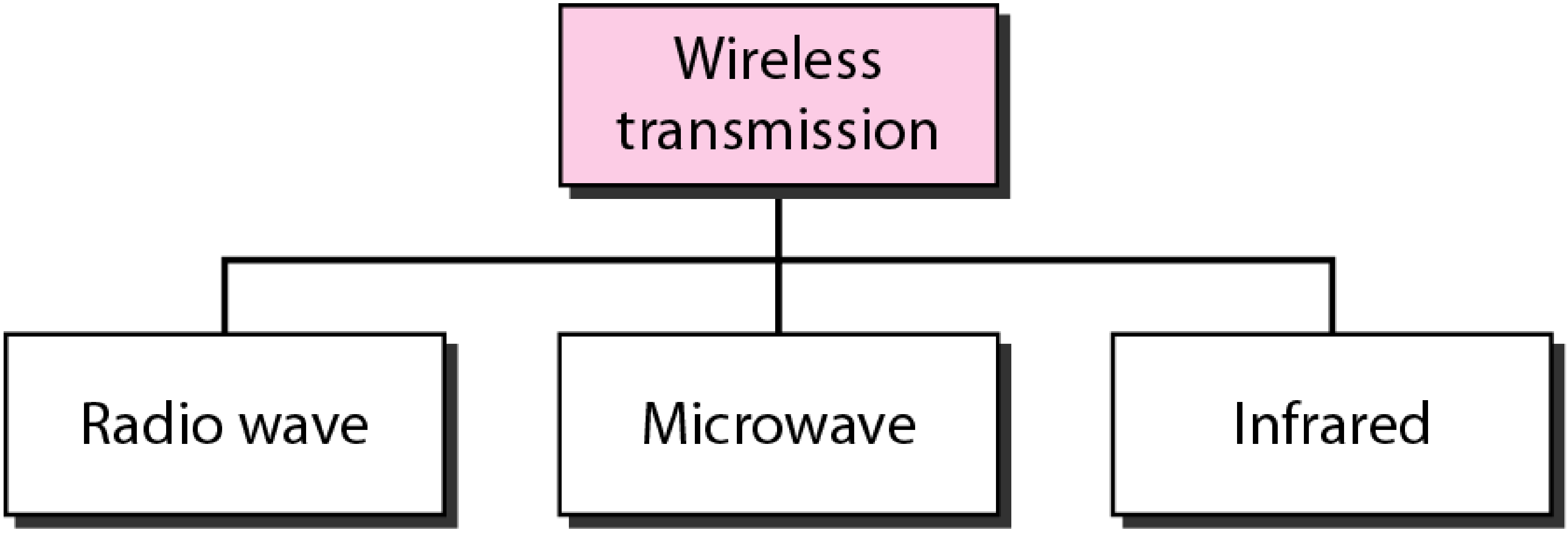


Table 7.4 *Bands*

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

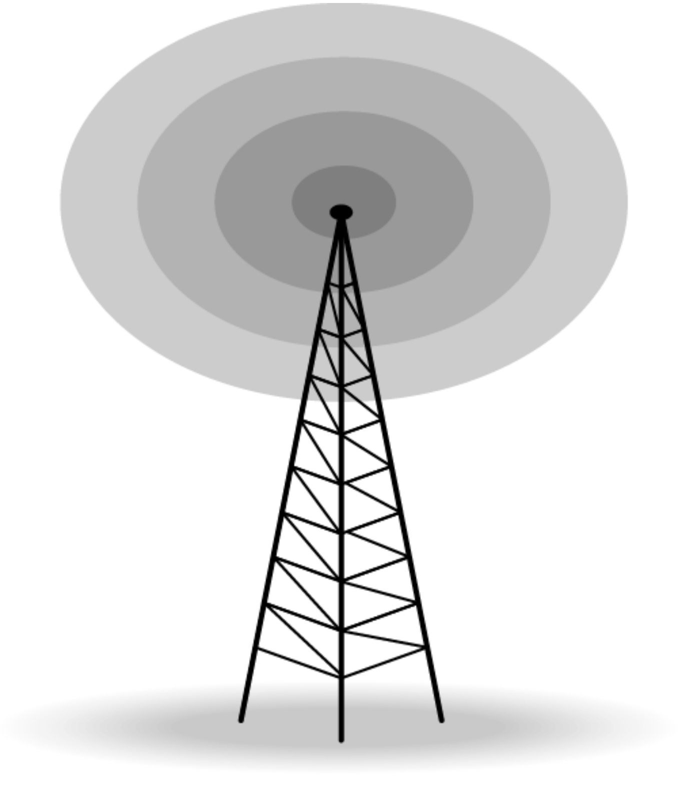
Figure 7.19 ***Wireless transmission waves***



Note

Radio waves are used for multicast communications, such as radio and television, and paging systems. They can penetrate through walls.
Highly regulated. Use omni directional antennas

Figure 7.20 ***Omnidirectional antenna***



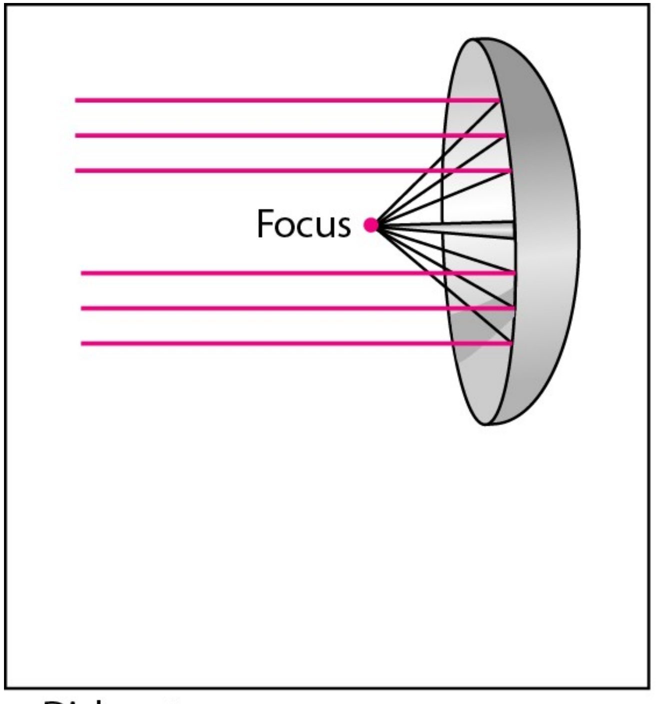
Note

Microwaves are used for unicast communication such as cellular telephones, satellite networks, and wireless LANs.

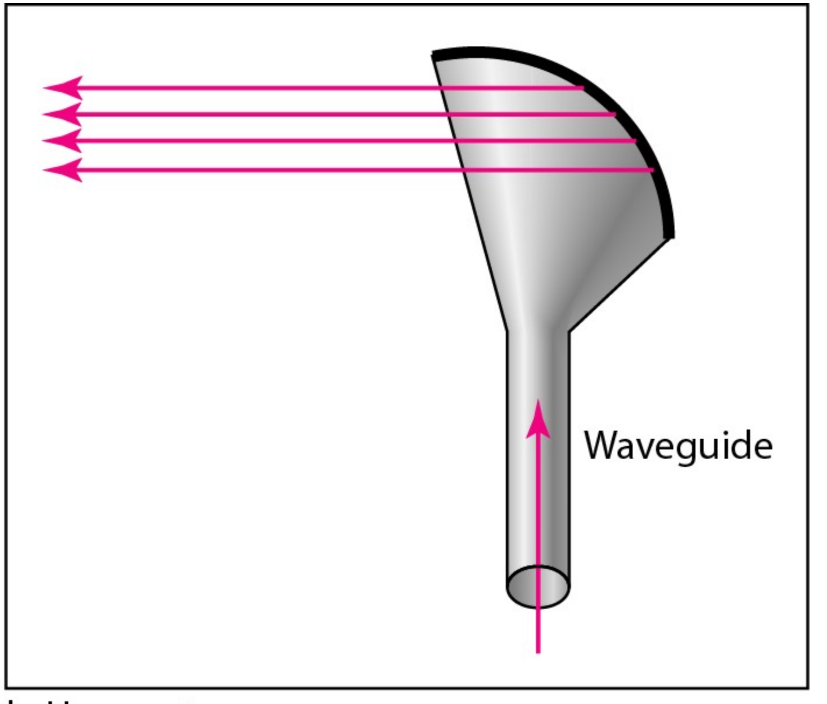
Higher frequency ranges cannot penetrate walls.

Use directional antennas - point to point line of sight communications.

Figure 7.21 *Unidirectional antennas*



a. Dish antenna



b. Horn antenna

Note

Infrared signals can be used for short-range communication in a closed area using line-of-sight propagation.

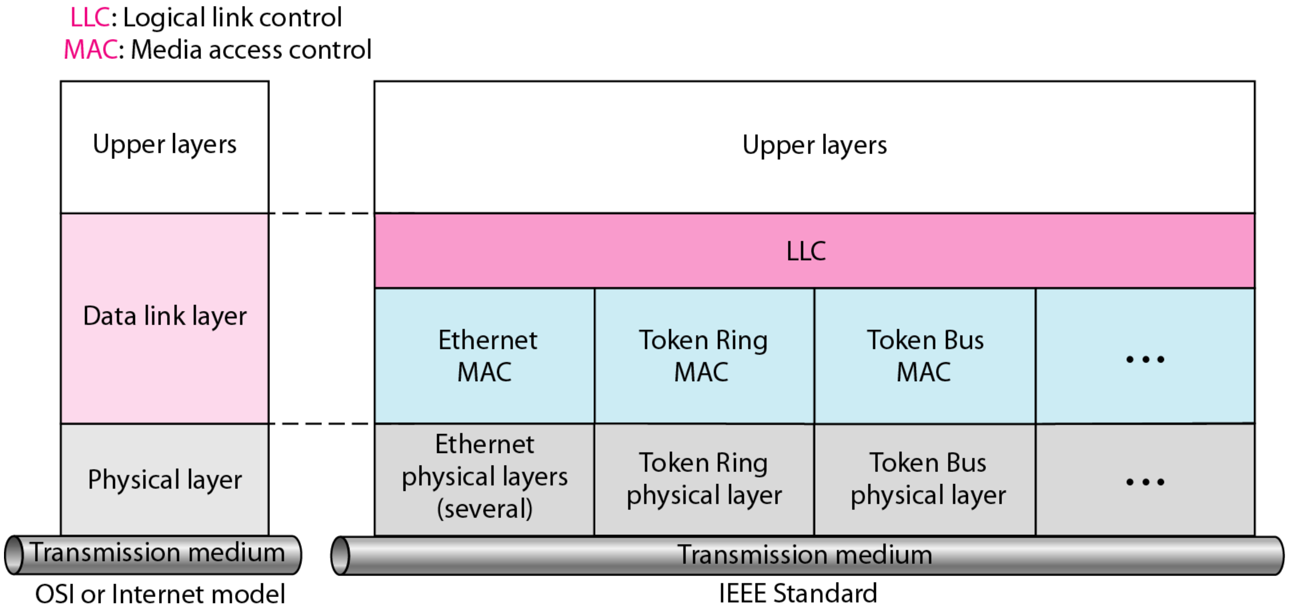
Wireless Channels

- Are subject to a lot more errors than guided media channels.
- Interference is one cause for errors, can be circumvented with high SNR.
- The higher the SNR the less capacity is available for transmission due to the broadcast nature of the channel.
- Channel also subject to fading and no coverage holes.

- BREAK!!!
- Up Next – Ethernet in Depth

IEEE Standards

- In 1985, the Computer Society of the IEEE started a project, called Project 802, to set standards to enable intercommunication among equipment from a variety of manufacturers. Project 802 is a way of specifying functions of the physical layer and the data link layer of major LAN protocols.

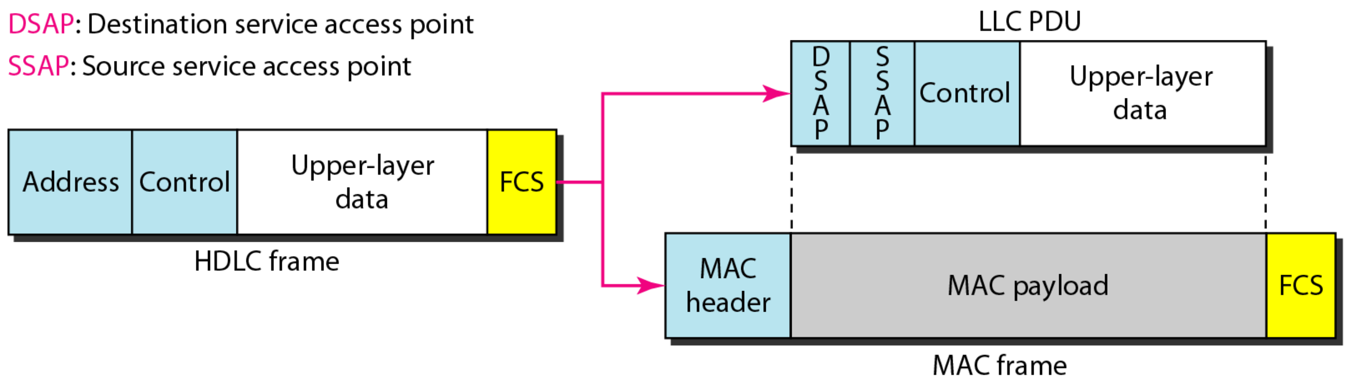


IEEE 802 Working Group

Active working groups	Inactive or disbanded working groups
802.1 Higher Layer LAN Protocols Working Group	802.2 Logical Link Control Working Group
802.3 Ethernet Working Group	802.4 Token Bus Working Group
802.11 Wireless LAN Working Group	802.5 Token Ring Working Group
802.15 Wireless Personal Area Network (WPAN) Working Group	802.7 Broadband Area Network Working Group
802.16 Broadband Wireless Access Working Group	802.8 Fiber Optic TAG
802.17 Resilient Packet Ring Working Group	802.9 Integrated Service LAN Working Group
802.18 Radio Regulatory TAG	802.10 Security Working Group
802.19 Coexistence TAG	802.12 Demand Priority Working Group
802.20 Mobile Broadband Wireless Access (MBWA) Working Group	802.14 Cable Modem Working Group
802.21 Media Independent Handoff Working Group	
802.22 Wireless Regional Area Networks	

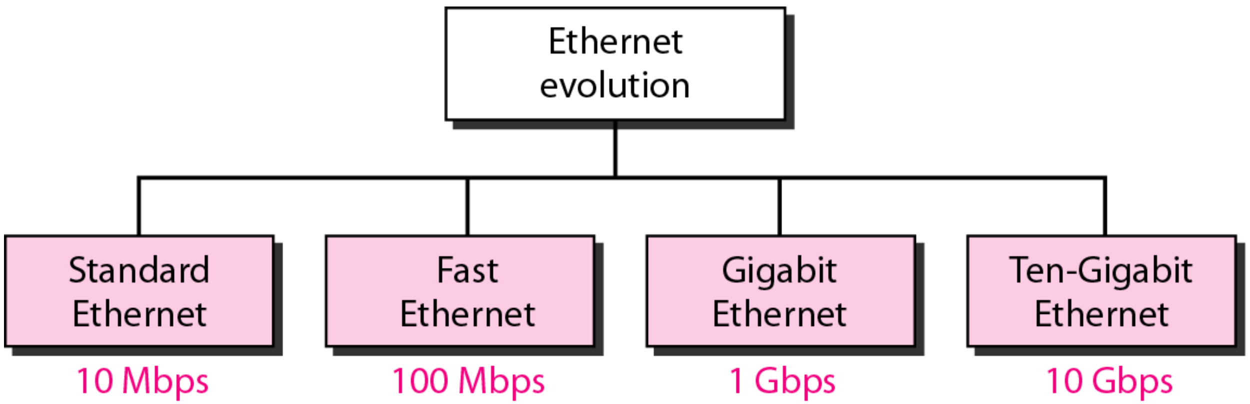
Logical Link Control (LLC)

- Framing: LLC defines a protocol data unit (PDU) that is similar to that of HDLC
- To provide flow and error control for the upper-layer protocols that actually demand these services



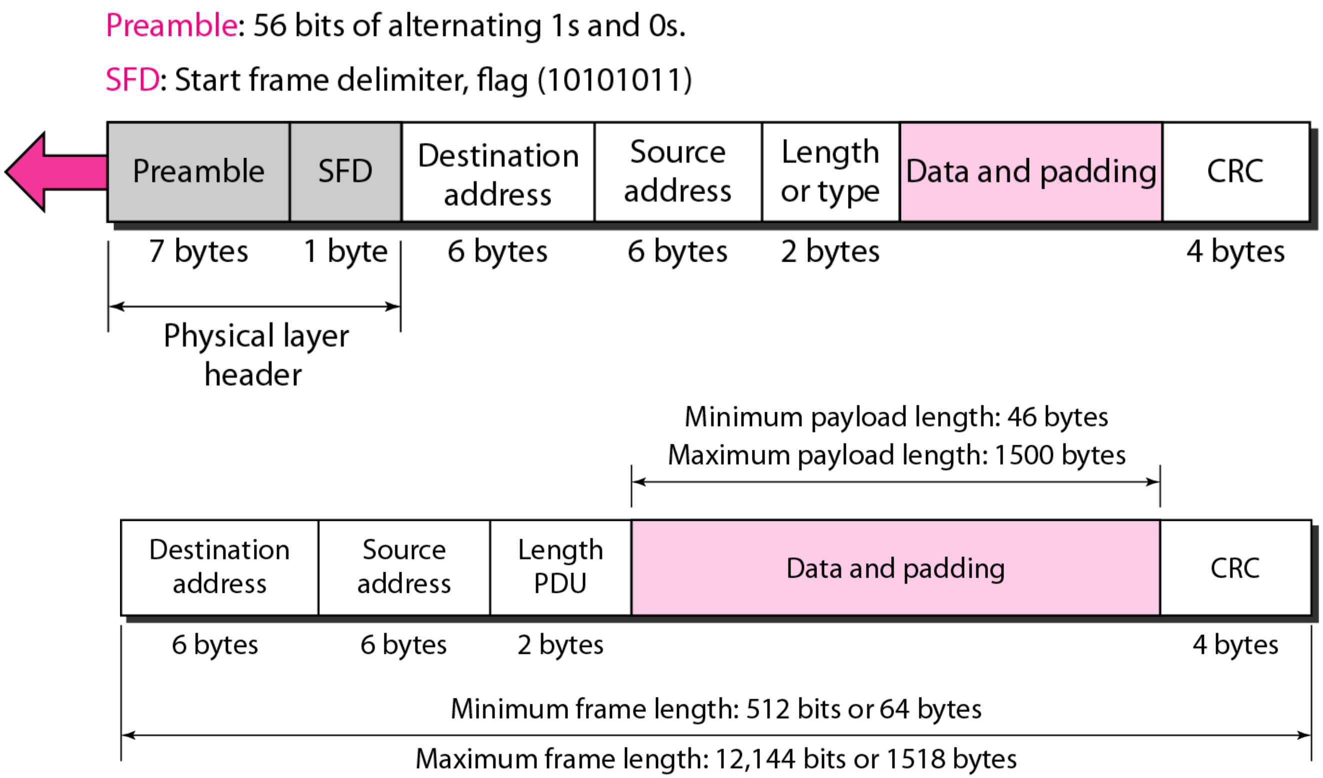
Standard Ethernet

- The original Ethernet was created in 1976 at Xerox's Palo Alto Research Center (PARC). Since then, it has gone through four generations



MAC Sublayer

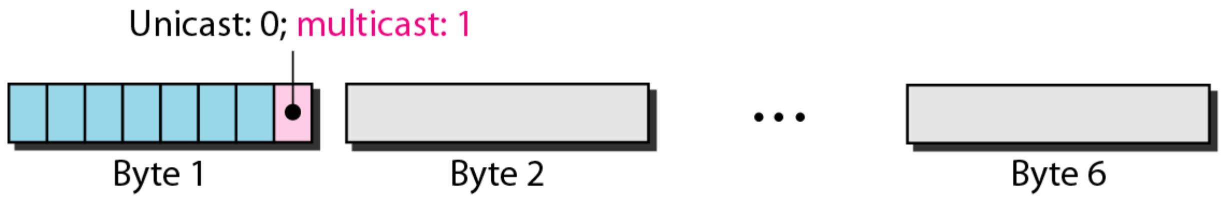
- Preamble: alerting the receiving system to the coming frame and enabling it to synchronize its input timing
- CRC: CRC-32



Addressing

- Ethernet address in hexadecimal notation

- The least significant bit of the first byte defines the type of address.
  If the bit is 0, the address is unicast; otherwise, it is multicast
- The broadcast destination address is a special case of the multicast address in which all bits are 1s



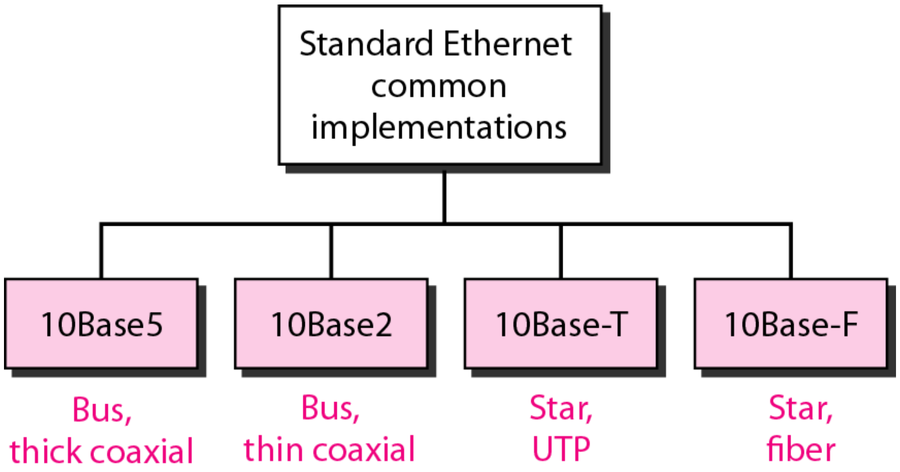
Ethernet

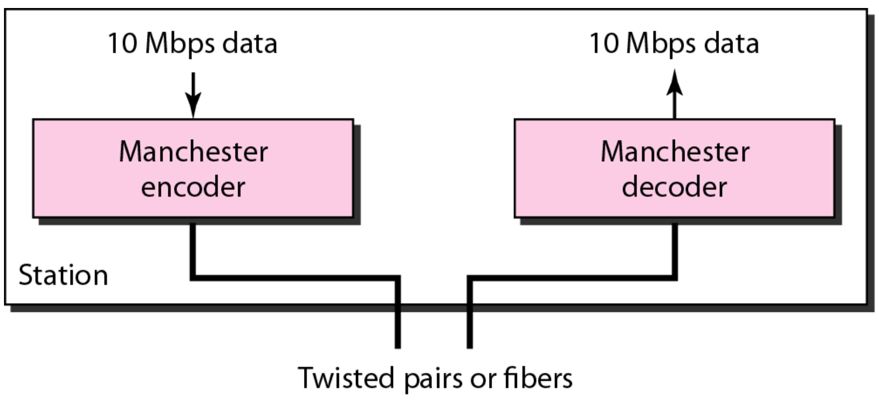
- Access method: 1-persistent CSMA/CD
- Slot time = rount-trip time + time required to send the jam sequence
  - 512 bits for Ethernet, 51.2 ***μ**s* for 10 Mbps Ethernet

- **Slot time and collision**

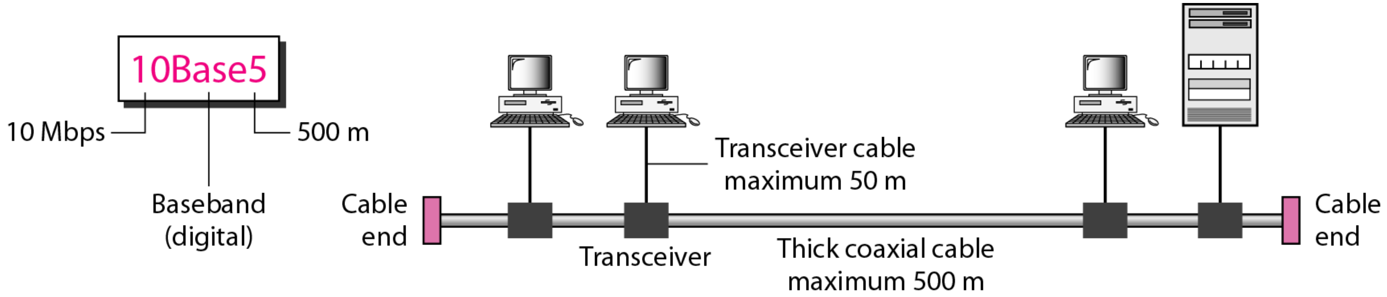
- Slot time and maximum network length
  - MaxLength = PropagationSpeed x SlotTime/2
  - MaxLength = $(2 \times 10^8) \times (51.2 \times 10^{-6}/2)$ = 5120 m
  - MaxLength = 2500 m 48 % of the theoretical calculation by considering delay times in repeaters and interfaces, and the time required to send the jam sequence

Physical Layer: Ethernet

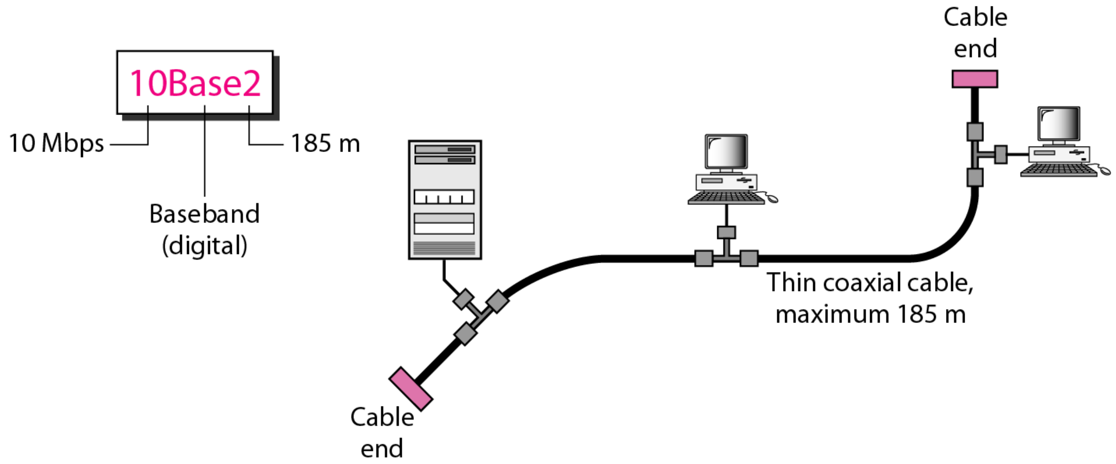




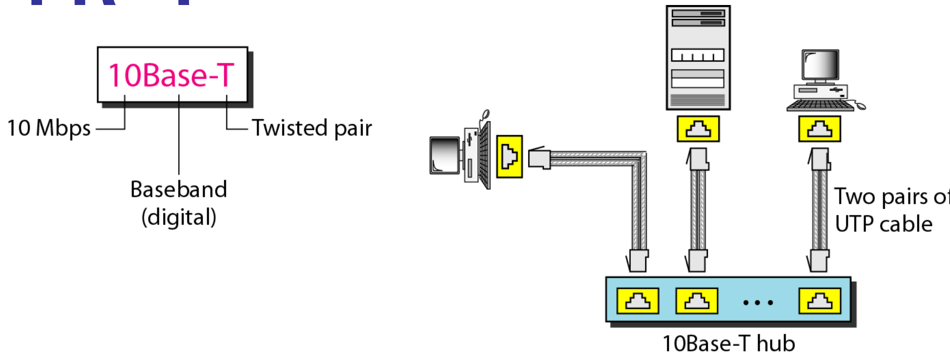
10Base5: Thick Ethernet



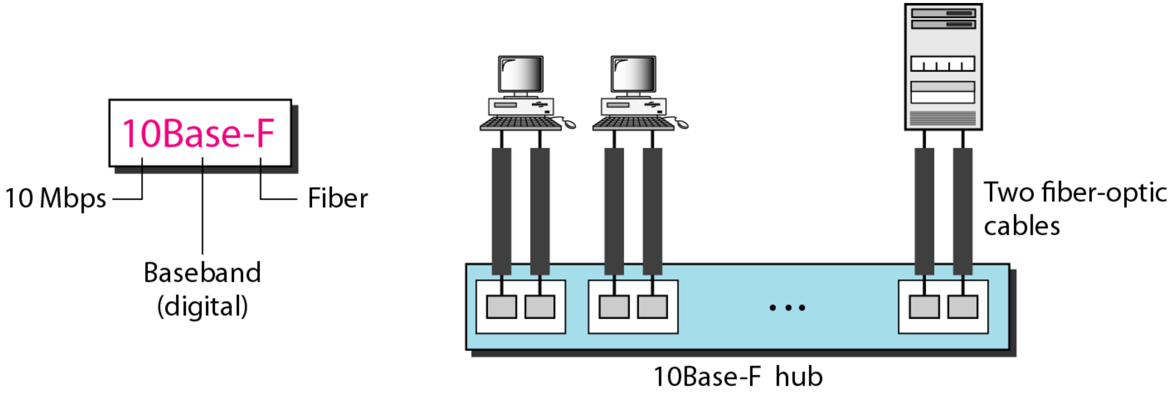
10Base2: Thin Ethernet



10BaseT: Twisted-Pair Ethernet



10Base-F: Fiber Ethernet

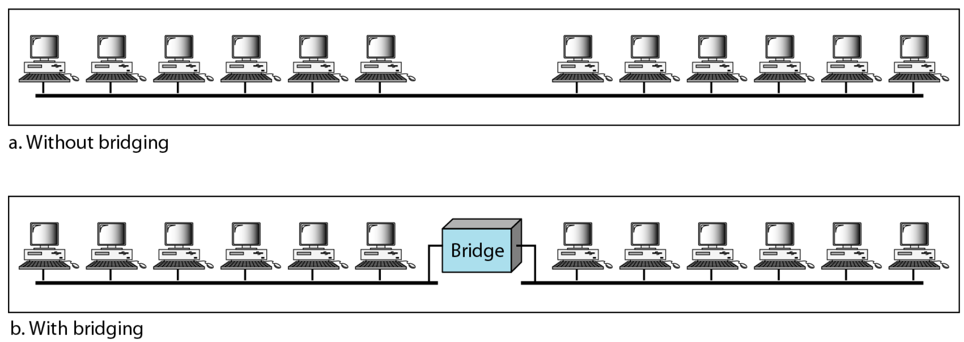


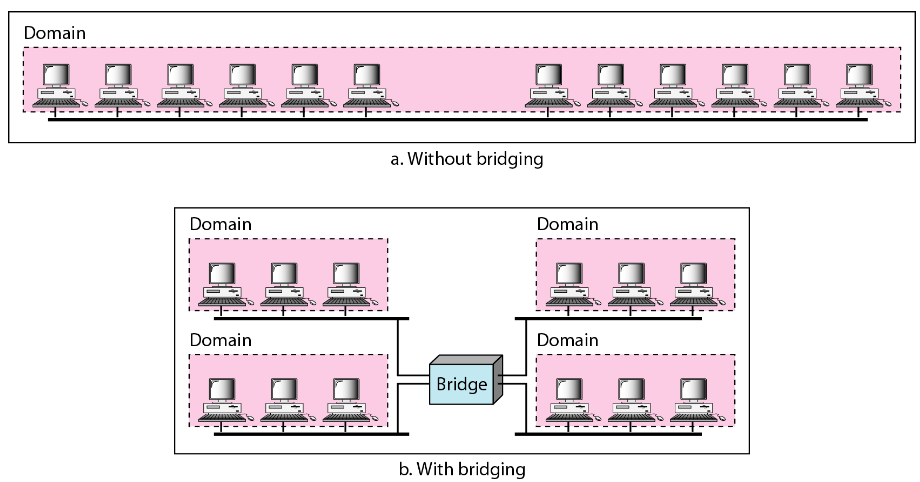
Summary of Standard Ethernet

Characteristics	*10Base5*	*10Base2*	*10Base-T*	*10Base-F*
Media	Thick coaxial cable	Thin coaxial cable	2 UTP	2 Fiber
Maximum length	500 m	185 m	100 m	2000 m
Line encoding	Manchester	Manchester	Manchester	Manchester

Changes in the Standard

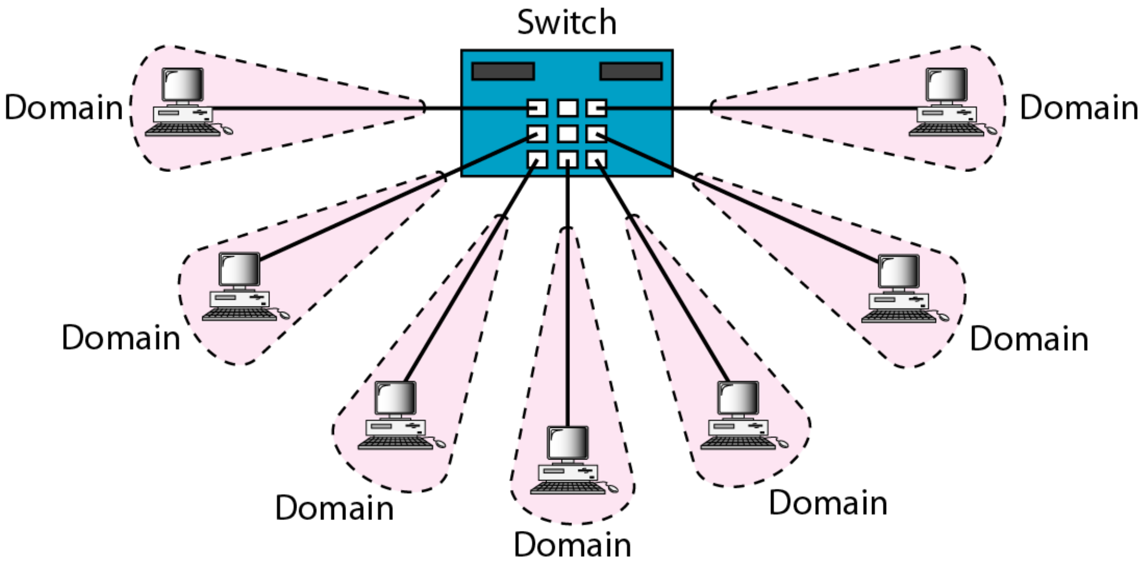
- Bridged Ethernet: Raising bandwidth and separating collision domains





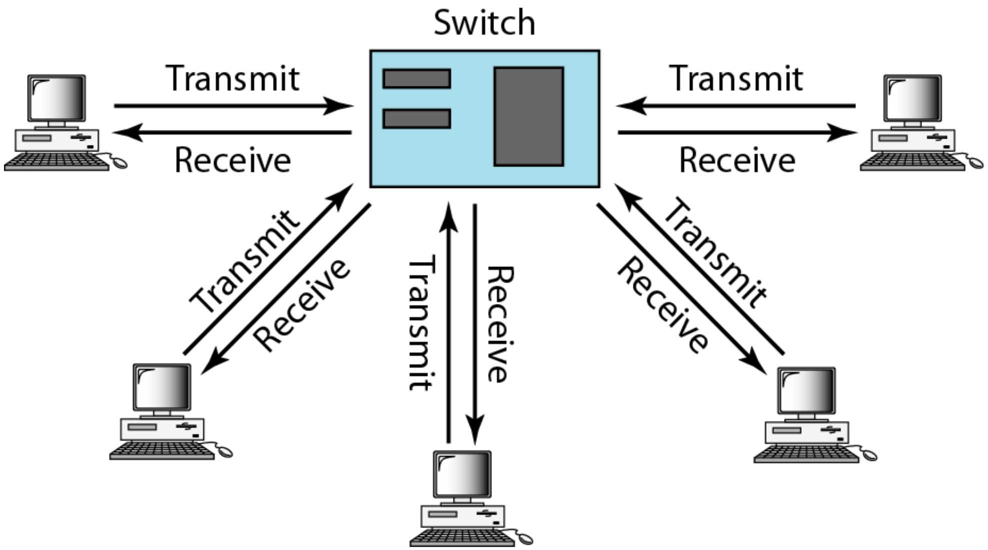
Changes in the Standard

- Switched Ethernet: N-port bridge



Changes in the Standard

- Full-duplex (switched) Ethernet: no need for CSMA/CD



Fast Ethernet

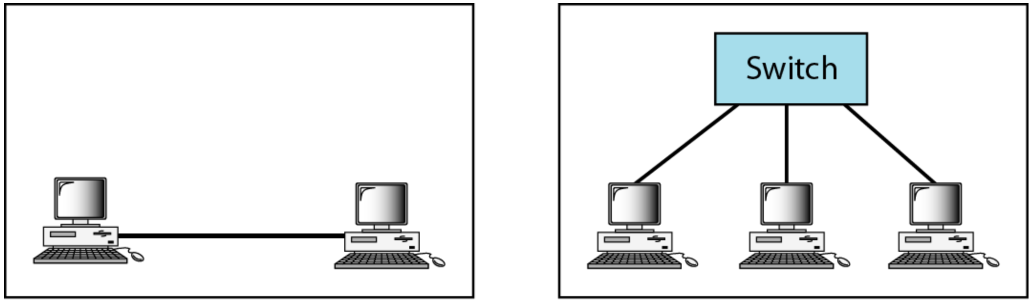
- Under the name of IEEE 802.3u
  - Upgrade the data rate to 100 Mbps
  - Make it compatible with Standard Ethernet
  - Keep the same 48-bit address and the same frame format
  - Keep the same min. and max. frame length

- MAC Sublayer
  - CSMA/CD for the half-duplex approach
  - No need for CSMA/CD for full-duplex Fast Ethernet

- Autonegotiation: allow two devices to negotiate the mode or data rate of operation

Fast Ethernet: Physical Layer

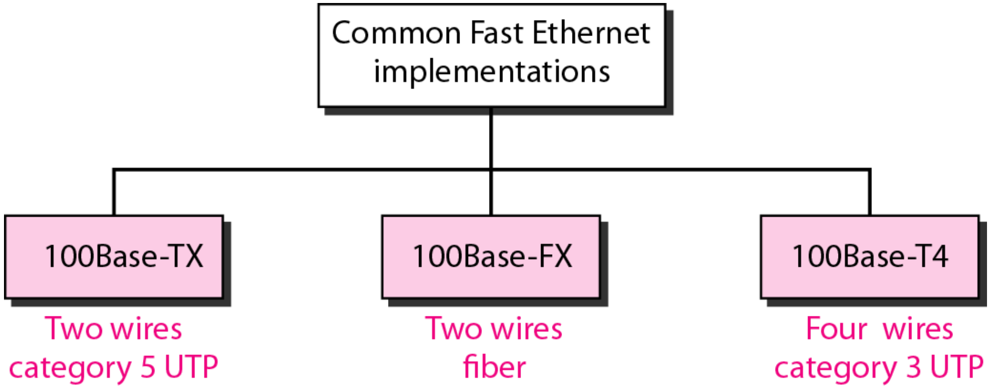
- Topology



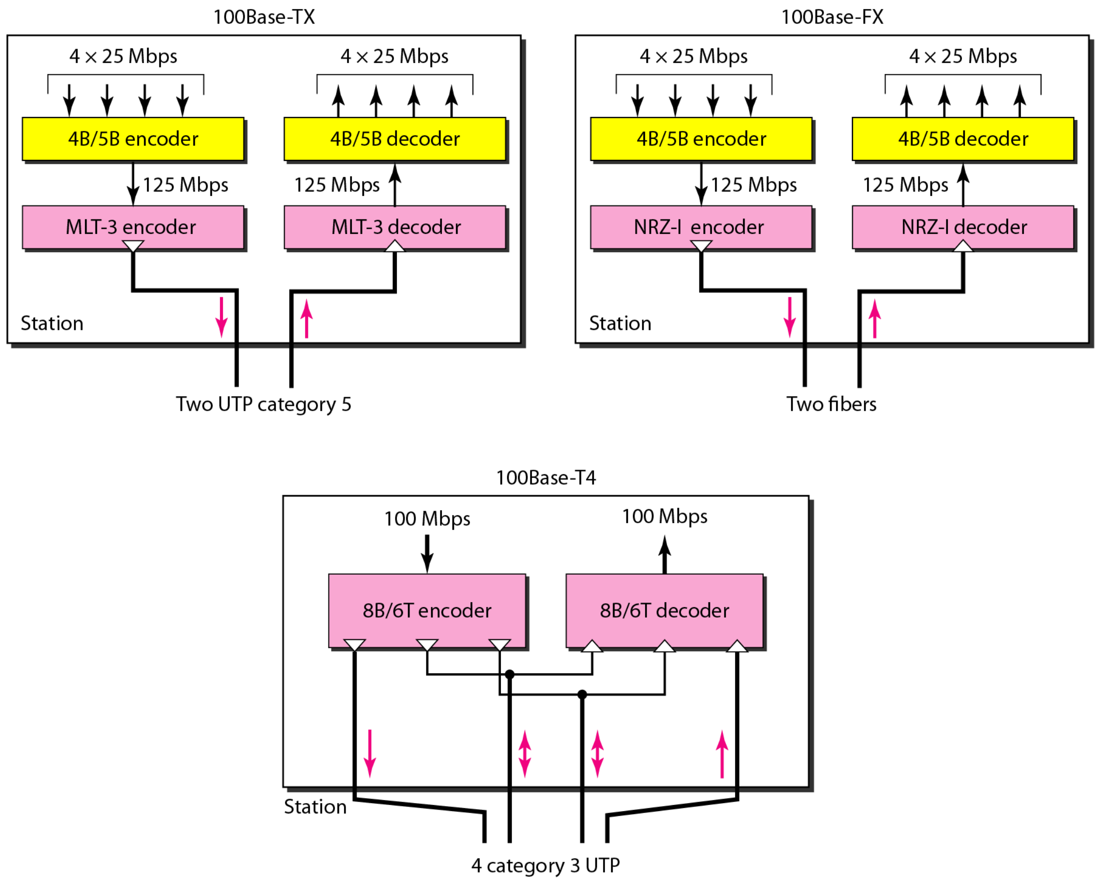
a. Point-to-point

b. Star

- Implementation



Fast Ethernet: Encoding



Summary of Fast Ethernet

Characteristics	*100Base-TX*	*100Base-FX*	*100Base-T4*
Media	Cat 5 UTP or STP	Fiber	Cat 4 UTP
Number of wires	2	2	4
Maximum length	100 m	100 m	100 m
Block encoding	4B/5B	4B/5B	
Line encoding	MLT-3	NRZ-I	8B/6T

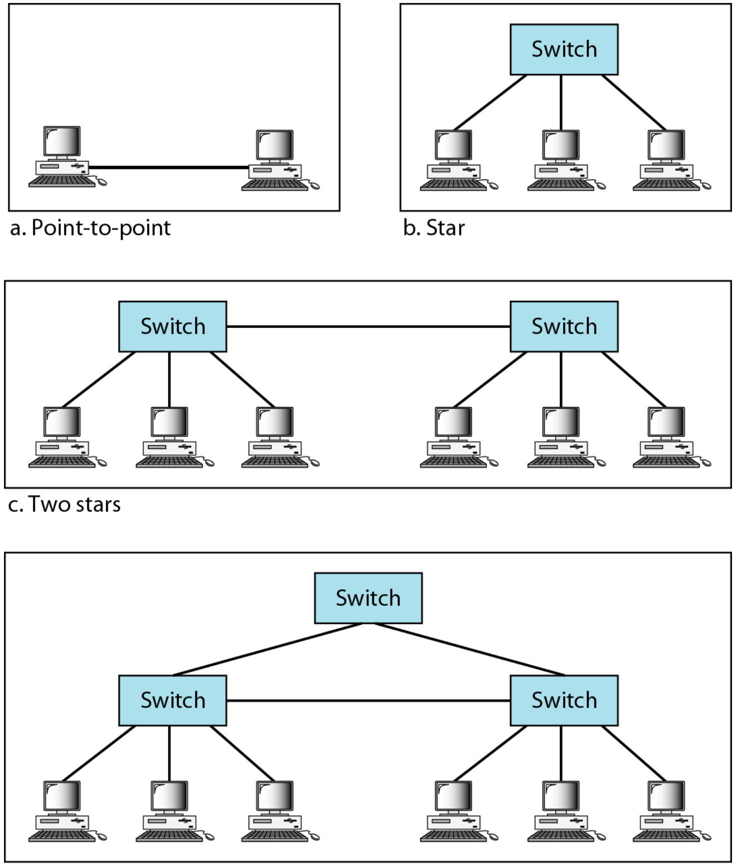
Gigabit Ethernet

- Under the name of IEEE 802.3z
  - Upgrade the data rate to 1 Gbps
  - Make it compatible with Standard or Fast Ethernet
  - Keep the same 48-bit address and the same frame format
  - Keep the same min. and max. frame length
  - Support autonegotiation as defined in Fast Ethernet

- MAC Sublayer
  - Most of all implmentations follows full-duplex approach
  - In the full-duplex mode of Gigabit Ethernet, there is no collision; the maximum length of the cable is determined by the signal attenuation in the cable.
- Half-duplex mode (very rare)
  - Traditional: 0.512 μs (25m)
  - Carrier Extension: 512 bytes (4096 bits) min. length
  - Frame bursting to improve the inefficiency of carrier extension

Gigabit Ethernet: Physical Layer

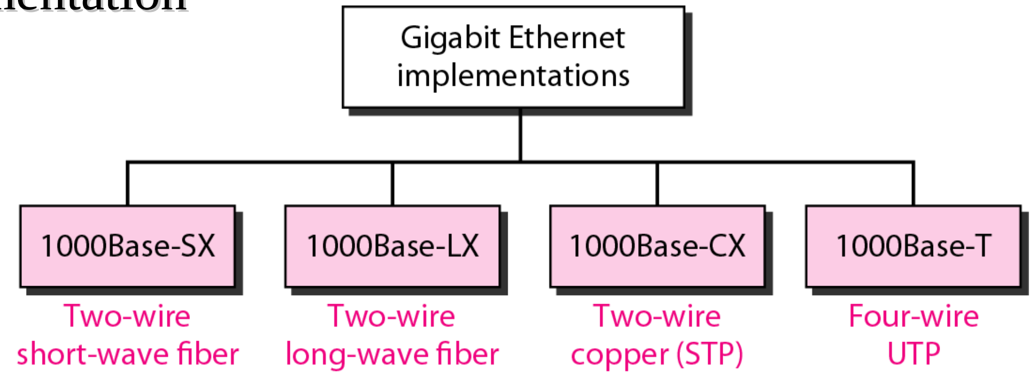
- Topology



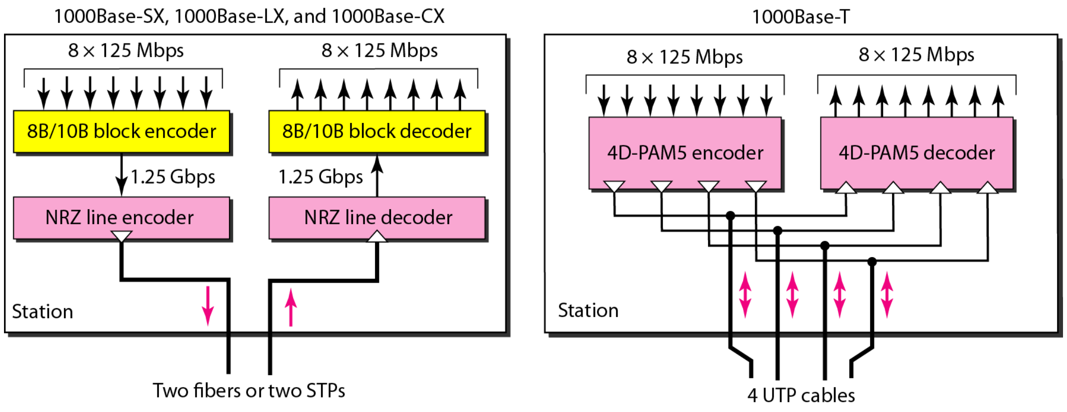
a. Point-to-point
b. Star
c. Two stars
d. Hierarchy of stars

Gigabit Ethernet: Physical Layer

- Implementation



- Encoding



Gigabit Ethernet: Summary

Characteristics	*1000Base-SX*	*1000Base-LX*	*1000Base-CX*	*1000Base-T*
Media	Fiber short-wave	Fiber long-wave	STP	Cat 5 UTP
Number of wires	2	2	2	4
Maximum length	550 m	5000 m	25 m	100 m
Block encoding	8B/10B	8B/10B	8B/10B	
Line encoding	NRZ	NRZ	NRZ	4D-PAM5

Ten-Gigabit Ethernet

- Under the name of IEEE 802.3ae
  - Upgrade the data rate to 10 Gbps
  - Make it compatible with Standard, Fast, and Giga Ethernet
  - Keep the same 48-bit address and the same frame format
  - Keep the same min. and max. frame length
  - Allow the interconnection of existing LANs into a MAN or WAN
  - Make Ethernet compatible with Frame Relay and ATM

- MAC Sublayer: Only in full-duplex mode → no CSMA/CD

Characteristics	*10GBase-S*	*10GBase-L*	*10GBase-E*
Media	Short-wave 850-nm multimode	Long-wave 1310-nm single mode	Extended 1550-mm single mode
Maximum length	300 m	10 km	40 km