

Chapter 02

Physical Layer

- Data Communications and Networking, With TCP/IP protocol suite Sixth Edition
- Behrouz A. Forouzan

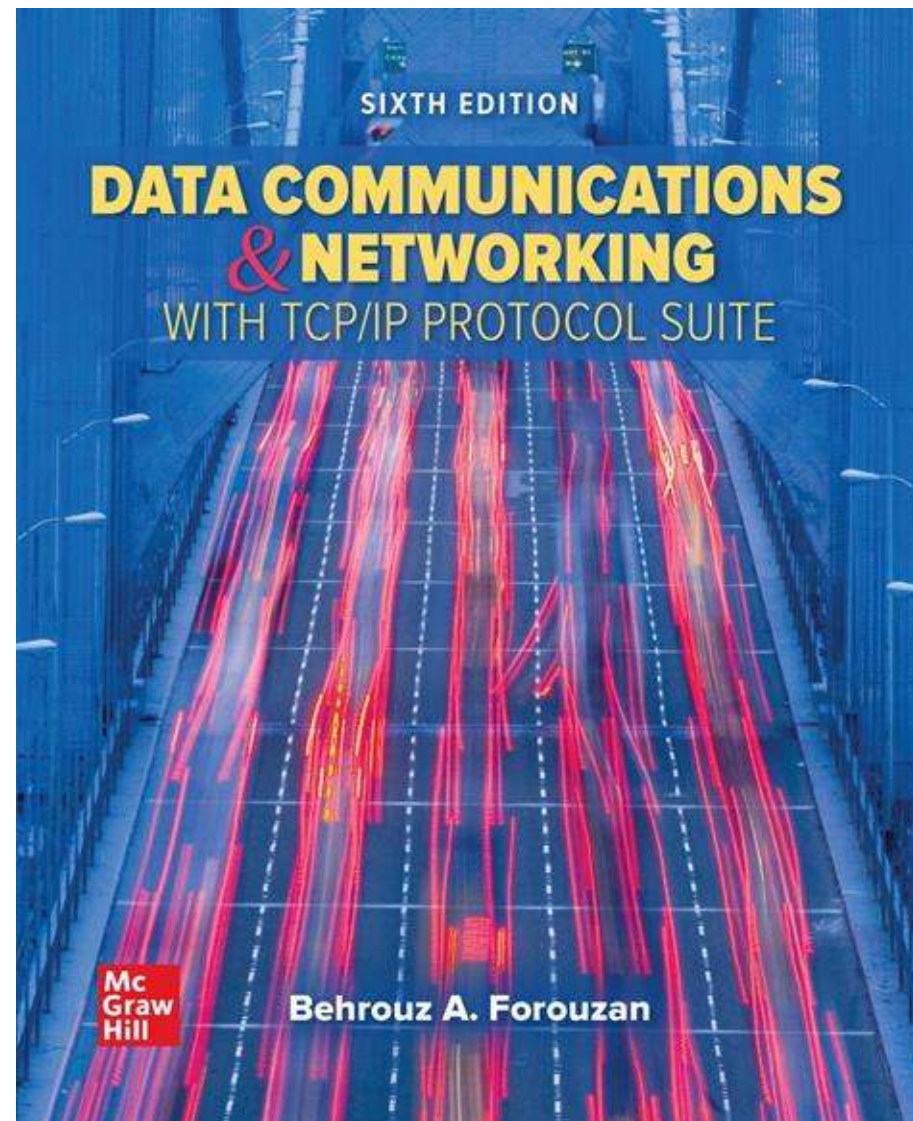


Figure 7.1 *Transmission medium and physical layer*

- **Transmission medium(channel)**: the physical path between the transmitter and the receiver. *very fast*
- Located below the physical layer
- Controlled by the physical layer

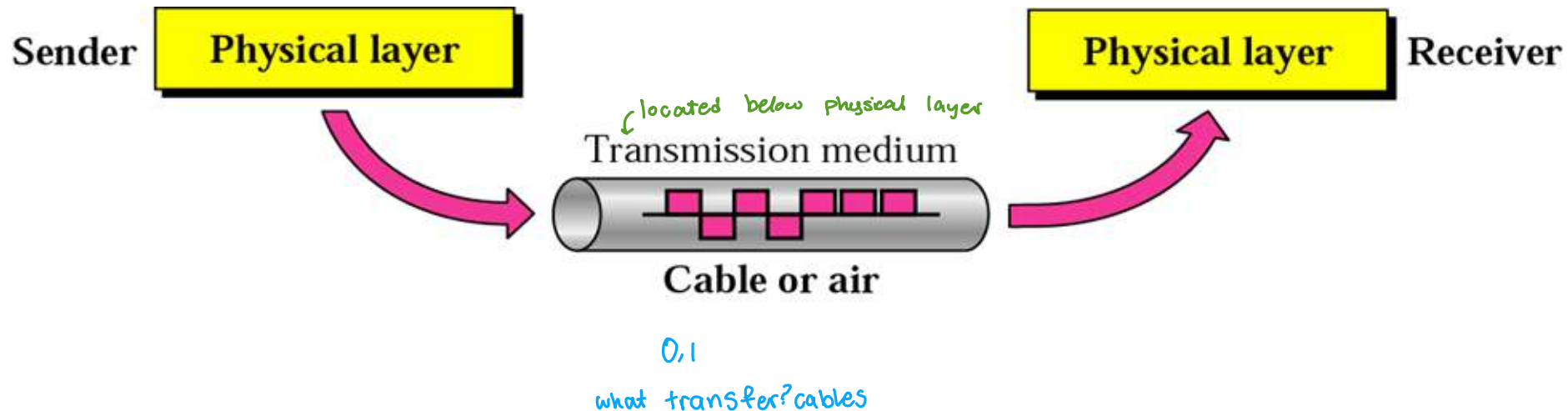
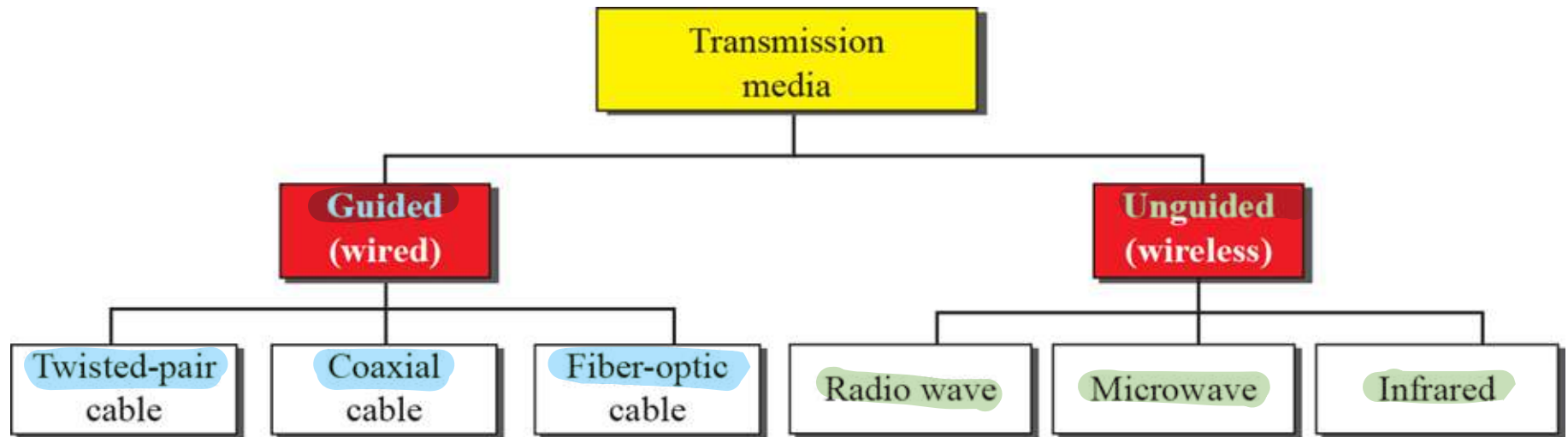


Figure 7.2: Classes of transmission media



7.1 Guided Media

Twisted-Pair Cable

Coaxial Cable

Fiber-Optic Cable

Twisted pairs

8 wires
4 pairs

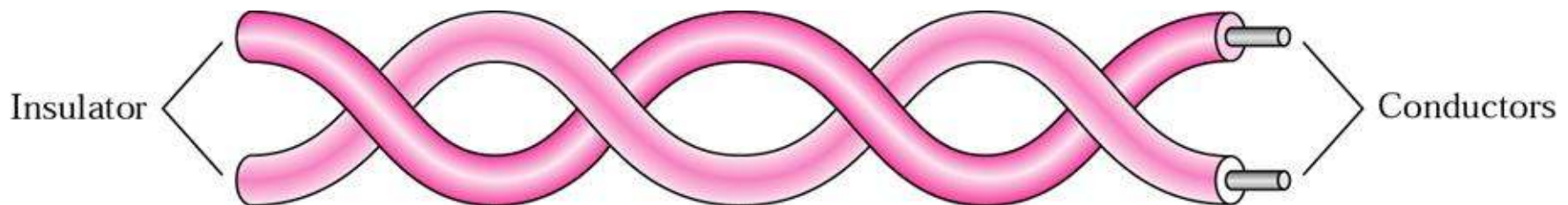
- pure color
- white mixed w/ color



Figure 7.3 *Twisted-pair cable*

copper wire: conductor
insulator: plastic

- A **twisted pair** consists of: two insulated **copper wires** in a regular **spiral pattern**
- A **wire pair** acts as a **single communication link**
- Twisted to **reduce electrical interference** from similar pairs **close by** (more twists means better quality)
creating field around it
- Used in:
 - Telephone network Between house and local exchange (subscriber loop)
 - LAN



of twist makes difference

Twisted Pair



Twist length of 7.5 cm to 10 cm

(a)



Twist length 0.6 cm to 0.85 cm

(b)

(a) Category 3 UTP. (b) Category 5 UTP.

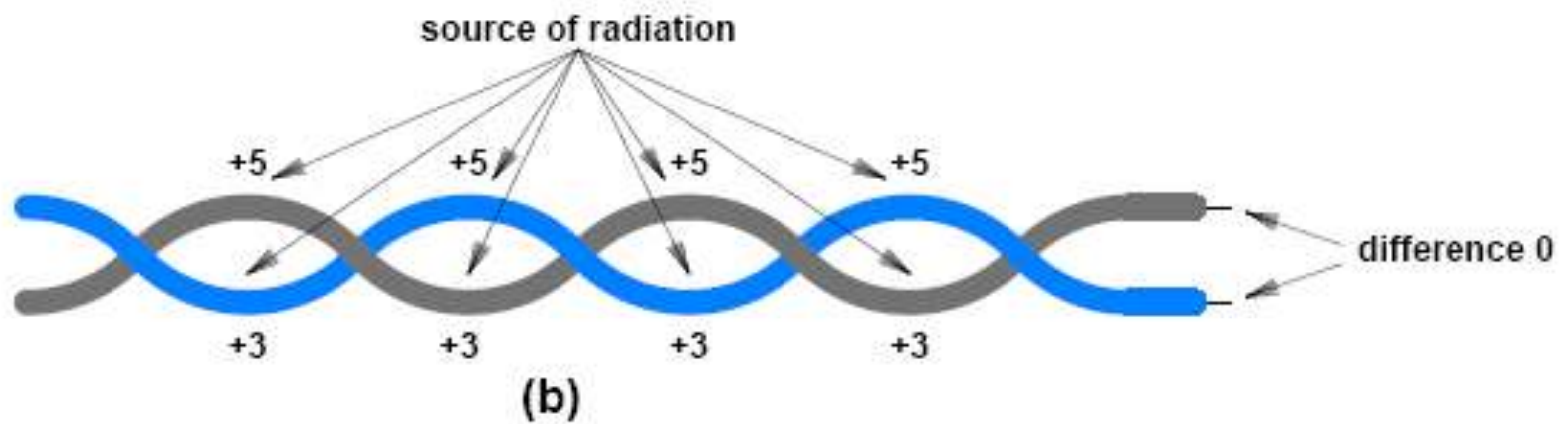
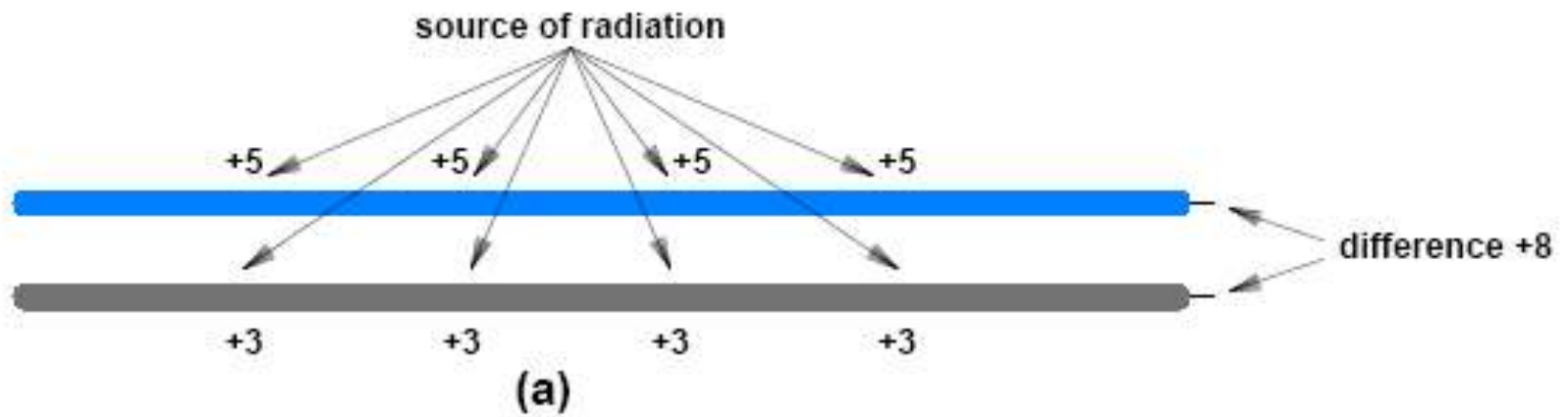
more twists, bigger num

① - Compare between category 3 UTP and category 5 UTP and how does

② the number of twists effect the efficiency of the transmission?

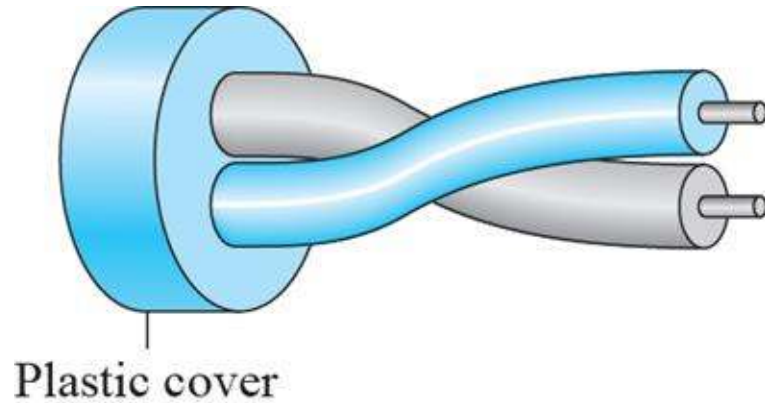
	Speed	Frequency	used?
① cat 3	10Mbps	16MHz	token ring & 10BASE-T Ethernet
cat 5	100Mbps	100MHz	Ethernet, Token Ring

② increase by enhancing cable ability to minimize internal crosstalk & reject EMI

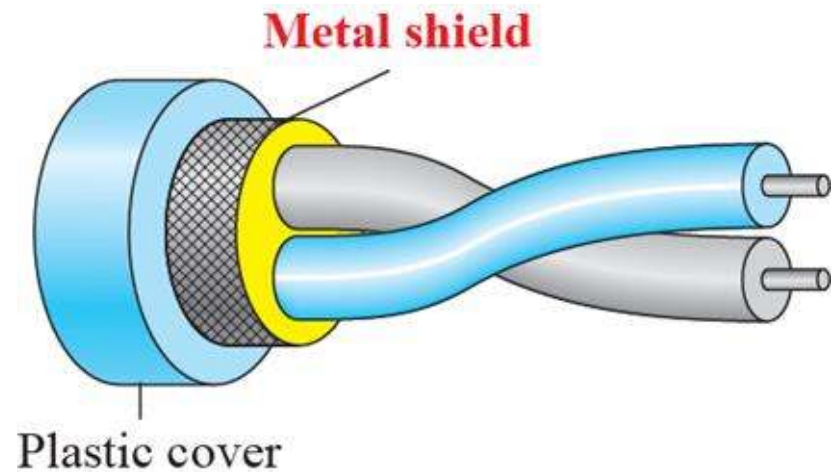


Unwanted electromagnetic radiation affecting (a) two parallel wires, and (b) twisted pair wiring.

Figure 7.4: UTP and STP cables



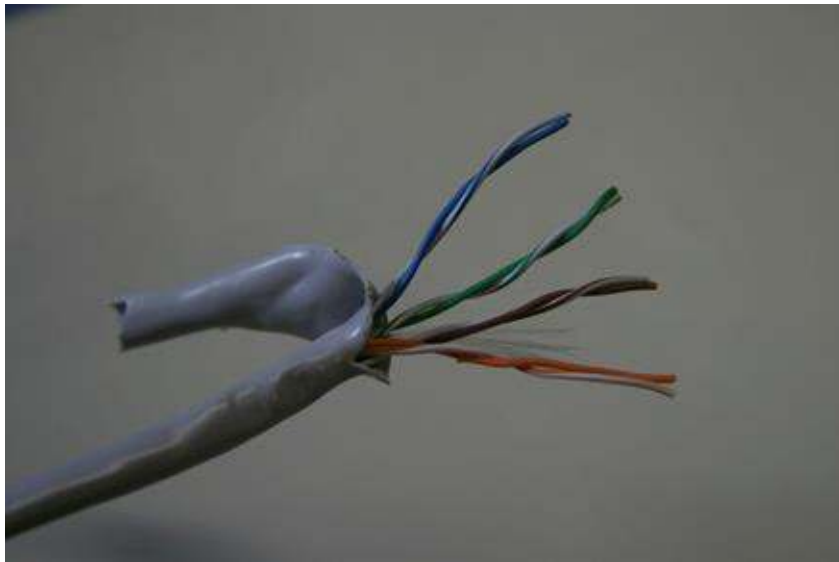
a. UTP



b. STP

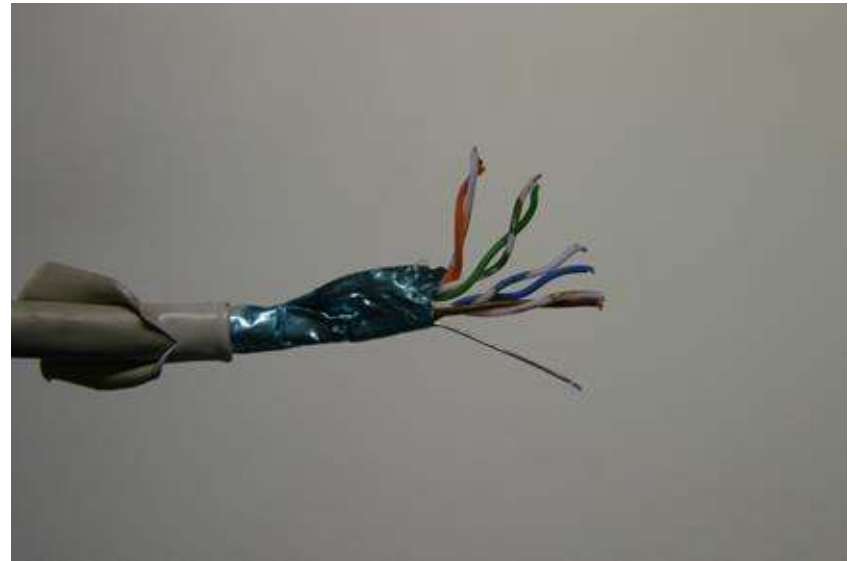
UTP: Unshielded Twisted Pair

STP: Shielded Twisted Pair



Unshielded Twisted Pair (UTP)

- Cheapest type of cable
- Easiest type to be installed
- Suffers from external Electromagnetic (EMI) interference



Shielded Twisted Pair (STP)

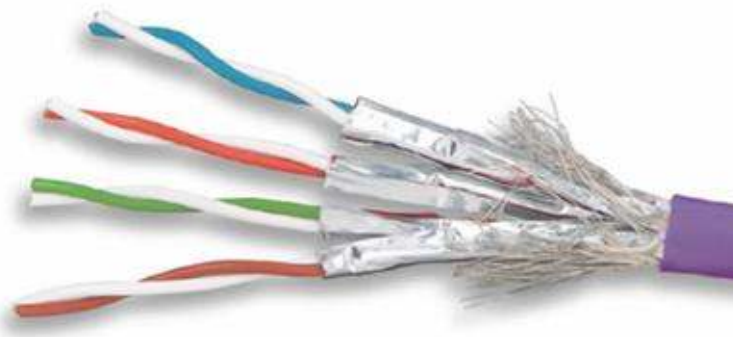
- Metal braid or covering that reduces interference
- More expensive \$\$
- Harder to handle (thick, heavy)

Can search on !!
my own

Table 7.1 Categories of unshielded twisted-pair cables

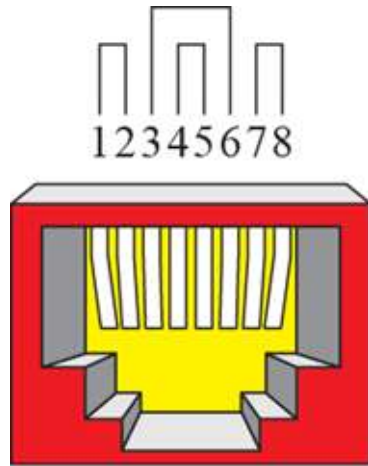
Category	Bandwidth	Max Data Rate	Shielding
CAT5e	100 MHz	1000 Mbps	UTP or STP
CAT6	250 MHz	1000 Mbps	UTP or STP
CAT6a	500 MHz	10 Gbps	UTP or STP
CAT7	600 MHz	10 Gbps	Shielded only
CAT8	2000MHz	25 Gbps or 40 Gbps	Shielded only

*not for
quiz
but, maybe
major*

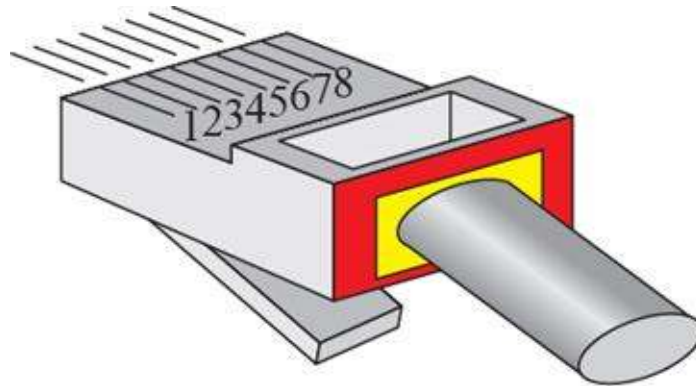


Shielded CAT8 up to 40Gbps – 24 m

Figure 7.5: UTP Connectors

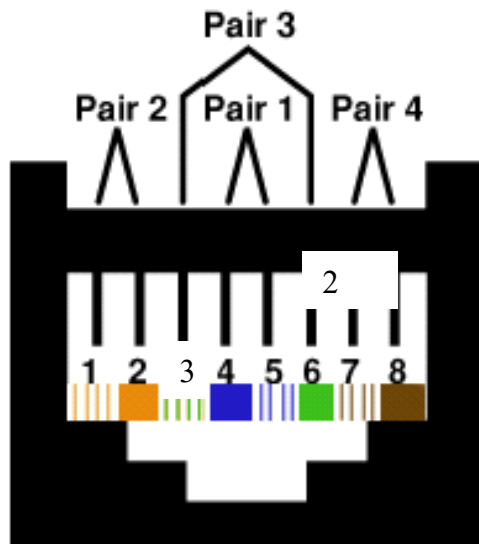


RJ-45 Female



RJ-45 Male

RJ=Registered Jack

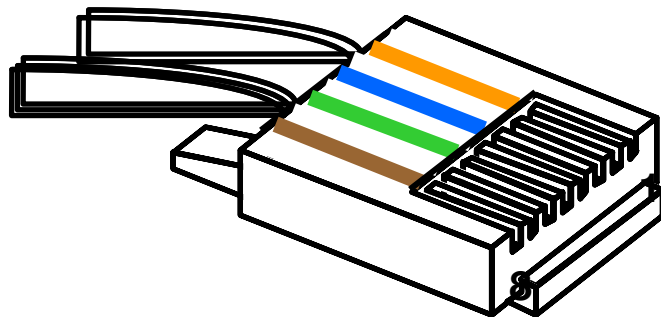
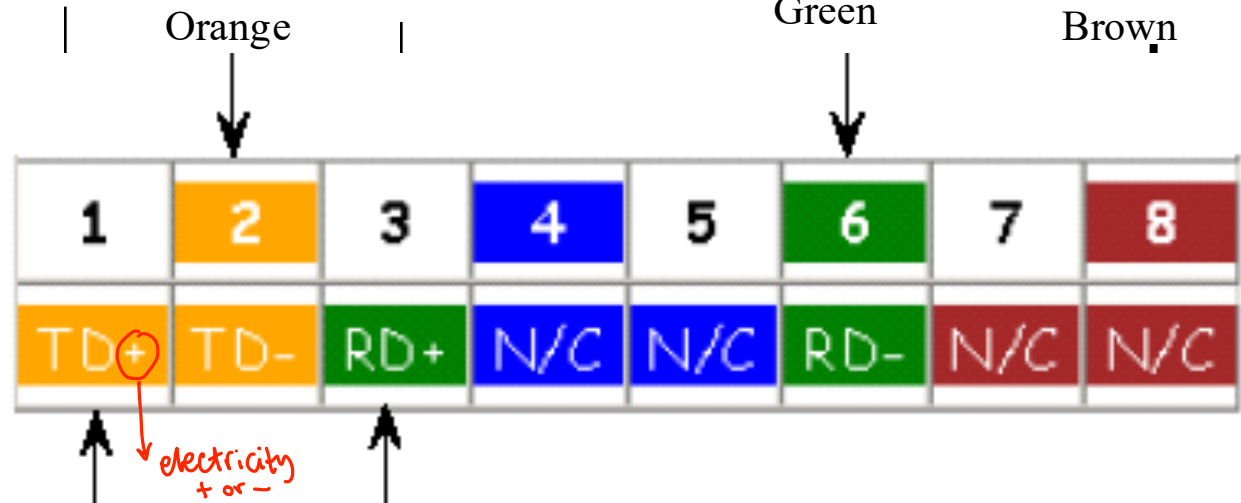


White/Orange

White/Green

Green

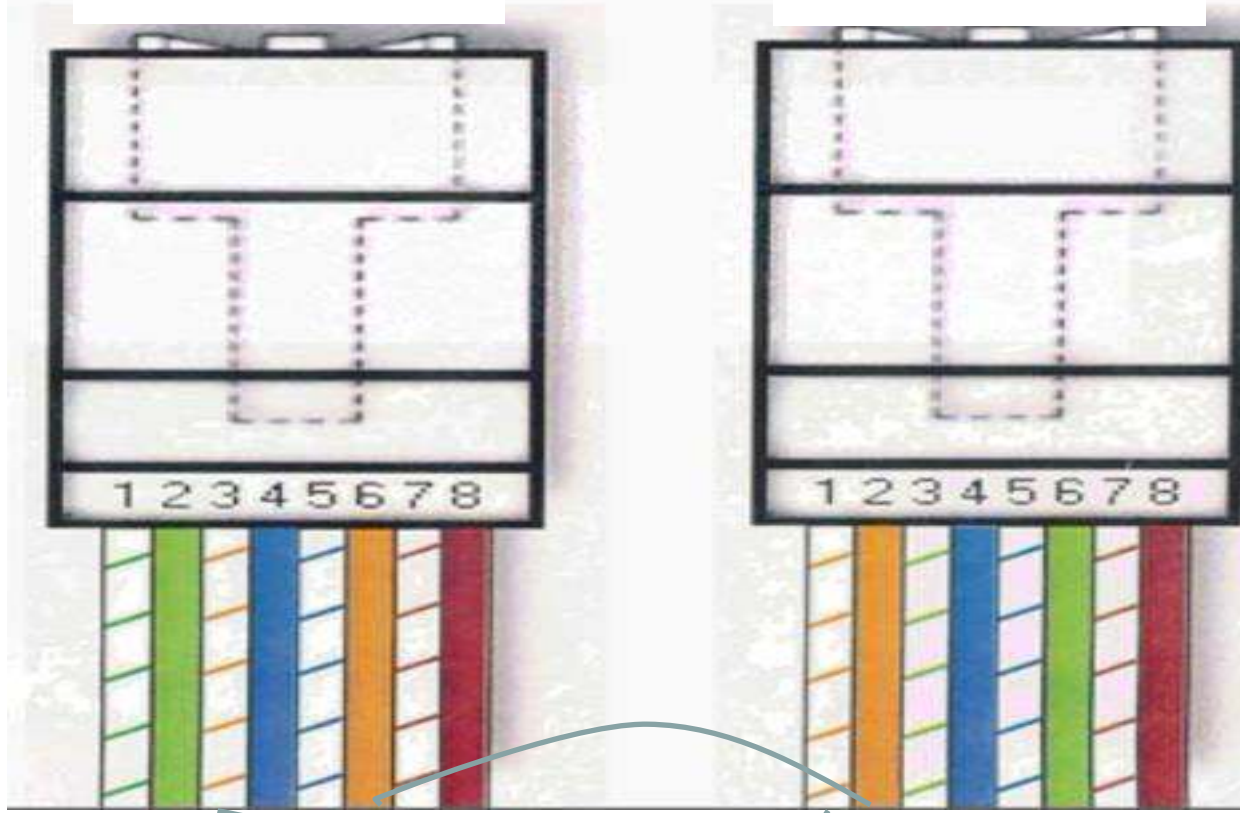
Brown



The RJ-45 Connector

TD+ : Transmit Data Positive value
 TD- : Transmit Data Negative value
 RD+ : Receive Data Positive value
 RD- : Receive Data Negative value

Crossover Cable



TD+ : Transmit
Data Positive value
TD- : Transmit
Data Negative
value
RD+ : Receive
Data Positive value
RD- : Receive
Data Negative
value

White/Orange

White/Green

Orange

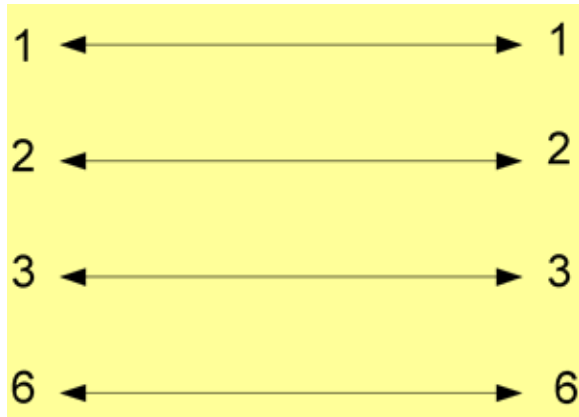
Green

Brown

1	2	3	4	5	6	7	8
TD+	TD-	RD+	N/C	N/C	RD-	N/C	N/C

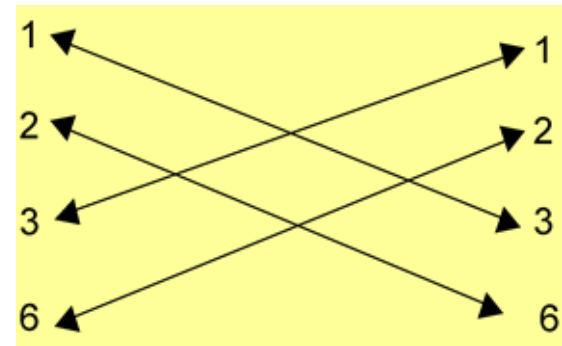
Ethernet Cabling

- Straight-Through Cabling



- PC to Switch/Hub
- Router to Switch/Hub

- Crossover Cabling

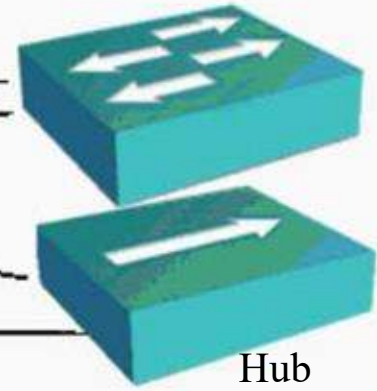
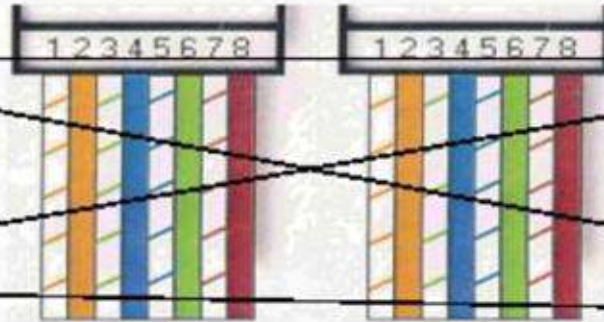


- PC to PC
- Hub to Hub
- Switch to Switch
- Hub to Switch
- Router to PC

ETHERNET CONNECTION RULES

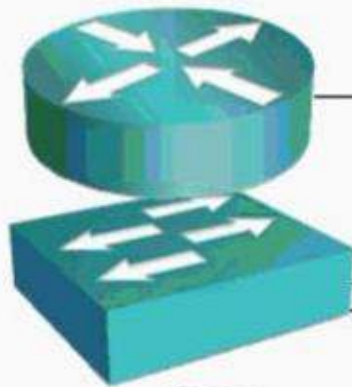
Router

Switch

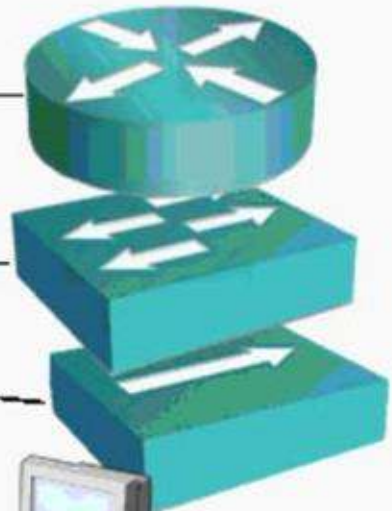
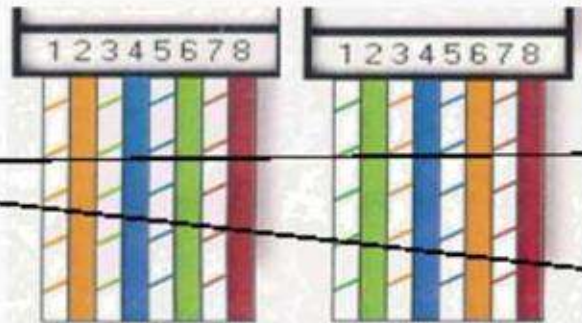


Hub

UNLIKE DEVICES USE STRAIGHT-THRU



colors swapped



LIKE DEVICES USE Crossover

Figure 7.7: Coaxial cable

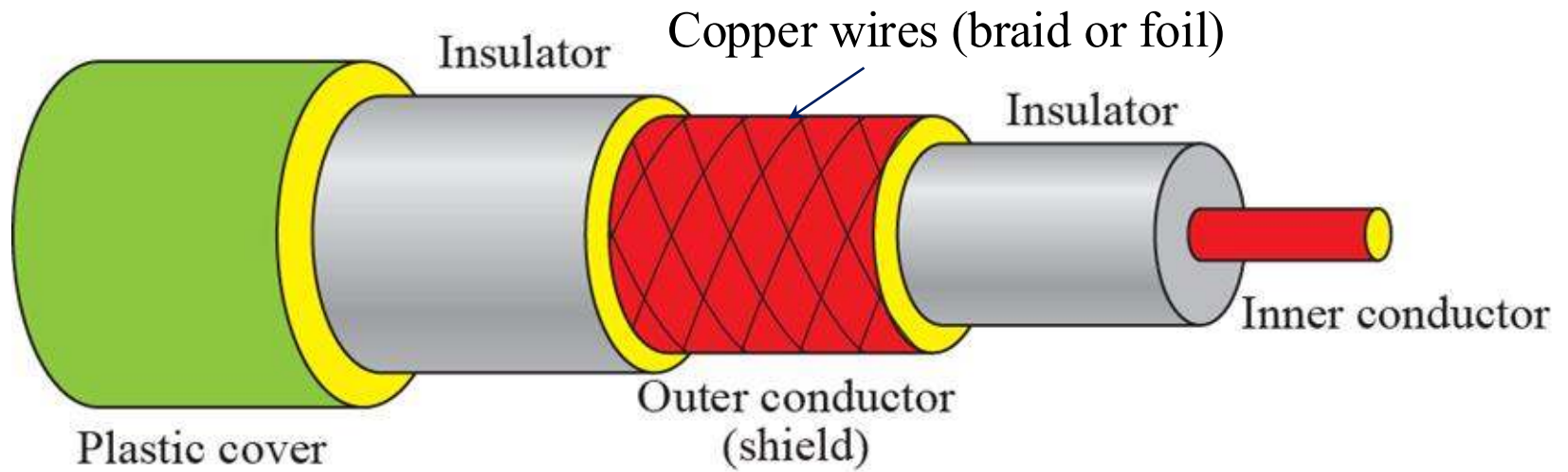
2 different layers

more \$\$

more efficient in stopping interference



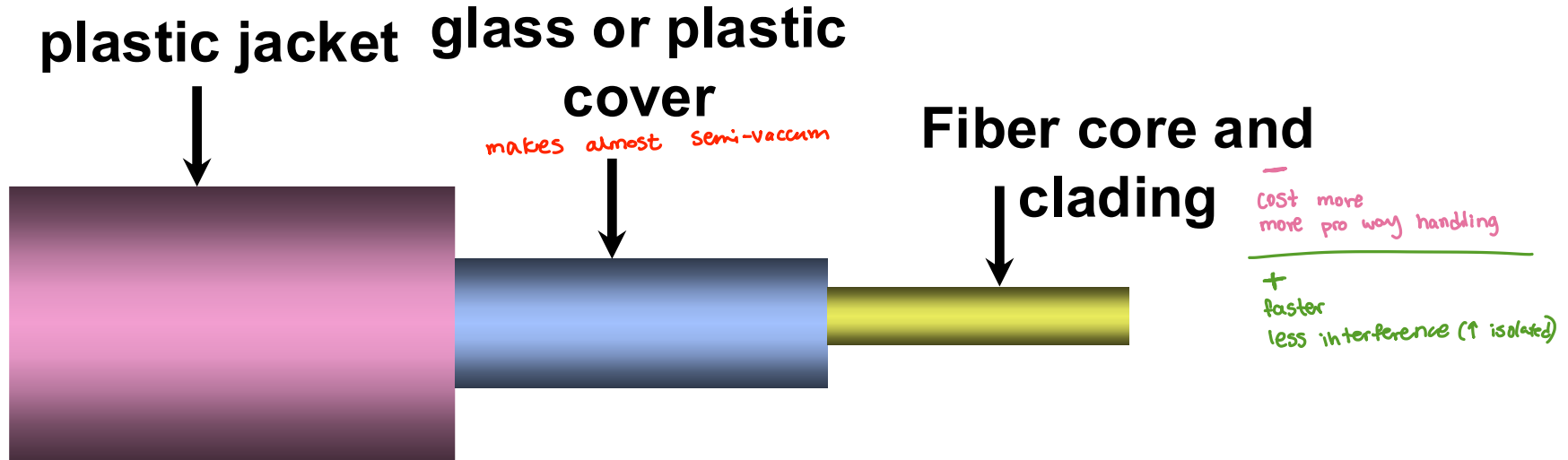
Coaxial Cable



Optical Fiber

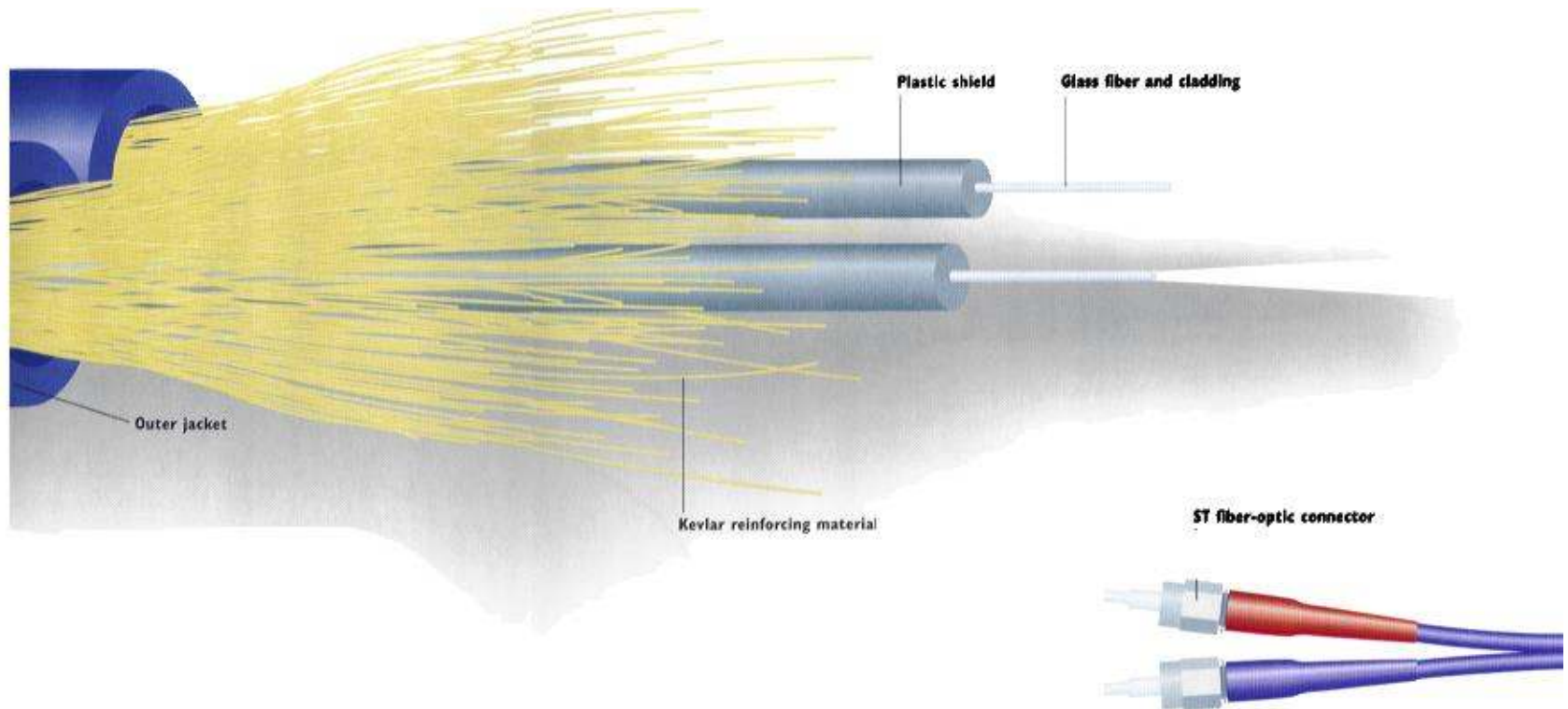
light pulses
(speed of light)

■ consists of **three concentric sections**



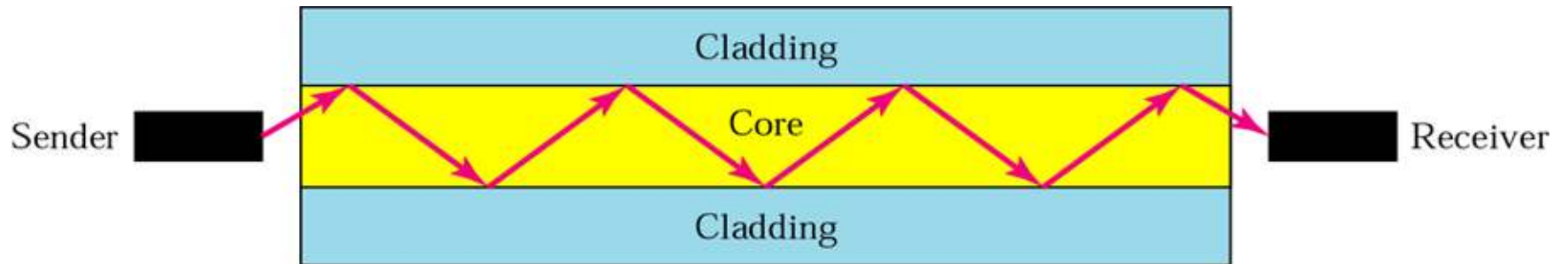
- **Core:** consists of one or more very thin **strands** or fibers made of **glass** or **plastic**
- Each fiber is surrounded by its own **cladding**, a **glass or plastic coating** that has **optical properties different from the core**
- **Jacket:** a plastic or other material acts as a layer to protect against moisture, crushing, and other environmental dangers.

Fiber Optic Cable



Optical Fiber

*Bounce over walls, until receiver
* animation will be provided **



Fiber Optics Properties

Advantages

- **Higher Bandwidth** *since dealing with light*
 - Data rates of hundreds of Gbps
- Smaller **size & weight** *empty glass*
- **Lower attenuation** (signal loss) *signal loss with distance*
 - **Greater repeater spacing**
 - Can run **50Km** at least without repeaters
- **No crosstalk** (no light leaking)
- Not affected by noise
- **highly secure** (no light leaking)

Disadvantages

- Needs special skills to install
- Cost: **more expensive** interfaces than electrical interfaces used with other types (twisted)

Implementation Issues	UTP Cabling	Fiber-Optic Cabling
Bandwidth supported	10 Mb/s - 10 Gb/s	10 Mb/s - 100 Gb/s
Distance	Relatively short (1 - 100 meters)	Relatively long (1 - 100,000 meters)
Immunity to EMI and Radio Frequency Interference	Low	High (Completely immune)
Immunity to electrical hazards	Low	High (Completely immune)
Media and connector costs	Lowest \$\$\$	Highest \$\$\$\$ \$ \$ \$ \$
Installation skills required	Lowest	Highest

7.2 Unguided Media: Wireless

Radio Waves

Microwaves

Infrared

Figure 7.19 *Wireless transmission waves*

Unguided media: signals are transmitted through air and are available to everyone who has a device that can receive them

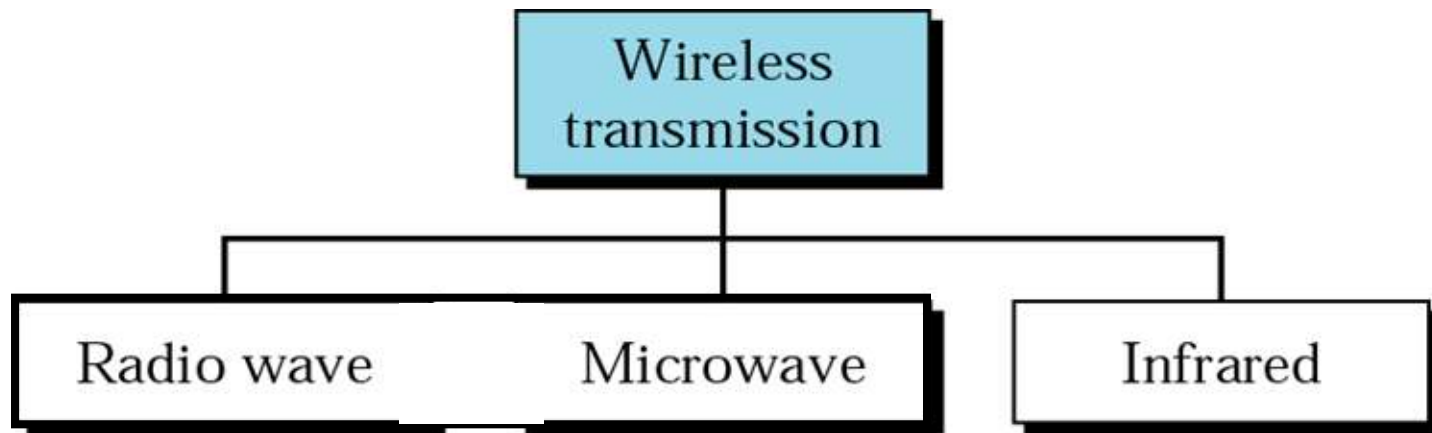
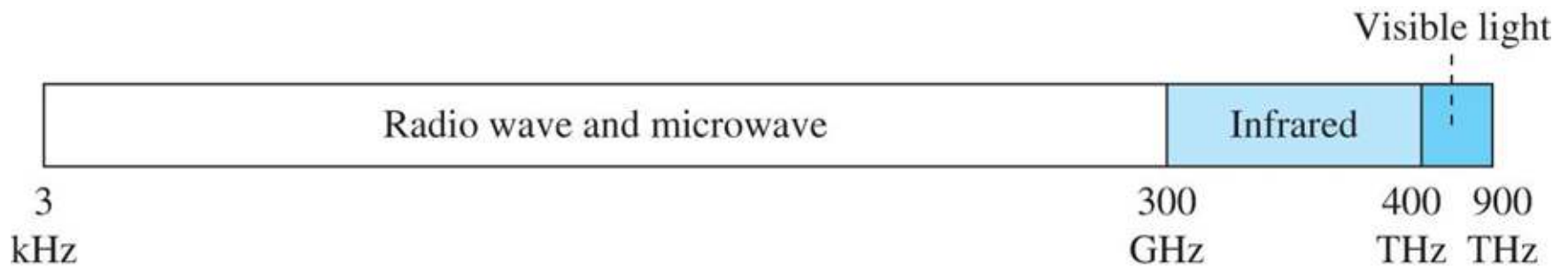
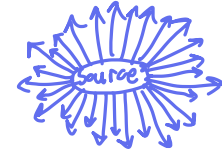


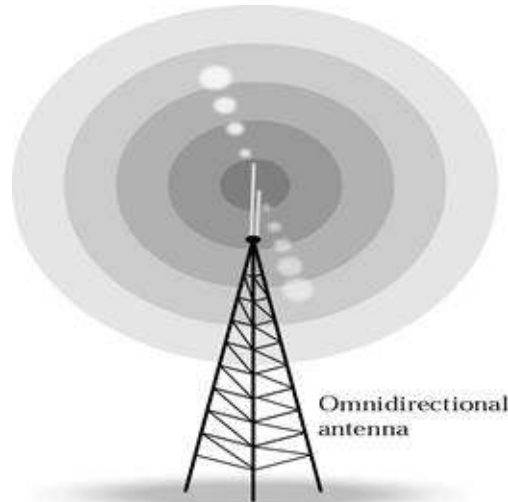
Figure 2.25 Electromagnetic spectrum for wireless communication



Radio waves ①



- Less than 300 MHz
 - **Omnidirectional** (signal propagates in all directions)
 - Can Travel long distances
 - Broadcast radio (AM,FM) ,TV





Note

Radio waves are used for multicast communications, such as radio and television

link to what
before?

②

Microwaves

- 300MHz to 300GHz (sub range from the Radio waves)
 - Travel in one direction (Unidirectional = line-of-sight propagation = straight lines)
 - Can be used for point to point for example between buildings to connect their LANs
 - Very high frequency microwaves, **cannot penetrate walls (disadv. if receivers are inside buildings)**
 - Used in Wireless networks, satellite communication, cellular phones

Note

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

3

Infrared

mixed with sunlight, won't work well

- 300GHz to 400THz
 - Have a very large bandwidth that is not yet completely utilized
 - Local- short distance communication because they cannot penetrate walls
 - Line-of-sight propagation (directional)
 - Used in local point-to-point Transmission
 - Applications: Wireless keyboard, mouse, remote control using **Infrared Data Association (IrDA) protocol**
 - **Cannot be used under the sun because** of the interference with the sun infrared rays
 - IrDA operates at 75kbps up to **8 meters**, and 1.15Mbps – 4Mbps over a distance of **1 meter**



Note

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

affected by sun

Quiz:

① MCQ

- Solving → (pen, pencil, calculator)
- theory

② T/F

Essay-based → Major