

Chapter 02

Physical Layer

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

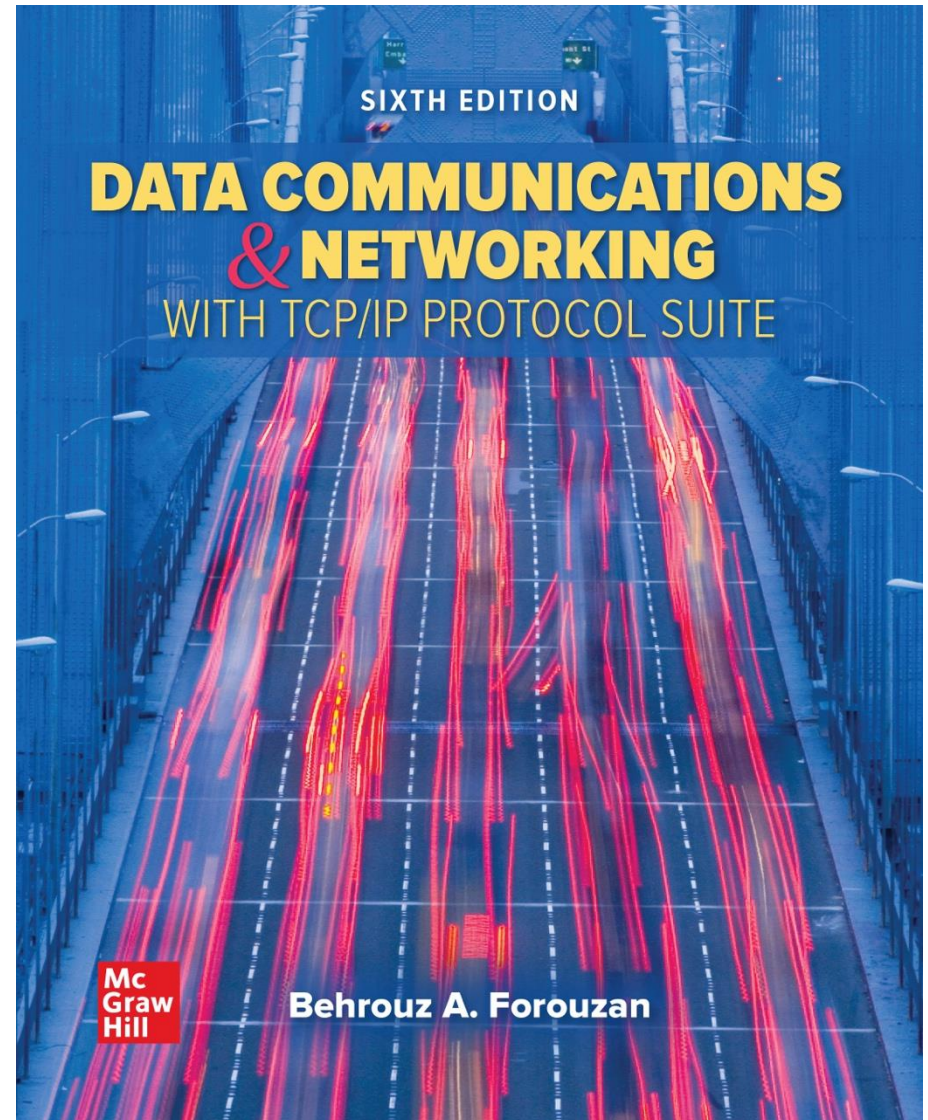


Figure 7.1 *Transmission medium and physical layer*

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

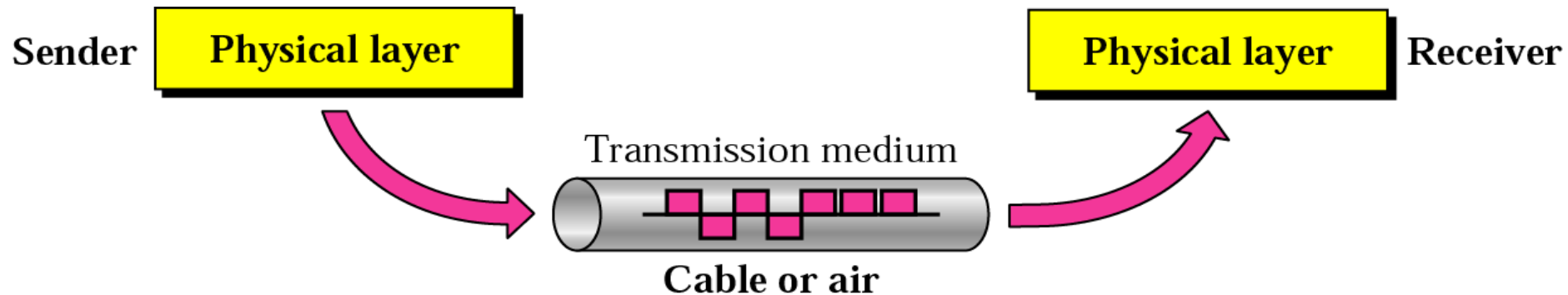
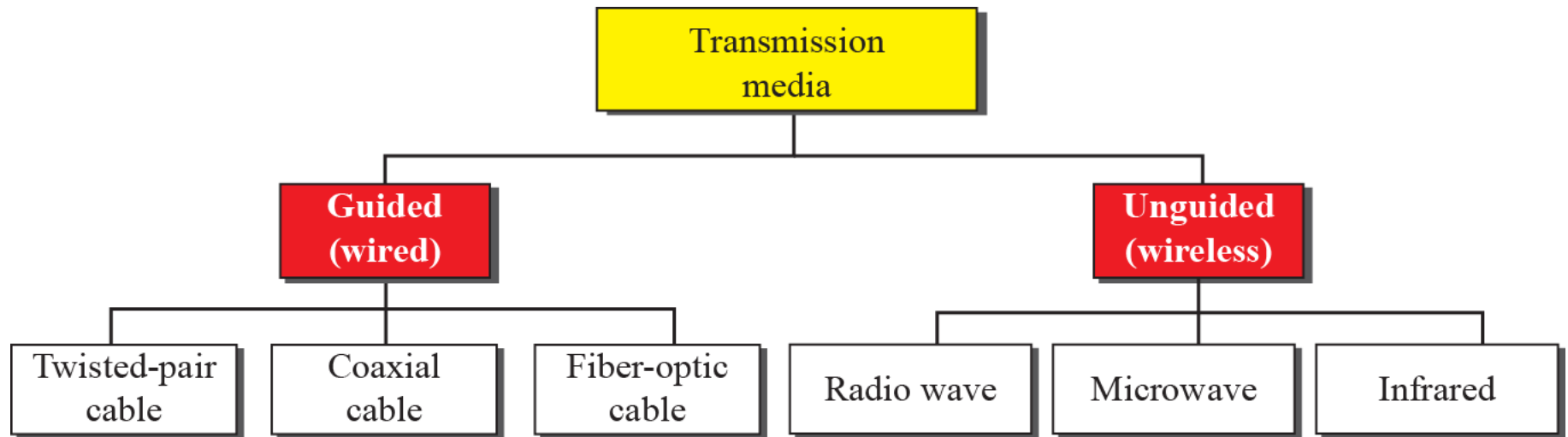


Figure 7.2: Classes of transmission media



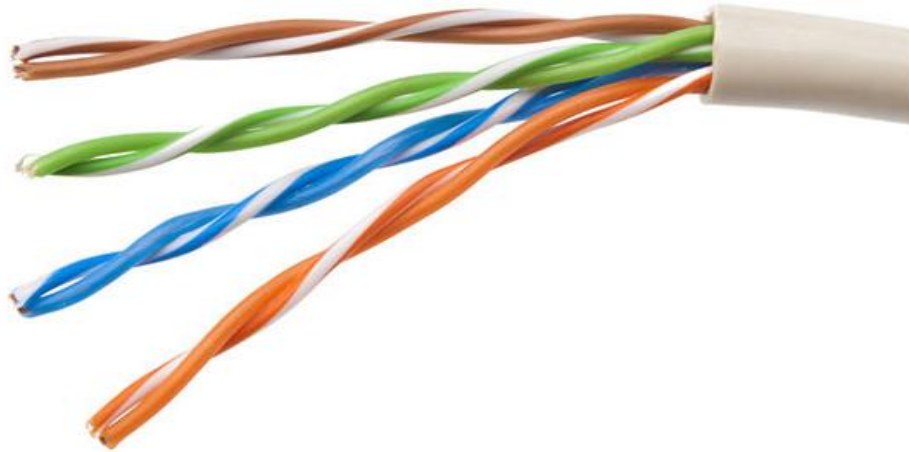
7.1 Guided Media

Twisted-Pair Cable

Coaxial Cable

Fiber-Optic Cable

Twisted pairs





```
Without twisting:
```

Wire pair 1 _____

↓ interference

Wire pair 2 _____


```
With twisting:
```

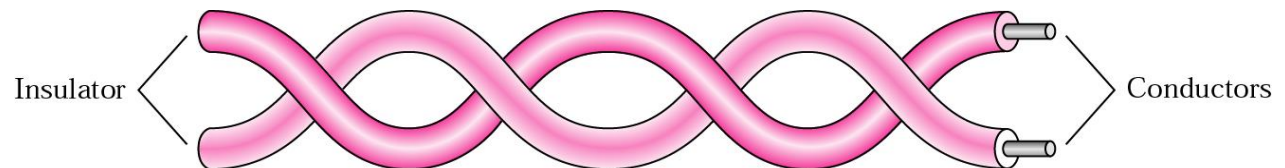
Pair 1 /\ /\ /\ /\ /\ /\ /\ /\

Pair 2 \/ \/ \/ \/ \/ \/ \/ \/

↓

Less interference (crosstalk)

- LAN



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.

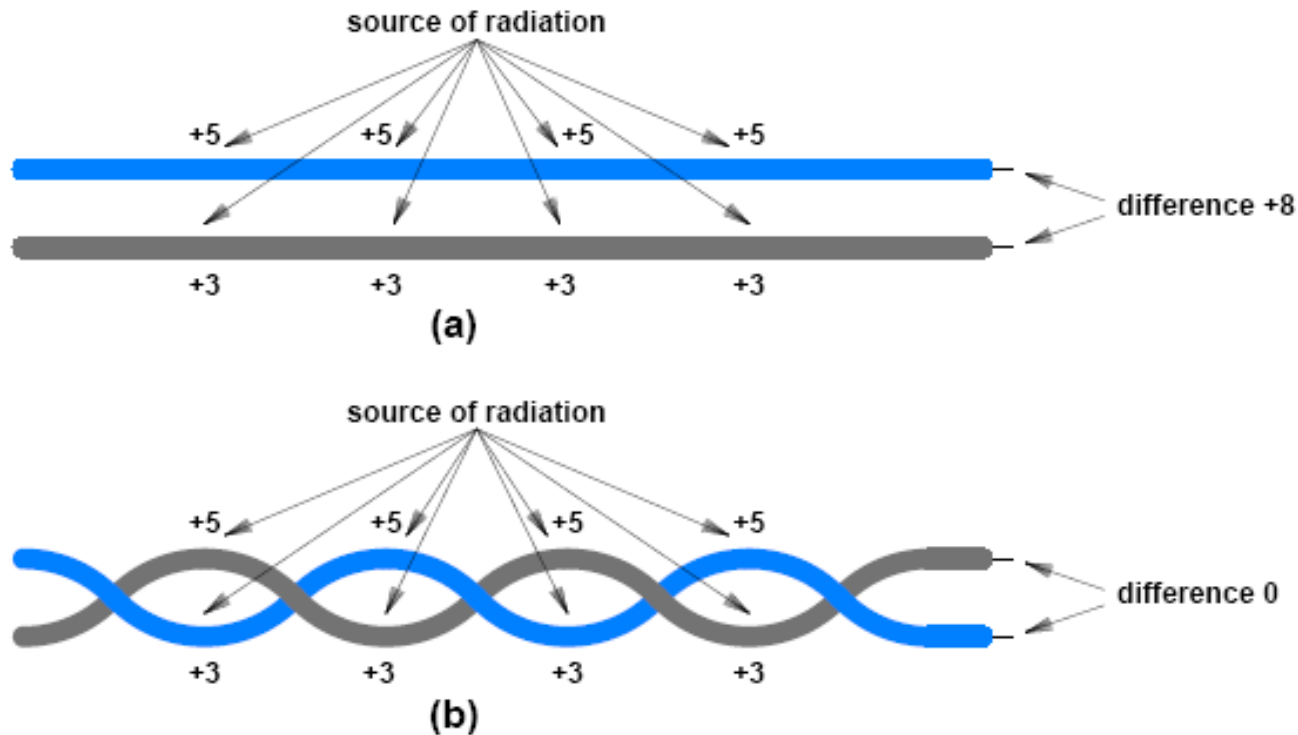
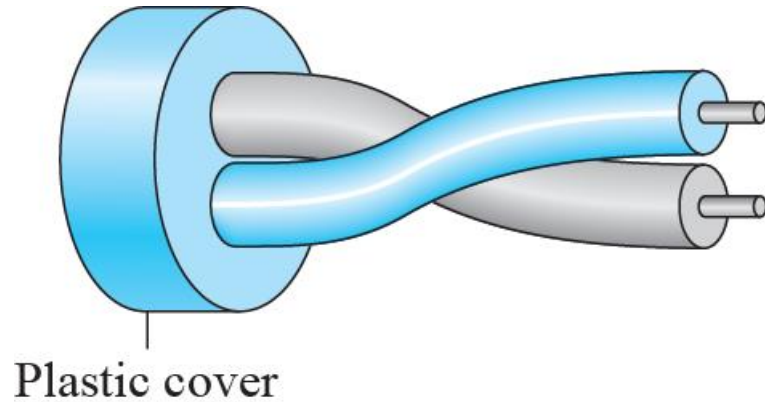


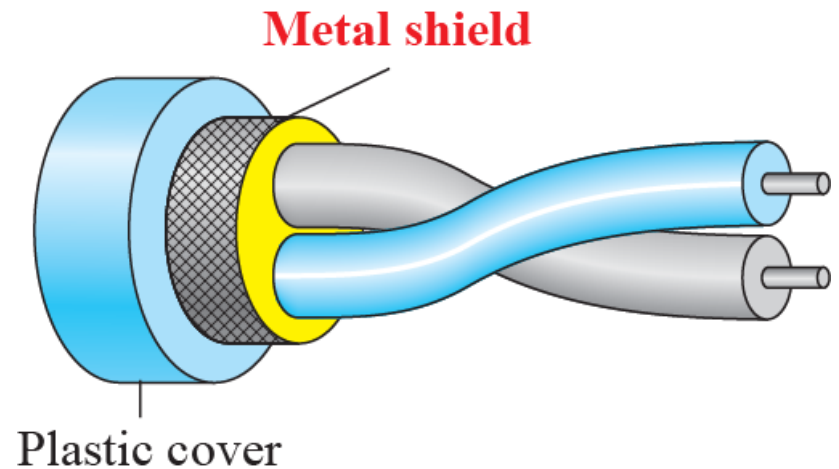
Figure 7.2 Unwanted electromagnetic radiation affecting (a) two parallel wires, and (b) twisted pair wiring.

B) The interference affects **both wires equally overall**, so the unwanted radiation is largely **canceled**.

Figure 7.4: UTP and STP cables



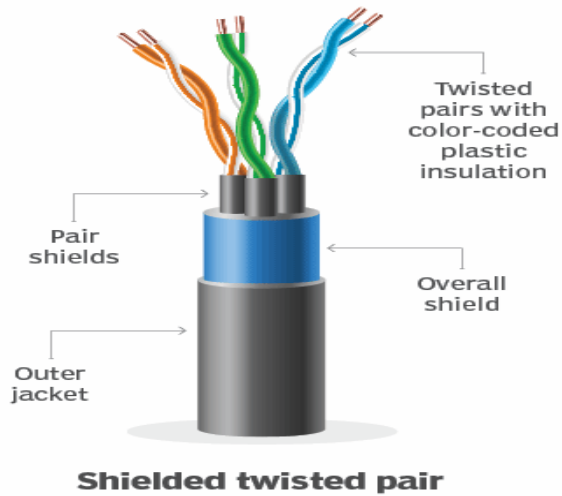
a. UTP



b. STP

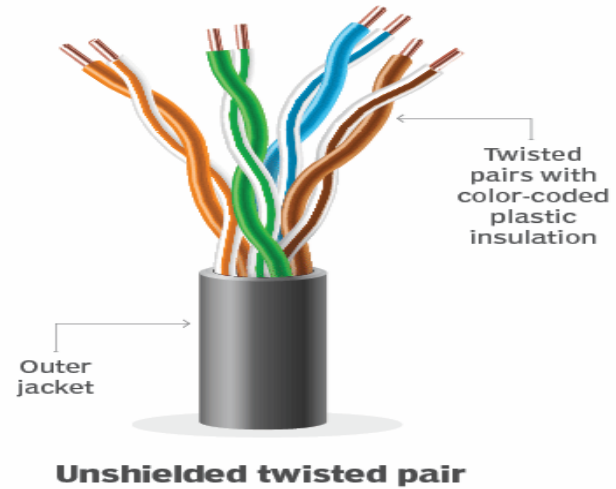
UTP: Unshielded Twisted Pair

STP: Shielded Twisted Pair



Shielded Twisted Pair (STP)

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

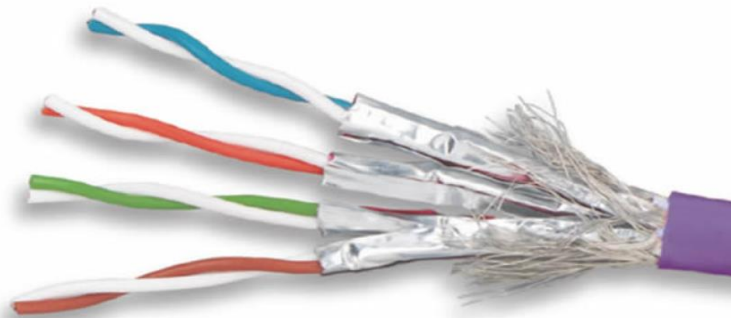


Unshielded Twisted Pair (UTP)

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

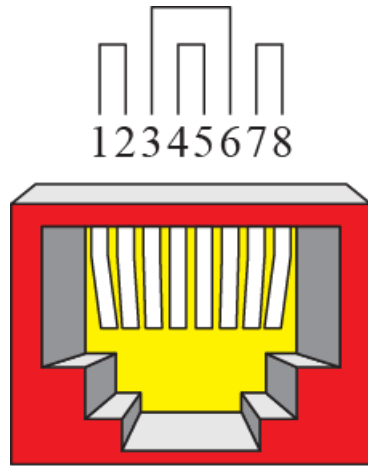
Table 7.1 Categories of unshielded twisted-pair cables

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



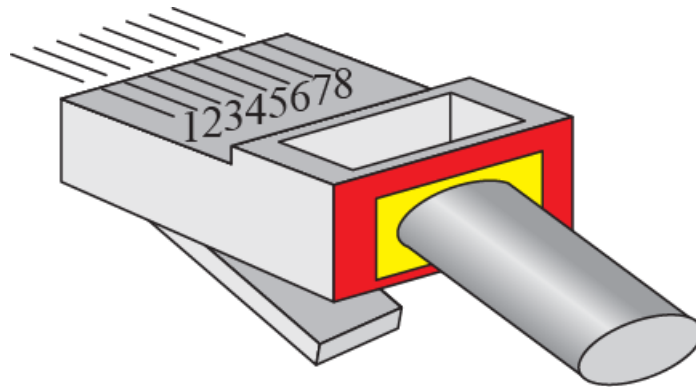
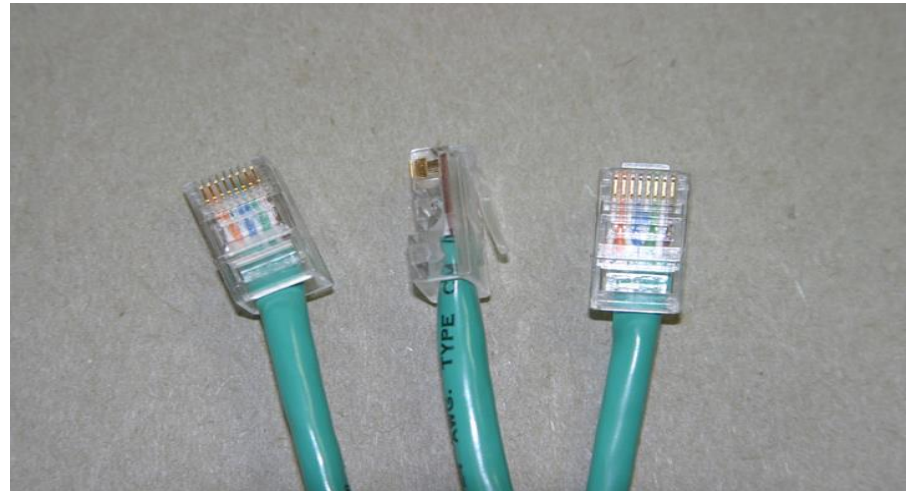
Shielded CAT8 up to 40Gbps – 24 m

Figure 7.5: UTP Connectors

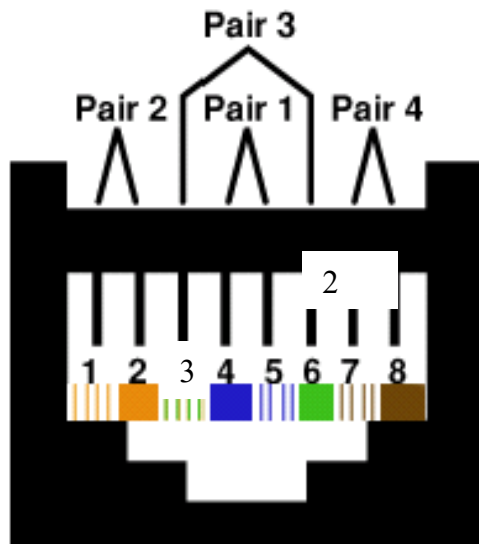


RJ-45 Female

RJ=Registered Jack



RJ-45 Male

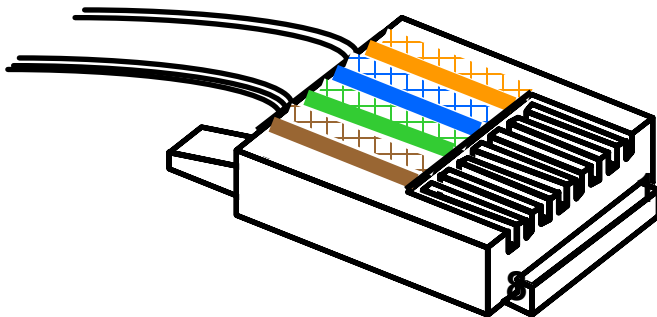
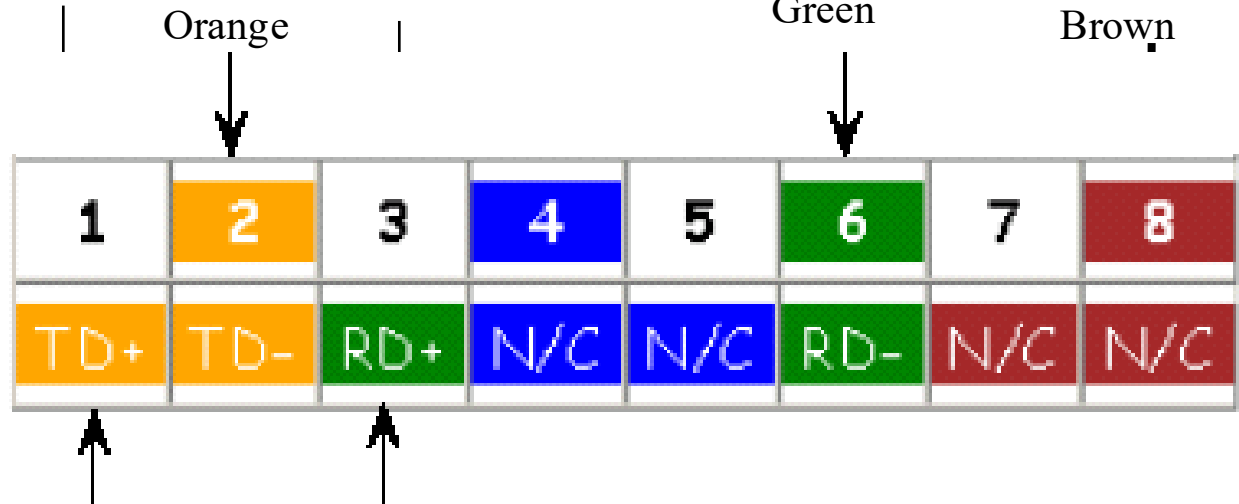


White/Orange

White/Green

Green

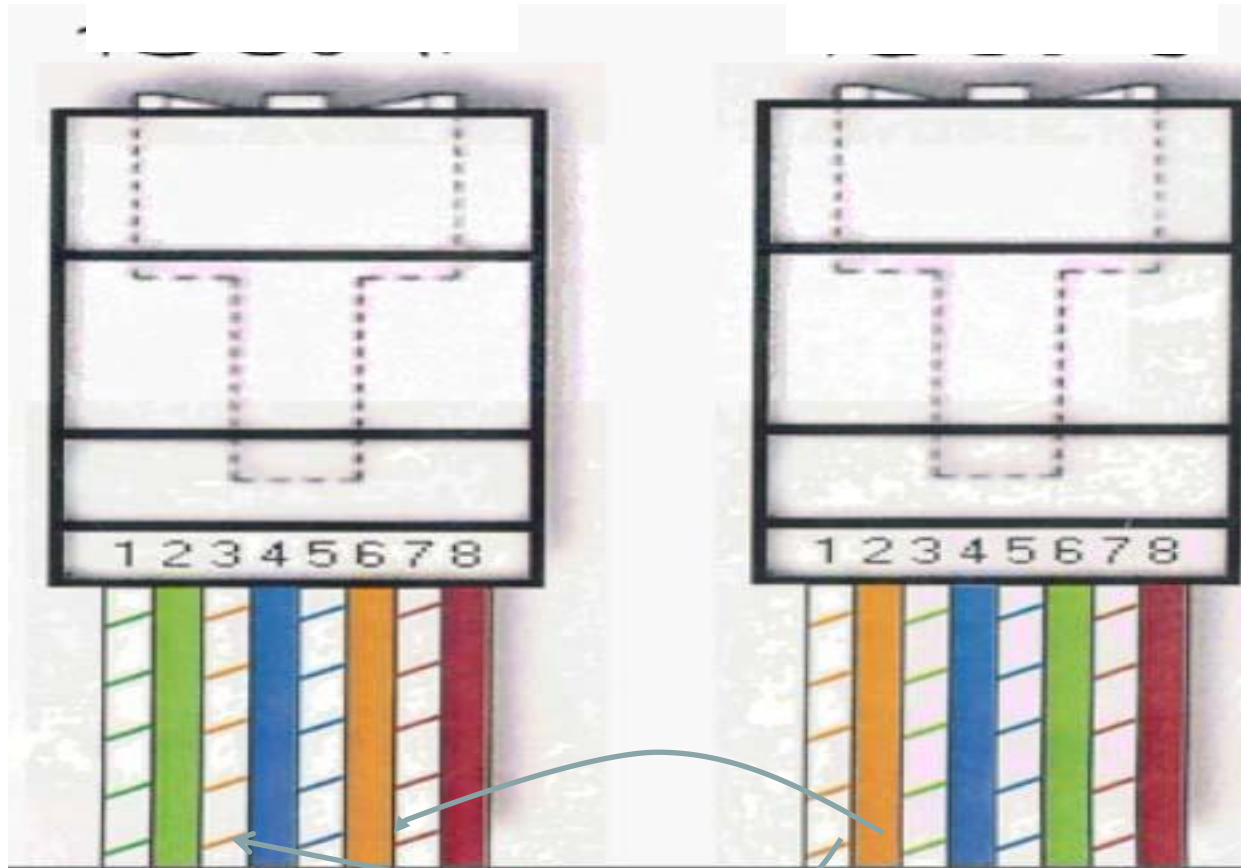
Brown



The RJ-45 Connector

TD+ : Transmit Data Positive value
 TD- : Transmit Data Negative value
 RD+ : Receive Data Positive value
 RD- : Receive Data Negative value
 N/C: **No Connection / Not Connected** → unused pin

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

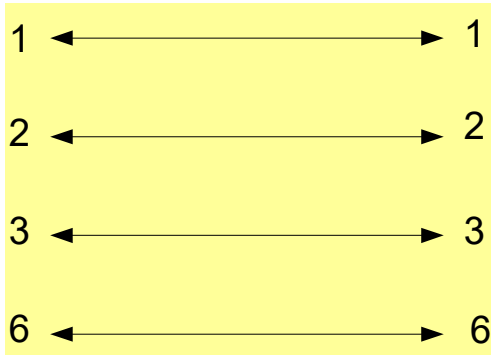
Green

Brown

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

Ethernet Cabling

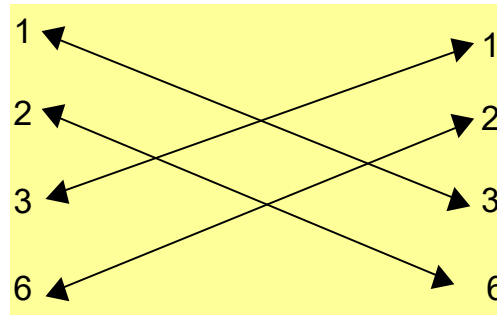
- Straight-Through Cabling



•PC to
Switch/Hub

•Router to
Switch/Hub

- Crossover Cabling

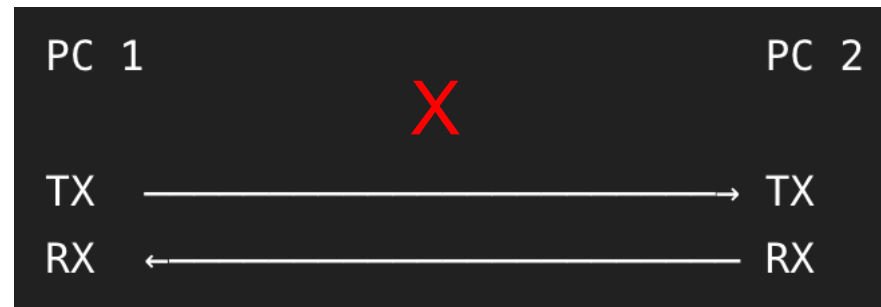


•PC to PC

•Hub to Hub

Switch to Switch

•Hub to Switch

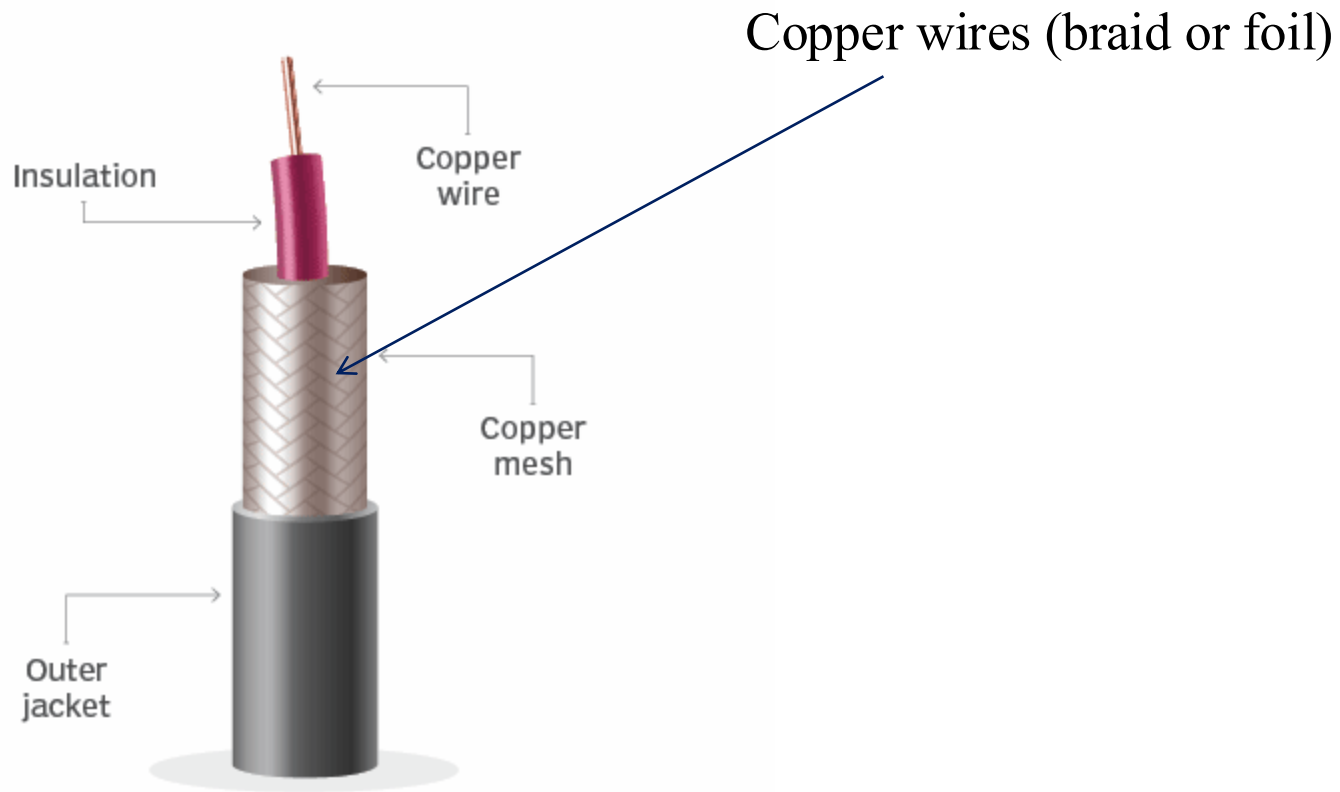


Crossover is needed

Figure 7.7: Coaxial cable

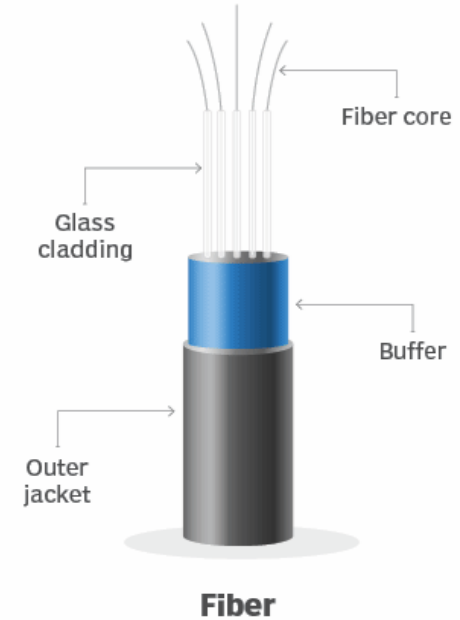
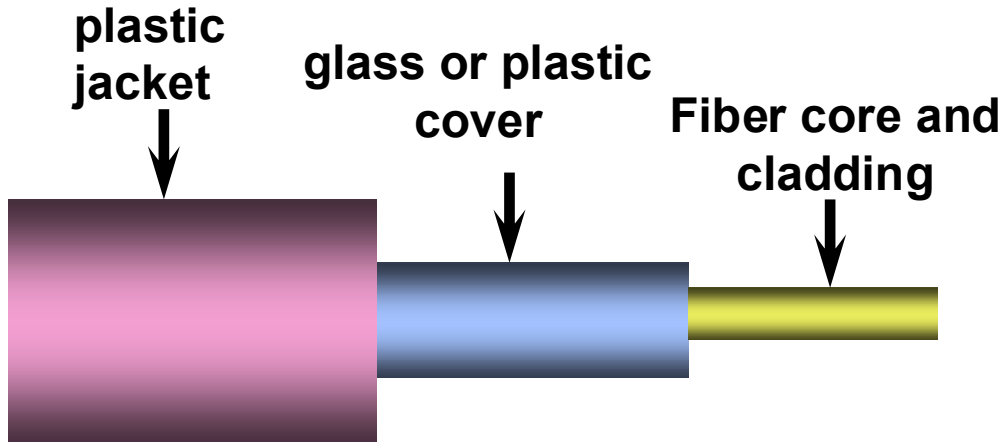


Coaxial Cable



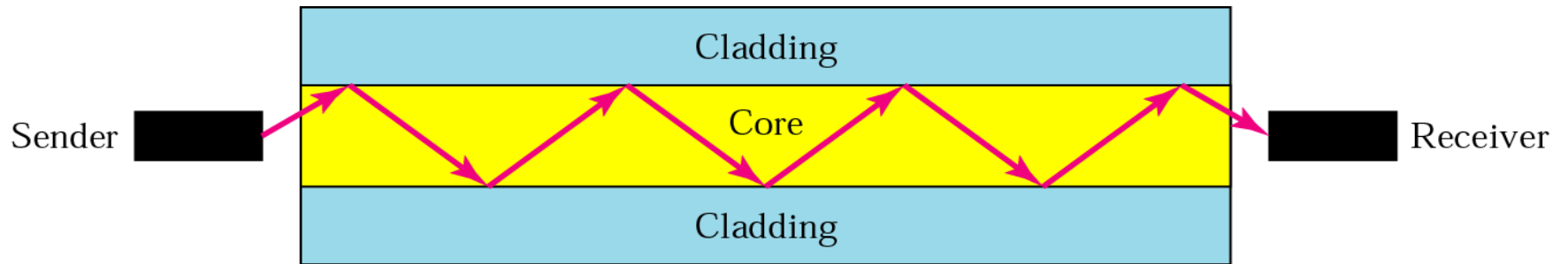
Optical Fiber

■ 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.

Optical Fiber



Fiber Optics Properties

Advantages

- **Higher Bandwidth**
 - Data rates of hundreds of Gbps
- Smaller **size & weight**
- **Lower attenuation** (signal loss)
 - **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**

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 (dangers)	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

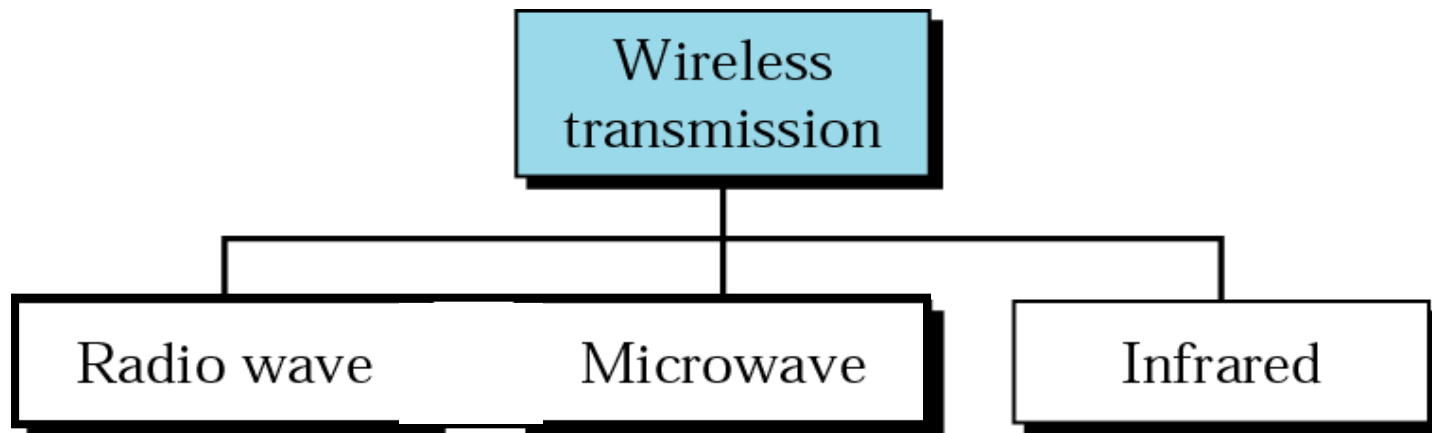
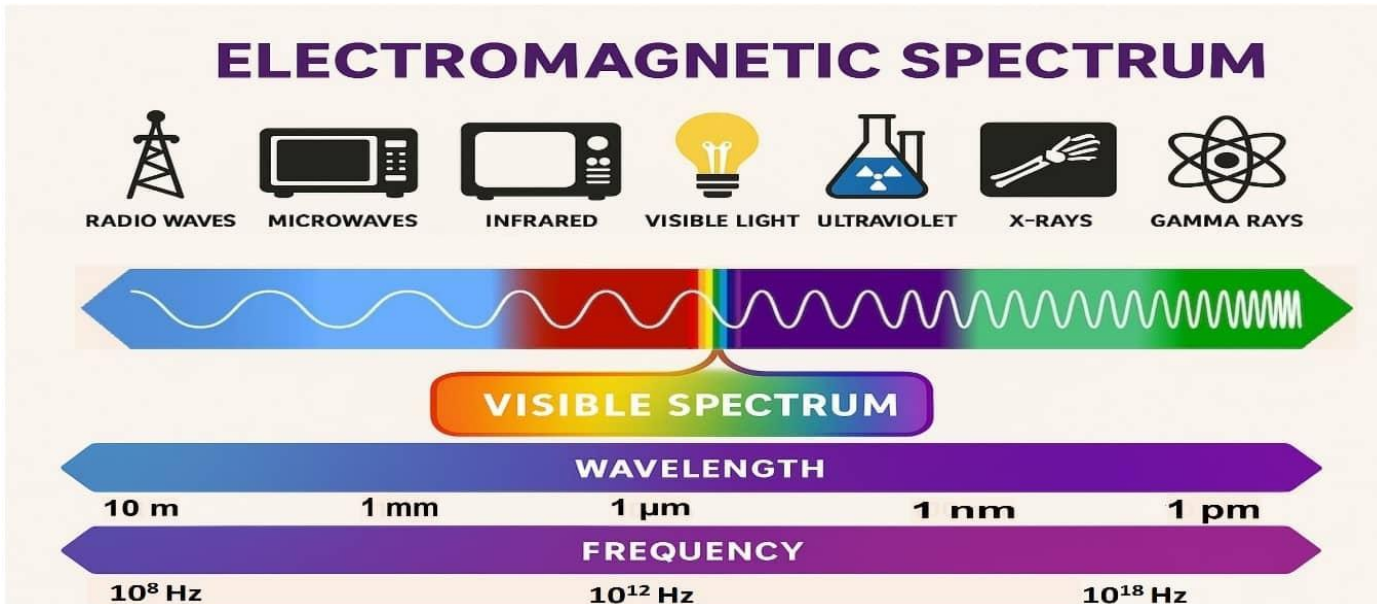
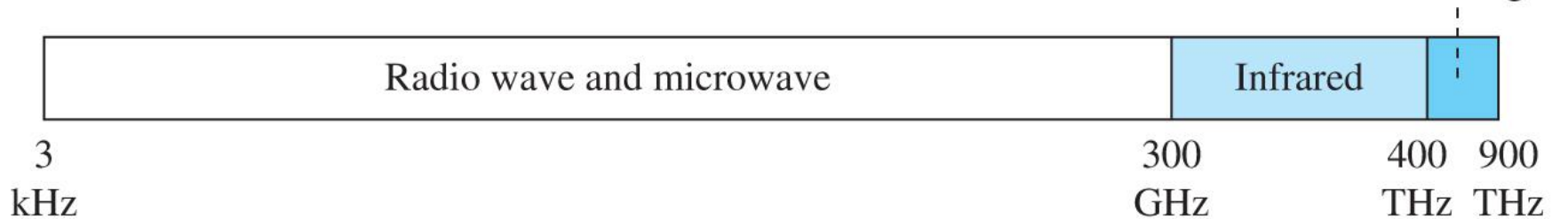


Figure 2.25 Electromagnetic spectrum for wireless communication

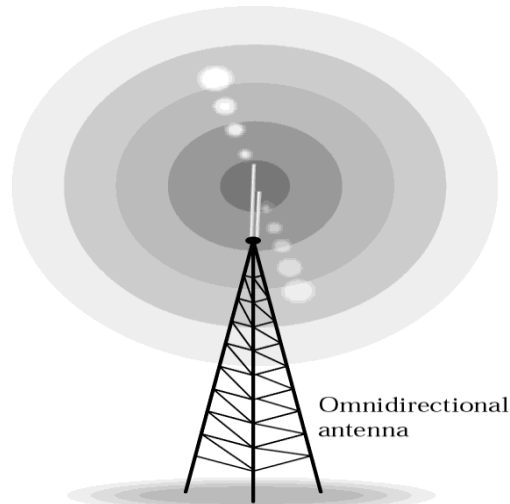
As we move **from left to right**, the frequency increases.

Frequency tells us **how many waves pass a point each second**.



Radio waves

- 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

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
 - **high frequency microwaves, difficult to pass walls (if receivers inside buildings)**
 - Higher frequency → shorter wavelength → more difficulty passing through obstacles such as walls.
 - Used in Wireless networks, satellite, cellular phones.
 - microwaves carry information through the air.

Note

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

Infrared (IR Wireless)

- 300GHz to 400THz
 - Have a very large bandwidth
 - Local- short distance communication because they cannot penetrate walls
 - Line-of-sight propagation (directional)
 - Used in local point-to-point Transmission
 - Applications: remote controls, some wireless headphones, and some wireless computer peripherals.
 - Use **Infrared Data Association (IrDA) protocol**
 - **Cannot be used under the sun because** of the interference with the sun infrared rays
 - Replaced by Bluetooth Technology

Note

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