Physical Layer-3
07.10.2019

BLM 3051 Veri İletişimi
(Data Communication)

Tech. Assist. Kübra ADALI
Assoc. Prof. Dr. Veli Hakkoymaz

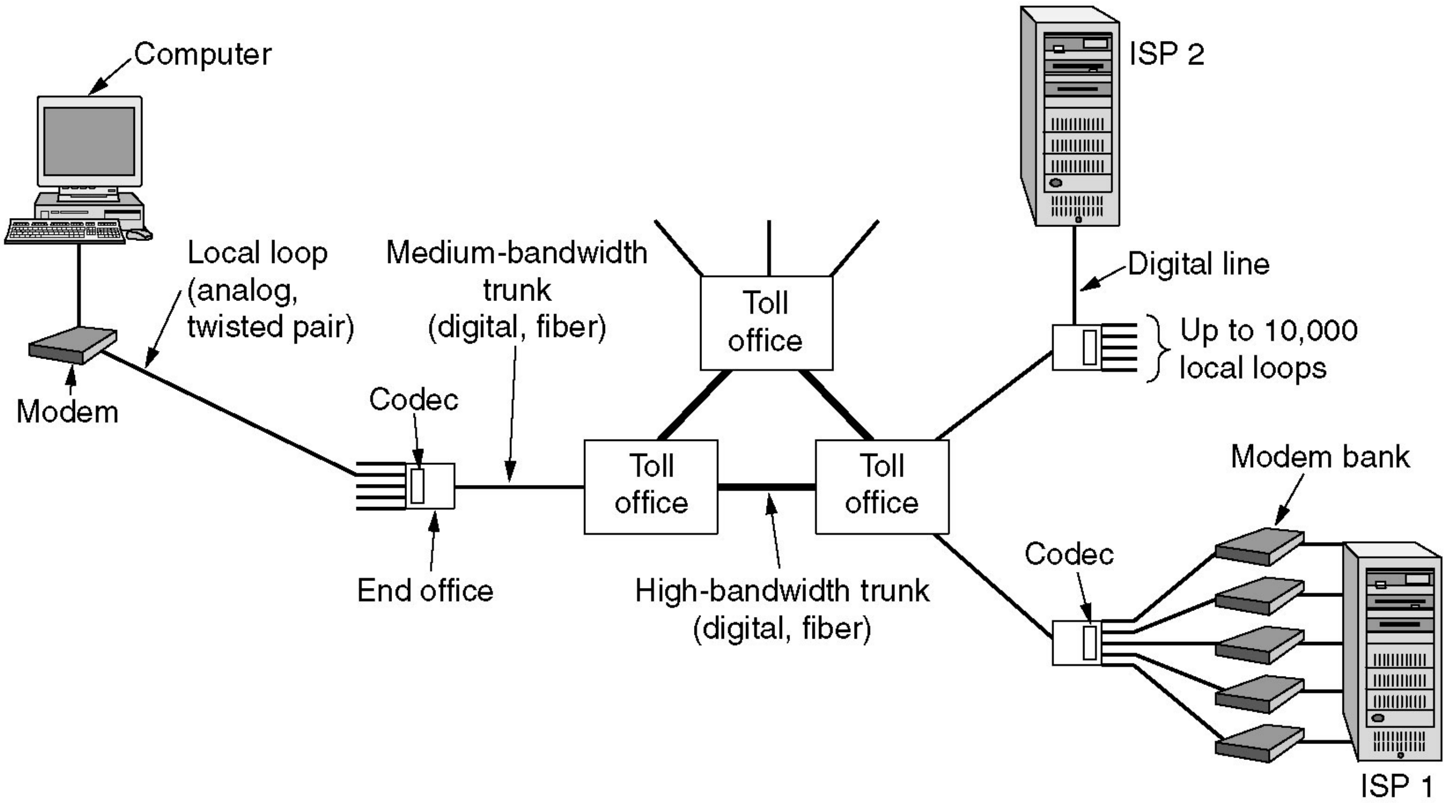
References:

- *Computer Networks*, Andrew Tanenbaum, Pearson, 5th Edition,2010.
- *Computer Networking, A Top-Down Approach Featuring the Internet*, James F.Kurose, Keith W.Ross, Pearson-Addison Wesley, 6th Edition, 2012.

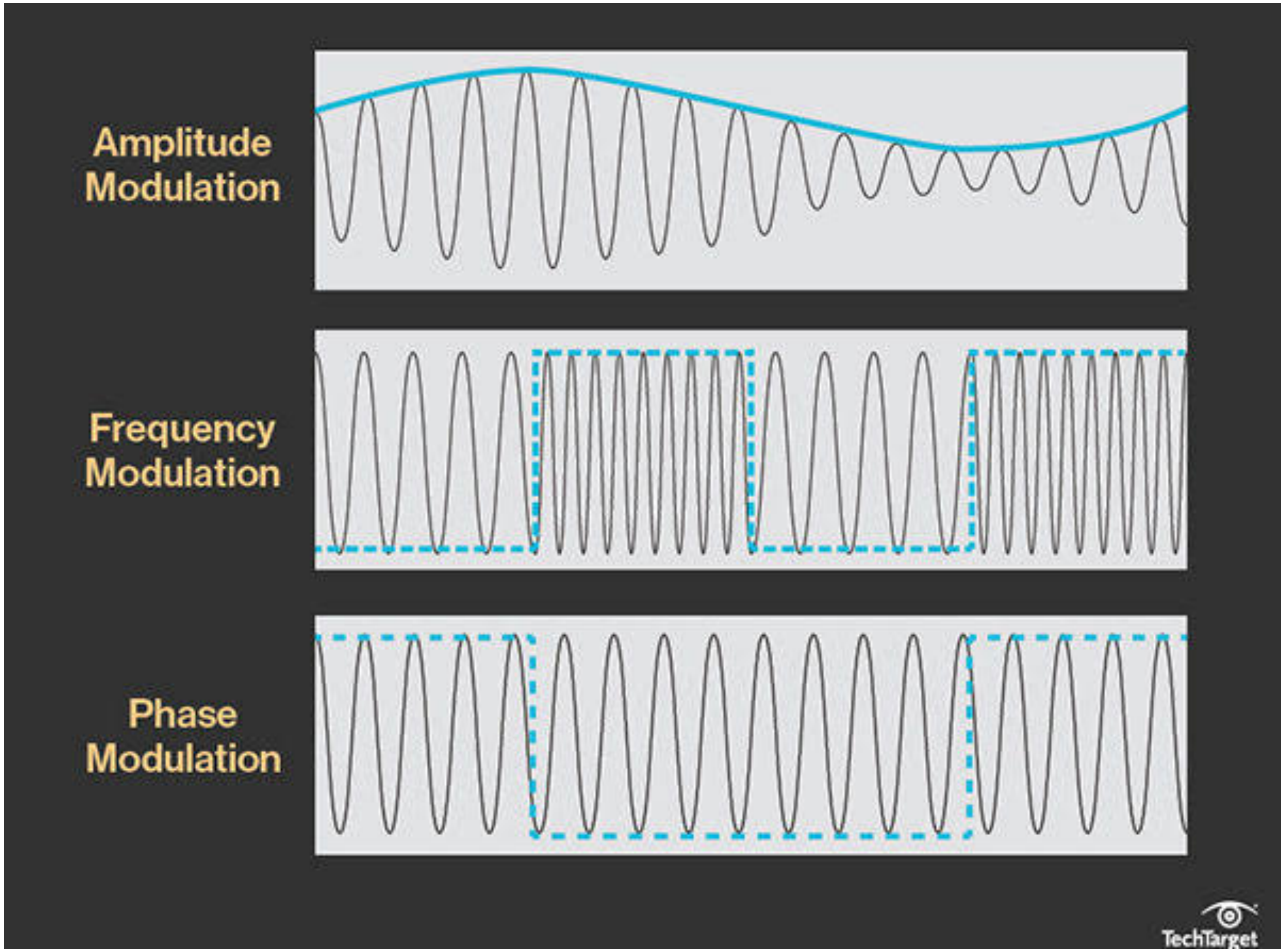
.**BLG 337 Slides** from İTÜ prepared by Assoc. Prof.Dr. Berk CANBERK

Analog and Digital Transmssions

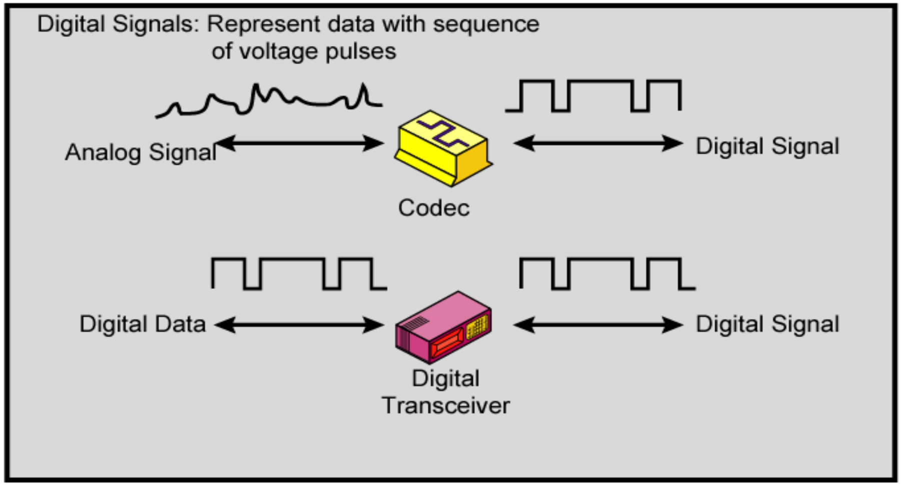
While a computer call is being done, the conversions and transmissions are done bye the modems and codecs.

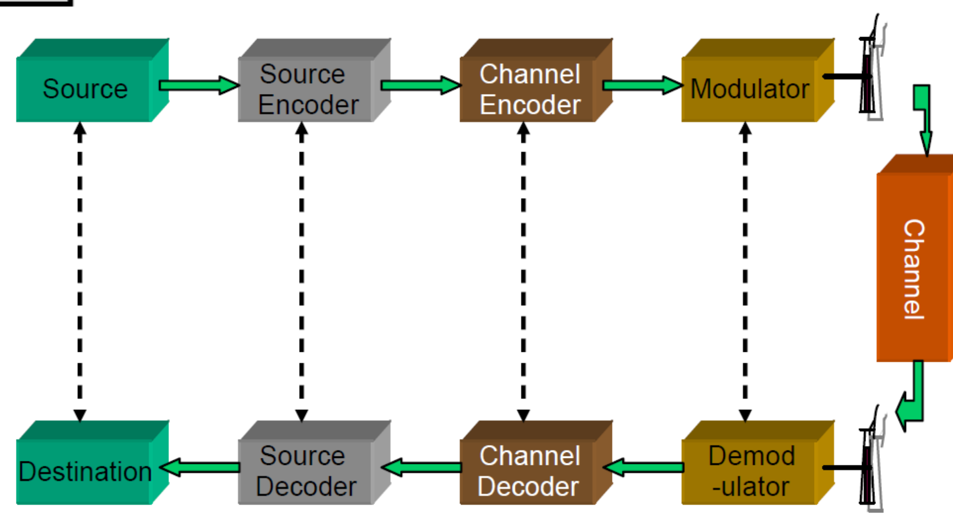


Modulation Techniques



Analog & Digital Data Carried By Digital Data





Encoding - Decoding

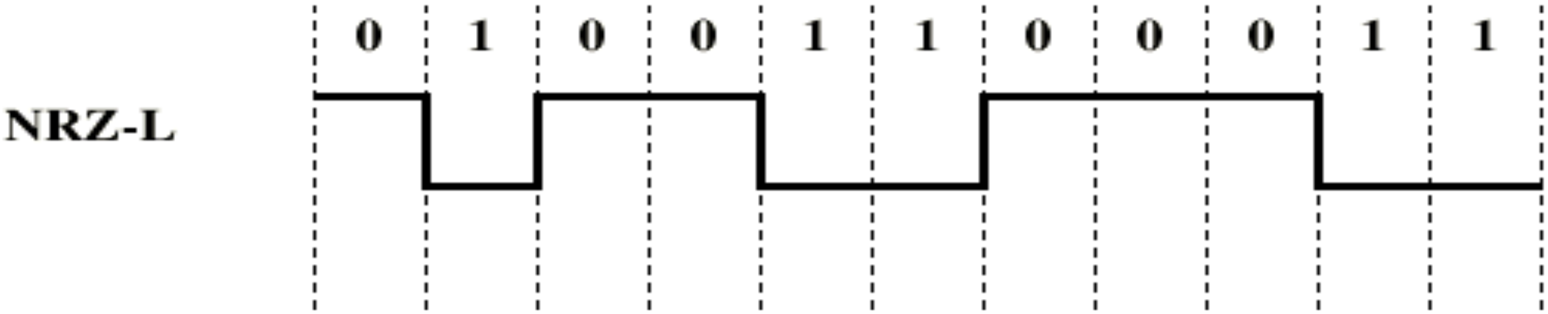
Encoding Types

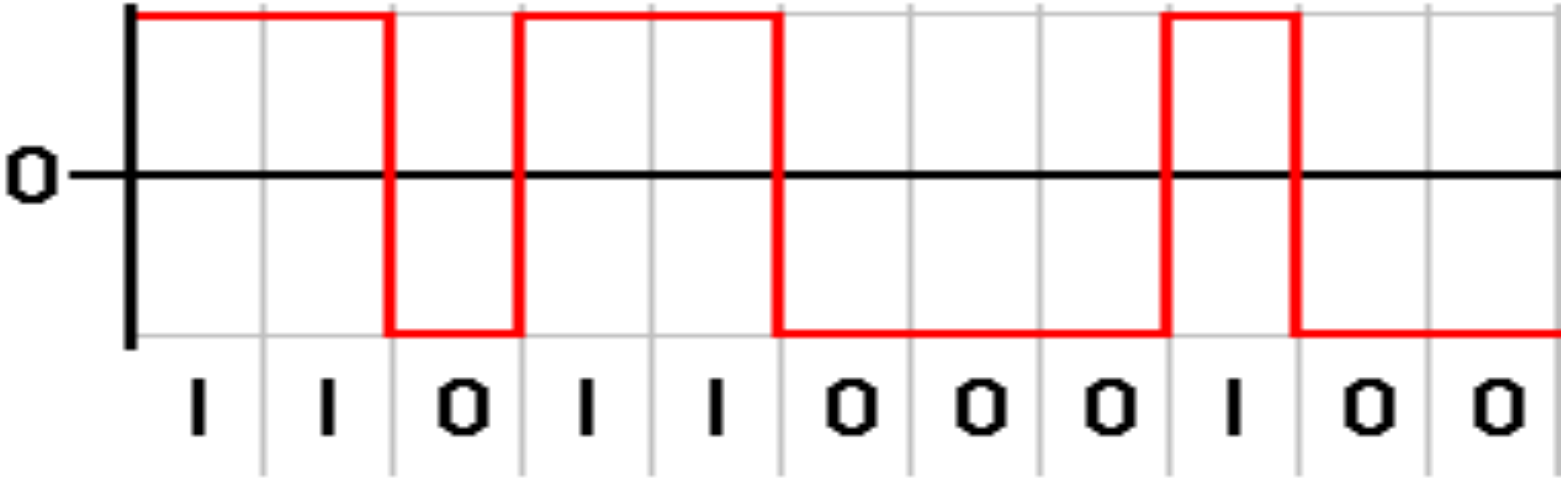
- ✓ **NRZ(Non-return to zero level)**
- ✓ **Manchester**

NRZ(Non-return to zero level)

- ✓ Absence of voltage for the 0 value, constant positive value for the value of 1.
- ✓ Voltage is constant for each of the values 1 and 0.
- ✓ Two separate voltages for 0 and 1 bits.
- ✓ Negative voltage for one value and positive for the other

NRZ(Non-return to zero level)

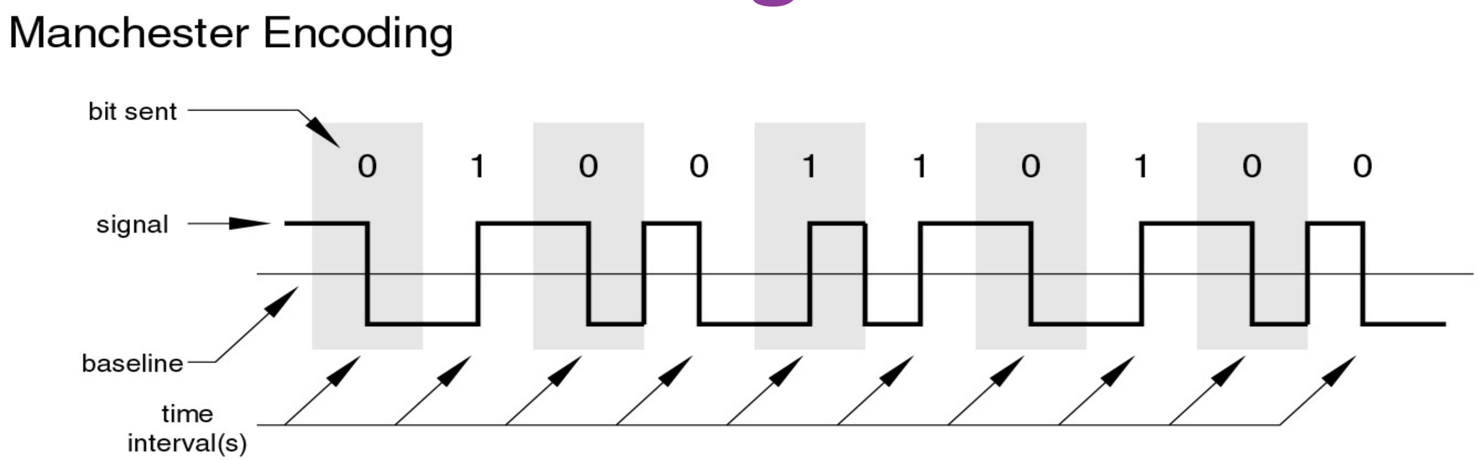


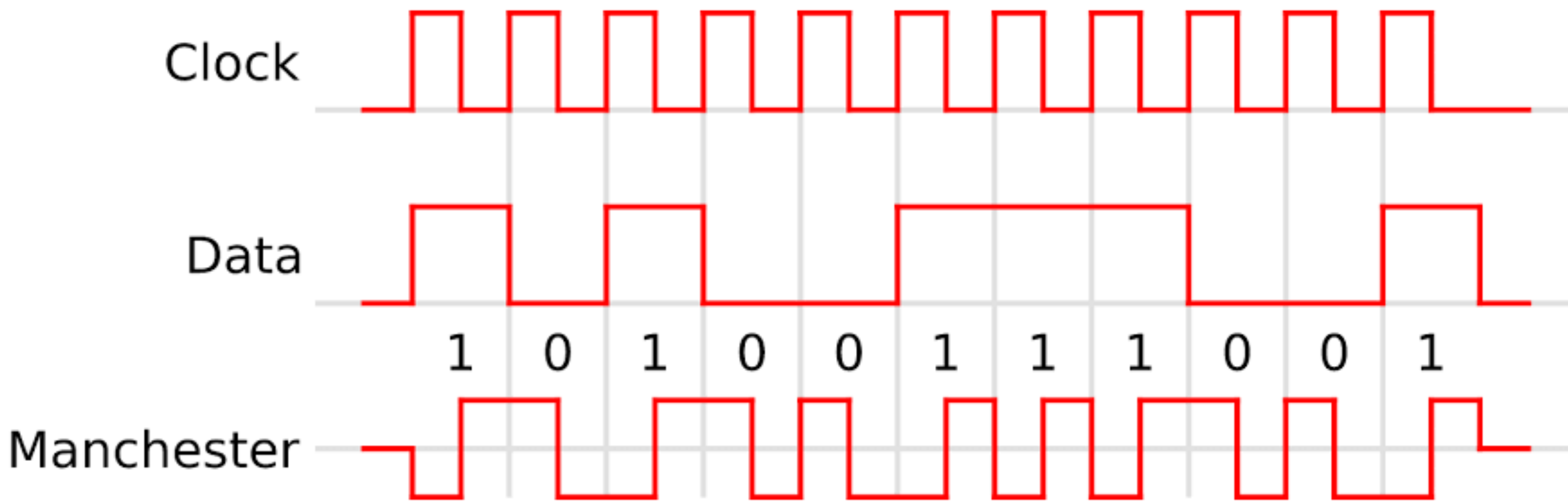


Manchester Encoding

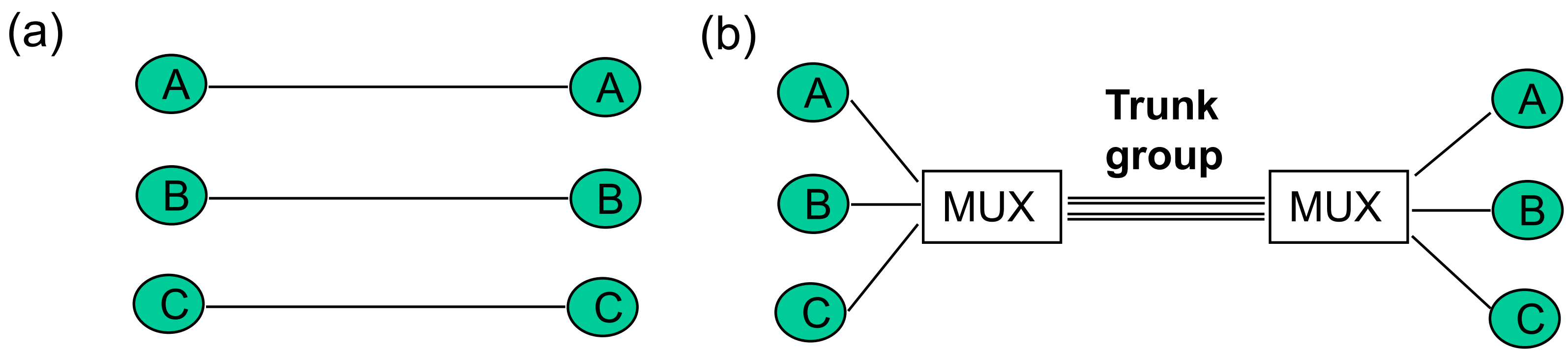
- ✓ Level change in the middle of each period
- ✓ **Low to high represents the value one.**
- ✓ **High to low represents the value zero.**
- ✓ The change is done by clock and data
- ✓ Used by IEEE 802.3Negative voltage for one value and positive for the other

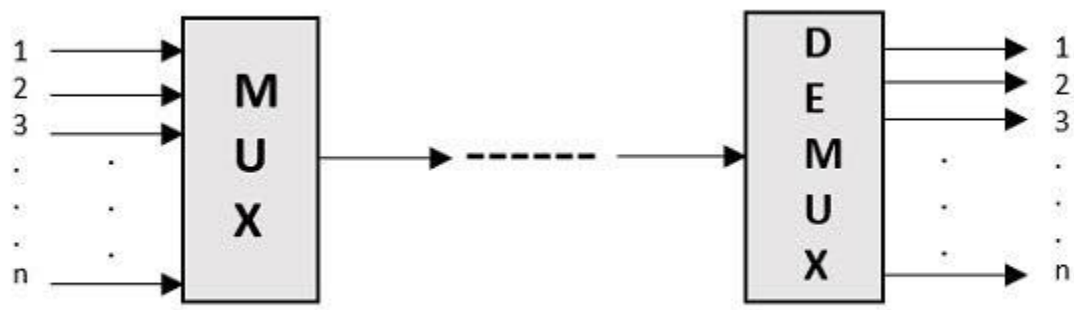
Manchester Encoding





Multiplexing





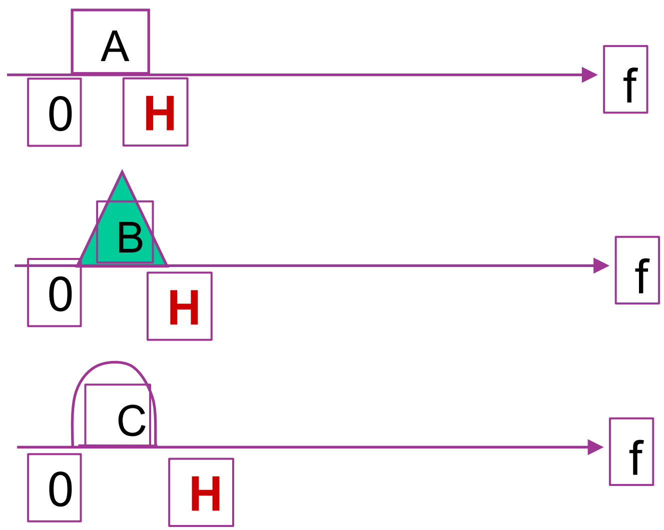
Multiplexing and Demultiplexing

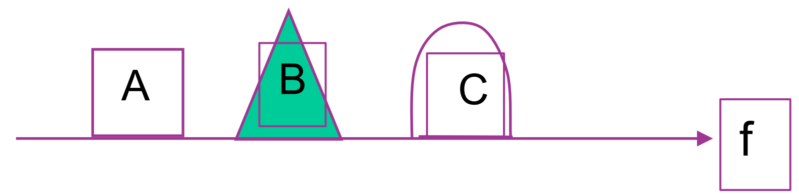
Multiplexing Types

- ✓ Frequency Division Multiplexing
- ✓ Wavelength Division Multiplexing
- ✓ Time Division Multiplexing

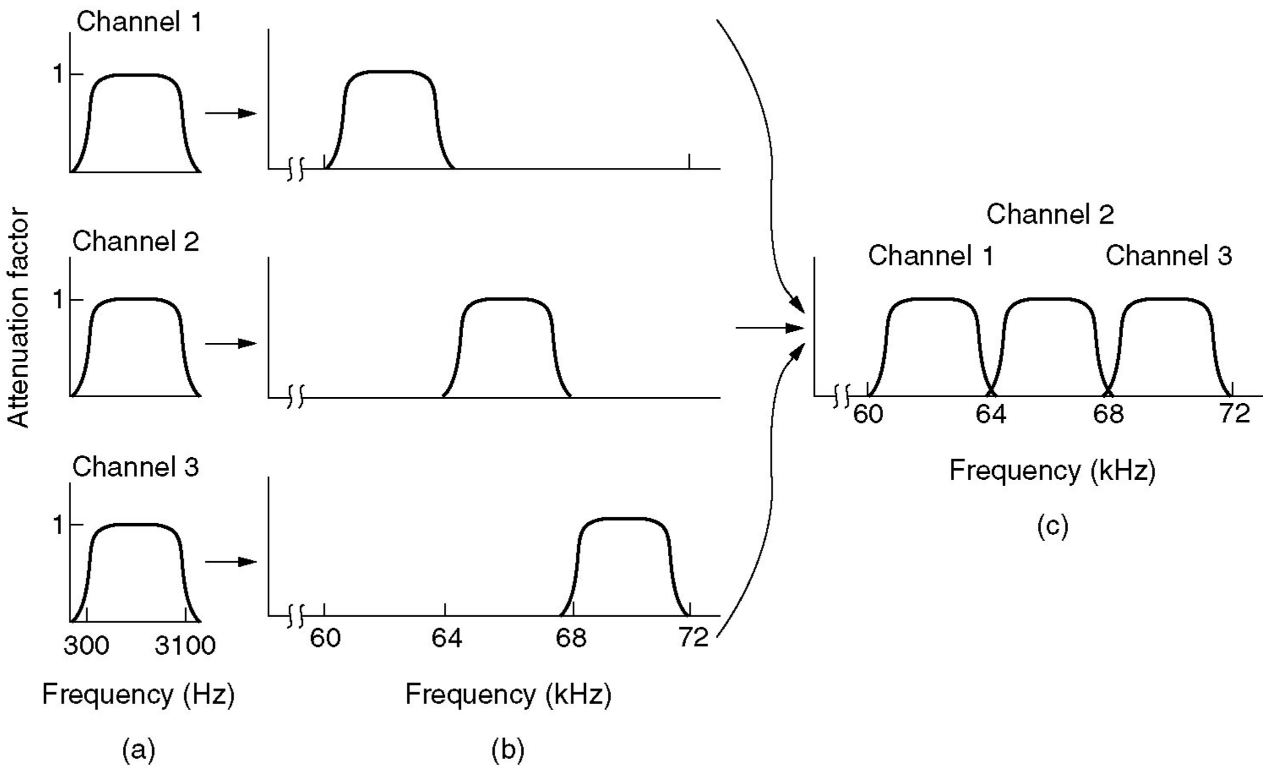
Frequency Division Multiplexing

- ✓ The signals are combined by the reference of bandwidth.
- ✓ Individual Signals. Combined Signals



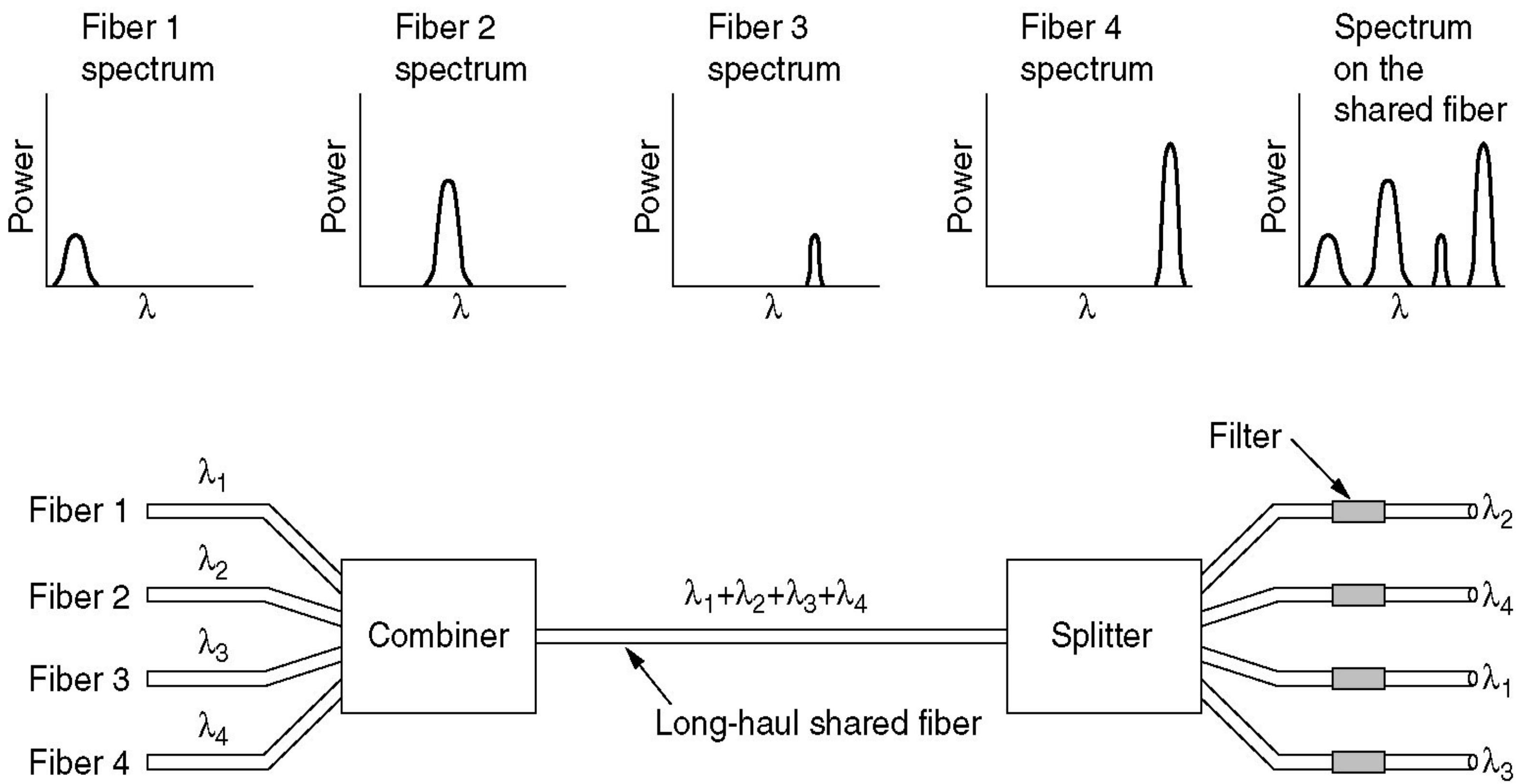


Frequency Division Multiplexing



- A: original frequencies
- B: Frequencies in the bandwidth
- C: The multiplexed channel

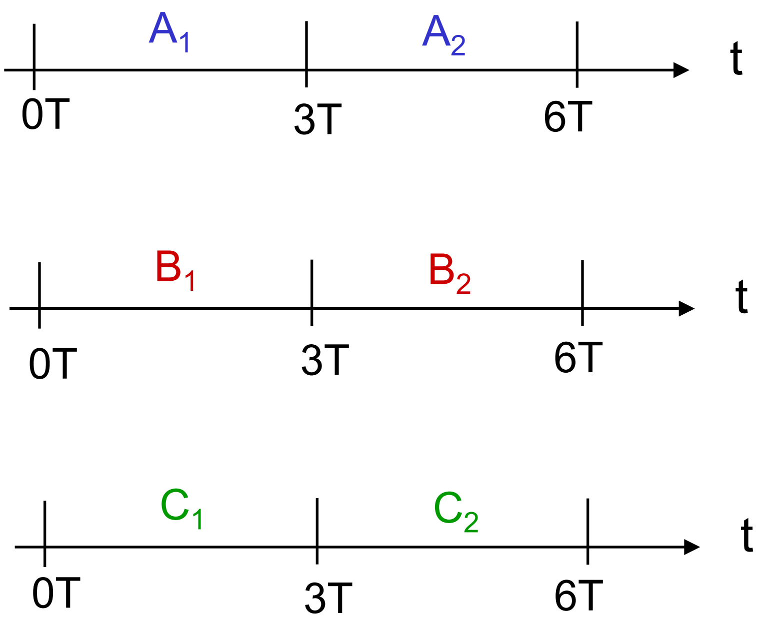
Wavelength Division Multiplexing



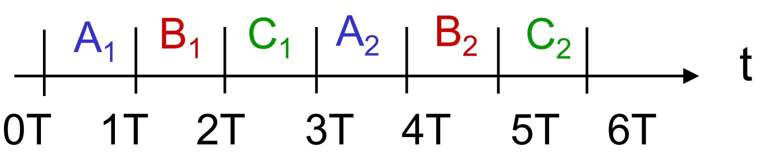
Time Division Multiplexing

- ✓ The signals are combined by the reference of time.
- ✓ Each signal transmits one unit in 3T seconds

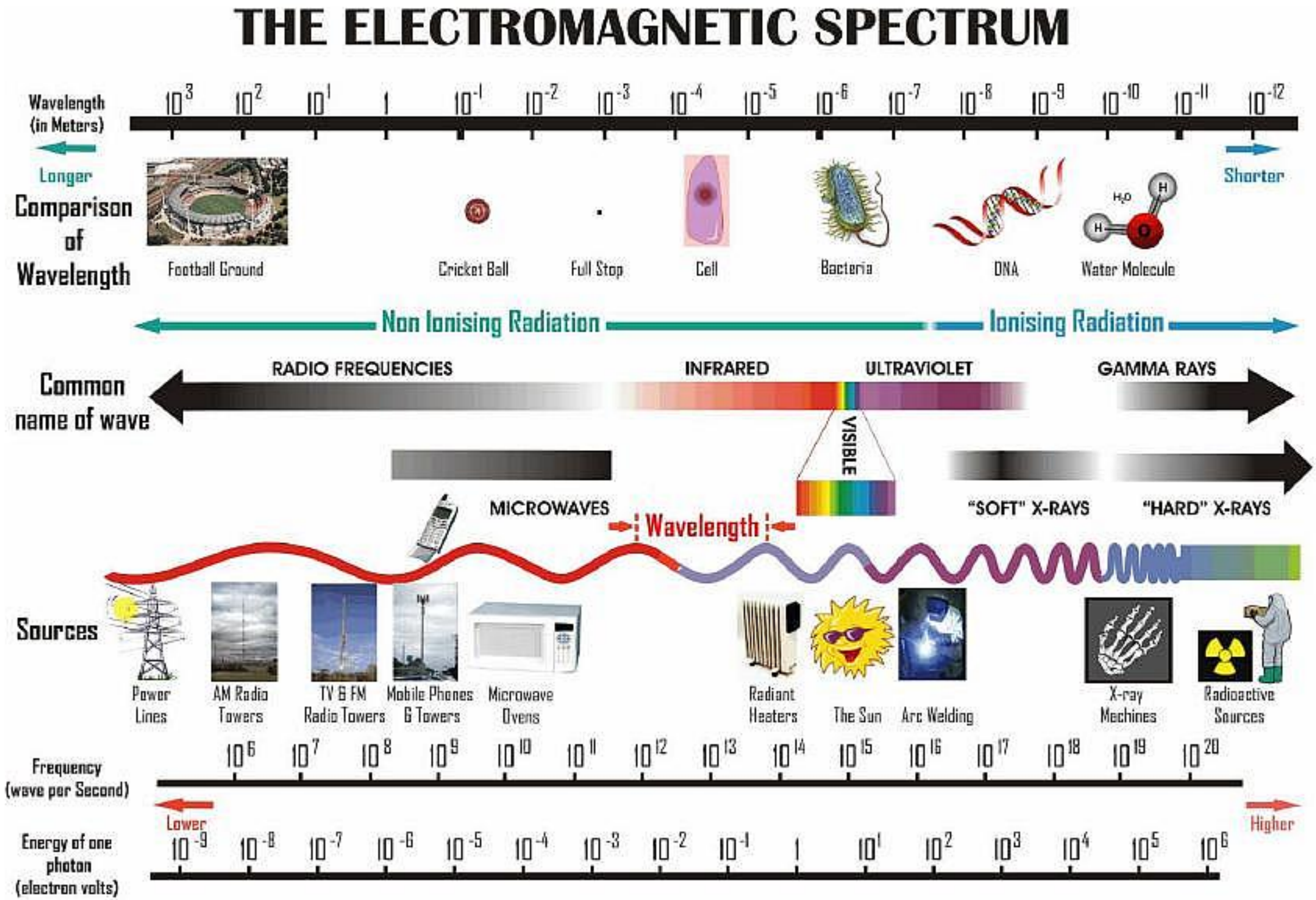
- ✓ Individual Signals.



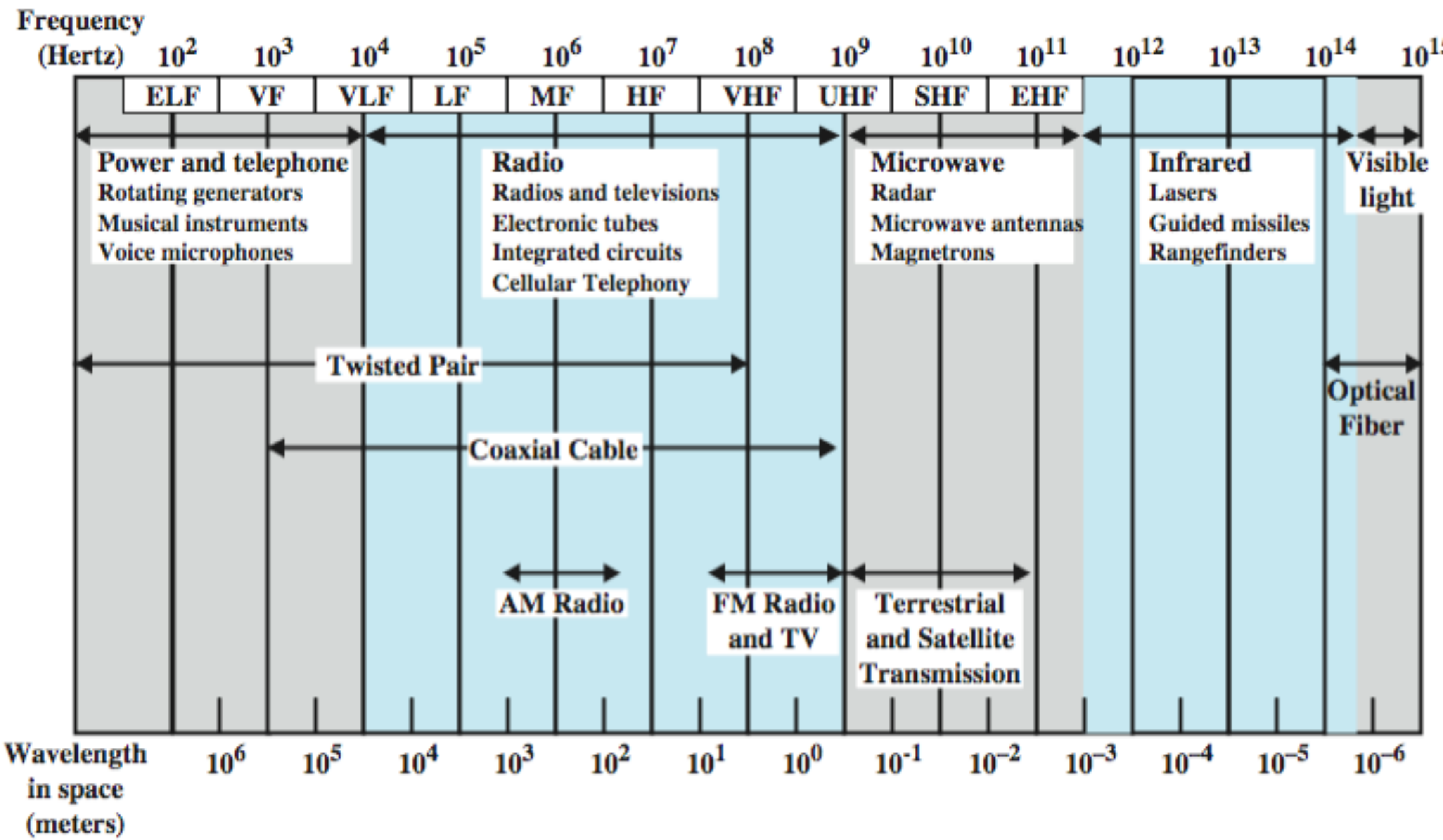
Combined Signals



Electromagnetic Spectrum



Electromagnetic Spectrum - 2



ELF = Extremely low frequency
VF = Voice frequency
VLF = Very low frequency
LF = Low frequency
MF = Medium frequency
HF = High frequency
VHF = Very high frequency
UHF = Ultrahigh frequency
SHF = Superhigh frequency
EHF = Extremely high frequency

Electromagnetic Waves

- ✓ The movement of electrons produces the electronic waves, and these waves could propagate through the space.

  - The speed of the electron vibrations directly effects the frequency
  - We can use the electromagnetic waves by using suitable antennas in receiving and sending them.

- ✓ **These waves are measured by "Hertz": the number of times the related wave is repeated in one second.**

- ✓ The name of it comes from the German scientist Heinrich Hertz who observed in 1887, and it is also firstly introduced by James Maxwell in 1865.

The features of Electromagnetic Waves

✓ The main features of the electromagnetic waves:
  - amplitude
  - f=frequency
  - l=wavelength
  - C=speed of light

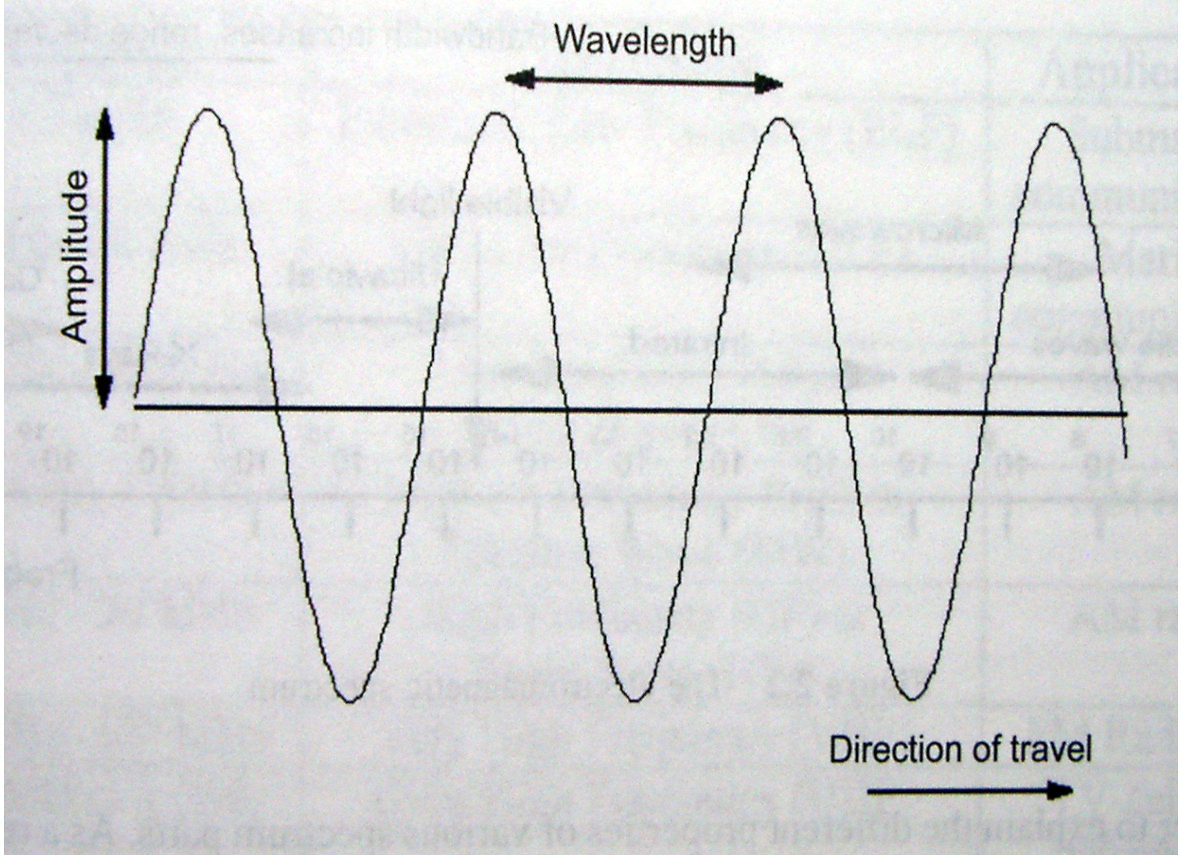


Figure 2.1 Wavelength and amplitude of an electromagnetic wave

Electromagnetic Spectrum

- ✓ spectrum: range of electromagnetic radiation
- ✓ band: spectrum parts

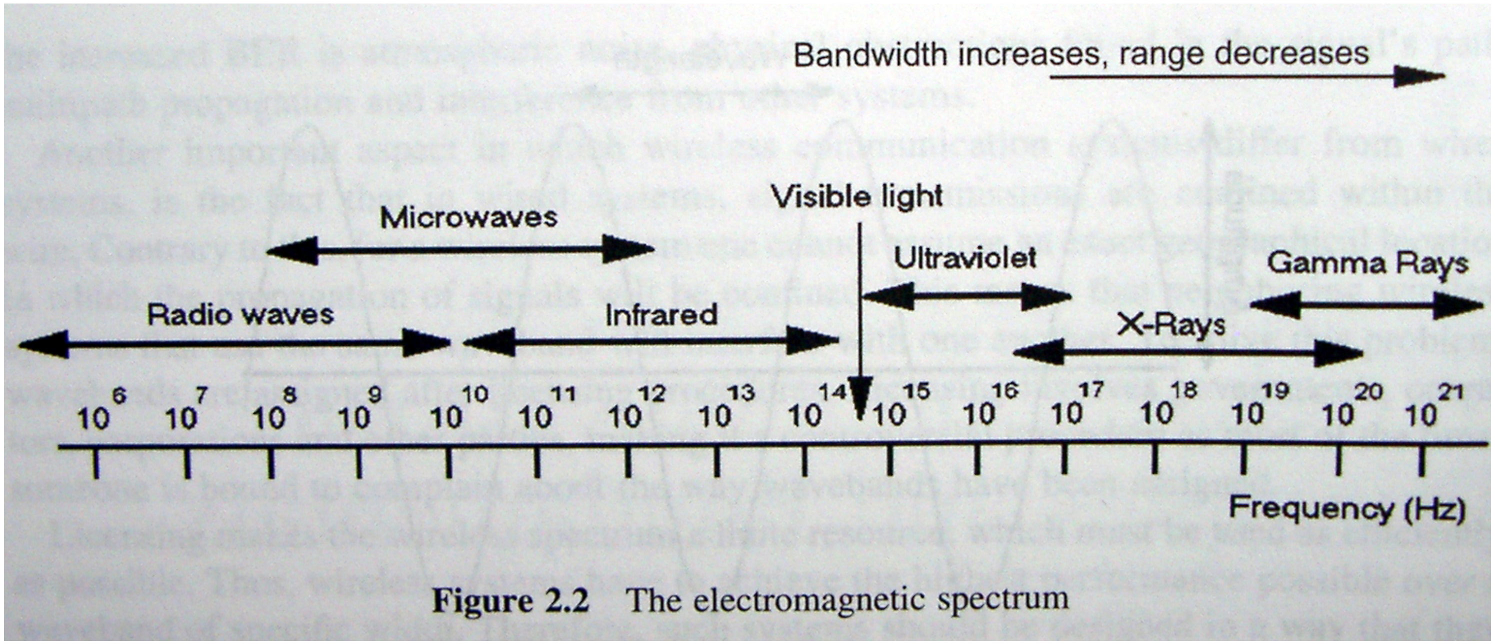


Figure 2.2 The electromagnetic spectrum

Capacity (more data to carry per cycle) ↑

Range of the band ↓

Radio and Micro Waves

- HF band used for worldwide transmission:
  - HF signals can travel very large distances, due to its nature that can be reflected off the ionosphere.

Frequency	Band name	Applications
< 3 KHz	Extremely Low Frequency (ELF)	Submarine communications
3 KHz -30 KHz	Very Low Frequency (VLF)	Marine communications
20 KHz -300 KHz	Low Frequency (LF)or Long Wave (LW)	AM radio
300 KHz -3 MHz	Medium Frequency (MF) or Medium Wave (MW)	AM radio
3 MHz - 30 MHz	High Frequency (HF) or Short Wave (HW)	AM radio
30 MHz -300 MHz	Very High Frequency (VHF)	FM Radio-TV
300 MHz - 3 GHz	Ultra High Frequency (UHF)	TV-cellular telephony
3 GHz - 30 GHz	Super High Frequency (SHF)	Satellites
30 GHz - 300 GHz	Extra High Frequency (EHF)	Satellites-radars

Figure 2.3 The various radio bands and their common use

Microwaves

- ✓ smaller and weaker wavelengths than radio waves
- ✓ easily effected by objects

Frequency	Band name	Applications
0.4 GHz - 1.5 GHz	L	Broadcasting-cellular
1.5 GHz - 5.2 GHz	S	Cellular
3.9 GHz - 6.2 GHz	C	Satellites
5.2 GHz - 10.9 GHz	X	Fixed wireless-satellite
10.9 GHz - 36 GHz	K	Fixed wireless-satellite
36 GHz - 46 GHz	Q	Fixed wireless
46 GHz -56 GHz	V	Future satellite
56 GHz -100 GHz	W	Future cellular

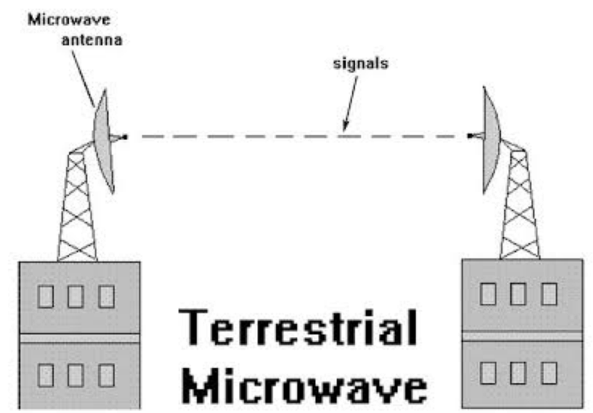
Figure 2.4 The various microwave bands and their common use

Antennas

- Electrical conductor that collect outcoming electromagnetic energy and propagate the electromagnetic energy.
- Transmission
  - Sended as Radio frequency energy from transmitter
  - Converted to electromagnetic energy
  - Done By antenna
  - Radiated into surrounding environment
- Reception
  - Electromagnetic energy impinging on antenna
  - Converted to radio frequency electrical energy
  - Fed to receiver
- Same antenna often employed for transmission and reception

Terrestrial Microwave

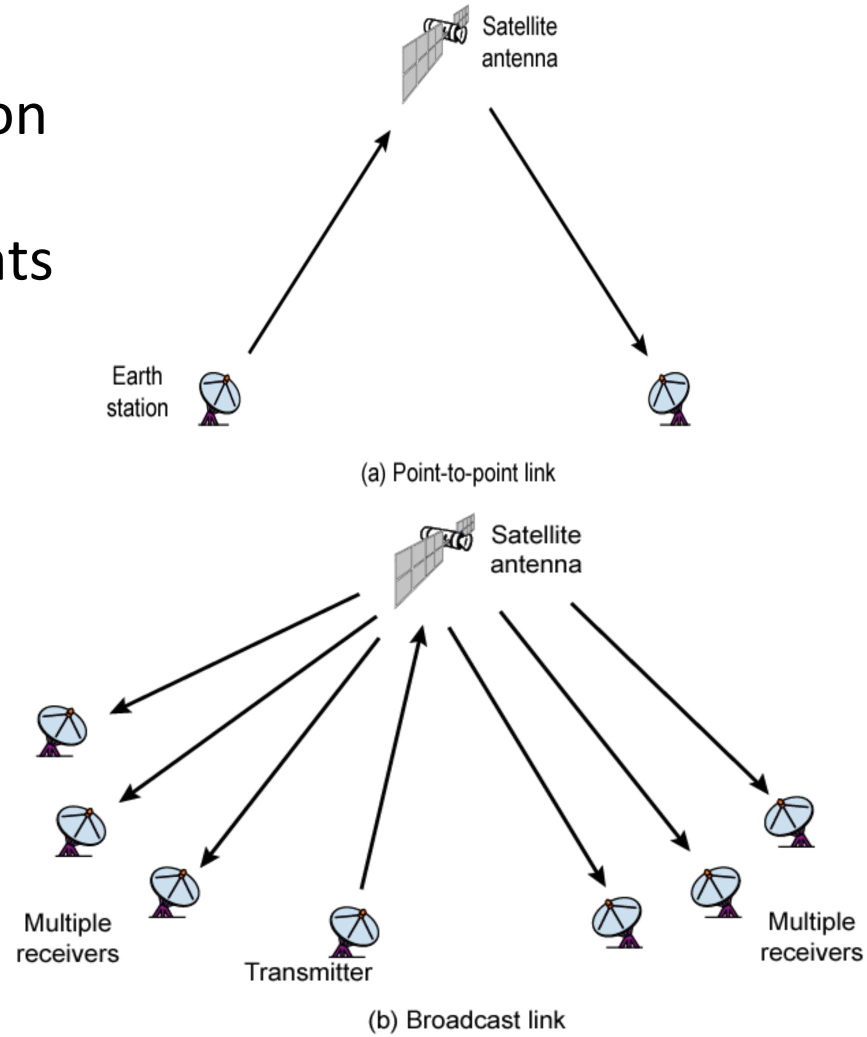
- Line of sight:depends on the sight
- Parabolic dish (Antenna shape)
- Focused beam
- Long distance telecommunications
- Higher frequencies give higher data rates



Pic6.12 Terrestrial Microwave

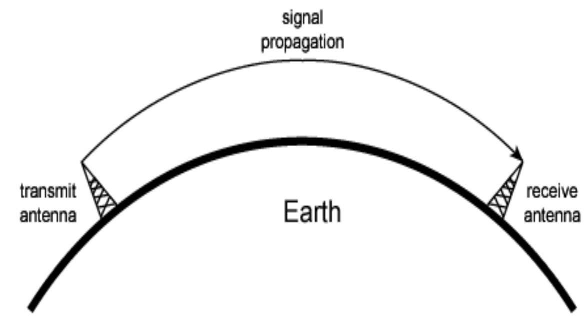
Satellite Microwave

- ✓ Uses satellite as a relay station
- ✓ Satellite receives on one frequency, amplifies or repeats signal and transmits on another frequency
    - Television
    - Long distance telephone
    - Private business networks

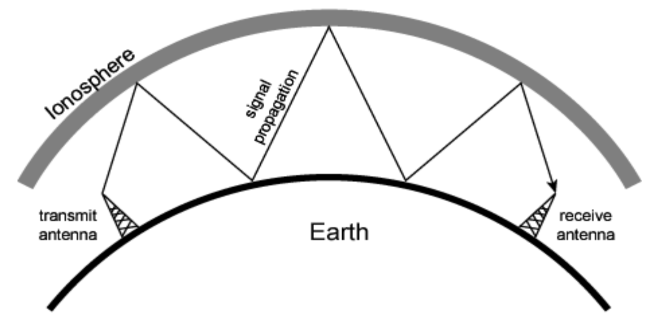


Wireless Propagation

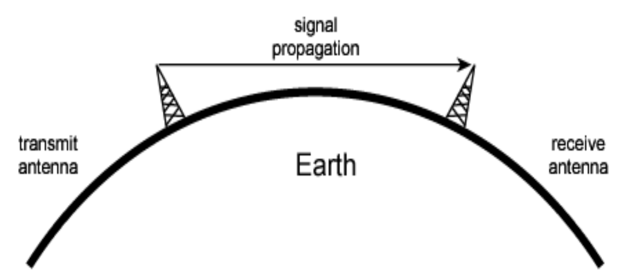
- Signal travels along three routes:
  - **Ground wave**
    - Follows contour of earth
    - Up to 2MHz
    - Used as AM radio
  - **Sky wave**
    - Amateur radio, BBC world service, Voice of America
    - Signal reflected from ionosphere layer of upper atmosphere
    - (Actually refracted)
  - **Line of sight**
    - May be further than optical line of sight due to refraction
    - Above 30Mhz



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



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



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

Infrared

- emitted by very hot objects
  - A good example: human body (night vision applications)
  - frequency changes due to the temperature of the emitting body
- line-of-sight, point-to-point
  - of no use outdoors (interfered by heat of sun)
- Short distances: 10 meters
- IrDA: Infrared Data Association

Microwave and Infrared Bands

- ✓ Most wireless networking traffic is in the microwave frequency bands.
  - some licensed, some unlicensed
- ✓ Infrared:
  - for short-range wireless communication

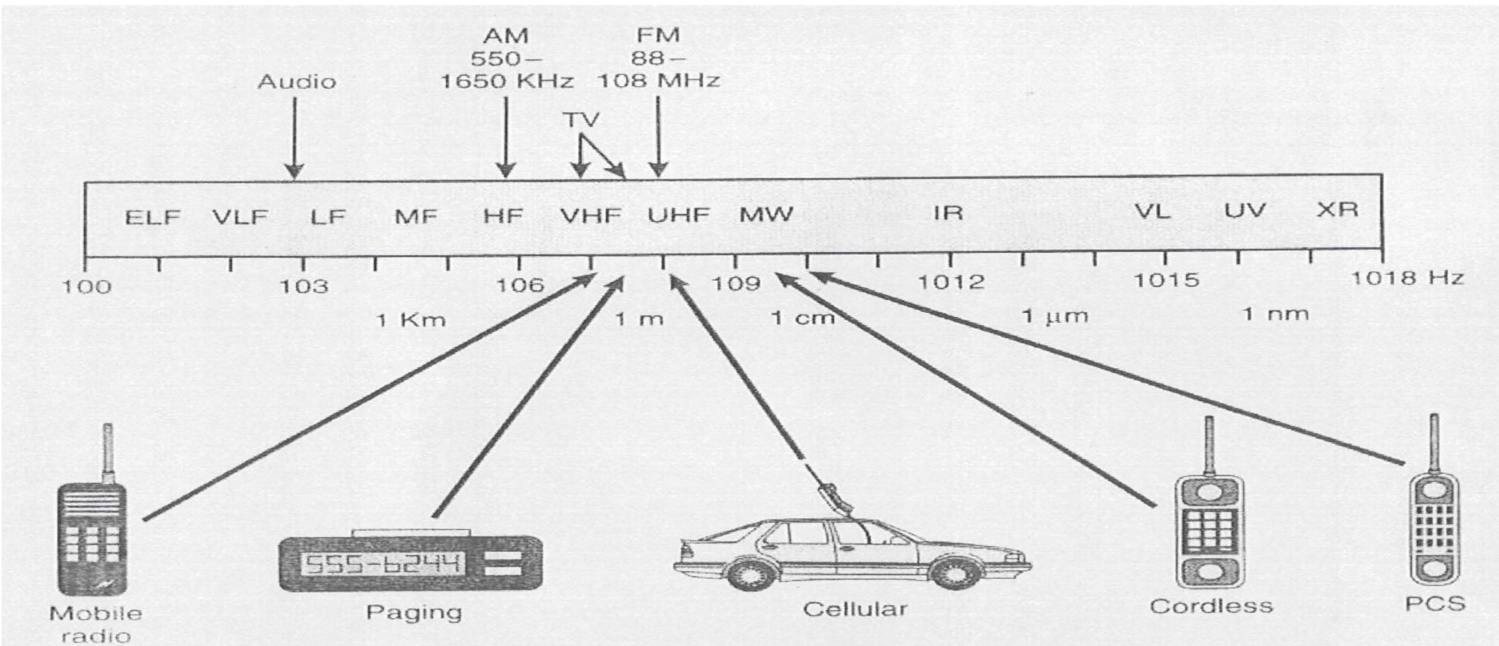


Figure 2.12 The radio spectrum.

Spectrum Regulation

- ITU = Int'l Telecommunications Union
  - a worldwide spectrum regulation org.
  - the world usage is divided into 3 parts:
    - American continent
    - Europe, Africa, and former Soviet union
    - rest of Asia and Oceania
- Methods for assigning spectrum
  - Lottery (to be objective and fair)
  - Comparative bidding
    - such as pricing, technology, etc.
  - Auction (who pays more wins!)

Licensed Microwave Band

- The valid time of a license is 10 years.
  - A company can’t have the license and not use it.
  - Bandwidth is regarded as a resource that the public wants and needs.
- Examples: cellular, paging, PCS

Unlicensed Microwave Band

- Known as ISM band.
  - industrial, scientific, and medical
  - WiFi!

- Also on the same microwave band, but no license required.
  - **spreading spectrum** is essential : to prevent from interfering primary (licensed) users.

Model of Wireless Propagation

- ✓ Free Space Path Loss
- ✓ Slow/Fast Fading

Shannon's Formula (Recap)

- an upper bound on the bit rate W of any channel of bandwidth H Hz:

$$W = H \log_2(1 + S/N)$$

S/N = signal to thermal noise ratio

- For conditions in real world, the calculated number is practically impossible:
  - free space path loss
    - proportional to r^{-2}, where r is the distance between transmitter and receiver (sometimes at higher exponent)
  - Doppler shift
    - a signal transmitter and receiver are moving relative to one another
  - slow/fast fading

Main Terms

- ✓ Reflection:
  - The electromagnetic wave falls on an object whose dimension is much larger than the wavelength of the current wave of the object.
- ✓ Scattering:
  - The wave falls on an object that has dimensions which are in the order of the wavelength
- ✓ Diffraction (or shadowing):
  - when the wave falls on an impenetrable object
  - in this case, the secondary waves continue behind the obstructing body

Types of Slow Fading

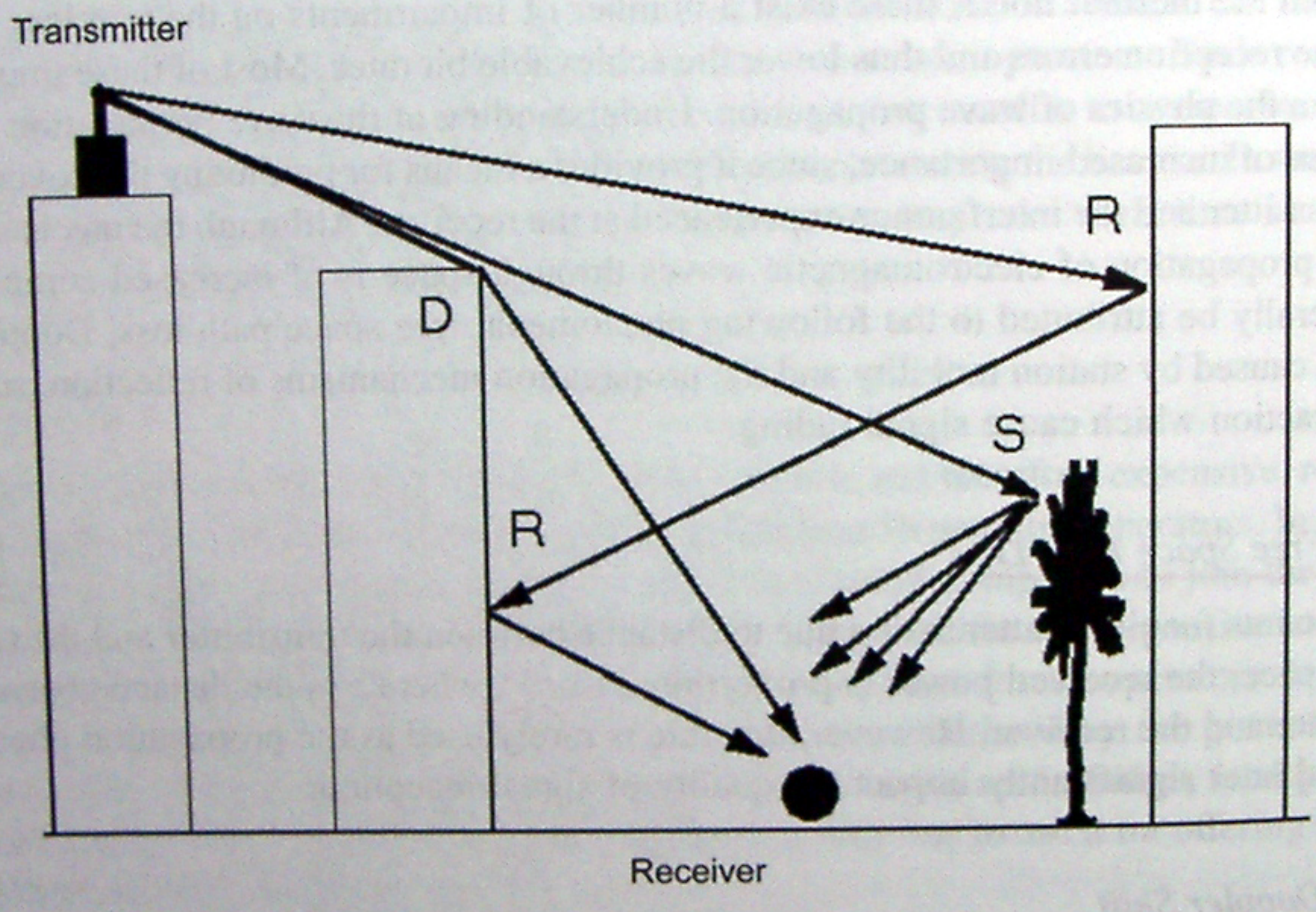


Figure 2.5 Reflection (R), diffraction (D) and scattering (S)

Fast Fading : Examples

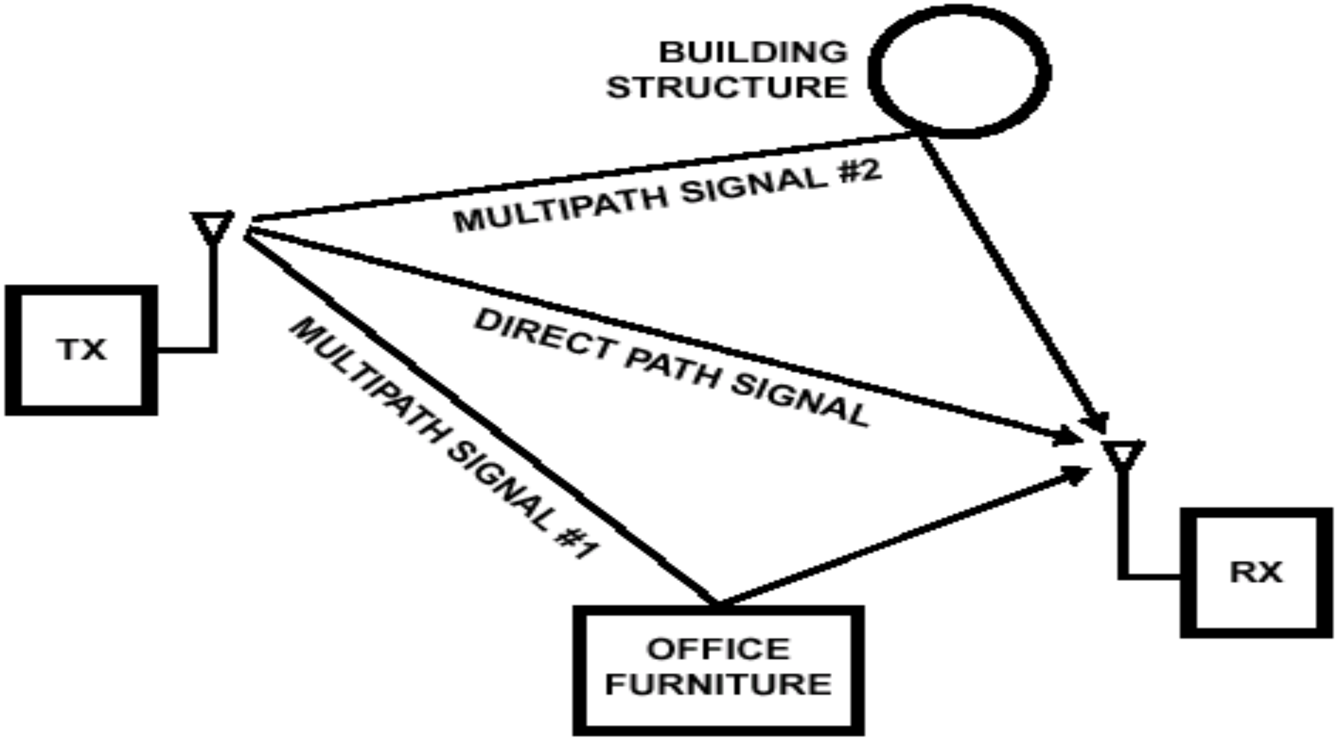


FIGURE 2. MULTIPATH

Fast Fading : Examples

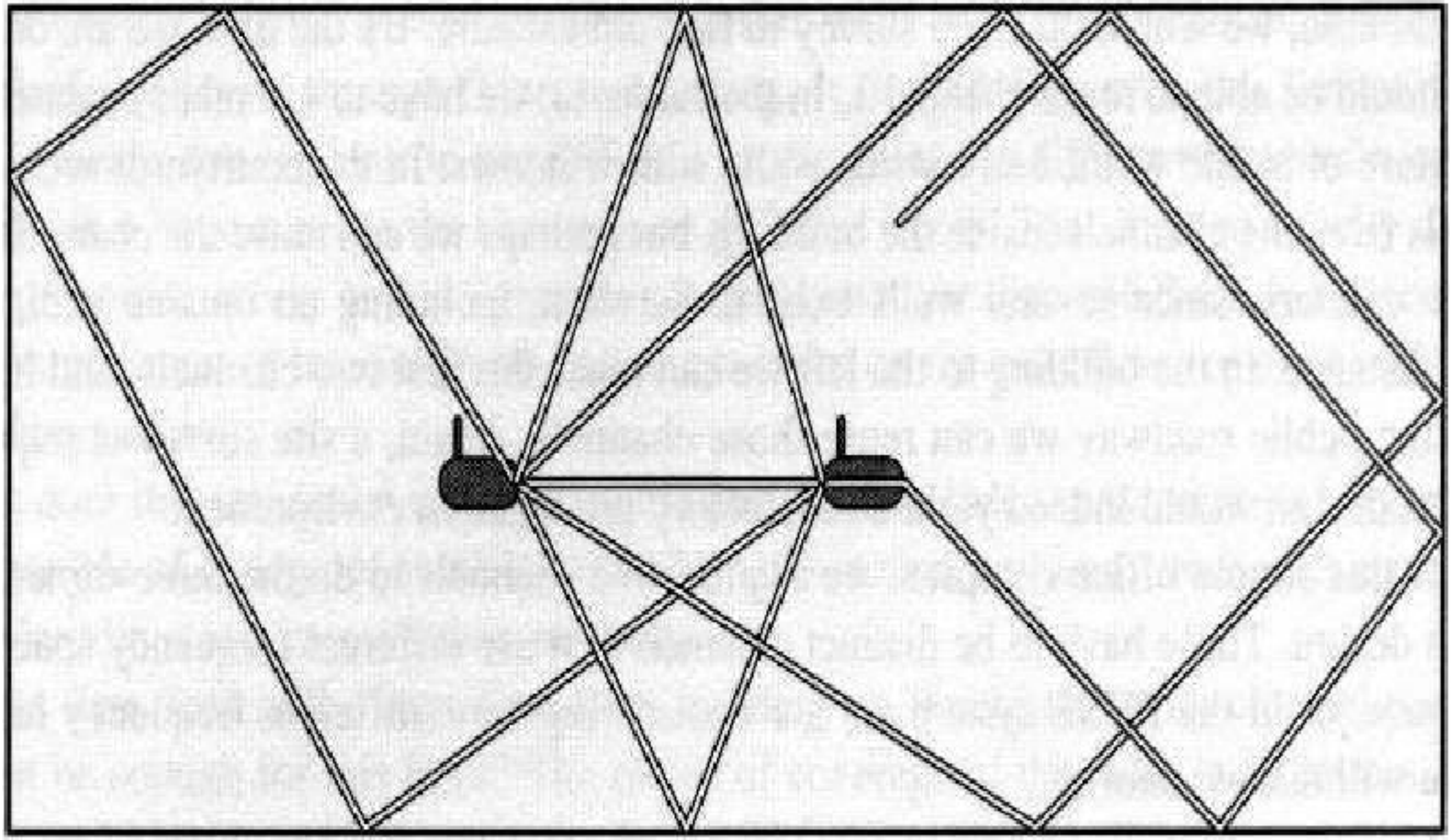


Figure 6.4 Multipath example indoors.