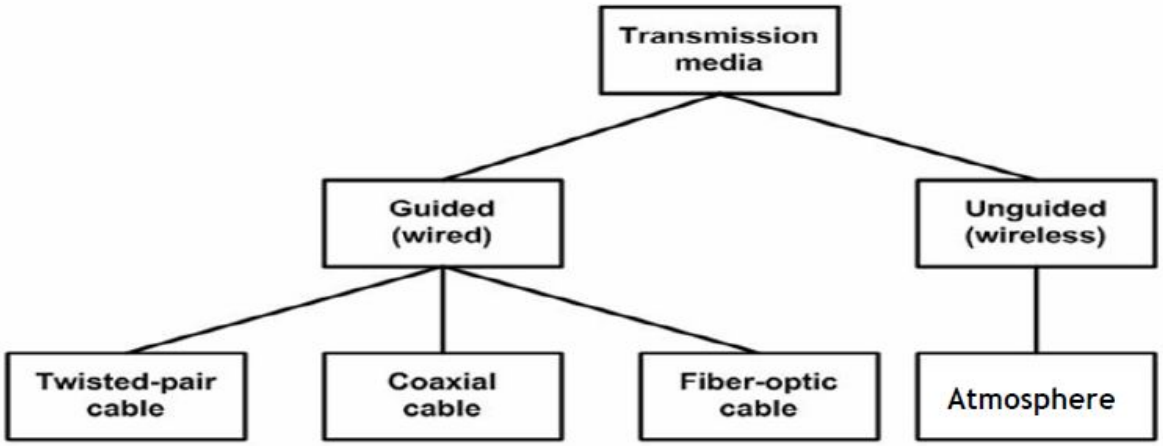
SRM UNIVERSITY AP
Amaravati

Computer Networks

Physical Layer

Transmission Terminology

- Data transmission occurs between a transmitter & receiver via some medium
- Guided medium
  - eg. twisted pair, coaxial cable, optical fiber
- Unguided / wireless medium
  - eg. air, water, vacuum

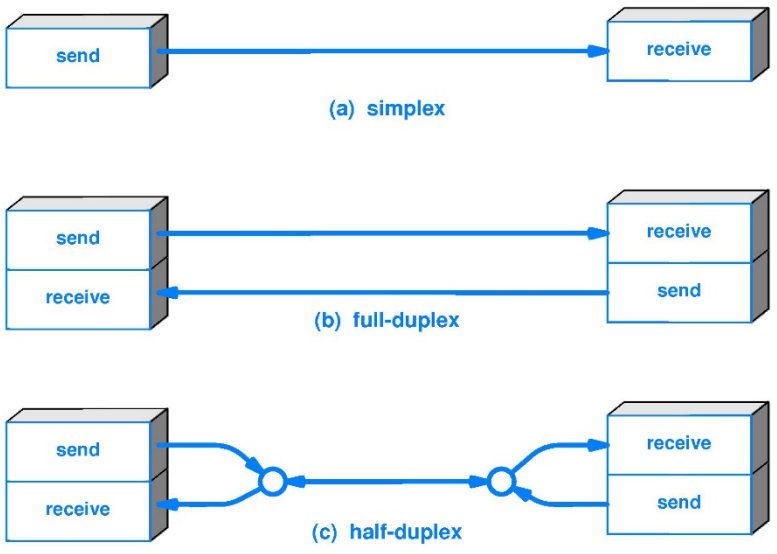


Transmission Terminology

- Direct link
  - no intermediate devices
- Point-to-point
  - direct link
  - only 2 devices share link
- Multi-point
  - more than two devices share the link

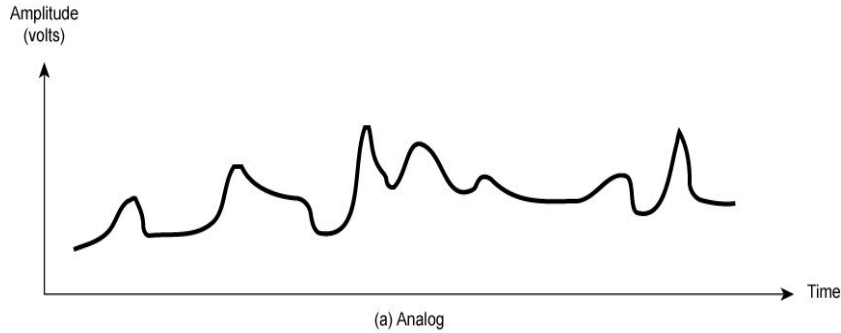
Transmission Terminology

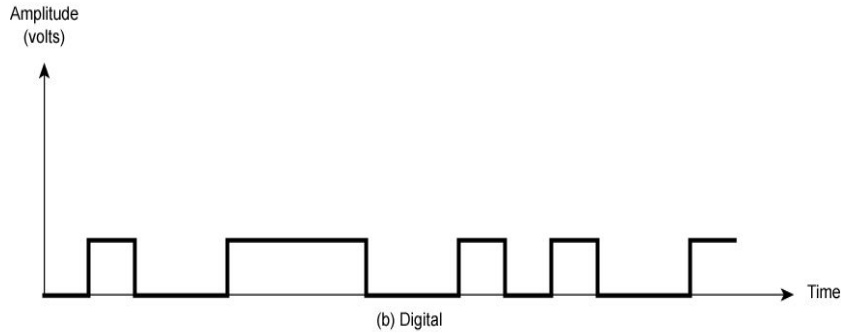
- Simplex
  - one direction
    a) eg. television
- Half duplex
  - either direction, but only one way at a time
    a) eg. police radio
- Full duplex
  - both directions at the same time
    a) eg. telephone



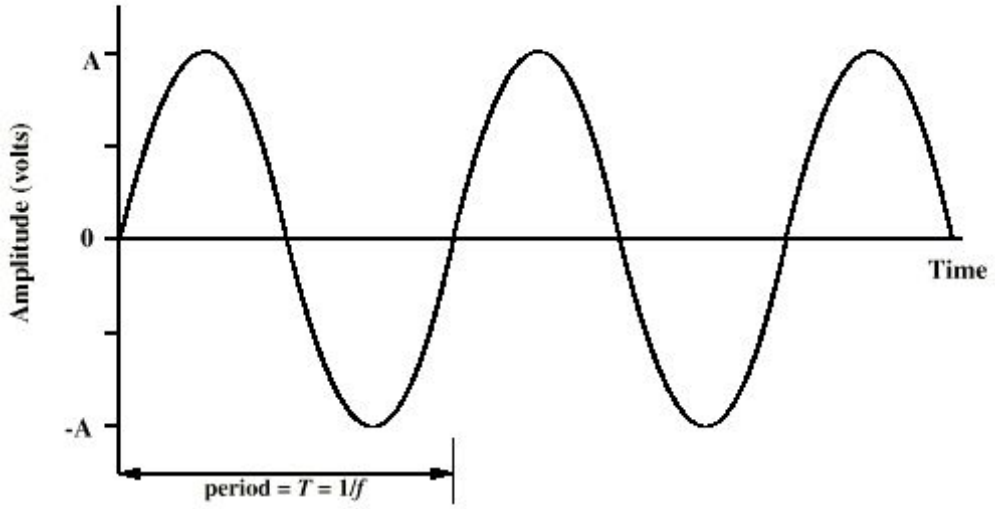
Frequency, Spectrum and Bandwidth

- Time domain concepts
  - Analog signal
    - Varies in a smooth way over time
  - Digital signal
    - Maintains a constant level then changes to another constant level
  - Periodic signal
    - Pattern repeated over time
  - Aperiodic signal
    a) Pattern not repeated over time

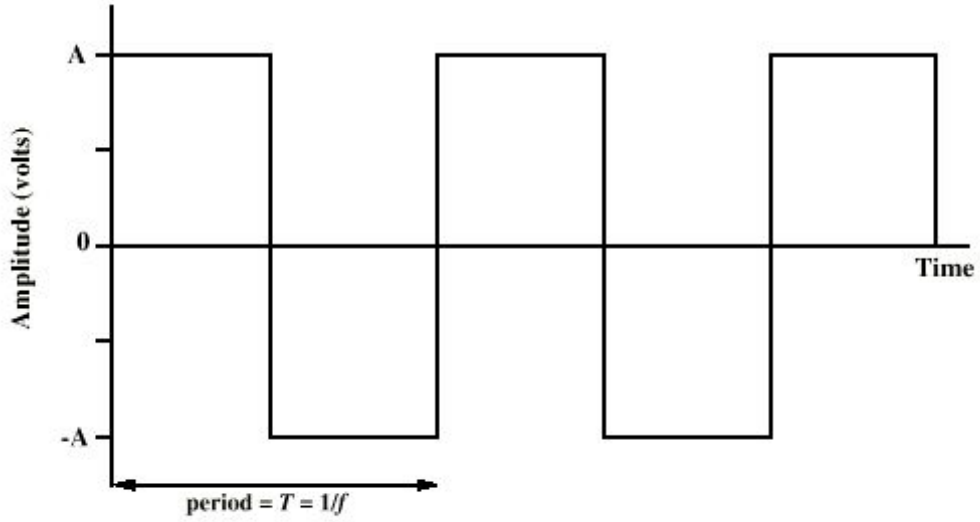




Periodic Signals



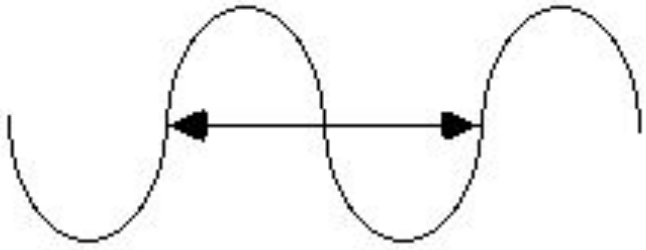
(a) Sine wave



(b) Square wave

Wavelength, Period and Frequency

- Arrow indicates one cycle of the signal.
- Period(T) : The time it takes to complete a cycle
- Frequency : Number of cycles per second
  - Frequency=1/T

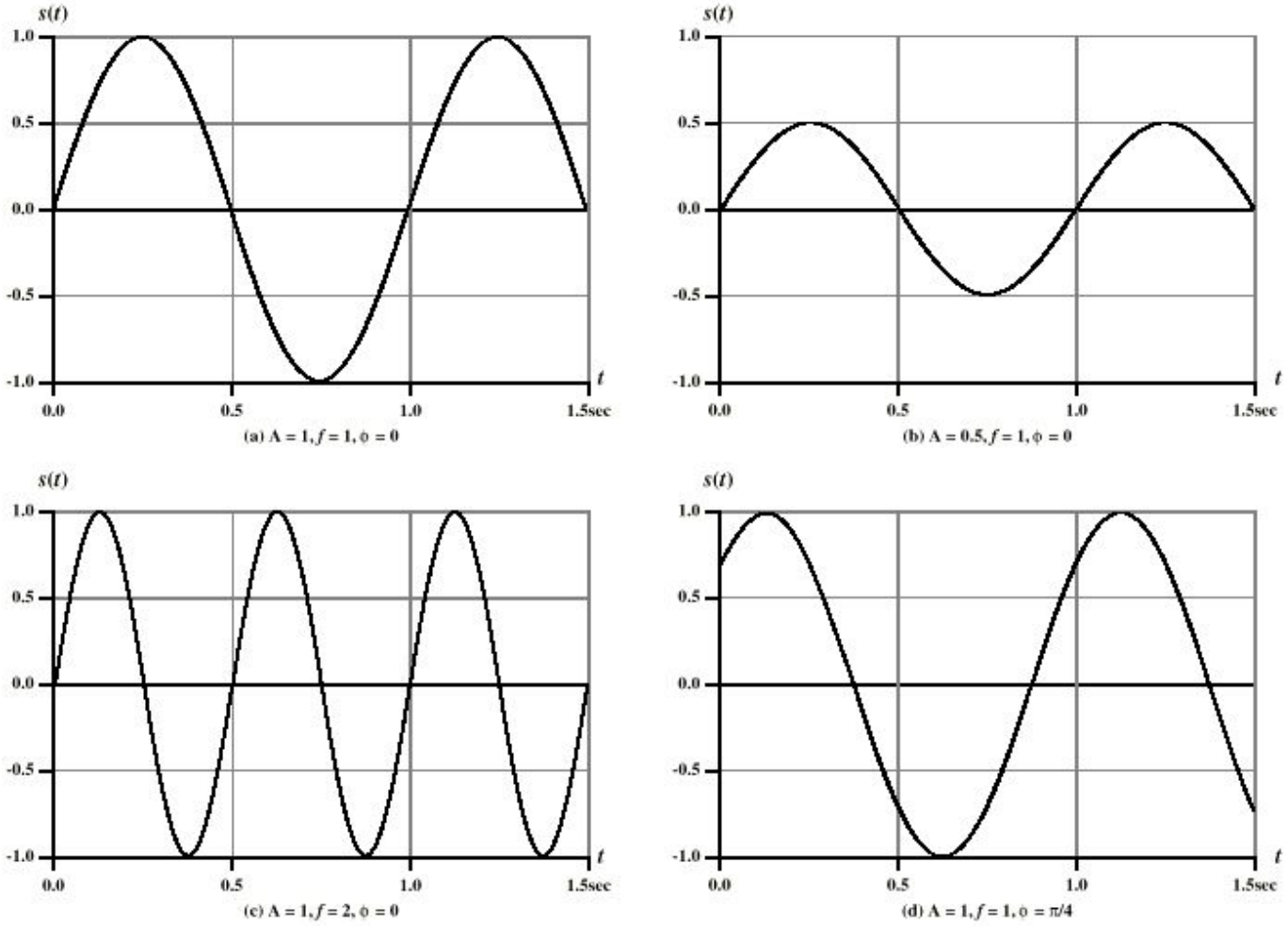


- Frequency (f)
  a) Rate of change of signal
  b) Hertz (Hz) or cycles per second
  c) Period = time for one repetition (T)
  d) T = 1/f
  e) Wavelength : Distance occupied by one cycle.
  f) Amplitude : Value of the signal at different instants of time.
  g) Peak amplitude (A) : Maximum strength of signal
  h) Volts

a) Phase (φ)
  b) Relative position in time

http://www.procato.com/calculator-wavelength-frequency/

Varying Sine Waves
$s(t) = A \sin(2\pi ft + \Phi)$

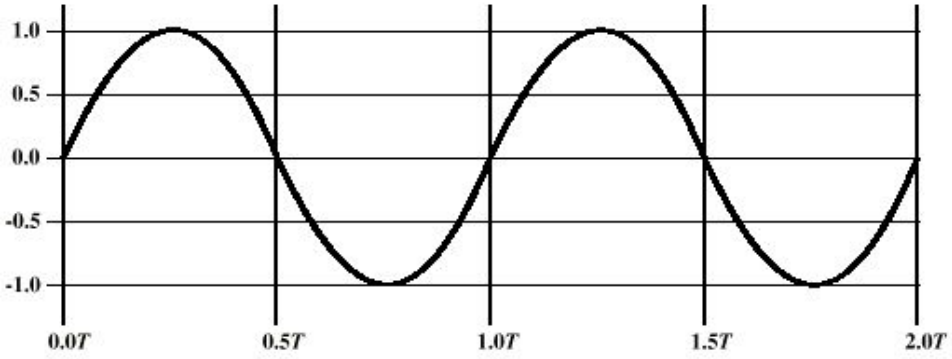


Frequency Domain Concepts

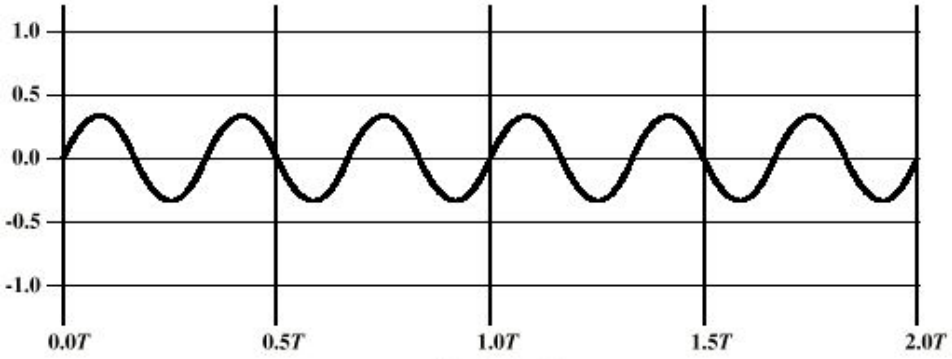
- Signals are made up of many frequencies
- Components are sine waves
- Fourier analysis can show that any signal is made up of component sine waves
- Can plot frequency domain functions

Addition of Frequency Components (T=1/f)

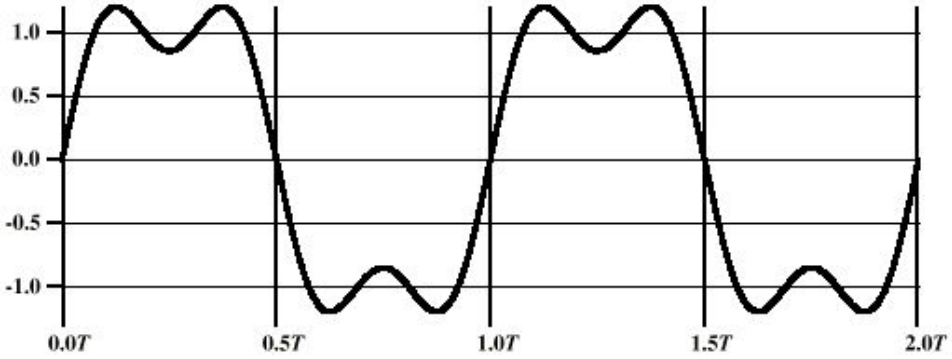
- c is sum of *f* & *3f*



(a) sin ($2\pi ft$)



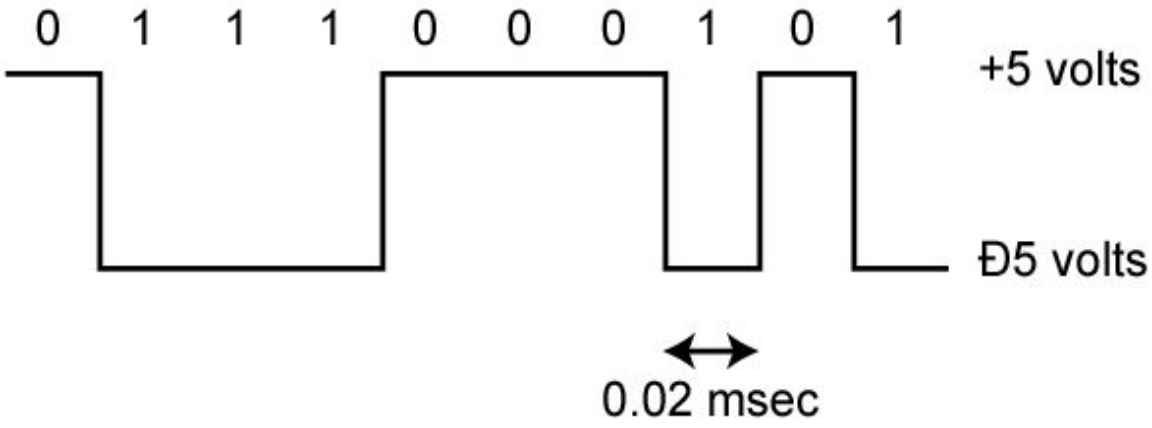
(b) (1/3) sin ($2\pi(3f)t$)



(c) ($4/\pi$) [sin ($2\pi ft$) + (1/3) sin ($2\pi(3f)t$)]

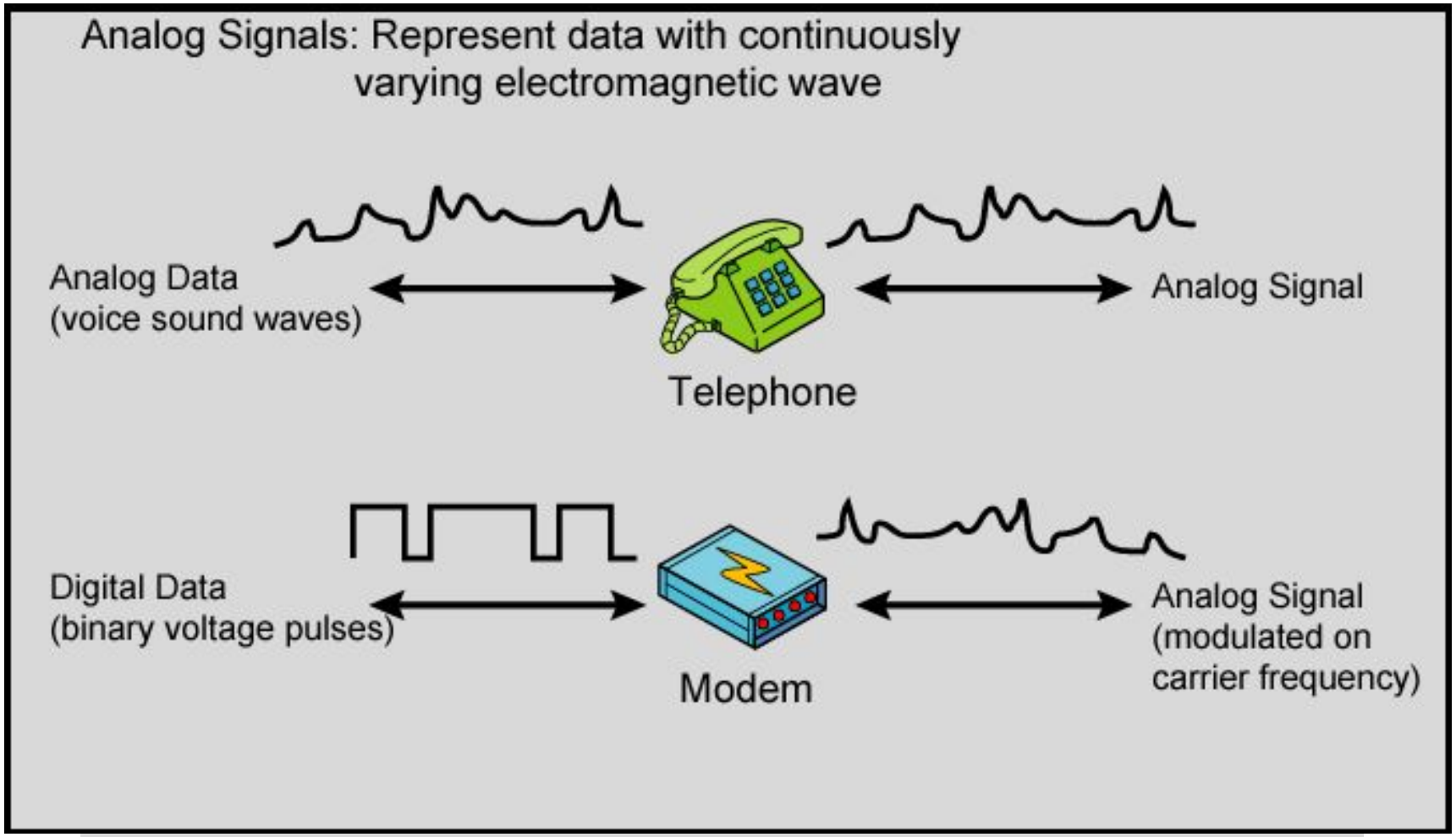
Digital Data

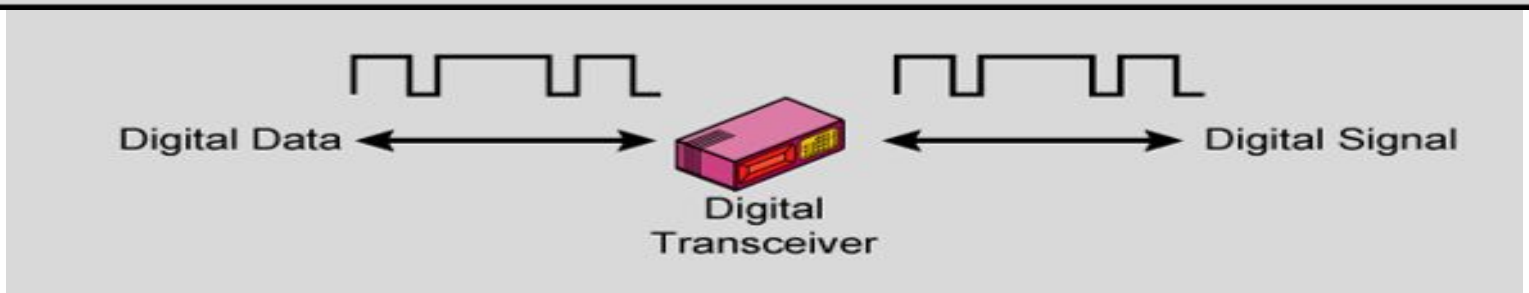
- As generated by computers etc.
- Achievable Bandwidth depend on data rate.



User input at a PC is converted into a stream of binary digits (1s and 0s). In this graph of a typical digital signal, binary one is represented by Ð5 volts and binary zero is represented by +5 volts. The signal for each bit has a duration of 0.02 msec, giving a data rate of 50,000 bits per second (50 kbps).

Analog and Digital Signals





Transmission media

a) **Magnetic media**

a) Tapes, diskettes

b) Supports very high data rate (high bandwidth)

c) A 8 mm tape = 7 GB □ A 50*50*50 Cm box = 1000 tapes =7000 GB

7000GB/24 Hrs= 648 Mbps 7000GB/1Hr=15Gbps

a) Sometimes it's cheaper and faster to load a box of tapes in your car!

b) Problem: Delay !

c) **Twisted pair (1)**

a) Simply two wires twisted together – thickness=1mm

The twisting cuts down on electrical interference.

a) Heavily used in the phone system

Typical office has four pairs for phones.

a) Until some Kilometers/ Some Mbps

b) For Analog and Digital

Transmission media (2)

a) Twisted pair (2)

a) Bandwidth depends on thickness and distance

Need repeater for long distances

a) Category 3 and 5 - with 5 having more twists and better insulation.

b) Popular by UTP (Unshielded Twisted Pair)

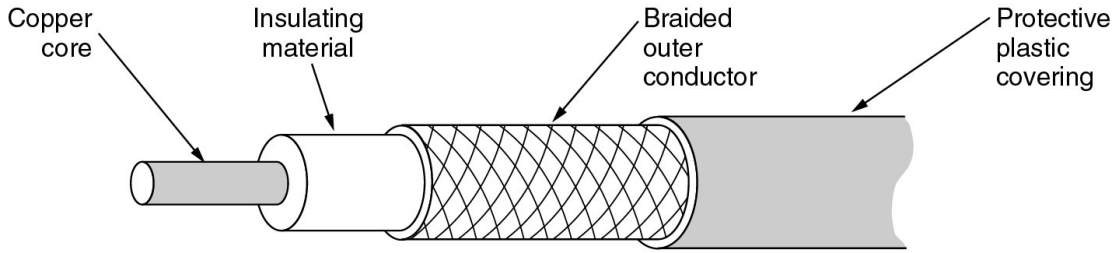
Cat3

Cat 5

- UTP = Unshielded Twisted Pair
  - Cat 3: Home telephone lines
  - Cat 5: Fast Ethernet (100 Mbps)
  - Cat 5e: Gigabit Ethernet (1 Gbps)
  - Cat 6: 10-Gigabit Ethernet (10 Gps) up to 100 m
  - Cat 6A: Better quality Cat 6
  - Cat 7: Includes shielding (not in common use)

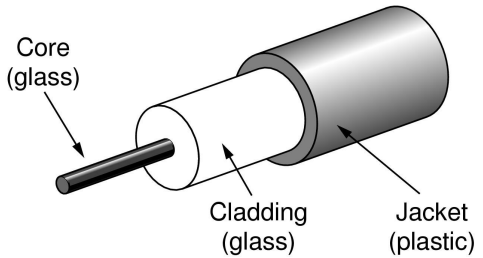
Transmission Media (3)

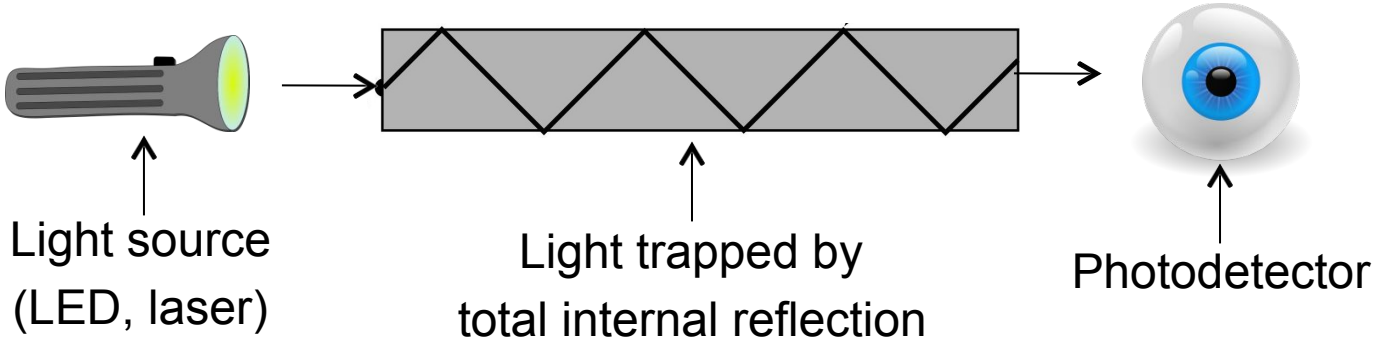
- **Baseband Coaxial cable**
  - a) Used for digital transmissions (called baseband)
  - b) Works only with half-duplex.
  - c) Mostly used in LAN(steady drop after 0.62 miles)
  - d) Data rates is 10 Mbps for 1 Km distance.
  - e) Low cost(No need modems) and easy to use.
  - f) Now being replaced by fiber.
- **Broadband Coaxial cable**
  - a) Used for analog transmissions (called broadband.)
  - b) Use 300 MHz for long distances using Frequency Multiplexing(FDM)
  - c) Operates at distances up to 100 km (metropolitan area!)
  - d) Interfaces must convert digital signals to analog and vice versa.
  - e) Designed for long distances - can use amplifiers.



Transmission Media (4)

- Fiber Optic (1)
  - a) Transmission of light through fiber.
  - *b)* *Fiber medium:* Current technology carries light pulses for tremendous distances (e.g., 100s of kilometres) with virtually no signal loss.
  - *c)* *Light source:* typically a Light Emitting Diode (LED) or laser diode. Running current through the material generates a pulse of light.
  - *d)* *A photo diode light detector*, which converts light pulses into electrical signals.
  - e) Including 3 components:
    - a) Light source: Pulse of light=1, absence of light=0
    - b) Transition medium: an ultra-thin fiber of glass
    - c) detector: generate an electrical pulse when light falls on it





Transmission Media (4)

- Advantages of Fiber optics:
  - Very high data rate(response time=1ns, data rate = 1 Gbps).
  - Very low error rate(almost negligible).
  - Much thinner than existing copper wires
  - Not susceptible to electrical interference (lightning) or corrosion (rust).
  - Greater repeater distance than coax.

Comparison of fiber optic and copper wire

	Fiber	Copper
Bandwidth	Higher	Lower
Distance between repeaters	30 KM	5 Km
Interference	Low	High
Cost	High	Low
Flow	Uni-directional	Bi-directional

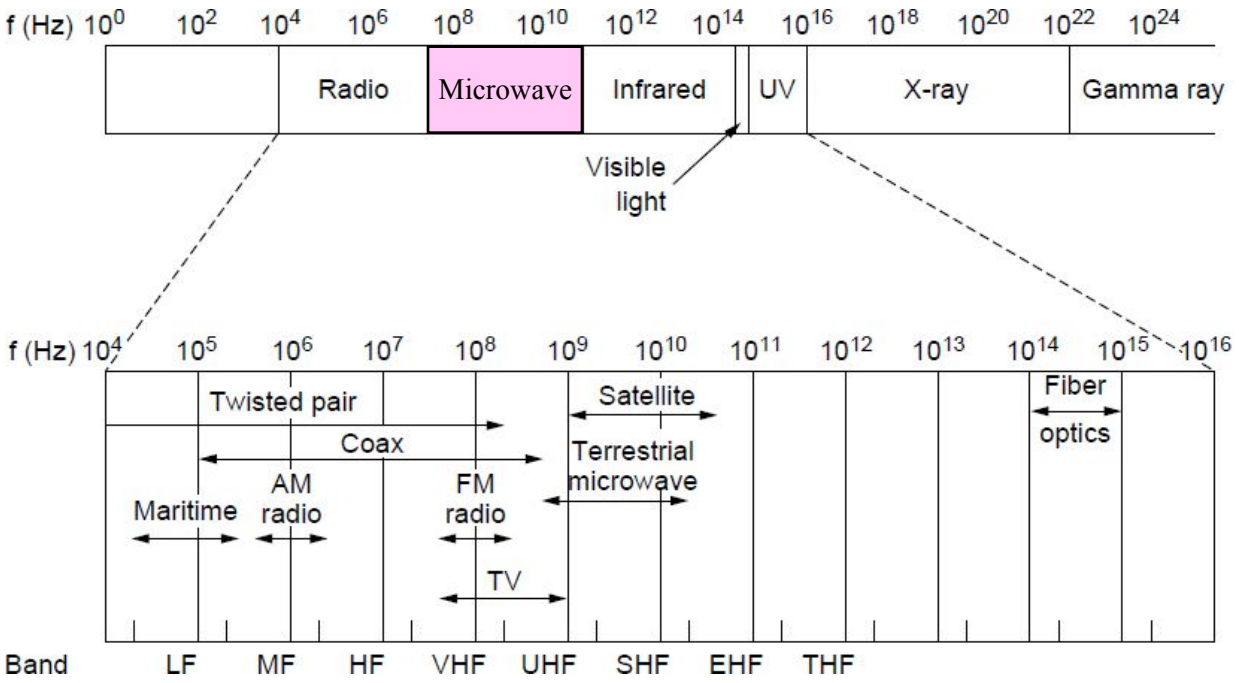
Wireless transmission

- Radio transmission
- Microwave Transmission
- Lightwave Transmission
- Satellites

Electromagnetic Spectrum (1)

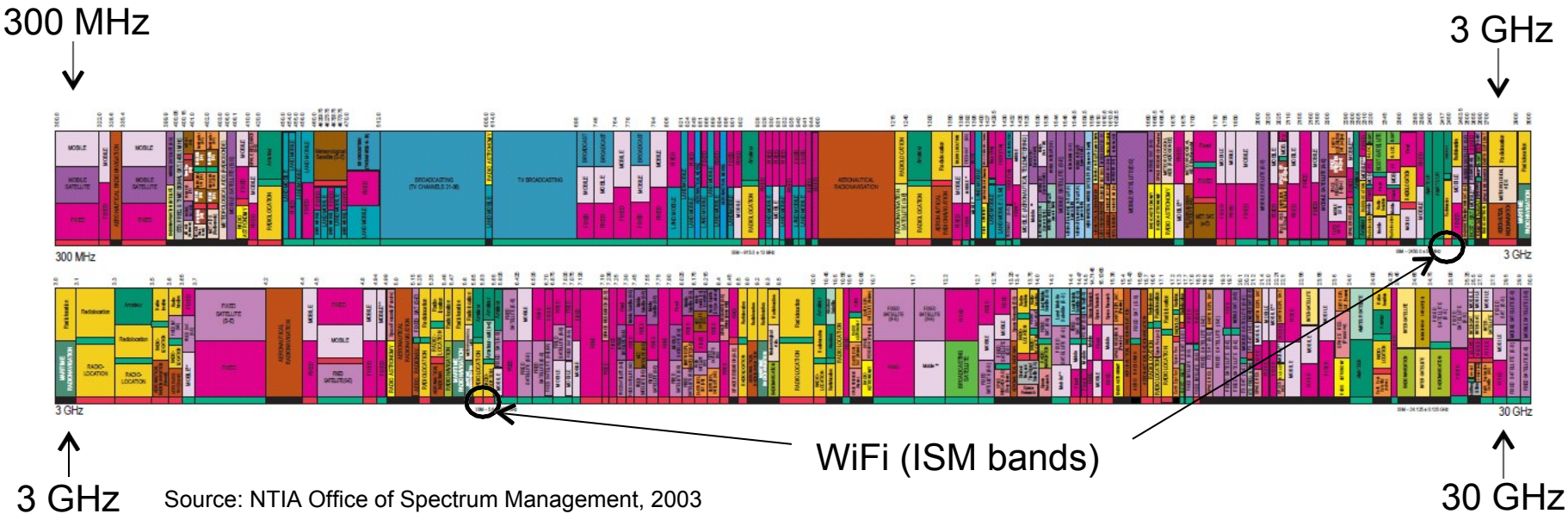
Different bands have different uses:

- Microwave: LANs and 3G/4G; < Networking focus



Electromagnetic Spectrum (2)

To manage interference, spectrum is carefully divided, and its use regulated and licensed, e.g., sold at auction.

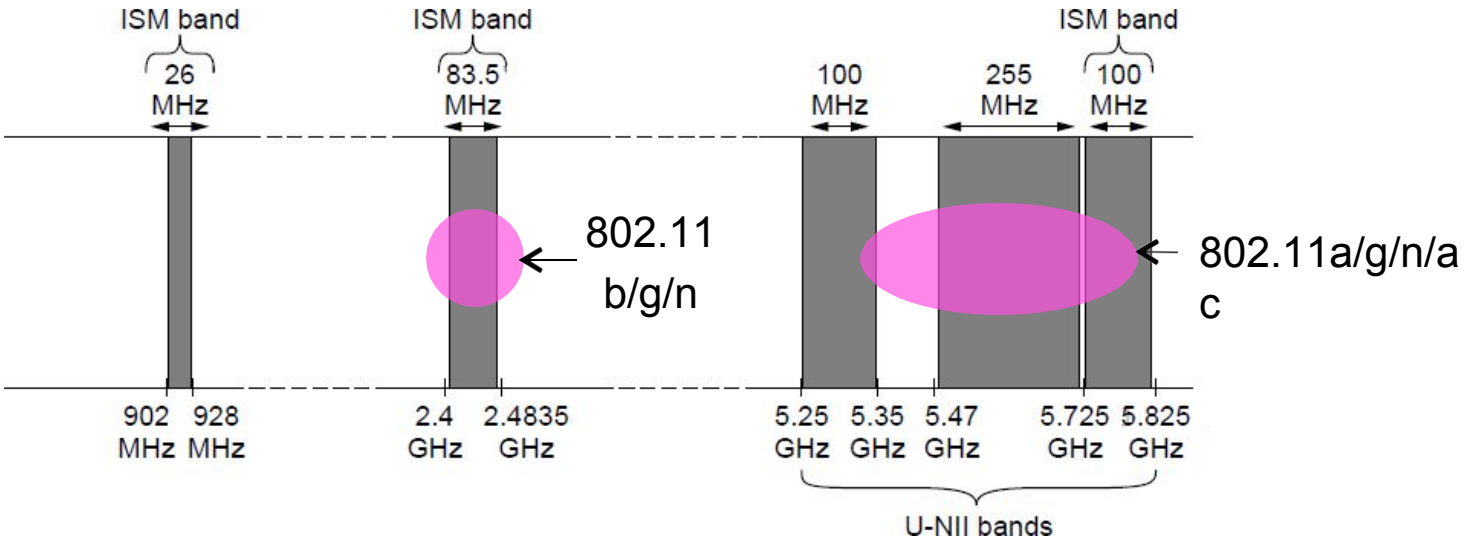


Part of the US frequency allocations

Electromagnetic Spectrum (3)

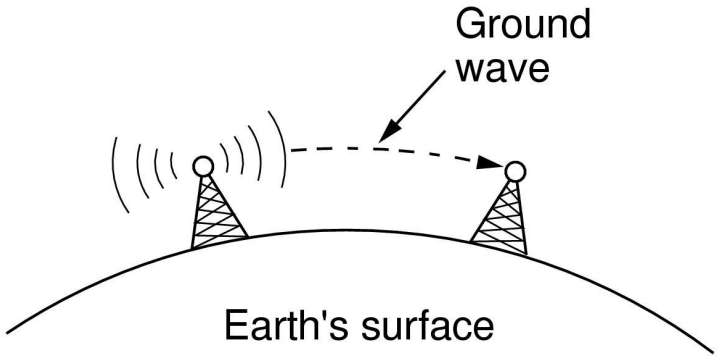
Fortunately, there are also unlicensed ("ISM") bands:

- Free for use at low power; devices manage interference
- Widely used for networking; WiFi, Bluetooth, etc.

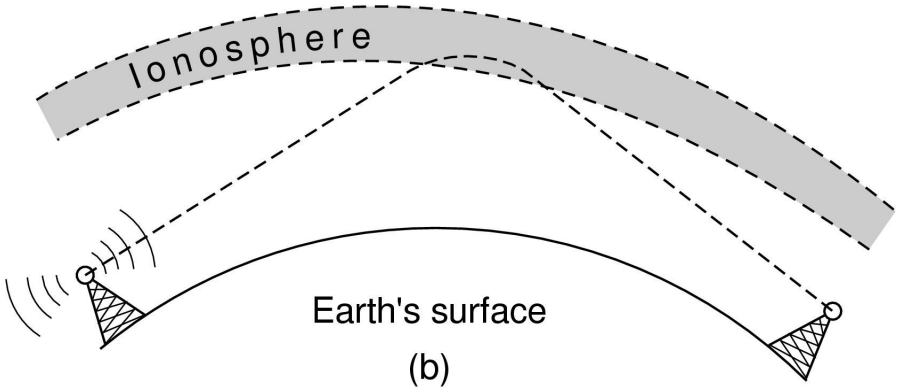


Radio Transmission

Radio signals penetrate buildings well and propagate for long distances with path loss



In the VLF, LF, and MF bands, radio waves follow the curvature of the earth



In the HF,UHF band, radio waves bounce off the ionosphere.

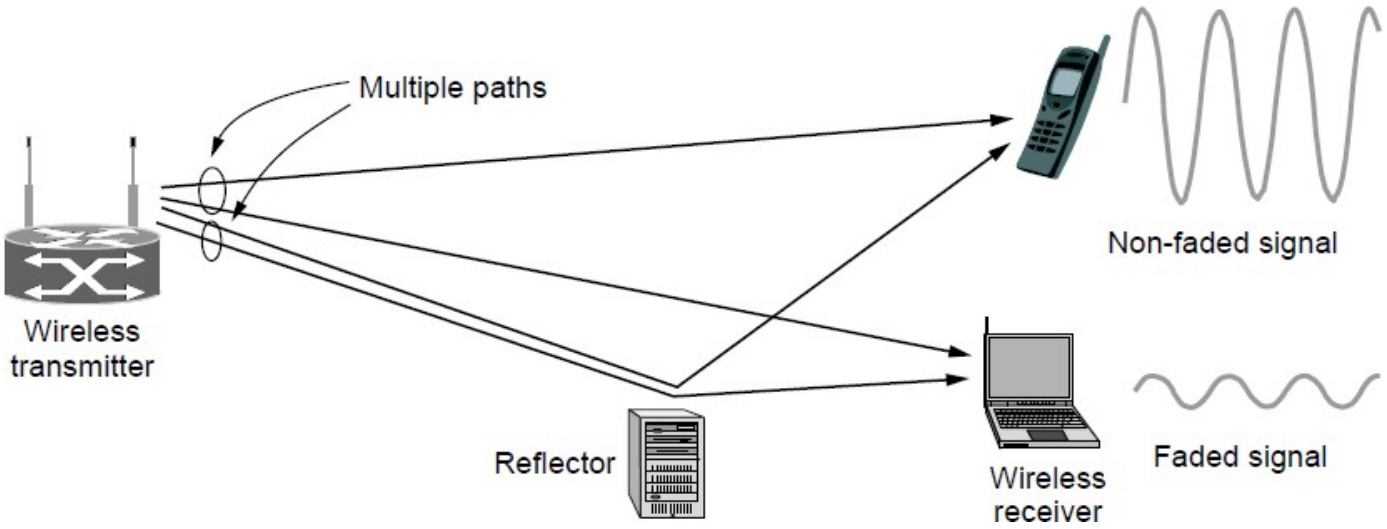
Ionosphere : The layer of the earth's atmosphere which contains a high concentration of ions and free electrons and is able to reflect radio waves. It lies above the mesosphere and extends from about 80 to 1,000 km above the earth's surface.

https://en.wikipedia.org/wiki/Radio_spectrum

Microwave Transmission

Microwaves have much bandwidth and are widely used indoors (WiFi) and outdoors (3G, satellites)

- Signal is attenuated/reflected by everyday objects
- Strength varies with mobility due multipath fading, etc.



Communication Satellites

Satellites are effective for broadcast distribution and anywhere/anytime communications

- Kinds of Satellites
  - Geostationary (GEO) Satellites
  - Low-Earth Orbit (LEO) Satellites

Kinds of Satellites

Satellites and their properties vary by altitude:

- Geostationary (GEO), Medium-Earth Orbit (MEO), and Low-Earth Orbit (LEO)