Introduction

Mobile and Wireless Networking

Important?

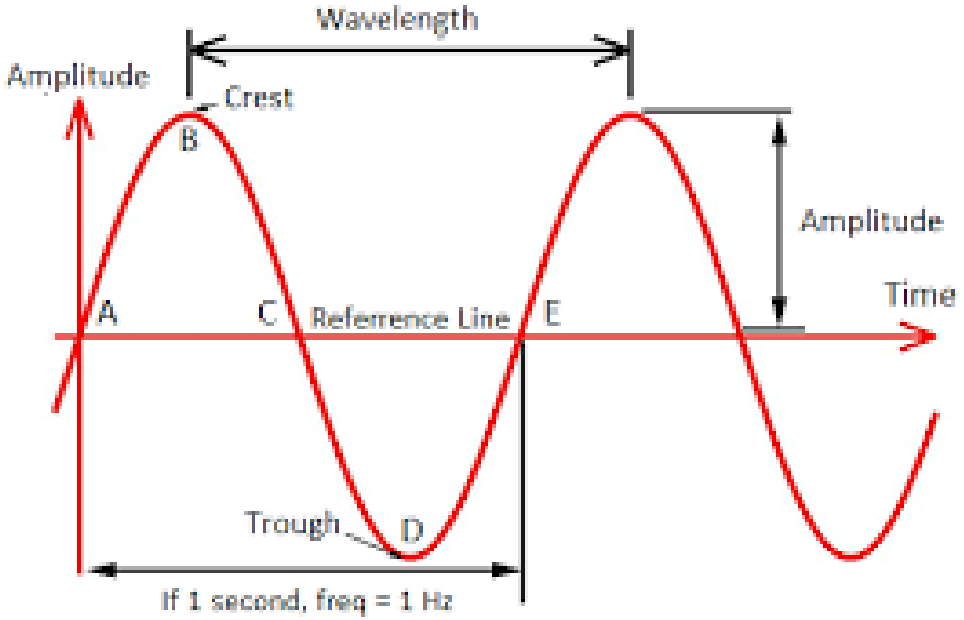
- I hear and I forget,
- I see and I remember,
- I do and I understand
  - *Confucius*

What is Wireless and Mobile Communication?

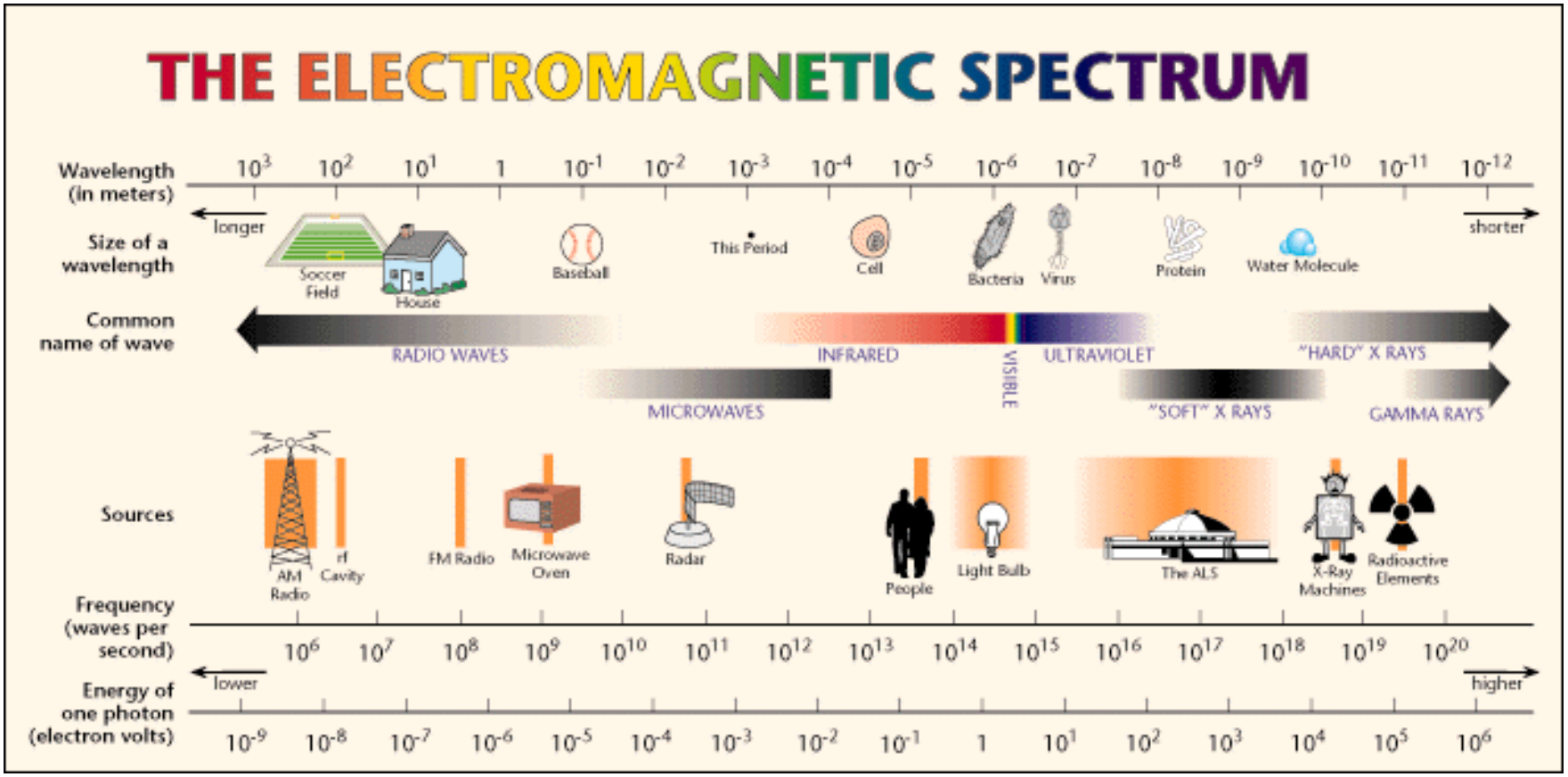
Wireless Communication

- Transmitting voice and data using electromagnetic waves in open space
- Electromagnetic waves
  - Travel at speed of light ($c = 3x10^8$ m/s)
  - Has a frequency (f) and wavelength (λ)
    - $c = f \times \lambda$
  - Higher frequency means higher energy photons
  - The higher the energy photon the more penetrating is the radiation

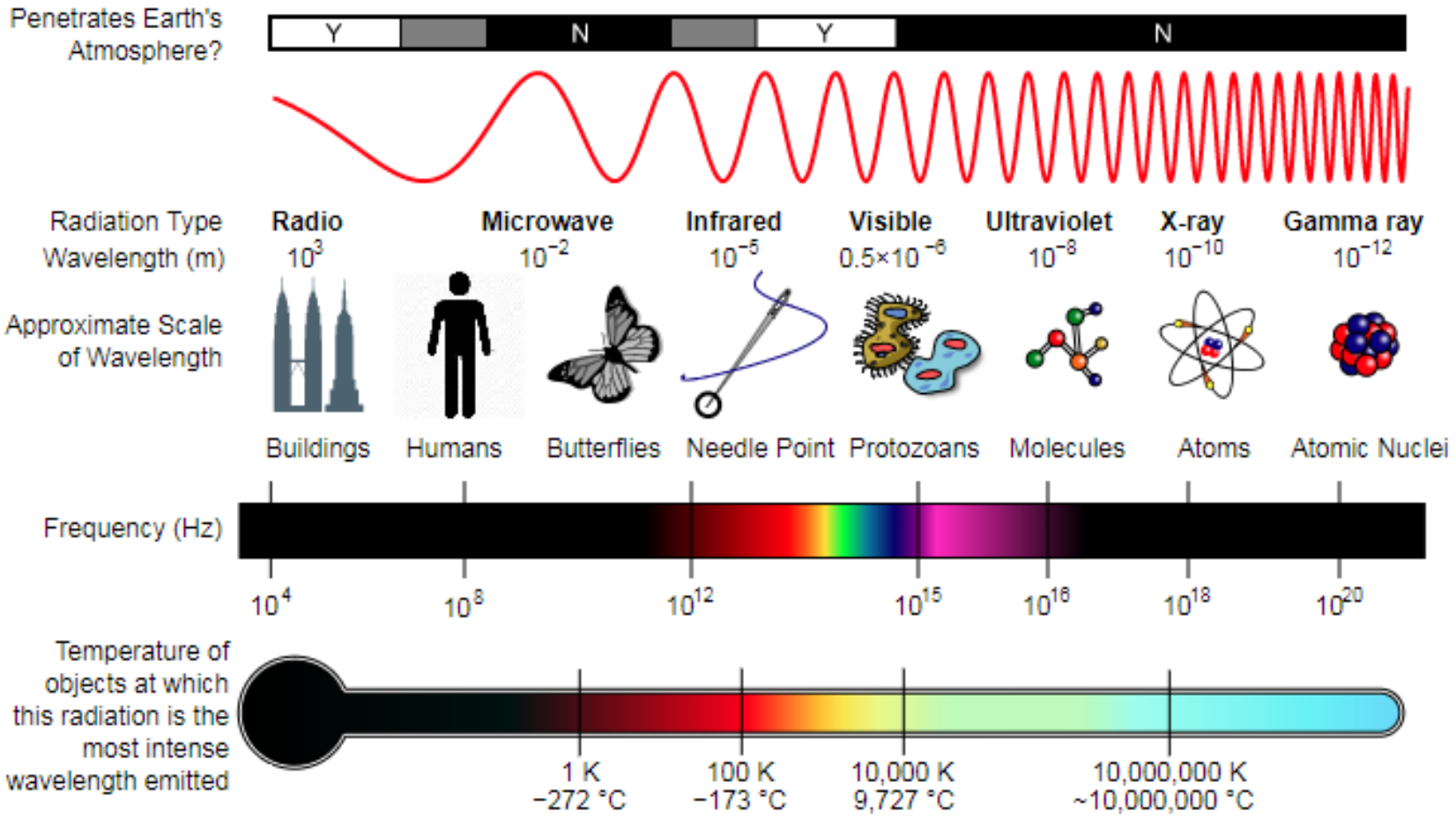
Electromagnetic Wave



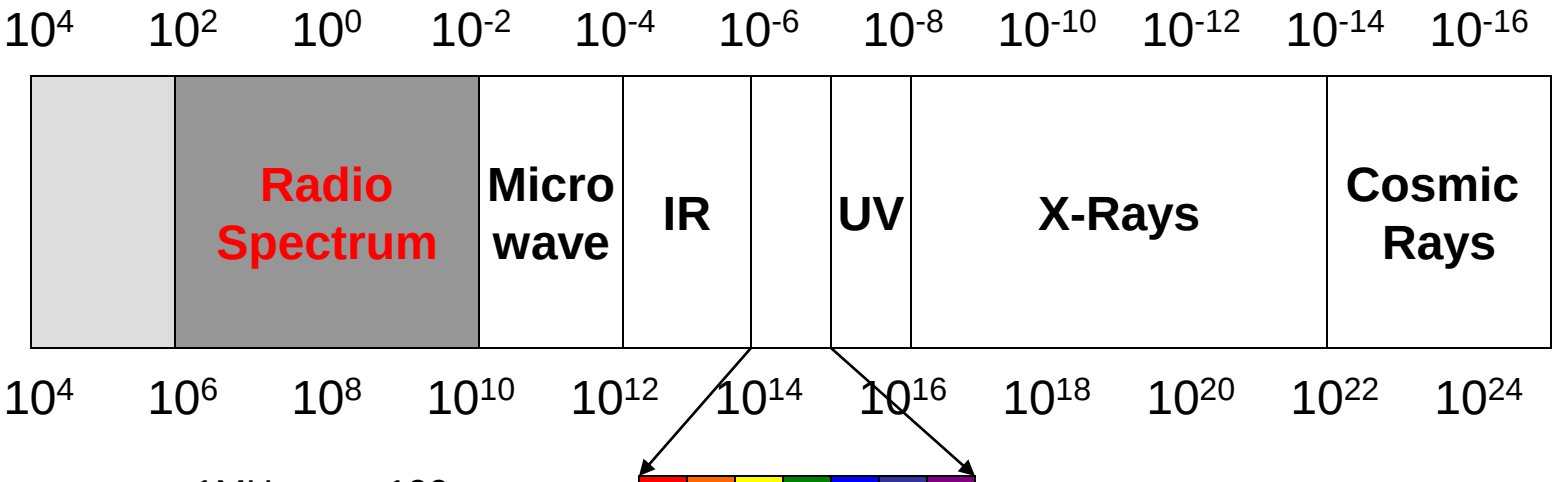
Electromagnetic Spectrum



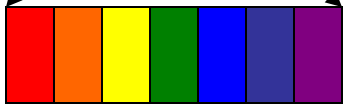
Electromagnetic Spectrum



Electromagnetic Spectrum



1MHz ==100m
100MHz ==1m
10GHz ==1cm



Visible light

< 30 KHz	VLF
30-300KHz	LF
300KHz – 3MHz	MF
3 MHz – 30MHz	HF
30MHz – 300MHz	VHF
300 MHz – 3GHz	UHF
3-30GHz	SHF
> 30 GHz	EHF

Wavelength of Some Technologies

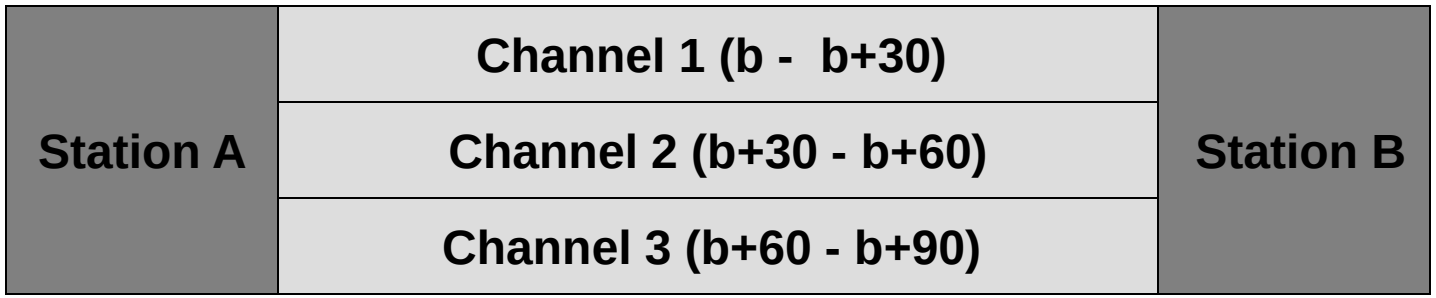
- GSM Phones:
  - frequency ~= 900 Mhz
  - wavelength ~= 33cm
- PCS Phones
  - frequency ~= 1.8 Ghz
  - wavelength ~= 17.5 cm
- Bluetooth:
  - frequency ~= 2.4Gz
  - wavelength ~= 12.5cm

Frequency Carries/Channels

- The information from sender to receiver is carrier over a well defined frequency band.
  - This is called a channel
- Each channel has a fixed frequency bandwidth (in KHz) and Capacity (bit-rate)
- Different frequency bands (channels) can be used to transmit information in parallel and independently.

Example

- Assume a spectrum of 90KHz is allocated over a base frequency b for communication between stations A and B
- Assume each channel occupies 30KHz.
- There are 3 channels
- Each channel is simplex (Transmission occurs in one way)
- For full duplex communication:
  - Use two different channels (front and reverse channels)
  - Use time division in a channel



Simplex Communication

- Normally, on a channel, a station can transmit only in one way.
  - This is called simplex transmision
- To enable two-way communication (called full-duplex communication)
  - We can use Frequency Division Multiplexing
  - We can use Time Division Multiplexing

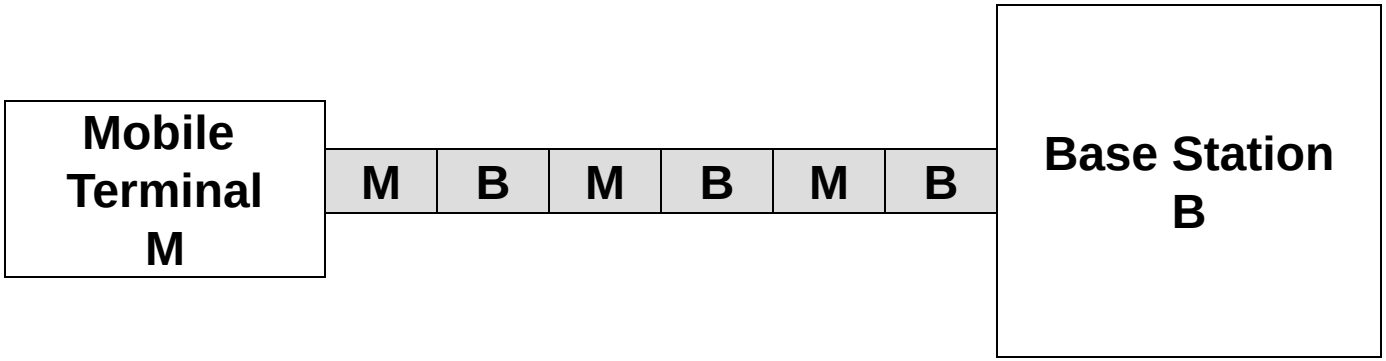
Duplex Communication - FDD

- FDD: Frequency Division Duplex

Forward Channel and Reverse Channel use different frequency bands

Duplex Communication - TDD

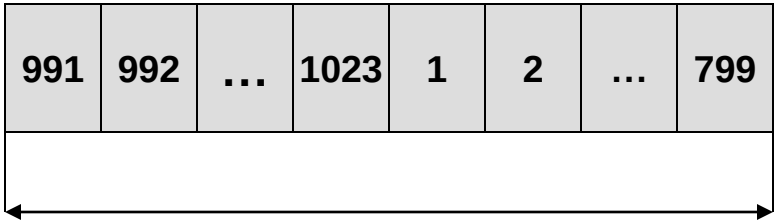
- TDD: Time Division Duplex



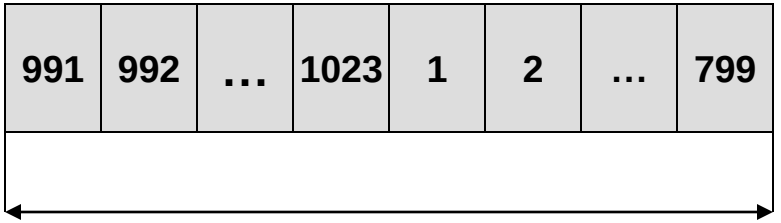
A singe frequency channel is used. The channel is divided into time slots. Mobile station and base station transmits on the time slots alternately.

Example - Frequency Spectrum Allocation in U.S. Cellular Radio Service

Reverse Channel



Forward Channel



Channel Number	Center Frequency (MHz)
Reverse Channel 1 <=N <= 799	0.030N + 825.0
991 <= N <= 1023	0.030(N-1023) + 825.0
Forward Channel 1 <=N <= 799	0.030N + 870.0
991 <= N <= 1023	0.030(N-1023) + 870.0

(Channels 800-990 are unused)

Channel bandwidth is 45 MHz

What is Mobility

- Initially Internet and Telephone Networks is designed assuming the user terminals are static
  - No change of location during a call/connection
  - A user terminals accesses the network always from a fixed location
- Mobility and portability
  - Portability means changing point of attachment to the network offline
  - Mobility means changing point of attachment to the network online

Degrees of Mobility

- Walking Users
  - Low speed
  - Small roaming area
  - Usually uses high-bandwith/low-latency access
- Vehicles
  - High speeds
  - Large roaming area
  - Usually uses low-bandwidth/high-latency access
  - Uses sophisticated terminal equipment (cell phones)

The Need for Wireless/Mobile Networking

- Demand for Ubiquitous Computing
  - Anywhere, anytime computing and communication
    - You don’t have to go to the lab to check your email
  - Pushing the computers more into background
    - Focus on the task and life, not on the computer
    - Use computers seamlessly to help you and to make your life more easier.
  - Computers should be location aware
    - Adapt to the current location, discover services

Some Example Applications of Ubiquitous Computing

- You walk into your office and your computer automatically authenticates you through your active badge and logs you into the Unix system
- You go to a foreign building and your PDA automatically discovers the closest public printer where you can print your schedule and give to your friend

More Examples

- You walk into a Conference room or a shopping Mall with your PDA and your PDA is smart enough to collect and filter the public profiles of other people that are passing nearby
  - Of course other people should also have smart PDAs.
- The cows in a village are equipped with GPS and GPRS devices and they are monitored from a central location on a digital map.
  - No need for a person to guide and feed them
- You can find countless examples

How to realize Ubiquitous Computing

- Small and different size computing and communication devices
  - Tabs, pads, boards
  - PDAs, Handhelds, Laptops, Cell-phones
- A communication network to support this
  - Anywhere, anytime access
  - Seamless, wireless and mobile access
  - Need for Personal Communication Services (PCS)
- Ubiquitous Applications
  - New software