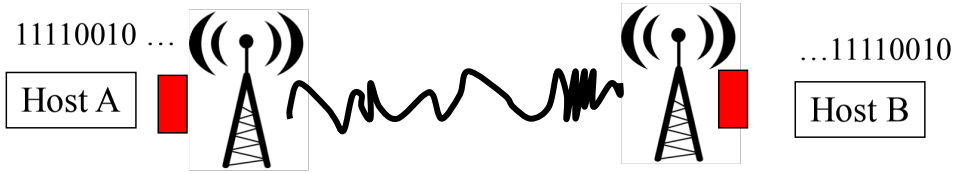
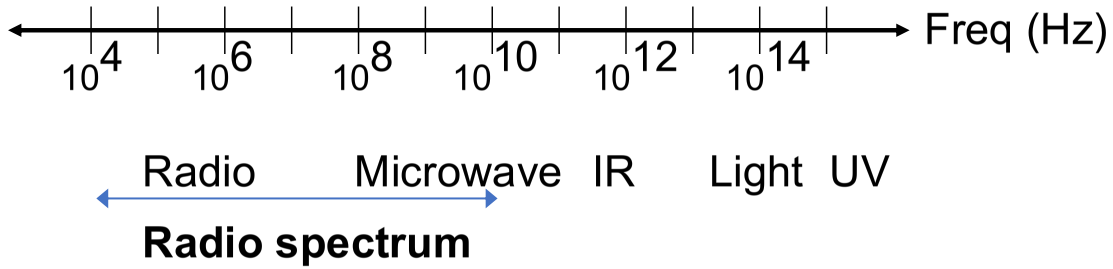
Wireless communication

The wireless medium

- Data is carried over the electromagnetic waves propagating through space



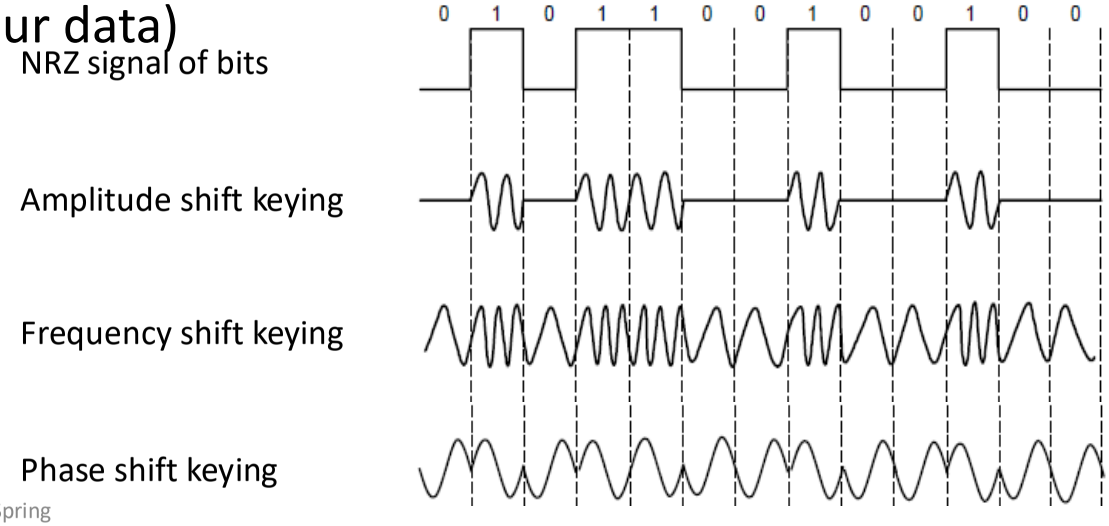
Electromagnetic spectrum (EM)



- The EM spectrum can be classified into radio, microwave, IR, etc based on the wavelength/Frequency
- Most communication happens in the radio spectrum. Different technologies can use a specific band
- Different from wired medium, the signal needs to be superimposed on the radio spectrum

How does the waves carry information: Modulation

- To modulate, you can change the amplitude, the phase, or the frequency
- You modulate the carrier signal (the em wave) with the modulating signal (your data)

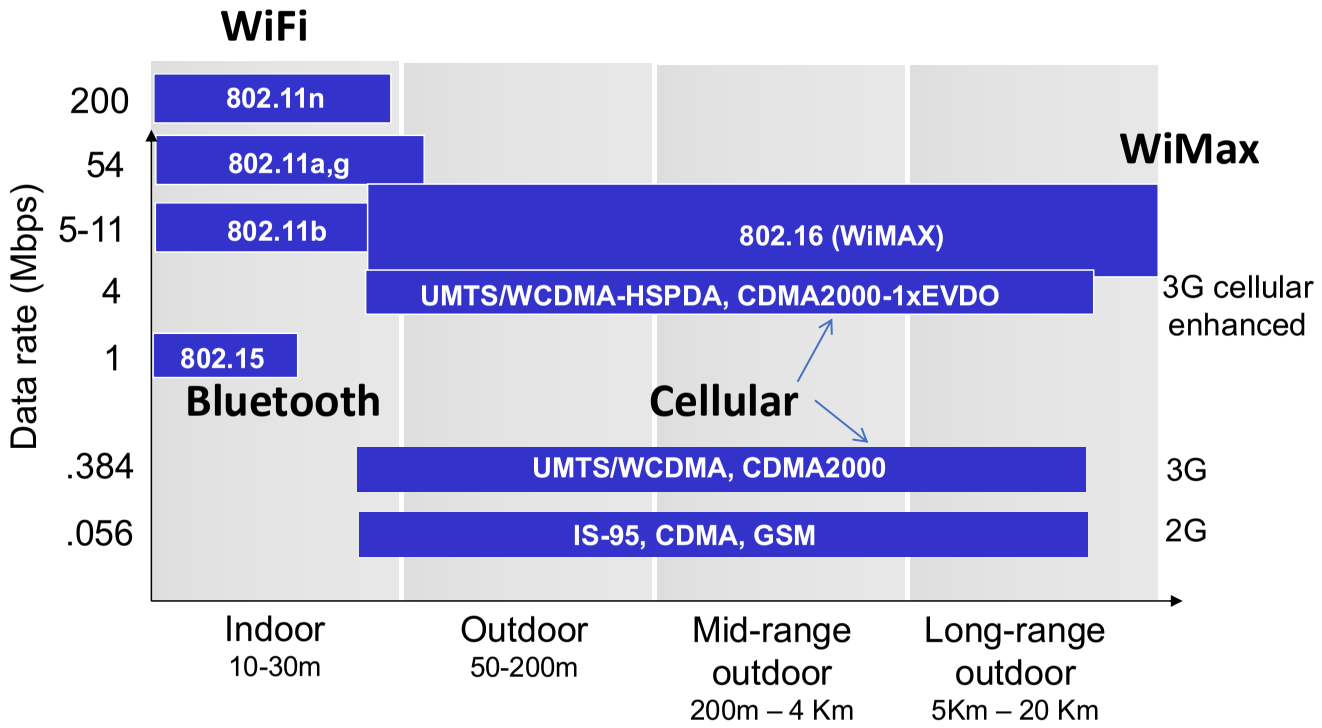


Radio spectrum

- Travel long distances, penetrate through buildings
- Omnidirectional
- Used by radio, TV stations (when TV stations where analog), Microphones, Cellular, Public safety, Government,….

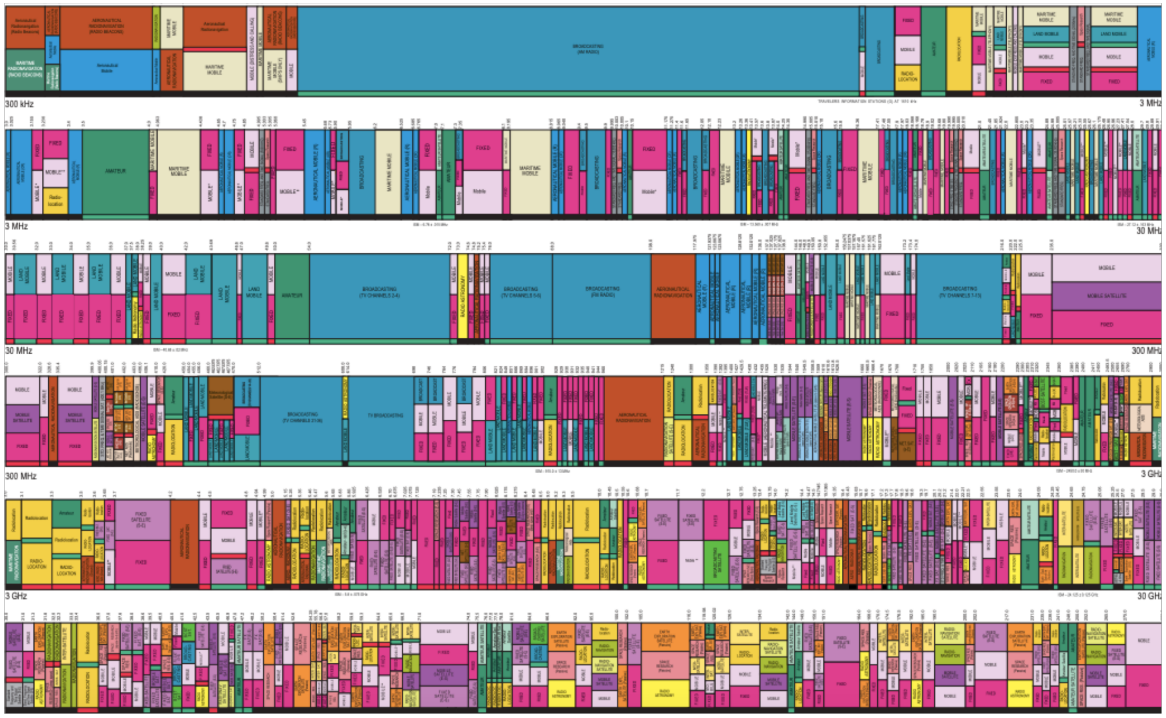
- But……
  - Interference is a huge problem
  - This is why there is a lot of noise and losses

Example Wireless Technologies



Radio spectrum is allocated to different technologies

https://www.ntia.doc.gov/files/ntia/publications/2003-allochrt.pdf



Cellular versus WiFi

- Licensed versus Unlicensed
  - Government regulates spectrum and companies pay for licensed spectrum
  - Anyone can use the unlicensed spectrum
- Long range versus short range
  - MAC protocols are very different for cellular and WiFi.
  - Cellular cannot use CSMA/CA unlike WiFi. Instead, medium access control is done in the physical layer
- Low versus high frequency
  - WiFi works at a higher frequency of the spectrum,
  - In general, higher frequency means lower range, but higher data rate

Sharing medium in cellular

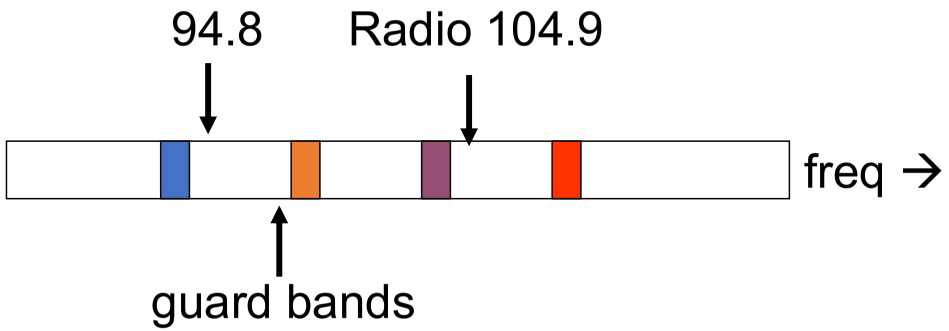
Uses TDMA, FDMA, and CDMA

Different cellular technology differ in the kind of multiple access technology they use

Works well for cellular because it has tight control over the clients and can synchronize across them

Frequency Division Multiple Access

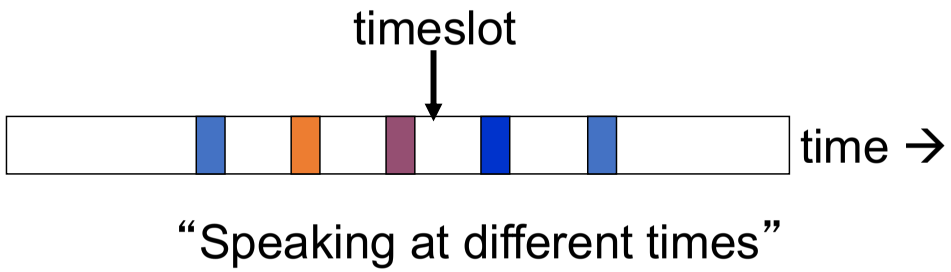
- Simultaneous transmission in different frequency bands



"Speaking at different pitches"

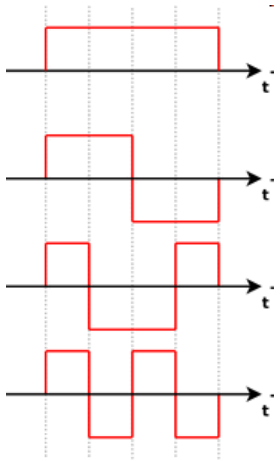
Time Division Multiple Access

- Timeslice given frequency band between users
  - Used extensively inside the telephone network (GSM)



Code Division Multiple Access

- Give each user a different code
  - All users send at once
  - Each user is given a chip code
  - User data is modulated using their chip code
- Codes are orthogonal to each other
  - Can correlate for one code
- Widely used for 3G mobile phones



Four mutually orthogonal chip codes

What next in cellular technology? 5G

- It is useful to think of cellular Network/telephony in terms of *generations*:
  - 0G: Briefcase-size mobile radio telephones
  - 1G: *Analog* cellular telephony
  - 2G: *Digital* cellular telephony (GSM, CDMA)
  - 3G: *High-speed* digital cellular telephony (including *video telephony*)
  - LTE (4G): IP-based "anytime, anywhere" voice, data, and multimedia telephony at *faster* data rates than 3G

Fifth Generation or 5G

- Releasing existing spectrum for communication
- Multiple input multiple output antennaes
- Combining WiFi and cellular
- Low range bluetooth/BLE for Internet of things
- Using millimeter wave technology
- ……