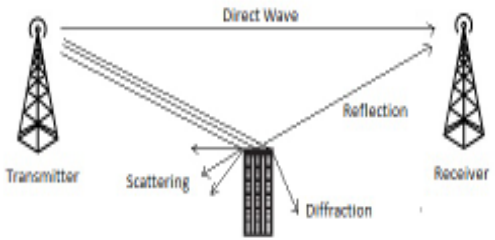


TECHNICAL CHALLENGES INVOLVED

Unit 1 Chapter 2 and 3 : WIRELESS COMMUNICATIONS

Andreas F. Molisch

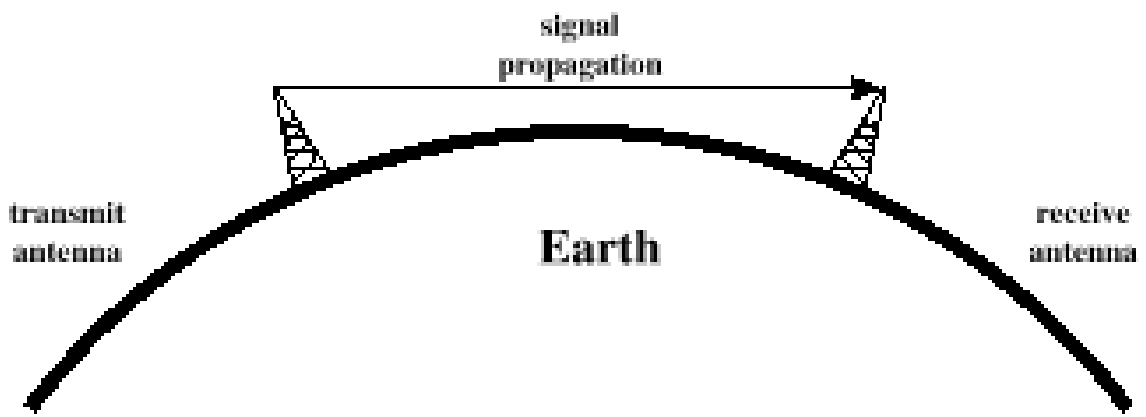
2.1,2.2,2.3 and 2.4 && 3.2

For more details on Fading refer 5.9 of Upena Dalal

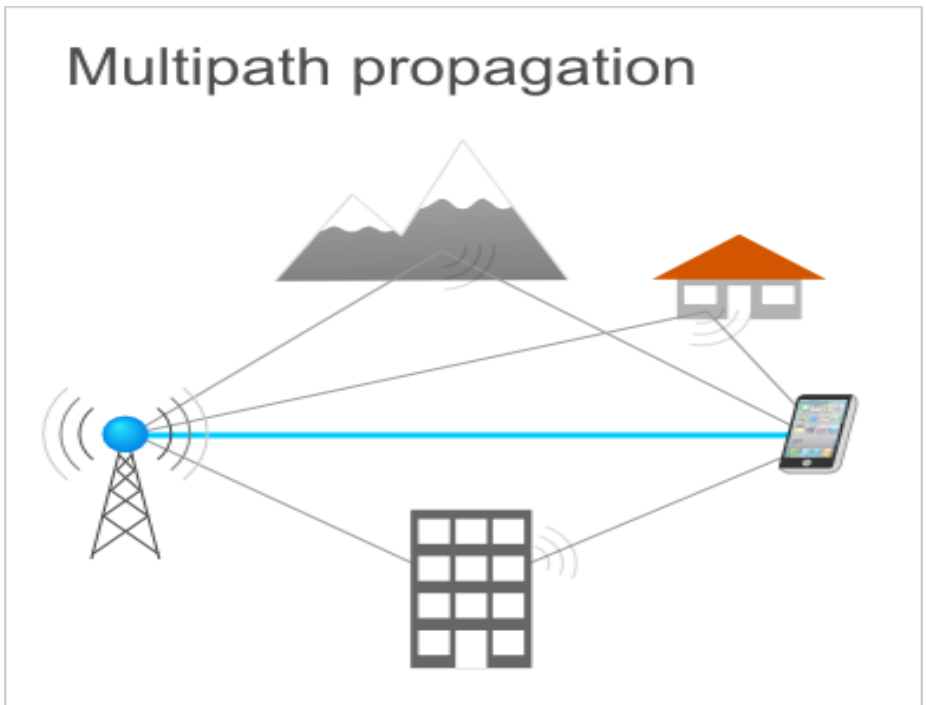
Challenges includes:

- multipath propagation
- spectrum limitations
- energy limitations
- user mobility.

Line-of-Sight Propagation

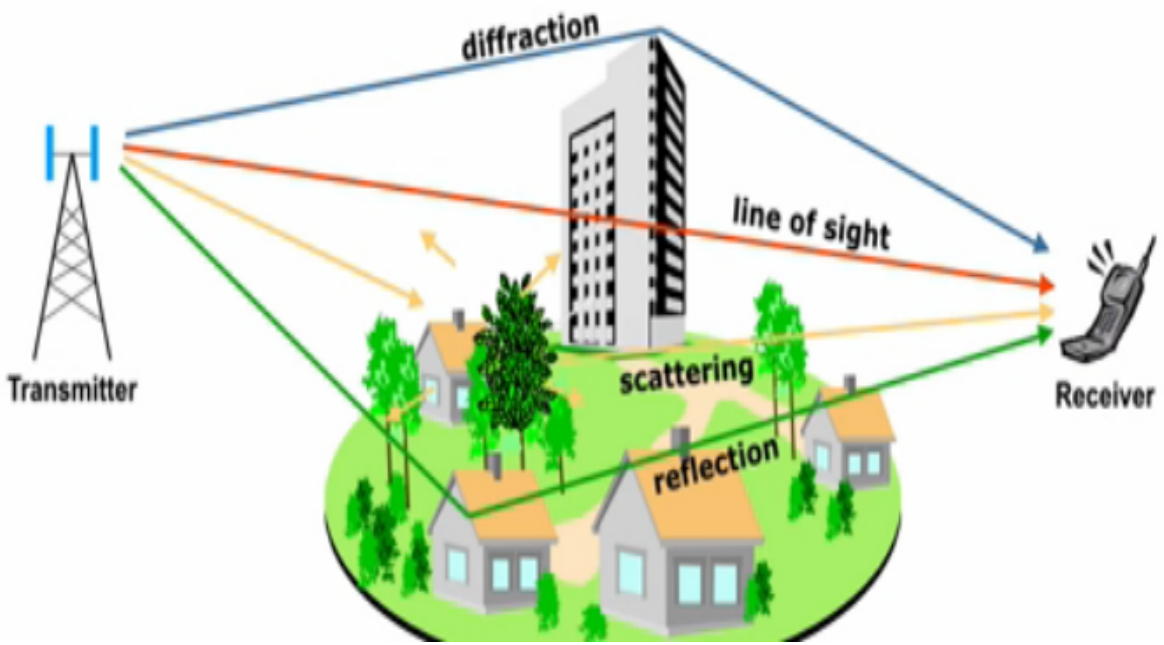


Non Line of sight is obstructed by obstacles like buildings



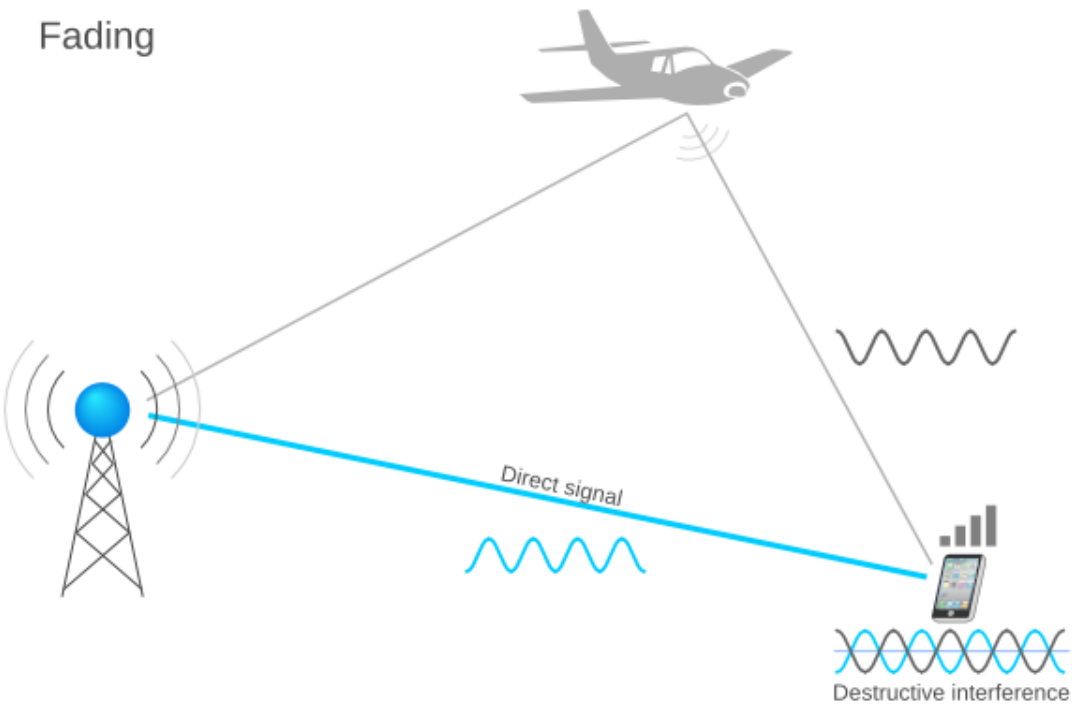
Multipath is a propagation phenomenon that causes the transmitted signal to be sent on two or more paths to the receiver.

- Reflection: object is large compared to wavelength
- Scattering: object is small or its surface irregular
- Diffraction: at edges of buildings, roofline etc.



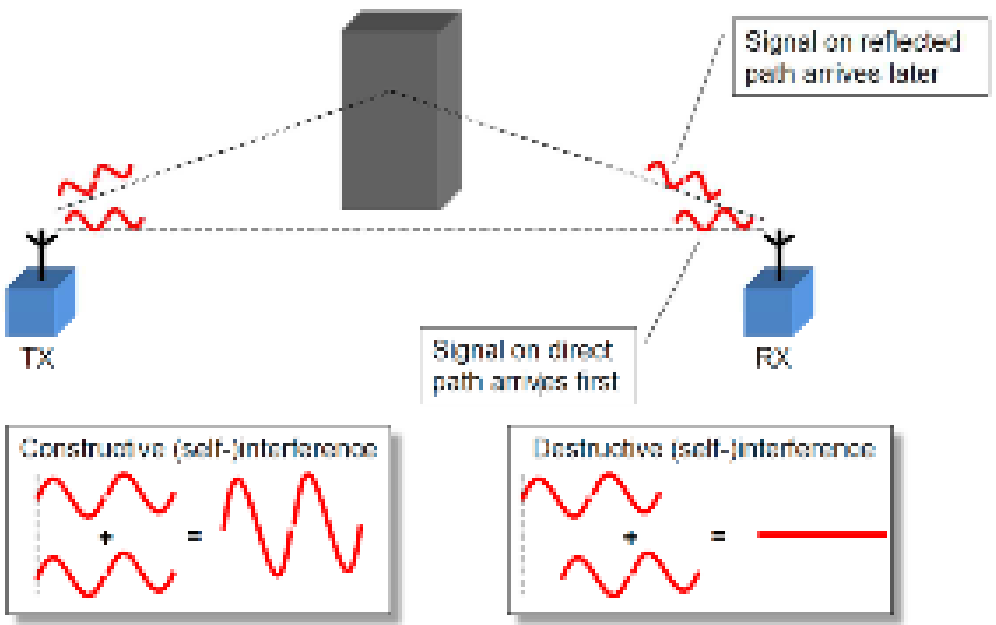
Implication of multipath propagation

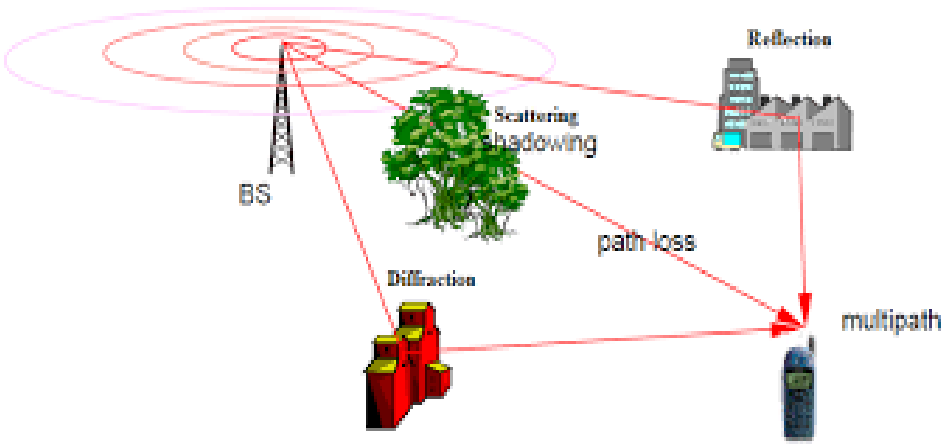
- Fading
- Intersymbol interference



Fading is a phenomenon cause by the constructive and destructive interference of two or more copies of the same signal that arrive at the receiver at different times.

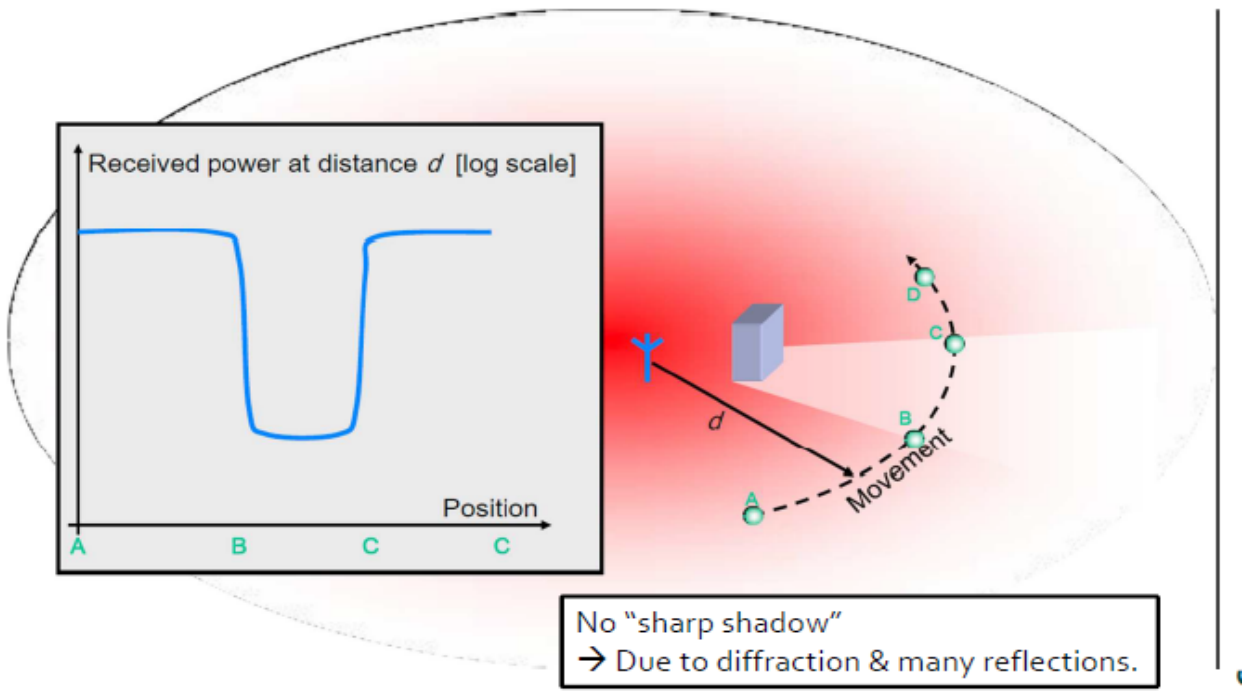
Small-scale Fading





Shadowing : Signal strength loss after passing through obstacles

Large-scale Fading



No "sharp shadow"
→ Due to diffraction & many reflections.

Usually the digital information that is transmitted will be in the form of square waveform representing the 1's and 0's. When this square waveform mixes with the noises and non linarites in the channel, the square waveform starts to spread and merge with the adjacent symbol sequence, making the data there to be unreadable. At the receiver end this data is wrongly decoded.

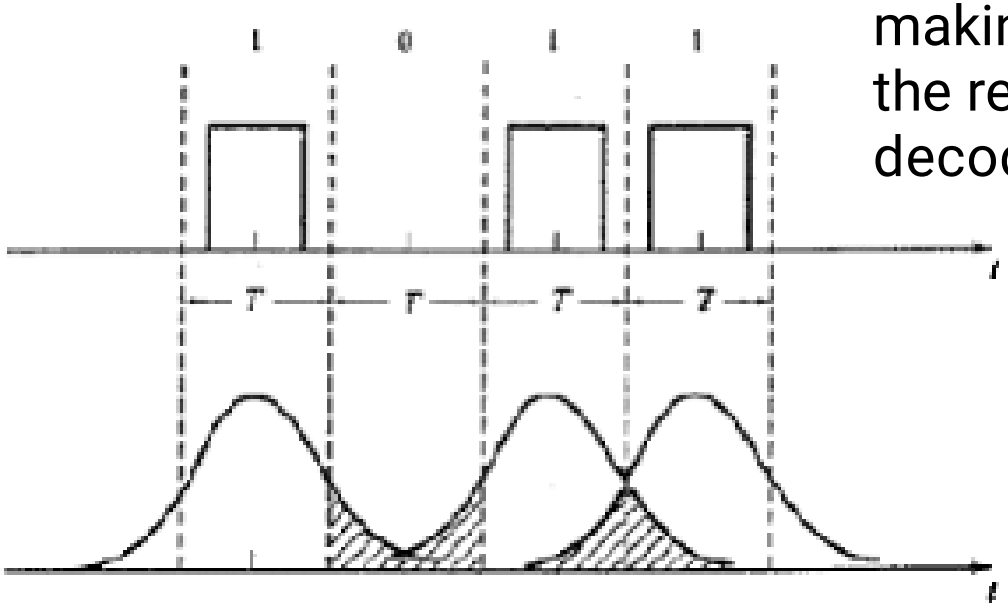
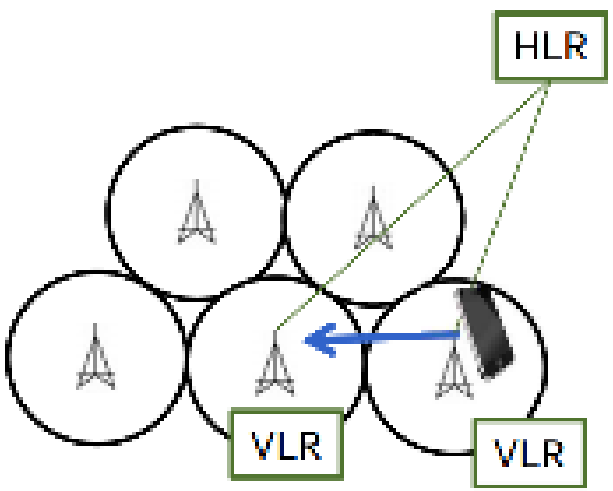


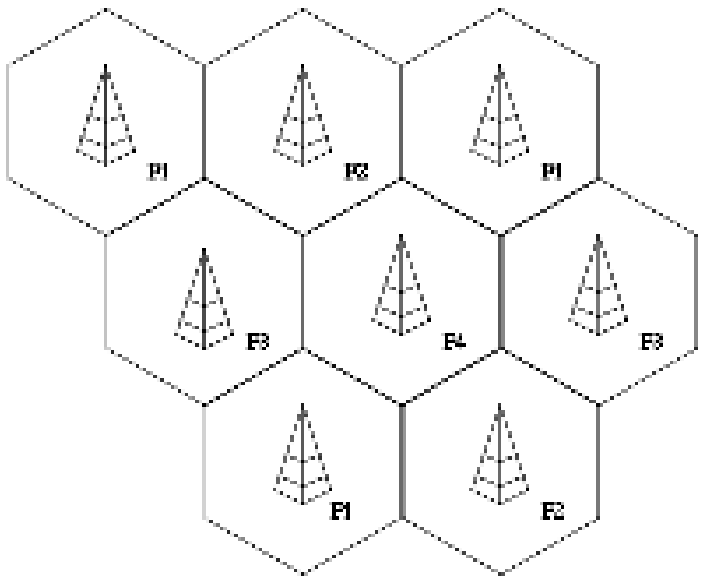
Fig 1: Inter Symbol Interference.

User Mobility

Home Location Register (HLR) and the Visitor Location Register (VLR).

If an MS moves across a cell boundary, a different BS becomes the *serving BS*; in other words,
the MS is *handed over* from one BS to another.





- If there is an incoming call for a certain MS (user), the network has to know in which cell the user is located.
- The first requirement is that an MS emits a signal at regular intervals, informing nearby BSs that it is “in the neighborhood.”
- Two databanks then employ this information: the *Home Location Register* (HLR) and the *Visitor Location Register* (VLR).
- The HLR is a central database that keeps track of the location a user is currently at; the VLR is a database associated with a certain BS that notes all the users who are currently within the coverage area of this specific BS.
- Consider user *A*, who is registered in San Francisco, but is currently located in Los Angeles.
- It informs the nearest BS (in Los Angeles) that it is now within its coverage area; the BS enters that information into its VLR. At the same time, the information is forwarded to the central HLR (located, e.g., in New York).
- If now somebody calls user *A*, an enquiry is sent to the HLR to find out the current location of the user. After receiving the answer, the call is rerouted to Los Angeles. For the Los Angeles BS, user *A* is just a “regular” user, whose dataare all stored in the VLR

Spectrum limitations

Spectrum assignment

- <100 MHz: CB radio, pagers, and analogue cordless phones.
- 100–800 MHz: broadcast (radio and TV)
- 400–500 MHz: cellular and trunking radio systems
- 800–1000 MHz: cellular systems (analogue and second-generation digital); emergency communications
- 1.8–2.0 GHz: main frequency band for cellular and cordless
- 2.4–2.5 GHz: cordless phones, wireless LANs and wireless PANs (personal area networks); other devices, e.g., microwave ovens.
- 3.3–3.8 GHz: fixed wireless access systems
- 4.8–5.8 GHz: wireless LANs
- 11–15 GHz: satellite TV

1. High frequency → higher loss
2. High frequency → available bandwidth is larger

Frequency reuse

- Available spectrum is limited
- → the same frequency (range) has to be used at many different locations
- Regulated spectrum:
  - a single operator owns the spectrum, and can determine where to put TXs
  - cell planning so that interference adheres to certain limits
- Unregulated spectrum:
  - Often only one type of service allowed,
  - Nobody can control location of interferers
  - Power of interferers is limited by regulations

Limited Energy

- **Power amplifiers: linear v.s. non-linear**
  - Non-linear amplifiers have > 50% efficiency. Linear amplifiers do not.
  - Implications: "signal format" (modulation)
- **Signal processing components**
  - CMOS: slower, but energy-efficient
  - ECL: faster, but energy-hungry
- **Receive Sensitivity: minimum required received power**
  - GSM BS: -100 dBm
  - If -80 dBm (100 times larger):
    - TX power is 100 times larger
    - Battery has to have 100 times more capacity
    - 200g → **20 kg!**

Need: To be able to calculate how far we can go with the equipment we have

A link budget is accounting of all of the gains and losses from the transmitter, through the medium (free space, cable, waveguide, fiber, etc.) to the receiver in a telecommunication system.