Lecture (04)
WLAN RF Principles (cont,…)

CS IT

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Agenda

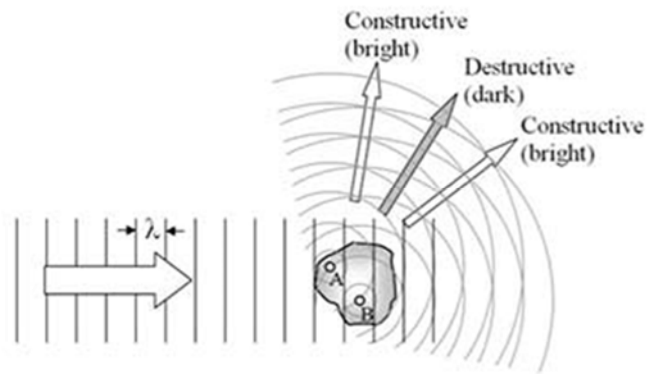
- ~~Characteristics of Wireless Networks~~
- ~~Influences on Wireless Transmissions~~
  - ~~Free Path Loss~~
  - ~~Absorption~~
  - ~~Reflection~~
  - ~~Multipath fading~~
  - Scattering
  - Refraction
  - Line of Sight

Agenda (cont,..)

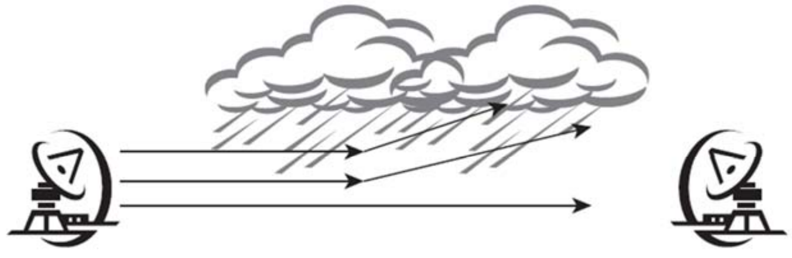
- Determining Signal Strength Influences
  - The Fresnel Zone
  - Received Signal Strength Indicator & Receive Channel Power Indicator
  - Signal-to-Noise Ratio
  - Link Budget

Scattering

- happens when the signal is sent in many different directions.
- This can be caused by some object that has reflective, yet jagged or rough edges, such as dust particles in the air and water.
- to illustrate the effects would be to consider shining a light onto a pile of broken glass.
- The light that is reflected shoots off in many different directions.
- The same is true with wireless, only the pile of glass is replaced with microparticles of dust or water.



Scattering (cont,..)



Wireless Signal Scattering

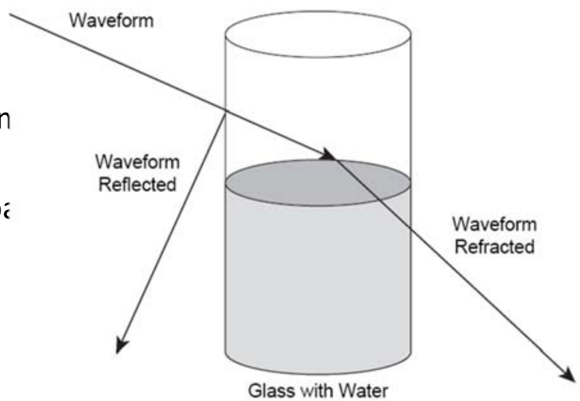
- On a large scale, imagine that it is raining.
- Large raindrops have reflective capabilities.
- When a waveform travels through those microparticles, it is reflected in many directions.
- This is *scattering.*

Scattering (cont,..)

- Scattering has more of an effect on shorter wavelengths, and the effect depends on frequency.
- The result is that the signal weakens.

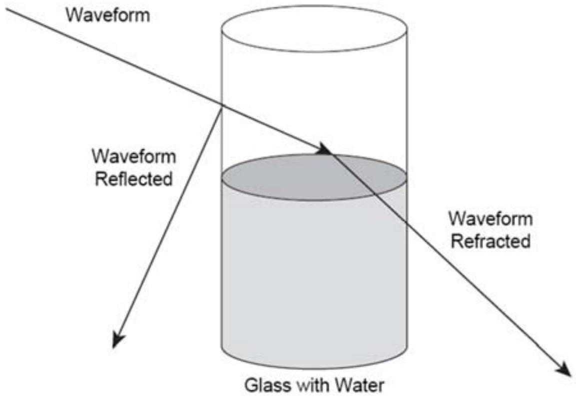
Refraction

- *Refraction is the change in direction of, or the bending of, a waveform as it pass*
  through something that
  different density.
- This behavior causes son
  of the signal to
- be reflected away and pa
  to be bent through the
  object.



The Refraction Issue

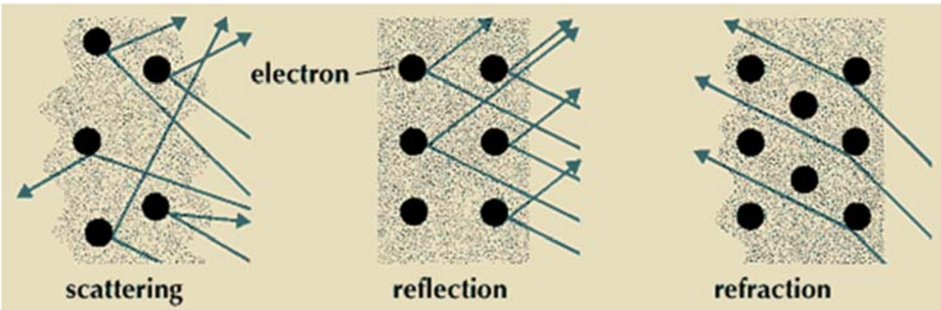
- To understand this consider A waveform is being passed through a glass of water.
- Notice that, because the glass is reflective, some of the light is reflected, yet some still passes through.
- The waveform that is passed through the glass is now at a different angle.



The Refraction Issue

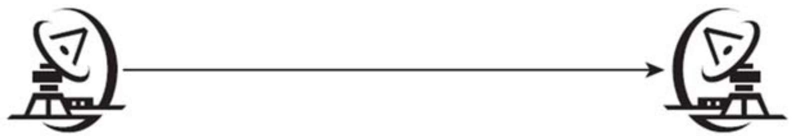
Refraction (cont,..)

- Because refraction usually has the most effect on outdoor signals,
  - dryness refracts away from the earth (as seen in dust particles),
  - and humidity refracts toward the earth.



Line of Sight

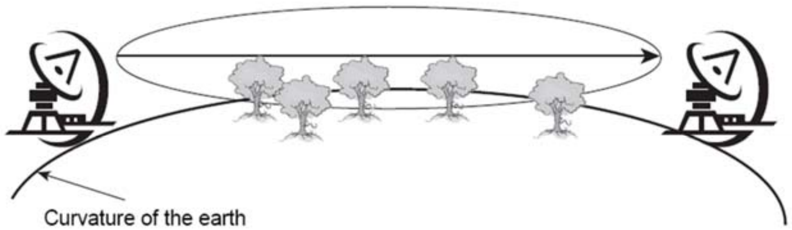
- As wireless signals travel farther distances, the signal widens near the midpoint and slims down nearer to the receiver.
- Figure below illustrates where two directional antennas are sending a signal between the two points.
- The fact that it appears to be a straight shot is called *visual line of sight (LOS).*



Directional Antennas and Line of Sight

Line of Sight (cont,..)

- Even though you see the other endpoint as a direct line, you must remember that the signal does not.

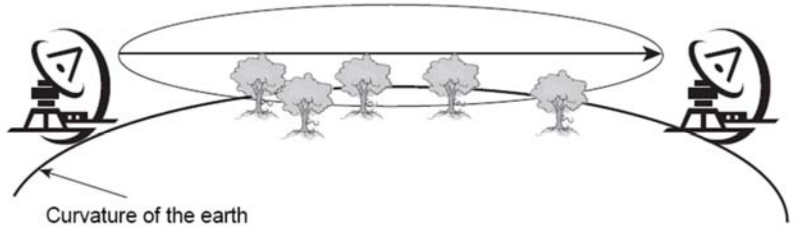


Directional Antennas and LOS with Obstructions

- the signal widens near the midpoint and slims down nearer to the receiver.

Line of Sight (cont,..)

- Although the path has no obvious obstacles, at greater distances the earth itself becomes an obstacle.
- This means that the curvature of the earth, as well as mountains, trees, and any other environmental obstacles, can actually interfere with the signal.



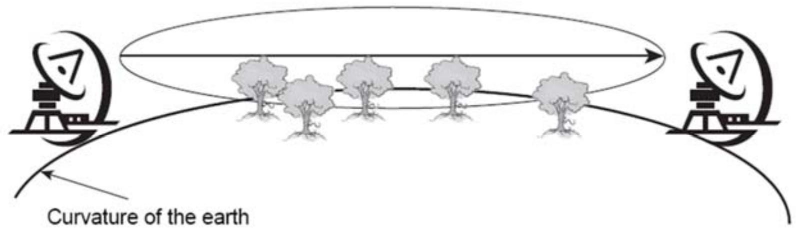
Directional Antennas and LOS with Obstructions

The Fresnel Zone

- Augustin-Jean Fresnel was a French physicist and civil engineer who lived from 1788 to 1827
- He correctly assumed that light moved in a wavelike motion transverse to the direction of propagation, and he was correct.
- Because of his work, a method for determining where reflections will be in phase and out of phase between sender and receiver is based on his name.
- This method determines what is called the *Fresnel zone.*

The Fresnel Zone (cont,..)

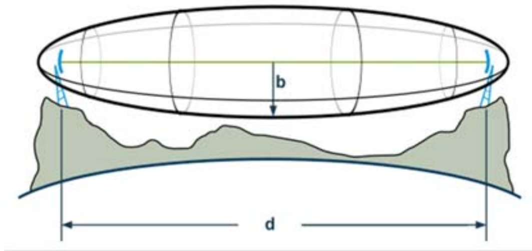
- First he divided the path into zones.
- The first zone should be at least 60 percent clear of obstructions.
- To visualize this, you can think of the shape of a ellipse, which is wider in the middle.



Directional Antennas and LOS with Obstructions

The Fresnel Zone (cont,..)

- However, with the Fresnel zone calculation, you use an equation to determine what the short diameter of the ellipse is at the middle.
- This helps to determine the width that a wave will be so you can make sure that no obstacles are in the path.



The Fresnel Zone (cont,..)

- The general equation for calculating the Fresnel zone radius at any point P in between the endpoints of the link is the following:

$$F_n = \sqrt{\frac{n\lambda d_1 d_2}{d_1 + d_2}}$$

F_n = The n^{th} Fresnel Zone radius in metres

d_1 = The distance of P from one end in metres

d_2 = The distance of P from the other end in metres

λ = The wavelength of the transmitted signal in metres

The Fresnel Zone (cont,..)

- *r* = radius in metres
- *D* = total distance in kilometres
- *f* = frequency transmitted in gigahertz.

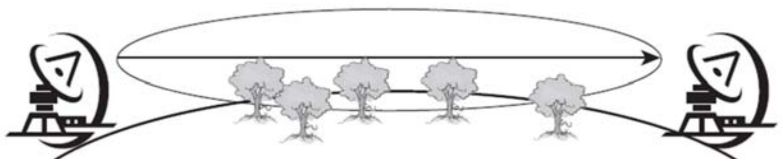
$$r = 8.657\sqrt{\frac{D}{f}}$$

The Fresnel Zone (cont,..)

- online Fresnel zone clearance calculator at *http://www.terabeam.com/support/calculations/fresnel-zone.php*

Example

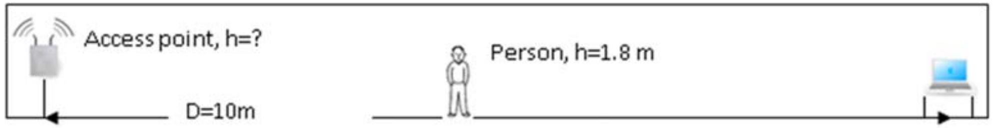
- for a 2.4-GHz system, at 11 Km
- Short radius of 1^{st} fresnel zone =18.5m
- You need 60% free of 1^{st} freesenel zone = 11.1 m
- you need to have the antennas mounted at 12 meters.



The Fresnel Zone (cont,..)

Example

- for a 2.4-GHz system, at 10m
- Short radius of 1st fresnel zone =8.657 $(0.01/2.4)^{0.5}$= 0.56m
- You need 60% free of 1st freesenel zone 0.56 m
- you need to have the antennas mounted at 0.34 m for a plain ground surface
- Considering that person's average length is 1.8 m
- So you need to have the antennas mounted at 2.14 m to avoid effect of persons existence in WLAN path.



Received Signal Strength Indicator & Receive Channel Power Indicator

- The Received Signal Strength Indicator (RSSI) measurement uses vendor-specified values.
- Because of this, you cannot relay on it to compare different vendors.
- The scale is usually represented in dBm
- RSSI is acquired during the preamble stage of receiving an 802.11 frame
- Receive Channel Power Indicator (RCPI), which is a functional measurement covering the entire received frame with defined absolute levels of accuracy and resolution.

Signal-to-Noise Ratio

- *Signal-to-noise ratio (SNR) is the term used to describe how much stronger the signal is* compared to the surrounding noise that corrupts the signal
- To understand this, suppose you walk into a crowded park with many screaming kids and speak in a normal voice while on the phone.
- The odds are that the noise is going to be so loud that the person on the other end will not be able to distinguish your words from all the noise around you that is also being transmitted over the phone, "This is how the wireless network operates"

Signal-to-Noise Ratio (cont,..)

- If the outside influences are causing too much noise, the receivers cannot understand the transmissions.
- When the software that runs your wireless card reports this measurement, it is best to have a higher number, but this is also built on the RSSI value, so it is vendor determined.

Link Budget

- *Link budget is a value that accounts for all the gains and losses between sender and receiver,* including attenuation, antenna gain, and other miscellaneous losses that might occur.
- This can be useful in determining how much power is needed to transmit a signal that the receiving end can understand.
- The following is a simple equation to factor link budget:

Received Power (dBm) = Transmitted Power (dBm) + Gains (dB) – Losses (dB)