CS
IT

Lecture (03)

WLAN RF Principles

By:

Dr. Ahmed ElShafee

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~~

Characteristics of Wireless Networks

Review of Wavelength

- A *wavelength is the distance between successive crests of a wave.*
- Or distance between one point in the AC cycle to the next point in the AC cycle.
- the waveform takes on a form called a *sine wave.*
- The waveform starts as an AC signal that is generated by a transmitter inside an access point (AP) and is then sent to the antenna, where it is radiated as a sine wave.
- During this process, current changes the *electromagnetic field around the antenna, so it transmits* electric and magnetic signals.

Characteristics of Wireless Networks (cont,..)

- Examples of common signals wave length
  - AM radio waveforms are 400 to 500 meters long.
  - Wireless waveforms in wireless LANS are only a few centimeters.
  - Waveforms sent by satellites are approximately 1 mm long.

Characteristics of Wireless Networks (cont,..)

Review of Frequency

- It is the rate at which something occurs or is repeated over a particular period or in a given sample or period.
- Or it is the rate at which a vibration occurs that constitutes a wave in a second
- Because frequency refers to cycles

Characteristics of Wireless Networks (cont,..)

- some facts
  - 1 cycle = 1 Hz
  - Higher frequencies travel shorter distances
  - When a waveform is seen once in a second = 1 Hz
  - 10 times in a second = 10 Hz
  - 1 million times in a second = 1 MHz
  - 1 billion times in a second = 1 GHz

Characteristics of Wireless Networks (cont,..)

Review of Amplitude

- The vertical distance between crests in the wave is called *amplitude.*
- Amplitude is the quantity or amount of energy that is put into a signal.
- Folks like the FCC and European Telecommunications Standards Institute (ETSI) regulate the amplitude.

Characteristics of Wireless Networks (cont,..)

Review of Effective Isotropic Radiated Power

- When an access point sends energy to an antenna to be radiated, a cable might exist between the two.
- A certain degree of loss in energy is expected to occur in the cable.
- To calculate EIRP, use the following formula:
- EIRP = transmitter output power – cable loss + antenna gain

Influences on Wireless Transmissions

- Some influences can stop a wireless signal from propagating altogether, whereas others might simply shorten the transmission distance.
- These influences are
  - Free Path Loss model,
  - absorption,
  - reflection,
  - scattering,
  - multipath,
  - refraction, and
  - line of sight.

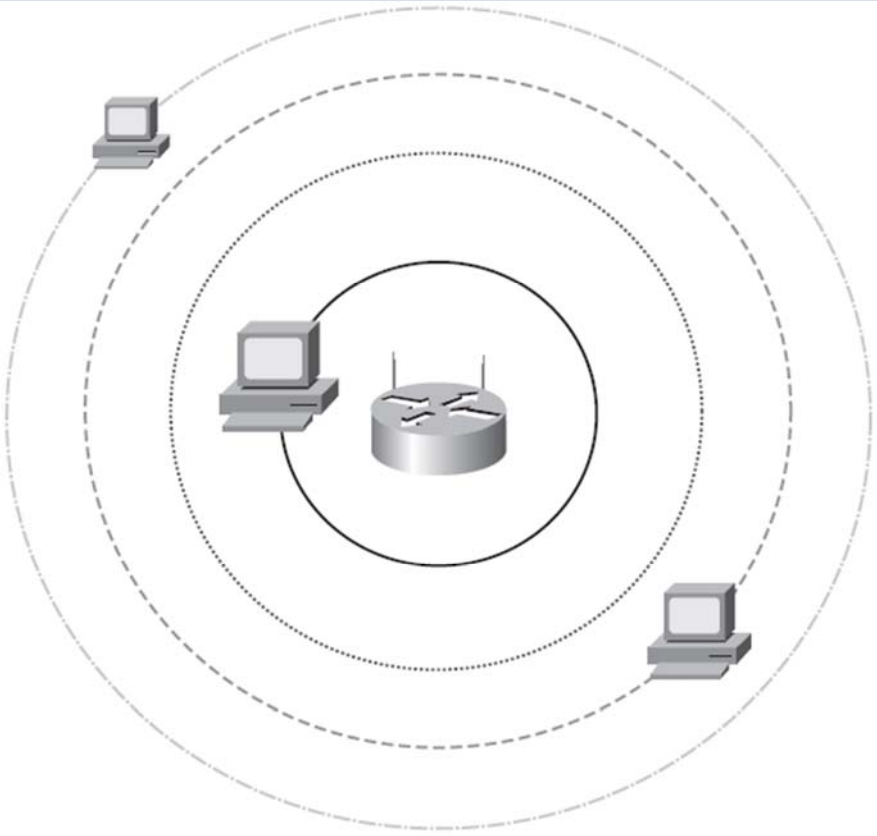
Free Path Loss

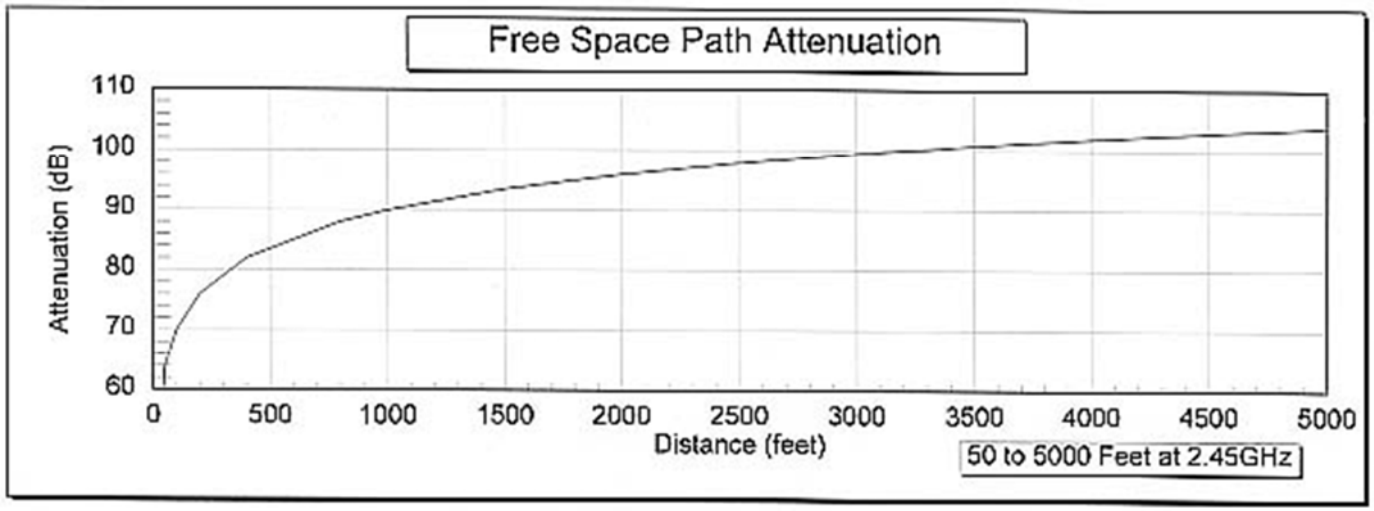
In telecommunication, free-space loss (FSL) is the loss in signal strength of an electromagnetic wave that would result from a line-of-sight path through free space (usually air),

with no obstacles nearby to cause reflection or diffraction.

It does not include factors such as the gain of the antennas used at the transmitter and receiver, nor any loss associated with hardware imperfections.

Free Path Loss (cont,..)





Free Path Loss (cont,..)

- A device closer to the transmitter usually gets a more concentrated signal, and a receiver farther away might get only one dot.

- it is found that the signal decreases in a way that is inversely proportional to the square of the distance from the source of the radio signal.
- Free-space path loss is proportional to the square of the distance between the transmitter and receiver, and also proportional to the square of the frequency of the radio signal.

- The equation for FSPL is

$$\mathrm{FSPL} = \left(\frac{4\pi d}{\lambda}\right)^2 = \left(\frac{4\pi df}{c}\right)^2$$

- is the signal wavelength (in metres),
- is the signal frequency (in hertz),
- is the distance from the transmitter (in metres),
- is the speed of light in a vacuum, 2.99792458×10^8 metres per second.

- **Free-space path loss in decibels (generic)**

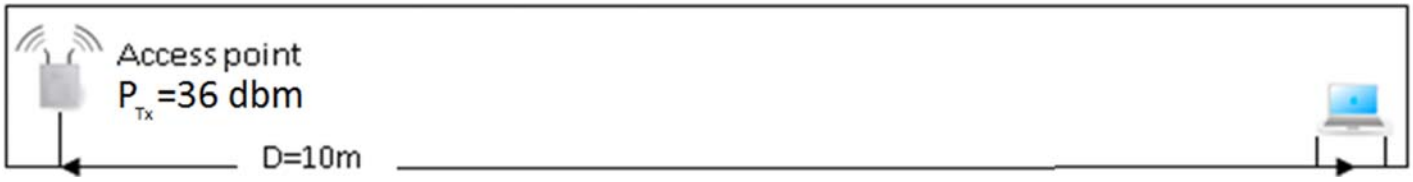
$$\begin{aligned}\mathrm{FSPL(dB)} &= 10\log_{10}\left(\left(\frac{4\pi}{c}df\right)^2\right)\\ &= 20\log_{10}\left(\frac{4\pi}{c}df\right)\\ &= 20\log_{10}(d)+20\log_{10}(f)+20\log_{10}\left(\frac{4\pi}{c}\right)\\ &= 20\log_{10}(d)+20\log_{10}(f)-147.55\end{aligned}$$

- **d: distance in meters**
- **f: frequency in Hz**

- **Free-space path loss in decibels (WLAN)**

$$\begin{aligned}\mathrm{FSPL(dB)} &= 10\log_{10}\left(\left(\frac{4\pi}{c}df\right)^2\right)\\ &= 20\log_{10}\left(\frac{4\pi}{c}df*10^9\right)\\ &= 20\log_{10}(d)+20\log_{10}(f)+20\log_{10}\left(\frac{4\pi}{c}*10^9\right)\\ &= 20\log_{10}(d)+20\log_{10}(f)+32.45\end{aligned}$$

- **d: distance in meters**
- **f: frequency in GHz**



- Example, find received signal strength in mWatts, assuming that path between access point and laptop is clear path.

ANS

FSPL = 20 $\log_{10}(10)$ + 20 $\log_{10}(2.4)$ + 32.45 = 20 + 7.6 + 32.45 = 60.05 db

$P_{Rx(dbm)}$ = 36 – 60.05 = - 24.05 dbm

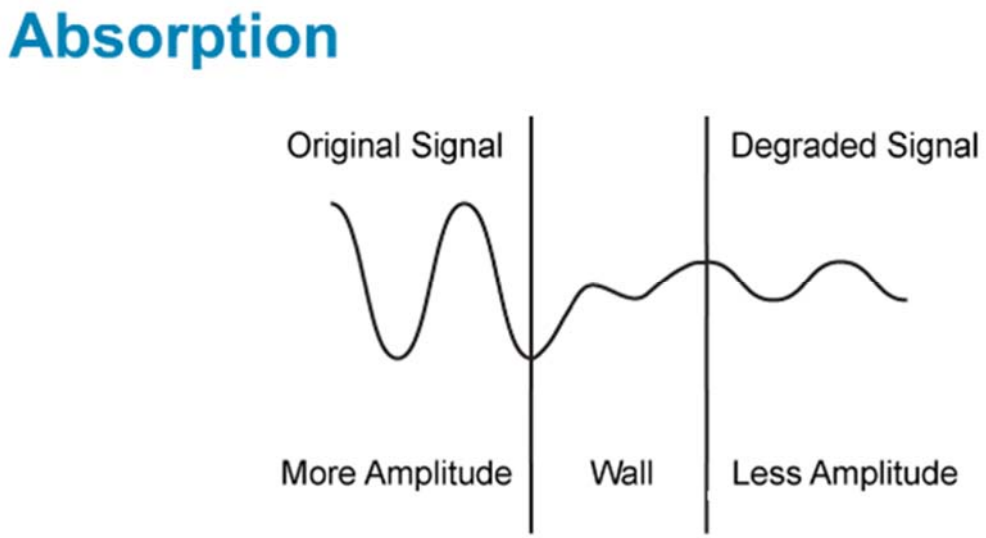
10 log $P_{Rx(mw)}$ = -24.05 → $P_{Rx(mw)}$ = 0.004 mw

Absorption

- An effect of absorption is heat. When something absorbs a wave, it creates heat in whatever absorbed the wave.
- This is seen in microwaves ovens. They create waves that are absorbed by your food, The result is hot food.
- Absorption reduces the amplitude of the signal, and reduces the travelling distance of that signal
- A problem you can encounter is that if a wave is entirely absorbed, it stops.
- Absorption does not change the wavelength or the frequency of the wave. These two values do not change as a wave is absorbed.

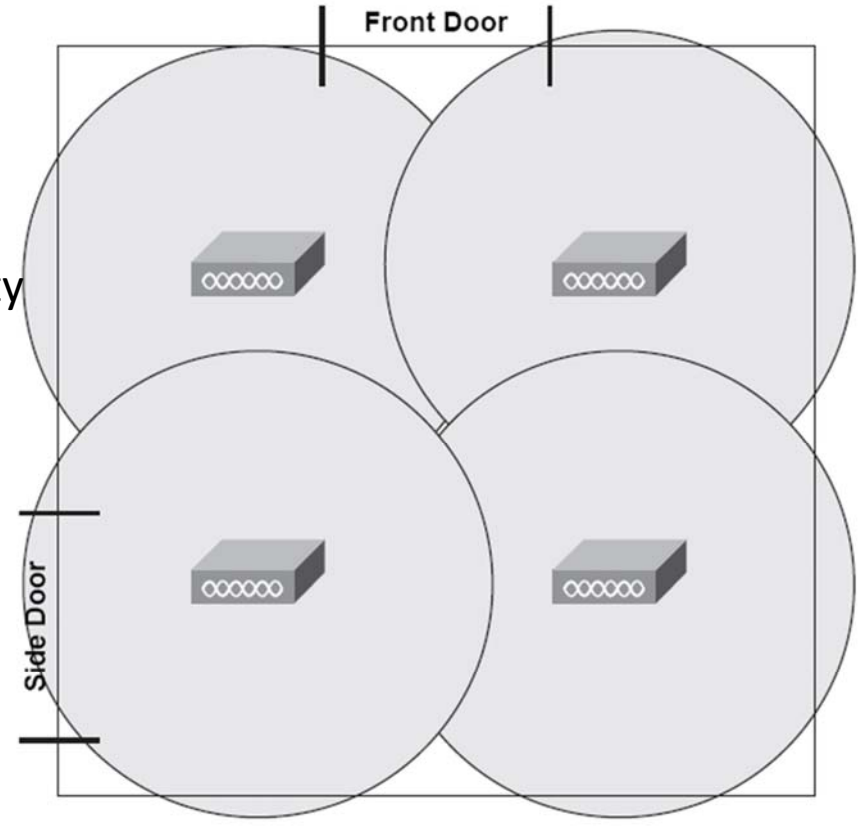
Absorption (cont,..)

- sources of absorption are; Walls, bodies, and carpet can absorb signals.



Absorption (cont,..)

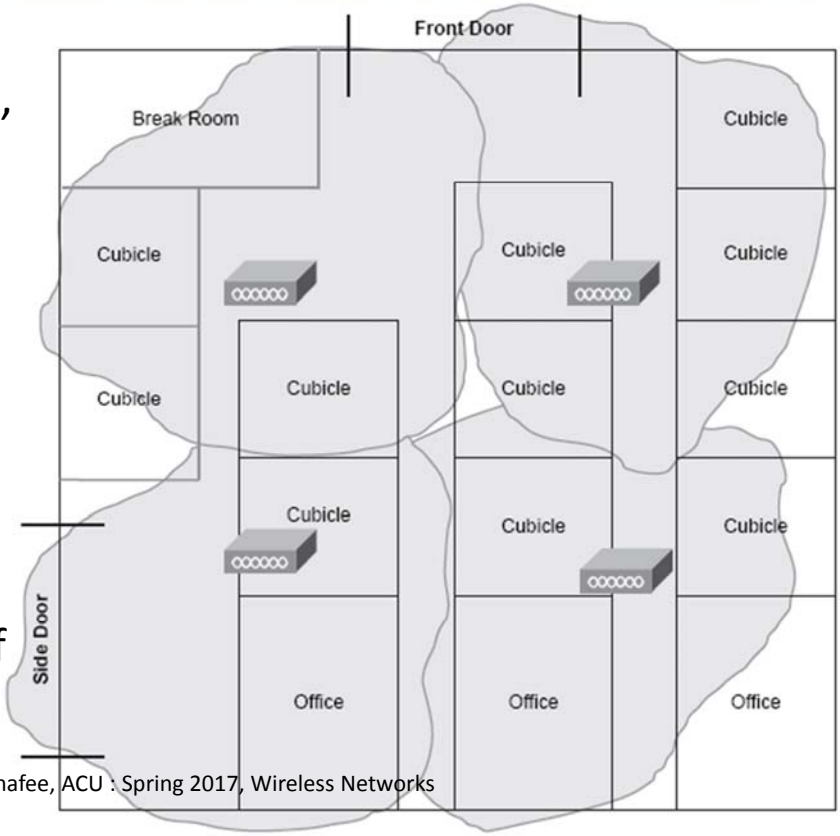
- Absorption and RF deployment:
- In the figure the four APs will provide plenty of coverage.
- This is because you cannot see absorption.
- Nothing causes the issue.

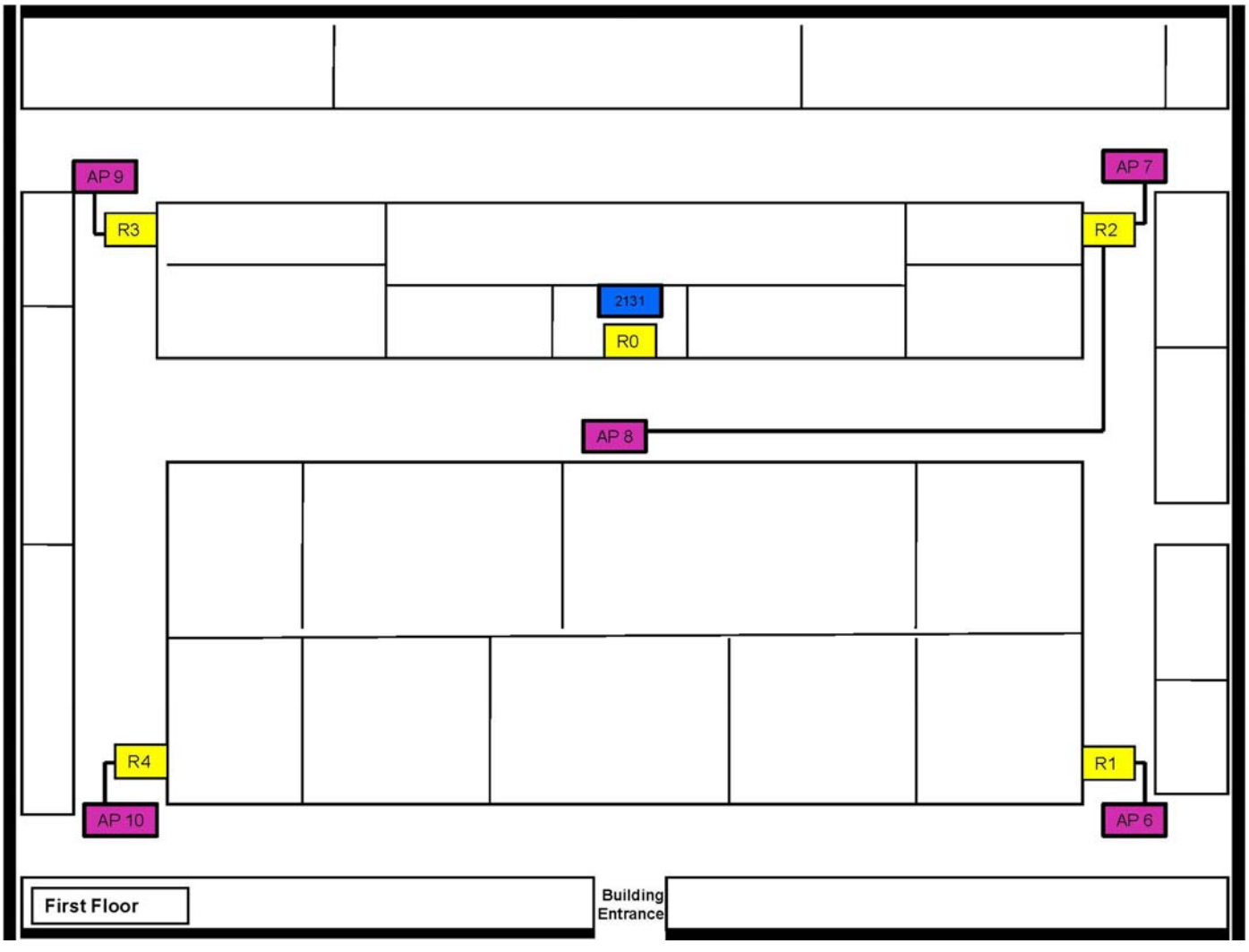


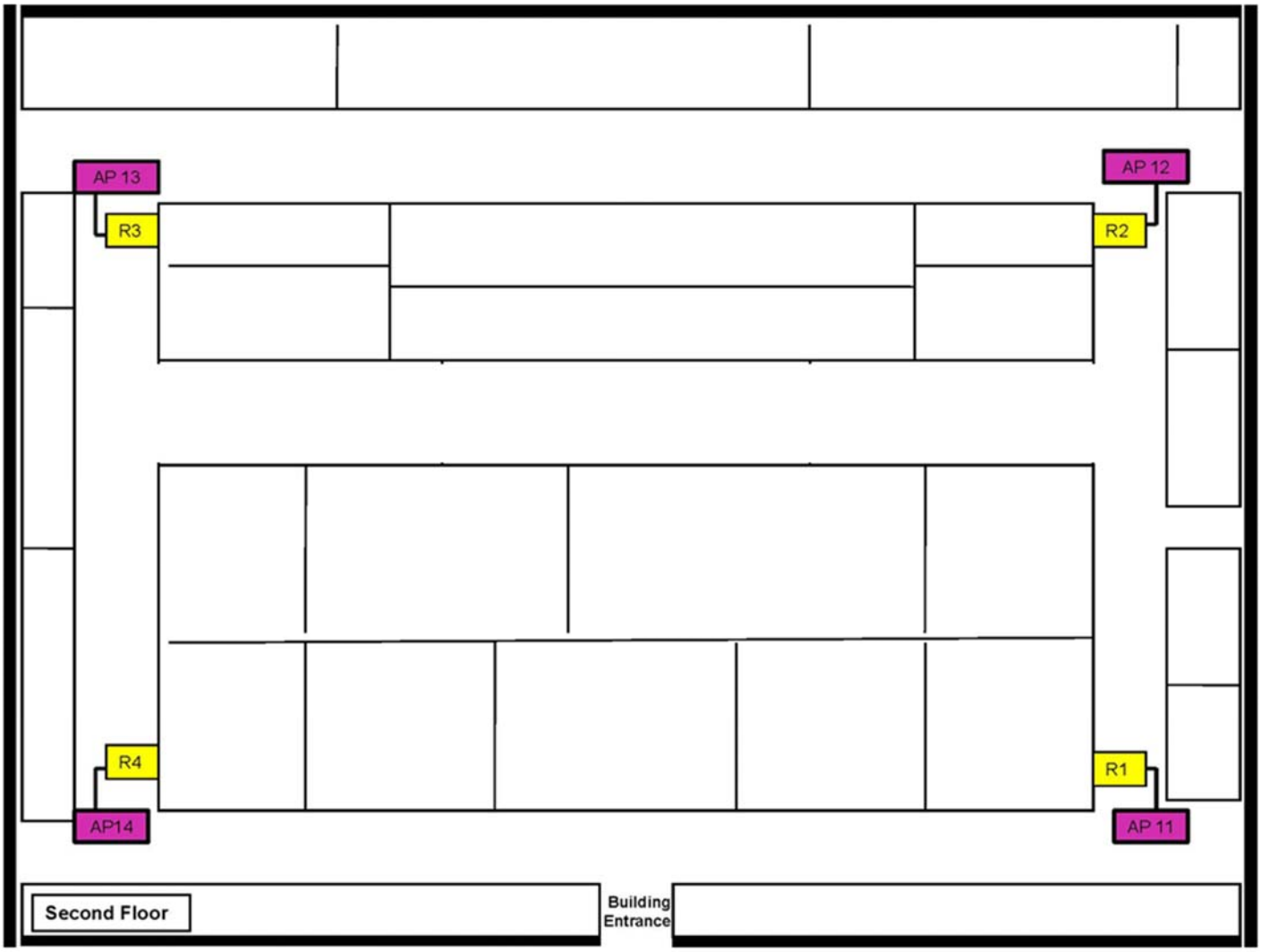
Absorption Before Office Move-In

Absorption (cont,..)

- Notice that with the furniture, cubicle walls, and other obstacles,
- the four APs that you originally thought would be sufficient no longer provide the proper coverage because of the signal being absorbed.
- This is an illustration of absorption.

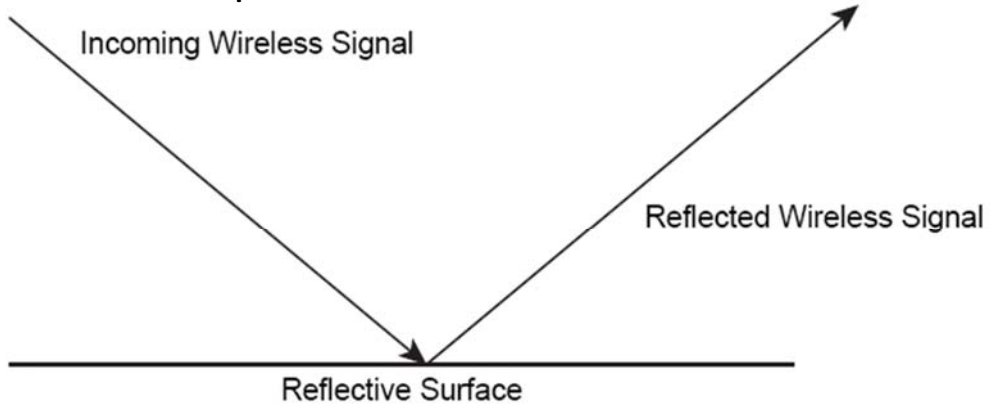






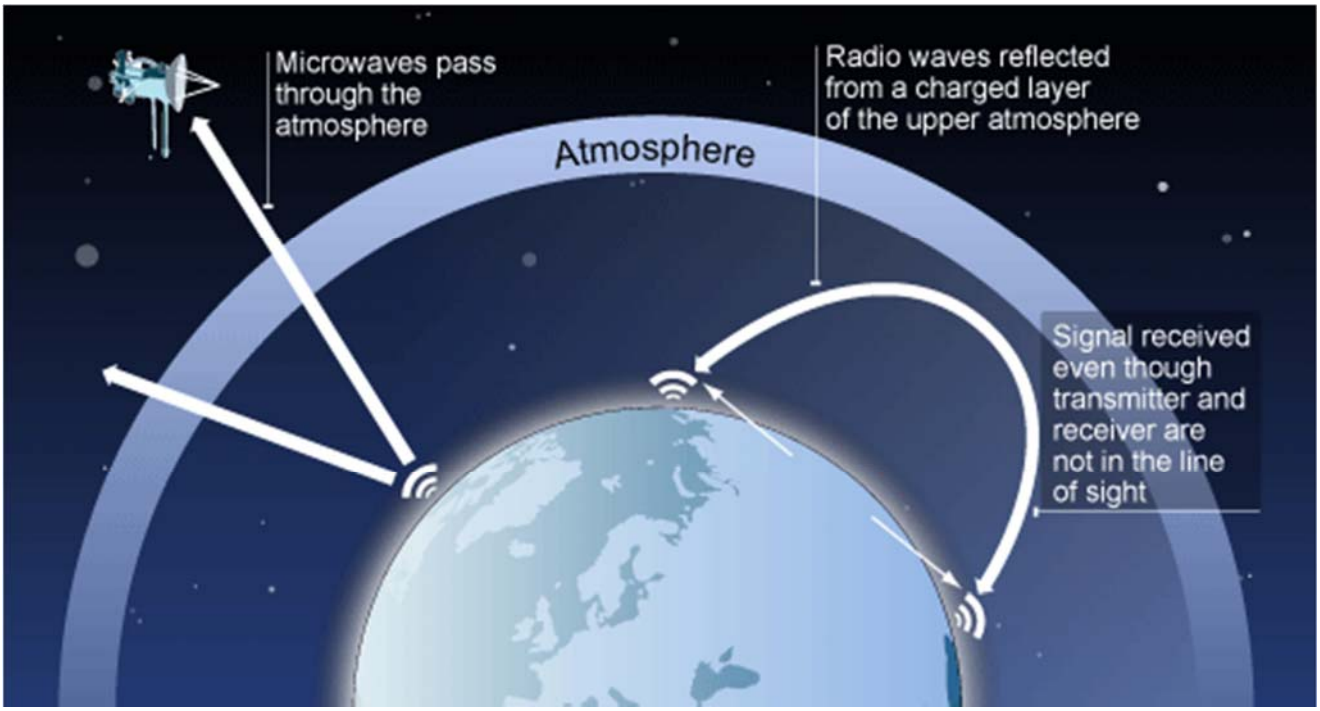
Reflection

- Reflection happens when a signal bounces off of something and travels in a different direction.
- This can be illustrated by shining a flashlight on an angle at a mirror, which causes it to reflect on an opposite wall.
- The same concept is true with wireless waveforms.



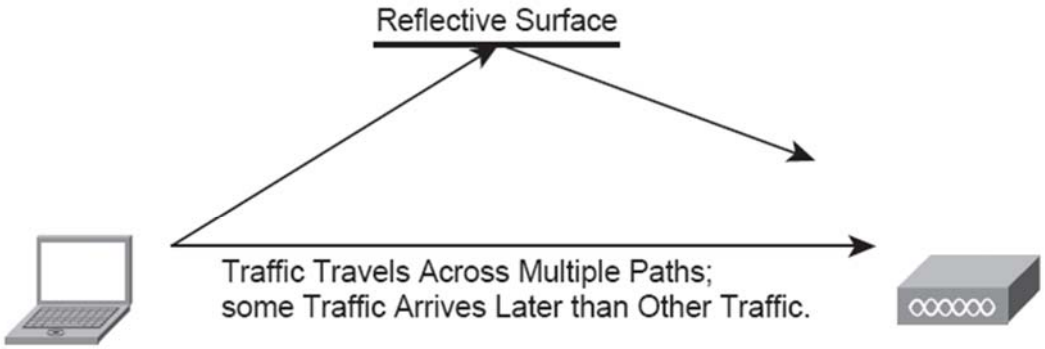
Reflection (cont,..)

- the reflection of the signal is reflected at the same angle that it hits the mirror.
- Reflection (reflected waves) considered to be a source of interference in an office environment.
- Offices do have objects with a reflective qualities (act as a reflector for electromagnetic waves basically metal or glassy objects), such as monitors and framed artwork with glass facing, metal art work.
- Reflection depends on the frequency.
- You will encounter some frequencies that are not affected as much as others.
- This is because objects that reflect some frequencies might not reflect others.



Multipath fading

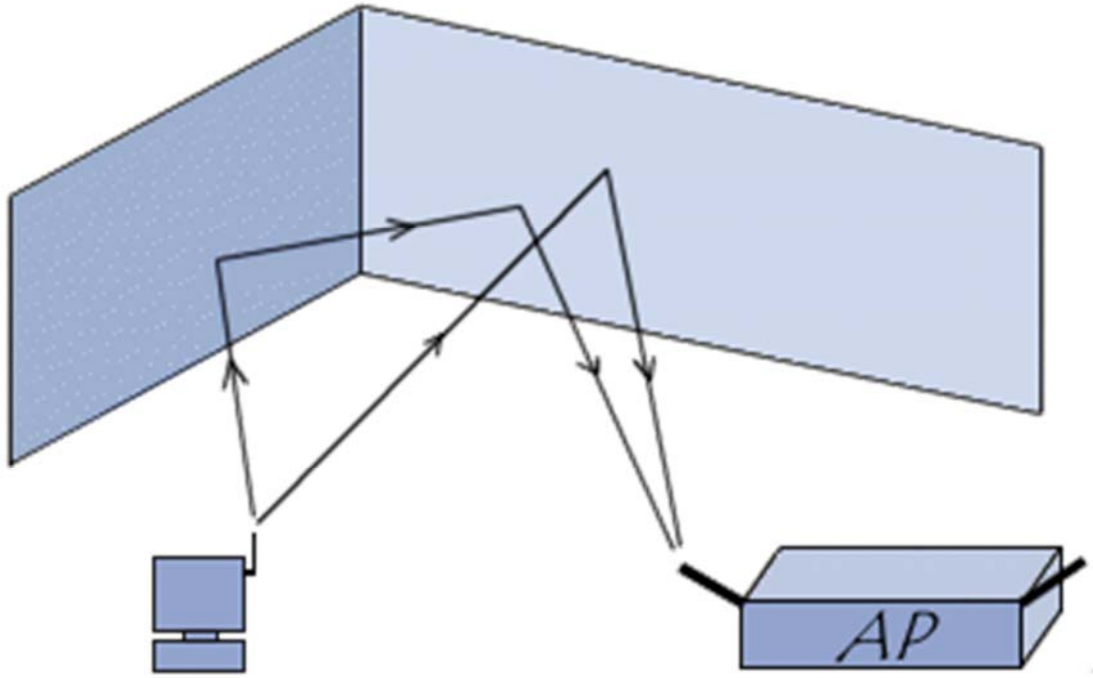
- *Multipath is what happens when portions of signals are reflected and then arrive out of* order at the receiver, as illustrated in Figure



The Multipath Issue

Multipath fading (cont,..)

- One characteristic of multipath is that a receiver might get the same signal several times over.
- This is dependent on the wavelength and the position of the receiver.
- Another characteristic of multipath is that it can cause the signal to become out of *phase.*
- *When you receive out-of-phase signals, they can cancel each other out, resulting* in a null signal.



Thanks,..

See you next week (ISA),…