lec 2.01: Wireless channel impairments and mitigation techniques

- Impairments: Phenomenon that reduce the signals strength/usefulness
- Mitigation: methods to proactively reduce impairment phenomenon

Impairments

1. Path Loss
2. Shadowing
3. Fading
4. MultiPath
5. Noise
6. Interference

Path Loss

- Even when line of sight exists signal attenuates with distance
  - Attenuation: reduction in force, effect or value of something
  - Loss is roughly proportional to $\frac{1}{d^2}$

Shadowing

- The attenuation that occurs from obstacles being in the path of the signal from transmitter to receiver
- Modelled with a log-normal distribution
  - Local mean power, expressed in dB, has a Gaussian distribution

Multi-path

- Due to reflection and scattering multiple version of the signal may arrive at the receiver.
- It is possible for out of phase versions of the same signal to cancel each other. This is a severe situation.
- Think if this as the signal splitting as it hits an uneven surface.
- Delay Spread: original signal is spread due to different delays pf parts of teh signal.

Fading (wireless)

- The signal loss as it propagates through a medium
- When referring to a wireless medium, fading is referencing Multi-Path signal loss i.e it's bouncing off of many different surfaces as the signal aims to reach the receiver.

Noise

- Unwanted signals added to the transmitted signal.
- Can come from both natural and man-made phenomenon.
- Sometimes modeled in the aggregate as a random signal in which power is distributed uniformly across all frequencies (white noise)
- *Signal to noise Ration* (SNR) is used as a measure of the quality of a channel.

Mitigation

1. Diversity
2. Directional Antennas
3. Coding and Modulation
4. Spread Spectrum
5. System Level mitigation

Diversity

- Combining independently received versions of the desired signal.

Types:

- Spatial Diversity: Multiple antennas
- Frequency Diversity: Multiple Frequencies
- Temporal Diversity: Repeated Transmissions
- Polarization diversity: Different Polarizations

Directional Antennas

- Arranging the antenna array elements in a certain geometry
- By appropriately weighing the elements one can maximise the gain in one direction while minimizing it in the other directions.
- Can be used to reduce interference

Coding and Modulation

Digital modulation schemes vary in

- power efficiency - how much power is needed to transmit
- Spectral efficiency - bits/second/Hz
- Robustness - to multipath fading, noise, interference
- Multi-carrier modulation splits the bit stream into several lower bit rate streams, each sent using independent carrier frequency
- forward error correction mitigates the effect of channel errors

Spread Spectrum

- Signals are distributed over a wide range of frequencies and then collected back at the receiver
- The signals are noise like and thus are difficult to detect and interfere with

Frequency Hopping

- Transmitter and receiver hopping between pre-defined frequency bands according to a pre-established and agreed hopping sequence.
- For security
- Fast and slow hopping (The amount of periods that a signal is transmitted over a certain frequency)

Direct sequence spread spectrum

The bit stream is XORed with a chipping sequence

The spreading factor determines the bandwidth of the signal to be transmitted

More resistant to fading and multipath as well as being much harder to detect.

Qs from lecture and answers

Q : what is the most detrimental wireless channel impairment for LAN?

A : Interference as access points are deployed very close to each other

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Q : What about WAN

A : Path loss and noise due to the distance between stations.

Q : What about hilly regions

A : Shadowing, the transmitter and receiver are not in line of sight