Lecture 3B

This is material that was omitted from the previous lectures due to lack of time.

Percentage of Area Coverage

- due to log-normally distributed shadowing the path loss at a fixed distance from the center of the cell will vary
- based on the mean signal level and the log-normal fading variance can compute the fraction of the users at the boundary of the cell that will have a signal above a given threshold
- it is also useful to determine the fraction of the *area* within a cell where the signal level is above a threshold (i.e. fraction where there is coverage)
- if we assume that users are uniformly distributed within the cell this is also the fraction of locations that will have service
- we can find the probability of being above threshold as function of the distance from center of cell
- by integrating this over the cell we can find the total fraction of the cell above threshold
- equation 3.79 or Figure 3.18 can be used to find the fraction of the cell covered from the log-normal shadowing variance (σ), the path loss exponent (n), and the fraction of coverage at the cell boundary
- *Warning:* Figure 3.18 contains errors (mislabeled curves?)

Terrain-Specific Propagation Prediction

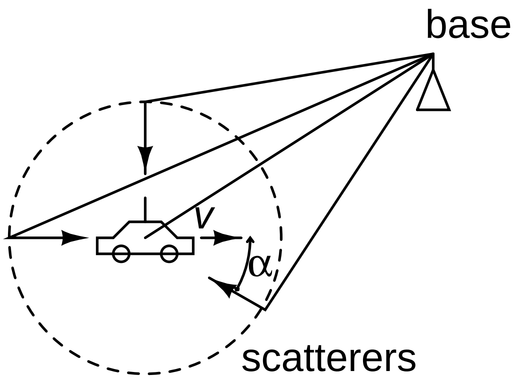
- general models such as Hata/Okumura or COST-231 are useful for system design (selection of cell sizes, modulation scheme, transmitter powers, etc)
- site-specific models are better-suited for propagation prediction in specific locations (e.g. for selection of a base station location)
- these models predict the path loss (and possibly the delay profile) for specific paths based on terrain information
- terrain information may come from topographic databases (USGS), municipal GIS systems, or surveys
- computer programs are used to predict the loss over specific paths using diffraction models and empirically-derived correction factors

Building Penetration Loss/Variance

- useful for predicting indoor coverage
- penetration loss is the difference between the signal strength outside and inside building
- highly dependent on building materials (e.g. glass vs aluminum siding)
- also depends on height and position inside building
- at cellular frequencies, penetration losses are on the order of 10 dB with large variances (about 8 dB)
- some buildings, shopping malls, tunnels, etc. use active RF re-distribution systems to provide indoor coverage

Clarke's Fading Model

- classical model for "Rayleigh" fading
- assumes fixed transmitter, mobile receiver, large number of scatterers uniformly distributed (in angle) around the mobile, signals arriving by different paths have equal amplitude, uniformly distributed phases, equal delays



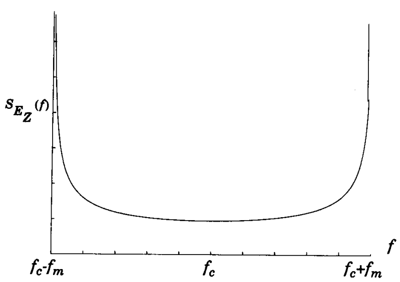
- the resulting phase is uniformly distributed in $[0, 2\pi)$ and the resulting magnitude is Rayleigh distributed

The Carrier Spectrum

- each signal component will experience a different Doppler shift which is a function of the angle α

- for an omnidirectional antenna and circularly uniform scatterers:

$$S(f) \propto \frac{1}{\sqrt{1 - \left(\frac{f-f_c}{f_m}\right)^2}}$$



The Envelope Spectrum

- we can also derive the spectrum of the envelope and from that two useful statistics: level crossing rates and average fade duration

- the number of positive-going threshold crossings of the envelope is:

$$N_R = \sqrt{2\pi} f_m \rho e^{-\rho^2}$$

where ρ is the threshold relative to the rms level

- and the average fade duration is:

$$\bar{\tau} = \frac{e^{\rho^2} - 1}{\rho f_m \sqrt{2\pi}}$$

Narrowband Fading Simulators

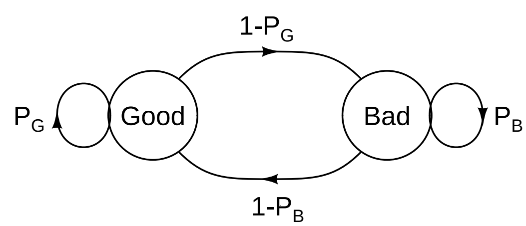
- simulation is an efficient way to to study many communication problems

- we can simulate the effect of the fading channel by splitting the RF signal into in-phase and quadrature components and modulating each component using Gaussian noise with the appropriate spectrum

- to simulate a frequency-selective (time-dispersive) channel we can use a multi-tap delay lines and modulate each tap in the same way

Gilbert Burst Error Channel Model

- to model burst-error channels we can use a two-state Markov model



- in one state (good) the error rate is zero, in the other (bad) it is 0.5

- simple to implement (using a random number generator)

- there are two parameters (roughly, error probability and burst length) which are determined by P_G and P_B

Measuring the Channel Response

- direct pulse measurements: practical only for short distances (broad bandwidth)

- sliding correlator: transmit a periodic PN signal, correlate received signal with local copy, peaks in output correspond to zero delay (modulo period) between received and reference signals, change (“slide”) local reference time to find peaks (and thus channel delays)

- swept CW signal: measure phase/amplitude change as function of frequency (transfer function), computed inverse Fourier transform is impulse response

- known wide-band signal: divide received spectrum by transmitted spectrum and take inverse Fourier Transform

- requires GPS or other high-accuracy time base for absolute delay, often delay profile is sufficient