Review Lecture

This lecture reviews the tasks you are expect to be able to do on the mid-term exam. You should be able to:

Wireless and Cellular Terminology

- state the most important advantages and disadvantages of wireless communications as compared to wired communications
- understand system descriptions that make use of the acronyms and terminology listed in Lecture 1.

Basic Concepts

- dB, dBm, dBV : convert voltages and power ratios to/from dB and absolute voltages and powers to/from dBm or dBV
- λ, c, f : find any one give the other two
- Erlangs : compute traffic in Erlangs from traffic intensity and mean call duration
- f_D, v, c, f_c : find any unknown if given the others

Cellular Concepts

- determine whether a cluster size is feasible ($N = i^2 + ij + j^2$)
- compute reuse factor ($1/N$)
- compute SIR in the general case $SIR = \frac{S}{I} = \frac{S}{\sum_{i=1}^{i_0} I_i}$ and for the special case that considers only the first ring of interferers and a power-law path loss:

$$\frac{S}{I} = \frac{S}{\sum_{i=1}^{i_0} I_i} = \frac{R^{-n}}{\sum_{i=1}^{i_0} D_i^{-n}} = \frac{(D/R)^n}{i_0} = \frac{(\sqrt{3N})^n}{i_0}$$

- compute improvement in SIR due to sectorization ($\frac{1}{\text{sectors}}$)

Antennas

- compute directivity given one antenna pattern
- compute gain given the antenna pattern and the reference antenna pattern
- compute distance to far field ($d > \frac{2D^2}{\lambda}$)

Free-Space Propagation

- compute the received power given the power density at a given distance and the new distance
- compute the received power using the Friis transmission formula:

$$P_r(d) = \frac{P_t G_t G_r \lambda^2}{(4\pi)^2 d^2}$$

- compute the EIRP from antenna gain and transmitter power ($P_t G_t$)
- compute power density from received power and effective apperture ($P_d = P_r/A_e$)
- compute effective apperture from directivity ($A_e = \frac{\lambda^2}{4\pi} D$)
- compute the field strength from power density and $\eta = 120\pi$ ($E = \sqrt{P_d \eta}$) (volts/metre)

Deterministic non-LOS Propagation Models

- list and give examples of three non-LOS propagation mechanisms
- 2-ray model
- approximate (large distance) 2-ray path loss
- knife-edge diffraction
- find locations of Fresnel zones ($\Delta = n\lambda/2$)
- compute knife-edge diffraction loss

Mean Path Loss

- compute the path loss using the following models:
- power law: $P_r(d) = P_0 \left(\frac{d}{d_0}\right)^{-n}$
- Okumura/Hata
- COST-231

Log-Normal Shadowing

- compute probability that signal level x is above threshold γ, if power level distribution is log-normal (dB values are normal) with mean μ and variance σ^2:

$$Pr[x > \gamma] = \frac{1}{2}\left(1 - \text{erf}\left(\frac{\gamma - \mu}{\sqrt{2}\sigma}\right)\right)$$

Trunking Efficiency

- define grade of services (GOS)
- determine if a problem meets the assumptions behind the Erlang-B formula
- compute traffic intensity, total traffic, GOS

Multipath Propagation - Statistical Characterization

- compute Doppler rate for given transmitter/reflector/receive geometry
- distinguish between slow- and fast-fading channels from Doppler rate and symbol rate
- relate coherence time and Doppler rate
- compute rms delay spread from channel impulse response or power delay profile
- distinguish between flat- and frequency-selective channels from delay spread and signal bandwidth
- relate coherence bandwidth and delay spread

Rayleigh and Ricean Distributions

- describe the scattering models giving rise to these two distributions
- state whether the envelope or the envelope squared is so distributed and convert to/from dB
- compute a probability that a Rayleigh or Ricean distributed variable is below a threshold given σ and either K or A

Percentage of Area Coverage

- compute fraction of a cell that has signal level above a threshold given this fraction at the cell edge, the log-normal shadowing variance (σ^2) and the path loss exponent (n) and the graph on page 108

Statistics from Clarke's Model

- describe the assumptions about scatterer locations and relative movement implicit in Clarke's model
- explain (qualitatively) how the Doppler spectrum would be affected by changes in the scatterer locations and relative velocities
- compute level crossing rate from the threshold level and the Doppler rate
- compute average fade duration from the threshold threshold level and the Doppler rate
- describe the structure of fading simulator

FM

- compute the modulation index of an analog FM signal
- compute the bandwidth of an FM signal using Carson's rule
- compute the SNR improvement for an FM discriminator demodulationg WBFM and operating above threshold

Digital Modulation

- compute the Shannon Capacity bound from the channel bandwidth and S/N
- compute the absolute, null-to-null, -3 dB, and 99% bandwidths from a graph of the Power Spectral Density of a modulated signal
- evaluate whether a channel meets the Nyquist no-ISI criteria
- for Nyquist filter, determine α from $H(f)$ and symbol rate
- compute the bandwidth from a plot of the Power Spectral Density of the modulated signal
- compute the spectral efficiency from the bandwidth and bit rate
- compute the relative power efficiency of two modulation schemes at given BER based on their BER versus E_b/N_0 plot
- for each of:
- BPSK
- DBPSK
- QPSK
- GMSK
- be able to:
- describe how the signal is generated (diagram)
- give the number of bits/symbol
- state whether it is a constant-amplitude signal
- give basis functions and signal space constellation (*x*SK only)
- compute bandwidth as function of symbol rate (”)
- compute error rate as function of E_b/N_0 for an AWGN channel
- list some advantages of constant-envelope modulation

Effect of Slow Fading on BER

- compute averate BER in slow fading given the BER in AWGN and pdf of the E_b/N_0

Spread Spectrum

- describe structure of DS-SS transmit spreading and receiver despreading
- find processing gain for DS-SS (N) as function of spread and de-spread bandwidths
- compute error rate for DS-SS assuming BPSK, and a large number of uncorrelated interferers
- list some advantages and disadvantages of DS-SS
- describe the structure of a FH-SS transmitter and receiver
- compute error rate for asynchronous FH-SS for K users, M channels, and bits/hop (N_b)

Diversity

- describe the mechanism used to obtain the following diversity branches:
- space
- time
- frequency
- polarization
- describe the operation of the following combining methods:
- selection
- maximal ratio
- switching
- compute the reduction in the probability of fading for M-branch selection diversity

FEC Coding

- identify basic code parameters: rate, minimum distance
- describe difference between block and convolutional codes
- describe meaning of k and n for block and convolutional codes
- perform a simple (linear search) maximum-likelyhood decoding process for a block code
- compute feasible block sizes (n), symbol sizes (t) and rates (k/n) for Hamming and BCH codes
- explain why a RS code is called a burst-error correcting code
- explain why concatenated coding can perform bettern than a single code of the same rate

Interleaving

- explain why are interleavers used with FEC codes
- compute output symbols for given input sequence and block interleaver dimensions
- compute delay through block interleaver