EE 597 Fall 2015
Assignment 2

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Due: September 23, 2015

1 Outage Probability as a function of distance for Log-Normal Shadowing

For the simple path loss with log-normal shadowing model, plot the outage probability as a function of distance, assuming $P_t = 30$dBm, the path loss at a reference distance of 1m is -30dB, the path loss exponent is 2.5, the standard deviation of the log-normal fading is 3dB, the noise level is -100dBm, and the SNR threshold for acceptable error rate is deemed to be 10dB. Now vary the path loss exponent and the standard deviation of the log-normal fading to different values. Plot and comment on how they affect the outage probability as a function of distance

2 Rate Adaptation

Browse thorough the following paper: Goodput Analysis and Link Adaptation for IEEE 802.11a Wireless LANs, by Daji Qiao, Sunghyun Choi, and Kang G. Shin

Consider a simple path loss model without shadowing. Use figure 8a from this paper, which relates throughput to the SNR. Assuming a transmit power of 23dBm, received power at a reference distance of 1m being -10dBm, and receiver noise of -90dBm, plot the goodput of 802.11a as a function of distance for path loss exponents 2 and 4.

3 MATLAB Simulation

Read Simulation Of Flat Fading Using MATLAB For Classroom Instruction by Prabhu and Shankar.

Now download and play with the matlab code for Rayleigh fading (raygen.m) provided at this link.

1. For each choice of mobile speed from $[0, 5, 10, 15, 20, 25]$, generate the `power_ray` series. Use a threshold size of `pow(3)` (corresponding to about 3.25dBm) to discretize this series into two channel states (1 if above threshold, 0 if below). Model the corresponding series as a two-state Markov chain and estimate the parameters p_{01} and p_{10} for each case.

2. For each speed, based on your estimated model parameters, plot the probability that the channel is good (1) in k discrete time steps, given that it is currently bad (0), for k ranging from 1 to 10

4 Link Transmission Policy

For a general, positively correlated 2-state Markov-Chain fading channel (i.e., one for which $p_{11} > p_{01}$), design a link transmission policy (that makes a decision on when to transmit the next packet given the current packet transmission is either successful or a failure) that minimizes ETX - W*Throughput, where W is some weighting parameter constant specified for a given application, and Throughput is the expected / average rate of successfully delivered packets per unit time. Show the performance obtained through simulations (in terms of this metric, make sure you average over sufficiently many slots) for the following P matrices:

1. $p_{01} = 0.1$ and $p_{11} = 0.2$
2. $p_{01} = 0.1$ and $p_{11} = 0.4$
3. $p_{01} = 0.1$ and $p_{11} = 0.9$

5 Channel Coding

Before solving this problem, you might want to revise EE450 channel coding parts and section 8.2 (Linear Block Codes), page 230 and corresponding examples from "Wireless Communications" by Andrea Goldsmith (*).

Consider Hamming code [7,4] with given generator matrix G:

$$\left[\begin{array}{cccc|ccc} 1 & 1 & 0 & 1 & 0 & 0 & 1 \\ 0 & 1 & 0 & 1 & 0 & 1 & 0 \\ 1 & 1 & 1 & 0 & 0 & 0 & 0 \\ 1 & 0 & 0 & 1 & 1 & 0 & 0 \end{array}\right] \tag{1}$$

1. Find all codewords of the code
2. Find corresponding parity check matrix
3. Use row and column operation to reduce G to systematic form and find its corresponding parity-check matrix. (check p233 section 8.2.2 from (*) for systematic linear block code form)
4. Give an example of received vector (7 bit) which the code can be used to detect error (syndrome). Find the error bit. (check p234 section 8.2.3 from (*) for syndrome testing)
5. Give an example of received vector (7 bit) which the code cann't be used to detect error (syndrome). Explain the reasons.

6 MIMO

Browse thorough the following paper:

Performance Analysis of ZF and MMSE Equalizers for MIMO Systems: An In-Depth Study of the High SNR Regime by Yi Jiang,Mahesh K.,Varanasi,Jian Li . (*)

Study Of Transmission Characteristics Of 2x2 Mimo System for OFDM Multiplexing and Bpsk Modulation With ZF Equalizer And MMSE Receivers by Bhagya. R, A. G. Ananth. (**)

Consider the receiver side linear equalization techniques ZF (Zero Force) and MMSE (Minimum Mean Sqaure Error) for a MIMO system.

1. Describe the difference between these two techniques (see ** section 4 and 5).
2. Cosider a 2x2 MIMO system employing spatial multiplexing with given antenna configuration, SNR=10dB. Write simulation code to collect empirical information at the receivers, plot the CDF of the SNR of the weakest stream for ZF and MMSE receivers. Comment on the result.

Simulation hint: Loop through time steps. For each time step: generate random channel matrix H, calculate SNR of each receiver, record the weaker one. (see * for SNR analysis at the MIMO receivers)