Wireless Networking: Fundamentals and Applications

Homework #2

Due: 1pm, Monday, December 19, 2011

=== Homework submission instructions ===

- Submit the answers for writing problems (including your programming report) through the CEIBA system (electronic copy) or to the TA in R432 (hard copy). Please write down your name and school ID in the header of your documents.
- Each student may only choose to submit the homework in one way; either all as hard copies or all through CEIBA except the programming assignment. If you submit your homework partially in one way and partially in the other way, you might only get the score of the part submitted as hard copies or the part submitted through CEIBA (the part that the TA chooses).
- If you choose to submit the answers of the writing problems through CEIBA, please combine the answers of all writing problems into only one file in the doc/docx or pdf format, with the file name in the format of "hw1_[student ID].{pdf,docx,doc}" (e.g. "hw1_b97902001.pdf"); otherwise, you might only get the score of one of the files (the one that the TA chooses).

Problem 1. Rate adaptation is not an easy task because it is not always a good strategy for a transmitter to decrease the bit-rate when the link experiences a high loss rate.

1. Under what conditions is the rate reduction a good idea? (10 points)
2. Under what conditions is it a bad idea? (10 points)
3. What mechanism does SampleRate propose to distinguish the above two situations? (10 points)

Problem 2. Say there exist a 3x2 link, which has a channel $H = \begin{bmatrix} h11 & h12 \\ h21 & h22 \\ h31 & h32 \end{bmatrix}$. How can a three-antenna transmitter transmit a signal x, but null its signal at two antennas of a two-antenna receiver? (20 points)

Problem 3. The signal component of a coherent PSK system is defined by

$$s(t) = A_c k \sin(2\pi f_c t) \pm A_c \sqrt{1-k^2} \cos(2\pi f_c t) \tag{1}$$

where $0 \le t \le T_b$, $0 \le k \le 1$ and the plus sign corresponds to symbol 1 and the minus sign corresponds to symbol 0. Both bits are sent with equal probability. The first term represents a carrier component included for the purpose of synchronizing the receiver to the transmitter.

1. Draw a signal-space diagram for the scheme described here. (5 points)

2. Show that, in the presence of additive white Gaussian noise of zero mean and power spectral density $N_0/2$, the average probability of error is

$$P_e = \frac{1}{2} Q\left(\sqrt{\frac{2E_b}{N_0}(1-k^2)}\right) \tag{2}$$

   where

$$E_b = \frac{1}{2} A_c^2 T_b \tag{3}$$

   (10 points)

3. Suppose that 10 precent of the transmitted signal power is allocated to the carrier component (i.e., $k^2 = 0.1$). Determine the E_b/N_0 required to realize a probability of error equal to 10^{-4}. (5 points)

4. Compare this value of E_b/N_0 with that required for a conventional PSK system with the same probability of error. (5 points)

Problem 4. In the on-off version of an ASK system, symbol 1 is represented by transmitting a sinusoidal carrier of amplitude $\sqrt{2E_b/T_b}$ where E_b is the signal energy per bit and T_b is the bit duration. Symbol 0 is represented by switching off the carrier. Assume that symbols 1 and 0 occur with equal probability. For an AWGN channel:

1. Provide a block diagram for a coherent receiver for this ASK signal. (5 points)

2. Determine the average probability of error for this ASK system with coherent reception. (10 points)

3. Suppose symbol 1 occurs with probability 2/3 and symbol 0 occurs with probability 1/3. How would the receiver design and probability of error change if the objective is to minimize the overall probability of error? (10 points)