EE 597 Fall 2020
Assignment 2

Assigned: Sept. 22, 2020
Due: 11:59 pm PDT, Oct. 6, 2020, via Blackboard

Problem 1. 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

Problem 2. Browse through 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.

Problem 3. Consider the following linear arrangement of two independent transmitter-receiver pairs (T1-R1, and T2-R2, respectively), where the numbers along the edges represent distance:

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[T1]--- 2 ---[R2]-- 1 --[T2]---- x ----[R1]
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Assume the SINR threshold for both receivers is 1, they both experience the same level of noise, and that the gain for each link is $1/d^2$ where d is the distance. For what values of the unknown distance x can there be a feasible power allocation at both transmitters that can satisfy both receivers simultaneously?

Problem 4. You have two sets of links (T1-R1 and T2-R2), with the gains given as follows: $g_{11} = 0.2$, $g_{22} = 0.9$, $g_{12} = 0.2$, $g_{21} = 0.2$. Let $\theta = 2$, $N = 1$ mW. Is it possible for both links to be operated simultaneously? If so, what is the minimum power solution? Sketch a labeled plot of the various operating regions of transmit powers for both links (i.e. a plot where the axes are P1 and P2 and you show the conditions under which either link can receive, and if possible, also the condition under which both links can receive). Repeat the above plot for when θ = 1 and comment on how that affects the operating regions and why.

Problem 5. Say the vector of ratios of noise to gain N_i/g_i for a set of five parallel channels is given as [3, 6, 1, 9, 5] in some suitably normalized units. Plot the optimal power allocated to each channel by water filling for sum-rate maximization, as the total power is varied.

Problem 6. Consider a transmitter with two parallel channels, 1 and 2, with gain to noise ratios g_1/n_1 and g_2/n_2 respectively. It is desired to allocate a total power P_t across so as to attain rates at both channels close to predefined target rates T1 and T2, respectively. This problem can be formulated as follows:

$$Minimize: \left[log\left(1+\frac{P_1 * g_1}{n_1}\right) - T1\right]^2 + \left[log\left(1+\frac{P_2 * g_2}{n_2}\right) - T2\right]^2$$

$$such\ that: \ P_1 + P_2 \leq P_t$$

Present a mathematical analysis of this problem using the method of Lagrange multipliers and KKT conditions, include some figures/plots, and explain how it is different from sum-rate maximization.

Problem 7. Imagine there are two radio links (T1-R1 and T2-R2) with the following gains: $g_{11} = 0.7$, $g_{22} = 0.4$, $g_{12} = 0.4$, $g_{21} = 0.1$. Let $\theta = 2$ and $N = 1$ mW.

(a) Determine the optimal power solution for this system of radios.

(b) Use the distributed Foschini-Miljanic algorithm to derive a feasible power solution. Does the algorithm give you the same answer as part (a)?

Recall that the power update equation for the Foschini-Miljanic algorithm is as follows:

$$P_L(t+1) = \frac{\theta}{SINR_L(t)} P_L(t)$$

where P_L and $SINR_L$ are the power allocated and the SINR for link L, respectively. θ is the minimum required SINR for operation and t represents time. You may initialize $P_L(0)$ to 1 mW.

(c) Draw a plot showing the operating regions for both links, with P_1 on the y-axis and P_2 on the x-axis. On this same plot show the power allocation chosen for each iteration of the Foschini-Miljanic algorithm. Also draw a plot showing the power allocated for each link vs. time.

(d) Is it a good idea to start with an initial power allocation of 0 mW for both links?

(e) Instead of $P_L(0) = 1$ mW, start the algorithm with different initial values. In particular, initialize $P_1(0)$ to 5 mW *below* and $P_2(0)$ to 5 mW *above* your answers from part (a). Does the algorithm still converge to the same answer from part (b)? Redraw the plots from part (c) with these new initial values.