EE 5505 | Prof. Jindal
Wireless Communication | March 9, 2010

Practice Problems for Midterm Exam

1. **Cell Radius**
   Consider a system that follows the simplified path loss model with $K = 10$ dB, $d_0 = 1$ m, $\gamma = 3$, and $P_t = 0$ dB. Assume the noise power in the bandwidth of interest is -87 dB.

   (a) If BPSK is used, what is the maximum cell radius such that all locations achieve a bit error rate no larger than 10^{-3}?

   (b) How does your answer change if QPSK is instead used?

2. **Small-Scale Fading**

   In this problem we study the effect of multipath, or small-scale fading. Consider the propagation environment shown in Figure 1, in which the received signal is the sum of two reflected paths. There is no line of sight path due to the obstruction that is directly in front of the TX. The TX and RX are each located **exactly midway** between the two reflecting walls. For the sake of simplicity, assume the reflection coefficient of the wall is one, i.e., the phase is not changed when the signal bounces off the wall. Furthermore, assume the system is narrowband.
   Note: For each of these parts you should provide only a short (a few sentences) explanation. You do not need to provide mathematical details.

   (a) If the receiver is moving directly away from the transmitter, as shown in Figure 1, does the received signal power fluctuate over time?

   (b) Now consider the scenario where the receiver is moving directly towards one of the reflecting walls, as shown in Figure 2. Does the received signal power fluctuate over time?

   (c) Now consider the scenario where the transmitter and receiver are much closer to one of the two walls, and the receiver is moving directly away from the transmitter, as shown in Figure 3. Does the received signal power fluctuate over time?

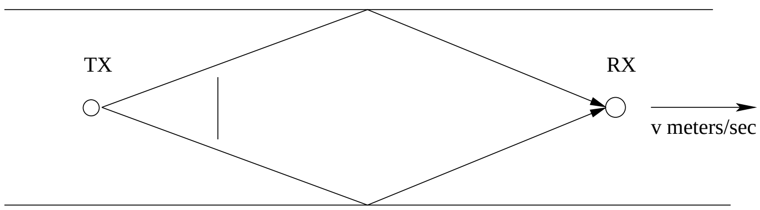

Figure 1: Small-Scale Fading, part(a)

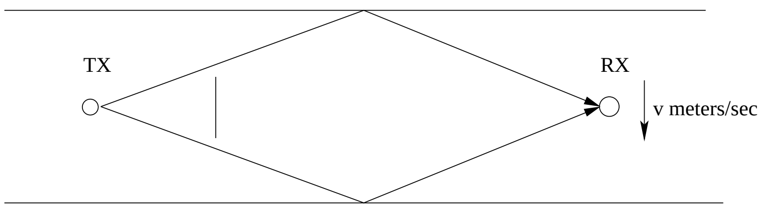

Figure 2: Small-Scale Fading, part (b)

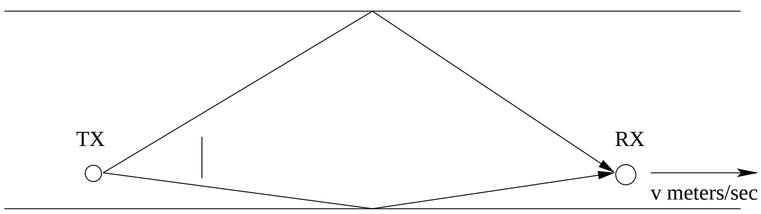

Figure 3: Small-Scale Fading, part (c)

3. **Wireless Channels**

In this problem we will discuss the nature of the small-scale fading for 3 different systems: Wimax, which has a signal bandwidth of 10 MHz, GSM, which has a signal bandwidth of 200 kHz, and IS-136, which has a signal bandwidth of 30 kHz. Furthermore, assume the carrier frequency is 1 GHz.

(a) Consider an indoor environment, where the longest path is 10 meters longer than the shortest path. Classify the three systems as either wideband (frequency-selective) or narrowband.

(b) Consider an outdoor environment, where the longest path is 2000 meters longer than the shortest path. Classify the three systems as either wideband (frequency-selective) or narrowband. For systems that are wideband, if OFDM was used approximately how long of a cyclic prefix (in terms of number of channel symbols) would be required?

(c) Assume the receiver is moving at 30 meters/sec. Furthermore, assume the symbol period is the inverse of the given signal bandwidths. For each of the three systems, approximate how much diversity would be experienced over a packet spanning 1000 data symbols.

(d) Repeat part(c) for a carrier frequency of 10 GHz.

(e) Does the coherence bandwidth depend on the carrier frequency?

4. **Diversity**
Consider a 2 branch diversity system (independent fading on the branches), where the first branch experiences Rayleigh fading with an average SNR of 10 dB and the received SNR on the second branch is uniformly distributed between 0 and 10 (in linear units, not dB).

   If selection combining is used, what is the probability that the SNR at the combiner output is less than or equal to 3 dB?

5. **Frequency Reuse**
In this problem we analyze the downlink of a cellular system. The signal from the desired base station as well as the signal from the interfering base station both follow the empirical path-loss model with $\gamma = 4$, $d_0 = 1$m, and $K = 1$. We assume that there is log-normal shadowing with $\sigma_{dB} = 6$ dB only on the link from the desired base station; there is **no shadowing on the interfering link**. Furthermore, **we ignore thermal noise** and thus study only the ratio between the desired signal power and the interference power. We assume each base station transmits with the same power, so the actual value of P_t is unimportant. **Note that there is no multipath fading in this problem.**

   (a) In the first scenario, which corresponds to frequency reuse factor equal to one, the mobile is a distance d away from the desired base station and is d away from the interfering base station. Find the SIR that is achieved with probability 0.9. (10 pts)