ECSE 6961: Fundamentals of Wireless Broadband Networks
Homework Problem Set: 3
(Lecture Slide Set: Wireless Channel)
Due Date: March 4th 2007; [40 points]

1. **[dB, dBm, dBi]:** ***[5 pts]*** A transmitter produces 50 W. Express in units of (a) dBm and (b) dBW. If this is applied to a 12 dBi gain transmit antenna at 900 MHz, find the received power Pr in dBm at a distance of 100m. What is Pr (10 km) in dBm? Assume unity gain receive antenna. Hint: Recall the path loss formula:

$$\frac{P_r}{P_t} = \left[\frac{\sqrt{G_l}\lambda}{4\pi d}\right]^2.$$

2. **[Path Loss Effects, Small Cells, Cell Edge]:** ***[10 pts]*** Consider a user in the downlink of a cellular system, where the desired base station is at a distance of 900 meters, and there are numerous nearby interfering base stations transmitting at the same power level. If there are 3 interfering base stations at a distance of 1 km, 3 interfering base stations at a distance of 2 km, and 10 interfering base stations at a distance of 4 km, use the empirical path loss formula to find the signal-to-interference ratio (SIR, i.e. the noise is neglected) when $\alpha = 3$, and then when $\alpha = 5$. Explain the implications of your results.

Empirical Path Loss Formula:

$$P_r = P_t P_o \left(\frac{d_o}{d}\right)^{\alpha}$$

the path loss exponent α and the measured path loss P_o at a reference distance of d_o. You don't need the values of Po and do to solve the problem.

3. **[Shadowing, Outage, Modulation Choice:]** ***[15 pts]*** Consider a WiMAX base station (BS) communicating to a subscriber, with the channel parameters: path loss (α) = 3.5, Po = −35dB, d0 = 1m, shadowing parameter (σ_s) = 5dB. We assume a transmit power of P_t = 1 Watt (30 dBm), a bandwidth of B = 10 MHz. Due to rate 1/2 convolutional codes, a received SNR of 14.7 dB is required for 16QAM, while just 3 dB is required for BPSK. Finally, we consider only ambient noise with a typical power spectral density of No = −173dBm/Hz, with an additional receiver noise figure of N_f = 6 dB (noise from all other sources).

The question is this: At a distance of 400 meters from the base station, what is the likelihood that the BS can reliably send BPSK or 16 QAM? {Hints: Find receive power, receive noise, compare to thresholds for BPSK/16QAM. The effect of the shadowing will matter. Use the simple empirical shadowing model below}:

$$P_r = P_t P_o \chi \left(\frac{d_o}{d}\right)^{\alpha}$$

4. [**Doppler spread**] ***[5 pts]*** Consider mobile nodes moving at speeds (v) of 60 km/h (car on a state road), 200 km/h (high speed train), 400 km/h (airplane taking off/landing). Consider two carrier frequencies fc = 900 Mhz (2G band) and 2.5 GHz (a WiMax band). What is the Doppler spread for each combination of v and fc ? What is the channel coherence time (Tc) in each case?