

**EE 455: Mobile Communications**  
**Lecturer: Dr. Berna Oslak**  
**FINAL**  
**Tuesday, 30 June 2020, 13:50-15:45**

**Q.1 (40p) Wireless Channel and Diversity**

A wireless channel observes two fading amplitudes,  $\alpha_1 = 0.2$  and  $\alpha_2 = 1.1$  with equal probabilities.

(a) What is probability of error for binary phase shift keying (BPSK) system if the average SNR ( $E_b/N_0$ ) is 10dB?

(b) If the channel does not observe fading, what would be the average SNR to achieve bit error rate that you calculated in part A?

(c) Suppose receiver is modified and number of antennas is increased from 1 to 3, and all three antennas observe the fading independently. A device measures the fading amplitudes (SNRs) of each antenna and utilizes signal coming from antennas whose fading amplitude (SNR) is the highest (also called Selective Combining). In that case, what would be the probability of error if SNR is 20 dB?

**Q.2 (40p) OFDM and Adaptive Scheme**

You are building a startup focused on OFDM technology. Your OFDM system has  $N$  subchannels with constant fading on each subchannel.

(a) Suppose the delay spread on the channel is 20ps. If the total channel bandwidth is 20 MHz, what size FFT in the OFDM implementation?

(b) Assume an OFDM system with 8 subchannels each of bandwidth 500 KHz. The total transmit power for the system is  $P = 400$  mW. With 400 mW transmitted on each subchannel, the received SNR on each subchannel is  $\gamma_i = 400/i$  (linear units),  $i = 1, \dots, 8$ . Due to complexity and power amplifier constraints, your startup system divides the transmit power of 400 mW equally divided among all the subchannels. What is the capacity of your OFDM system?

(c) Your competition adapts the transmit power so that the SNR per subchannel is constant. What is the capacity under this adaptive power policy?

**Q.3 (40p) Rake Receiver**

This problem illustrates the benefits of Rake receivers and the optimal choice of multipath components for combining when the receiver complexity is limited. Consider a multipath channel with impulse response

$$h(t) = \alpha_0\delta(t) + \alpha_1\delta(t - \tau_1) + \alpha_2\delta(t - \tau_2) \quad (1)$$

The  $\alpha_i$  are Rayleigh fading coefficients, but their expected power varies (because of shadowing) such that  $E[\alpha_0^2] = 5$  with probability 0.5 and 10 with probability 0.5,  $E[\alpha_1^2] = 0$  with probability 0.5 and 20 with probability 0.5, and  $E[\alpha_2^2] = 5$  with probability 0.75 and 10 with probability 0.25 (all units are linear). The transmit power and noise power are such that a spread-spectrum receiver locked to the  $i$ th multipath component will have an SNR of  $\alpha_i^2$  in the absence of the other multipath components.

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**Yijin Wang**



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