Department of Electrical Engineering, IIT Madras

EE5141 : Fundamentals of Wireless and Cellular Communications

Tutorial #1 **Sept. 2014**

0. The following questions from Chapter 2 of T.S.Rappaport's book (E-version!): pp:64 onwards

(i) 2.1
(ii) 2.3 (Impact of sectoring on SIR)
(iii) 2.4
(iv) 2.5 and 2.7 (Trunking efficiency related)
(v) 2.8
(vi) 2.10 (on cell splitting)
(vii) 2.14 and 2.15 (Rx sensitivity)
(viii) 2.18 (*optional*)
(ix) 2.20 (*optional*)

1. Consider a Direct Sequence (DS) CDMA system with spreading factor T/Tc = W=256. For each of the following scenarios, compute the number of uplink users this system can be simultaneously supported using pseudo-noise (PN) codes. Use the uplink capacity expression discussed in class. Neglect impact of other cell interference, and voice activity detection. Let SINR=5 in linear scale for the weakest link.
(a) Under strict equi-power control, all user signals arrive with power P. What is the pole capacity?
(b) All users arrive with the same power P. How many users can be supported when the noise rise allowed is: (i) 3dB, (ii) 6dB, and (iii) 10dB.

2. In the DS-CDMA system as above, we now allow half the users can arrive at power 2P, and the other half to remain at power P.
(a) In this case, what is the pole capacity?
(b) For a noise rise of 3dB, how many users will this system support?
(c) If at power 2P, one can support 50% more rate in bits/sec when compared to power P, which of the 2 systems (in Q.1 and Q.2) can support higher sum rate at pole capacity?

3. Now consider a 10MHz DS-CDMA system with W=1024. Assuming perfect uplink power-control, the aim is to compute the uplink power P required from each user at the base-station. Assume that on the linear scale the SINR required is 5, and the receiver noise variance is σ^2, answer the below:
(a) For N=1, what is the P required (as a function of σ^2) ?
(b) What is the pole capacity N_P of this system?
(c) For $0<N<N_P$, what is the expression for the set-point of P?
(d) Repeat (a) & (c) for the narrow-band W=128 example, with the same SINR=5 required for each uplink. Compare your results and discuss.

4. Assuming an ambient temperature of 300^{O} K, the thermal noise power spectral density at the receiver (in the dBm scale) can be taken as -174dBm. The path-loss exponent is n=2, and the 1m loss at the Tx end can be taken to be 40dB. Both the Tx and Rx use ideal omni antennas with gain of 0dBi. It is also given that the Rx noise figure is 5dB, and the required post-processing SINR = 6dB for the considered modulation. The Frequency-Division-Duplexed (FDD) communication link uses a one-way bandwidth of 1.25MHz, and the (peak) uplink transmit power P_T can be either 0dBm or 30dBm, based on the link distance. Three different multiple access schemes using the same modulation are considered for the **uplink**, namely: (a) FDMA with 25KHz channelization per user, (b) TDMA with 200KHz channelization for 8 user slots, and (c) DS-CDMA with 1.25KHz channelization and a spreading factor W=128.

(a) If the TDMA and FDMA use reuse 1/3 deployment, compare the number of simultaneous (voice) users, N, that can be supported on the uplink per base-station. Compare this number with the pole-capacity N_P of the DS-CDMA system.

(b) For the TDMA link, compute the maximum link distance possible, for both P_T = 0dBm and 30dBm.

(c) Repeat this for the FDMA link.

(d) Assuming only N=1 user is connected to the base-station, repeat this for DS-CDMA for both P_T = 0dBm and 30dBm.

(e) Repeat this when N= N_P-1 users are connected on the uplink to the DS-CDMA base-station

(f) Comment on your results. Which link is the longest?

(g) Define average transmit power P_A= (P_T x Duty-cycle) where Duty-cycle is the time fraction over which the mobile uplink is transmitting. What is the P_A for the 3 multiple access schemes?

5. Repeat Question 4 parts (b) thro (f) for path-loss exponent n=4. Compare your results.

6. The following questions from Chapter 3 of T.S.Rappaport's book (E-version), pp:133 onwards

(i) 3.1 **-- Expression for Brewster angle (*optional*)

(ii) 3.3 to 3.8 – 2-ray model (*optional*)

(iii) 3.9 to 3.11 – Knife edge diffraction model (*optional*)

(iv) 3.13 – Comparision of different path-loss models

(v) 3.17 and 3.18 – Log normal fading

(vi) 3.20 – City-wide network planning

(vii) 3.21 – Finding cell radius