S-72.3260 Radio Resource Management Methods 3 cr

Exam 11.12.2012
Part B: Open book tasks (4 tasks)

There are four problems in this part, out of which three best are taken into consideration in the grading.

You are allowed to use any literature that you feel useful.

Problem B.1

Consider the downlink direction of a two cell highway cellular system. The cells are symmetric and the inter cell site distance is 1 km. The first UE in each cell is assumed to be 100 m away from the base station and the second one is assumed to be 500 m away from the base station. Base station serves the UEs one by one using proportional fair scheduling. $P/(N_0B)$ is assumed to be 120 dB. The bandwidth of the system is B and the noise density is N_0 W/Hz. Co-channel interference is considered to be Gaussian noise (multi-user detection is not used). In case of reuse one is utilized the spectral efficiency (bit/s/Hz) of an user is

$$C_u = \frac{1}{2}\log_2\left(1+\frac{d_{u1}^{-m}P}{d_{u2}^{-m}P+N_0B}\right) \quad u=1,2$$

where d_{ub} is the distance between UE u served by the cell 1 and base station b=1,2 and m is the pathloss exponent. Numerical solution gives

$$C_1 \approx \begin{cases} 3.18 \text{ bit/s/Hz} & m=2 \\ 5.98 \text{ bit/s/Hz} & m=4 \end{cases}$$

$$C_2 \approx \begin{cases} 0.5 \text{ bit/s/Hz} & m=2 \\ 0.48 \text{ bit/s/Hz} & m=4 \end{cases}$$

a) Determine the spectral efficiency for both users when reuse 2 is applied. (4 p)

b) Compare the total throughput of reuse 1 with reuse 2 when path-loss exponent is 2 and 4. What can you conclude? (2 p)

c) What could be done further to improve the aggregate throughput of the cell? (2 p)

d) What could be done further to improve the throughput on the cell edge? (2 p)

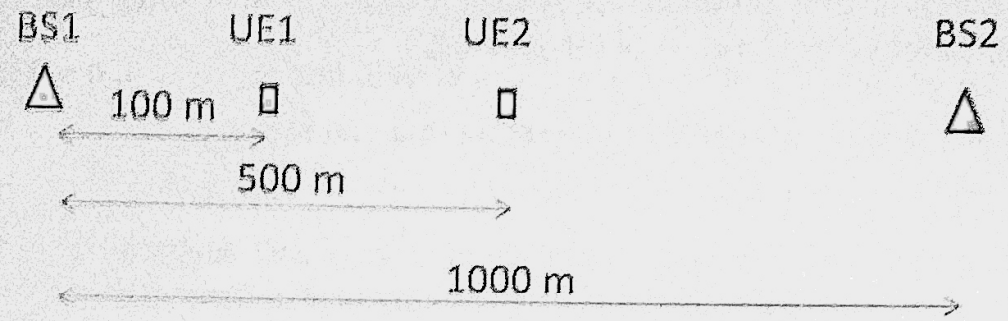

Figure 1. A two cell system

Problem B.2

Consider the two cell cellular system shown in Figure 2. The link gains are shown in the figure. Assume that the noise power at the receiver is -110 dBm.

a) Assume that both users transmit with fixed 21 dBm power. Determine the received SINR for both base stations. (2 p)

b) Determine the theoretical maximum common SINR that can be supported when power control is utilized. (4 p)

c) Assume that the required SINR is 4 dB. Determine the transmission power vector $\mathbf{p}^*$ such that the power consumption is minimized while the SINR-target is met. (4 p)

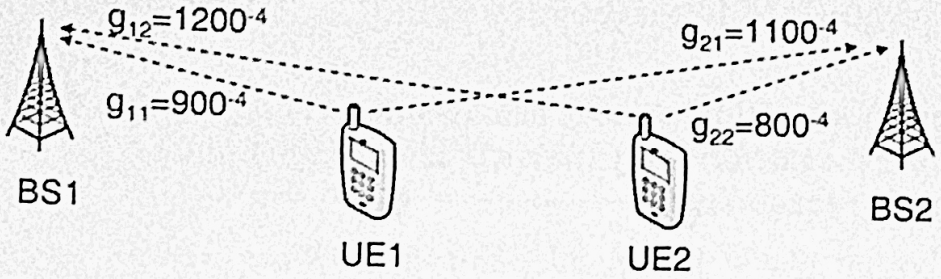

Figure 2.

Hint:

$$A=\begin{bmatrix} a_{11} & a_{12} \\ a_{21} & a_{22} \end{bmatrix}, \quad \det(A)=a_{11}a_{22}-a_{21}a_{12}$$

$$A^{-1}=\frac{1}{\det(A)}\begin{bmatrix} a_{22} & -a_{12} \\ -a_{21} & a_{11} \end{bmatrix}$$

Problem B.3

Consider opportunistic channel adaptive scheduling in HDR type of system in which the base station serves the users one-by-one. Consider the case, in which there are two users in the cell. The instantaneous data rate of the user i follows exponential distribution with mean $\bar{\mu}_i$. That is

$$\Pr\{\mu_i(t)\le\mu\}=1-\exp\left(-\frac{\mu}{\bar{\mu}_i}\right)$$

a) Determine the throughput in case the base station picks the user randomly at given instant of time. (4 p)

b) Determine the throughput in case the base station uses relative best channel adaptive scheduling. At given instant of time the base station selects the user that has the highest scheduling metric value

$$i^*=\arg\max\left\{\frac{\mu_i(t)}{\bar{\mu}_i}\right\}$$ (4 p)

c) Determine the multi-user diversity gain. (2 p)

Problem B.4

Consider a 6 × 6 MIMO system, and assume a coding scheme that can achieve the rate/diversity trade-off at any large finite SNR with the following equation:

$$d_{opt}(r) = (M_t - r)(M_r - r)$$

Let the multiplexing and diversity parameters r and d be defined as:

$$\lim_{SNR\to\infty} \frac{\mathrm{R(SNR)}}{\log_2 \mathrm{SNR}} = r \qquad \lim_{SNR\to\infty} \frac{\log \mathrm{P}_e(SNR)}{\log \mathrm{SNR}} = -d$$

If SNR=20 dB and data rate per unit hertz R=20 bps,

a) How many antennas should be dedicated for multiplexing and how many for diversity?

b) What is the maximum diversity gain?

c) What is the probability of error?