S-72.2211 Mobile Communication Systems and Services

Exam 9.3. 2010

All five tasks are evaluated and taken into account in the grading. The exam can be written in Finnish, Swedish or English.

1. Explain shortly the following concepts:
   a) multiplexing, and the different multiplexing alternatives
   b) duplexing, and the different duplexing alternatives
   c) timing advance
   d) circuit switching
   e) interference limited network
   f) spectral efficiency

2. Mobility-related procedures.
   a) Mention three reasons why the Mobile Station (MS) would perform cell search.
   b) Explain the concept of paging. When and where can a MS be paged? Explain the connection of paging, location area updating and Discontinuous Reception.
   c) Why is a Random Access procedure needed, and when is it used?
   (An expected answer to each of the three questions above would consist of a few sentences.)

3. Assume an Adaptive Modulation and Coding system with two Modulation and Coding Schemes (MCS) with transmission rates k_1 and k_2 ($k_1 < k_2$). The BLock Error Rate (BLER) function of the channel code is approximated by a step function so that each of the MCSs is characterized by a minimum required SNR value, γ_1 and γ_2 ($\gamma_1 < \gamma_2$) respectively. For example, if MCS1 is used, with transmission rate k_1, the transmission is correctly received if the SNR $\gamma \geq \gamma_1$, and erroneously received if $\gamma < \gamma_1$.
   a) The transmitter has a Channel Quality Indicator (CQI) which indicates the received SNR. Assume that the CQI is perfect, so that the transmitter knows the channel. The transmitter has to decide a switching point γ_s. If the SNR is larger than γ_s, MCS2 should be used, if the SNR is less than γ_s, MCS1 should be used. Throughput is defined as the amount of correctly received data. How would you choose the switching point for the two MCSs to achieve the best expected throughput?
   b) If there is a Log-normal error in the reported CQI (the reported CQI is the realized SNR plus an error in the dB-domain characterized by a Gaussian distribution with variance σ^2), how do you choose the switching point to achieve the highest expected throughput? It is assumed that the channel has a uniform SNR distribution in the dB-domain.

4. Assume a system with reuse factor 1, with base stations in a hexagonal cellular lattice. Calculate an approximate expression of the down-link carrier-to-interference ratio (C/I) along a line connecting the serving base station with one of the neighboring base stations. All base stations transmit with the same power. An accepted approximation is to take into account only the six base stations surrounding the serving base station, and to assume that the interference from each of these cells equals the interference from the nearest interfering base station. Fast fading and shadow fading are not taken into account. Path loss is assumed to follow an $r^{-\alpha}$ law, the distance between the base stations is denoted by D, and the distance from the serving base station by r. Assuming that the path loss exponent is 4, tabulate the numeric C/I-values for $r = 0.1D$, $r = 0.2D$, $r = 0.3D$, $r = 0.4D$, $r = 0.5D$.

5. Consider an uplink WCDMA system. The path loss model is

$$L_p = L_0 + 10\alpha \log(r)$$

in [dB], where L_0 is the path loss at 1 km distance, $\alpha = 3$ is the path loss exponent and r is the distance measured in km. The coverage area of a service is determined by a disk with the radius the distance from which a user transmitting with full power can receive required service. The fractional load of the system is

$$\eta = (1+f)\sum_{j=1}^{N} \frac{\rho_j \gamma_j}{G_j}$$

where $f = 0.6$ is the other-cell-to-own-cell interference ratio, ρ_j is the activity factor of user j, γ_j is her target SNR and G_j her processing gain (spreading factor). There are N users in the cell. In a link budget, the fractional load of the system is taken into account as an interference margin $IM = 10 * \log_{10}\left(\frac{1}{1-\eta}\right)$.

Consider the situation where first the fractional load is $\eta_0 = 0.5$, and all the N users are experiencing the same service. This base service is determined by the activity factor ρ, the SNR target γ and the processing gain G. Compare to the situation where the fractional load has increased to η_n as $N/2$ users enjoy improved service with twice the data rate by using half the spreading factor (their processing gain is $G/2$), while the remaining $N/2$ users still enjoy the base service. The activity factor and SNR target in the improved service are the same as in the base service. What is the ratio of the coverage areas of the base service with fractional loads η_n and η_0?

Hint: in fractional load calculations it is assumed that the load in neighboring cells changes in the same way as the load in the own cell.