S-72.2211 Mobile Communication Systems and Services

Exam 2.9. 2011

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

1. Provide short answers (at most a couple of sentences) to the questions below:
   a) What is the most important difference of teleservices and bearer services in GSM?
   b) What other services than tele- and bearer services exist in GSM?
   c) Teleservices in GSM can be clssified into four types. What are these?
   d) What is the difference of a GSM bearer service with a Transparent and a Non-transparent Quality of Service (QoS) attribute?
   e) In UMTS, there are four QoS classes. What are the differences of the Interactive and Background class? Mention example applications in these classes.
   f) What are the two other QoS classes in UMTS?

2. Explain the use of spreading and scrambling codes in WCDMA up- and downlinks.

3. Consider a single-cell network. The outdoor average path loss is modeled with a single slope model $L = 130{+}38\log(r)$, where the distance r is measured in kilometers. For indoor locations there is an additional average wall penetration loss L_{p}. Based on average path losses, what is the ratio of indoor coverage area to outdoor coverage area when i) $L_{\mathrm{p}} = 6\mathrm{dB}$ ii) $L_{\mathrm{p}} = 12\mathrm{dB}$?

4. Assume that downlink power control perfectly compensates average path loss. Path loss is assumed to follow a $r^{-\alpha}$ law, where α is the path loss exponent. The mobiles are assumed to be uniformly distributed in a circular cell with radius R so that the probability density function of the location of the mobiles is

$$p(r,\phi) = \frac{r}{\pi R^2},\ r \in [0,R],\ \phi \in [0,2\pi]\ .$$

   Power control operates so that the maximum transmit power P_{max} is used only when transmitting to users at the cell edge $r = R$. The minimum transmit power is $P_{\mathrm{min}} = 0$. The mean transmit power averaged over the mobile station spatial distribution is

$$P_{\mathrm{txm}} = \int_0^R \int_0^{2\pi} p(r,\phi) P_{\mathrm{tx}}(r)\, d\phi\, dr\ .$$

   a) All users are within the radius $r = R$. What is the fraction of users within the radius $r = R/2$ and $r = R/4$? (2 points)

   b) How many dB is the average base station power level lower than the maximum level (which would result without power control), when $\alpha = 2, 3, 4,$ and 5? (4 points)

5. 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, i.e. all SNR values are equally probable.