S-72.2211 Mobile Communication Systems and Services

Exam 12.3. 2008

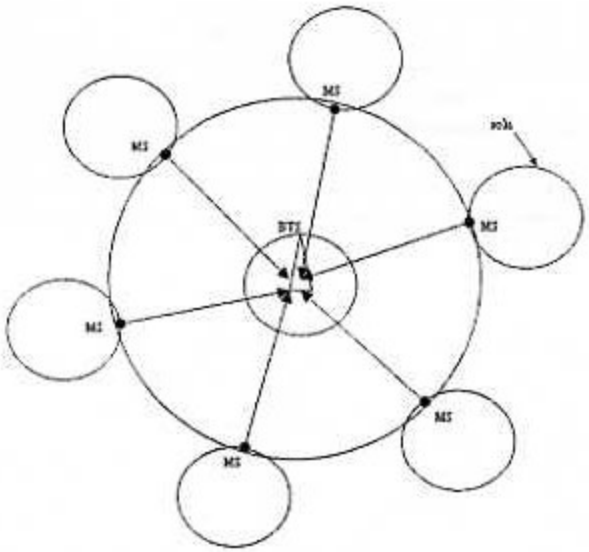
All five tasks are evaluated and taken into account in the grading.

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 Backround class? Mention example applications in these classes.
   f) What are the two other QoS classes in UMTS?

2. Mobility management.
   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? It is assumed that the channel has a uniform SNR distribution.
   b) If there is a Gaussian 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?

4. Assume that in a cellular system the co-channel Carrier-to-Interference Ratio (CIR) must be 15 dB at least 50% of the time. The path loss exponent is $\alpha = 4$. Estimate the minimum frequency reuse factor M in an ideal hexagonal cellular layout. Consider an uplink situation, where the carrier power and interference power are measured by an omni-directional base station at the centre of a cell. The normalized reuse distance is $\frac{D}{R} = \sqrt{3M}$ where the reuse factor $M = i^2 + ij + j^2$ for any pair of non-negative integers i, j. You may use the aproximation that the interfering users are as close as possible to the receiving base transceiver station, see the picture below.



5. The maximum spreading factor in the uplink direction of WCDMA is 256. Consider a single-cell network, where all interference is intra-cell interference. The fractional load in such a system is $\eta = \sum_j \frac{\rho_j \gamma_j}{G_j}$, where G_j is the processing gain of user j, ρ_j is his activity factor, and γ_j is his Signal-to-noise-plus-interfrence ratio (SINR) requirement.
   a) How many simultaneous SF=256 uplink users with the activity factor 0.4 can coexist in theory (according to the pole capacity), if the required SINR for such users is 3dB? Assume ideal power control (all users received with same power at the base station).
   b) Power control is malfunctioning for one user. This user is transmitting with constant power corresponding to the power required to meet the SINR requirement at the cell border. How near to the base station (measured in units of the cell radius) is this user, if he reduces the total number of uplink users to half the number found in sub-task a? The path loss exponent is 3, and slow and fast fading are not considered. Hint: the user with malfunctioning power control causes fractional load 1/2.