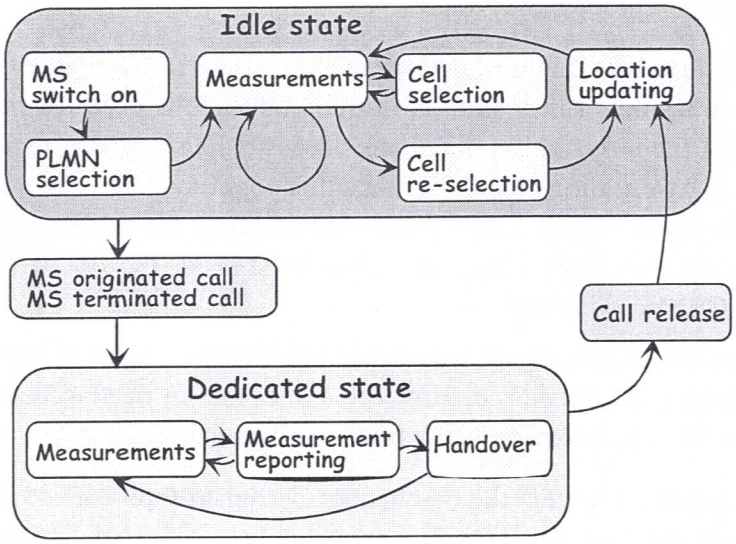
S-72.2211 Mobile Communication Systems and Services

Exam 3.9. 2010

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. In the figure below, a state machine for GSM mobility management is depicted.



a) Why does an idle state mobile station perform cell re-selection?
b) What does an idle state mobile station measure for cell re-selection?
c) When is a location update initiated?
d) What does an idle state mobile station do in order to be able to know if he has a MS terminated call coming?
e) What does an idle state mobile station do when initiating an MS originated call?
f) What core network elements are involved in location updating?
(Short answers to the six questions above are expected, at most a couple of sentences.)

2. WCDMA radio resource management.
a) Why is the near-far effect a problem particularly in the WCDMA uplink?
b) How is the near-far effect avoided in the WCDMA system? What are the consequences of the speed of the mobile station for avoiding the near-far effect?
c) Why is frequency reuse 1 possible in WCDMA but not in GSM? What are the advantages of having frequency reuse 1?
(An expected answer to each of the three questions above would consist of a few sentences.)

3. 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.

4. Timing advance is used in cellular systems to adjust the clock difference between a MS and the serving BS caused by propagation delay.

   a) In a GSM system, a call is initiated by the use of the random access channel, which is an access burst transmitted in a slot. No timing advance is used for random access channel. Irrespective of the propagation delay, the access burst should be received inside the slot as defined by the base station clock. To make this possible there is an additional guard interval of 60 bit periods in a GSM access burst. What would the maximum cell radius be, so that these 60 bits are sufficient to keep the access burst inside the slot? Hint: there are 156.25 bit periods in a GSM burst of 0.577 ms.

   b) Assume that a MS is moving directly towards the base station and that the required accuracy of timing advance is 1 bit period. How often does the TA need to be updated, if the velocity of the user is 3 km/h, 50 km/h, 120 km/h or 250 km/h?

5. 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.