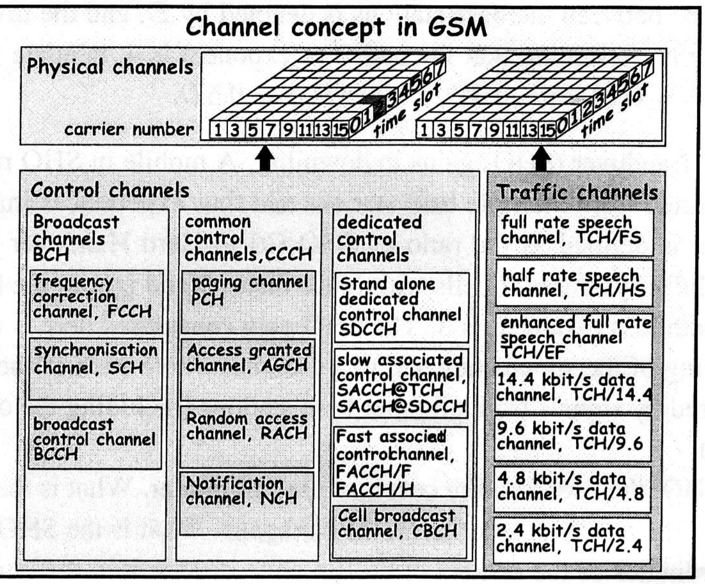
S-72.2211 Mobile Communication Systems and Services

Exam 16.5. 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. The picture below depicts the GSM channel structure.



a) How are the GSM physical channels defined?
b) Why are logical channels needed?
c) What is the relation of the logical channels to the physical channels?
d) What is the synchronization channel used for?
e) What is the Broadcast Control Channel used for?
f) A user has a dedicated Traffic Channel reserved for him. On which channel does the base station send Timing Advance commands to the user?
(Short answers to the six questions above are expected, at most a couple of sentences.)

2. Explain shortly the following concepts, and why they increase system capacity:

   a) Transmission power control
   b) Adaptive modulation and coding
   c) Scrambling in a CDMA system
   d) Frequency hopping
   e) Dynamic channel allocation
   f) Discontinuous transmission

3. Calculate the impact of load on coverage in a Direct Sequence CDMA system. Assume the path loss model $L_p = L_0 + 40\log(r)$, fast fading and shadow fading are not taken into account. Consider a service with a given data rate, and a corresponding receiver sensitivity S. When the fractional load $\eta = 0$ (and correspondingly the interference margin $IM = 0$), denote the area of coverage of this service with A. What would the coverage area of this service be in the cases and $\eta = 0.5$ and $\eta = 1$?

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. Calculate Soft Handover (SHO) gains in downlink. A mobile in SHO receives the same information transmitted from multiple base stations and thus experiences improved signal strength. The SHO gain is defined as the ratio of SHO C/I to Hard Handover (HHO) C/I. Assume a hexagonal cellular system of 7 cells with reuse factor 1 and ignore the fast and shadow fading effects. The path loss exponent is 3. The SHO gain considered here is the result of Maximum Ratio Combining of the signals targeted to a user, but where each of the signals targeted to the user is interfered by signals from all other base stations (including the other signals targeted to the same user).
   a) Two-way SHO: the user is at the center of the cell border. What is the SHO gain [dB]?
   b) 3-way SHO: the user is at a corner of the hexagons. What is the SHO gain [dB]?
   Hint: the coordinates of the centers of the six cells surrounding the one centered at the origin are $(\pm 3R/2, \pm\sqrt{3}R/2)$ and $(0, \pm\sqrt{3}R)$.