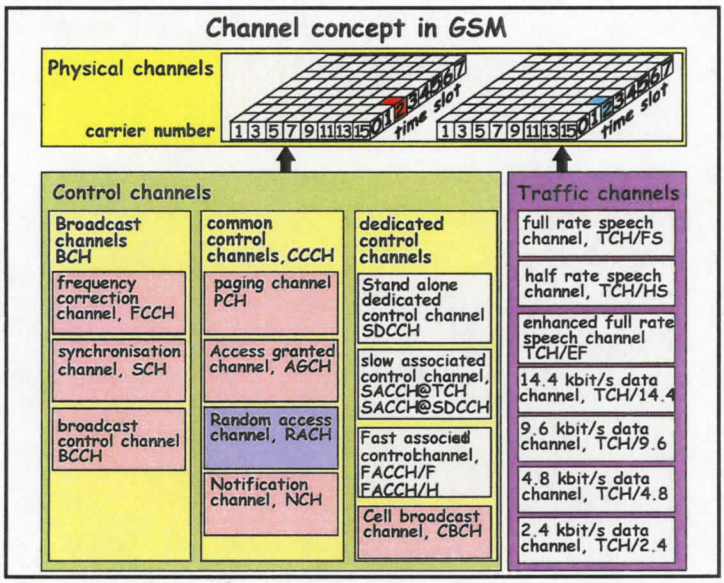
S-72.2211 Mobile Communication Systems and Services

Exam 4.11. 2013

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 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 $L = 130{+}48\log(r)$, 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 $P_{\min} = 0$. The mean transmit power averaged over the mobile station spatial distribution is

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

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. 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 4. 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 $(0, \pm\sqrt{3}R)$.