S-72.610 Mobile Communication Systems and Services (2 credits)
Exam 2.9.2005

1. **Give short answers to the subtasks (a - j), use figures when appropriate**

a) Give one example of a 1st, 2nd, and 3rd generation cellular system
b) List four propagation mechanisms (in addition to free space propagation and ground-wave propagation) important in mobile communication systems.
c) Which radio link parameters impact on the average path loss in the Hata-model?
d) Which mobile communication systems do you combine with GMSK, QPSK, and 8PSK?
e) How is average bit error probability calculated in the flat Rayleigh-fading channel?
f) Why is timing advance needed in the TDMA mobile phones?
g) How many coding classes are specified in GPRS for link adaptation?
h) Which phenomenon makes power control necessary in DS-CDMA?
i) How is bandwidth on demand (varying user rates) implemented in WCDMA?
j) Which modulation method and access method are used in TETRA?

Of the following six tasks the four best answers are considered

2. Based on average losses, calculate the indoor coverage area/outdoor coverage area ratio in a single cell with an outdoor base station. The outdoor average path loss is modeled with a single slope average path loss model, $L = 135 + 38\log(r_{km})$, and for indoor locations the additional average wall penetration loss is i) 8 dB, ii) 20 dB.

3. With M independent and Rayleigh-distributed diversity branches the cumulative distribution of the absolute-valued signal to noise ratio (snr=γ) after selection combining is given by the expression $P\{\gamma < \gamma\} = \prod_{i=1}^{M} (1 - \exp(-\gamma/\gamma_{mi}))$, where γ_{mi} is the average signal to noise ratio of each branch. Show that for low fading probabilities in a 2-branch diversity system, a reduction of the second branch average snr with d dB will reduce the diversity gain with d/2 dB.

4. The uplink and downlink fractional load in a CDMA-system are estimated from the expressions $\eta_{UL} = (1+f)\sum_{i=1}^{N} \frac{\gamma_i \rho_i}{G_i}$ and $\eta_{DL} = (1-\alpha+f)\sum_{i=1}^{N} \frac{\gamma_i \rho_i}{G_i}$ respectively. The fractional load results in a interference margin $IM = 10\log\left(\frac{1}{1-\eta}\right)$. Compare the downlink and uplink capacities in terms of number of users in a single service system, when
   - the interference margin is 6 dB,
   - the targer SIR-value is 5 dB,
   - the spreading gain is 128,
   - the user activity factor is 0.5,
   - the other to own cell interference ratio is 0.65,
   - the down-link orthogonality factor is 0.7.

5. In GSM the speech signal is sampled with 8 kHz sampling frequency and the samples are represented with 13 bits. List the steps the bits will undergo before they are transmitted in the TCH/FS with a 270.833 kbit/s rate over the radio interface. Give the bit rate after each step.

6 In GSM and EDGE adaptive multiple rate speech coding (AMR) is specified.
a) What are the reasons for using AMR, and describe shortly its functional principle?
b) What means the abbreviations AMR-NB, AMR-WB, TCH/AFS7.95, TCH/AHS7.95, O-TCH/AFS7.95, and TCH/WFS12?
c) Which method is used to match the channel encoder output rate to the constant rate required in the radio interface?
d) How does the receiver know which rate is used?
e) What is the rate control based on?

7. Draw the block diagrams and explain the block functions of the spreading and modulation procedure in UTRA-FDD down-link and up-link.