S-72.2211 Mobile Communication Systems and Services

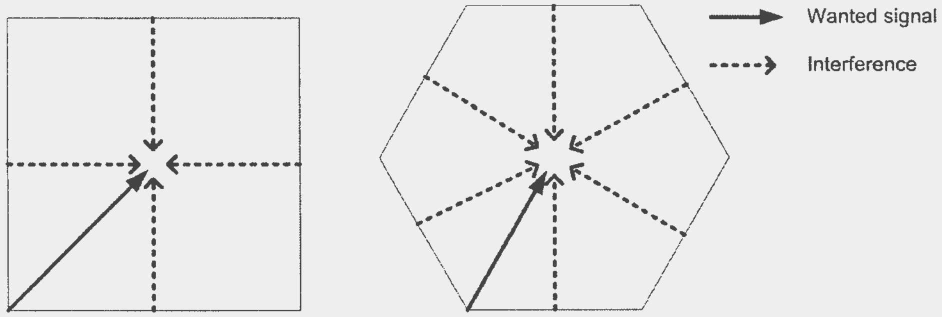
Exam 2.9. 2014

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. Duplexing. Provide short answers to the questions below:
   a) Why is duplexing needed?
   b) What is the main difference between Time Division Duplexing (TDD) and Frequency Division Duplexing (FDD)?
   c) What problems may arise from using TDD in a mobile communication system, and why?
   d) Why and when is a duplex gap needed in a FDD system?
   e) What benefits could there be in using TDD instead of FDD?
   f) Why do Code Division Duplexing systems not exist?

2. Mobility procedures.
   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?

3. Compare two alternative cellular system deployments, a square and a hexagonal one. The number of base stations is the same in both, and thus the cell area is the same as well. We take the cell area to be 1 km^2. The distance between base stations (Inter-site Distance, ISD), is thus 1 km in the square cellular system, and $\sqrt{\frac{2}{\sqrt{3}}} = 1.07$ km in the hexagonal system. The "radius" of a cell is the largest possible distance between a mobile station and the base station. It is $\mathrm{ISD}/\sqrt{2}$ km in the square system, and $\mathrm{ISD}/\sqrt{3}$ km in the hexagonal. **Calculate the worst-case uplink Carrier-to-Interference ratio in these two systems**, when the reuse factor is one, and only distance dependent path loss is taken into account. Consider the path loss exponent 4. In the worst case, the wanted signal comes from the distance of the cell radius, and the interference from the neighboring cells comes from the closest points on the cell border. Only the nearest interfering cells are considered, see the figure below—there are 4 and 6 of them, respectively. Give the result both in linear and dB scale.
   Hint: the worst case uplink interfernce comes from a distance ISD/2.



4. Consider an uplink WCDMA system. The path loss model in dB-scale is

$$L_p = L_0 + 10\alpha \log(r)$$

where L_0 is the path loss at 1 km distance, $\alpha = 3$ is the path loss exponent and r is the distance measured in km. The coverage area of a service is determined by a disk– the radius of this disk is the distance from which a user transmitting with full power can receive required service. The fractional load of the system is

$$\eta = (1 + f) \sum_{j=1}^{N} \frac{\rho_j \gamma_j}{G_j}$$

where $f = 0.6$ is the other-cell-to-own-cell interference ratio, ρ_j is the activity factor of user j, γ_j is her target SINR and G_j her processing gain (spreading factor). There are N users in the cell. In a link budget, the fractional load of the system is taken into account as an interference margin $IM = 10 * \log_{10}\left(\frac{1}{1-\eta}\right)$.

Consider the situation where first the fractional load is $\eta_0 = 0.5$, and all the N users enjoy the same basic service. This basic service is determined by the same activity factor ρ, SNR target γ and processing gain G for all users. Compare to the situation where the fractional load has increased to η_n as $N/2$ users enjoy improved service with twice the data rate by using half the spreading factor (their processing gain is $G/2$), while the remaining $N/2$ users still enjoy the basic service. The activity factor and SNR target in the improved service are the same as in the basic service. What is the ratio of the coverage areas of the basic service with fractional loads η_n and η_0?

Hint: in fractional load calculations it is assumed that the load in neighboring cells changes in the same way as the load in the own cell.

5. A cell is being planned. Preliminary measurements show that the average path loss L_p in dB including system losses and antenna gains can be modelled by

$$L_p = 130 + 10 \log_{10}(r^{\alpha})$$

where α is the path loss exponent and r is the distance measured in kilometers.

   a) Determine the required transmit power level to obtain a 5 km cell radius when the receiver sensitivity is -104 dBm and the path loss exponent is $\alpha = 3$.

   b) Later it turns out that the path loss exponent is $\alpha = 4$. What would the required transmit power level be to preserve the cell radius?

   c) To which value is the cell radius reduced, if the transmit power remains unchanged?