S-72.2211 Mobile Communication Systems and Services

Exam 14.5. 2012

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. Mobility-related 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?
   (An expected answer to each of the three questions above would consist of a few sentences.)

2. Provide short answers (at most a couple of sentences) to the questions below:

   a) What benefits would there be in a CDMA system if the UL users in a cell would be chip-synchronous?

   b) Is the UL in WCDMA synchronous?

   c) Why is it necessary that the UL users within a cell of a TDMA system are synchronized?

   d) How is synchronicity of UL transmissions within a cell achieved?

   e) In GSM, the UL transmissions need not be perfectly synchronized. What sets the upper limit of acceptable asynchronizity in GSM?

   f) What reasons could there be to synchronize the cells in a cellular network so that all Base Stations use a common time reference?

3. How many percent will the coverage area increase if a gain term in the radio link budget is improved with 5 dB, and the path loss exponent of the single slope average loss model is i) 3.0, ii) 4.0, and iii) 5.0?

4. In WCDMA, the chip rate is 3.84 Mchips/s.

   a) Assume a single cell system with the user bit rate after channel coding 15 kbits/s and the E_b/I_0 requirement for proper reception 5 dB, where E_b is the bit energy and I_0 is the experienced interference. With user activity factor 0.4 and AWGN noise not considered, how many users in a cell, theoretically, can be simultaneously served in the uplink direction?

   b) Repeat the calculation for a multicell system when the other-to-own-cell interference ratio is 0.6.

   Hint: When all users have the same service with constant rate, the capacity in number of users is obtained from the SIR expression $\gamma = \frac{GP}{\rho(1+f)(N-1)P}$, where G is the processing gain, P is the transmit power of the users, N is the number of users and f is the other-cell-to-own-cell interference ratio. Note that the processing gain can be calculated from the chip rate and the user bit rate. In Uplink WCDMA, BPSK modulation is used for data transmission.

5. 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 $\sqrt{\frac{2}{\sqrt{3}}}$ 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 ISD$/\sqrt{2}$ km in the square system, and ISD$/\sqrt{3}$ km in the hexagonal. **Calculate the worst-case 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.