S-72.2211 Mobile Communication Systems and Services

Exam 18.2. 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. GSM mobility and measurements.

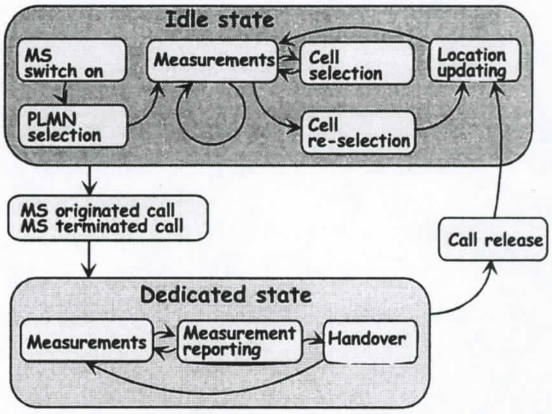
   a) What is the purpose of the random access channel (RACH)?

   b) In which procedures in the figure to rhe right is RACH used?

   c) What does it mean that RACH is a contention based channel?

   d) What does a dedicated state mobile station measure for handover purposes, and how does he know what to measure?

   e) What measurement results is a dedicated state mobile station reporting to the base station in GSM?



   f) In GSM traffic channels and downlink control channels, the last frame in a multiframe is a so-called idle frame. What is the purpose of this idle frame?

   (Short answers to the six questions above are expected, at most a couple of sentences.)

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

   a) What is the most important difference of teleservices and bearer services in GSM?

   b) What other services than tele- and bearer services exist in GSM?

   c) Teleservices in GSM can be classified according to four dominant attributes into four types. What are these?

   d) What is the difference of a GSM bearer service with a Transparent and a Non-transparent Quality of Service (QoS) attribute?

   e) UMTS bearer services are divided in four QoS classes. What are the differences of the Interactive and Background class? Mention example applications in these classes.

   f) What are the two other QoS classes in UMTS?

3. We have a hexagonal cellular system with $N_c = 252$ carriers, where Radio Resource Managemant is based on frequency reuse. The worst allowed Carrier-to-Interference Ratio is 4dB. We can fit 8 TDMA channels on each carrier, and one call requires one such channel. What is the system capacity in calls/cell, when we assume a single slope path loss model with path loss exponent $\alpha = 2$ or $\alpha = 4$?

   Hint: It is allowed to make a worst-case analysis of an uplink system, where the interferers are as close to the interfered Base Station as possible.

Reuse

$C \cdot M = N_{cell} \cdot N_{ch}$ 8·252

Cap.

$\frac{C}{N_{cell}} = \frac{N_{ch}}{M}$

4. Timing advance is used in cellular systems to adjust the clock difference between a MS and the serving BS caused by propagation delay.

    a) In a GSM system, a call is initiated by the use of the random access channel, which is an access burst transmitted in a slot. No timing advance is used for the random access channel. Irrespective of the propagation delay, the access burst should be received inside the slot as defined by the base station clock. To make this possible there is an additional guard interval of 60 bit periods in a GSM access burst. What would the maximum cell radius be, so that these 60 bits are sufficient to keep the access burst inside the slot? Hint: there are 156.25 bit periods in a GSM burst of 0.577 ms. The speed of light is $c = 3 \cdot 10^8$m/s.

    b) Assume that a MS is moving directly towards the base station and that the required accuracy of timing advance is 1 bit period. How often does the TA need to be updated, if the velocity of the user is 3 km/h, 50 km/h, 120 km/h or 250 km/h?

5. Consider a two-cell LTE system on a line. Base Station 1 (BS1) is located at the origin, BS2 at location $x = 4.5$. BS1 is serving a user located at $x = 2$, and BS2 a user located at $x = 3$, and the unit of length is km. We are interested in downlink operation. Both BSs transmit with $P_{tx} = 43$dBm, and they are transmitting to a signal bandwidth of $W = 18$MHz.

    (a) The thermal noise power at both receivers is $N = -93.4$dBm. We assume that the noise bandwidth equals W. The thermal noise level is $N_{\mathrm{T}} = -174$dBm/Hz. What is the noise figure of the receivers?

    (b) Path loss in dB-scale follows the model $L = L_0 + 10\alpha \log_{10}(d/d_0)$, where d is the distance between the transmitter and receiver, $d_0 = 1$km. The path loss exponent is $\alpha = 4$. The constant $L_0 = 112$dB encorporates all other gains and losses in the system. Fading is not considered. Calculate the received powers at the two receivers of the transmissions of the two transmitters (four values).

    (c) Reuse 1 is used. Caculate the Signal-to-Interference-plus-Noise Ratios (SINRs) of the two users for their wanted signal. Estimate the data rate of the two users: Subtract an implementation margin of 2 dB from the dB-valued SINR, estimate the data rate from these implementation limited SINRs using the signal bandwidth, and Shannon's law. The temporal efficiency of LTE is $E_T = 0.7$ information symbols/s/Hz.

    (d) Assume that the two cells perform Inter-Cell Interference Coordination (ICIC), and agree to mute the transmission on half of the bandwidth each. Thus in the non-muted part, there would be no interference from the other cell. What would the data rates of the two users be in this case, using the implementation limited Shannon's law? Hint: in this case, the received wanted signal power and noise power would be the same as above, the used transmit power is halved by muting.

    (e) If the objective of the network is to maximize the sum of the rates of the users, which method is better, reuse 1 from (c), or ICIC from (d)?