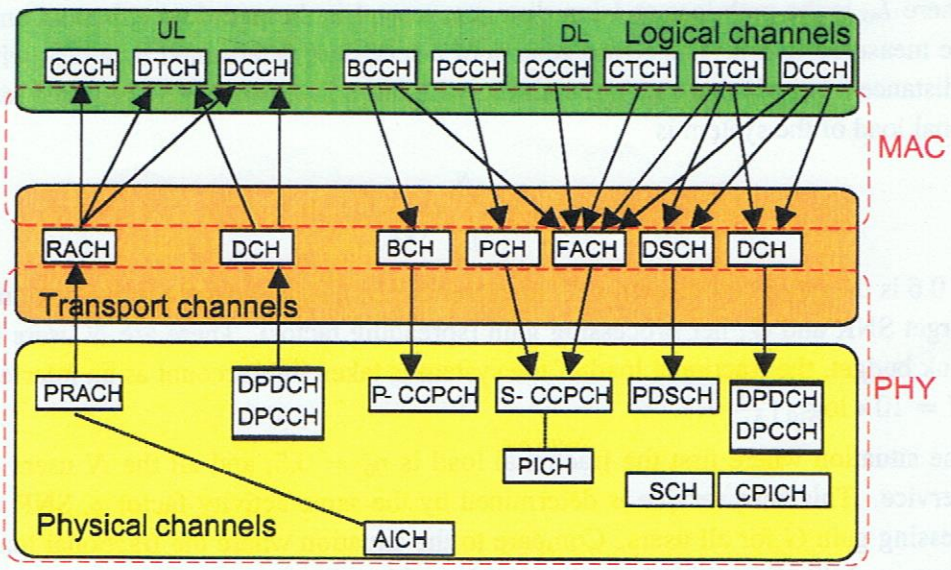
S-72.2211 Mobile Communication Systems and Services

Exam 6.3. 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. Duplexing. Provide short answers (a couple of sentences) to the questions below:
   a) What does full & half duplexing mean?
   b) In what type of duplexing between uplink & downlink traffic is full duplexing a relevant concept?
   c) What problems may arise from using Time Division Duplexing (TDD) in a mobile communication system?
   d) Why is a duplex gap needed in a Frequency Division Duplexing (FDD) system?
   e) What benefits could there be in TDD instead of FDD?
   f) Why do Code Division Duplexing systems not exist?

2. The picture below shows the channel structure of WCDMA. In logical channel names, the first letters stand for Common, Dedicated, Broadcast and Paging, and the second letters stand for Control and Traffic. In transport channel names, we have four-letter acronyms with the two first letters meaning either Random Access, Forward Access or Downlink Shared, or then we have a three-letter acronym with the first letter the same as one of the first letters in logical channel names. Among physical channels we have some obvious ones, with P for "Physical" appended, as well as Dedicated Physical Data and Control Channels (DPDCH and DPCCH), as well as Primary and Secondary Common Control Physical Channels.



a) What determines a physical channel in WCDMA?
b) What is the role of transport channels in WCDMA? What are the essential characteristics of the transport channels?
c) A user has a dedicated connection for a WCDMA voice call. In addition to dedicated traffic, the Radio Resource Control protocol at the mobile station sends handover measurement data to the network. Over which physical channel is this data transmitted?

3. We have a 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.

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 an uplink WCDMA system. The path loss model is

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

   in [dB], where L_0 is the path loss at 1 km distance, $\alpha = 4$ is the path loss exponent and r is the distance measured in km. The coverage area of a service is determined by a disk with the radius 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 SNR 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 service. This base 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 base service. The activity factor and SNR target in the improved service are the same as in the base service. What is the ratio of the coverage areas of the base 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.