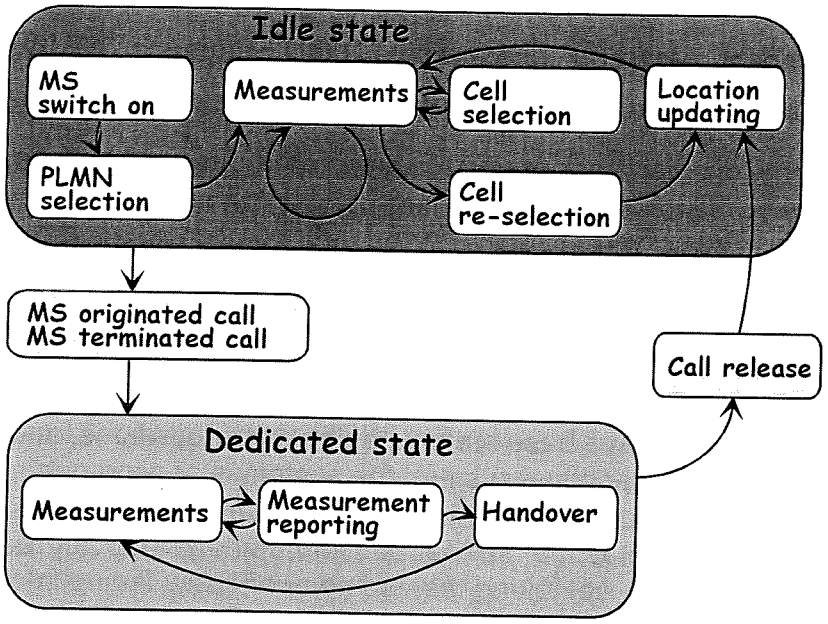
S-72.2210 MOBILE COMMUNICATION SYSTEMS AND SERVICES

Exam 21. 12. 2006

All five tasks are evaluated and taken into account in the grading. Persons performing a programming task may leave one task undone, or indicate which task may be exchanged against a fulfilled programming task.

1. In the figure below, a state machine for GSM mobility management is depicted.



a) Why does an idle state mobile station perform cell re-selection?

b) What does an idle state mobile station measure for cell re-selection?

c) When is a location update initiated?

d) What does an idle state mobile station do in order to be able to know if he has a MS terminated call coming?

e) What does an idle state mobile station do when initiating a MS originated call?

f) What core network elements are involved in location updating?

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

2. Consider N-branch diversity with selection combining. The diversity branches are statistically independent and on average equally strong. The cumulative distribution function of the signal to noise ratio (absolute value) after combining is

$$F(\gamma) = \left(1 - \exp\left(-\gamma/\bar{\gamma}\right)\right)^N,$$

where $\bar{\gamma}$ is the average received SNR of each diversity branch, γ is the post-combining instantaneous received SNR. A user is enjoying a service that requires instantaneous SNR = 5 dB for proper reception, at least 95% of the time. What is the average required SNR in case there is no diversity and in case there is two-branch diversity?

3. Assume a system with reuse factor 1, and base stations located on a hexagonal lattice. Calculate an approximate expression of the down-link carrier-to-interference ratio (C/I) along a line connecting the serving base station with one of the neighboring base stations. All base stations transmit with the same power. An accepted approximation is to take into account only the six base stations surrounding the serving base station, and to assume that the interference from all of these cells equals the interference from the nearest interfering base station. Fast fading and shadow fading is not taken into account.

Path loss is assumed to follow an $r^{-\alpha}$ law, the distance between the base stations is denoted by *D*, and the distance from the serving base station by *r*. Assuming that the path loss exponent is 4, tabulate the numeric C/I-values for *r*=0.1*D*, *r*=0.2*D*, *r*=0.3*D*, *r*=0.4*D*, *r*=0.5*D*.

4. Calculate the impact of load on coverage in a Direct Sequence CDMA system.

Assume the path loss model $L_p = L_o + 40\log(r)$, fast fading and shadow fading is not taken into account. Consider a service with a given data rate, and a corresponding receiver sensitivity S. When the fractional load $\eta = 0$ (and correspondingly the interference margin $IM = 0$), denote the area of coverage of this service with A. What would the coverage area of this service be in the cases $\eta = 0.5$ and $\eta = 1$?

5. Compare a system with omni-directional base station antennas (antennas radiating with equal power to all directions) to a system with sectorized base station antennas. Assume that both systems have base stations at the same positions, and that the reuse factor is one. In the omni-directional system, the system is serving one user per channel per cell, and in the sectorized system, one user per channel per sector is served. The system capacity is estimated as the number of users per km^2 that can reach a given data rate with 50% availability (i.e. not taking fast fading or shadow fading into account). This data rate is selected so that with a uniform distribution of user locations in the cells, 95% of the users in a non-sectorized system reach this data rate. Power control is not used.

a) Assume that the total base station transmission power is the same in the sectorized and non-sectorized case. Why are higher carrier-to-interference ratios possible in a non-sectorized system than in a sectorized system?

b) Why is the downlink system capacity higher in a sectorized system than in a non-sectorized one?

c) How does the situation in uplink differ from the situation in downlink, related to the carrier power, the interference power, and the system capacity?

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