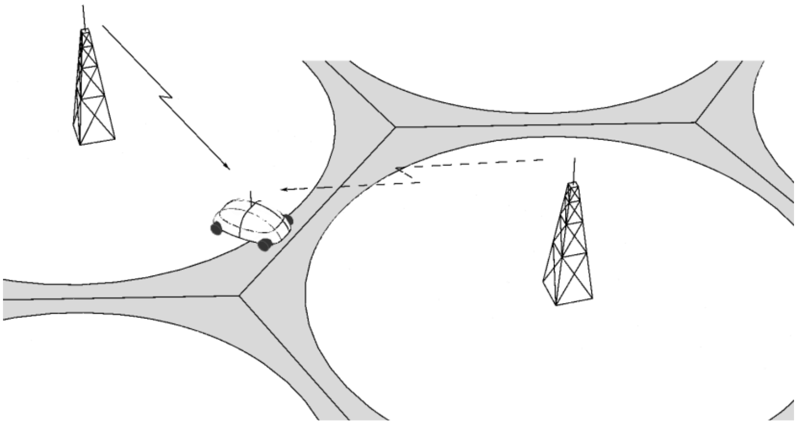
KTH Information and Communication Technology

IK2510 Wireless Networks

Exam 2010-10-18, 9:00–13:00, Room C21,C22. Teacher in charge: Jens Zander, 0708-521461

Open Book exam with Text Books, formula sheets (BETA or similar), printed lecture notes, dictionaries, tables are allowed. *Solutions, own notes or other hand written* material are **not** allowed. Calculators are allowed, but all other electronic equipment, such as mobile phones, tablets etc must be switched off and may not be brought to the seat.



1. A cellular channel limited system uses a hexagonal cell pattern employing symmetric channel reuse with a total of $C = 120$ channels. The base stations are located in the center of the cell and the signal strength can be assumed to decay as r^3. Assume that the mobile stations are uniformly distributed.

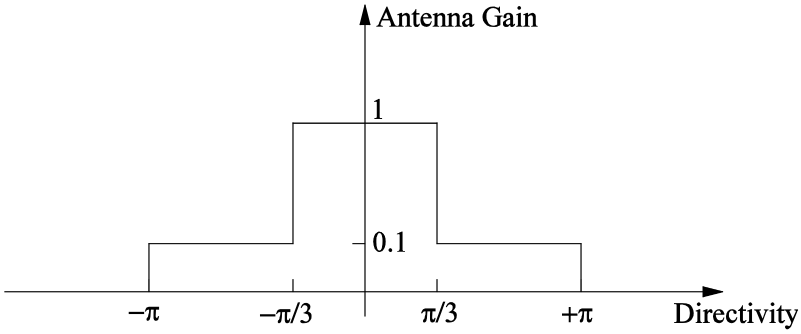
   a) For simplicity: consider downlink communication. Assume that all base stations are sending with the same power. Design the system for a 12 dB SIR, with the receiving mobile at a cell corner, and determine the system capacity in channels/cell? Now, if the SIR is less than 16 dB the mobile looks for a handover candidate. Assume that the SIR is constant when the mobile is moving round in a circle with the base station in the center. Redesign the system so that the number of channels, reserved for handovers is proportional to the probability of active handover algorithm (round to integer). What is now the system capacity in channels/cell (used for new calls)? (1.5p)

   b) The time interval between new call arrivals is exponential distributed with an average of 6 seconds and the duration of a call is also exponential distributed with an average of 30 seconds. Using the channel configuration in a), determine the blocking probability (of new calls) in terms of p_0, the probability that all channels are free. (1.5p)

Hint: Consider a hexagonal cell plan with cell distance 1. If the signal strength decays as d^{α} then the interference sum I(α) = $\sum_i^{\infty} d_i^{-\alpha}$ over all distances d_i to neighboring cell centers is

α	2.0	2.5	3.0	3.5	4.0	5.0	10.0	∞
$I(\alpha)$	∞	18.12	11.03	8.77	7.71	6.76	6.03	6.00

2. Consider the uplink of a DS-CDMA system, with base stations having omni-directional antennas, employs a perfect received power control and voice activity detection with a voice activity factor $q = 0.5$. The mobile users within the system are Poisson distributed with a mean of 8 users/cell. Inter cell interference can be considered about 60% of own cell interference.



The assignment failures within the system occur when the system load $L = 1 - \eta$ exceeds 50%.

a) Determine the pole capacity M_p of this system if the assignment failure rate should not exceed 20%. (1.5p)
b) Determine the assignment failure rate if the CDMA system employs directional antennas with the antenna diagram shown in the figure above and base stations placed on the corners of the cells. (1.5p)

3. In the uplink of a mobile packet radio system, a large number of terminals access a central station using a slotted ALOHA multi-access scheme. Since the terminals are a different distances from the central receiver, they are received at different signal levels. If the ratio between the signal level of the strongest received packet and the (sum of the) other packets is large enough the strongest packet may still be received even if there is a collision (“capture”). Assume that the signal level decays as the α-th power of the distance, where α=4 and that the noise can be neglected within the circular design coverage area. Packets are assumed to be transmitted according to a Poisson process, with a uniform distribution over all the cell area.

a) Determine the cumulative distribution function (CDF) of the received power from a terminal!

b) Determine/estimate the maximum throughput of the uplink of the system provided that the probability of correct packet reception when more than two packets are colliding can be neglected Assume a SIR threshold for correct reception of 6 dB!

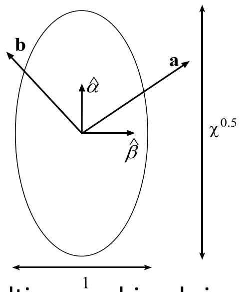
c) What is the probability to get more than 2 colliding packets as function of the offered load γ ? For which γ:s is it reasonable to neglect this event ?

4. In a cellular mobile broadband access system a modulation scheme is used that provides a data rate

$$R(\gamma)=\begin{cases}0 & \gamma<4dB\\ 100\gamma & 4dB\le\gamma\le 20dB\\ 10^4 & \gamma>20dB\end{cases}\quad \text{kbit/s,}$$

where γ is the received signal-to-interference ratio. Assume that the received signal power in a single circular cell with uniformly distributed users follows an inverse power-law with α = 4. Assuming that the interference is constant and the system is designed to provide 400 kbit/s at the cell boundary, what is the expected (average) data rate of a user ?

5. The network company *NetTwo* is to deploy a radio network within the rural parts of Sweden. The question for the company is whether to build space- or polarization diversity? Using the assumptions stated below:
   a) With which antenna configuration will the company have to build the least no of sites to cover the same area? (1p)
   b) How many more sites per area unit are required for the non-preferred solution if we assume a maximum error probability of 10^{-2}? (3p)



Assumptions:

i. Assume that the towers are high and that the channel cross polar discrimination χ *=9dB*

ii. That the propagation constant α=2

iii. Assume that the system is noise- and uplink limited

iv. That the channel is subject to Rayleigh fading

v. That the distribution function for the SNR of the resulting combined signal for the two branch diversity system for different power correlation factors, ρ, is given by the figure below