WIRELESS COMMUNICATIONS
CLASS PROJECT

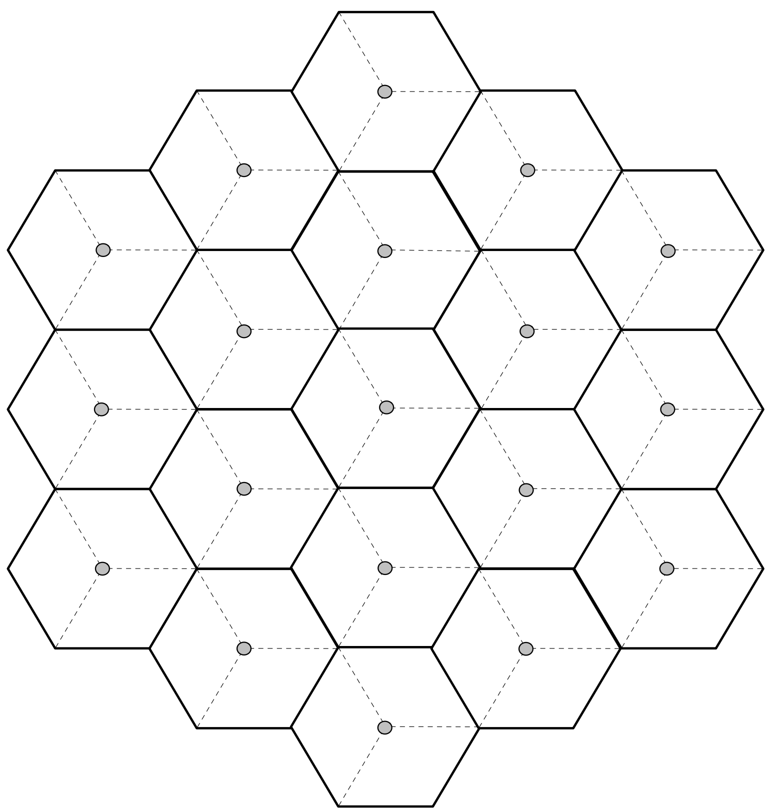
Report due date: Before the final exam.

Submission procedure: By email to Prof. Lozano (angel.lozano@upf.edu).

Objectives:

1. To develop competences related to teamwork and project management.
2. To learn how to simulate a communication system.
3. To practice and expand many of the theoretical concepts learned in class.

Description: the simulation universe should consist of 19 hexagonal cells: a central cell and two rings of interfering cells, as shown in the figure below. Each cell should have 3 identical sectors, as shown also in the figure.



Consider interference-limited conditions, with thermal noise neglected.

The simulation is restricted only to the uplink.
Consider a specific channel, on which there is a single user per sector (the rest are on orthogonal channels). The user positions are uniformly random within their sectors.

The user terminals have a single omnidirectional antenna.
Every base sector has a single directional antenna that spans 120°.

The pathloss exponent is $\upsilon = 3.8$.
The shadow fading is log-Normal with an 8-dB standard deviation.
There is no multipath fading.

In order to generate the required data, a large number of snapshots should be simulated. (The number of snapshots should be large enough that the curves generated are smooth, at least 1000.) On each snapshot, users should be randomly placed and fresh shadow fading values should be generated.

Note: to avoid edge effects, data should be compiled only in the central cell (any one of its sectors suffices because of symmetry, although all can be used to improve the statistics).

Computing platform: MATLAB or Python.

Deliverables (per team):

1. A zip file with all the MATLAB/Python files. They should be functional and have sufficient comments to allow for proper interpretation.

2. A brief report consisting of 2 sections:
   (a) A list of the MATLAB/Python functions, their inputs and outputs, and their interoperability. (Length: less than 1 page).
   (b) Plots and comments addressing the questions below.

Note 1: Make sure the plots you include are large enough to be readable (preferably no more than two figures per page), include legends to identify the various curves, and cover the correct range of values.

Note 2: Please be concise. A report is not better just because it's longer. Rather, the perfect report is that which, while containing all the required information, is as brief as possible.

Note 3: In order to generate CDF curves in MATLAB, you may use the command ecdf.

Questions:

1. Let the power control be inactive. Assuming universal bandwidth reuse in all the sectors and cells (reuse factor 1), generate the CDF of SIR (in dB). Repeat assuming universal bandwidth reuse across cells, but different bandwidth in each sector (reuse factor 3). Repeat assuming bandwidth reuse factor 3 across cells and also 3 across sectors (total reuse factor 9). Plot the three CDFs together. If we want at least -5 dB of SIR per user, does any of the reuse factors achieve it with 97% probability?
2. Activate the fractional power control. With reuse factor 3, what is the power control exponent that maximizes the percentage of users with SIR $\geq$ -5 dB? Plot the CDF of SIR (in dB) with such power control exponent.
3. Re-address question 2 for pathloss exponents $\upsilon = 3$ and $\upsilon = 4.5$. Plot the SIR (in dB) CDFs for $\upsilon = 3$, 3.8 and 4.5 together. Briefly discuss whether a small or a large exponent is preferable in interference-limited conditions. How can the system designer affect the exponent?
4. Set the pathloss exponent back at $\upsilon = 3.8$, disable the power control, and let the bandwidth be 100 MHz. Suppose that a family of constellations and codes with an SNR gap to capacity of 4 dB is available, and that the error probability is negligible. Plot the CDF of the throughput achievable by users for the reuse factors 1, 3, and 9. Compute the average bit rate as well as the bit rate attained by 97% of users in each case. Remember to take into account that the available bandwidth at each sector depends on the reuse factor!