Networked Life: Questions and Answers Q1

1. Is it true that in the case of a cellular system with base stations, all channel receivers are in the same physical location? Hint: is it sensible to use multiple base stations (BS) in the same cell to improve reception?

**Answer:**

We may consider the cellular structure of slide 8 with higher degree of granularity. More specifically, in each cell we may consider two base stations and associate a part of the spectrum to each one of them. In this way, we reduce the maximum possible distance between the BS and the mobile stations (MS) to reduce transmit power and still avoid the interference with neighboring cells, but with the cost of the additional required equipment (the BSs).

1. Why obtaining equal SIR for each channel at the base station could make sense (slide 19)? Hint: fairness towards different MSs?

**Answer:**

Since the capacity of the channel depends on the SIR (slide 16), equalizing the SIR means that the MSs transmit with the same rate (fairness), thus we overcome the near-far problem.

1. To make things simpler we assumed that each user of a channel cares to achieve a minimum SIR. How to justify that?

**Answer:**

Most applications that run on the mobile station require a certain bit rate in order to work properly (e.g., real-time video). Offering a higher bit rate may not result in any noticeable improve of quality. Of course, it does not hurt. But it comes at a cost (use more power and drain the battery faster).

1. In slide 24 we mention that in our case a user gets value from the system by hurting others. Can you think of other similar setups?

**Answer:**

Any system with negative externalities. For instance, the download rate of any user in the Internet reduces the potential rate of other users due to the finite capacity of the network. The consumption of electricity during peak hours leads to higher prices for all the consumers, talking louder in a meeting, etc.

1. Is the socially optimal solution (slide 23) practically interesting? Under what assumptions (or conditions in practice)? Hint: how can a central location know the information about the gains? If it asks the stations, will they report the truth?

**Answer:**

The social planner must have full information to solve the social welfare optimization problem (minimize the power cost while achieving the required SNR). In the case of power control, it must have information about the channel gains of each MS, meaning that the MSs must inform it about their transmission power at all times. In the power control case, the centralized optimal solution coincides with the distributed one (selfish users running best response, i.e., DPC), meaning that each MS would have the incentive to truly reveal the transmitting power to the BS, and thus the channel gains.

1. Our distributed power control algorithm as modeled in slide 32 assumes that all senders are synchronized and act together in each step. What you expect that happens in reality? Should this be a problem for our results?

**Answer:**

DPC can even be carried out asynchronously: each radio has a different clock and therefore a different definition for timeslots. One can prove that under general conditions of relaxing synchrony convergence takes place.

Of course, in real systems the timeslots are indeed asynchronous and power

levels are discrete. Asynchronous and quantized versions of DPC have been implemented in all the CDMA standards in 3G networks. Some standards run power control 1500 times every second, while others run 800 times a second. Some discretize power levels to 0.1 dB, while others between 0.2 and 0.5 dB.

1. What is a dominant strategy for a given game? Why such strategies are interesting? A game has always a dominant strategy? For a NE, the strategy that corresponds is dominant? Hint: In the Haw-Dove game, is there a dominant strategy? What are the NEs?

**Answer:**

When the best response strategy of a player is the same no matter what strategy the other player chooses, we call that a dominant strategy. It might not exist for a specific game. But, when it does, a player will obviously pick a dominant strategy. (book pages 11-12). The strategy that corresponds to a NE is not necessarily dominant. For instance, in the Haw-Dove game there is no dominant strategy for any of the players, but the game has two pure NEs.

1. Write down the equations to compute the NE for randomized strategies for the players in the coordination game in slide 53. Assume player A uses a coin and player B a coin
2. Hint: Assume in this NE that player A uses coin and player B uses coin .

**Answer:**

Let player A be the row player and be the probability that he chooses the upper row and the probability that he chooses the bottom row. Similarly let be the probability that the column player B chooses the left column and the probability that he chooses the right column. Then, the following equations must hold.

Equation (1) reads as follow: Given that player A maximizes her payoff by randomizing, she must be indifferent between choosing any of her two strategies, i.e., they must generate equal payoffs (which are functions of ).

Same for equation (2) regarding player B.

By solving the system of equations, we get .

1. Compare the condition for having a feasible solution to the optimization problem as shown for in slides 29 and 65. What is the physical interpretation of the corresponding formula for the spectral radius?

**Answer:**

In slide 29, feasibility requires that the two lines intersect. This condition is formulated as: , which is equivalent to , i.e., the condition formulated in slide 65 in terms of the eigenvalues. In the general case for , the maximum eigenvalue of the matrix must be smaller than 1. The physical interpretation is that for fixed channel gains if we arbitrarily increase the requirements on the SIRs or the cross-channel gains we will eventually become infeasible.