Obligatory assignment 1, TEK5010 Multiagent systems, 2018

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Mobile base station placement using game theory

A large sporting event, like Holmenkollen, is expected to draw crowds of spectators that completely saturate the local communication system. Consequently, a telecommunication company is contracted to provide network connectivity by using a number of elevated mobile base stations. The question is how do we fly these UAV nodes in order to provide optimal connectivity for the many ground based mobile phone users?

In this obligatory assignment we will try to answer this question using a game theoretic approach (in the next obligatory assignment we will try to address the same question using swarm intelligence methods). In the following we assume self-interested agents: mobile phone users maximize bandwidth (i.e. chose connectivity based on base station signal power) and each base station maximize the number of served phones (i.e. count the number of connected devices).

1) How could Hotelling's famous 1929-paper [1] be a good starting point for a game theoretic analysis of this problem?
2) Assuming all mobile phone users are uniformly spread out on a 1D line segment served by 2 mobile base stations:
    a. What is the equilibrium outcome? Is this Nash? Can you prove it?
    b. How does this equilibrium compare to the socially optimal outcome? Could you give a measure compering these two outcomes?
3) You can now assume that mobile phone users are uniformly spread out over a 2D square area:
    a. Could you simulate the 2 base stations serving this crowd? A very simple mechanism for base station movement could be to evaluate change in objective value based on local movement without taking the other base stations into account. Do you end up in a Nash equilibrium? And how does this equilibrium compare to the socially optimal outcome?
    b. More base stations are added to the area. Could you simulate and describe the equilibrium outcome as the number of base stations increases? How do these equilibriums compare to the socially optimal outcome?
4) Include game matrices for modelling the strategic interaction between the mobile base stations:
    a. How does this compare to the decision theory approach, especially in terms of computational complexity as the number of base stations increase?
    b. Is it possible to coordinate the competing network providers into a socially optimal outcome by altering the objective function of the base stations? For instance, one could try to maximize the total served bandwidth (possibly together with the number of connected devices)? Discuss your options.

References

[1] Hotelling, Harold (1929), "Stability in Competition", Economic Journal, 39 (153) 41–57.