CSE 516: Homework 3

Due: April 10, 2014 by 5 PM in Jolley 507

Note: Some of the questions on this homework are more open-ended than those on previous homeworks. Please explain your answers and your reasoning in detail. As usual, please keep in mind the collaboration policy as specified in the course syllabus. If you discuss questions with others you **must** write their names on your submission, and if you use any outside resources you **must** reference them. Grading will take into account how clearly you communicate your solutions, so please write your answers up carefully. There are 4 questions on 2 pages.

1. (30 points) **Giving back to those who pay:** A company with n employees, who each work at their own desks, with company-allocated computers, just received a gift of m awesome new computers from a wealthy donor. The company is very sophisticated in how it does things, so it gives each employee an annual budget of $20,000 for equipment to improve their working lives, and it achieves excellent results in terms of productivity by using this approach. The company wishes to figure out how best to allocate these new computers; in effect, it must determine which of its n employees will get the m new computers, with each of those employees getting exactly one of those computers. The old computers of these workers will be donated to charity. Each worker knows the value to her, in terms of added productivity (which correlates well with annual bonus), of getting one of these new computers. Without loss of generality, order the workers in terms of decreasing value of getting a new computer – thus, the true valuations, in decreasing order, are $v_1, v_2, \ldots, v_n$, with $v_1 < \$20,000$. The company wishes to elicit truthful valuations from its employees. One option is just to run a VCG mechanism, with employees paying from their equipment budgets (assume this takes place on Jan 1, before anyone has had the chance to spend anything from their budget). The issue is that this doesn't really align with the company's goals – the computers were free, the budgets can be used for other purposes, so why make the employees spend from their budgets? But how can they get incentive compatibility otherwise?

   The company comes up with an idea. They'll run a two-stage mechanism. The first stage is the ordinary VCG, with payments being collected from participants. In the second stage, the company will take all the payments, and then give that money *back* to the employees' equipment funds in some manner. They propose two possible alternatives. For notational convenience, let a_i be the $(m+1)$th highest bid from an agent other than i, and b_i be the $(m+2)$th highest bid from an agent other than i. In alternative (1), the second stage payment to employee i should be $\frac{m}{n}a_i$. In alternative (2) the second stage payment to employee i should be $\frac{m}{n-m-1}a_i - \frac{m(m+1)}{(n-m-1)(n-m-2)}b_i$. Assume that $n \geq 2m+3$.

   Answer the following questions in the context of these two two-stage mechanisms:

   - Are the mechanisms incentive compatible? Do they make no positive transfers? Are they individually rational? (Prove your claims)
   - How much of the VCG payments does the second stage give back to the employees for each of the two mechanisms?

- Is one of these mechanisms always better (in terms of how much it gives back) than the other for any set of valuations? If not, how do they differ, and in which cases would you want to use one rather than the other, if your goal is to give back as much as possible?

2. (20 points) **Voting in multiattribute domains** A condo complex with five residents is having a debate about whether to build a new swimming pool (P or $\neg P$), and also a new squash court S or $\neg S$. Of course, condo fees will go up according to whichever options are selected. Two residents have the following preferences: $(P, \neg S) \succ (\neg P, S) \succ (\neg P, \neg S) \succ (P, S)$. Two others have the preferences $(\neg P, S) \succ (P, \neg S) \succ (\neg P, \neg S) \succ (P, S)$. The fifth has preferences $(P, S) \succ (P, \neg S) \succ (\neg P, S) \succ (\neg P, \neg S)$.

   - Suppose residents are asked to vote individually on each of the two issues, swimming pool and squash court, and everyone is *hopeful* about their preferences with respect to the other issue (they assume the other vote will turn out the way they want). What will be the outcome of the two votes? Is this good or bad in the context of the overall preferences?
   - Suppose instead you hold a Borda count election over the entire set of alternatives, and everyone is truthful. What is the outcome? Is this good or bad?
   - Now suppose you scale this problem to more general yes/no ballot initiatives, and there are more than two of them on the ballot. Leaving aside incentive compatibility, what are the other problems with the Borda count approach?
   - Going back to the original problem, suppose you instead have sequential votes on the issues, with the outcome of each vote being revealed before going on to the next one. What would the outcomes be in the example, assuming hopeful voting in terms of as-yet-undetermined outcomes? Are there strategic issues here, and what is the effect of the chosen sequence of votes?

3. (20 points) **Voting for sushi:**. Working with the "ordered" version of the sushi3b dataset, downloadable from `http://www.kamishima.net/sushi/` (download `sushi3.tgz` and uncompress it to find sushi3b ordered), run a Borda count election and an instant runoff election, assuming the types of sushi are the candidates and these are the reported preferences. Report the results. Think about how to deal with the fact that you don't have complete preferences here. Can you find any manipulation opportunities in this data? What does this experience tell you?

4. (30 points) **Prediction markets:** From Tuesday, April 1st, to Thursday, April 3rd, you will have the opportunity to participate in a prediction market. Shares in the market will liquidate at 100 if the top ranked submission on `http://www.reddit.com/r/aww/` at 11:42 AM central time on April 3rd includes a cat, and 0 otherwise. Trading will stop at 11:00 AM central time. You may trade as you wish during the game, but for the purposes of this problem, write down what you would consider a good trading strategy for this market. Things you should definitely think about include (1) how to estimate the probability of the outcome that each share pays off 100, especially as a function of how much time is left in the market and the current state of the reddit page; (2) how to trade given your current holdings, the market price, your budget, your current estimate of the probability, and how much time is left in the market. **Do not violate reddit's terms of use in working on this problem or playing the prediction market game.**