CSCE 475/875 Multiagent Systems

Examination - Solution

November 7, 2017

Name:

NUID:

☐ Undergraduate ☐ Graduate

You have 75 minutes to complete the examination.

1. **(25 total points) Mechanism Design. Given the following Definition (Groves mechanisms)** Groves mechanisms *are direct quasilinear mechanisms* $(\chi, \wp)$, *for which*

$$\chi(\hat{v}) = arg \max_x \sum_i \hat{v}_i(x),$$
$$\wp_i(\hat{v}) = h_i(\hat{v}_{-i}) - \sum_{j \neq i} \hat{v}_j(\chi(\hat{v})).$$

(a) (8 points) What does $\chi(\hat{v})$ do? What does $\wp_i(\hat{v})$ do? What do the two components in $\wp_i(\hat{v})$ do?

Solution: $\chi(\hat{v})$ is the social choice: it finds the candidate or choice that yields the highest total sum of all agents' valuations. $\wp_i(\hat{v})$ is the payment that an agent has to pay back to the mechanism given the valuations of the agents. The first component of this payment is considered a "fee" or "tax" that an agent must pay. It is a heuristic function that is based on all other agents' valuations except the agent's. The second component of this payment is considered a "kickback" that an agent receives. It is the sum of all other agents' valuations of the social choice, obtained from the first equation above.

(b) (9 points) What is the dominant strategy under any Groves mechanism? Justify your answer.

Solution: The dominant strategy under any Groves mechanism is truthtelling. The key is because of the kickback component in the payment function. This kickback component depends on how all *other* agents value the social choice. That is, if the agent votes for a social choice that is beneficial to, say, a large majority of other agents, then this this kickback component is large. And vice versa. Thus, how other agents benefit from the social choice becomes an internal factor for the agent: it does well too if other agents do well. Therefore, if the agent lies in order to gain and hurts other agents' benefits, then it will suffer; and if the agent lies in order to benefit other agents, then it will also suffer from loss of utility from the social choice outcome. Hence, truthtelling is the dominant strategy.

(c) (8 points) Define clearly the Clarke Tax for $h_i(\hat{v}_{-i})$. What is the rationale behind this design? (***Hint***: Pivotal agents)

Solution: The Clarke Tax for $h_i(\hat{v}_{-i})$ is $\sum_{j \neq i} \hat{v}_j(\chi(\hat{v}_{-i}))$. This definition is based on the social choice outcome as if the agent didn't vote (note the $\hat{v}_{-i}$ in the social choice function). Thus, the tax is the sum of all *other* agents' valuations of the social choice outcome of all those other agents have valued (without the agent voting). Looking at this tax component and the kickback component, if an agent's vote benefits all other agents as a whole, then its kickback component will be greater than its tax component, and thus it will be rewarded instead of being penalized. On the other hand, if an agent's vote hurts all other agents as a whole, then its kickback component will be smaller than its tax component, and thus it will be penalized. If its vote does not change the social choice outcome, then the tax and kickback components are the same, and thus it will be neither rewarded nor penalized: its vote is *not* pivotal, and thus no benefits nor penalties.

2. (25 points) Auction. Consider a *cartel* or a *bidding ring* that uses the 2nd price auction protocol.

(a) (15 points). Describe the bidding ring protocol clearly.

Solution: The bidding ring has a ring center. It solicits bids from its ring members. It submits the highest bid price, $\hat{v}_1^r$, to the main auction, and also records the second highest bid price in the ring, $\hat{v}_2^r$. If $\hat{v}_1^r$ does not win the main auction, then the ring center does not do anything further. If $\hat{v}_1^r$ wins the main auction, with the second highest bid price in the main auction being $\hat{v}_2$, then the ring center ask the member—the winning bidder—who submits $\hat{v}_1^r$ to pay the $max(\hat{v}_2, \hat{v}_2^r)$. The ring center then pays the main auction $\hat{v}_2$ and gives the winning bidder the item accordingly. Furthermore, the ring center pays *k* to each bidder in its ring regardless of whether his or her bid wins or not.

(b) (10 points). In which situation would the ring center (leader) lose money for running the ring? In which situation would the ring center (leader) gain? What type of ring members is preferred by the ring center (leader)? Why?

Solution: The ring center would lose money for running the ring if $\hat{v}_2^r - \hat{v}_2 < k/n$ where *n* is the number of members in its right. And it would gain when $\hat{v}_2^r - \hat{v}_2 > k/n$. The ring center prefers ring members who are risk averse. This is because members who are risk averse will tend to submit a higher bid in order to secure a win. This will lead to a higher $\hat{v}_2^r$ and thus $\hat{v}_2^r - \hat{v}_2$ is more likely to be greater than k/n.

3. (25 points) Problem Solving with MAS.

(a) (6 points) What is the elegance of coherence in the *emergent* behavior in a multiagent system? (*Hint:* Globally directed vs. local decision making) What is the tradeoff? Why is this idea central to a good MAS design?

Solution: The elegance of coherence in the emergent behavior in a multiagent system stems from the tradeoff in this manner. Self-interested agents make local decisions, allowing each to be autonomous and responsive, without having to synchronize its decisions with all other agents (e.g., waiting for all other agents to provide some data). However, such autonomy could lead to agents conflicting each other's actions or decisions, resulting in a chaos in the overall system behavior. Chaos is not desirable. On the other hand, in a globally directed system, all agents follow a centralized policy or decision making process, and thus the system is likely to behave accordingly and generate desirable outcome directly. While guaranteeing desirable outcomes, such a system defeats the purpose of having agent-based solution in the first place: where agents are supposed to be observing, making autonomous decisions, and acting to ensure timely and optimal responses that each should make in a dynamic, complex environment. Thus, the dilemma is that the problem that warrants an agent-based solution could lead to high autonomy and chaos. A good MAS design retains high autonomy (local decision making) while the agents interacting in the environment leading to an overall behavior that is desirable. This overall behavior is often "emergent", as it is not "globally directed", but "emerges" from agents making local decisions. The elegance part is that when a coherent behavior emerges, we have the best of both worlds: autonomous agents making local decisions and a desirable, non-chaotic overall system behavior.

(b) (10 points) Describe your final project in terms of its overall problem to be addressed, agents, and environment design.

Solution: Project-Dependent.

(c) (9 points) Identify and describe one of the hypotheses in your final project, provide rationales behind why this hypothesis is worthwhile to be investigated, and outline your experimental plan clearly on how to investigate this hypothesis.

Solution: Project-Dependent.

4. (25 points) Hodgepodge.

(a) (8 points) Describe the fundamental concept behind a voter (or a candidate)'s ***weight-updating approach*** of a social ranking system where each voter is also a candidate.

Solution: In a social ranking system, each voter is also a candidate. The weight-updating approach is an *iterative* approach, where it loops until every voter's weight converges. When updating a voter's weight, it is based on the number of votes that the voter receives as a candidate, and also on the quality of the voters who vote for the candidate. For example, if a voter *A1* has also received votes from others, then that *A1*'s vote also is weighted more. This is quasi-transitive: if two candidates received the same number of votes, and if one of the candidates whose voters are ranked higher—i.e., themselves receive more votes—than the other candidate's, then that candidate wins.

(c) (8 points) Identify the basic steps of the Contract Net Protocol.

Solution: There are five basic steps. First, the contractor agent announces the task that it needs help to solve. Second, every other agent considers the list of tasks announced and ranks them according its needs, resources, and expertise. Third, every other agent computes and submits a bid if it is available and able to solve the task. It is possible for an agent to submit bids to multiple tasks at the same time. Fourth, the contractor agent receives the bids for its task and ranks them. Fifth, the contractor agent awards the task to the winning bidder. The winning bidder carries out the task and reports the results to the contractor agent.

(d) (9 points) Given the table of preferences from five different voters for their favorite states in the Midwest Region, using the Borda count scheme and pairwise elimination order, which state is the winner? (Please fill out the Table below AND ***list the # votes each state receives***.)

	Borda ranking (e.g., 7 = most preferred)					
States	**Voter 1**	**Voter 2**	**Voter 3**	**Voter 4**	**Voter 5**	**Total Borda Counts**
Colorado	7	0	7	5	4	23
Illinois	6	1	0	6	5	18
Indiana	5	2	1	7	6	21
Iowa	4	3	2	0	7	16
Kansas	3	4	3	1	0	11
Missouri	2	5	4	2	1	14
Nebraska	1	6	5	3	2	17
Oklahoma	0	7	6	4	3	20

<table>
<tr><th>Round 1</th><th>Round 2</th><th>Round 3</th><th>Round 4</th></tr>
<tr><td>Colorado</td><td rowspan="2">Illinois (3 vs 2)</td><td rowspan="4">Iowa (3 vs 2)</td><td rowspan="8">Oklahoma (3 vs 2)</td></tr>
<tr><td>Illinois</td></tr>
<tr><td>Indiana</td><td rowspan="2">Iowa (3 vs 2)</td></tr>
<tr><td>Iowa</td></tr>
<tr><td>Kansas</td><td rowspan="2">Missouri (4 vs 1)</td><td rowspan="4">Oklahoma (4 vs 1)</td></tr>
<tr><td>Missouri</td></tr>
<tr><td>Nebraska</td><td rowspan="2">Oklahoma (4 vs 1)</td></tr>
<tr><td>Oklahoma</td></tr>
</table>