Participation Behavior and Social Welfare in Repeated Task Allocations

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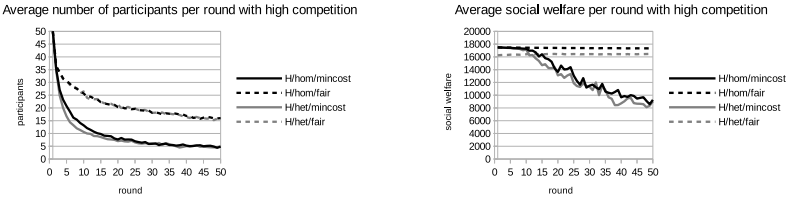
Overview Task allocation problems have focused on achieving one-shot optimality. In practice, many task allocation problems are of repeated nature, where the allocation outcome of previous rounds may influence the participation of agents in subsequent rounds, and consequently, the quality of the allocations in the long term. In [1], we investigate how allocation influences agents' decision to participate using prospect theory, and simulate how agents' participation affects the system's long term social welfare. We compare two task allocation algorithms in this study, one only considering optimality in terms of costs and the other considering optimality in terms of primarily fairness and secondarily costs. The simulation results demonstrate that fairness incentivizes agents to keep participating and consequently leads to a higher social welfare.

Methodology We consider a multi-round task allocation problem, in which each round has its own subset of jobs. The objective is to maximize the social welfare over all rounds. We assume agents decide for themselves whether they would like to participate in bidding in a certain round or not, using a participation probability, which will be dependent on earlier allocation outcomes.

To model the participation decision using prospect theory, we use the average proportion in the previous round over all agents as the reference point in the editing phase, and a positive (or negative) difference between an agent's proportion in the previous round and the average proportion as a gain (or loss). The intuition is that if an agent feels being treated worse in comparison with others, she might be more uncertain and will care less about participating again, because the time and effort put in the preparation when participating can then be seen as a loss. In order to take into account the experience from previous rounds into the participation probability, we will apply simple exponential smoothing.

Experiments We are interested in the development of the social welfare over multiple rounds and how two different allocation algorithms, a min-cost max-flow algorithm and a fair algorithm, influence the social welfare. Therefore, we conduct a simulation study. We will use a first-price sealed-bid auction where the allocation and the number of jobs bid on from all agents will be made available after each round. We look at several scenarios for both the jobs that are being auctioned (*homogeneous* and *heterogeneous* costs), and the agents that are



(a) Number of participants (b) Social welfare

Fig. 1. Average number of participants and social welfare per round over 20 experiments over 50 rounds with high competition.

bidding on the jobs (*low* and *high* competition). For each of the four scenarios, we conduct 20 experiments with 50 rounds, 50 agents and 250 jobs.

We observe that in the low competition case the average number of participants does not differ much between the different cost cases and allocation algorithms over the rounds. This is due to a limited number of bids, resulting in similar allocations regardless of allocation algorithm. Similarly, the average social welfare over the 20 experiments is not very different between the different cases with low competition. In the high competition case, however, the average number of participants when using the fair algorithm is substantially higher than when using the minimum-cost algorithm as the rounds progress (see Fig. 1a). This is due to the jobs being allocated more evenly among agents, which results in higher participation probabilities over all rounds. The social welfare is also substantially higher for the fair algorithm as rounds proceed, and even seems to be stagnant (see Fig. 1b). This is due to the larger number of participants still present, which enables more bids for the algorithm to choose from. The stagnancy stems from the nature of the problem, where it is the maximum social welfare for the problem setting. For the *H/het* scenario, the fair allocation obtains a lower social welfare in the earlier rounds compared to the minimum-cost allocation, but eventually surpasses it, due to the larger number of participants still present.

Allocation algorithms that take into account the participants' behaviors are especially of importance in settings like the sharing economy, which is upcoming in the past years, in which participants share their idle resources and anyone is free to enter and leave as they wish. Therefore, it is important to encourage their participation and to yield an overall higher social welfare, which can be accomplished by ensuring some portion of the market share to the players.

References

1. Q. C. Ye and Y. Zhang, *Participation Behavior and Social Welfare in Repeated Task Allocations*, IEEE International Conference on Agents, pp. 94–97, 2016.