Exercise 5: An Auctioning Agent for the Pickup and Delivery Problem

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1 Bidding strategy

Because we don't have information about other agents at the beginning, so in the first auction round, we just use the marginal cost of our agent to decide the bidding, and we also want to acquire the first task to convenient our following biddings. The minimum cost of delivering a task is picking up the task at the pickup city of this task which we denoted as $taskCost$. Above all, our first bidding is

$$max(marginalCost, taskCost * 0.8) \tag{1}$$

When we get the bidding result of the first round, we can use the bidding of the opponent agent to estimate the home cities of vehicles owned by this opponent agent. That is we compute the cost of delivering the first task starting from every city, we choose the starting city corresponding to the closest cost to bidding as one home city of the opponent agent, and we also add some random home cities to the opponent agent.

After the first round, we can get the number of opponent agents and some information (home cities) about them. In the following rounds, we use this information to estimate the marginal costs of opponent agents. When we need to bid for a task, we compute the marginal cost of our agent denoted as $myMarginalCost$, and the marginal cost of the opponent agent denoted as $opMarginalCost$, besides, we also use two ratios, $myRatio$ and $opRatio$, which is between 0.8 and 1.5, to adjust biddings. Our bidding for the task is mainly decided by following formula

$$max(myRatio * myMarginalCost, opRatio * opMarginalCost) \tag{2}$$

Another mechanism to decide our bidding is that we don't want to have negative profits finally, so our bidding of this round can't be too low. And we want to get more tasks at the beginning rounds to convenient following bidding, so we multiply our bidding with a ratio, which is increasing with the auction goes on but smaller than 1, to make our final bidding a little smaller. Sometimes, The delivery of a task doesn't need more cost, that is the marginal cost is 0. But we don't want to delivery this task freely, we use the $taskCost$ which is defined above as our bidding.

When we get the result of this round, if the opponent bidding, $opBidding$, is bigger than its marginal cost $opMarginalCost$, we increase its ratio $opRatio$ for our underestimation of the opponent marginal cost, otherwise, we decrease the ratio. The way to adjust the ratio of our agent is that if the winner of this round is our agent, we increase $myRatio$, otherwise we decrease $myRatio$. That is

$$\begin{cases} opBidding > opMarginalCost, thenincreaseopRatio \\ opBidding < opMarginalCost, thendecreaseopRatio \end{cases} \tag{3}$$

$$\begin{cases} winner = \quad myAgent, thenincreasemyRatio \\ winner = \quad opAgent, thendecreaseopRatio \end{cases} \tag{4}$$

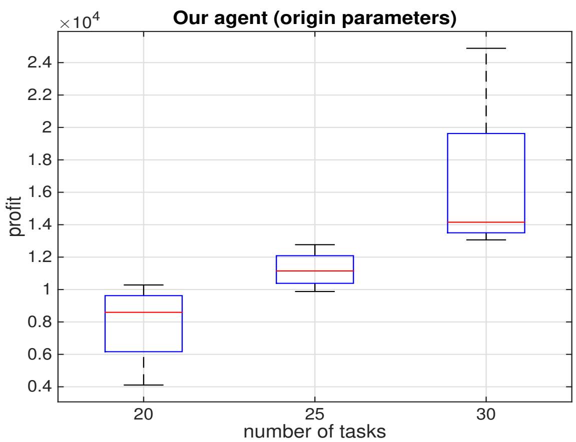
And if the bidding of an opponent is much smaller than our estimation, that means our information of this opponent maybe wrong. To refine our guess of this opponent agent, we add the pickup city of previous task into the home cities of the opponent agent.

Because we don't know how many tasks will be in this auction, if the number of task is very small, their probability distribution won't be very useful, and we also don't know the exact information of opponent agents, so we can't make full use of the probability. Above all, we don't use much knowledge of the probability distribution to decide our bidding, we just want to win more tasks at the beginning in order to get more chances of delivery following tasks without more cost, so we can get get more profits from these tasks.

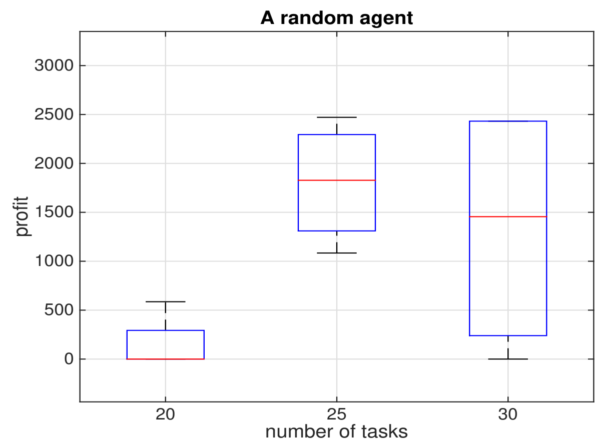
2 Results

2.1 Experiment 1: Comparisons with dummy agents

In this experiment we evaluate how our results vary when the number of tasks changes. In this experiment, we compare our agent's performance with that of provided dummy agent (random). We then compare performances of different version of our agents (different parameters) in next experiment.



(a) Profit of our agent



(b) Profit of a random agent

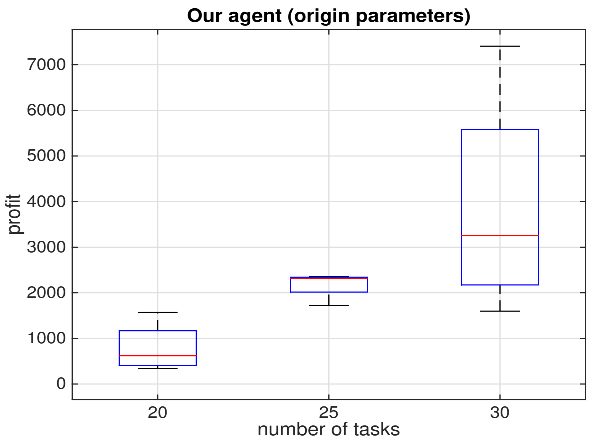
2.1.1 Setting and Observations

Above two box-plots compare profits of our agent and a random agent. We get the box-plots via repeating each experiment for 4 times. We can see that as the number of tasks increasing, the total profits of both agents go up, but we cannot make an definite conclusion as the profit of each task varies significantly. It can be observed that our agent outperforms the random agent significantly in all cases. This result meets our expectations as the dummy agent bids randomly, however, our agent can adjust itself based on opponent's bid, hence it is reasonable for our agent outplays the random one.

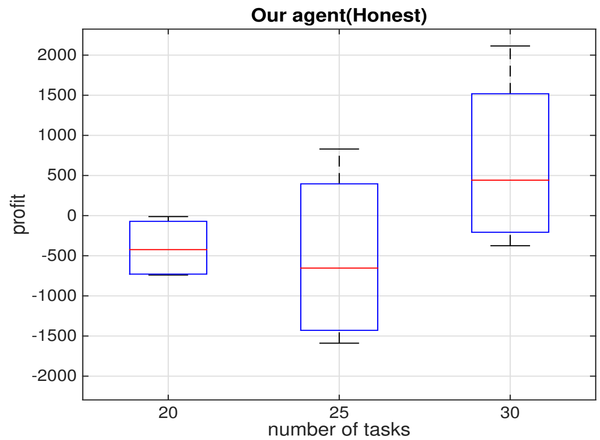
2.2 Experiment 2: Evaluating parameters

2.2.1 Setting and Observations

Next, we evaluate how internal parameters can impact the agents' performance. We firstly adjust our agent to be an honest agent, i.e., it always bid according to its true marginal cost for a task. We firstly observe that the profits increase along with the growth of number of tasks but again, we cannot make a



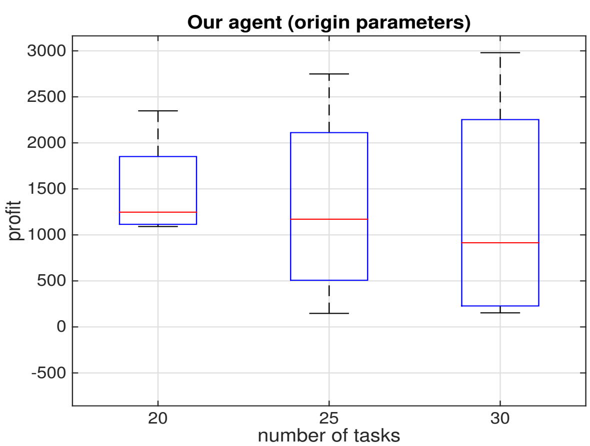
(a) Profit of our agent



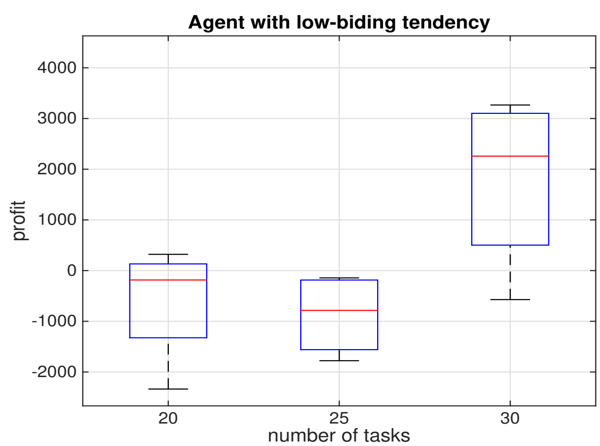
(b) Profit of a honest agent

definite conclusion due to the distribution of task rewards. However, we see that the absolute profits in both cases are much smaller that in Experiment 1, because now the real competition exits. The honest agent is outperformed by the agent with default parameters. Hence, we can conclude that our biding strategy introduces positive impacts.

Following figures show performance comparison between the original agent and the agent with a low-biding trend, meaning that this agent tends to bid relatively smaller than its marginal cost and also than the agent with original parameters. We see that in this case when the number of tasks is small, the original agent outperforms the low-biding one. However, we can see that when the number of tasks is large, the low-biding agent wins. We can interpret this result as follows: as the price is low, it is possible that the low-biding agent can get more tasks in the starting rounds. Hence, this agent can bid with a lower price than other agents since it can piggyback more tasks when going along same paths with same cost, resulting in high profits.



(a) Profit of our agent



(b) Profit of a low-bid tending agent