Assignment 5: Sponsored Search Auctions

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1. Designing a Bidding Agent

The balanced budged bidding agent is found in pjl14bb.py

2. Experimental Analysis

a. 5 truthful agents:

```
./auction.py --perms 1 --seed 2 --iters 200 Truthful,5
```

Average utility of truthful agents ~ $350.

5 balanced bidding agents:

```
./auction.py --perms 1 --seed 2 --iters 200 Pjl14bb,5
```

Average utility of balanced bidding agents ~ $700.

The average utility of the pool of balanced bidding agents is higher than the average utility of the pool of truthful agents. This is expected because each of the balanced bidding agents will bid lower than their true values, which increases the revenues for each agent as compared to agents that bid right at their true values.

b. 4 truthful agents, 1 balanced bidding agent:

```
./auction.py --perms 10 --seed 2 --iters 200 Truthful,4 Pjl14bb,1
```

Average utility of 4 truthful agents ~ $400
Average utility of 1 balanced bidding agent ~ $600

1 truthful agent, 4 balanced bidding agents:

```
./auction.py --perms 10 --seed 2 --iters 200 Truthful,1 Pjl14bb,4
```

Average utility of 1 truthful agent ~ $700
Average utility of 4 balanced bidding agents ~ $675

With 4 truthful agents and 1 balanced bidding agents, the average utility of the truthful agents benefits slightly due to the lower bid of the balanced bidding agent in the pool. The average utility of the balanced bidding agent is still higher than the average utility of the truthful agents. With 4 balanced bidding agents and 1 truthful agent, the average utility of the truthful agent benefits from the other agents reporting lower values. The average utility of the balanced bidding agents is close to the average utility of the truthful agent as they report lower values to increase their expected utility. The incentive to follow the balanced bidding strategy is higher than the incentive to follow the truthful strategy as shown in this exercise.

3. Auction Design and Reserve Prices

a. The VCG auction code is found in vcg.py

b. GSP, no reserve price, all 5 agents balanced bidding:

```
./auction.py --perms 1 --seed 2 --iters 200 --reserve 0 --mech gsp Pjl14bb,5
```

Average daily revenue ~ $4300

The average daily revenue increases as the reserve price goes from 0 to 60, and decreases after 60 until the revenue is zero. Therefore the revenue optimal reserve price is 60, which generates an average daily revenue of about $5000.

c. VCG, no reserve price, all 5 agents truthful bidding:

```
./auction.py --perms 1 --seed 2 --iters 200 --reserve 0 --mech vcg Truthful,5
```

Average daily revenue ~ $4200

The average daily revenue increases as the reserve price goes from 0 to 85, and decreases after 85 until the revenue is zero. Therefore the revenue optimal reserve price is 85, which generates an average daily revenue of about $5200.

The revenue optimal reserve price of the VCG auction is higher than that of the GSP auction. In the GSP auction, a bidder above the reserve price pays the reserve price rather than any price below the reserve price for a potential payment, which increases revenue. In the VCG auction, a bidder above the reserve price pays a product of the reserve price and number of clicks, and bidders getting slots below the first price lower the payment, and so the revenue optimal price for the VCG mechanism is lower than that for the GSP mechanism. This result is what was expected.

d. Reserve price 0, switch from GSP to VCG – balanced bidding agents run GSP until round 24, and then switch to VCG.

```
./auction.py --perms 1 --seed 2 --iters 200 --reserve 0 --mech switch Pjl14bb,5
```

Average daily revenue ~ $3800

Switching from GSP to VCG produces a lower average daily revenue than continually using the GSP or VCG mechanisms. There is a short-term revenue loss when switching that can't be immediately made up because the VCG prices are lower than the GSP prices in the short term and bidders haven't had the time to adjust their bids to the change.

e. This assignment taught us that balanced bidding is advantageous strategy for bidding over truthful bidding, especially if the majority of agents in an auction are balanced bidding. GSP and VCG mechanisms each have their own strengths and weaknesses, as both are used in real world ad auctions. While bidders try and maximize their expected utility and employ balanced bidding strategies that bid below their values, companies that run the ad auctions try and choose designs that maximize their expected revenue from the auctions. The VCG auction when bidders are truthful has a similar expected revenue to the GSP auction when bidders employ a balanced bidding strategy, which could explain why companies could use the GSP mechanism for their ad auctions if bidders report under their true values, while VCG mechanisms could be used when bidders have an incentive to report their true values. Many companies currently use the GSP mechanism, but are unwilling to switch to the VCG mechanism due to short term loss in revenue.

4. Budget Constraints

a. The budget-constrained auction agent code is found in pjl14budget.py

b. The agent designed started from the balanced bidding agent. Changes were made to the bid function in order to try and account for the budget constraints. In a setting competing with other agents, it could be important to conserve budget during peak hours (at the edges of the 48 periods) when there is a lot of traffic and competition for slots from other agents. The agent thus bids conservatively during these hours as to try and avoid exhausting the budget when other agents drive up the prices. The agent targets slots that would maximize expected utility during non-peak hours in the middle of the 48 periods, and bids normally according to the balanced budget strategy during these hours. The idea is to use the budget in a way to ensure that there would be some users that would see the ads, even at less ideal times, and hedge on the peak periods in favor of ensuring that we can have an adequate budget to bid comfortably to maximize utility in other less competitive periods.