Vicious Strategies for Vickrey Auctions

Felix Brandt[*]
Institut für Informatik
Technische Universität München
D-80290 München, Germany
brandtf@in.tum.de

Gerhard Weiß
Institut für Informatik
Technische Universität München
D-80290 München, Germany
weissg@in.tum.de

ABSTRACT

We show that the Vickrey auction, despite its theoretical benefits, is inappropriate if "antisocial" agents participate in the auction process. More specifically, an antisocial attitude for economic agents that makes *reducing the profit of competitors* their main goal besides maximizing their own profit is introduced. Under this novel condition, agents need to deviate from the dominant truth-telling strategy. This paper presents a strategy for bidders in repeated Vickrey auctions who are intending to inflict losses to fellow agents in order to be more successful, not in absolute measures, but relatively to the group of bidders.

1. INTRODUCTION

Two key problems to be addressed in the area of multiagent systems are automated resource allocation and task assignment among the individual agents. As a solution to these problems it has become common practice to apply well known results and insights from auction theory and well understood auction protocols like the English auction, the Dutch auction, and the Vickrey auction. Among the different protocols, the Vickrey auction [3] (also known as second-price sealed-bid auction) has received particular attention within the multiagent community and has been applied in a variety of contexts like e-commerce, operating systems, and computer networks. The Vickrey auction is favored because it requires low bandwidth and time consumption and because it possesses a dominant strategy, namely, to bid one's true valuation [3, 1]. These characteristics make the Vickrey auction protocol particularly appealing from the point of view of automation. The reverse Vickrey auction, as it is used for *task assignment scenarios* works as follows: each bidder willing to execute a task makes a sealed bid expressing the amount he wants to be payed for task execution, and the bidder submitting the lowest bid wins the auction; the winner receives an amount equaling the second lowest bid (and his payoff thus is the second lowest bid minus his prime costs for execution). If there is more than one winning bid, the winner is picked randomly. This paper deals with the reverse Vickrey auction; it should be noted, however, that all presented considerations and results do also hold for Vickrey auctioning in its original formulation.

[*]The primary author of this paper is a PhD student.

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2. ANTISOCIAL BIDDING AGENTS

In most multiagent applications it is assumed that the objective of an agent (or of a team of agents) is to maximize his absolute profit without caring for the profits made by the other agents. However, in many real-world applications it is more realistic to assume that agents may be present that try to gain as much money as possible *relative* to others (their competitors). In fact, it is real-world practice that a company accepts a lower profit or is even willing to sell goods at a loss if this financially damages a competing company or at least helps to bind available and gain new costumers. In other words, in many scenarios it is wise to take into consideration the availability of "antisocial agents," that is, agents who accept small losses if they can inflict great losses to other agents. To make this more precise, we develop a formal description of this antisocial attitude. As a starting point for this formalization, it appears to be reasonable to assume that an antisocial agent wants to maximize the difference between his profit and the gain of his competitors; this means that the own profit on the one hand and the other agents' losses on the other hand are considered to be of equal importance from the point of view of this antisocial agent. In a two-player scenario, this view captures the antisocial agent's intention to be better than his rival. To achieve a higher degree of flexibility in describing and analyzing antisocial agents, it is useful to think of different degrees of anti-sociality like "aggressive anti-sociality" (where it is an agent's objective to harm competitors at any cost) and "moderate anti-sociality" (where an agent puts somewhat more emphasis on his own profit rather than the loss of other agents). These considerations lead to our formal specification of an antisocial agent (or an agent's antisocial attitude) as an agent who tries to maximize the weighted difference of his own profit and the profit of his competitors. Precisely, an antisocial agent i intends to maximize his *payoff*[1] that is given by

$$payoff_i = \quad (1-d_i)profit_i \quad - \quad d_i \sum_{j \neq i} profit_j \quad , \qquad (1)$$

[1]The payoff for a non-antisocial agent is simply his profit.

where $d_i \in [0,1]$ is a parameter called *derogation rate*. The derogation rate formally captures, and allows to modify, an agent's degree of antisocial behavior. It is obvious that this formula covers "regular" agents by setting $d = 0$. If d is higher than 0.5, hurting others has greater priority than helping yourself. A purely destructive agent is defined by $d = 1$. We say an agent is *balanced antisocial* if $d = 0.5$, e.g., his own profit and the profit of his competitors are of equal importance.
The implications of this formalized notion of an antisocial attitude on the Vickrey auction is enormous. In fact, the dominant strategy (to bid one's private value v) has to be replaced by a strategy that fulfills weaker equilibria. Suppose an antisocial agent i knows the two lowest private values v_1 and v_2 (one of them possibly being his own). A very effective bidding strategy for this agent is to bid

$$b_i = \begin{cases} v_i - d_i(v_i - v_1) + \epsilon & \text{if } v_i > v_1 \\ v_i + d_i(v_2 - v_i) & \text{else} \end{cases}. \qquad (2)$$

This strategy is in *Maximin equilibrium* for arbitrary antisocial agents, i.e. it is an optimal strategy to reduce the possible losses that occur in worst case encounters. If only balanced antisocial bidders participate in the auction process, the strategy is even in *Nash equilibrium*. In other words, if all agents apply this strategy, there is no reason for a single agent to deviate from it (see [1] for proofs of these theorems).

Obviously, in the general case, an agent does not know the private value of other bidders. However, in principle an agent has several possibilities to figure out that value, for instance by means of *espionage*, careful *estimation*, *bribing* the auctioneer or by *learning* from previous auctions.
This paper deals with the latter technique. We consider the auctioning of a fixed number of tasks, that repeats for several rounds. Now, suppose an antisocial agent loses an auction in the first round. When the same task is auctioned in subsequent auctions, he reduces his bid from round to round by a small margin s until he is awarded the contract and receives the amount p which he assumes to be the lowest private value v_1. Figure 1 displays the modified strategy. The algorithm works somewhat stable in dynamic environments where agents can vanish and new ones appear from time to time. If the step size s equals the private value ($s = v$), this algorithm emulates an aggressive, but dangerous strategy that uses zero-bids to figure out v_1. Generally, a careful agent should use a small step size s in order to be safe that the competitor already suffered huge losses before he makes negative profit himself. A reasonable setting of s depends on the number of rounds, the distribution of private values and his derogation rate (an upper bound for s is specified in [1]).
If the task execution contracts are not binding and can be breached by paying a penalty (leveled commitment contracting), the unavoidable loss an agent produces by underbidding the cheapest competitor can be reduced by breaking the negative contract. Due to the fact that the only reason for closing that deal is to figure out the private value of another agent, the agent has no incentive to really accomplish the task. Therefore, a contractee should break the contract if the loss he makes by accepting the contract is greater than the penalty he pays by breaking the deal. Supposing the common definition of a penalty as a fraction of the contract value, agent i is better off breaching the contract if $p \leq \frac{v_i}{pr+1}$ with p being the actual task price and $pr \in [0;1]$ the penalty rate.

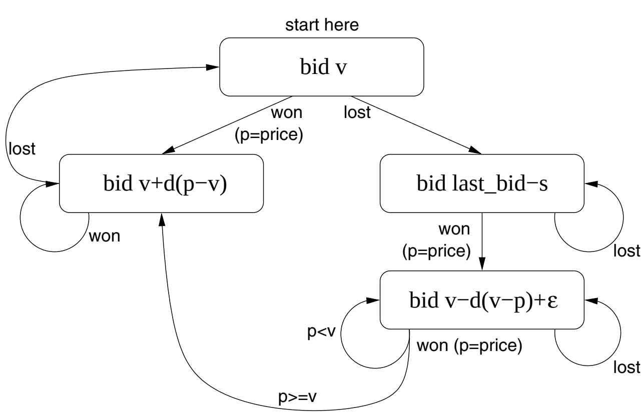

Figure 1: Antisocial strategy for repeated auctions

3. CONCLUSIONS

The antisocial attitude for agents and its formalization introduced in this paper leads to a significant need for important changes in strategic behavior of agents. As argued above, and as it is obviously implied by many real-world applications, it is necessary to take the existence of antisocial agents into consideration. The paper focused on the Vickrey auction and showed that this auction protocol, in addition to other known deficiencies [2], is vulnerable to antisocial bidders. This is an effect of the second-price policy which enables easy price manipulation. As the common *English* auction for private value bidders is equivalent to the Vickrey auction, all strategies in this paper work for English auctions as well. The inability to prevent profit reduction can be regarded as a major disadvantage of those two auction types as *Dutch* and *first-price sealed-bid* auctions do not suffer from antisocial strategies.
One problem that arises using the new strategy in repeated Vickrey auctions is that if there is more than one inferior, antisocial agent, only the one that intends to cut off the cheapest agent's profit by the highest margin should reduce his bid. All other bidders should stay with bidding their private value, since they would lose money once without harming anyone in the following rounds.
The behavior described in this paper can be seen as an opposite of *bidder collusion* where bidders coordinate their bids in order to help each other. In contrast, antisocial agents bid with the intention to harm others.

4. REFERENCES

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