Agent-based simulation model of online auctions in NetLogo

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Abstract. *The need to understand the behavior of bidders increases with the popularization of online auctions. Every bidder is seeking the way to buy items as cheap as possible, but then again all participants in the process should be satisfied. But there are bidders who participate in auctions and wait until the very last moment to submit their bids, not allowing others to react (properly) to their bids. So sometimes one doesn't get some items because somebody offered less than 0.5% more money for the same item. For that reason we decided to simulate online auction(s) in order to see what would happen if, after the regular (English) auction was over, agents had an opportunity to offer within another (sealed-bid) auction. This would ensure that seller agents receive more money, but it would also allow (early) bidders to react to "late submissions" in order to buy items after all.*

Keywords. multiagent, auctions, simulation, NetLogo

1 Introduction

An agent is a computer system that is situated in some environment and that is capable of autonomous action in this environment in order to meet its design objectives; intelligent agent is autonomous, reactive, proactive and capable to communicate with other agents [1].

Because agents possess certain properties, they can be used to solve some problems that may seem complex at first. As is described in [2], there are many different fields in MASs for solving different kinds of problems as internet-based commerce, Internet agents (assistants) who have been designed in order to collect and filter information from the network, prototyping of new software products, and many others. Agents can be used for simulating auctions, and in this paper we will put accent on one specific aspect of English auctions.

Online auctions are a popular and effective medium for procuring goods and services in both business to business and business to consumer electronic commerce. Some of the well-known auction houses include eBay, Amazon.com, Yahoo!Auction, Priceline, UBid and many others. These auction houses conduct many different types of auctions, but the most popular ones are English, Dutch, first-price sealed-bid and second-price sealed-bid (also known as Vickrey) auctions.

There are many papers on multiagent systems and auctions, and many different aspects of trading are examined. In [3] authors examine some other attributes (beside price) that may be interested in auctions as well. Some auctions enable buyers to bid on combination of items [4]. Some authors also explore false bids. There are papers that explore optimal strategies that agents could use. There is some research on multiple auction sites, etc. Although some papers are interesting, one can say that some proposed architectures and models are quite complex.

The problem that we find interesting is how to ensure a fair competition with bidders who only participate in (literally) last seconds of the auction, thus reducing the chance for others to respond to changed prices properly.

The rest of the paper is described as follows: in the next part the problem is described. Further on the model is described, then some simulation results are presented, and finally, the conclusion is given.

2 Problem description

According to [5], there are two types of auction agents: early bidders, who can bid any time during the auction, and snipers, who wait (until the end of auction, usually last few seconds) in order to bid. Although we want to bid in auctions in order to buy some item, and because snipers usually bid within the last few seconds, we are unable to react to price changes. During the analysis of the most popular online auction site preliminary research has revealed that this happens very often; further on, we have found out that the price (in the last few minutes) increases up to 15%.

In an English auction, the auctioneer begins with the lowest (acceptable) price and bidders are free to raise their bids successively until there are no more offers to raise the bid, or until the end of the auction is reached. The winner is the bidder with the highest bid.

To deal with the mentioned problem, we decided to build a simulation model that attempts to bridge the difference between the early bidders and snipers. The idea is, after the English auction is over, to start another sealed-bid auction in which only bidders who had raised the price of some item in the last minute of English auction can participate.

For the purpose of this paper we focus on the last minute of the English type auction in order to determine snipers and the price, and then we start a new sealed-bid auction. In particular, we describe the model of English auction with time limit as the main auction, and the second sealed-bid auction (as a postponed auction). In sealed-bid auctions every participant gives the sealed-bid (known only to him and auctioneer) to the auctioneer. Auctioneer then decides who offered the highest bid, and determines whose won the item.

3 System description and implementation

We consider the auction in which the auctioneer determines which items are being sold to one of n bidders (see Figure 1) who submit their bids over time to auctioneer. A bidder can send more than one bid during the auction. After the auction, auctioneer awards the item to the bidder that placed the highest bid. If there was more than one bid within the last minute, auctioneer would start another auction where each bidder (that placed the bid within the last minute) has only one (additional) opportunity to place the highest sealed-bid. Hereby, we find two things interesting:

1. Early bidders have the opportunity to win the item
2. Sellers can earn more money

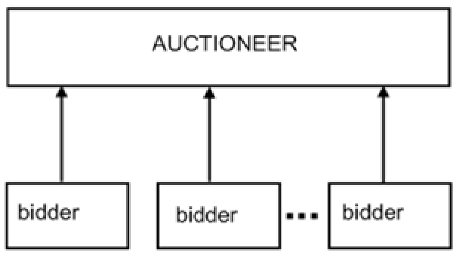

Figure 1: Auctioneer and bidders

Figure 2 shows the interaction between bidders, auctioneer and items. At any point of time a bidder can find out the price for the item that is being offered. Each bidder receives (regularly) information relevant for some ongoing auctions, and can submit bids if the conditions are satisfied (bidder has to be motivated, has to have enough money, etc.).

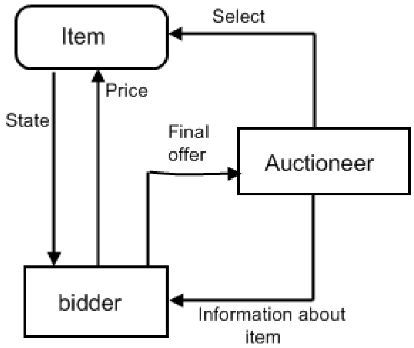

Figure 2: Interaction between bidders, auctioneer and item

For implementation purposes of the simulation model we used three types of agents: bidders, auctioneer, and items. Item agents have to generate the price for certain items with respect to the given parameters. One task of the auctioneer (Figure 2) is to select the item that was not sold yet, and place it to the auction.

```
to put_item_on_auction
        if (exists (available items) and not exists(item on auction))
        set an item to auction end if
    if (exists (item on auction))
        auction takes place
    else
        auction has finished
    end if
end
```

Another task of the auctioneer is to receive offers from bidders, to evaluate them, and send feedback to all bidders. Further on, after the English auction is over, the auctioneer starts another, sealed-bid auction:

```
to sealed_auction
    determine the bidders who can participate in this auction from the list of active bidders
    for (each customer who participates in this auction)
        if (customer did not abandon the offer) bidder bids his last offer end if
    end for
    determine the bidder with the highest offer
    set item variables
        item bidder = bidder_with_highest_offer
        item price = highest price offered
        item is ready for sale
end
```

There are several parameters important for each buyer: money (how much is a buyer ready to pay for some item), money wallet (money in the wallet), motivation factor, and probability for buying the item. The most important parameter is money:

$$Money = P_S + random(P_S * F_R * M) \qquad (1)$$

P_S is the price of the item one minute before the end of the auction. Price rise factor (F_R) represents percentage growth rate in the last minute of the auction (obtained within the analysis mentioned before).

The motivation of bidders to buy some items is represented by the motivation factor M. If the bidder buys the item, his motivation factor decreases 3%, whereas other bidders increase their motivation according to the following formula; PF and PR represent final and real price. The final item price is the price achieved in auction, and the real price is the item price on the free market:

$$M = M + (0,03 * (1 - \frac{P_F}{P_R})) \qquad (2)$$

4 Simulation results

In the next part of the paper simulation results are presented.

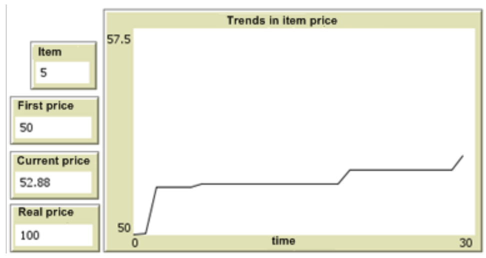

Figure 3: Trends in item prices during one English auction

An example with fluctuation of price (in English auction) is shown in Figure 3; one can see that price rises until the very end of auction. 60 seconds (30 units) before the end (x-axis) of current auction the price was 50 units (y-axis), and over the last minute has grown up to 52,88 units (an increase of 5,7 percent).

Figure 4 shows the number of successfully purchased items (for each of 13 bidders) within the regular (English) auction (left column), and the auction that took place after the regular auction (right column). The x axis represents the bidders, and y axis represents the number of items that bidders bought. We can see that (within additional sealed-bid auction) some agents lost some already bought items, and some agents managed to buy even more items than in regular auction. For example, if there was only one (English) auction, agent 1 would buy 10 items (left column), but with this new sealed-bid auction agent 1 managed to buy only 8 items (right column).

Figure 4: Histogram of buying items before and after the regular auction

Figure 5 shows how the price for one item changed within 30 auctions. Histogram in Figure 5 shows the number of bidders competing for some item in each simulation (the number of bidder was between 1 and 8). Lower line shows the prices achieved within the regular (English) auction, while the upper line shows the price achieved within the additional (sealed-bid) auction. In 30 auctions the price for the single item increased about 5.4%.

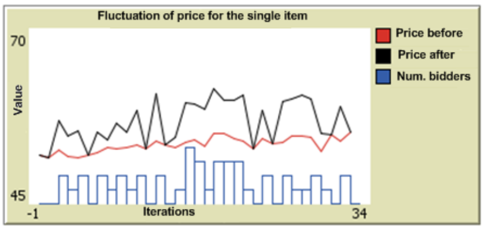

Figure 5: Fluctuation of price for the single item within 30 auctions

5 Conclusion

We believe that agent-based simulations can be an important tool for understanding the complex phenomena in such auctions where bidders get a fair chance to win the item. In this paper we simulated a popular style online auction (English auction) with fixed duration, where bidders can bid more than once. After the regular auction was ended, auctioneer would start (if there was a need) another sealed-bid auction with bidders who had put their bid within the last minute of the regular auction. Preliminary results show that items were sold at a higher price (more than 5 % on average), and that early bidders had the opportunity to win the item as well. In future research we could endow agents with some knowledge on sealed-bid auctions and implement certain strategies as well.

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