Proc. Fourth International Conference on Semantics, Knowledge and Grid, SKG 2008
Beijing, China, December 3-5, 2008, pp. 355-358.

A Study on Diverse Scholar Agents Participating in the Second Price Sealed Bid Citation Auction

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***Abstract*— An objective of this paper is to study how agents in *citation auctions* behave in terms of their strategies as well as how their perceptions of the Internal Private Values IPVs) impacts those strategies. These issues are studied using several auction mechanisms, such as the Second Price Sealed Bid (SPSB) auction, the Generalized Vickrey Auction (GVA), and the Uniform Price Sealed Bid (UPSB) auction. Using experiments, each auction mechanism is analyzed and its performance in citation auction measured to find their fitness for citation auctions. The results show that optimistic agents perform well in balanced populations of scholar agents biding in a single market. It is also studied how *scholar agents* decide in which market to bid, given the competing population of scholars with agents in multiple markets. Finally, the need for a global recommender to help agents to decide how to behave when participating in a single market is evaluated.**

I. INTRODUCTION

For many years, both the scientific community and the volume of the scientific work have been steadily growing. These growth is unstoppable, because publications became the key measure of research evaluation as well as a conduit of research benefits to the society. However, the space for publications in established venues is growing at much lower pace, creating ever deepening scarcity of reputable outlets for huge number of candidate works. That is why the scientific community uses peer review for their selection which suppose to ensure the quality and suitability of the selected works for publication. In addition to several other major problems with peer-review, perhaps the authors' most common complaint is that it is painfully slow and skewed: it typically takes several months (sometimes years) from the submission to the paper's publication, sometimes with delays caused by disputes with unacceptable reviews. On the other hand, the publications most common complaint is that this process is costly: it is hard to find highly qualified and available reviewers for selecting papers. The *citation auction* is a publication selection method alternative to the peer-review. It makes selection automatically (i.e., without human evaluation of submissions) and it is also very fast [1].

The objective of this paper is to study how agents in citation auctions behave in terms of their strategies as well as their perceptions of the Internal Private Values (IPVs). This is studied using the Second Price Sealed Price (SPSB) auction that is well suited for citation auctions [1], the Uniform Price Sealed Bid (UPSB) auction [2], as suggested in [3], and also the Generalized Vickery Auction (VGA), discussed in [13]. The paper starts with the discussion how scholar agents may prefer one market over another in view of competition in both. Then, the need for a global recommender helping agents to decide how to bid depending on competition from other agents in the given market is evaluated.

A Scholar Agent envisioned in [4] has its first architecture implemented in Alpha Release 1 that uses c*itations* ¢ as an auction currency [5] to make explicit the internal private value that authors assign to the quality of their submission. The higher the bid, the more likely the paper will be selected for publication. If the bid correctly predicts the paper's quality, the authors will earn extra citations compared to those that they expended for the price exacted by the win; otherwise they will lose their money (in citations ¢).

We envision that scientists will delegate bidding to their agents who will work on their behalves. The agents will tailor their bids in accordance to budget restrictions set up by the scientists. For rational scientists, the budget will be related to the IPV assigned to the work submitted for publication [4]. The *Scholar Agents* aim to help the scientists to estimate the value of their papers by exploring target audiences as well as *the competition* for publication, as further discussed in the paper. Additionally, scientists can select the level of risk that they are willing to accept in the bidding by setting up the proper type of agents' behavior. As discussed in [1], citation auctions behave better than other approaches for automatic publication selection.

This paper is organized as follows. Section 2 introduces the experiments with different types of agents and discusses how they perform in perfectly balanced markets. Section 3 discusses conditions under which scholar agents decide to move from one market to another. Section 4 analyzes how to encourage competition and balance populations to achieve a stable market. Finally, Section 5 provides the conclusions.

II. The Experiment

Nine types of agents are designed accordingly to the schema inspired by [10] and [11]. In terms of their internal private valuations (IPVs) agents are classified as Optimistic, Pessimistic, and Realistic, with the last one making its valuations in the middle of the first two. In terms of their bidding strategies, agents can be Aggressive, Defensive, or Neutral, again the latter bidding in between the first two. The classification of nine synthetic agents is shown in Table 1.

Table 1. The Nine synthetic agents Classified according to their IPVs and bidding strategies

Perception vs. Strategy	Neutral	Aggressive	Defensive
Optimistic	A1	A4	A7
Realistic	A2	A5	A8
Pessimistic	A3	A6	A9

Each agent makes a bid for publishing a paper with the same consensus value of ¢4 (four citations). Each type of agent is assigned a different perception of its own private value of its contribution, and a different target value for its bids. Hence each agent follows its own strategy. The values of their IPVs and bids in ¢ are shown in Table 2.

Table 2. The set up of IPV and target price for each type of agent

	Optimistic	Realistic	Pessimistic	Optimistic-Aggressive	Realistic-Aggressive	Pessimistic-Aggressive	Optimistic-Defensive	Realistic-Defensive	Pessimistic-Defensive
Target price	4	3	0.5	5	3	1	3	2	0
IPV	5	3	1	5	3	1	5	3	1
Consensus price	4	4	4	4	4	4	4	4	4
Agent Code	**A1**	**A2**	**A3**	**A4**	**A5**	**A6**	**A7**	**A8**	**A9**

Regarding the auctions mechanisms that we apply and compare here, SPSB applies only to auctions with a single unit of goods offered and therefore with one winner. This could be the case of a call for papers that accepts one unique paper out of a bunch of submissions.

If there are many homogeneous goods to be sold and each bidder can bid only for one good, the generalization of Second Price Sealed Bid - SPSB for this case is easy and it is Uniform Price Sealed Bid UPSB. This could be the case of a call for papers with several (uniform) slots though every scientist can submit only **one** paper. The price is calculated as the first non winning bid of bidders other than the winning agents.

If bidders can bid for many goods with different prices, the generalization of SPSB auction is called Generalized Vickrey Auction - GVA [13]. In GVA, each bidder pays for the won goods the prices that were bid for the goods that would go to the highest remaining bidders if that winner were not present in the auction. Selecting papers then becomes just selecting the highest bids and computing appropriate prices for them.

Experiments with behavior of the agents competing for publishing are conducted using the following three scenarios: (1) one accepted paper using the SPSB auction, (2) two accepted papers with the GVA auction, and (3) two accepted papers using the UPSB auction. Each experiment repeats a series of 20 auctions along with the three scenarios. These series are run twice to confirm results.

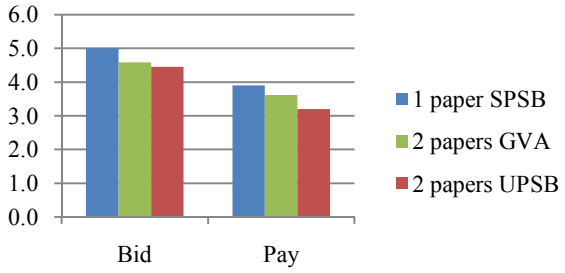
Tables 3, 4 and 5 show percentage of auctions in which agent participate (column "FB" in the tables), what are the average bids (column 'Bid') in every scenario, the average payment for the win (column 'Pay'), as well as the earnings of the agents (column 'Earn') that are equal to the average difference between the bid and the price paid. Finally, the expected earnings (column 'E(Earn)') are equal to the average difference between the IPV of every participating agent and the price paid for winning the publication. Table 3 also shows the earnings and expected earning regarding the payments, in percentage.

Experiments show that the winning bids and payments decrease when more papers are accepted, regardless of the mechanism.

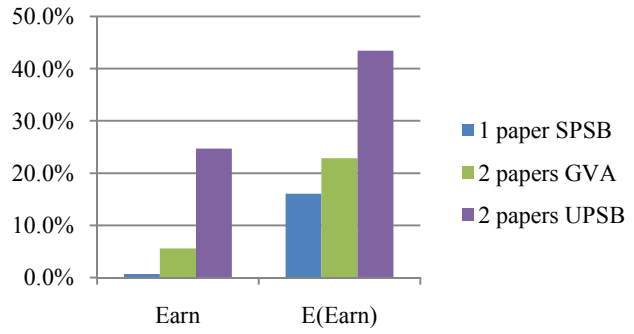
Regarding the agents' behavior of the agents, Tables 4, 5 and 6 show that agent A4, who is the optimistic-aggressive agent, ends up winning bids in any of the scenarios (column 'FB'). Yet, this is not necessarily good in terms of agents' earnings.

Table 3. Comparison between SPSB, GVA and UPSB Auction Results

	Bid	Pay	Earn	E(Earn)
1 paper SPSB	5,0	3,9	0,0	0,6
2 papers GVA	4,6	3,6	0,2	0,8
2 papers UPSB	4,5	3,2	0,8	1,4



Percentage regarding payments	Earn	E(Earn)
1 paper SPSB	0,6%	16,0%
2 papers GVA	5,6%	22,9%
2 papers UPSB	24,7%	43,4%



A. *Bidding*

Taking into account their perception of the IPV, the optimistic agents participate in 80% - 90% of auction rounds in all scenarios, while the realistic agents participate only in abuot the 5% - 8% rounds. The pessimistic agents are virtually out of any auction; they barely can win any auction and are almost outliers. This demonstrates that optimistic perception combines well with SPSB, GVA and UPSB auction mechanisms for winning bids, as long as sufficient resources (wallet) are backing up those bids. As [12] claims, those who aim higher perform better, though they are incurring a risk.

The surprising result is that earnings and expected earnings are better for optimistic agents, when enough citations are in their wallets, than for the other type of agents. We cannot make any conclusion regarding the strategy (aggressive vs. defensive) on the basis of currently collected results.

TABLE 4. PERFORMANCE OF AGENTS IN ONE PAPER ACCEPTED WITH SPSB

1paperSPSB	Agent	**FB**	BID	PAY	**Earn**	**E(Earn)**
Optimistic-Aggressive	A4	50,0%	5,9	4,0	0,0	1,0
Optimistic	A1	20,0%	4,3	3,9	0,1	1,1
Optimistic-Defensive	A7	10,0%	4,0	4,0	0,0	1,0
Realistic	A2	15,0%	4,0	3,9	0,1	-0,9
Realistic-Aggressive	A5	5,0%	4,0	4,1	-0,1	-1,1

B. *Earnings*

Agents earn little money in the one paper SPSB scenario, while they earn much more in any of the other two paper scenarios. In the two papers GVA scenario, the optimistic agents earned 0.17 citations on average, and realistic ones earned 0.38. In two papers UPSB scenario, the optimistic agents earned 0.7 citations while realistic ones 1.1. The differences between those averages are not large, so basically, it could be said that the two types of agents earned more or less similar amounts. Yet, the expectancy of earning was much higher among optimistic agents than among realistic once, but that effect was entirely expected. It is remarkable that the two papers GVA scenario is not yielding as much earning as the two paper UPSB scenarios. As a result, realistic agents outperform the optimistic ones in the former scenario. The justification for this conclusion is presented in Table 7 which shows wealth accumulated (accumulated earnings) by each type of agent under the different auction mechanisms.

TABLE 5. PERFORMANCE OF AGENTS IN TWO PAPERS ACCEPTED WITH GVA

2papersGVA	Agent	**FB**	BID	PAY	**Earn**	**E(Earn)**
Optimistic-Aggressive	A4	36,8%	5,2	3,9	0,1	1,1
Optimistic	A1	39,5%	5,3	3,8	0,2	1,2
Optimistic-Defensive	A7	7,9%	4,0	3,5	0,5	1,5
Realistic	A2	7,9%	4,0	4,0	0,3	-1,0
Realistic-Aggressive	A5	7,9%	4,0	4,0	0,5	-1,0

TABLE 6. PERFORMANCE OF AGENTS IN TWO PAPERS ACCEPTED WITH UPSB

2papersUPSB	Agent	**FB**	BID	PAY	**Earn**	**E(Earn)**
Optimistic-Aggressive	A4	32,5%	5,4	3,0	1,0	2,0
Optimistic	A1	45,0%	4,1	3,5	0,5	1,5
Optimistic-Defensive	A7	2,5%	4,0	3,0	1,0	2,0
Realistic	A2	12,5%	3,8	2,8	1,2	0,2
Realistic-Aggressive	A5	7,5%	4,0	3,0	1,0	0,0

TABLE 7. WEALTH BY TYPES OF AGENTS IN THE DIFFERENT SCENARIOS

Acc Wealth	1 paper SPSB	2 papers GVA	2 papers UPSB
Optimistic	0,67	5,7	22,8
Realistic	0,35	2,4	8,8

III. DECIDING IN WHICH MARKET TO BID

These experiments have been developed with a uniform distribution of types among agents. We introduced 3 optimistic, 3 pessimistic, and 3 realistic agents as well as 3 aggressive, 3 defensive, 3 neutral agents. This population mix of biding agents gives a lot of advantage to the optimistic agents, and, to much lesser degree, to the aggressive ones. Therefore, the knowledge about the competitors, especially about the types of competing agents in a market, is relevant. This kind of information allows agents to adapt their strategies to every market, by taking into account the distribution of

types of agents that reside (meaning bid) in a market. Therefore each agent must *be aware* of its own type and must monitor the distribution of agents in a market. Another important consideration is to predict how many citations are to be earned from that market from the publishing a good scientific work in the associated publication venue. Thus, optimistic agents should prefer markets with mostly pessimistic agents, because in such market very aggressive bidding wins auction without incurring high final payments. On the other hand, the pessimistic agents should go for markets with no optimistic agents, which are unfortunately also attractive for the optimistic agents. Hence, it is likely that the dynamic equilibrium is likely to develop with similar ratio of optimistic to pessimistic agents in all markets. Higher than average ratio in one market would motivate some of the optimistic agents to move out, decreasing this ratio, while the market with low ratio would attract additional optimistic agents, until its ratio would increase to the average.

From the single agent perspective, a simple thing that an agent can do is to look for markets with the highest expected earnings and lowest competition. Hence, the strategy of avoiding competition may work well. How such strategy may work is the subject of our future work.

IV. CONCLUSIONS

It is good for scholar agents to be optimistic in GVA, and even better in UPSB, when perfectly balanced populations with as many optimistic, realistic and pessimistic agents as possible create a good operating environment. UPSB simplifies the auction design, and enables agents to earn more with this one than with different auction mechanisms.

When having many markets in which they can participate, scholar agents have yet another decision to make which is to choose the market in which they will bid for publication. Acting in their self-interests, the agents will collectively balance the populations of the markets. Hence, the "invisible hand" of the markets will ensure stability of market population and the balance of the types of bidders participating in the auctions. On the other hand, markets will encourage competition by using auction mechanisms that help scholar agents earn the most from the auction as well as earn the most from their publications by widely disseminating the journal or proceedings and by ensuring the wide indexing of the published papers.

Finally, this is all about what [14] suggests to the scientific community: scientists must market better their research results. There would exist opportunities for introducing new marketing techniques, such as the citation recommenders [15, 16], so that papers that are recommended will earn increased income for their authors in terms of their citations ¢. This new approach may positively impact the scientific community by allowing the scientists to market better their papers.

ACKNOWLEDGEMENTS

This research was partially funded by the European Union project Nº 216746 PReservation Organizations using Tools in AGent Environments (PROTAGE), FP7-2007- ICT Challenge 4: Digital libraries and content as well as by the US National Science Foundation grant OISE-0334667 and the PR2007-0432 Salvador de Madariaga Grant.

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