Can Priced Options Solve the Exposure Problem in Sequential Auctions?

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The exposure problem appears whenever an agent with complementary valuations bids to acquire a bundle of items sold sequentially, in independent auctions. In this letter, we review a possible solution that can help solve this problem, which involves selling options for the items, instead of the items themselves. We provide a brief overview of the state of the art in this field and discuss, based on recent results presented in [Mous et. al. 2008], under which conditions using option mechanisms would be desirable for both buyers and sellers, by comparison to direct auctioning of the items. The paper concludes with a brief discussion of further research directions in this field.

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1. INTRODUCTION

Auctions are considered to be an important part of the growing electronic commerce, as they can efficiently allocate goods and resources between agents. An important practical issue in the deployment of auction mechanisms is that people may desire bundles of items, which in many real-life market settings are sold sequentially or in simultaneously ascending auctions. Whenever a buyer agent can obtain synergy between these items, he faces the exposure problem. The exposure problem has been studied before in, e.g. [Boutilier et al. 1999; Osepayshvili et al. 2005; Juda and Parkes 2006a; Robu and La Poutré 2007]. Informally, the problem occurs whenever an agent may buy a single item at a price higher than what it is worth to him, in the hope of obtaining extra value through synergy with another item, sold later. However, if he then fails to buy the second item at a profitable price, he ends up with a loss.

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The main way to address this problem in existing e-commerce literature is to replace sequential allocation with a one-shot mechanism that allows agents to bid on combinations of items. Combinatorial auctions have been very successful in both theory and practice [Cramton et al. 2006]. However, combinatorial mechanisms do have some limitations. The first of these limitations is computational: they typically require a central point of authority to receive all the bids and compute the optimal allocation. Even if the progress can be made on the computational winner determination problem (indeed, considerable progress has been made, e.g. in [Sandholm 2002], among others), many allocation problems occurring in practice are inherently decentralized and sequential. Different sellers may prefer, for a variety of reasons, to sell their items separately - or even through different markets, as the number of electronic auction sites online indicates. Furthermore, and perhaps more importantly, in many application settings, not all resources that are to be allocated are known in advance, but they appear dynamically over time. In this letter, we review results obtained by taking a different approach, which preserves the sequential, decentralized structure of the market, but involves auctioning *options* for the items, instead of the items themselves.

2. OPTIONS AS A SOLUTION: AN OVERVIEW

An option is a contract between the buyer and the seller of a item, where the buyer has the right to choose in the future whether or not he will purchase the item against the pre-agreed *exercise price*. The seller is then bound to sell the item at the demand of the buyer. Since the buyer gains a right, he has to pay the *option price* regardless of whether he will exercise the option or not.

Options help a synergy buyer with the exposure problem. He still has to pay the option price, but if he fails to complete his desired bundle, then he does not pay the exercise price as well, and thus he limits his loss. The risk of not winning subsequent auctions is partly transferred to the seller, who may miss out on the exercise price. However, the seller can benefit indirectly from additional synergy buyers participating in the market, who would have otherwise stayed out.

In existing literature, to our knowledge, there has been only limited work studying the use of options to reduce the exposure problem. The first work to introduce an explicit option-based mechanism for sequential-auction allocation of items to the MAS community is [Juda and Parkes 2006a; 2006b]. They create a market design with free (i.e., zero-priced) options, in which buyers place their bid through proxy agents provided by the mechanism. They show that, in this market design, truth-telling is a dominant strategy on the part of the buyers. The sellers are incentivised to use the proposed options mechanism by market entry effects. However, there may be cases when the market entry effects are not sufficient to motivate the sellers to offer options for free (due to the risk of remaining with their items unsold). In such cases, only positively-priced options can provide sufficient incentive for both sides to use the mechanism. Furthermore, the design proposed in [Juda and Parkes 2006a] may fail when several synergy buyers are active in the market simultaneously.

Priced options have a long history of study in finance (see [Hull 2003] for an overview). However, the option pricing models employed in financial markets usually depend on an underlying asset and assume its true value moves independently

of the local actions of individual agents (e.g. this motion is assumed to be Brownian for Black-Scholes models). This crucial assumption does not hold for the online, sequential auctions considered in most e-commerce literature. Another relevant work is [Gopal et al. 2005], which uses options to solve a related, but different problem of auctioning multiple copies of the same item. Options are also related to leveled commitment mechanisms [Sandholm and Lesser 2002]. In leveled commitment, however, both parties have the possibility to decommit from a contract by paying a penalty, which can create complex strategic reasoning problems - whereas in our model the right to exercise an option is bought by one party in advance.

3. AUCTIONING OPTIONS INSTEAD OF ITEMS

By comparison to the above approaches, our recent work [Mous et al. 2008] takes a slightly different approach. Rather than attempting to design a complex, custom-made mechanism, our goal is to investigate under which conditions selling options for the items would be more beneficial for both sides in a market (sellers and buyers), by comparison to a direct auction for the items.

An option is defined by two prices, so an adjustment needs to be made to the standard auction with bids of a single price. We consider a model in which buyers obtain the right to buy the item for a certain exercise price in the future. The value of such an option may be different for different market participants depending on their exposure risks. Therefore, we fix the exercise price and allow for a flexible, market-determined option price. The seller determines the exercise price of an option for the item he has for sale and then sells this option through a first-price auction. Buyers bid for the right to buy this option, i.e., they bid on the option price. The options considered are European style, as we assume the buyer(s) decide whether to exercise them after the sequence of auctions ends. Note that in this model, direct auctions appear as the particular case of fixing the exercise price at zero: such options would always be exercised, assuming free disposal.

Our approach and analysis can be characterized as decision-theoretic, meaning both buyer and seller reason with respect to expected future prices. In the mentioned paper [Mous et al. 2008], we take a two-step approach. First, we consider a setting in which n complementary-valued items are auctioned sequentially, assuming there is only one synergy buyer (the competition consists of local bidders desiring only one item). In such a direct, sequential auction, the buyer may bid less than his true value, due to the uncertainty of acquiring future items in his desired bundle. If, instead, options are sold for these items, the agent may bid an option price corresponding to a higher total amount (option + exercise price) than in a direct sale, because he does not have to pay the exercise prices if he fails to get the desired combination. However, the seller takes an exposure risk by auctioning options instead of items (that of not collecting the exercise price), and in order for him to have an incentive to offer options, he expects an increase in the bids he receives, greater than some minimum bound. For this restricted setting, we were able to show analytically that using priced options can increase the expected profit for both the synergy buyer and the seller, compared to auctioning the items directly. We were also able to derive analytically the equations for the minimum and maximum bounds between which the bids of the synergy buyer should fall, in

order for both sides to have an incentive to use options.

In the second part of the paper, we experimentally study market settings in which multiple synergy buyers are active simultaneously. In such settings, the problem of fixing the right exercise price becomes harder, because the seller has to maximize expected buyer participation, but at the same time reduce his own exposure. While some synergy buyers lose because of the additional competition, others may actually benefit, because sellers have an incentive to fix exercise prices at levels which encourage participation of more buyers.

4. CONCLUSION AND FUTURE DIRECTIONS OF WORK

To reply to the question posed in the title, while priced options do not always completely eliminate the exposure problem, they can significantly reduce it. The use of options instead of direct sale can increase the expected payoff from participating in a sequential-auction market for both buyers and sellers. This encourages market participation of buyers with complementarities who would otherwise stay out.

There are many aspects of options that could be investigated in further work. On the theoretical side, further work could compare decision-theoretic approaches (i.e., reasoning based on expected future prices) to more game-theoretic, equilibrium-based approaches to this problem. On the experimental side, it would be interesting to construct the simulation of a market in which sellers auction options for their items, but at exercise prices they are free to fix themselves. In such a setting, at least some of the benefits of using options could be achieved, yet without imposing the protocol on the sellers. Finally, the expected benefits of using options may increase if some of the agents participating in the market are risk averse. In this case, utilities of different agents for the same expected monetary payoff (profit/loss) are different, which can change the market dynamics (see [Robu and La Poutré 2007]).

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