An Experimental Comparison of Combinatorial Procurement Auctions

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The need for new procurement auction mechanisms that allow for rich bid types such as bundle bids on multiple items has been raised in many situations in industrial procurement. In addition to strategic problems, the design of these combinatorial auctions exhibits hard computational problems. For example, the winner determination typically leads to NP-hard allocation problems in combinatorial auctions. Recently, researchers have focused on pricing and information feedback in iterative combinatorial auctions. Several auction designs have been proposed in the literature using different types of ask prices, such as linear (i.e. item-level) or non-linear (i.e. bundle) ask prices. Although, there have already been a number of successful applications in the field, little is known about the bidding behavior in combinatorial procurement auctions.

Lab experiments are an excellent method to observe the human behavior in a controlled economic environment and they are an important complement to theoretical and computational models as well as field studies. In a set of lab experiments at the TU München in Spring 2007, we examined four different auction formats: the sealed-bid Vickrey-Clarke-Groves (VCG) auction and iterative Combinatorial Auctions (ICAs) such as iBundle, the Combinatorial Clock auction, and ALPSm. iBundle (Parkes and Ungar, 2000) uses non-anonymous and non-linear prices, calculates a provisional revenue maximizing allocation at the end of every round and increases the prices based on the bids of non-winning bidders. The Combinatorial Clock auction is based on linear and anonymous ask prices (Porter et al. 2003, Ausubel et al. 2006). In each round, the ask prices on all over demanded items were increased by a fixed minimum increment and the auction closes when no item is overdemanded. The fourth auction format was the ALPSm auction format, which also uses anonymous linear ask prices. However, instead of increasing the prices directly, the auction lets the bidders submit priced bids and calculates so called pseudo-dual ask prices (Bichler et al. 2007). The termination rule and the eligibility rules have been adapted.

Experimental analysis

In our experimental setting, we have used four different value models, two with three, one with six and one with nine items. Bidders were interested in up to 27 bundles depending on the number of auctioned items. We provided some level of bidder decision support. The bidders did not have to calculate their payoffs manually as the MarketDesigner platform allowed them to enter their valuations privately in the user interface and the system would calculates the payoff of each bundle in each auction round. The bidders can then rank the bundles based on payoffs. The main criteria in our analysis were allocative efficiency, revenue distribution, and speed of convergence.

Experimental results

Although bidder behavior was heterogeneous and did not follow a pure best-response strategy in any of the auction formats, we did achieve high levels of efficiency in all auction formats. We found significant differences in auctioneer‘s revenue, but there was no such difference across the different value models. We assume the main reason to be the bidder decision support that made it fairly easy for bidders to find out the profitable bundles and follow a particular strategy.

We found significant differences in the number of auction rounds. The number of auction rounds in ALPS and the CC was lowest. This has two reasons: First, eligibility rules forced bidders to bid on more than the demand set. Second, jump bids have been used in ALPS. Clearly, iBundle had a significantly higher number of auction rounds, although data does not even contain the 3 auctions with the biggest value model as well as one medium sized auction which lasted more than 160 rounds before cancelation.

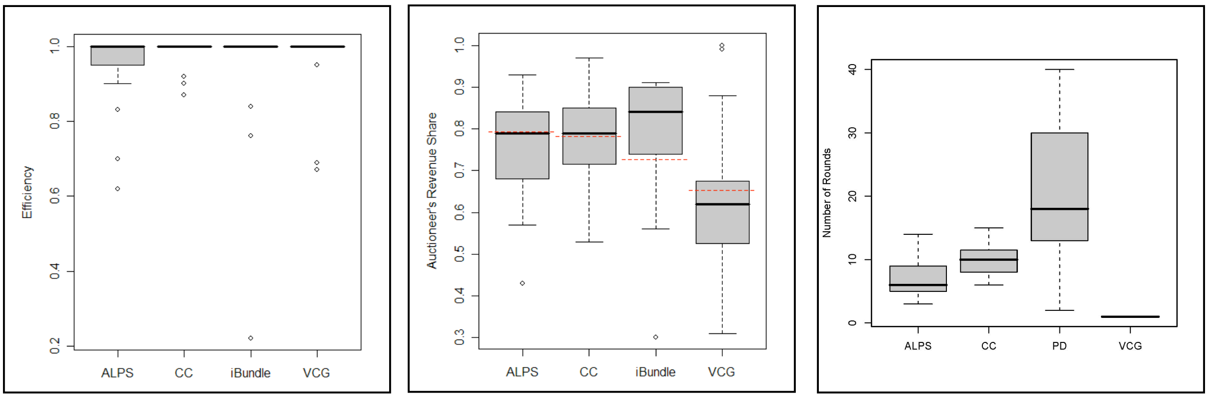

Figure 1: Efficiency, Auctioneer's Revenue Share and Number of Conducted Rounds

We have also analyzed the bidding behavior in iterative CAs and found that across all auctions only a few bids are pure best response bids, i.e. bids submitted on the bundle with the highest payoff. In ALPS 59% of the bids (including jump bids) were submitted on one of the three bundles with the highest payoff, but only 7% were pure best response bids. This can be explained by eligibility rules and non-monotonicity in prices. In the Combinatorial Clock auction, bidders cannot submit jump bids, but the same eligibility rules apply. Here, the percentage of bids on one of the top three bundles was 66%. There are no eligibility rules in iBundle and theory predicts bidders to follow a best-response strategy, however, only 13% of the bids were best-response bids in our iBundle experiments.

Combinatorial auctions are more complex for a bidder than traditional single-item auctions. The bidder has to choose one or more bundles from a set that is exponential in the number of items, plus he has to decide on the bid price on any of these. Our experiments suggest that combinatorial auctions of up to 9 items can achieve very high levels of efficiency, with only minimal bidder decision support. In the future, we plan to extend our analysis to larger combinatorial auctions with more than 10 items.

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