

## **Bidding strategies and their impact on revenues in combinatorial auctions**

**Na An, Wedad Elmaghraby and Pinar Keskinocak**

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School of Industrial and Systems Engineering, Georgia Institute of Technology, Atlanta,

GA 30332-0205, USA

Tel: +1 404 894 2431; Fax: +1 404 894 2301; E-mail: engp8759@isye-gatech.edu

*Na An is a PhD student in the School of Industrial and Systems Engineering at Georgia Institute of Technology. She received her BEng degree in mechanical engineering from Northeastern University, China, in 1995 and MEng degree in mechanical engineering from National University of Singapore in 2000.*

*Wedad Elmaghraby joined the School of Industrial and Systems Engineering at Georgia Institute of Technology as an assistant professor in 2000. She received a PhD in industrial engineering and operations research from the University of California at Berkeley. Prior to joining Georgia Tech, Dr Elmaghraby was on the faculty in the Operations Management Department at New York University's Stern School of Business. Her research interests include auction theory, contracts and market design. Her current areas of application are e-commerce in logistics, procurement strategies in supply chains, and energy markets.*

*Pinar Keskinocak is the Coca-Cola Assistant Professor in the School of Industrial Engineering at Georgia Institute of Technology. She received her PhD in Operations Research from Carnegie Mellon*

*University, and her MS and BS in Industrial Engineering from Bilkent University, Turkey. Before joining Georgia Tech, she worked at IBM TJ Watson Research Center in Yorktown Heights, NY.*

### **ABSTRACT**

**KEYWORDS:** *combinatorial auctions, bidding strategy, single-round auctions.*

*Combinatorial auctions are commonly used for the allocation of discrete, complementary resources. The goal of this research is to shed light onto the critical question of how bidders should bid in combinatorial auctions given that evaluating and submitting all possible bundles is not practical for the bidders and the auctioneer. Within this setting, the research investigates in what constitutes a 'good bidding strategy'. In particular, a simple and efficient model is proposed for evaluating the value of any bundle, given pairwise synergies, design bidding strategies that efficiently select desirable bundles, and evaluate the performance of different bundling strategies under various market settings. From simulations, several interesting observations are made, one of which suggests that educating bidders is of greater value to the auctioneer than increasing the number of bundles each bidder is allowed to submit.*

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## INTRODUCTION

In markets where capacity and services are being auctioned, natural complementarities may exist across items. Two items are complements (exhibit synergies) when their combined value is larger than the sum of their independent values. Slots of capacity may be complements, since there are economies of scale in the transaction costs (eg material handling, documentation and tracking). Lanes in a transportation network may be complements if a group of lanes (eg if they are geographically close or form continuous routes) can lead to higher efficiency for a carrier. In combinatorial auctions (CA), a bidder can express his synergies among items by submitting bids on groups (or bundles) of goods, and wins either all or none of the items in a bundle. For these reasons, the use of CA in industrial settings has increased of late. For example, Sears Logistics Services (SLS) (Ledyard *et al.*, 1999) and The Home Depot, Inc. (Elmaghraby and Keskinocak, 2003) used CA for procuring logistics services. Sears Logistics saved over \$84m running six CA.

While the ability to submit bundle bids would appear to be a great advantage to bidders, surprisingly, in many applications of CA, most bidders do not submit bundle bids. For example, an analysis of the data received from a company which has run CA for transportation services found that, in a single-round auction for 140 lanes, only five out of 46 bidders submitted bundles, and only 18 bundle bids were submitted compared with 2,398 single-item bids. Industry observers explain this situation by the bidders' lack of understanding on how to bid in CA (Plummer, 2003), which is mainly due the novelty of large CA and the complexity of identifying profitable bidding strategies. The distinguishing feature of CA is that the number of possible bundles is exponential in the number of items. In addition to the complexity of knowing

their valuations over all possible bundles, the bidders face the problem of deciding *which* bundles to submit. Evaluating and submitting all possible bundles would be prohibitively time consuming both for the bidders and the auctioneer, who needs to solve the winner determination problem, which is NP-hard. With some special bundle structures, the winner determination problem is polynomially solvable (Rothkopf *et al.*, 1998). Therefore, it is of practical importance to develop bidding strategies that are efficient and effective, ie, can be computed in reasonable time and result in profitable allocations for the bidders by identifying a set of bundles which best represent their preferences.

Some companies, such as Logistics.com, provide carriers with software tools to allow them visualise the shipper's network and the groups of lanes a carrier might consider for bidding. To the best of the author's knowledge, however, there are no tools available which 'suggest' to bidders on which bundles to bid. In addition, research on bidding strategies has been very limited; much of the previous research focuses on multi-round CA, while single-round CA are commonly used in practice. For multi-round CA, a few papers (eg, Kwon *et al.*, 2003; Parkes, 1999, Wurman and Wellman, 2000) consider a myopic best response bidding strategy where in each round bidders select new bundles to submit to maximise their utility given the current ask prices for bundles or items; these papers assume that the bidders know their values for all possible bundles. For single-round CA, Berhault *et al.* (2003) propose combinatorial bidding strategies to coordinate a team of mobile robots to visit a number of given targets in partially unknown terrain. Their experimental setting emphasises the uncertainty in information on valuations and its effect on simple bidding strategies. Song and Regan (2002) present a bidding