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Second International Workshop, DEECS 2006
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Preface

Welcome to the second International Workshop on Data Engineering Issues in E-Commerce and Services (DEECS 2006) in conjunction with the 8th IEEE Conference on E-Commerce Technology and the third IEEE Conference on Enterprise Computing, E-Commerce and E-Services. The purpose of the DEECS workshop is to provide an annual forum for exchange of state-of-the-art research and development in e-commerce and services. Since the increasing demand on e-commerce and services, we are witnessing a continuing growth of interest in the workshop.

The increased number of submissions this year includes a record number from Asia. We received 47 papers: 6 from North/South America, 9 from Europe, and 32 from Asia. Of these, 15 regular papers and 8 short papers were accepted. The technical program reflects an increasing development of principles in service engineering, service-oriented architecture, data and knowledge engineering, and business models and analysis. It also reflects an increased emphasis on system and tool implementation, and applications to service practices, evidencing a maturation of the underlying principles.

Many people worked hard to make this year's workshop a success. The Program Committee members carefully reviewed and discussed every paper, and made difficult decisions. The expert opinions of many outside reviewers were invaluable in making the selections and ensuring the high quality of accepted papers. We also thank authors for their interest and contribution. We thank members of the workshop committee for helping to ensure that the workshop ran smoothly. We also thank organizers of the 8th IEEE Conference on E-Commerce Technology and the third IEEE Conference on Enterprise Computing, E-Commerce and E-Services, for their support and help for the workshop. Without these efforts, this workshop would not have been possible, and we are truly grateful.

June 2006

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An Approach to Detecting Shill-Biddable Allocations in Combinatorial Auctions

Tokuro Matsuo[1], Takayuki Ito[2], and Toramatsu Shintani[2]

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Abstract. This paper presents a method for discovering and detecting shill bids in combinatorial auctions. Combinatorial auctions have been studied very widely. The Generalized Vickrey Auction (GVA) is one of the most important combinatorial auctions because it can satisfy the strategy-proof property and Pareto efficiency. As Yokoo et al. pointed out, false-name bids and shill bids pose an emerging problem for auctions, since on the Internet it is easy to establish different e-mail addresses and accounts for auction sites. Yokoo et al. proved that GVA cannot satisfy the false-name-proof property. Moreover, they proved that there is no auction protocol that can satisfy all three of the above major properties. Their approach concentrates on designing new mechanisms. As a new approach against shill-bids, in this paper, we propose a method for finding shill bids with the GVA in order to avoid them. Our algorithm can judge whether there might be a shill bid from the results of the GVA's procedure. However, a straightforward way to detect shill bids requires an exponential amount of computing power because we need to check all possible combinations of bidders. Therefore, in this paper we propose an improved method for finding a shill bidder. The method is based on winning bidders, which can dramatically reduce the computational cost. The results demonstrate that the proposed method successfully reduces the computational cost needed to find shill bids. The contribution of our work is in the integration of the theory and detecting fraud in combinatorial auctions.

1 Introduction

This paper presents a method for detecting shill bids in combinatorial auctions. Auction theory has received much attention from computer scientists and economic scientists in recent years. One reason for this interest is the fact that Internet auctions such as Yahoo Auction and eBay have developed very quickly and widely. Also, auctions in B2B trades are increasing rapidly. Moreover, there is growing interest in using auction

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mechanisms to solve distributed resource allocation problems in the field of AI and multi-agent systems.

Combinatorial auctions have been studied very widely as one of most important auction formats. In a combinatorial auction, bidders can make bids on bundles of multiple different items. The main issue in a combinatorial auction is its winner determination problem. The computation for winner determination is an NP-complete problem, since there can be exponential numbers of bundles of items and an auctioneer needs to find a bundle combination that maximizes revenue. Many studies have approached this problem by investigating a variety of search algorithms.

The Generalized Vickrey Auction (GVA) is one of the combinatorial auctions that are strategy-proof, i.e., the dominant strategy is for bidders to declare their true evaluation value for a good, and its allocation is Pareto efficient. Many scientists in the field of auction theory have focused on GVA because of its strategy-proof property. The details of GVA are described in Section 2.

As Yokoo et al. pointed out, false-name bids and shill bids are an emerging problem for auctions, since on the Internet it is easy to establish different e-mail addresses and accounts for auction sites. Bidders who make false-name bids and shill bids can benefit if the auction is not robust against false-name bids. A method to avoid false-name bids and shill bids is a major issue that auction theorists need to resolve.

Yokoo et al. proved that GVA cannot satisfy the false-name-proof property. Moreover, they proved that there is no auction protocol that can satisfy all of the three major properties, i.e., false-name-proof property, Pareto efficiency, and strategy-proof property. Thus, they have developed several other auction protocols that can satisfy at least the false-name-proof property. However, satisfying the false-name proof property prevents them from developing Pareto efficient and strategy-proof protocols.

On the contrary, in this paper we propose a method for detecting shill bids with GVA in order to avoid them. Our algorithm can judge whether there might be a shill bid from the results of the GVA's procedure. If there is the possibility of a shill bid, the auctioneer can make the decision of whether to stop allocation of items based on the results. Namely, we build an algorithm to find shill bids in order to avoid them. This differs from the approach of Yokoo et al., which builds mechanisms to avoid shill bids.

A shill bid is defined as two or more bids created by a single person, who can unfairly gain a benefit from creating such bids. Therefore, the straightforward way to find shill bids is to find a bidder whose utility becomes negative when his/her bids and those of another bidder are merged. The merging method is described in Section 3. However, this straightforward method requires an exponential amount of computing power, since we need to check all of combinations of bidders. Thus, in this paper, we propose an improved method for finding a shill bidder. The method is based on the brute force algorithm, and it can dramatically reduce the computational cost.

The rest of this paper consists of the following six parts. In Section 2, we show preliminaries on several terms and concepts of auctions. In Section 3, shill-biddable allocations are defined and discussed. In Section 4, the brute force algorithm used in this paper is introduced. In Section 5, we explain how we handle a massive number of bidders. Finally, we present our concluding remarks and future work.

2 Related Work

Milgrom analyzed the shill-biddable feature in VCG [6]. Bidders in GVA can profitably use shill bidders, intentionally increasing competition in order to generate a lower price. Thus, the Vickrey auction provides opportunities and incentives for collusion among the low-value, losing bidders. However, this work does not refer to the method of detecting shill bidding in combinatorial auctions.

Yokoo et al. reported the effect of false-name bids in combinatorial auctions [13]. To solve the problem, Yokoo, Sakurai and Matsubara proposed novel auction protocols that are robust against false-name bids [11]. The protocol is called the Leveled Division Set (LDS) protocol, which is a modification of the GVA and it utilizes reservation prices of auctioned goods for making decisions on whether to sell goods in a bundle or separately. Furthermore, they also proposed an erative Reducing(IR) protocol that is robust against false-name bids in multi-unit auctions [12]. The IR protocol is easier to use than the LDS, since the combination of bundles is automatically determined in a flexible manner according to the declared evaluation values of agents. They concentrate on designing mechanisms that can be an alternative of GVA. Due to our fundamentally different purpose, we do not simply adopt off-the-shelf methods for mechanism design.

Some studies[2][7][9] proposed methods for computing and calculating the optimal solution in combinatorial auctions. These analyses contributed to the pursuit of a computational algorithm for winner determination in combinatorial auctions, but they did not deal with shill bidding and are fundamentally different approaches from our work. However, some of these algorithms can be incorporated in our work. Combinatorial auctions have a computationally hard problem in which the number of combinations increases when the number of participants/items increases in an auction, since agents can bid their evaluation values as a set of bundled items.

Sandholm[7] propose a fast winner determination algorithm for combinatorial auctions. Also, Sandholm[9] showed how different features of a combinatorial market affect the complexity of determining the winners. They studied auctions, reverse auctions, and exchanges, with one or multiple units of each item, with and without free disposal. We theoretically analyzed the complexity of finding a feasible, approximate, or optimal solution.

Fujishima et al. proposed two algorithms to mitigate the computational complexity of combinatorial auctions [2]. Their proposed Combinatorial Auction Structured Search (CASS) algorithm determines optimal allocations very quickly and also provides good "any-time" performance. Their second algorithm, called VSA, is based on a simulation technique. CASS considers fewer partial allocations than the brute force method because it structures the search space to avoid considering allocations containing conflicting bids. It also caches the results of partial searches and prunes the search tree. On the other hand, their second algorithm, called Virtual Simultaneous Auction (VSA), generates a virtual simultaneous auction from the bids submitted in a real combinatorial auction and then carries out simulation in the virtual auction to find a good allocation of goods for the real auction. In our work, to determine optimal allocations quickly in each GVA, we employ the CASS method. However, Fujishima's paper does not focus on shill bids.

Leyton-Brown et al. proposed an algorithm for computing the optimal winning bids in a multiple units combinatorial auction [5]. This paper describes the general problem in which each good may have multiple units and each bid specifies an unrestricted number of units desired for each good. The paper proves the correctness of our branch-and-bound algorithm based on a dynamic programming procedure. Lehmann et al. proposed a particular greedy optimization method for computing solutions of combinatorial auctions [4]. The GVA payment scheme does not provide for a truth-revealing mechanism. Therefore, they introduced another scheme that guarantees truthfulness for a restricted class of players.

3 Preliminaries

3.1 Model

Here, we describe a model and definitions needed for our work. The participants of trading consist of a manager and bidders. The manager prepares multiple items, and bidders bid evaluation values for what they want to purchase.

- In an auction, we define that a set of bidders/agents is $N = \{1, 2, \ldots, i, \ldots, n\}$ and a set of items is $G = \{a_1, a_2, \ldots, a_k, \ldots, a_m\}$.
- $v_i^{a_k}$ is bidder i's evaluation value at which the ith bidder bids for the kth item $(1 \le i \le n, 1 \le k \le m)$.
- $v_i(B_i^{a_k, a_l})$ is bidder i's evaluation value at which the ith bidder bids for the bundle including the kth and lth items $(1 \le i \le n,\ 1 \le k, l \le m)$. The form of this description is used when the bidder evaluates more than two items.
- $p_i^{a_k}$ is the payment when agent i can purchase an item a_k. When the bidder i purchases the set of bundles of items, the payment is shown as $p_i(B_i^{a_k, a_l})$.
- The set of choices is $G = \{(G_1, \ldots, G_n) : G_i \cap G_j = \phi, G_i \subseteq G\}$.
- G_i is an allocation of a bundle of items to agent i.

Assumption 1 (Quasi-linear utility). *Agent i's utility u_i is defined as the difference between the evaluation value v_i of the allocated good and the monetary transfer p_i for the allocated good. $u_i = v_i - p_i$. Such a utility is called a quasi-linear utility, and we assume the quasi-linear utility.*

Assumption 2 (Free disposal). *Regarding the true evaluation values of any bidder, for bundles B and B', if $B \subset B'$, $B \neq B'$, $v_i(B, \theta_i) \le v_i(B', \theta_i)$ holds.*

Namely, in this paper, when the number of items in a bundle increases, the total evaluation values for the bundle decrease. This means that free disposal is assumed.

Each bidder i has preferences for the subset $G_i \subseteq G$ of goods, which here is considered a bundle. Formally, each bidder has type θ_i, that is, in a type's set Θ. Based on the type, we show that the bidder's utility is $v_i(G_i, \theta_i) - p_i^{G_i}$ when the bidder purchases item G_i for $p_i^{G_i}$. Note that $(v_i(G_i, \theta_i))$ is bidder i's evaluation value of bundle $G_i \subseteq G$.