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O.R. Applications

Multiattribute electronic procurement using goal programming

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Abstract

One of the key challenges of current day electronic procurement systems is to enable procurement decisions transcend beyond a single attribute such as cost. Consequently, *multiattribute procurement* have emerged as an important research direction. In this paper, we develop a multiattribute e-procurement system for procuring large volume of a single item. Our system is motivated by an industrial procurement scenario for procuring raw material. The procurement scenario demands multiattribute bids, volume discount cost functions, inclusion of business constraints, and consideration of multiple criteria in bid evaluation. We develop a generic framework for an e-procurement system that meets the above requirements. The bid evaluation problem is formulated as a mixed linear integer multiple criteria optimization problem and goal programming is used as the solution technique. We present a case study for which we illustrate the proposed approach and a heuristic is proposed to handle the computational complexity arising out of the cost functions used in the bids.

Keywords: Goal programming; e-Procurement; Multiattribute auctions; Multiple criteria optimization; Configurable bids; Business rules; Volume discount cost functions; Bid evaluation problem; Mixed integer linear program

1. Introduction

The Internet and Internet-based technologies are impacting businesses in many ways. With the increasing pressure that companies are experiencing as markets become more global, the Internet continues to play a critical role to speed up operations and to cut costs. By enabling new business processes, Internet also helps organizations to react quickly and efficiently in order to keep up with changing market requirements. One such business process that has gained much attention in recent times is Business-to-Business e-procurement. e-Procurement is an Internet-based business process for obtaining materials and services and managing their inflow into the organization. Procurement is an important part of the more general *supplier selection* or *vendor*

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selection problem [3,48], which is concerned with the selection of candidate suppliers, determining the nature of contracts with them, and then selecting the best set of suppliers among the alternatives.

Initially, in the past few years, naive use of Internet and information technologies saw complex back-end applications supporting supply chains of large companies, with simple front-end e-catalog systems supporting procurement. Recent trends are focusing on user friendly applications that embed sophisticated business logic and algorithms. This involves identifying, evaluating, negotiating, and configuring optimal groupings of suppliers' bids, which are received in response to a buying organization's Request-for-Quote (RFQ). The objective is usually to minimize the total procurement cost subject to various business constraints. This need is present during the initial stage of awarding business to suppliers on new products, and is also present when primary suppliers are unable to deliver supplies (e.g., in the case of a strike, natural disaster, financial default, or other event that causes a work stoppage) to existing products. Such a procurement process, with suppliers bidding in response to buyer's RFQ and the buyer evaluating the bids, borders on the *auction* mechanism. Auction is a market mechanism with well-defined set of rules for determining the terms of an exchange of something for money [36]. Auction mechanisms enable automated negotiation and dynamic pricing, which are not only useful for selling but also in procurement where the buyer is the auctioneer and the sellers are bidders. Numerous major companies have either used or are in the process of using Internet-based automated auction and negotiation mechanisms for their procurement operations. For example, retailers in footwear, home products and fashion are using GlobalNetXchange private auction exchange, auto manufacturers are using Covisint's auctions capabilities, and GE uses its own Global Exchange Services to help procure goods more effectively from suppliers [17]. There are many published case studies of successful deployment of e-auctions in procurement, for example, see [16,18,23,30]. For a more general overview of use of auctions in e-procurement see [9].

1.1. Motivation

The complexity of a procurement process depends primarily on the number and the quantity of the items procured and also the business constraints associated with it. Procuring a single indivisible item is the simplest form of automated negotiation mechanism used in e-procurement. The suppliers respond to the buyer's RFQ with a bid price. The winning supplier is the one who quotes the lowest bid price. Many commercial systems[1] are available with no complex or expensive software and can be deployed within hours of identification of a new procurement opportunity. However, there are certain industrial procurement scenarios which demand more expressive bids and flexible bid evaluation techniques.

A team of researchers from General Motors Research (which included the last three authors of this paper) recently used an approach based on procurement auctions and optimization techniques to solve an industrial procurement problem [9]. This approach, soon to be deployed as a web application within General Motors Corporation (GM Corp), allows business users to determine an optimal allocation of awards to bids using the application over the company's intranet. The procurement corresponds to that of an important raw material for automotive manufacturing. The overall commodity sourcing process is shown in Fig. 1. Within GM, a huge amount of this commodity is sourced every year. To gain maximum cost savings (at a sufficiently high level of desired quality), GM uses a centralized demand aggregation and reselling application for the whole supply chain. This application attempts to combine the individual commodity requirements of its processors and plants, with GM's direct commodity requirements to create large orders. These larger orders often qualify for significant volume discounts with the commodity suppliers. GM then resells a portion of the purchased commodity to its processors to cover their material needs. The overall process is very complex and manual approaches for determining an allocation of awards to the suppliers require enormous effort.

The requirements for the commodity are aggregated within a centralized system. The tool looks at the catalogs of the approved suppliers and sends RFQs. The suppliers submit *configurable bids* [6] to the tool in response to the RFQ. A configurable bid gives either a base price for a bundle and quantity, or a volume discount price, which is a function of quantity. The bid consists of various attributes, with a value specified for each of these attributes. A supplier can also specify some logical rules for assigning some discounts to specific

[1] SpeedBuy from http://www.edeal.com; and many solutions from http://www.freemarkets.com.