Supplier Selection and Order Allocation Based on Integer Programming

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ABSTRACT

The ability to assess and select new suppliers quickly and efficiently is a critical requirement for improving the agility of manufacturing supply chains. The Digital Manufacturing Market (DMM) is a web-based platform for intelligent supply chain configuration. This research enhances the DMM’s performance by developing a column generation method for solving the supplier selection problem. The objective of the proposed method is to maximize the technological competencies of the selected suppliers while meeting their capacity constraints. The column generation method resolves the issue of limited scalability of a traditional linear programming formulation and can be integrated into the DMM. Additionally, using test generated problems, this research evaluates the effect on reducing the threshold distance traveled by semi-finished parts in the work orders. The results show that an economy of distance can be imposed with little effect on average match compatibility.

Keywords: Column Generation, Digital Manufacturing Market, Linear Programming, Nonlinear Programming, Supplier Selection, Supply Chain Configuration

INTRODUCTION

Manufacturing companies continuously strive to improve the responsiveness and flexibility of their supply chains by finding alternative means of sourcing. Managing the sourcing process has been a challenge in the last decade for many corporations (Saen, 2009). In particular, supplier discovery and evaluation is increasingly becoming complex and resource-intensive in global supply chains. There is a need for computational tools and techniques for efficient identification of prospective suppliers to enable rapid formation and reconfiguration of agile supply chains. This need is more pronounced when supply chain transactions are conducted on the web, where a huge number of stakeholders are involved in trading manufacturing services. Electronic marketplaces (e-market) for manufacturing services have recently become popular venues for sourcing particularly among small and medium sized companies. A web-based framework allows for interaction with a far greater number of potential suppliers and also

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enables automation of computational tasks like supplier discovery and evaluation.

Despite their advantages, existing manufacturing e-markets fail in building accurate connections between buyers and sellers due primarily to the syntactic (keyword-based) nature of the search. Ameri and Dutta (2008) proposed a semantic approach to supplier selection by developing a market framework, called Digital Manufacturing Market (DMM), based on the Semantic Web (SW) technology. DMM is an agent-based environment in which buyers (i.e., manufacturing companies) describe their needs by posting queries and sellers (i.e., suppliers) state their capabilities by creating advertisements. Both buyers’ needs and sellers’ capabilities are represented by software agents using a formal ontology called Manufacturing Service Description Language (MSDL) (Ameri, 2006). Semantic search engines quantify the similarities between service provisions (advertisements) and service requests (queries). The details of the semantic search methodology are in (Ameri & Dutta, 2008).

The semantic search engine returns a numeric similarity or matching score between 0 (completely dissimilar) and 1 (completely similar) for each DMM advertisement-query pair. Suppliers (i.e., sellers) are ranked according to the similarity assessment, and the supplier with the highest similarity score is selected to fulfill a service. This methodology of one-to-one matching is adequate if manufacturers’ work orders require only a few services and the supply chain has few suppliers. However, as the size of the supply chain increases, the one-to-one matching technique becomes less efficient. Also, the matching mechanism in DMM does not reflect the trade-offs on operational criteria, such as time, cost, and capacity. The similarity score is purely based on technological criteria, such as the available processes and equipment, achievable geometries and tolerances, and required materials.

This paper studies a supply chain configuration problem in which manufacturing companies place work orders requiring several services that can be provided by multiple suppliers. This problem relates to a Multiple Sourcing Supplier Selection Problem (MSSSP). While a Single Sourcing Supplier Selection Problem finds the best supplier to satisfy a work order, MSSSP finds more than one supplier that will satisfy portions of the work order. Three mathematical optimization models are proposed. The contribution of the models is that they simultaneously consider operational and technological aspects such as suppliers’ technological competency, capacity, and geographic location, and manufacturers’ expected lead time for work orders. All models maximize the semantic similarity score between requested services and suppliers’ advertisements.

The first model is a linear program named the traditional formulation without distance constraints. It considers only suppliers’ capacity and provides a baseline. The second model is a nonlinear program that, including suppliers’ capacity, also incorporates manufacturers’ expected lead times for work orders and suppliers’ geographic locations. This model is named the traditional formulation with distance constraints. The third model is a linear program that uses the column generation method to solve the first model more efficiently. It is called the column generation formulation. We show that the column generation method efficiently resolves the issue of limited scalability observed in the traditional formulation without distance constraints. The paper is divided into four sections. They are literature review, problem assumptions and mathematical optimization models, numerical results, and conclusions.

LITERATURE REVIEW

Electronic markets are defined as a network information system that enable buyers and sellers to exchange information, transact, and perform other related activities (Lancastre & Lages, 2006). Electronic markets require dynamic coordination of their business agents (Mahdavi, Mohebbi, Cho & Paydar, 2008). Agile supply chain configuration (ASCC) plays a key role in the efficiency of electronic markets.
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