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Designing intelligent agents to support long-term partnership in two echelon e-Supply Networks

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ABSTRACT

Realizing the dynamic nature of information flow and the conflicting objectives of members play vital role in effective design of e-Supply Networks (e-SN). While there are some research in the SN literature proposing different dynamic and intelligent coordination mechanisms, the impact of the proper definition of data structure and long-term relationship in modeling both coordination and negotiation mechanisms have not been addressed deeply. In this paper, we propose three overlapping services including intelligent matching of partners, proposal generations, and long-term contract management. The process begins with the selection of qualified partners based on the similarity of users profiles in a multidimensional space defined by network attributes. Then, a coordination mechanism for long-term agreements is proposed such that the generated proposals in e-SN encourage buyers to reveal their demand in advance. The proposed mechanism introduces the importance of strategic buyers for suppliers in modeling and decision making process. To illustrate the model efficiency, a prototype system has been modeled and is compared to the traditional tendering mechanism. The validation results confirm the model efficiency in providing long-term decisions in a dynamic environment.

1. Introduction

Recent Internet-based technologies such as web services provide us with additional opportunity to deal with complex supply chains. For instance, information technology provides an infrastructure for integrating the internal and external activities of a company so that it connects the geographically distant supply chain members together to form a network system. In the same vein, electronic markets have eliminated the geographical obstacles and provided opportunities for the meaningful investigation of the buyer–supplier relationships in supply chains. Hence, the traditional linear supply chains are converted into an e-Supply Networks (e-SN) in which collaboration among partners, real-time decision making, and automation of conventional activities are improved.

e-SN is an electronic-based, dynamic, and distributed supply system (Mohebbi, Shafaei, & Cho, 2011) comprised of many transactional echelons where the membership, the structure of interaction, and the nature of network attributes as represented by informational flow change dynamically over time (Mahdavi, Mohebbi, Zandakbari, Cho, & Mahdavi-Amiri, 2009). Indeed, an e-SN is comprised of independent input nodes, such as buyers with their corresponding information, influencing on each output node, i.e. suppliers, so that according to the input layer attributes and output layer capabilities in terms of the scope of work and available capacity different flows can be obtained. Thus, it can be inferred that there is a couple of key factors affecting the success of an e-SN: (a) realizing the dynamic nature of information flow in a web-based environment and, (b) a proper cooperation mechanism among distributed supply network members.

In an e-SN, new buyers and suppliers join, existing buyers and suppliers may move out, and new products are introduced or replacing existing ones; hence, the network structure is dynamically altering in terms of relations among nodes (arcs) which are mainly due to changes in preferences and performances over time. Such situations, i.e. the sheer number of participants and difficulties to rapidly identify suitable partners, reinforce the idea that the definition of information structure, the way we acquire and maintain the information, and the governing rules have critical roles in the success of the system (Cho, Mahdai, Mahdavi-Amiri, Mohebbi, & Zandakbari, 2011). In other words, while it is well-accepted by supply chain executives that information sharing can lead to enhanced supply chain performance (see La Londe & Ginter, 2004), the source, potential magnitude, and the allocation of the improvements across channel members are not clear (Sahina & Robinson, 2005).

Today's global e-marketplaces have changed their way of thinking to mitigate one of the most important failures of their ancestors: the "chicken and egg" problem. Buyers do not desire

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to commit to an e-market unless there are a substantial number of suppliers connected to it, and vice versa. One of the best examples of such rethinking is the MFG.Com, an online-based global sourcing marketplace for the manufacturing industry, which instead of using transaction-based fee, allows the buyers to freely utilize the service while the suppliers should pay a subscription fee. According to Mitch Free, founder and CEO of MFG.com, the user rating system is their core which rates the suppliers' quality, timely delivery and customer service, and buyers' timely payment, quality of technical data and ease of doing business. In addition, public e-marketplaces such as Amazon and eBay, unlike their consortium specific cousins, have felt the financial success through the years. Here, the concept of information sharing, reviewing previous buyers comments and ratings also looks to be amazing to the buyers. In other words, product reviews possess critical information regarding buyers concerns and their experience with the product which is essential to firms business intelligence for the purpose of conceptual design, personalization, product recommendation, better buyers understanding, and finally attract more loyal customers (Zhan, Loh, & Liu, 2009).

As addressed before, the second factor affecting the success and performance of an e-SN is designing a proper cooperation/coordination mechanism. SN coordination can be defined as the coordination of the distributed decisions of organizations or participants on material flow, information flow and financial flow. Indeed, the internationalization and globalization of markets, and customer orientation of B2B and B2C sectors, as well as the emergence of the knowledge society, require new patterns of cooperation among suppliers, trading partners and customers in supply chain to successfully respond to the e-business demands (Manthou, Vlachopoulou, & Folinas, 2004). Paradigm of agility also advocates cooperation as a route for gaining competitiveness (Wadhwa, Mishra, Chanb, & Ducq, 2010).

Generally speaking, coordination consists of horizontal coordination (Andersen & Christensen, 2005) and vertical coordination (Fiala, 2005). Horizontal coordination refers to the mechanism where the member of one echelon, such as buyers, share their experience and information to transfer the effect of interaction among themselves. The vertical information sharing implies that the upstream (i.e., supplier) and downstream (i.e., buyers) participants of the supply chain share information. Thus, the suppliers have access to the collective information that is required to coordinate the supply chain and each buyer has also access to the suppliers setups and holding cost information.

The coordination of a supply chain, however, requires accurate and timely information about the operational decisions and activities to be shared among all members to deal with uncertainties (Li & Wang, 2007). Such information is those which the parties are willing to share with their partners and hence does not include the member's confidential information. It can be, therefore, concluded that the main issue on SN coordination is to establish a suitable structure of information which should be shared among the network members (Mohebbi & Shafaei, in press). Intelligent agents are an alternative technology to perform business activities in e-SN such as collecting information from both sides, tracing the data exchange between layers and within nodes, and assisting the network members in decision making. One of the advantages of the intelligent agents is that they facilitates information sharing via the network leading to an effective decision making while preventing the parties to access the undesired information of each other. A multi-agent system means that the real system of interest is modeled as a set of interacting agents in a defined environment (i.e., as an agent system) and implemented in a simulation software (Lattila, Hilletofth, & Lin, 2010).

In this study, we define new services taking into account the aforementioned key concepts for designing e-SN and then implement an agent-based e-supply network. The proposed system uses service oriented architecture (SOA) in the core. All of the proposed services including intelligent matching of partners, proposal generations, and long-term contract management are based on information sharing concept. These services are categorized into three overlapping groups as shown in Fig. 1. The service of intelligent matching facilitates the selection of qualified partners based on the similarity of users profiles in a multidimensional space defined by network attributes. The process begins with smart classification of the attributes and then the concept of discrepancy between the performances of nodes for meeting the buyers needs along with an improved weighting process is utilized. Since e-SN is an open and dynamic system, we also apply an updating process for the performance of each supplier based on buyers opinions about the corresponding supplier in fulfilling the contract terms. After determining the most promising partners, a coordination mechanism for long-term agreements are proposed such that the generated proposals in e-SN encourage buyers to reveal their demand in advance. Here, we have changed the viewpoint of a one-shot purchase to a multi-period demand which can be delivered in separated packages in different periods. The mechanism introduces the importance of strategic buyers for suppliers in modeling and decision making process. This approach allocates the benefits of the mechanism to all partners and optimizes the network global objective function as well.

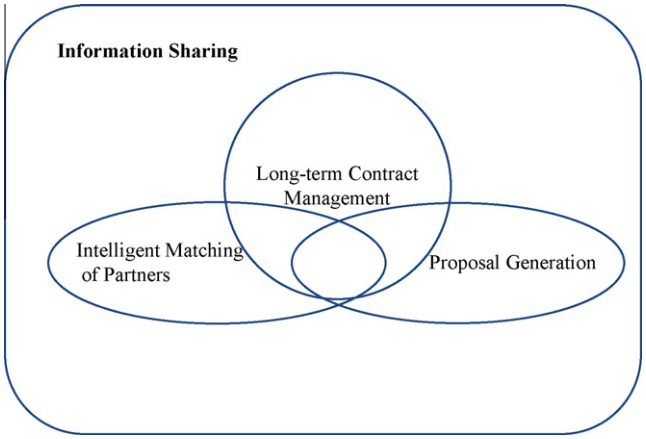

Fig. 1. Service categories.

The remainder of the work is organized as follows: In Section 2, the literature on the use of intelligent agents in e-supply network coordination is reviewed. In Section 3, a detailed mechanism for the model is presented. Section 4 describes the implementation details for the simulation and gives results on the performance of the model. Finally, the conclusions are given in Section 5.

2. Literature review

The multi-agent systems (MASs) are alternative technologies for automated decisions and coordination in SN because of the certain features such as distribution, collaboration, autonomy, and intelligence. An agent is a software entity, which is characterized with environment awareness, ongoing execution, autonomy, adaptiveness, intelligence, mobility, anthropomorphism and reproduction. Thereby, a MAS consists of a number of agents, which interact with each other in order to carry out tasks through cooperation, coordination and negotiation (Wooldridge, 2002). They can monitor and retrieve useful information, and do transactions on behalf of their owners or analyze data in the global markets (Xue, Wang, Shen, & Yu, 2007). Therefore, the major challenge of