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Production planning, negotiation and coalition integration: A new tool for an innovative e-business model

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ABSTRACT

Despite the positive expectations and although they are nowadays considered the most spread Business to Business (B2B) solution, e-marketplaces are still far from representing a real tool for the extended enterprise: as the dramatic down-turn in the e-commerce sector demonstrated, e-business initiatives require solid business models that clearly relate the services provided to the overall profitability of the company. In this paper, we take a particular but quite general e-marketplace business model as our point of departure and use that model to motivate the development of algorithms to support management of trade among buyers and sellers. Specifically, e-marketplaces profitability can be increased by an integration of production planning, negotiation and coalition support tools. Production planning tools allow to create a link between commercialization and production activities, supplying a better service for customer, negotiation tools allow to make transactions taking into account both buyers' and sellers' goals and, finally, coalition represent the proposed course of action for small and medium suppliers not able to fully respond to the customer requests. This paper presents an innovative approach, based on multi-agent system, and a concerning simulation test-bed conducted to demonstrate, in a quantitative way, the advantages arising by adopting the proposed approach.

1. Introduction and motivation

With the movement of business to the internet, one of the most popular e-commerce models to emerge has been that of the e-marketplace. An e-marketplace is an electronic exchange where firms register themself as sellers or buyers to communicate and conduct business over the internet. There are many types of e-marketplaces based on a range of business models. They may operate on a cost-recovery basis by an independent third party (such as an industry association) or be set-up as a business offering, with a middle-person providing a value-added function such as transaction services. Services offered by e-marketplaces include business directory listings, electronic catalogues for online purchasing of goods and services and trading or transaction services. More recently researchers have sought to exploit the electronic infrastructure of e-marketplaces and the wealth of information that can be gathered in e-marketplaces to provide sophisticated methods of matching buyers and sellers, using agent-based, auction-based, and broker-based techniques. Of the work in this area that has addressed profitability of the e-marketplace, the overriding concern has been for maximization of single period revenues, with less attention paid to how the techniques fit within a more strategic business model. However, as the dramatic down-turn in the e-commerce sector demonstrated, e-business initiatives require solid business models that clearly relate the services provided to the overall profitability of the company. To be fully interactive, a company needs to be able to understand the business concepts represented in the interchanged data, and apply business-specific rules to trigger the appropriate actions. Particularly, the company needs to exchange data with their trading partners, who may be using different platforms and a variety of data formats. In order to achieve this, the enterprise needs to increase its IT investments and integrate legacy data, residing in the existing applications. To make business transactions more efficient and to get over the issues related to the use of different platforms and/or use of different data formats from a company and its trading partners, the authors use a multi-agent system (MAS) approach as point of departure and use it to support management of trade among buyers and sellers: each object represents an agent and the system evolves through a message-sending engine managed by a discrete event scheduler. Through the use of this technology is possible to focus the research on developing those value-added services (VASs) allowing to improve e-marketplace effectiveness. As stressed in Wise and Morrison [1] and in Perrone [2], in such B2B applications transactions are not enough to guarantee profitability. The authors identify the origin of this flaw in the following reasons:

- Most of the e-marketplaces, especially those seller or buyer oriented, put respectively buyers and sellers in a price

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competitions that brings advantages only for the e-marketplace owner (the seller and the buyer), but not for the other participants.
- Sellers get very little advantage in staying in an e-marketplace because the possibility to spread the business is in part neglected by the price reduction.
- e-Marketplace owner seems not to provide its customers (e-marketplace participants) with distinctive offering and services that allow to improve profitability.

The report of Aberdeen Group [3] shows how the impact of the e-marketplace improves the performance of each enterprise area. Then, this report shows the e-procurement performance between 2001 and 2006, in particular the increase of enabled suppliers, numbers of users and the number of transactions. Therefore, the e-procurement contributes significantly to reduce operation costs and increase the performance of the enterprise. Moreover, it is not surprising to see that many firms involved in the elaboration of the report, plan to grow their e-business "footprint" by investing in distinct applications: nearly one of every five of them plans to invest in contract compliance and supplier performance management in the near future. The authors, starting from this perspective, in order to recovery profitability in e-marketplaces, propose an innovative software integration of production planning, negotiation and coalition support tools. Undeniably, production planning tools allow creating a link between commercialization and production activities providing a better service for the customer, which can gain reliable information about order availability and timing, and for the supplier, that can correctly plan resources utilization in order to achieve lower costs. On the other hand, negotiation tools allow making transactions able to take into account both buyers' and sellers' identities and goals, providing a better global satisfaction. Furthermore, coalition may be a big chance for small and medium suppliers not able to fully respond to the customer request: collaboration among different agents is a basic issue in a stay-together economy. The specific focus of the research presented in this paper is, on one hand, to propose a MAS architecture for enabling automatic trading in manufacturing e-marketplaces and, on the other hand, to test different types of VAS models that the MAS architecture is able to support. The paper is organized as it follows. Section 2 presents a brief state of the art on coalition tool as a VAS for e-marketplace context. The specific research environment is described in Section 3. Section 4 presents the agent-based model, while Sections 5–7 respectively report the three VAS models that the authors propose to improve e-marketplace effectiveness. The simulation of the numerical case study and the accomplished conclusions are shown in Section 8.

2. State of the art on coalition tool

Multi-agent negotiation is usually a situation where agents may have different goals, and each agent tries to maximize its own utility without concerning for global utility achievement. In multi-agent systems, the agents are provided with an interaction protocol, but each agent will choose its own strategy [4–6]. A self-interested agent will choose the best strategy for itself, which cannot be explicitly imposed from outside. Therefore, such protocols are designed using a non-cooperative, strategic perspective. On the other hand, in e-marketplace environment, small and medium enterprises (SMEs) opportunities might be fostered by improving cooperation among them. From this perspective, the research considers the impact that sellers' coalitions might have on e-marketplace effectiveness. A coalition is a set of self-interested agents that agree to cooperate to achieve a goal that, in this case, can be considered the agreement with the buyer. This kind of coalition was thoroughly investigated within game theory studies [7,8]. A primary motivation for players to form coalitions is to improve their surplus. There are three basic problems in coalition formation in a given game: whether a stable coalition exists, how to share profit among the participants and who should be in a given coalition (coalition generation). Most of the related works are just concentrated on theoretical aspects of coalitions. Shehory and Kraus [9] have provided distributed coalition formation schemes for MAS mainly focusing on increasing the group's total utility. They also limit the highest coalition size by an integer k; that means that the algorithms they proposed cannot be applied to large coalitions. In another paper they aimed at increasing the total utility and at reaching the stable payoff division among agents [10]. Yet, the algorithms restrict the size of each coalition to guarantee the practical computation time. Lerman and Shehory [11] have proposed a new model for coalition formation and applied it to coalition formation among buyer agents in an e-marketplace. Yamamoto [12] describes global behaviour of a set of agents, from the macroscopic point of view, by differential equations and simulates how buyer coalitions evolve and reach the steady state. However, the model does not assist individual agents either to form a coalition or to negotiate surplus distribution. In this work it will be showed how, by integrating MAS and game theory approaches, it is possible to realize a coalition-based VAS able to supporting both the constitution and the surplus sharing activities. The above mentioned issues are not dealt with from a macroscopic perspective; the analysis concentrates upon the single player who's acting in the game. One of the purposes of this paper is to analyse the beneficial implications of coalition constitution among firms (the joint profit of the firms that are members of the coalition) beyond to analyse the private profitability. One major concerns related to coalition studies is, indeed, the difference between private incentives and social incentives and, particularly, whether the equilibrium coalition structure that satisfies private incentive conditions is socially desirable. The existing literature [13–15] on endogenous coalitions formation almost exclusively examines games with symmetric players. In this case, the value of coalition, i.e., the joint profits of firms, depends only on the number of members in each coalition in a given alliance structure. However, in games with asymmetric players, coalition value depends not only on the number of members, but also on the composition of the coalition, that means that players take care about the identity of other members of the partnership. Probably the first study on group formation can be traced back to von Neumann and Morgenstern's seminal book on game theory [16]. Starting with the study of two-player games, von Neumann and Morgenstern discuss the extension of the theory to larger numbers of players, and emphasize the importance of the formation of groups (coalitions in the parlance of game theory) in the study of strategic situations. The issue of coalition formation has been a central aspect of cooperative game theory, leading to the development of a number of cooperative solution concepts. In recent years, the study of coalition formation has been revived, due to the development of a number of applications in economics, and with a slight change on emphasis [10,17,18]. The recent literature proposes to look at coalition formation as a non-cooperative process, by explicitly spelling out the procedures by which individual players form groups and networks. Another important aspect is that a coalition formation can be considered an important cooperation method in MAS. Within coalitions, agents may be able to jointly perform tasks that they would otherwise be unable to perform, or will perform poorly. To allow agents forming coalitions, this paper proposes a coalition formation mechanism that includes a protocol as well as