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Agent-based bilateral multi-issue negotiation scheme for *e*-market transactions

Yee Ming Chen *, Pei-Ni Huang

Department of Industrial Engineering and Management, Yuan Ze University, 135 Yuan-Tung Rd, Chung-Li, Tao-Yuan, Taiwan, ROC

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ABSTRACT

Software agents are flexible, autonomous, and dynamic computational entities. For electronic market (*e*-market) applications, the wide variety of choices to the consumers has introduced the problem of information searching. Meanwhile, there are also so many issues for the participants that require negotiations to find the best deal. In this paper, we present a bilateral multi-issue negotiation scheme, which deploys risk seeking/averse strategies and cost-oriented/benefit-oriented tactics to explore the negotiation space of possible trade-off for the one that is most likely to be acceptable. In particular, it focuses on the incorporation of the level of vagueness of preferences for those issues (either crisp or fuzzy) and multi-objective decision-making techniques. The goal of this research is to design an effective model and some constraints-based fuzzy rules and relax of these constraints to their prevailing transaction circumstances.

1. Introduction

Recently the rapid proliferation of the Internet is stimulating the transformation of traditional markets into electronic markets (*e*-markets). Classical theories cannot adequately cover the dynamics of complex computing systems, such as the *e*-market, creating the need for new methods. Consequently, computing scientists and experts have joined their efforts with economists and mathematicians to create a novel approach for modeling and evaluating market processes. Software agents are encapsulated computer systems situated in some environments such as the Internet and are capable of flexible, autonomous actions in *e*-market environment to meet their design objectives [1,2]. It is argued that software agents can provide a high level of intelligence and autonomy for enhancing the effectiveness of *e*-market. For example, a person that wants to purchase an item can be represented by a software agent. This agent negotiates for the item on behalf of the person and can eventually purchase the item for him when all conditions are met. Software agents can, meanwhile, incorporate experiential knowledge of past transactions to streamline the effects of volatile demand across multiple *e*-marketplaces. The negotiating agents are capable of exchanging proposals, evaluating proposal, and also accepting or rejecting proposals to reach mutual deals. Thus, there is a growing importance of understanding how people develop software agents for these fields [3].

Software agents are autonomous, interact with other agents, and enable approaching inherently distributed problems with negotiation and coordination capabilities [4]. The negotiation mechanism is often the most complex, since it requires evaluation and decision-making under uncertainty, based on multiple issues (attribute) of quantitative and qualitative nature, involving temporal and resource constraints, risk and commitment problems, varying tactics and strategies, domain specific knowledge and information asymmetries, etc. [5]. Thus, the objective of this paper is to develop the agent-based negotiation scheme which can be seen as a decision-making process of automatically resolving a conflict involving many parties over mutual goals to enhance negotiation agents' decision-making processes in *e*-market. In this research, we propose a series of negotiation processes through employing fuzzy logic to evaluate different scale of each issue, generating similarity matching with bilateral alternatives offered by buyer agent and supplier agents, and then modeling some constraints-based fuzzy rules for sellers when receiving counter-proposal by buyer, consequently proceeding to trade-off mechanism between both sides to gain an agreement. This negotiation scheme is mainly classified into five parts. We first defined negotiation parameters set and iso-curve computation in preliminary setting. Second, negotiation alternative processing service will be proposed to select buyer's alternative based on iso-curve. After selecting negotiation alternative, buyer agent will send its alternative (counter-proposal) to supplier agents to determine if it satisfies suppliers' constraints or not, then decide iso-curve relaxation which is buyer's subjective behavior. Consequently, we use trade-off to find out buyer's partner and determine which issues need to change which along with the iso-curve. At the last

* Corresponding author.
E-mail address: chenyeeming@saturn.yzu.edu.tw (Y.M. Chen).

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part, post-negotiation analysis, we will compare two results from the preceding trade-off strategies (i.e., risk-seeking and risk-averse) to let decision-making know how to make the most beneficial decision for company. An example application to negotiate a supplier selection among participants demonstrates to the agents how to adjust its negotiation issues parameters and reach its agreement.

In this paper, our main contribution illustrates the design and development of negotiation agents to enhance the degree of autonomy and the efficiency of *e*-market. In particular, it is providing a platform which can negotiate not only quantitative attributes but also qualitative issues realized fuzzy logic. And make this negotiation scheme more practical in a real world and worthy to implement. The rest of the paper is organized as follows. Section 2 briefly reviews some methodologies proposed of negotiation. The details of the scheme we proposed and the reasons that lie behind are given in Section 3. The performances of the one-to-many multi-issue negotiation scheme are evaluated and discussed in Section 4. The application is explained through the computers assembling *e*-market as our case study in Section 5. Additionally, the novel features of agents in this work are compared with several related systems in Section 6. Finally, the last section contains some conclusions and perspectives.

2. Background review

Agent technologies have been widely used by the computer community to develop systems that can replace some of the intelligent activities of human beings. There have also been several approaches from computer scientists for developing intelligent software methods and protocols for automated negotiation. Automated negotiation mechanisms in such *e*-market need to represent, in a machine understandable way, the product characteristics, the request/offer descriptions and the preferences of the users entering the marketplace. In fact, differently from *e*-marketplaces dealing with undifferentiated products in, e.g., an automotive *e*-marketplace price cannot be the only issue to negotiate on, but also other features as warranty, delivery time, as well as model, color, optional, have to be taken into account. Moreover such issues may not be established in advanced, as it is a common assumption in many other negotiation scenarios (task and resource allocation, auctions). Therefore there is a need for knowledge representation languages able to model relations among issues and to allow agents share a common protocol during the negotiation.

When considering research in automated negotiation, three topics need to be dealt with [6]. First, negotiation protocols are the set of rules that govern the interaction. These cover, the permissible types of participants (e.g., the negotiators and relevant third parties), the negotiation states (e.g., accepting bids, negotiation closed), the events that cause state transitions (e.g., no more bidders, bid accepted), and the valid actions of the participants in particular states (e.g., which can be sent by whom, to whom and at when). Generally, negotiation protocols fall into two categories: auctions and bilateral negotiations. Here, we consider the latter. Such protocols involve two parties (a service supplier and buyer) and an alternating offers protocol in which the parties take turns to submit offers and counter-offers until they come to a mutually acceptable agreement over the terms and conditions of a trade or one of the parties withdraws. The second topic for research is the negotiation objects (also called negotiation contracts) are the range of issues over which agreement must be reached. These may single issues, such as price, or multiple issues relating to price, quality, timing, etc. Also relevant here are the allowable operations on these objects. In the simplest case, the structure and contents of the agreement are fixed, and negotiation amounts to accepting or rejecting the offer. The next level, however, offers flexibility to change the values of the issues in the negotiation object, through counter-proposals, changing the structure of the negotiation object (by adding guarantees, for example), and so on. One of the most promising uses for contract net is to create an electronic marketplace for buying and selling goods. An important idea to note is that each agent is self-interested, meaning that the final solution maybe be the best for the agents involved, but not for the group as a whole. Under a contract net system, a user could specify the good he wanted as well as a price maximum price he was willing to pay. The agent program would then find other user(s) willing to sell the good within the desired price range. Contract net can also be improved by dynamically evolving and expanding. Agents will be free to join or leave the system (or network) at their choosing [7]. Finally, the most important topic for this research is the reasoning models which provide the decision making methods the agents employ to compute their negotiation moves. A variety of methods have been used to try and improve the effectiveness of the agents' negotiation capabilities.

For example, the possibility-based approach [8,9] has been used to perform multi-agent reasoning under uncertainty for bilateral negotiations. The Bayesian learning method [10] has also been used to model multi-issue negotiation in a sequential decision making model. Kowalcyzk [11] modeled the multi-issue negotiation process as a fuzzy constraint satisfaction problem. Luo et al. [12] developed a fuzzy constraint based framework for bilateral multi-issue negotiations in semi-competitive trading environments. Chen and Wang [13] used fuzzy similarity to compute tradeoffs among multiple issues during bilateral negotiations.

The range of researches and problems in this *e*-market transactions area is clearly wide, yet two important tasks must be done: (1) formalize the negotiation process; and (2) incorporate necessary negotiation knowledge and intelligence into the computer Web system which carries out the negotiation. Fig. 1 illustrates buyer/supplier agents negotiate in the Internet through web server in *e*-market. It shows the relationships between negotiation servers, Web servers, client computers, and humans in the negotiation process. In addition, some of the clients may have application systems to maintain the inventories of goods or the information about the services they provide.

In the proposed architecture of platform, a potential number of buyer and suppliers are involved in one-to-many bilateral negotiation to buy goods and services. Additionally, incorporation of human and enterprise negotiation knowledge and intelligence enables a negotiation platform to conduct automated negotiations effectively and intelligently on behalf of its clients. The knowledge

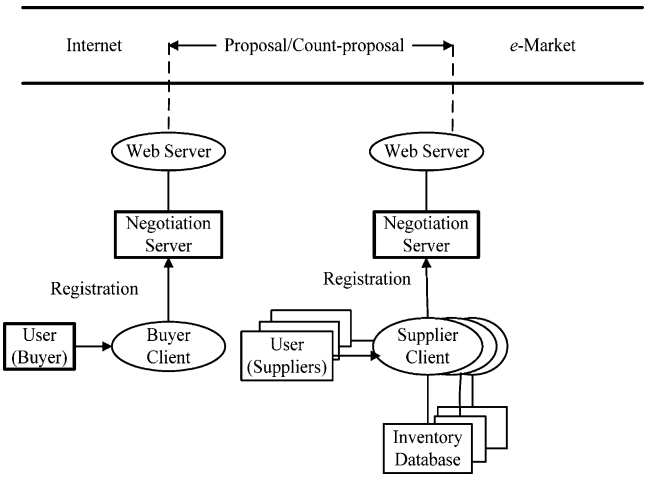

Fig. 1. The bilateral negotiation in the architecture of *e*-market platform.