Journal of King Saud University – Computer and Information Sciences (2016) xxx, xxx–xxx

King Saud University

Journal of King Saud University – Computer and Information Sciences

www.ksu.edu.sa
www.sciencedirect.com

A mathematical model with flexible negotiation strategies for agent based negotiations in dynamic e-commerce environments

P.K. Haleema *, **N.Ch.S.N. Iyengar**

School of Computer Science and Engineering, VIT University, Vellore, Tamilnadu, India

Received 8 May 2016; revised 20 October 2016; accepted 14 November 2016

KEYWORDS

Software agent;
e-Commerce negotiation;
Bi-lateral;
Multi-lateral;
Multi-issue

Abstract In this paper, a mathematical model with flexible negotiation strategies for agent based negotiations is developed which can be applied suitably in bilateral/multilateral multi-issue negotiation environments. Unlike the existing approaches for offer value computation for the negotiation issues, this model considers not only the reservation values but also the offer values proposed in the preceding negotiation round. This approach for offer value computation enables the traders to reach consensus much quicker than the existing approaches. This model considers the compelling urge of the trader in buying/selling a product based on which the reservation values are adjusted automatically at the end of the negotiation process in order to reach consensus in a deal which is otherwise not possible. The formula devised in this model to determine the concession speed of each negotiation issue handles the dynamicity of the negotiation environment and reflects the importance of each negotiation issue from the traders' perspective. The effectiveness of the proposed strategies is evaluated using various hypothetical cases representing the real-world negotiation scenarios in an e-commerce environment. The test results show that the proposed negotiation strategies are able to optimize the utility process and also improve the rate of reaching consensus in the negotiation process.

1. Introduction

In the current scenario, business transactions have become unthinkable without Internet services, thanks to its cheaper cost and wide bandwidth availability. It becomes inevitable for any business to embrace e-services to exploit the advantages of internet technologies in order to survive in the competitive market. The development of e-shopping portals transformed the traditional way of buying and selling goods into a more convenient, cost and time saving benefits for both

* Corresponding author.
E-mail addresses: contact@haleema.in (P.K. Haleema), nchsniyr@vit.ac.in (N.Ch.S.N. Iyengar).

Peer review under responsibility of King Saud University.

ELSEVIER Production and hosting by Elsevier

http://dx.doi.org/10.1016/j.jksuci.2016.11.004
1319-1578

buyers and sellers. e-Commerce encompasses a broad range of issues including security, trust, reputation, law, payment mechanisms, advertising, ontologies, on-line catalogues, and back-office management. Agent technologies can be applied to any of these areas where a personalized, continuously running, semi-autonomous behaviour is desirable (Guttman et al., 1998). A software agent is a computational entity which perceives, acts upon its environment and is autonomous in its behaviour (Weiss, 1999). Negotiation in e-commerce domain is an emerging topic of research. There are a considerable number of research works being carried out in designing automated negotiators capable of making autonomous decisions depending upon the prevailing e-market situations. Design of automated negotiators involves three major operations such as identifying the negotiation objects, defining the negotiation protocols, and devising the agent's decision making models (Jennings et al., 2001). The negotiating agents are capable of exchanging proposals, evaluating proposals, and also accepting or rejecting proposals to reach mutual deals (Chen and Huang, 2009). Faratin et al. (1998) named the sequence of offers and counter-offers in a two-party negotiation as a *negotiation thread* and also proposed to implement multi-party, many issues negotiations as multiple concurrent threads.

Sim and Wang (2004) designed negotiation agents that employ fuzzy rules to provide flexibility in making concessions to reflect the changing market conditions. He and Jennings (2004) proposed the design of intelligent bidding agent that uses fuzzy techniques to make bidding decisions in the face of uncertainty, to make predictions about the likely outcomes of auctions, and to alter the agent's bidding strategy in response to the prevailing market conditions. Matos et al. (1998) adopted an evolutionary approach by mapping the strategies and tactics to the genetic material in a genetic algorithm and showed the relative success of different strategies against different types of opponents in different environments. Lau et al. (2008) proposed a negotiation knowledge discovery method based upon non-parametric approach that supports multi-party many-issue negotiation situations in dynamic negotiation environment and a probabilistic negotiation decision making mechanism to improve the performance of negotiation agents.

Narayanan and Jennings (2005) developed a negotiation model that can adapt the agent's strategy in response to resources availability and variation in negotiation parameters. Kwon (2009) proposed a two-step approach for bilateral multi-attribute consensus formation by developing an algorithm based on collaborative learning theory at step one to recognize the negotiation feasible space and then reducing the time taken for optimization at step two. Ren et al. (2009) extended Market-Driven Agents (MDA) negotiation models by designing agent negotiation strategies that are capable of making adjustable rates of concession in an open and dynamic negotiation environment.

Wang and Wong (2013) proposed a three-staged adaptive negotiation behaviour configuration mechanism to tackle the negotiation dynamics and provided a computational model to organize agent-based e-commerce negotiations with adaptive negotiation behaviours. Ren and Zhang (2014) proposed a negotiation model to dynamically modify agents' negotiation behaviours based upon the changes in the number of participants in the e-market and the agents' motivation on accomplishment of a negotiation.

Liang et al. (2012) have developed a methodology to appraise the performance of intelligent agents and demonstrate the use in the B2C e-commerce negotiation process. Baarslag et al. (2011) summarized the result of ANAC 2011 competition which aims to advance the state-of-the-art in the area of practical bilateral multi-issue negotiations, and to encourage the design of agents that are able to operate effectively across a variety of negotiation scenarios. Chen and Weiss (2015) proposed a negotiation approach called OMAC*, the decision making component of which adaptively adjusts its utility expectations and negotiation moves by enabling the agents to efficiently model opponents in real-time through discrete wavelet transformation and non-linear regression with the Gaussian processes. OMAC* outperformed the top agents from ANAC 2012, 2011 and 2010 in a broad range of negotiation scenarios. Patrikar et al. (2015) proposed a multilateral automated negotiation system based upon linear programming and pattern matching techniques that outperforms negotiation systems based upon fuzzy inference logic, multithreading, linear programming and genetic algorithm.

Deployment of automated negotiators in e-commerce transactions greatly reduces the human efforts and time consumed. The design of automated negotiators involve the consideration of various issues including the number of parties – bilateral or multilateral (one buyer/one seller, one buyer/many sellers, many buyers/one seller, many buyers/many sellers) involved in the negotiation process, the number of negotiation issues (price, date of delivery, warranty, etc) on which mutual agreements are to be achieved, the number of negotiation rounds – fixed/variable and partial/complete/no knowledge on opponents negotiation strategies and priorities. As the real e-market is dynamic in nature, an automated negotiator embedded with fixed negotiation scheme cannot outperform well compared to the ones that are capable of adopting flexible negotiation schemes depending upon the current e-market situation in order to emerge as the ultimate winner.

In this paper, a mathematical model with the flexible negotiation strategies is being devised which can be applied to generate proposals/counter proposals basically in bilateral (one buyer – one seller) single-issue/multi-issue negotiation environments. In case of multilateral negotiation environments where there could be one-to-many, many-to-one, many-to-many buyer/seller combinations, the same model can be applied to generate required number of proposals/counter proposals simultaneously on a one-to-one basis. Flexibility in the proposed negotiation strategy is also achieved by making it suitable for the negotiation environments that are based on either a specific time limit or a number of negotiation rounds. The remaining content of the paper is organized as follows: Section 2 introduces the mathematical model for the agent based negotiation strategies. Section 3 illustrates the effectiveness of the proposed strategies with hypothetical cases representing real world trading environment. Section 4 concludes the paper by identifying the future direction of further research.

2. Mathematical model with flexible negotiation strategies

Bilateral negotiations in an e-commerce environment involve two parties: a buyer and a seller. The negotiation begins when either the buyer/seller makes a proposal for the product to

Please cite this article in press as: Haleema, P.K., Iyengar, N.C.S.N. A mathematical model with flexible negotiation strategies for agent based negotiations in dynamic e-commerce environments. Journal of King Saud University – Computer and Information Sciences (2016), http://dx.doi.org/10.1016/j.jksuci.2016.11.004