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Unanimously acceptable agreements for negotiation teams in unpredictable domains

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ABSTRACT

A negotiation team is a set of agents with common and possibly also conflicting preferences that forms one of the parties of a negotiation. A negotiation team is involved in two decision making processes simultaneously, a negotiation with the opponents, and an intra-team process to decide on the moves to make in the negotiation. This article focuses on negotiation team decision making for circumstances that require unanimity of team decisions. Existing agent-based approaches only guarantee unanimity in teams negotiating in domains exclusively composed of *predictable and compatible issues*. This article presents a model for negotiation teams that guarantees unanimous team decisions in domains consisting of *predictable and compatible*, and also*unpredictable* issues. Moreover, the article explores the influence of using opponent, and team member models in the proposing strategies that team members use. Experimental results show that the team benefits if team members employ Bayesian learning to model their teammates' preferences.

1. Introduction

In the last decade, there has been an increase in the profit earned by electronic commerce systems. This increase has lead to a strong interest of the academic world in researching problems related to e-commerce (Ngai and Wat 2002; Grieger 2003; Wareham et al. 2005). As of today, most e-commerce systems rely on users manually browsing their catalogs and selecting which goods they desire to buy. This task may end up being time consuming and suboptimal in terms of users' preferences, especially as the number of items and services offered on the Web increases. Therefore, it is necessary to propose mechanisms that helps costumers take better decisions while saving their time efforts.

Agent-based electronic commerce has been proposed as a solution to such problems (Guttman et al. 1998; Sierra and Dignum 2001; Oliveira and Rocha 2001; He et al. 2003). In an agent-based e-commerce system, autonomous agents act on behalf of their users with the goal of finding and closing satisfactory deals. Automated negotiation is one of the most common approaches when implementing these systems since they allow different electronic parties to reach agreements by exchanging offers and feedback (Lomuscio et al. 2003; Nguyen and Jennings 2005; Buffett and Spencer 2007; Iau 2007; Chan et al. 2008). The benefits of automated negotiation and agent-based e-commerce are many. Being brief, some of the most important include:

- As stated, browsing online catalogs for an optimal deal may be time consuming. The state-of-the-art in automated negotiation can complete complex negotiations for multiple issues in less than a few minutes (Klein et al. 2003a; Williams et al. 2011; Baarslag et al. 2012).
- On the one hand, automated negotiation saves the user from having to browse the entire catalog. Additionally, its personal agent is directed by the preferences of the user in the negotiation, which should result in deals that are adjusted to the personal liking of the individual. Personalization has been reported to increase user satisfaction in many computational systems (Ball et al. 2006; Liang et al. 2007). On the other hand, a dynamic process like automated negotiation allows sellers to adapt their deals to the users' preferences, their current business needs, and their competitor dynamics (He et al. 2003).
- Agreements achieved by human negotiators, suffer from the *leaving money on the negotiation table* effect (Thompson 2003). This means that human negotiators are content with current agreements, which are usually suboptimal, when they could have performed much better. Agents in automated negotiation

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have been reported to provide agreements close to the optimal solution (Lai et al. 2008).

- Compared to centralized and offline approaches (e.g., preference aggregation, recommendation approaches, etc.), automated negotiation is a dynamic and parallel process. For instance, some centralized approaches like preference aggregation are computationally hard especially if the preference space is combinatorial (Chevaleyre et al. 2007). On the other hand, recommendation approaches only filter prospective deals, but they do not close specific contracts adapted to business needs. Contrarily, automated negotiation can be adapted to current business needs (e.g., concede to gain customers and close fast deals). Additionally, as stated above, team members are also motivated by their own personal interests. Therefore, it is possible that some team members show opportunistic behavior inside the team. In such cases, preference aggregation may be manipulated by exaggerating preferences. Additionally, each parties' preferences are private, therefore making it difficult for the other parties to exploit and manipulate. This latter factor is important, since nowadays most users in electronic applications care about the information they filtrate in systems (Taylor 2003).

Most negotiation mechanisms proposed for e-commerce settings have focused on solving bilateral or multiparty negotiations where parties are individual agents (Faratin et al. 1998; Zeng and Sycara 1998; Klein et al. 2003b; Nguyen and Jennings 2005; Coehoorn and Jennings 2004; Buffett and Spencer 2007; Lai et al. 2008; Williams et al. 2011; Sanchez-Anguix et al. 2013; Aydoğan and Yolum 2012). However, some real life scenarios involve negotiation parties that are not necessarily formed by single individuals. Instead, each party may be formed by more than a single individual. For instance, imagine that a group of travelers wants to go on a holiday together. As a group, they have to negotiate with several travel agencies to get the best travel package for the group. Despite sharing a common goal, each member in the multiplayer party may also be motivated by its own personal interests Mannix (2005) and Halevy (2008). Therefore, the group not only faces a possibly difficult negotiation with the travel agency, but it also needs to deal with the conflict present in the group. This type of multi-individual negotiating party has been studied in the social sciences under the name of *negotiation team* (Thompson et al. 1996; Brodt and Thompson 2001).

As far as the authors are concerned, multi-individual parties have been overlooked in automated negotiation research. The use of computational models for negotiation teams opens doors for new types of interesting and novel applications in electronic commerce. The inclusion of agent-based negotiation teams allows for e-commerce systems to deploy dynamic deal mechanisms for groups, making of e-commerce a more social system. Classically, when purchasing for groups in e-commerce systems, one representative takes decisions for the whole group. Either he makes decisions according to his own preferences or the group needs to engage in a human negotiation which is usually a costly process due to different schedules, logistics, lack of communication problems or interpersonal conflict (Behfar et al. 2008). With the inclusion of agent-based negotiation teams these problems are eluded since autonomous agents take decisions jointly while saving time and efforts for their users.

We believe that agent-based negotiation teams could provide potentially interesting new services:

- Electronic markets for groups of travelers: Online travel agencies offer their services by means of online catalogs where users can browse different products like flights, hotels, restaurants, activities, etc. The possibilities for travels are vast, and usually a single travel operator may offer thousands of possible trip packages/services. Exhaustively looking through this online catalog for an optimal deal becomes an unfeasible task for humans. Additionally, more often than not, travel is a social activity for groups (e.g., friends, family, young people, etc.). Users can benefit from agent-based negotiation teams since they can exhaustively look for deals while taking the preferences of the group into account and saving efforts. Service providers can also benefit from these models since they could adapt their business strategies in a dynamic way and add a level of personalization that may help to retain customers. Moreover, offering the possibility for groups to close travel deals based on their preferences is a value-added service, that as far as we know, is not currently offered by the industry. As an example of its application, users may indicate to their personal agents their desire to go on a travel together. Then, the agents prepare to negotiate with different travel agencies in order to provide a complete and satisfactory travel package for the users. The fact that the negotiation is carried out automatically by electronic agents also gives room to looking for several alternatives in parallel. Once several trip packages have been negotiated, the personal agents may communicate the agreements to users, who can validate them in the last instance.
- Electronic support for agricultural cooperatives: Agricultural cooperatives are supposed to be democratic institutions where groups of farmers join together to save resources for the distribution of their products. One of the main problems of agricultural cooperatives is the principal-agent problem (Ortmann and King 2007). Basically, despite being democratic institutions, agricultural cooperatives are managed by a board of directors who take decisions on behalf of the democratic institution. It has been reported in the literature (Ortmann and King 2007) that dissatisfaction in cooperatives comes from the fact that the goals of members are not aligned with those of the managers. As a novel application for electronic commerce, agent-based negotiation teams may provide support for the processes that are carried out by cooperatives. For instance, the negotiations between agricultural cooperatives and distributors may be supported by an electronic market where the agricultural cooperative is modeled as an agent-based negotiation team. Each member may be represented by an electronic and personal agent that participates in the negotiation team according to the preferences of its owner. This way, if the model is capable of ensuring unanimity with regards to team decisions, it may be possible to avoid the principal-agent problem. Of course, agricultural cooperatives are large institutions and considerable research has still to be done to provide scalable and fair computational models. However, research as the one presented in this article contributes to the obtention of such models in the long term.
- Groups of energy producers in the smart grid: The smart grid is addressed to be the next generation network for electricity distribution (Farhangi 2010). In this network, energy generation may come from geographically distributed small generators (e.g., green energy generators) that have to compete with large energy producers. Decisions at the smart grid have to be taken dynamically since energy production and consumption may vary or face unexpected events (Ramchurn et al. 2012). Recently, agent-based electronic commerce has been proposed as proper paradigm for this scenario due to its dynamic nature and adaptive response (Brazier et al. 2002; Lamparter et al. 2010; Morais et al. 2012; Ramchurn et al. 2012). If small generators want to compete with large generators like power plants, they may need to group together and act together as a single generator. Agent-based negotiation teams can give support for the group decision making of small generators in a dynamic