Studying the impact of negotiation environments on negotiation teams' performance

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A B S T R A C T

In this article we study the impact of the negotiation environment on the performance of several intra-team strategies (team dynamics) for agent-based negotiation teams that negotiate with an opponent. An agent-based negotiation team is a group of agents that joins together as a party because they share common interests in the negotiation at hand. It is experimentally shown how negotiation environment conditions like the deadline of both parties, the concession speed of the opponent, similarity among team members, and team size affect performance metrics like the minimum utility of team members, the average utility of team members, and the number of negotiation rounds. Our goal is identifying which intra-team strategies work better in different environmental conditions in order to provide useful knowledge for team members to select appropriate intra-team strategies according to environmental conditions.

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1. Introduction

Agreement technologies [26,37] conform an emergent research area among scholars in artificial intelligence and autonomous agent systems. Autonomous software agents act reactively and proactively with the objective of maximizing their human users' goals. Nevertheless, as systems tend to be more complex, so do agents' goals, and agents cannot achieve their goals without the cooperation of other agents. Given the open nature of many multi-agent systems, conflict may be inherent among agents. Hence, distributed mechanisms that allow agents to solve conflict and cooperate are a necessity. Agreement technologies have been actively researched bearing in mind the aforementioned necessity.

Automated negotiation [22,18,25] is one of the core topics in agreement technologies. Basically, agents in conflict engage in an automatic offer exchange process which gradually leads towards a final solution, or agreement, that solves conflict and makes cooperation among agents possible. The most common use for automated negotiation has been electronic commerce [24], but it should be highlighted that the applicability of this technology has been demonstrated in other domains like collaborative design [21], labor management disputes [42], and mediation between human negotiation parties [3].

Despite being widely studied by scholars from different disciplines like artificial intelligence, game theory, and social sciences, studies have largely focused on processes whose parties (bilateral, or multiparty) are formed by single individuals [10,8,11,16,6,12,1,14,13]. However, some real world scenarios bring about negotiation parties that are formed by more than a single individual. For instance, when an organization negotiates with another organization the selling of a product line, it is

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usual for organizations to send a group of representatives to negotiate with the other organization. Another example, probably a more quotidian example, involves a married couple that negotiates the purchase of a house with a seller. In this case, the married couple is actually a negotiation party which is formed by two individuals instead than a single individual party. To conclude with the list of real examples, the reader could also think of a group of friends that want to go on a holiday together. This party, conformed by all the friends, has to negotiate a deal with the travel agency if they want to achieve their desired goal.

This kind of multi-individual party is known in the social sciences as a negotiation team [43,2,1,14]: *a group of interdependent people that join and act together as a single negotiation party because of their shared interests, related to a negotiation.* The rationale behind negotiation teams is mainly twofold. First, team members may have different expertise and negotiation skills that are needed to tackle the negotiation problem successfully. Second, the multi-individual entity that negotiates may be formed by multiple stakeholders with different sub-goals and preferences regarding the final negotiation outcome. We can imagine how an IT company may send a negotiation team formed by experts (different knowledge and skills) from the sales department, marketing department, and R&D department to successfully negotiate a new project with the local administration, how the wife and the husband may have different opinions with respect to house pricing, location, and facilities, and how each friend may have different interests regarding hotel location, number of days to spend, and pricing regarding their travel.

Electronic applications, and consequently automated negotiation, are not alien to scenarios that may involve agent-based negotiation teams (ABNTs). For instance, group travel e-markets, group buying in e-markets, electronic management of farming cooperatives, negotiation support systems for real human teams, and agent-based simulation may be some of the applications where ABNT may be used. From our point of view, we are interested in ABNT whose members may have different preferences regarding the negotiation issues, and, more specifically, we are interested in models for electronic markets.

In this paper, we present four intra-team strategies for an ABNT that negotiates with a single opponent. Intra-team strategies, also known as team dynamics, govern which decisions are taken as a team, and how and when those decisions are taken [34]. The relationship between intra-team strategies and team performance is direct. Hence, it became the focus of our current research. It has been documented that environment conditions such as the deadline, concession speed, and reservation utility may affect the impact of single-individual bilateral strategies [10]. However, in the team case, new conditions like the number of team members, team preferences' diversity, and the emergent effect of aggregating team members' behaviors/actions may also end up affecting team performance. Prior to the negotiation process, negotiation teams face the challenge of selecting which intra-team strategy should be employed. If environmental conditions have an effect on the performance of the different intra-team strategies, the intra-team strategy for the negotiation at hand should be selected accordingly to the current environmental conditions inferred by team members. Our research goal is identifying which intra-team strategies perform better according to different negotiation environments under different team performance measures. The long term goal is employing the results of this article for helping team members to select the proper intra-team strategy.

Hence, four intra-team strategies that guarantee four minimum levels of unanimity regarding team decisions are presented in this article: representative (no unanimity guaranteed), Similarity Simple Voting (plurality/majority guaranteed), Similarity Borda Voting (semi-unanimity guaranteed), and Full Unanimity Mediated (unanimity guaranteed). Due to the large amount of variables that may affect the negotiation, we employ an empirical approach to study the behavior of the four intra-team strategies. We study and identify which are the most appropriate strategies according to different environmental conditions and team performance measures. This article, is partially based on our previous work regarding intra-team strategies for negotiation teams [35,33], where we presented initial results and simulations. In this article, we extend our empirical experiments by incorporating new environmental conditions (i.e., team size, different deadlines), carrying out a more fine-grained analysis of previous environmental conditions (i.e., deadline, concession speeds), and presenting revised versions of the four intra-team strategies.

The article is organized as follows. First, we describe the assumptions of our negotiation model (Section 2). After that, the details of the four intra-team strategies are thoroughly described in Section 3. Then, in Section 4 the article depicts which negotiation environments and team performance metrics have been studied, and it presents the results and analysis of our experiments. Afterwards, the present work is related to other works in the area of artificial intelligence and automated negotiation (Section 5). Finally, we briefly state the conclusions of our study and point out some future and interesting lines of work in Section 6.

2. General model description

In this section, we describe the assumptions of our model. We have divided the assumptions in two different categories: general assumptions and opponent assumptions. The general assumptions directly affect the nature of the negotiation at hand and are shared between parties (e.g., protocol, number of parties, attribute types, etc.), whereas opponent assumptions describe the strategy carried out by the opponent.