

Agent-Based Negotiation Teams

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Abstract

Agent-based negotiation teams are negotiation parties formed by more than a single individual. Individuals unite as a single negotiation party because they share a common goal that is related to a negotiation with one or several opponents. My research goal is providing agent-based computational models for negotiation teams in multi-agent systems.

1 What are Negotiation Teams?

The main subject of my PhD thesis is negotiation teams. In the last few years, research in agent-based negotiation research has mainly focused on negotiation processes where parties are formed by single individuals. However, in real world scenarios negotiations are usually carried out by teams [Behfar *et al.*, 2008; Brodt and Thompson, 2001; Thompson *et al.*, 1996]. This is especially true in organizational settings, where parties may decide to send teams formed by different stakeholders' representatives. Even though stakeholders share a common goal which is relevant to the negotiation process, they may have different preferences regarding other negotiation sub-goals [Halevy, 2008]. Therefore, sending a negotiation team is also a tool to let organizational stakeholders participate in relevant negotiations which affect their welfare. Furthermore, negotiation processes may be inherently complex and, thus, it may be wise to send teams formed by individuals with different expertise and skills [Behfar *et al.*, 2008; Koc-Menard, 2009]. Even though, real world negotiations usually involve teams, team dynamics are complex and it has stopped social sciences from studying the problem further [Behfar *et al.*, 2008; Brodt and Thompson, 2001; Halevy, 2008; Koc-Menard, 2009; Thompson *et al.*, 1996].

Agent-based systems are not alien to negotiation scenarios where it may be interesting to employ negotiation teams. For instance, imagine a tourism e-market application. It is usual for groups of friends/families to organize their holidays together since they want to spend some time together. However, friends usually have different preferences regarding trip conditions (e.g., cities to visit, hotel location, leisure activities, number of days to spend, budget limitations, etc.). Humans may be extremely slow at coming with a proper negotiated deal that accounts for everyone's preferences. Thus, agents representing each friend could form a negotiation team

that negotiates with travel agencies in an e-market to obtain a quick and good trip package for the group. The application of negotiation teams is not limited to the aforementioned example. It can be extrapolated to other domains such as electronic farming cooperatives, customer coalitions, agent organizational merging, labor negotiations, and so forth. Thus, there is a need for computational models that provide solutions for agent-based systems.

As far as we know, there are not studies which have addressed the problem of negotiation teams from the point of view of software agents. My main thesis goal is providing computable models for agent-based negotiation teams in software agent societies. More specifically, I am interested in negotiation models for intra-team dynamics, which I have termed as intra-team organizations. An intra-team organization defines the distribution of roles used by agents in the negotiation, which intra-team strategy is used (which decisions are taken by the team and how and when these decisions are taken), and how agents decide their initial strategy to carry out with the opponent. These models may allow agents to solve team negotiations, such as the ones mentioned above, as optimally as possible while being computable. Additionally, since negotiation teams have not been thoroughly studied by social sciences due to the complexity of team dynamics, some of the results provided by my thesis may also prove useful for social sciences.

2 Completed and Ongoing Research on Negotiation Teams

We started studying social sciences' literature. From this study, I was able to propose a general workflow of tasks for agents that participate in a negotiation team [Sánchez-Anguix *et al.*, 2010]. My thesis work has focused on intra-team organizations, which covers part of the general workflow (part of the pre-negotiation and the whole negotiation process). Basically, an intra-team organization governs how the team behaves and it is structured during the negotiation process (i.e., team dynamics). I decided to focus on this problem because it is possibly one of the issues which affects team performance the most. The aspects that I consider in an intra-team organization are:

- **Roles:** It refers to the responsibilities that the teammates assume. For instance, we may find a flat structure where

all of the teammates have the same duties or more complex organizations where there is a certain distribution of tasks according to agent capabilities.

- Intra-team strategy: This aspect defines which decisions are taken by the negotiation team (e.g., offers to send, offer acceptance, leave negotiation), and how (e.g., voting) and when these decisions are taken (e.g., before/during the negotiation process).

As of today, we have focused on studying intra-team organizations for negotiation teams which have members with possibly conflicting preferences. Thus, despite the fact that they share some common goals, they may have different preferences regarding the different negotiation attributes options. Therefore, the problem has a dual nature since teammates need of the other teammates to complete the negotiation with the opponent, but they also want to optimize their preferences as much as possible. Even though it seems reasonable to assume that teammates may have different preferences even in the simplest example, very little research has been done in social sciences [Halevy, 2008]. Thus, results obtained from proposed computational models focusing on intra-team strategies may provide useful results for both software agents and human processes.

I argue that environmental conditions affect intra-team organization's performance. For example, some intra-team organizations may work better in long negotiation processes whereas other may prove more adequate in environments with short deadlines. A team of agents should select their intra-team strategy according to what they believe it is the best given what they know about the current environmental conditions. The adequateness of an intra-team strategy should be considered from the point of view of utilitarian and computational results. My current simulations take into account team preference diversity (intra-team conflict), the length of the negotiation process (short/long deadline), and the concession strategy of the opponent (boulware or concenter). We have proposed four different intra-team organizations for a team of agents which negotiates with an opponent following an alternating bilateral protocol in different negotiation environments [Sánchez-Anguix *et al.*, 2011]. These strategies differ in the level of consensus they are able to obtain (representative, majority, semi-unanimity, unanimity). Initial results suggest that there is not a universally better strategy for all of the negotiation environments and proposed metrics. Thus, it is necessary to thoroughly study how the different intra-team strategies are affected by the different environmental conditions.

3 Future Work

My current work focuses on identifying which of the proposed intra-team organizations work better given certain environmental conditions. However, my work still needs some mechanisms to apply the useful knowledge provided by simulations. More specifically, I plan on working in the following aspects: (i) further study more environmental conditions such as competition and other opponent concession strategies; (ii) propose new intra-team organizations; (iii) provide mechanisms that allow agents to identify environmental conditions as closely as possible; (iv) provide mechanisms that allow

agents to re-organize themselves during the negotiation process due to changing environmental conditions.

Since related work in social sciences is also limited, we are working with Prof. Katia Sycara to provide computational models which take into account cultural factors in a negotiation team setting in order to provide useful tools for social sciences and human negotiators.

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