Thesis

Complex negotiations in multi-agent systems

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In this thesis, we propose automated negotiation models for complex scenarios. More specifically, we focus on (i) negotiations where agents have limited computational resources, and (ii) negotiations where negotiation parties are formed by more than a single individual (i.e., negotiation teams). In the former case, we propose a bilateral model that obtains statistically equivalent results to models that explore the whole non-linear utility function while using less computational resources. In the latter case, we propose automated negotiation models for a negotiation team that negotiates with an opponent by means of the bilateral alternating protocol. We put a special emphasis on models that are able to guarantee unanimity with regards to team decisions in the negotiation.

Keywords: negotiation teams, automated negotiation, agreement technologies, multi-agent systems

1. Introduction

In the last few years, the term agreement technologies has been used to address mechanisms that promote the resolution of conflicts in computational systems. Among agreement technologies, automated negotiation is proposed as one key mechanism in conflict resolution. In this thesis we propose: (i) automated negotiation models for devices with limited computational resources (i.e., Ambient Intelligence). The largest corpus of multi-issue negotiation models has focused on economic optimality or negotiations with linear utility functions, while giving limited attention to devices with scarce computational resources. In these negotiations *complexity stems from achieving economically efficient agreements while reducing the use of computational resources*; (ii) negotiation models for agent-based negotiation teams. Most negotiation models have focused on negotiations where parties are composed of single individuals. However, many negotiations in the real world consist of parties formed by multiple individuals, also known as negotiation teams [1]: a group of travelers negotiating a trip package with a travel agency, agricultural cooperatives negotiating distribution channels with providers, an organization that negotiates the selling of a product with another organization, politics, etc. In this case *complexity stems from handling intra-team conflict and deciding negotiation steps while negotiating with the other party* (i.e., handle opponent conflict). As far as we are concerned, the topic of agent-based negotiation teams is introduced with this thesis.

2. Automated negotiation for devices with limited computational resources

Computational resources are scarce in Ambient Intelligence domains due to the capabilities of devices. For this matter, we propose a non-mediated bilateral multi-issue negotiation model whose goal is optimizing computational resources while maintaining a good performance in the negotiation process [6]. The preferences of the agents are represented by means of non-linear utility functions that present dependencies between negotiation issues. Hence, it is assumed that the whole agreement space cannot be sampled. We employ niching genetic algorithms and genetic operators to tackle this problem. In the pre-negotiation, each agent samples its own utility function by means of a niching genetic algorithm. The effect of this sampling is that offers obtained are highly fit for one's own agent and significantly different, allowing to search in the negotiation for win-win situations. During the negotiation, each agent samples a few offers by means of genetic operators that are applied over received offers and one's own offers. The heuristic behind this sampling is that resulting offers obtained by genetic operators have

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genetic material from one's own agent and the opponent's offers. Thus, these new offers may be interesting for both parties. Finally, genetic operators and similarity heuristics act as a learning mechanism that implicitly guides the offer sampling and selection of which offers must be sent to the opponent. The results show that the proposed model is able to obtain statistically equivalent results in terms of economic efficiency to models that sample the whole search space while sampling fewer samples in several orders of magnitude.

3. Agent-based negotiation teams

Negotiation teams are groups of interdependent agents that join together as a single negotiation party because of their shared interests in the negotiation at hand. Thus, it is a multi-individual party. The reasons to employ a negotiation team are varied. First, the domain may be inherently complex and it needs the expertise and knowledge of different agents. Second, the entity that negotiates may be formed by different stakeholders whose preferences have to be represented. For instance, when a group of travelers negotiates a group trip package with a travel agency, the preferences of all the travelers should be represented in the final agreement. When an organization negotiates it sends individuals from different departments due to their specialized knowledge. This thesis focuses on this latter case, where teammates have diverging preferences (i.e., intra-team conflict) and they should decide on which negotiation steps to take in order to reach an agreement with the opponent (i.e., external conflict) [3,4,5].

We have proposed different intra-team strategies for a team that negotiates with an opponent by means of the alternating bilateral protocol. Intra-team strategies define what decisions should be taken by the team, and how and when these decisions are taken. In this case they define what offers should be sent to the opponent and whether or not opponent's offers should be accepted. The proposed strategies cover different ranges of minimum unanimity levels with regards to team decisions, but we put a special emphasis on strategies that guarantee unanimity with regards to team decisions in different domains. These domains include additive utility functions with predictable and unpredictable issues. Additionally, we have studied how different environmental factors like preference similarity, the deadline length, the team size, and the opponent strategy affect the performance of intra-team strategies. Results have shown that depending on the environmental conditions, different intra-team strategies perform better.

4. Conclusions and future work

In this thesis, we have proposed negotiation models for devices with limited computational resources, and negotiation models for agent-based negotiation teams. As far as we know, the field of agent-based negotiation teams is introduced with this thesis. As future work, we plan to study negotiation teams where team members have different expertise and information of the negotiation domain. The thesis can be consulted in [2].

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