Knowing Each Other in Argumentation-based Negotiation

(Extended Abstract)

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ABSTRACT

Argumentation-based negotiation has emerged as an important topic in multi-agent systems over the last years. Although there are many studies of frameworks that enable agents to negotiate through the exchange of arguments, there is a lack of reasoning methods that employ the (usually incomplete) knowledge an agent may have about his opponent. This work addresses this issue by providing a reasoning mechanism that allows negotiating agents to take into account information about their counterparts. Thus an agent may support his own decisions by using arguments that are meaningful for his opponent. Experimental results highlight the impact of the proposed approach in the negotiation process.

Categories and Subject Descriptors

I.2.11 [**Distributed Artificial Intelligence**]: Multiagent Systems

General Terms

Experimentation

Keywords

Argumentation, Negotiation, Collective decision making

1. INTRODUCTION

Over the last years argumentation-based negotiation (ABN) has gained an increasing interest in the multi-agent field (see e.g. [2]). Two important underlying hypotheses shared by all works in ABN are (a) the selection of arguments that an agent uses to justify his offer to his opponent or to attack or defend another argument, is based solely on his knowledge about the world and his self-interest (b) the knowledge that an agent has about his opponent comes exclusively from their interaction during the negotiation.

The above assumptions seem rather counterintuitive. Consider, for instance, a simple scenario where a car salesperson negotiates with a rich potential buyer over the purchase of a car. Driven by his self-interest to maximize profit, the salesperson suggests the new top of the range Ferrari model. However, the arguments that he will possibly use to justify the offer to the customer, are quite different than the high profit this sale carries, and would rather argue about the very strong motor, the exceptional handling, etc. Moreover, a competent salesperson is expected to use arguments that are appropriate for the customer, even without any prior interaction between them.

This work presents a new perspective to ABN that captures these intuitions in an argumentation based reasoning mechanism for negotiation, where agents use both the knowledge they have about the world (as in the existing works) as well as the (usually incomplete) knowledge they have about the other agents in order to make the crucial decisions at any time. More precisely this new perspective considers that agents use their own arguments for choosing the offers to propose but, whenever possible, use arguments that are *meaningful* for their opponents to support those offers. This policy is also applied for the arguments that agents use for attacking the opponent's arguments.

This paper provides a brief, high-level, description of the new ABN reasoning mechanism, along with a selection of experimental results that confirm what one might intuitively expect: knowledge on the opponent may have a positive impact on the length of the negotiation as well as the quality of the obtained solutions.

2. THE NEGOTIATION MECHANISM

The negotiation framework of this work is the one of [3]. We assume two agents, α and β, who are involved in a bilateral negotiation over a set of offers (options) $\mathcal{O} = \{o_1, ..., o_n\}$ which are identified from a logical language $\mathcal{L}$. As in [3] it is assumed that an agent α has a *theory* represented in an abstract way, that consists of a set of arguments; a function that returns the arguments which support a given offer, and a defeat relation between arguments. This defeat relation is computed by combining a conflict relation between arguments and a preference relation on the set of arguments.

Moreover, we assume that each agent has also knowledge about the other agent he could negotiate with. The theory agent α has on β has the same structure as the agent's α own theory, but we suppose it to be incomplete, as the knowledge α has on β is partial. The important part of this theory is the set of arguments agent α knows. This set can be empty if α does not know anything about β, or contains a subset of β's arguments. We must note that the knowledge an agent has about his opponent is incomplete but accurate (i.e. as far as arguments, preferences on these arguments and conflicts).

In [4], Rubinstein introduced the *Alternating Offers pro-*

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tocol for bargaining between agents. This protocol has been adapted in the argumentation-based negotiation context in [3]. In this work we adapt the *negotiation strategy* that is used in [3] by considering the case where agents have some partial knowledge about their opponent.

The new reasoning mechanism we have implemented realizes this new strategy which corresponds to the main idea proposed in this paper. According to this idea, agents use their own negotiation theory in order to find the best offer to propose to their opponent. This offer is supported by the current "strongest" acceptable (wrt the defeat relation) argument in the agents' theory. Then they use the partial knowledge they have on their opponent in order to find whether this offer is supported by an acceptable argument in the opponent's argumentation theory. If this is the case, this argument is sent for supporting the proposed offer. Otherwise they are looking whether there exists an argument that supports this offer in the opponent's theory, that is not currently acceptable, but which could be defended by their own theories in order to become an acceptable one. The same policy is also applied for choosing the arguments that are used for attacking the arguments of the opponent. However, if such arguments do not exist, agents use the arguments of their own theories for supporting or defending an offer as it is done in the frameworks where agents have no knowledge on the opponent.

3. EXPERIMENTAL EVALUATION

The experimental evaluation is based on two systems. The first implements the method of [3], that does not utilize any form of knowledge about the opponent agent, whereas the second system is an implementation of our approach.

Agent theories have been generated randomly, as sizeable real-life argumentation theories are not readily available. Random theory generation also facilitates the process of creating structurally diverse theories. Indeed, the experimental suite used in this work includes a variety of agent theories with up to 230 arguments, that differ regarding the relation between the preferences on the epistemic arguments of the negotiating agents, as well as the knowledge an agent possesses about his opponent. The experimental suite contains test cases that are generated by assigning values to two parameters. The first parameter concerns the percentage of common preferences between epistemic arguments ($\succeq_e$) shared by the agents, with values 100% and 50%. The second parameter concerns the portion of the knowledge (i.e. arguments) each agent has on his opponent ($\mathcal{A}^{\alpha,\beta}$), with values 0%, 25%, 50% and 100%.

In the following, R_K denotes the round where an agreement is found by using our system (agents have some knowledge K about each other) and $R_{\neg K}$ the round where an agreement is found with the system of [3] (without knowledge about each other). D_K (resp. $D_{\neg K}$) is the distance between the outcome of the negotiation found with our system (resp. with the system of [3]) and the optimal (or ideal) solution for each agent (see [1]). Then, nR_K is the number of negotiations where our system found an agreement in less rounds than the system of [3]; $nR_{\neg K}$ is the number of negotiations where the system of [3] found an agreement in less rounds than our system; nD_K denotes the number of negotiations where the distance of the outcome of the negotiation from the optimal solution is smaller for at least one agent and not worse for the other agent in our system than in the one of [3]; $nD_{\neg K}$ is the number of negotiations where the distance of the outcome of the negotiation from the optimal solution is smaller for at least one agent and not worse for the other agent in [3] than in our system. Table 1 presents the comparative results for the experiments where *both systems have found an agreement* (the number of such negotiations over the 180 experimented per test is given in column $nAgr$). Each test (row) consists of 180 negotiations. The number of arguments involved is between 60 and 230 for each agent's theory.

Table 1: Comparison of the systems

	nR_K	$nR_{\neg K}$	$nAgr$	nD_K	$nD_{\neg K}$
$\succeq_e$: 100%, $\mathcal{A}^{\alpha,\beta}$: 100%	45	0	152	5	1
$\succeq_e$: 100%, $\mathcal{A}^{\alpha,\beta}$: 50%	20	2	152	0	0
$\succeq_e$: 100%, $\mathcal{A}^{\alpha,\beta}$: 25%	0	0	152	0	0
$\succeq_e$: 100%, $\mathcal{A}^{\alpha,\beta}$: 0%	0	0	152	0	0
$\succeq_e$: 50%, $\mathcal{A}^{\alpha,\beta}$: 100%	47	1	141	3	2
$\succeq_e$: 50%, $\mathcal{A}^{\alpha,\beta}$: 50%	4	2	141	1	0
$\succeq_e$: 50%, $\mathcal{A}^{\alpha,\beta}$: 25%	0	0	141	0	0
$\succeq_e$: 50%, $\mathcal{A}^{\alpha,\beta}$: 0%	0	0	141	0	0

The analysis of the experimental results summarized in Table 1 gives us useful information about: (1) the usability in practice of argumentation based negotiation and the way it computationally behaves while scaling in a bilateral negotiation context (2) the performance of our approach. Concerning the first point, our work is (as far as we know) the first one to empirically show that a Dung-based abstract preference-based argumentation framework behaves computationally well while scaling in a bilateral negotiation context. We ran 1440 negotiation experiments which, when resulted in agreement, did so in reasonable execution times. More precisely the average time for an agrement was between 10s and 15s for a size of 60 arguments for each agent theory and 45s for a size of 230 arguments for each agent theory. Concerning the second point, the results show that our system improves the performance of the system of [3] regarding two important criteria, namely the *length of the negotiation* when there is an agreement and the *quality* of the agreement. More precisely concerning the criterion of length, the use of knowledge about the other agent has, (no matter what the % of knowledge about the other agent is), a significant positive impact on the negotiation shortening. This can be important especially for time constraint negotiations. Finally it is worth noting that both systems find exactly the same solution and in the same round when in our system there is no knowledge at all on the opponent.

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5. REFERENCES

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