Could negotiation among agents be regarded as an argumentative process?

Alejandro G. Stankevicius* Alejandro J. García†

Grupo de Investigación en Inteligencia Artificial (GIIA)
Departamento de Ciencias de la Computación
Universidad Nacional del Sur
Bahía Blanca - Buenos Aires - ARGENTINA
e-mail: {ags,ajg}@cs.uns.edu.ar

1 Introduction

The building of an *intelligent agent* has become the main concern of Artificial Intelligence (AI) [5]. Unfortunately, this enterprise proved to be unattainable, in particular given the complexity involved with the formal definition of intelligence. To overcome this problem, several researchers suggested the notion of *rational agents* as a substitute for the notion of intelligent agent [14, 15, 11]. Consequently, mainstream AI nowadays strives for defining what a rational agent is.

Although consensus about the properties meet by rational agents is hardly ever reach, we can single out some features that seem recurrent:

1. Knowledge representation.
2. Reasoning capabilities.
3. Proactivity.
4. Autonomy.
5. Interaction.

An agent naturally requires a way of representing its knowledge and also an inferential apparatus to conclude from it; this accounts for properties 1 and 2. Proactivity, the ability of an agent to trigger some activity by its own, is considered essential in several agent definitions. The next property, autonomy, segregates those entities with a centralized control that we are not interested in considering as agents. Finally, the characterization of a solipsists agent is certainly of no use. The attractive domains for agent-based applications are precisely those that revolves around agent interaction.

Note that by combining autonomy with interaction we hopelessly run into conflicts. These conflicts arise from the different world views entailed by autonomy, clashed against one another by interaction. However, the agents with conflicting positions can start a negotiation in order to come to a mutual agreement (if they intend to). As a consequence, one might think that negotiation plays a key role in the multi-agent system development. Despite of this, it has been largely put aside in AI, perhaps given the complexity of defining *just one* rational agent.

*Supported by a fellowship of Secretaría General de Ciencia y Tecnología, UNS.
†Partially supported by Fundación OSDIC.

The traditional approach for modeling multi-agent negotiation resorts to game theory [13]. Even though several insightful issues have been explored under this conception, it depends on the strong assumption that each agent is aware of the complete pay-off matrix (*i.e.*, they know their preferences and also the preferences of their counterparts) *before* the negotiation begins. Clearly, this assumption restrains game-theoretic based negotiation from being applicable in real world scenarios.

In this paper we endorse the alternative approach that negotiation can be seen as an argumentative process. Recent progress in defeasible argumentation favors dialectical characterizations (*e.g.*, Prakken's dialogue game [12], Simari's dialectical trees [16]). Under this view, two parties take opposing positions regarding a certain matter, and alternatively pose reasons backing their stances. Notably, the similarity with negotiation is striking. In the next section we delve into this similarity. Later, section 3 highlights the related work in the field, and finally section 4 states our conclusions.

2 Negotiation as dialectical argumentation

Defeasible Logic Programming is an extension of traditional logic programming that is expressive enough to represent incomplete and potentially contradictory information [3]. This expressiveness is obtained by applying ideas from *defeasible argumentation* in order to decide between conflicting goals [17]. In this formalism, an argument represents a defeasible reason for a certain conclusion. In turn, a conclusion q is said to be justified only when it is supported by a justified (*i.e.*, non-defeated) argument $\mathcal{A}$. In order to establish whether $\mathcal{A}$ is a non-defeated argument, the system looks for counter-arguments that could be defeaters for $\mathcal{A}$. Since defeaters are also arguments, there may exist defeaters for the defeaters, and so on, thus requiring a complete recursive analysis. This recursive analysis is structured in this framework as a *dialectical tree*, whose formal definition[1] follows.

Definition 2.1 Let $\mathcal{A}$ be an argument for q. A *dialectical tree* for $\langle \mathcal{A}, q \rangle$, denoted $\mathcal{T}_{\langle \mathcal{A}, q \rangle}$, is recursively defined as follows:

1. A single node labeled with an argument $\langle \mathcal{A}, q \rangle$ with no defeaters is by itself the dialectical tree for $\langle \mathcal{A}, q \rangle$.

2. Let $\langle \mathcal{A}_1, q_1 \rangle, \ldots, \langle \mathcal{A}_n, q_n \rangle$ be all the defeaters for $\langle \mathcal{A}, q \rangle$. We construct the dialectical tree for $\langle \mathcal{A}, q \rangle$, $\mathcal{T}_{\langle \mathcal{A}, q \rangle}$, by labeling the root node with $\langle \mathcal{A}, q \rangle$ and by making this node the parent node of the roots of the dialectical trees for $\langle \mathcal{A}_1, q_1 \rangle, \ldots, \langle \mathcal{A}_n, q_n \rangle$. ■

Note that a dialectical tree encompasses all the arguments that can affect the status of the argument placed at its root. Consequently, given a dialectical tree $\mathcal{T}_{\langle \mathcal{A}, q \rangle}$, it is easy to establish whether $\mathcal{A}$ is a non-defeated argument for q (see [4] for the algorithm).

As shown in [18], any dialectical tree can effortlessly be reinterpreted as a dispute between two opposing parties. On the one hand, there is a *proponent* who tries to back the conclusion supported by the argument in root of the dialectical tree. Simply put, the proponent provides the arguments in the odd levels of the dialectical tree. On the other hand, there is an *opponent* who tries to defeat any argument given by the proponent. Likewise, the opponent accounts for the arguments in the even levels of the dialectical tree. This is the particular view that has allowed us to consider the definition of a negotiation protocol based upon dialectical argumentation as feasible.

[1] the missing definitions for some of the preliminary notions can be found in [17, 16, 4].

3 Related Work

Given the space restrictions, we focus our discussion on the related work that address negotiation from an argumentation-based perspective.

Parsons *et al.* have developed over a series of papers [9, 10] the idea that negotiation can indeed be seen as an argumentative process. Unfortunately, they have adopted a rather simplistic argumentation system [8] as the foundation of their negotiation protocol. For instance, this argumentation system lacks reinstatement, an attractive property present in many argumentative frameworks [2, 1, 17, 4, 11]. In fact, our work was initially motivated by the limitations identified in this approach.

According to Kraus *et al.* [7], the work by Parsons *et al.* allegedly follows from their previous results in [6]. Therefore, Kraus *et al.* shares our position regarding agent negotiation, albeit they adopt a multi-modal logic as the representation for the agent knowledge. We believe that in doing this, they have to neglect implementability somewhere as a consequence of the (widely acknowledged) tenuous link between theoretical work in modal logics and their applications. In contrast, our work attempts to preserve both expressiveness and implementability.

4 Conclusions

We firmly endorse—following what we have argued—that negotiation among rational agents clearly resembles a dialectical analysis like the present in almost every formalization of defeasible argumentation. Therefore, the same methods and techniques developed for this type of analysis can be adopted as a guidance to tackle multi-agent negotiation.

Moreover, this approach is being undertaken as the first author's Master Thesis (recent progress on this subject can be found at `http://cs.uns.edu.ar/giia.html`).

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