Towards a Semantics for Argumentative Systems*

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ABSTRACT

Defeasible argumentation is one of the approaches that attempt to address the challenges arising when we reason defeasibly, with several formalisms in the literature reaching a mature state. Nowadays, several of them started shifting their semantics towards a dialectical characterization. Therefore, we believe that a sufficiently generic model of the process of dialectical reasoning could also serve as an abstract model of what happens inside an argumentative systems.

To that end, in this article we lay the foundations required for such a generic model, proposing a line of research whose central objective is attaining that abstract semantics for argumentative systems.

Keywords: knowledge representation, defeasible reasoning, argumentation, dialectics.

1 INTRODUCTION

The start of the 80's mark a revolution in the Knowledge Representation and Reasoning (KR&R) field. For thousands of years *monotonicity*, the property that assures that current results will not be invalidated by the mere adding of new premises, was regarded as a required feature of KR&R formalisms. However, most intelligent beings (humans included) do not satisfy it, showing non-monotonic aspects in their regular behavior. Suddenly, monotonic reasoning became a burden, deemed to be avoided [3, 10]. To overcome this, a new kind of reasoning, called *defeasible reasoning* (a form of non-monotonic reasoning too), emerged as a new field within the KR&R community. In this context, *defeasible argumentation* [4] is one of the approaches that address the new challenges arising when we attempt to reason defeasibly.

Nowadays, defeasible argumentation has become one of the hottest topics in defeasible reasoning, with several formalisms in the literature reaching a mature state [12, 17, 8, 5, 1]. Granted, most of these system share several key aspects among them. For instance, in an article surveying the state of the art in argumentation systems, Prakken and Vreeswijk [9] identified the following core notions, common to every formalism:

1. They provide an underlying logic.
2. They formally define the concept of argument.
3. They capture when two arguments are in conflict.
4. They also capture when an argument defeats another.
5. They provide a mechanism for determining the ultimate state of arguments.

Every argumentative system begins by defining an *underlying logic* where knowledge is initially codified. Even though these systems behave non-monotonically, most of these logics tend to define a monotonic entailment. The rationale is that the addition of new premises should allow the construction of new *arguments* (possibly changing the conclusions sanctioned by the system as a whole), without requiring to invalidate previous deductions. These arguments, the second notion in common, are usually associated to proofs or deductions in this underlaying logic. In this context, an argument is understood as a tentative piece of reasoning supporting a given conclusion. However, not every conclusion drawn on this logic leads to an argument, since these systems usually impose additional restriction on those derivations, such as being based on consistent premises, being minimal, etc.

Regarding the third common aspect, every system easily allows you to construct arguments for *conflicting* conclusions. This relation among arguments is also called *attack* or *counter-argumentation* in some systems. Although the

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most obvious form of conflict is the support of complementary conclusion, an argument may conflict with another for other reasons, for example, when the first denies one of the premises of the second. Considering that this relation only captures disagreement between arguments, it cannot tell appart successful attacks from those that are not. The relation called *defeat*, fourth notion common to every argumentative system, is a refinement of the previous relation that only reflects successfull attacks. Note that this relation captures the conditions under which an argument is able to deny the conclusive force of another argument, effectively vanquishing the latter. On some systems, this relation is called *attack* as well, or *interference*. Even though the conflict relation is usually symmetric, the defeat relation is usually not: some sort of argument comparison criterion is applied to determine which argument prevails in those reciprocal conflicts.

Finally, defeat alone is not enough to determine the *final state* of an argument, as it only sanctions what is the outcome of the conflict between two particular arguments. This key notion, also common to every argumentative system, is used to determine the set of conclusions sanctioned by the formalism. Therefore, several alternatives have been explored in the literature, for instance fix point vs. constructive semantics, single vs. multiple state assignments, skeptic vs. credulous semantics, etc. All these proposal identify at least two disjoint sets: one containing those arguments that are *warranted*, and the other containing those that are not. In a sense, an arguments is warranted when it is not defeated, or when its defeaters are in turn defeated, since defeater are arguments as well. Note that this process may continue recursively, as long as additional defeaters of any defeater remain to be considered. This accounts why warranted arguments are sometime called *undefeated* in other theories, though they have been termed *justified* or *active* as well.

During the 90's, several prominent formalisms started shifting their semantics towards a dialectical characterization, abandoning their original fixpoint semantics or recursive definitions. For instance, the recursive definition of arguments active on a given level from Simari-Loui theory [12] later became the dialectical analysis structured as a tree [11], or the fixpoint semantics of the theory of Prakken and Sartor [7] was then replaced with the concept of dialogical games [8]. Nowadays, every major argumentative system has been reformulated to accommodate a dialectical variant of its semantics,[1] which generally also became the preferred way of capturing it.

[1]with the notably exception of Pollock's theory [5].

Therefore, a sufficiently generic model of the process of dialectical reasoning could also serve as an abstract model of what happens inside an argumentative systems. To that end, in the next section we lay the foundations required for such a generic model, proposing a line of research whose central objective is attaining that abstract semantics for argumentative systems. Then, in section 3 we briefly explore other works already introduced in the literature which follow a like approach. Finally, section 4 presents the conclusions drawn during this article and outline the work immediately ahead.

2 KEY ASPECTS OF DIALECTICAL REASONING

Suppose we want to describe what is going on inside the mind of an intelligent reasoner implementing a theory of dialectical argumentation. Lets imagine the context where this reasoning usually takes place: a given agent comes up with a new claim, and it is about to weigh the chance that claim have of being sanctioned. This claim will be scrutinized under a careful dialectical analysis, where reasons for and against it are to be considered. Evidently, this agent must be willing to assume at least two distinctive roles. Sometimes it will seek out reasons supporting this claim, but often times it will becomes a sort of "devil's advocate", questioning those very same reasons it just put forth. Note that this duality can be observed in most argumentative systems too, where authors have agreed to call *proponent* the role where it supports the claim under consideration, and *opponent* the role where it questions it. These reasons being argued for and against the initial claim are all based upon the same knowledge base, namely the knowledge base of the agent performing both roles.

In order to introduce the remaining core notions, we have to resort to a useful analogy also used to introduce the dialectical flavor of many argumentative systems: we will conceive the whole reasoning process in dialectical terms as if it were a game, where two contenders take turns to introduce further reasons, either supporting or contradicting the initial claim. This intuitive analogy has been used to convey complex concepts such as those that make up the dialectical reformulations of Simari-Loui's system[11] or Prakken-Sartor's theory [8].

Under this conception, one may wonder what a *turn* or a *move* within this dialogical game stands for. It is clear that each move should either consolidate or attack the initial claim, according to the role being performed. Considering the nature of the systems being modeled, it is safe to assume that these reasons being put forward will

be structured as *logical arguments*. With this in mind, the exchange of these arguments usually explores a given aspect of the topics being disputed to the fullest extent, until no further argument can be played addressing that issue, to then start discussing another aspect, and another aspect, until all the aspects of the initial topic are also exhausted. This behavior is modelled in several of the theories of defeasible argumentation under the term *argumentation line* [1, 5, 8]. An argumentation line is a mere sequence of related moves—an argument, followed by one of its defeaters, followed in turn by a defeater of this defeater, and so on, so forth.

We believe this concept plays a key role upon which we can erect an abstract model of dialectical reasoning. In contrast, other alternative models previously considered in the literature assign this central role to the argument [6]. Our decision stem from the fact that the notion of argumentation line is the smallest piece of reasoning still showing dialectical features; once we go down to the argument level, it is quite difficult to identify the role dialectics plays down there. For instance, we can describe in what state a given dispute is by providing the set of all the (partial) argumention lines explored insofar. In a sense, this set of argumentation lines represents a *snapshot of the dispute* being conducted.

Once we are able to formally capture the state a given dispute can be in, another issues should also be resolved, such as:

- Which player should move next?
- What is the set of available legal moves?
- Is the dispute over? If so, who has prevailed?

These important aspects should be carefully addressed, considering that answering these questions in way entirely reasonable in a given context can easily preclude this model from being applicable in some other context, where those policies may no longer be relevant or even feasible. We can take this into account by not making these decisions, providing only a scheme which should be later instantiated according to the needs at hand. For instance, every argumentative systems clearly states how proponent and opponent should alternate, which arguments can be put forward in a given context, or what has been the outcome of the dialectical analysis just performed.

Finally, once we are able to formally model each of the states that a given dispute may traverse, we should also capture how these states relate to each other. In a sense, all the notions briefly introduced so far just model the *static* side of a dispute (for instance, which move can be played next, or which argumentation lines have been explored so far), but we have not capture its *dynamics* yet. Not whitstanding, we can easily take its dynamics into account through a transition function, which formally models the effect of playing a given move in the context of a particular state of a dispute. This transition function by relating the state of a dispute before and after playing a given move actually captures the dynamics of the dialogical game we intend to model.

With this last concept we covered all the relevant aspects involved in the process of dialectical reasoning. In the next section we briefly overviews other related work present in the literature.

3 RELATED WORK

To begin with, this approach was first suggested in a groundbreaking work of R. Loui [2]. The author considered in the article the existence of a generic model for argument-based dialectical reasoning. He successfully introduced a set of abstract notions that were able to capture the dynamics of many attractive theories of defeasible argumentation. However, Loui involvement with this line of research was rather tangential since he was mainly concerned with adding resource-boundedness into defeasible argumentation.

Later, H. Prakken took Loui's work in dialectical reasoning into what he calls dynamic debates involving several agents [6]. He proposed a model of dialectical argumentation in accord to Loui's designs, somewhat resembling the scenario depicted in section 2. The author did not explore what could have been done with that model, using it as a intermediate stage later to be reinterpreted as if it were a model multiagent interaction. In particular, Prakken's main goal was to allow the agents taking part in this interaction to dynamically modify their knowledge bases.

Finally, we too have pursued a similar line of research over a series of articles [15, 13, 16, 14], striving to define an abstract model for the agent interaction in multiagent systems. Even though an intermediate model of dialectical reasoning was also introduced, it never became the main focus of our attention, whereas now we intend to explore its potential to the fullest extent.

4 CONCLUSIONS AND FUTURE WORK

In this article we have briefly sketched a research line for developing an abstract semantics for argumentative systems. To do so, we intend to take advantage of the fact that most argumentative systems allow some sort of dialectical recast of their original semantics. We figure that by developing a sufficiently generic model of the process

of dialectical reasoning, we may end up characterizing an abstract semantics for these systems. As a future work, we ought to refine the preliminary work outlined in section 2, so to formally define an abstract model of dialectical reasoning in accord to those guidelines.

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