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An axiomatic analysis of structured argumentation with priorities

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ABSTRACT

Several systems of semantics have been proposed for structured argumentation with priorities. As the proposed semantics often sanction contradictory conclusions (even for skeptical reasoners), there is a fundamental need for guidelines for understanding and evaluating them, especially their conceptual foundation and relationship.

In this paper, we present an axiomatic analysis of the semantics of structured defeasible argumentation both with and without preferences by introducing a class of ordinary attack relations satisfying a set of simple and intuitive properties. We show that there exists a "normal form" for ordinary attack relations in the sense that stable extensions wrt any ordinary attack relation are stable extensions wrt the normal attack relations.

We relate the ordinary semantics to other approaches, especially to the ASPIC+ framework and the prioritized approaches in logic programming.

1. Introduction

Prioritized defeasible reasoning has been studied extensively [35,34,8,15,44,40,10,26,24,43]. Distinct semantics are proposed that could give different (even contradictory) answers to the same query as the following example illustrates.

Example 1.1. Consider a knowledge base K (adapted from [10,11]), consisting of three defeasible rules

$$d_1 : \textit{Dean} \Rightarrow \textit{Professor} \quad d_2 : \textit{Professor} \Rightarrow \textit{Teach} \quad d_3 : \textit{Administrator} \Rightarrow \neg \textit{Teach}$$

and two strict rules

$$r : \textit{Dean} \rightarrow \textit{Administrator} \quad r' : \neg \textit{Administrator} \rightarrow \neg \textit{Dean}$$

with $d_1 \prec d_3 \prec d_2$[1] and $d_i \preceq d_i$, $i = 1..3$.

Suppose we know some Dean. The question is *whether the dean teaches.*[2]

Proposed semantics in literature deal with this example differently.

An influential and important approach to structured argumentation is the ASPIC+ framework. Modgil and Prakken [34] proposed four attack relations based on the last- or weakest-link principles coupled with the elitist- or democratic-orderings

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[1] $d \prec d'$ means that d is less preferred than d'.

[2] The relevant arguments concerning this question are given in Figs. 3, 4.

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that are arguably the most prominent attack relations proposed until now in the ASPIC+ framework. One of these four attack relations, the one based on the weakest link and elitist ordering leads to semantics with respect to which *the dean does not teach* while the other three as well as the non-argument-based approach of Brewka and Eiter [10] lead to conclusion that *the dean does teach*. □

As the proposed approaches to defeasible reasoning with priorities [35,34,8,15,44,40,10,26,24,43] often sanction contradictory conclusions (even for skeptical reasoners) there is a fundamental need for guidelines for understanding and evaluating them, especially their conceptual foundation and relationship when a user applies prioritized defeasible reasoning in reality.

A key property for evaluating the semantics of structured argumentation is the attack monotonicity. For a quick illustration of this property imagine you have a lively dancing bird in your garden and you know that it is a penguin.[3,4] Suppose some neighbour tells you that the bird is most likely a penguin.[5] Will it change anything in your beliefs about your bird? Of course not. This is an example of the property of irrelevance of redundant defaults stating that adding redundant defaults into your knowledge base does not change your beliefs. This simple and natural property follows from the property of attack monotonicity. Proposed semantics in literature behave differently wrt these properties.

Example 1.2 *(A Sherlock Holmes investigation).* Sherlock Holmes is investigating a case involving three persons P_1, P_2 and S together with the dead body of a big man. The case could be represented by the following knowledge base.

1. The knowledge that one of the persons is the murderer is represented by three strict rules:

$$r_1:\ Inno(P_1), Inno(S) \rightarrow \neg Inno(P_2)$$ [6]

$$r_2:\ Inno(P_2), Inno(S) \rightarrow \neg Inno(P_1)$$

$$r_3:\ Inno(P_1), Inno(P_2) \rightarrow \neg Inno(S)$$

2. S is a small child who cannot kill a big man. This fact is captured in the base of evidence $BE = \{Inno(S)\}$.
3. The legal principle that people are considered innocent until proven otherwise could be represented in two ways:
   - By three defeasible rules

$$d_1:\ \Rightarrow Inno(P_1) \quad d_2:\ \Rightarrow Inno(P_2) \quad d:\ \Rightarrow Inno(S)$$

   - By two defeasible rules

$$d_1:\ \Rightarrow Inno(P_1) \quad d_2:\ \Rightarrow Inno(P_2)$$

   as S is innocent, and hence the defeasible rule $d :\Rightarrow Inno(S)$ is intuitively redundant.
4. After digging around, it becomes clear to Holmes that P_1 has a strong motive to kill the victim while there is nothing connecting P_2 to the dead man. He hence will focus his investigation on P_1. This knowledge is represented by a preference

$$d_1 \prec d_2$$

   stating that Holmes gives higher priority (in his investigation) to the scenario in which P_2 is innocent than to the other one.

Let KB_1 be the knowledge base containing the strict rules r_1, r_2, r_3, the three defaults d_1, d_2, d and the fact that S is innocent together with the preference $d_1 \prec d_2$.

Further let KB_0 be the knowledge base obtained from KB_1 by removing defeasible rule $d :\Rightarrow Inno(S)$.

Due to the fact that S is innocent, we expect that default d will have no impact on the belief sets of the knowledge base KB_1. In other words, *both KB_1 and KB_0 are expected to have identical belief sets*, concluding

$$\neg Inno(P_1),\ Inno(P_2)$$

Surprisingly, KB_0, KB_1 have different belief sets wrt the semantics based on attack relations employing the democratic order proposed and studied by Modgil and Prakken in [34] as elaborated below.

For ease of reference, we refer to the attack relations proposed and studied by Modgil and Prakken in [34] as MP-attack relations in the rest of this example.

[3] In other words, it is an undisputed fact to you that the bird is a penguin. According to Definition 3.3, $BE = \{penguin\}$.
[4] Remember Mumble, the main penguin character in the animated movie Happy Feet?
[5] In other words, you add a defeasible rule $\Rightarrow penguin$ to your knowledge base.
[6] Inno stands for Innocent.