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Conflict-free and conflict-tolerant semantics for constrained argumentation frameworks

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ABSTRACT

In this paper we incorporate integrity constraints in abstract argumentation frameworks. Two types of semantics are considered for these constrained frameworks: conflict-free and conflict-tolerant. The first one is a conservative extension of standard approaches for giving coherent-based semantics to argumentation frameworks, where in addition certain constraints must be satisfied. A primary consideration behind this approach is a dismissal of any contradiction between accepted arguments of the constrained frameworks. The second type of semantics preserves contradictions, which are regarded as meaningful and sometimes even critical for the conclusions. We show that this approach is particularly useful for assuring the existence of non-empty extensions and for handling contradictions among the constraints, in which cases conflict-free extensions are not available.

Both types of semantics are represented by propositional sets of formulas and are evaluated in the context of three-valued and four-valued logics. Among others, we show a one-to-one correspondence between the models of these theories, the extensions, and the labelings of the underlying constrained argumentation frameworks.

1. Introduction

Dung's argumentation framework [20] is a graph-style representation of what may be viewed as a dispute. It is instantiated by a set of abstract objects, called arguments, and a binary relation on this set that intuitively represents attacks between arguments. These structures have been found useful for modeling a range of formalisms for non-monotonic reasoning, including default logic [27], logic programming under stable model semantics [21], three-valued stable model semantics [30] and well-founded model semantics [29], Nute's defeasible logic [22], and so on.

Despite their general nature, experience shows that in some cases argumentation frameworks lack sufficient expressivity for accurately capturing their domain, and some extra apparatus is needed to gain a more comprehensive representation of the relations among the arguments. This observation motivated several

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works, like those of Amgoud and Cayrol [1], Bench-Capon [12], and Modgil [25], in which in addition to the argumentation framework itself, some additional meta-knowledge is provided, e.g. in terms of ranking values or preference relations on the arguments. This helps to refine and improve the process of selecting the arguments that can collectively be accepted according to the argumentation framework at hand.

In this paper we formalize the additional knowledge that is linked to argumentation frameworks in terms of *integrity constraints*, that is, conditions that every accepted set of arguments must satisfy. Let us demonstrate the advantages of using constraints by means of a few simple and (for the time being) informal examples.

Example 1. Medical systems, as well as legal systems, are rule-based, and as such they are naturally representable by argumentation frameworks (see, e.g., [26]). Yet, even in these systems not all the rules are of equal importance or relevance for specific cases. Thus, for instance, arguments referring to concrete results concerning medical tests of a particular patient are usually given precedence over, say, arguments referring to general symptoms of a disease. This may be expressed by constraints obliging the reasoner to take these test results into account when stating a diagnosis (i.e., include them in every accepted set of arguments obtained by the framework), or by extra rules that confront arguments that not necessarily attack one another. More generally, integrity constraints provide means of expressing relations among the arguments which are not representable by 'standard' attack relations.

Example 2. The incorporation of constraints may be useful in handling scenarios where an argumentation framework is viewed as a dynamic process [13]. For instance, constraints may encode the *expected outcome* of an argumentation framework, or may help to evaluate the consequences of an argumentation framework in light of new arguments (see [16]).

Example 3. Constraints may also serve as a means for keeping the semantics of an argumentation framework coherent. To see this, consider the three arguments in the last example of [10]: "John will be on the tandem bicycle because he wants to", "Mary will be on the tandem bicycle because she wants to" and "Suzy will be on the tandem bicycle because she wants to". Here, integrity constraints may explicitly specify that these three arguments are in a collective conflict when the tandem has only two seats – a fact which is difficult to grasp only by standard semantical approaches to argumentation systems (see [10]).

Example 4. The use of meta-knowledge, e.g. in terms of integrity constraints, is a convenient way for accommodating conflicting arguments. Consider, for instance, an information system representing information about the theory of light. Here, the phenomena of interference on one hand and the photoelectric effect on the other hand may stand behind conflicting arguments about whether light is a particle or a wave. Any choice between such arguments would obviously be arbitrary, and the dismissal of one of them would unavoidably yield erroneous conclusions about the nature of light. The incorporation of suitable constraints, forcing the acceptance of *both* arguments, could be an effective way of keeping the underlying theory realistic and non-biased.

Interestingly, in the last two examples integrity constraints have opposite roles: in Example 3 (and often also in the context of Example 2) they serve as an additional mechanism that *excludes conflicts* among accepted arguments, while in Example 4 (and sometimes also in Example 1) they actually *adapt for conflicts* which are inherent to the state of affairs. Clearly, such opposing situations require two different treatments, and in this paper we refer to both of them, namely, we consider coherence-based (or *conflict-free*) constrained systems on one hand and paraconsistent (or *conflict-tolerant*) systems on the other hand. In both cases we show how argumentation frameworks and integrity constraints are incorporated, define appropriate semantics for maintaining conflicts, and describe corresponding methods of representing and computing their consequences.