Towards Advanced Systems for Abstract Argumentation

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Abstract. Within the last years, and in particular due to the first edition of the International Competition on Computational Models of Argumentation (ICCMA) in 2015, the field of formal argumentation has seen an increasing number of systems for Dung's abstract argumentation framework. However, the majority of the current approaches rely on reductions to other solving paradigms like SAT-solving and Answer-Set Programming, thus leaving genuine features of abstract argumentation rather unexploited. In this talk, we present a few directions for the development of next-generation argumentation systems that take recent theoretical advances into account and discuss challenges as well as potential pitfalls in this endeavor.

Keywords. Abstract argumentation, Computational models, Argumentation systems

Within Artificial Intelligence, argumentation has become one of the major fields over the last two decades [1]. In particular, abstract argumentation frameworks (AFs) introduced by Dung [2] are a simple, yet powerful formalism for modeling and deciding argumentation problems that are integral to many advanced argumentation systems. Evaluating AFs is done via so-called semantics (cf. [3] for an overview) that deliver subsets of jointly acceptable arguments. In contrast to other communities, the multitude of semantics is seen as a virtue of formal argumentation rather than a weakness. Consequently, systems for abstract argumentation are expected to deal with, and even exploit, this particular fact.

In 2015, the first edition of the International Competition on Computational Models of Argumentation (ICCMA) [4] took place and compared the performance of 18 submitted solvers[1]. For ICCMA'15, four semantics were taken into account. For the next edition of ICCMA[2], three further semantics will be considered. As it turned out, the top-ranked systems in ICCMA'15 are based on reductions to other paradigms like propositional SAT-solving, Answer-Set Programming or Constraint Satisfaction (see [5] for an overview of such methods).

In this talk, we want to focus on two recent research directions in the field of abstract argumentation, which seem appropriate to be integrated to existing systems:

First, we review the *Explicit Conflict Conjecture*, originally proposed in [6] for stable semantics. In a nutshell, this conjecture states that whenever two arguments are known

[1] http://argumentationcompetition.org/2015
[2] http://www.dbai.tuwien.ac.at/iccma17/

to not occur together in any extension of the given AF, an attack between these arguments can be added to the AF without changing its extensions. Such a behavior would mimic the well-known concept of conflict-driven clause learning [7] which proved extremely successful in SAT-solvers. We will show that the conjecture does not hold for several semantics, following the presentation in [8]. Hence, conflict learning in abstract argumentation needs additional care, but it is open under which situations such a form of optimization (which explicitly tells the solver that an observed conflict between two arguments is given) can be faithfully applied.

Second, we will discuss certain ways how the mentioned multitude of semantics can be exploited in practice. Indeed, a folklore approach is to first compute the grounded extension (which is the minimal complete one and thus contained in all preferred and stable extensions), reduce the AF accordingly, and finally compute the required extensions, see, e.g., [9]. Another approach is to try to make smart use of the fact that, e.g., preferred extensions are the subset-maximal admissible (and complete) ones. Cegartix [10] and ArgSemSAT [11] are examples of systems that use this fact and try to navigate towards preferred extensions using several calls to SAT or ASP solvers. Therefore these systems can be seen as a combination of the reduction-based method with genuine argumentation methodology. However, a more fine-grained picture about the relationship between semantics is given by so-called two-dimensional signatures [12], which we shall focus on here. For instance, such a signature for stable and preferred semantics is just defined as $\Sigma_{\mathbf{ST},\mathbf{PR}} = \{(\mathbf{ST}(F), \mathbf{PR}(F)) \mid F \text{ is an AF }\}$, where $\mathbf{ST}(F)$ (resp. $\mathbf{PR}(F)$) denotes the stable, resp. preferred, extensionsof F. Knowing the exact shape of this signature might yield shortcuts in systems for computing preferred extensions (recall that each stable extension is also preferred): Since stable extensions are known to be easier to compute, one could start with enumerating stable extensions and then, by looking up $\Sigma_{\mathbf{ST},\mathbf{PR}}$, the search space for the remaining preferred extension could be pruned. As an example, the actual characterization of $\Sigma_{\mathbf{ST},\mathbf{PR}}$ shows that in case one has found $\{a,b\}$ and some $S \cup \{a\}$ as stable (and therefore also preferred) extensions of a given AF, one can safely exclude any $S' \cup \{b\}$ with $S \cap S' \neq \emptyset$ as candidates for possible preferred extensions. In the talk, we will review results concerning two-dimensional signatures for several semantics and discuss their possible implications in practice.

Finally, we shall also briefly review other methods that have been studied. On the one hand, dialogues (see, e.g., [13,14,15]) and advanced labeling algorithms (see, e.g., [16]) have been explored as a tool to derive extensions. On the other hand, there are several approaches that take the topology of the AF into account (see, e.g., [17,9,18] for SCC-based techniques; [19] for splitting; [20] for partial evaluation; [21] for a dedicated algorithm on bipartite AFs; or [22] for dynamic programming on tree decompositions of AFs).

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