A Dynamic Logic Framework for Abstract Argumentation

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Abstract

We provide a logical analysis of abstract argumentation frameworks and their dynamics. Following previous work by several authors, we express attack relation and argument status by means of propositional variables and define acceptability criteria by formulas of propositional logic. We here study the dynamics of argumentation frameworks in terms of basic operations on these propositional variables, viz. change of their truth values. We describe these operations in a uniform way within a well-known variant of Propositional Dynamic Logic PDL: the Dynamic Logic of Propositional Assignments, DL−PA. The atomic programs of DL−PA are assignments of propositional variables to truth values, and complex programs can be built by means of the connectives of sequential and nondeterministic composition and test. We start by showing that in DL−PA, the construction of extensions can be performed by a DL−PA program that is parametrized by the definition of acceptance. We then mainly focus on how the acceptance of one or more arguments can be enforced and show that this can be achieved by changing the truth values of the propositional variables describing the attack relation in a minimal way.

Argumentation is a reasoning model based on the construction and on the evaluation of arguments. The seminal approach by Dung represents an argumentation framework $\mathcal{AF}$ as a set of abstract arguments, the structure and origin of which are left unspecified, along with an attack relationship between arguments (Dung 1995). This paper builds on this framework. Dung and his followers have defined semantics for the evaluation of the acceptability of arguments (see (Baroni and Giacomin 2009) for a comprehensive overview). We focus in this paper on extension-based semantics, that define collectively acceptable sets of arguments, called extensions.

Dung's $\mathcal{AF}$ has already been represented in various logics, notably in propositional logic, starting with (Besnard and Doutre 2004). There, $\mathcal{AF}$ is described by means of a boolean formula in a logical language whose propositional variables represent the attacks (the *attack variables*). Furthermore, extensions of the $\mathcal{AF}$ under a given semantics σ can also be described by means of boolean formulas constraining valuations to correspond to the extensions under the semantics. This is done in an extension of the language of attack variables by variables representing argument acceptance.

Based on such a logical representation, several authors have recently investigated the dynamics of the $\mathcal{AF}$, such as (Baumann 2012; Booth et al. 2013; Bisquert et al. 2013; Coste-Marquis et al. 2013). They start by distinguishing several kinds of modification of the $\mathcal{AF}$, such as the addition or the removal of attacks, or the enforcement of the acceptability of an argument a (e.g. such that a is part of at least one extension). All these papers build on previous work in belief change, either referring to AGM theory (Alchourrón, Gärdenfors, and Makinson 1985), such as (Booth et al. 2013; Coste-Marquis et al. 2013), or to KM theory (Katsuno and Mendelzon 1992), such as (Bisquert et al. 2013). They express the modification as a logical formula describing some *goal*, i.e., a property that $\mathcal{AF}$ should satisfy: the task is to revise/update $\mathcal{AF}$ so that this formula is true.

The above papers do not provide a single framework encompassing at the same time $\mathcal{AF}$, the logical definition of the enforcement constraint and the change operations: there is usually one language for representing $\mathcal{AF}$ and another language for representing constraints, plus some definitions in the metalanguage connecting them. This has motivated us to look for a general, unified logical framework for both the representation and the modification of argumentation frameworks.

Our approach makes use of a flexible yet simple logic: Dynamic Logic of Propositional Assignments, abbreviated DL−PA (Balbiani, Herzig, and Troquard 2013). DL−PA is a simple instantiation of Propositional Dynamic Logic PDL (Harel 1984; Harel, Kozen, and Tiuryn 2000) whose atomic programs are assignments of propositional variables to either true or false. Complex programs are built then from atomic programs by the standard PDL program operators of sequential composition, nondeterministic composition, and test. We here moreover add a less frequently considered PDL program operator, namely the converse operator. The language of DL−PA has formulas of the form $\langle\pi\rangle\varphi$ and $[\pi]\varphi$, where π is a program and φ is a formula. The former expresses that φ is true after *some* possible execution of π, and the latter expresses that φ is true after *every* possible execution of π. It is shown in (Balbiani, Herzig, and Troquard 2013) that every DL−PA formula can be reduced to an equivalent propositional formula. The reduction extends to the converse operator in a straightforward manner and provides a syntactical representation of the modified belief base.

We start by showing that the construction of extensions under a given semantics can be performed by a DL−PA program that is parametrized by the formula describing the semantics. Then we consider modifications of the attack relation and/or of the extensions. Modifications of the extensions are enforced by changing the attack relation only (addition or removal of attacks between the existing arguments). This can be achieved by changing the truth values of the attack variables. More precisely, to every input formula A describing the desired modification we associate a DL−PA program π_A implementing the update by A. We can then check whether a formula C is true in all (resp. in some) extensions of (the argumentation framework resulting from) the update of $\mathcal{AF}$ by the goal A.

Our approach extends and generalises previous work that was presented at KR'2014 (Doutre, Herzig, and Perrussel 2014).

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