Dynamics in Argumentation with Single Extensions: Attack Refinement and the Grounded Extension

(Extended Abstract)

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ABSTRACT

We introduce nine attack refinement principles stating whether the extension stays the same if we add a single attack, and we show that the grounded extension satisfies five of them. We define also an extension called acyclic attack refinement by adding a loop condition, and we show that the grounded extension satisfies one of the acyclic attack refinement principles. Moreover, we define an extension called conditional attack refinement taking alternative attackers into account, and we give an example of a conditional attack refinement principle satisfied by the grounded extension.

Categories and Subject Descriptors

I.2.11 [**Distributed Artificial Intelligence**]: Multiagent systems

General Terms

Theory

Keywords

Argumentation theory, abstract argumentation, dynamics of argumentation, argumentation refinement

1. REFINEMENT IN ARGUMENTATION

Dung [5] introduces a framework for abstract argumentation with various kinds of so-called semantics, and Baroni and Giacomin [1] introduce a framework to study general principles of such semantics. Since Dung's argumentation framework is static in the sense that the argumentation framework is fixed, the dynamics of argumentation has been studied mainly in dialogue games, for example as a proof theory for argumentation semantics. We are interested in defining principles for the dynamics of argumentation. In this paper, we study whether the semantics of an argumentation framework changes when we refine or add attack relations between arguments. In this paper we consider only the case in which the semantics of an argumentation framework contains precisely one extension. Examples are the grounded and the skeptical preferred extension.

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DEFINITION 1. *Let $\mathcal{N}$ be the universe of arguments. A single extension acceptance function $\mathcal{A} : 2^{\mathcal{N}} \times 2^{\mathcal{N}\times\mathcal{N}} \to 2^{\mathcal{N}}$ is*

1. *a total function which is defined for each argumentation framework $\langle \mathcal{B}, \to \rangle$ with finite $\mathcal{B} \subseteq \mathcal{N}$ and $\to \subseteq \mathcal{B} \times \mathcal{B}$, and*
2. *which maps an argumentation framework $\langle \mathcal{B}, \to \rangle$ to a subset of $\mathcal{B}$: $\mathcal{A}(\langle \mathcal{B}, \to \rangle) \subseteq \mathcal{B}$.*

The refinement relation between argumentation frameworks considers either the arguments, the attack relation, or both.

DEFINITION 2 (REFINEMENT). *Let $\langle \mathcal{B}, \mathcal{R} \rangle$ and $\langle \mathcal{C}, \mathcal{S} \rangle$ be two argumentation frameworks.*

- *$\langle \mathcal{B}, \mathcal{R} \rangle$ is an* argument *refinement from $\langle \mathcal{C}, \mathcal{S} \rangle$ iff $\mathcal{C} \subseteq \mathcal{B}$ and $\forall a, b \in \mathcal{C}$, $a\mathcal{R}b$ if and only if $a\mathcal{S}b$.*
- *$\langle \mathcal{B}, \mathcal{R} \rangle$ is an* attack *refinement from $\langle \mathcal{C}, \mathcal{S} \rangle$ iff $\mathcal{B} = \mathcal{C}$ and $\mathcal{S} \subseteq \mathcal{R}$.*
- *$\langle \mathcal{B}, \mathcal{R} \rangle$ is an* argument-attack *refinement from $\langle \mathcal{C}, \mathcal{S} \rangle$ iff $\mathcal{C} \subseteq \mathcal{B}$ and $\mathcal{S} \subseteq \mathcal{R}$.*

For the definition of principles in the following section, it is useful to distinguish between rejected and undecided arguments. The following definition gives Caminada's [3] translation from extensions to three valued labelling functions. Caminada uses this translation only for complete extensions, such as the grounded extension, such that an argument is accepted if and only if all its attackers are rejected, and an argument is rejected if and only if it has at least one attacker that is accepted. We use it also for extensions which are not complete, such as the skeptical preferred extension, such that Caminada's labelling principles may not hold in general. We assume only that extensions are conflict free, i.e., an accepted argument cannot attack another accepted argument.

DEFINITION 3 (REJECTED AND UNDECIDED ARGUMENTS). *Let $\mathcal{A}(AF)$ be a conflict free extension of an argumentation framework $AF = \langle \mathcal{B}, \to \rangle$, then $\mathcal{B}$ is partitioned into $\mathcal{A}(AF)$, $\mathcal{R}(AF)$ and $\mathcal{U}(AF)$, where:*

- *$\mathcal{A}(AF)$ is the set of accepted arguments,*
- *$\mathcal{R}(AF) = \{a \in \mathcal{B} \mid \exists x \in \mathcal{A}(AF) : x \to a\}$ is the set of rejected arguments, and*
- *$\mathcal{U}(AF) = \mathcal{B} \setminus (\mathcal{A}(AF) \cup \mathcal{R}(AF))$ is the set of undecided arguments.*

2. ATTACK REFINEMENT PROPERTIES

We consider the situation where the set of arguments remains the same but the attack relation may grow. In particular, we consider principles where we add a single attack $a \rightarrow b$ to an argumentation framework. We distinguish whether arguments a and b are accepted, rejected or undecided.

PRINCIPLE 1 (ATTACK REFINEMENT). *A single extension acceptance function $\mathcal{A}$ satisfies the $\mathcal{XY}$ attack refinement principle, where $\mathcal{X}, \mathcal{Y} \in \{\mathcal{A}, \mathcal{R}, \mathcal{U}\}$, if for all argumentation frameworks $AF = \langle \mathcal{B}, \rightarrow \rangle$, $\forall a \in \mathcal{X}(AF) \forall b \in \mathcal{Y}(AF)$: we have $\mathcal{A}(\langle \mathcal{B}, \rightarrow \cup \{a \rightarrow b\} \rangle) = \mathcal{A}(AF)$.*

The following proposition states that the grounded extension satisfies five of the nine $\mathcal{AA}, \mathcal{AR}, \mathcal{AU}, \mathcal{RA}, \mathcal{RR}, \mathcal{RU}, \mathcal{UA}, \mathcal{UR}$ and $\mathcal{UU}$ attack refinement principles.

PROPOSITION 1. *The grounded extension satisfies the $\mathcal{AR}$, $\mathcal{RR}$, $\mathcal{UR}$, $\mathcal{RU}$ and $\mathcal{UU}$ attack refinement principles.*

The $\mathcal{AR}$, $\mathcal{RR}$ and $\mathcal{UR}$ attack refinement principles are satisfied, because an attack on a rejected argument does not change the extension, and the $\mathcal{RU}$ and $\mathcal{UU}$ attack refinement principles are satisfied, because an attack on an undecided argument that does not change its status does not change the extension. This can be shown by induction on the construction of the grounded extension. $\mathcal{AA}$ attack refinement is not satisfied, because extensions have to be attack free. Likewise, $\mathcal{UA}$ attack refinement is not satisfied, because in the grounded extension there is no undecided argument attacking an accepted argument, so the accepted argument becomes undecided. $\mathcal{AU}$ attack refinement is not satisfied, because the undecided argument becomes rejected, which may make other arguments accepted. $\mathcal{RA}$ attack refinement is not satisfied, because if we add an attack from a rejected argument a to an accepted argument b, then b may turn to undecided when a is rejected because of b. The latter counterexample suggests the following principle, which adds a loop condition to the basic refinement principles.

PRINCIPLE 2 (ACYCLIC ATTACK REFINEMENT). *A single extension acceptance function $\mathcal{A}$ satisfies the acyclic $\mathcal{XY}$ attack refinement principle, where $\mathcal{X}, \mathcal{Y} \in \{\mathcal{A}, \mathcal{R}, \mathcal{U}\}$, if for all argumentation frameworks $AF = \langle \mathcal{B}, \rightarrow \rangle$, $\forall a \in \mathcal{X}(AF) \forall b \in \mathcal{Y}(AF)$: if there is no odd length sequence of attacks from b to a then $\mathcal{A}(\langle \mathcal{B}, \rightarrow \cup \{a \rightarrow b\} \rangle) = \mathcal{A}(AF)$.*

PROPOSITION 2. *The grounded extension satisfies the acyclic $\mathcal{RA}$ attack refinement principle.*

The case of $\mathcal{AU}$ attack refinement is more complicated since an attack from an accepted argument to an undecided argument changes the status of the latter to rejected. The following principle says that there are alternative attackers ensuring that the extension does not change.

PRINCIPLE 3 (CONDITIONAL ATTACK REFINEMENT). *A single extension acceptance function $\mathcal{A}$ satisfies the conditional $\mathcal{XY}(\mathcal{ZT})$ attack refinement principle, where $\mathcal{X}, \mathcal{Y}, \mathcal{Z}, \mathcal{T} \in \{\mathcal{A}, \mathcal{R}, \mathcal{U}\}$, if for all argumentation frameworks $AF = \langle \mathcal{B}, \rightarrow \rangle$, $\forall a \in \mathcal{X}(AF) \forall b \in \mathcal{Y}(AF)$: if $\forall c \in \mathcal{Z}(AF)$ with $b \rightarrow c$, $\exists d \neq b \in \mathcal{T}(AF)$ with $d \rightarrow c$, then $\mathcal{A}(\langle \mathcal{B}, \rightarrow \cup \{a \rightarrow b\} \rangle) = \mathcal{A}(AF)$.*

PROPOSITION 3. *The grounded extension satisfies the conditional $\mathcal{AU}(\mathcal{UU})$ attack refinement principle.*

3. RELATED RESEARCH

Besides the work of Baroni and Giacomin on principles for the evaluation of argumentation semantics, there is various work on dialogue and a few very recent approaches on the dynamics of argumentation. Cayrol *et al.* [4] define a typology of argument refinement (called revision in their paper), and they define conditions so that each type of refinement becomes a revision (called classical revision in their paper), in the sense that the new argument is accepted. Rotstein *et al.* [6] introduce the notion of dynamics into abstract argumentation frameworks, by considering arguments built from evidence and claims. They do not consider abstract arguments and general principles like we do in this paper. Barringer *et al.* [2] consider internal dynamics by extending Dung's theory in various ways, but without considering general principles.

4. CONCLUDING REMARKS

Argument refinement can be defined incrementally as the addition of an unconnected argument, and afterwards adding attack relations. Here we can distinguish again three cases, whether the added argument is accepted, rejected or undecided.

Attack and argument abstraction can be defined as the duals of refinement. For example, the grounded semantics satisfies the $\mathcal{AA}$, $\mathcal{AU}$, $\mathcal{UA}$, $\mathcal{UR}$, $\mathcal{RA}$, $\mathcal{RU}$ and $\mathcal{RR}$ attack abstraction principles, leaving two interesting cases for further principles: the removal of an attack relation from an undecided argument to another undecided argument, i.e., $\mathcal{UU}$, and the removal of an attack relation from an argument that is accepted to an argument that is rejected, i.e., $\mathcal{AR}$. Thus, the interesting cases are different from the interesting cases for argument refinement, $\mathcal{RA}$ and $\mathcal{AU}$.

Besides the grounded semantics, other single extension semantics can be tested against our principles, such as the skeptical preferred semantics or the ideal semantics, and our principles can be generalized to the multiple extension case, for example for preferred or stable semantics.

5. REFERENCES

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