Acceptability semantics accounting for strength of attacks in argumentation

Cayrol Claudette¹ and Devred Caroline² and Lagasquie-Schiex Marie-Christine³

Abstract. We consider argumentation systems with several attack relations of different strength. We focus on the impact of various strength attacks on the semantics of such systems. First, we refine the classical notion of defence, by comparing the strength of an attack with the strength of a counter-attack. Then, we propose different ways to compare defenders, and sets of defenders. That enables us to define admissible sets offering a best defence for their elements.

1 Argumentation framework with attacks of various strength

Argumentation is based on the evaluation of interacting arguments (which support opinions, claims, decisions,...) and the selection of acceptable sets of arguments. Most of the argumentation-based proposals are instantiations of the Dung’s abstract system [2], which is reduced to a set of arguments (completely abstract entities) and a binary attack relation, which captures the conflicts between arguments. The increasing interest for the argumentation formalism has led to numerous extensions of the basic abstract system, particularly for making a distinction between various kinds of attacks [4, 7, 8], and more precisely for taking into account the relative strength of the attacks [3, 5, 7, 6].

Starting from the abstract argumentation system with varied-strength attacks proposed by [6], we redefine the notion of defence and come to novel extensional semantics accounting for strength of attacks. We consider the abstract system defined in [6]:

Def 1 (Argumentation system with attacks of various strength – ASvs) An argumentation system with attacks of various strength is a triple \((A, \ATT, \succeq)\) where \(A\) is a finite set of arguments, \(\ATT\) is a finite set of binary attack relations \(\langle\cdot,\cdot,\cdot\rangle\) on \(A\) and \(\succeq\) is a binary relation on \(\ATT\).

The relation \(\succeq\) represents a relative strength between the attack relations. It is only assumed reflexive. The corresponding strict relation is denoted by \(\succ\). AS denotes the classical system \((A, \ATT, \succeq)\) associated with the argumentation system \(\text{AS}_{\text{vs}} = (A, \ATT, \succeq)\).

Classically, if an argument \(A\) is attacked by an argument \(B\), any attacker of \(B\) is relevant for inhibiting the attack on \(A\), thus defending \(A\). With attacks of different strength, it is natural to require that the attack on \(B\) is strong enough to reinstate \(A\).

The following definition captures the idea of relevant defender:

Def 2 (vs-defence – vs means “various-strength”) Let \(A, B, C \in A\) such that \(C \sucesq B\) and \(B \succeq A\). \(C\) vs-defends \(A\) against \(B\) (or \(C\) is a vs-defender of \(A\) against \(B\)) iff \(\succeq\) is not strictly stronger than the one from \(C\) to \(B\).

Note that a vs-defender exactly corresponds to a “not weak defender” proposed in [6]. We define a vs-admissible (vs-adm) set as a conflict-free set which proposes a valuable defence for each of its elements:

Def 3 (vs-admissibility) Let \(S \subseteq A\). \(S\) is conflict-free in \(AS_{\text{vs}}\) iff \(\forall A, B \in S, B \succeq A\) then \(C \succeq A\) (iff \(S\) is conflict-free in the associated \(AS\) in Dung’s sense). \(S\) vs-defends \(A\) iff \(\forall B \in A, A\) if \(B\) attacks \(A\) then \(\exists C \in S\) such that \(C\) vs-defends \(A\) against \(B\). \(S\) is vs-adm iff \(S\) is conflict-free and \(\forall A \in S, S\) vs-defends \(A\).

vs-admissibility requires the classical notion of conflict-free; so, for any vs-adm set \(S\), no attack may occur between elements of \(S\). And, as vs-defence refines classical defence, each vs-adm set is also admissible (adm for short) in Dung’s sense. The converse is false: Let \(C \succeq B\), with \(\forall C \in A\), \(\forall A, B\); \(\{C, A\}\) is adm but not vs-adm. Note also that the empty set is vs-adm. From the notion of vs-admissibility, it is straightforward to revisit classical semantics, as, for instance, the preferred semantics, which produces maximal (for set-inclusion) adm sets of arguments (for the stable, grounded and complete semantics – see [1]).

Def 4 (preferred vs-extension) Let \(S \subseteq A\) be a vs-adm set. \(S\) is a preferred vs-extension of \(AS_{\text{vs}}\) iff \(\exists S' \subseteq A\) such that \(S \subseteq S'\) and \(S'\) is vs-adm.

Ex 1 Consider \(AS_{\text{vs}}\) with \(A = \{A, B, C_1, C_2\}\), \(\ATT = \{(\cdot,\cdot,\cdot)\}\) with \(\succeq = \{(A, B), (B, A), (C_1, B), (C_2, B)\}\), and \(\succeq\) defined by \(\succeq\) as below. \(AS_{\text{vs}}\) can be depicted by the graph:

\[
\begin{align*}
C_1 & \succeq B \succeq A \\
& \text{if } B \succeq A, C_1 \text{ is the only vs-defender of } A, \\
& \text{otherwise } C_1 \text{ and } C_2 \text{ are vs-defenders of } A. \\
& \text{In both cases, } \{A, C_1, C_2\} \text{ is the only preferred vs-extension.}
\end{align*}
\]

2 Semantics accounting for the quality of defence

A vs-adm set proposes a valuable defence for each of its elements. The next step is to take into account the existence of attacks of various strength for evaluating the quality of a valuable defence, and for selecting vs-adm sets which offer a best defence. If an argument \(B\) attacks an argument \(A\), comparing two attacks against \(B\) enables to compare two defenders of \(A\) against \(B\). So, we propose to compare defences at different levels: comparing two vs-defenders of a same argument, comparing two sets which collectively vs-defend a same argument and comparing two vs-adm sets.

Def 5 (Comparison of vs-defenders) Let \(A, B, C_1, C_2 \in A\) such that both \(C_1\) and \(C_2\) are vs-defenders of \(A\) against \(B\) with \(C_1 \succeq B\) and \(C_2 \succeq B\). \(C_1\) is better than \(C_2\) if \(\succeq\) is strictly better than \(\succeq\) than \(\succeq\).
Now, let $S_1$ and $S_2$ be two sets which collectively vs-defend $A$. We say that the defence of $A$ offered by $S_2$ is as strong as the defence of $A$ offered by $S_1$, denoted by $S_2 \supseteq A S_1$, if $S_2$ improves the defence of $A$ offered by $S_1$ on at least one defender of $A$. The corresponding strict relation is denoted by $S_2 \succ A S_1$.

**Def 6 (Set-comparison wrt the defence of an argument)** Let $S_1$ and $S_2$ be two sets of arguments which vs-defend $A$. $S_2 \supseteq A S_1$ if there exist $C_1 \subseteq S_1$ and $C_2 \subseteq S_2 \setminus S_1$ such that $C_1$ and $C_2$ are vs-defenders of $A$ and $C_2$ is strictly better than $C_1$, $S_2 \supseteq A S_1$ iff $(S_2 \supseteq A S_1$ and not $S_1 \supseteq A S_2$).

**Ex 2** Assume that $C_1$, $C_2$ and $C_3$ are three vs-defenders of $A$ against $B$ with $C_3$ strictly better than $C_2$ and $C_2$ strictly better than $C_1$. We have $\{C_1, C_2, C_3\} \supseteq A \{C_1, C_3\}$ since $C_2$ is strictly better than $C_1$ and $C_2$ does not belong to $\{C_1, C_3\}$. In contrast, according to the definition proposed in [6], these sets are incomparable.

The third step towards the evaluation of the quality of the defence is the comparison of two vs-adm sets. A vs-adm set vs-defends each of its elements. So, it makes sense to compare two vs-adm sets wrt one or several elements of their intersection. So the defence proposed by $S_2$ is said globally as strong as the defence proposed by $S_1$ if $S_2$ offers a stronger defence than $S_1$ for at least one common element.

**Def 7 (Set-comparison of vs-adm sets)** Let $S_1$ and $S_2$ be two vs-adm sets. $S_2 \supseteq A S_1$ if there exists an argument $A$ in $S_1 \cap S_2$ such that $S_2 \supseteq A S_1$, $S_2 \supseteq A S_1$ iff $(S_2 \supseteq A S_1$ and not $S_1 \supseteq A S_2$).

**Ex 3** This example has been taken from [6].

$$F \xrightarrow{E} C \xrightarrow{C} \{B \xrightarrow{B} A\}$$

Assume that $C$ and $D$ are two vs-defenders of $A$ and $F$. Let $S_1 = \{A, C, F\}$ and $S_2 = \{A, D, F\}$. $S_1$ and $S_2$ are vs-adm.

If we assume that $\{B\} \succ A$, we have $S_1 \supseteq A S_2$ and $S_2 \supseteq F S_1$. So, $S_1$ and $S_2$ are equivalent wrt Def 7.

Finally, we come to novel extensional semantics accounting for the quality of the defence. What seems to be relevant is to choose vs-adm sets that fulfill two requirements: (1) offering a strongest defence for their elements (or in other words, a defence which cannot be improved wrt an argument without being damaged wrt another argument) (2) being maximal for set-inclusion (in order to avoid the empty set as an output). This leads to two proposals depending on the priority between these two requirements. The first one produces maximal for set-inclusion strong-adm sets.

**Def 8 (Max-strong-adm set)** Let $S \subseteq A$. $S$ is a strong-adm set iff $S$ is vs-adm and $S$ is maximal for the relation $\supseteq$ (see Def 7) among the vs-adm sets. $S$ is max-strong-adm iff $S$ is strong-adm and $\exists S^* \subseteq A$ such that $S \subseteq S^*$ and $S^*$ is strong-adm.

As the empty set is strong-adm, there always exists at least one max-strong-adm set.

**Ex 4** It is a variant of Ex 3, replacing $D \xrightarrow{D} B$ by $D \xrightarrow{D} B$. Assume that $\{B\} \succ A$, $\{A, C\}$ and $\{A, D\}$ are strong-adm, the defence is at best for $A$ and $D$. $\{A, D\}$ is also strong-adm, the defence is at best for $A$ and for $F$. However, $\{A, C, F\}$ is not strong-adm since $\{A, D, F\} \supseteq \{A, C, F\}$. So, the max-strong-adm sets are $\{A, C\}$ and $\{A, D, F\}$.

An alternative proposal of semantics consists in comparing the global defence offered by preferred vs-extensions. In other words, the quality of the defence is considered only for maximal vs-adm sets. That leads to select strong-preferred sets:

**Def 9 (Strong-preferred set)** Let $S \subseteq A$ be a preferred vs-extension. $S$ is strong-preferred iff $S$ is maximal for the relation $\supseteq$ (Def 7) among the preferred vs-extensions.

**Ex 4 (cont’d)** The preferred vs-extensions are $\{A, D, F\}$ and $\{A, C, F\}$. As $\{A, D, F\} \supseteq \{A, C, F\}$, the only strong-preferred set is $\{A, D, F\}$.

However in some cases, there exists no strong-preferred extension.

Both semantics aim at selecting maximal vs-adm sets defending at best their elements. However, they do not consider the quality of the defence at the same level. A max-strong-adm set $S$ gathers all the arguments that $S$ defends at best. It is as each argument of $S$ would be treated separately. In contrast, a strong-preferred set offers a globally strongest defense for a maximal set of arguments. A deeper discussion of these novel semantics can be found in [1].

3 Concluding remarks

Our proposal is a further contribution to the development of argumentation with various attacks of different strength, based on the abstract framework introduced by [6]. The common basic idea is to use the relative strength of the attacks for disregarding some of the defences. In [6], this idea is formalised by the notion of defense condition, a set of requirements in the relative strength of attacks and counter-attacks. [6] handles expansive sets of defense conditions, and proposes several interesting semantic notions. In contrast, we focus on only one defence condition, the vs-defence, and we come to extensional semantics, by revisiting classical ones, and by investigating defence comparisons.

A subject for further research is the definition of other semantics, related to the decision problem of credulous acceptability: namely, focussing on one particular argument, a classical issue is to compute a proof, under the form of a minimal admissible set containing this argument. Taking into account attacks of various strength suggests to search for the best proofs.

**REFERENCES**


