Towards Ordering Sets of Arguments

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1 Introduction

Formal argumentation [2] describes a family of approaches to modeling rational decision-making through the representation of arguments and their relationships. A particular important representative approach is that of abstract argumentation [5], which focuses on the representation of arguments and a conflict relation between arguments through modeling this setting as a directed graph. Here, arguments are identified by vertices and an *attack* from one argument to another is represented as a directed edge. This simple model already provides an interesting object of study, see [3] for an overview. Reasoning is usually performed in abstract argumentation by considering *extensions*, i. e., sets of arguments that are jointly acceptable given some formal account of "acceptability". Therefore, this classical approach differentiates between "acceptable" arguments and "rejected" arguments.

In this paper, we take a more general perspective on this issue by considering orders—i. e., partial orders in the most general setting—over sets of arguments. So we compare different sets of arguments based on their acceptability and then calculate an order accordingly to this comparison. In this work we discuss this idea in more detail. We motivate our work by presenting cases which are not yet handle, by similar formalism, like *ranking semantics* [1].

This work is structured as follows: First we present abstract argumentation frameworks in Section 2. After motivating our work with a look at related work in Section 3 we turn in Section 4 to a first idea for a research question using classical semantics and discuss why this approach is not enough to order sets of arguments. In Section 5 we present a few ideas for future work approaches.

2 Abstract Argumentation

Following [5], an *(abstract) argumentation framework AF* is a pair $(\mathcal{A}, \mathcal{R})$, where $\mathcal{A}$ is a finite set of arguments and $\mathcal{R}$ is a set of attacks between arguments, i. e. $\mathcal{R} \subseteq \mathcal{A} \times \mathcal{A}$. An argument a is said to *attack* b if $(a, b) \in \mathcal{R}$. We call an argument a *acceptable with respect to a set* $S \subseteq \mathcal{A}$ if for each $b \in \mathcal{A}$ with $(b, a) \in \mathcal{R}$, there is an argument $c \in S$ with $(c, b) \in \mathcal{R}$. An argumentation framework $(\mathcal{A}, \mathcal{R})$ can be illustrated by a directed graph with vertex set $\mathcal{A}$ and edge set $\mathcal{R}$.

Semantics are given to argumentation frameworks by means of *extensions*, i. e., sets of mutually acceptable arguments. An extension E is a set of arguments

$E \subseteq \mathcal{A}$ that is intended to represent a coherent point of view on the argumentation modelled by AF. Arguably, the most important property of a semantics is its admissibility. An extension E is called *admissible* if and only if

1. E is *conflict-free*, i. e., there are no arguments $A, B \in E$ with $(A, B) \in \mathcal{R}$ and
2. Every $A \in E$ is *acceptable with respect to* E,

and it is called *complete* (co) if, additionally, it satisfies

3. A is *acceptable with respect to* E then $A \in E$.

Different types of classical semantics can be phrased by imposing further constraints. In particular, a complete extension E

- is *grounded* (gr) if and only if E is minimal,
- is *preferred* (pr) if and only if E is maximal, and
- is *stable* (st) if and only if $\mathcal{A} = E \cup \{B \mid \exists A \in E : (A, B) \in \mathcal{R}\}$.

Example 1. Consider the abstract argumentation framework AF_1 from Figure 1.In AF_1 there are three complete extensions E_1, E_2, E_3 defined via

$$E_1 = \{A_1\}$$
$$E_2 = \{A_1, A_3\}$$
$$E_3 = \{A_1, A_4\}$$

E_1 is also grounded and E_2 and E_3 are both stable and preferred.

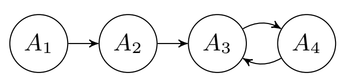

Fig. 1. Abstract argumentation framework AF_1 from Example 1.

3 Motivation

To motivate our work lets first look at related work and see how the approach of ordering semantics is handled there. The so called *ranking-based semantics* [1] is a line of work which provide an assessment of arguments, more precisely they rank arguments based on acceptability i. e. if argument a is at least as acceptable as argument b then $a \succeq^{\sigma} b$. There are a lot of different approaches like a ranking with respect to a categoriser function [7] or based one a two-person zero-sum strategic game [6].

However all these semantics only consider the relationships between arguments and do not look at sets of arguments. We want to compare sets, so we

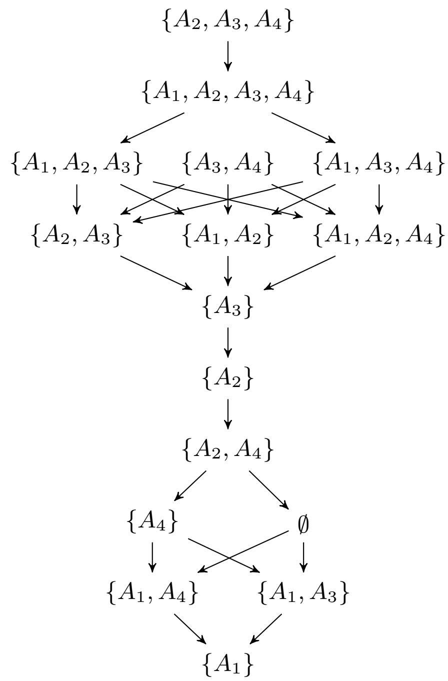

Fig. 2. Ordering $\preceq_{\tau}^{AF}$ from Example 2; arrows indicate that a set is strict acceptability and the most acceptable sets are at the bottom.

propose a different type of semantics the *ordering semantics*, which provides a order over sets of arguments i. e. the set of arguments $\{a, b\}$ is at least as acceptable as the set of arguments $\{c, d\}$ then $\{a, b\} \succeq^{\sigma} \{c, d\}$.

Lets look at an example to motivate this work a little bit better.

Example 2. Consider again the argumentation framework AF_1 from Example 1. Figure 2 shows an exemplary ordering of all sets of arguments.

It is clear, that a set only containing the argument A_1 is more acceptable then any other singleton set. In this example we note that some sets of arguments are not comparable. This can yield some undesirable behavior of the ordering. So we should keep it in mind while constructing a ordering semantics.

4 Research Question

The first step to order sets of arguments is to define a function, which can answer the question: Is a set of arguments s_1 at least as acceptable as a set of arguments s_2? The classical semantics already provide a simple way to answer this question: either the set is an extension or not. So we could define a function like: a set of arguments s_1 is at least as acceptable as a set of arguments s_2 if s_1 is a extension with respect to an semantics σ while s_2 is not a extension with respect to the same semantics σ. However this function provides only two different levels i.e. s is extension or not, and inside these levels we can not differentiate between two sets. So our aim should be to find a way to differentiate two sets on the same level, this is especially relevant when considering two sets of arguments that are no extensions wrt. the classical semantics. With the classical semantics there is no way to differentiate these two sets. It is clear, that not every set of arguments which does not satisfy a specific semantics should be considered acceptable on the same level.

Example 3. Consider the same argument framework AF_1 from Example 1. The set $s_1 = \{A_1\}$ is grounded but not preferred, if we compare this set with the set $s_2 = \{A_3, A_4\}$— a set which is not even conflict-free— based on the preferred semantics, both these sets would be on the same level, the second level. This ordering is correct but not intuitive, s_1 should be on a higher level then s_2.

Based on these observations we can determine two directions we should tackle in detail when we start from the classical semantics:

1. If a classical semantics gives multiple extensions for an argumentation framework, we can differentiate those with different levels of acceptability .
2. For two sets of arguments that are no extensions wrt. the classical semantics, we can differentiate those with different levels of acceptability.

While comparing sets it can occur, that two sets are not comparable and therefore we cannot justify any kind of relationship between these sets. So we cannot order every possible sets easily. We have to keep the incomparable sets in mind if we want to construct any ordering semantics.

5 Future works

The next step we will take is to formally define ordering semantics and based on this definition we will propose different approaches for this problem. For this we again should consider ranking semantics as a starting point. We should try to translate the ideas from a few commonly used ranking semantics, for an overview see [4], to order sets of arguments. Another approach we should consider is the work from Rienstra and Thimm [8]. They do not rank arguments rather they calculate a ranking over labeling using ranking functions. These ranking functions can also yield to a useful ordering semantics.

One step for future work is to find a way to evaluate different ordering semantics approaches. For that we should consider a similar idea as for the evaluation of ranking semantics. Here we look at properties which are satisfied by a ranking semantics, for example the property *Void Precedence* [6, 1] says that an argument without any attack is more acceptable then an argument with at least one attack. In a similar vein we should define properties, which a "good" ordering semantics should satisfy. Based on these properties we can then evaluate any ordering semantics approach.

Another idea is to find a way to combine ranking arguments and ordering sets of arguments. One way is to generate a ranking over arguments based on an ordering over sets of arguments and the other way around, so an ordering based on a ranking. This combination can also yield to an another way to evaluate any approach.

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