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Verification in Incomplete Argumentation Frameworks

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What is Abstract Argumentation?

A tool for non-monotonic reasoning, where an argumentation is modelled as a **directed graph**:

atomic arguments ↔ nodes
binary attack relation ↔ vertices

The objective is to identify sets of arguments that are **simultaneously acceptable** with regard to the attack relation.

Introducing Incompleteness

We want to represent a broader set of application scenarios:

- **intermediate states** in an elicitation process
- when **merging different beliefs** about an argumentation framework's state
- cases where complete information cannot be obtained

Previous work:

- *Attack*-incomplete argumentation frameworks were introduced by Coste-Marquis et al. [3] and studied by us [1] with regard to the complexity of verification.
- *Argument*-incomplete argumentation frameworks were introduced and their complexity was analyzed by us [2].

Argumentation Frameworks [4]

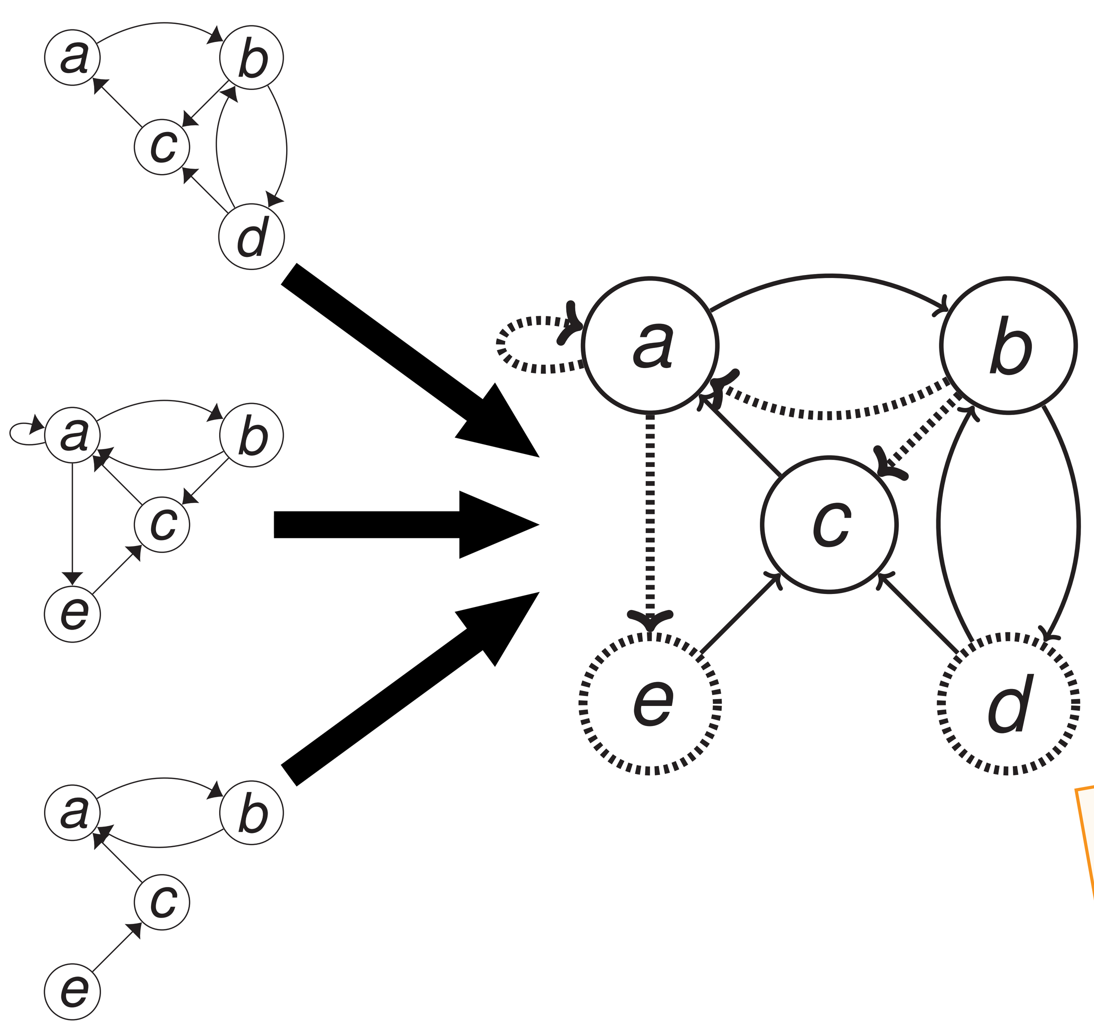
An *argumentation framework* is a pair $\langle \mathcal{A}, \mathcal{R} \rangle$, with a set of *arguments* $\mathcal{A}$ and an *attack relation* $\mathcal{R} \subseteq \mathcal{A} \times \mathcal{A}$.

A subset $S \subseteq \mathcal{A}$ is

- *conflict-free* if $\forall a, b \in S : (a, b) \notin \mathcal{R}$,
- *admissible* if S is conflict-free and $\forall a \in S$: a is acceptable with respect to S,
- *preferred* if S is a maximal (w.r.t. set inclusion) admissible set,
- *stable* if S is conflict-free and $\forall b \in \mathcal{A} \setminus S : \exists a \in S$ with $(a, b) \in \mathcal{R}$,
- *complete* if S is admissible and contains all $a \in \mathcal{A}$ that are acceptable w.r.t. S, and
- *grounded* if S is the least (w.r.t. set inclusion) fixed point of the characteristic function of $\langle \mathcal{A}, \mathcal{R} \rangle$.

An argument $a \in \mathcal{A}$ is *acceptable* w.r.t $S \subseteq \mathcal{A}$ if for each $b \in \mathcal{A}$ with $(b, a) \in \mathcal{R}$ there is a $c \in S$ such that $(c, b) \in \mathcal{R}$.

The *characteristic function* $F_{AF} : 2^{\mathcal{A}} \to 2^{\mathcal{A}}$ of $\langle \mathcal{A}, \mathcal{R} \rangle$ is defined by $F_{AF}(S) = \{a \in \mathcal{A} \mid a \text{ is acceptable w.r.t. } S\}$.



Incomplete Argumentation Frameworks

An *incomplete argumentation framework* is a quadruple $\langle \mathcal{A}, \mathcal{A}^?, \mathcal{R}, \mathcal{R}^? \rangle$, where $\mathcal{A}$ and $\mathcal{A}^?$ are disjoint sets of arguments and $\mathcal{R}$ and $\mathcal{R}^?$ are disjoint subsets of $(\mathcal{A} \cup \mathcal{A}^?) \times (\mathcal{A} \cup \mathcal{A}^?)$.

An argumentation framework $\langle \mathcal{A}^*, \mathcal{R}^* \rangle$ with $\mathcal{A} \subseteq \mathcal{A}^* \subseteq \mathcal{A} \cup \mathcal{A}^?$ and $\mathcal{R}|_{\mathcal{A}^*} \subseteq \mathcal{R}^* \subseteq (\mathcal{R} \cup \mathcal{R}^?)|_{\mathcal{A}^*}$ is called a *completion* of $\langle \mathcal{A}, \mathcal{A}^?, \mathcal{R}, \mathcal{R}^? \rangle$.

$\mathcal{A}$: Arguments known to exist
$\mathcal{A}^?$: Possible additional arguments
$\mathcal{R}$: Attacks known to exist
$\mathcal{R}^?$: Possible additional attacks

For a set $\mathcal{A}^*$ of arguments with $\mathcal{A} \subseteq \mathcal{A}^* \subseteq \mathcal{A} \cup \mathcal{A}^?$, define the *restriction of* $\mathcal{R}$ *to* $\mathcal{A}^*$ by $\mathcal{R}|_{\mathcal{A}^*} = \{(a, b) \in \mathcal{R} \mid a, b \in \mathcal{A}^*\}$.

s-Verification [5]

Given: An argumentation framework $AF = \langle \mathcal{A}, \mathcal{R} \rangle$ and a subset $S \subseteq \mathcal{A}$.
Question: Is S an **s** extension of AF?

S is an **s** extension of $\langle \mathcal{A}, \mathcal{R} \rangle$ if S is **s** in $\langle \mathcal{A}, \mathcal{R} \rangle$, for all **s** $\in$ {conflict-free, admissible, preferred, stable, complete, grounded}.

s-Inc-Possible-Verification (s-IncPV)

Given: An incomplete argumentation framework $IAF = \langle \mathcal{A}, \mathcal{A}^?, \mathcal{R}, \mathcal{R}^? \rangle$ and a set $S \subseteq \mathcal{A} \cup \mathcal{A}^?$.
Question: Is there a completion $AF^* = \langle \mathcal{A}^*, \mathcal{R}^* \rangle$ of IAF such that $S|_{\mathcal{A}^*} = S \cap \mathcal{A}^*$ is an **s** extension of AF^*?

s-Inc-Necessary-Verification (s-IncNV)

Given: An incomplete argumentation framework $IAF = \langle \mathcal{A}, \mathcal{A}^?, \mathcal{R}, \mathcal{R}^? \rangle$ and a set $S \subseteq \mathcal{A} \cup \mathcal{A}^?$.
Question: For all completions $AF^* = \langle \mathcal{A}^*, \mathcal{R}^* \rangle$ of IAF, is $S|_{\mathcal{A}^*} = S \cap \mathcal{A}^*$ an **s** extension of AF^*?

Results

s	Verification [4]	IncPV	IncNV
Conflict-free	in P	in P	in P
Admissible	in P	NP-c.	in coNP
Stable	in P	NP-c.	in coNP
Complete	in P	NP-c.	in coNP
Grounded	in P	NP-c.	in coNP
Preferred	coNP-c.	DP-h., in Σ_2^p	coNP-c.

Next Steps

- Close gaps in complexity results
- Cover new semantics
- Consider other decision problems

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