Resolution-based argumentation semantics

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COMMA 2008, Toulouse, France
The context: Dung’s Argumentation Framework

\[ \text{AF} = \langle A, \rightarrow \rangle \]

**Semantics S**

*Set of extensions* \( \mathcal{E}_s(\text{AF}) \)

**Defeat Status**

*(Justification Status)*

[Justified arguments: belong to all extensions]
Several argumentation semantics

- Grounded Semantics
- Preferred Semantics
- Recent proposals, e.g. prudent, semistable, CF2 semantics

How to evaluate and compare them [without examples]?

- General criteria considering conflict definition (Amgoud, Caminada 07)
- General criteria focusing on semantics definition (Baroni, Giacomin 06)

  - strong admissibility
  - admissibility
  - [weak, CF] reinstatement
  - Directionality
  - I-maximality
  - Skepticism-Adequacy
  - Resolution-Adequacy

NONE OF TRADITIONAL AND RECENT SEMANTICS SATISFY ALL OF THEM
Aim of the work and presentation plan

CAN DESIRABLE CRITERIA BE SATISFIED ALTOGETHER?
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YES!!!

RESOLUTION-BASED SCHEME (see also Modgil 06)
OF SEMANTICS DEFINITION:
From S to S*
Resolution-based grounded semantics
Resolution-based preferred semantics
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CAN DESIRABLE CRITERIA BE SATISFIED ALTOGETHER?

YES!!!

RESOLUTION-BASED SCHEME OF SEMANTICS DEFINITION:
From S to S*
Resolution-based grounded semantics
Resolution-based preferred semantics

PRESENTATION PLAN

1) Review of desirable criteria definitions

2) Definition and evaluation of resolution-based semantics
I-maximality principle

A semantics \( S \) satisfies the "I-maximality principle" iff

\[
\forall AF, \ \forall E_1, E_2 \in \mathcal{C}_S(AF) \text{ if } E_1 \subseteq E_2 \text{ then } E_1 = E_2
\]

- Grounded and preferred (as well as prudent, semistable, ideal and CF2-semantics) satisfy I-maximality
- Complete semantics do not
Admissibility and reinstatement principles

**Admissibility**

∀ AF, ∀ E ∈ \(\mathcal{E}_s(AF)\)

- E is conflict-free
- E defends all of its arguments

**Reinstatement**

∀ AF, ∀ E ∈ \(\mathcal{E}_s(AF)\)

- if E “defends” α then \(α \in E\)

[weak and CF reinstatement entailed]

**Admissibility + reinstatement = complete extensions**

- Grounded and preferred (as well as complete-based) semantics: YES
- CF2 semantics: NO (admissibility is not satisfied)
Directionality principle

Basic idea

Extension membership of an argument is determined by its ancestors, while it is not affected by the arguments it defeats.

Definition

∀ AF, ∀ U “unattacked set” of AF,

\[ \{ (E \cap U) \mid E \in \mathcal{C}_s(AF) \} = \mathcal{C}_s(AF \downarrow_U) \]

Semantics behavior

• Both preferred and grounded semantics satisfy directionality
Directionality: example with preferred semantics

\[ \alpha \rightarrow \beta \rightarrow \delta \]
\[ \alpha \rightarrow \beta \rightarrow \delta \]
\[ \alpha \rightarrow \beta \rightarrow \gamma \]

\[ \alpha \rightarrow \beta \rightarrow \delta \rightarrow \gamma \]
\[ \alpha \rightarrow \beta \rightarrow \delta \rightarrow \gamma \]
\[ \alpha \rightarrow \beta \rightarrow \delta \rightarrow \gamma \]
Skepticism related criteria

The informal notion of skepticism

Making “less|more committed choices” for arguments, i.e. assigning to them “less|more decided” justification states.

Two kinds of skepticism relations

A basic skepticism relation $\preceq^E$ between sets of extensions:

$$E_1 \preceq^E E_2$$

denotes that $E_1$ is “at least as skeptical as” (or “not more committed” than) $E_2$

A skepticism relation $\preceq^A$ between argumentation frameworks:

$$AF_1 \preceq^A AF_2$$

denotes that $AF_1$ is “at least as skeptical as” $AF_2$

Adequacy criteria

Skepticism relations between $AF_1 \leftrightarrow$ Skepticism relations between $E_i$
Skepticism relations between sets of extensions

Comparison between two extensions $E_1$ and $E_2$: $E_1 \subseteq E_2$

**A direct generalization: the $\preceq_E$ relation**

$$E_1 \preceq_E E_2 : \quad \bigcap E_1 \subseteq \bigcap E_2$$

**A finer generalization: the $\preceq_W$ relation**

Comparison between an extension $E_1$ and a set of extensions $E_2$:

$$\forall E_2 \in E_2 \quad E_1 \subseteq E_2 \quad (\text{e.g. GE}_{AF} \text{ contained in any pref. extension})$$

$$E_1 \preceq_W E_2 : \quad \forall E_2 \in E_2, \quad \exists E_1 \in E_1 : E_1 \subseteq E_2$$
Skepticism relation between argumentation frameworks

The Basic idea

More skeptical (less committed)

Less skeptical (more committed)

The General relation

$\text{AF}_1 \ \text{vs.} \ \text{AF}_2$

$\text{AF}_1 \preceq^A \text{AF}_2$
Skepticism relation between argumentation frameworks

\[ \preceq_A \text{-maximal AF [resolutions in (Modgil 06)]} \]
Skepticism-related criteria definition

Skepticism-adequacy of a semantics

Given a skepticism relation $\leq^E$ between sets of extensions, a semantics $S$ is $\leq^E$-adequate iff for any $AF_1$, $AF_2$

$$AF_1 \leq^A AF_2 \implies \mathcal{E}_S (AF_1) \leq^E \mathcal{E}_S (AF_2)$$

Resolution-adequacy of a semantics

Given a skepticism relation $\leq^E$ between sets of extensions, a semantics $S$ is $\leq^E$-resolution-adequate iff for any $AF$

$$\bigcup_{AF' \in \text{RES}(AF)} \mathcal{E}_S (AF') \leq^E \mathcal{E}_S (AF)$$

Implication orders

- $\leq^E_W$-adequacy $\implies \leq^E_\cap$-adequacy
- $\leq^E_W$-resolution-adequacy $\implies \leq^E_\cap$-resolution-adequacy
Adequacy criteria in action: grounded vs. preferred semantics

\[ \mathcal{E}_{GR}(AF) = \{\emptyset\} \]
\[ \mathcal{E}_{PR}(AF) = \{\{\alpha, \delta\}, \{\beta, \delta\}\} \]
\[ U_{AF' \in \text{RES}(AF)} \mathcal{E}_S(AF') = \{\{\alpha, \delta\}, \{\beta, \delta\}\} \]

Preferred semantics: resolution adequate
Grounded semantics: NO
Adequacy criteria in action: grounded vs. preferred semantics

- Grounded semantics: skepticism adequate

\[ \text{GE}_{AF \leftrightarrow (\beta, \alpha)} \subseteq \text{GE}_{AF} \]

\[ \Leftrightarrow \subseteq_{W} - 	ext{adequate} \]

- Preferred semantics: NO

\[ \alpha \text{ and } \beta \text{ definitely justified} \]

All arguments provisionally defeated
Defining resolution-based semantics

The Basic idea

A semantics should be...

$$\mathcal{E}_S (AF) \leq^E \mathcal{E}_S (AF')$$

More skeptical w.r.t. extensions of a resolution

$$\cup_{AF'} \mathcal{E}_S (AF') \leq^E \mathcal{E}_S (AF)$$

Less skeptical w.r.t. extensions of all resolutions

[Grounded semantics: too much skeptical, preferred: too much committed]

The definition

Given a semantics $S$, its resolution-based version is $S^*$ such that

$$\mathcal{E}_{S^*} (AF) = \text{MIN} \ (\cup_{AF' \in \text{RES}(AF)} \mathcal{E}_S (AF'))$$
General desirable properties

I-maximality

• Achieved by definition: $\mathcal{E}_{S^*}(AF) = \text{MIN} \ldots$

Skepticism-adequacy

• For any semantics $S$, $S^*$ satisfies $\preceq_W$-skepticism-adequacy

Resolution-adequacy

• $S$ is I-maximal $\Rightarrow$ $S^*$ satisfies $\preceq_W$-resolution-adequacy

Admissibility and reinstatement

• $S$: complete extensions $\Rightarrow$ $S^*$ satisfies admissibility and reinstatement

BOTH RESOLUTION-BASED GROUNDED AND PREFERRED SEMANTICS SATISFY ALL OF THESE PRINCIPLES
Examples

\[ \mathcal{E}_{PR^*}(AF) = \mathcal{E}_{GR^*}(AF) = \{\{\alpha, \delta\}, \{\beta, \delta\}\} \]

\[ \mathcal{E}_{PR^*}(AF) = \mathcal{E}_{GR^*}(AF) = \{\varnothing\} \]
And directionality?

- Resolution-based **grounded semantics satisfies** directionality
  [see the paper for a –complicated– proof]
- Resolution-based **preferred semantics does not**
And directionality?

- Resolution-based **grounded semantics satisfies** directionality
  
  [see the paper for a –complicated– proof]

- Resolution-based **preferred semantics does not**

\[
\mathcal{E}_{PR^*} : \{\{\alpha, \varepsilon, \eta\}, \{\theta, \iota, \zeta\}\}
\]

\[
\mathcal{E}_{PR^*} : \{\emptyset\}
\]
Conclusions

- All desirable criteria (I-maximality, admissibility, reinstatement, directionality, skepticism adequacy, resolution adequacy) can be satisfied altogether
- Resolution-based version of traditional semantics:
  - GR*: satisfies all desirable criteria
  - PR*: does not satisfy directionality

- Future work:
  - resolution-based version of other semantics
  - is GR* useful in practice?
    ... algorithms and complexity...