

Semantics – Capturing Sets of “Justifiable” Arguments

Paul E. Dunne
Dept. of Computer Science
University of Liverpool
United Kingdom

ECAI 2010 Tutorial: Paul E. Dunne

1

Acceptable Arguments I

- *Acceptance* of a given argument, x , is defined with respect to sets S
 x is *acceptable* w.r.t. S if any attack y on x is itself attacked by some z in S , i.e.
 $\langle y, x \rangle \in A \Rightarrow \exists z \in S \langle z, y \rangle \in A$
- This view, however, ignores any other properties of S

ECAI 2010 Tutorial: Paul E. Dunne

2

Acceptable Arguments II

- S may be “inconsistent”: it might contain arguments – z and w – with $\langle z, w \rangle \in A$.
- S is ‘useful’ as a possible defence only if it is *conflict-free*
 $\forall z, w \in S \langle z, w \rangle \notin A$ and $\langle w, z \rangle \notin A$

ECAI 2010 Tutorial: Paul E. Dunne

3

Admissible Sets of Arguments

- A set of arguments, S , is *admissible* if it is *conflict-free* and each of its members is *acceptable* w.r.t. S .
- Admissible sets provide the basic context for examining ideas of “maximally consistent sets of beliefs”.
- 3 forms are introduced by Dung:
Grounded; *Preferred*; *Stable*

ECAI 2010 Tutorial: Paul E. Dunne

4

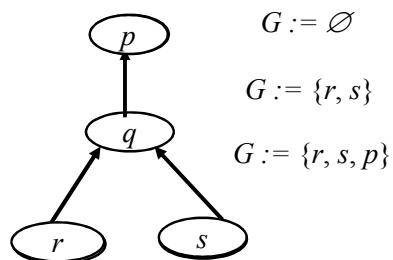
Grounded Extensions

1. $G := \emptyset$
 2. $G := G \cup \{y : y \text{ is acceptable w.r.t. } G\}$
 3. Iterate (2) until no change in G
- Construct the admissible set, G , by simplifying $H(X, A)$ until no further change results: first X has all arguments in G and those attacked by G removed. A is formed by the set of attacks induced by X .

ECAI 2010 Tutorial: Paul E. Dunne

5

Grounded Extensions



ECAI 2010 Tutorial: Paul E. Dunne

6

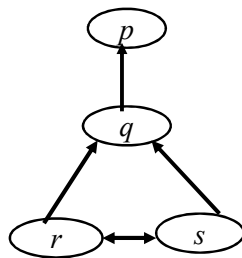
Pros and Cons

- Always some grounded extension
- But it might be the empty set.
- Grounded extension is unique
- But this rules out 'valid' alternatives.
- Can be computed efficiently.

ECAI 2010 Tutorial: Paul E. Dunne

7

Empty Grounded Extension



ECAI 2010 Tutorial: Paul E. Dunne

8

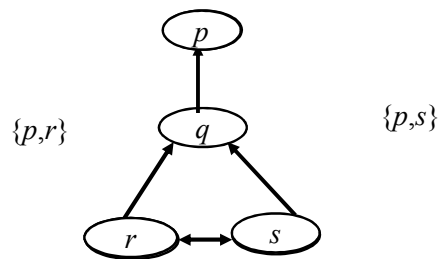
Preferred Extensions

- A *preferred extension* is any *maximal admissible set w.r.t. $\subseteq$* .
- The grounded extension is a subset of every preferred extension.
- An argument system may have more than one preferred extension.

ECAI 2010 Tutorial: Paul E. Dunne

9

Multiple Preferred Extensions



ECAI 2010 Tutorial: Paul E. Dunne

10

Pros and Cons

- Preferred extension always exists.
- But this might still be empty.
- Multiple extensions give rise to richer acceptance classes.
- But this creates complications with interpretation.
- Algorithmic questions are non-trivial.

ECAI 2010 Tutorial: Paul E. Dunne

11

Stable Extensions

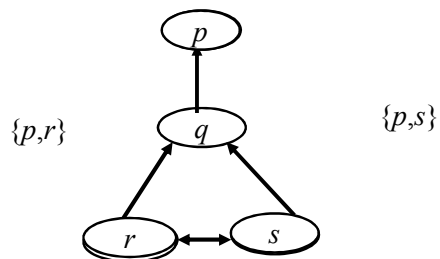
- A *stable extension* is a set S for which every argument, y , that is not in S is attacked by some argument, z , in S , i.e.

$$\forall y \notin S \exists z \in S: \langle z, y \rangle \in A$$
- Every stable extension is a preferred extension, (but not *vice-versa*).

ECAI 2010 Tutorial: Paul E. Dunne

12

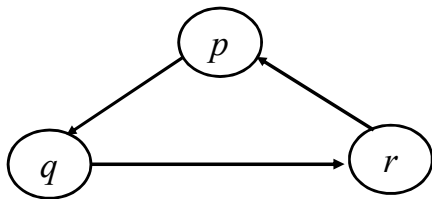
Stable Extensions



ECAI 2010 Tutorial: Paul E. Dunne

13

Case with no stable extension



ECAI 2010 Tutorial: Paul E. Dunne

14

Pros and Cons

- Stable extensions are never empty.
- But there could be *no stable extension*.
- Testing if a given S is stable is “easy”.
- But deciding if any stable extension is present is “hard”.

ECAI 2010 Tutorial: Paul E. Dunne

15

Further notions of “justified” set

- A number of proposals have appeared promoting additional *extension-based* semantics in AFs.
- That is, specifications of predicates, $\sigma(S)$ where $S \subseteq X$ to describe suitable collections of arguments

$$E_{\sigma}(X,A) = \{S \subseteq X : \sigma(S)\}$$

defining the σ -extensions of $\langle X,A \rangle$.

ECAI 2010 Tutorial: Paul E. Dunne

16

Computational problems

- Given $S \subseteq X$ in $\langle X,A \rangle$ decide if $\sigma(S)$. (*Verification*)
- Given $p \in X$ decide if there is any S for which $p \in S$ and $\sigma(S)$. (*Credulous acceptance*)
- Given $p \in X$ decide if $p \in S$ for every S in $E_{\sigma}(X,A)$ (*Sceptical acceptance*)
- Decide if $E_{\sigma}(X,A)$ is non-empty or contains a non-empty element. (*Existence and non-emptiness*)

ECAI 2010 Tutorial: Paul E. Dunne

17

Novel semantics

- These can be considered in two classes
Specific new models
Parametric models
- The latter describe *additional conditions* that can be imposed on sets of arguments that meet the constraints of a “traditional” (or other) extension-based semantics.

ECAI 2010 Tutorial: Paul E. Dunne

18

Semi-stable semantics

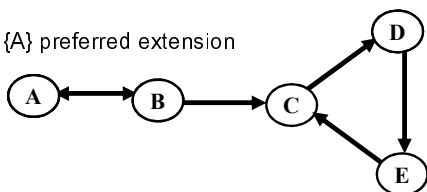
- Introduced in Caminada (2006).
- $\sigma(S)$ holds when S is both *admissible* and the *union* of S with those *arguments attacked* by S is *maximal*.
- Coincident with stable semantics when a stable extension exists.
- Every semi-stable extension is preferred but the converse does not hold.
- Stage semantics use conflict-free sets whose union with those arguments attacked is maximal.

ECAI 2010 Tutorial: Paul E. Dunne

19

Example (from Caminada, 2006)

{A} preferred extension



{B,D} semi-stable extension

ECAI 2010 Tutorial: Paul E. Dunne

20

Why semi-stable extensions?

- Unlike stable case, semi-stable extensions always exist (in *finite* AFs).
- Thus provide an intermediate semantics that combines some properties of admissible, preferred and stable sets.

ECAI 2010 Tutorial: Paul E. Dunne

21

Why not semi-stable extensions?

- Existence issues in *infinite* frameworks: known that there are frameworks with *no semi-stable extension* (construction of Verheij, 2006). Open question as to whether existence guaranteed in *finitary* AFs.
- Computational hardness: credulous acceptance is *harder* than in *any alternative semantics*. (shown in Dvorak & Woltran, IPL, 2010 improving bounds of Dunne & Caminada, JELIA08)

ECAI 2010 Tutorial: Paul E. Dunne

22

Ideal semantics

- Introduced in Dung, Mancarella, and Toni (COMMA 2006, AIJ 2007)
- Motivated by looking for “intermediate sceptical” status between membership in *grounded extension* and membership in *all preferred extensions*.
- Former can be seen as too restrictive; latter too liberal.

ECAI 2010 Tutorial: Paul E. Dunne

23

Ideal Semantics

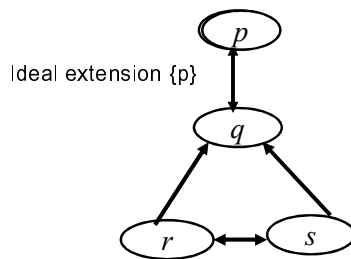
- S is an *ideal set* if it is *admissible* and a *subset of every preferred extension*.
- S is an *ideal extension* if it is a *maximal* such set.
- Ideal semantics are *unique status*: exactly one ideal extension in any AF.
- But this, again, may be the *empty set*.

ECAI 2010 Tutorial: Paul E. Dunne

24

Example

Grounded extension $\emptyset$



ECAI 2010 Tutorial: Paul E. Dunne

25

Ideal semantics

- Also defined in ABFs.
- Testing membership of an argument in the ideal extension is “easier” than testing sceptical acceptance w.r.t. preferred semantics.
- Construction of ideal extension in AFs and ABFs is easier than finding all sceptically accepted arguments.
- These, however, are still “hard”.
- The ideal extension indirectly leads to “efficient” methods for a special case of propositional formula minimization.

ECAI 2010 Tutorial: Paul E. Dunne

26

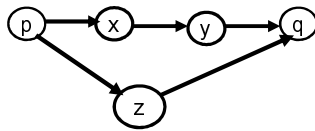
Parametric Models

- *Prudent semantics* consider Dung's notion of “indirect attack” and “controversial arguments”. Considered in work of Coste-Marquis et al (2005+).
- p indirectly attacks q if “there is an odd length sequence of attacks from p to q ” (direct attack has length 1).
- Although $\{p, q\}$ may be (Dung) conflict-free, prudent semantics argue that these should *not be regarded as such* in the presence of indirect attacks.

ECAI 2010 Tutorial: Paul E. Dunne

27

Example



$\{p, q\}$ (Dung) admissible, but p both defends q (against z) and (*indirectly attacks* q (by defending y against x)

ECAI 2010 Tutorial: Paul E. Dunne

28

A problem

- Although the concept of “*indirect attack*” is from Dung’s original paper this does not elaborate the interpretation of “*an odd length sequence of attacks from p to q*”.
- For example: *simple* path? repeated *arguments*? repeated *attacks*?
- The last two raise issues with semantics, the first, however, has the computational drawback that deciding if $\{p, q\}$ is *prudently conflict-free* is hard via a result of Lapaugh and Papadimitriou from 1984.

ECAI 2010 Tutorial: Paul E. Dunne

29

Resolution-based semantics

- Proposed by Baroni and Giacomin (COMMA 2008).
- Builds on the observation that many problems in interpreting AF argument status stem from “*mutually attacking arguments*”, i.e. pairs $\{p, q\}$ where both $\langle p, q \rangle$ and $\langle q, p \rangle$ are attacks.

ECAI 2010 Tutorial: Paul E. Dunne

30

Resolution-based semantics

- Extension based semantics are proposed relative to the (set of) AFs that are the result of *resolving* all mutual attacks, that is removing exactly one of $\{<p,q>, <q,p>\}$ in each case.
- Resulting extensions are chosen as the *minimal* $\sigma(S)$ sets over all resolutions.
- For example, the *resolution-based grounded extensions* of $<X,A>$ select the *minimal* sets among the grounded extensions over all possible resolutions of $<X,A>$.

ECAI 2010 Tutorial: Paul E. Dunne

31

Resolution-based semantics

- Resolution-based grounded semantics have a number of significant semantic benefits as discussed in Baroni and Giacomin's paper.
- These have been shown to be achievable without losing computational efficiency. (Baroni, Dunne, and Giacomin, IJCAI 2009; COMMA 2010)

ECAI 2010 Tutorial: Paul E. Dunne

32

"A plethora of semantics" (Simari, 2006)

- Proliferating new notions of "set of justifiable arguments" begins to resemble the (doomed) quest for "the ultimate non-monotonic logic" (late 1970s onward).
"various kinds of motivations have been used to support the introduction of new semantics w.r.t. 'classical' proposals ... these kinds of heterogeneous intuitions hardly lend themselves to systematic comparisons ... it is not surprising that comparisons are ... ingeniously devised so as to bring to light patently different behaviours ..."
P. Baroni & M. Giacomin, AIJ, 171:675-700, 2007

ECAI 2010 Tutorial: Paul E. Dunne

33

Principle-based evaluation

- Rather than engineer finely nuanced distinctive extension-based semantics, more promising approaches focus on characteristics that “reasonable semantics” should have.
- The paper by Baroni & Giacomini identifies a number of criteria setting out conditions as a basis for evaluating any semantics. Other mechanisms are proposed in Caminada & Amgoud (AIJ, 171:286-310, 2007).

ECAI 2010 Tutorial: Paul E. Dunne

34

Summary

- The concept of “extension-based” semantics as capturing sets of justifiable arguments has proved a core idea within AFs.
- Dung’s “canonical” semantics have since been extended (including a number of techniques, e.g. CF2, not discussed above) resulting in a wide ranging collection of views.
- Rather than debate the merits of semantics X over semantics Y, recent trends have started to focus on features that proposals should have in common, rather than solely on what makes them distinctive.

ECAI 2010 Tutorial: Paul E. Dunne

35
