3. Argumentation Frameworks

- Argumentation current hot topic in AI.
- Historically more recent than other approaches discussed here.
- Basic idea: to construct acceptable set(s) of beliefs from given KB:
  1. construct arguments (beliefs with associated reasons),
  2. determine jointly acceptable arguments (extensions),
  3. accept their conclusions.
- Assumption: step 2 can be done independently and abstractly.
- Dung's Abstract Argumentation Frameworks widely used tool.

Argumentation Frameworks, ctd.

Abstract Argumentation

- Arguments are “atomic”, their structure irrelevant.
- All that matters are attacks among arguments.
- Argumentation frameworks (AFs) represent attack relations.
- Semantics formalize different intuitions about how to solve conflicts and how to pick acceptable arguments.
- Semantics map an AF to subsets of its arguments (extensions).
- Nonmonotonic: new argument may throw out what was accepted.

Definition

Argumentation Frameworks

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- A is a set of arguments,
- $R \subseteq A \times A$ is a relation representing "attacks". ("defeats")

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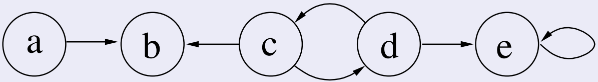

Semantics: minimal requirement no conflicts

Conflict-Free Set

Given an AF $F = (A, R)$.
A set $S \subseteq A$ is conflict-free in F, if, for each $a, b \in S$, $(a, b) \notin R$.

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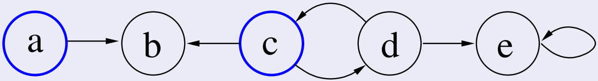

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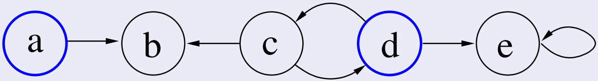

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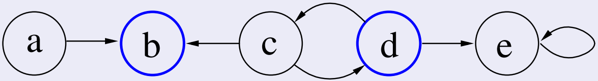

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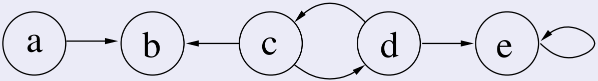

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No undefended attacked arguments

Admissible Set

Given an AF $F = (A, R)$. A set $S \subseteq A$ is admissible in F, if

- S is conflict-free in F
- each $a \in S$ is defended by S in F,
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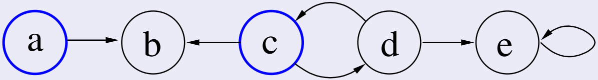

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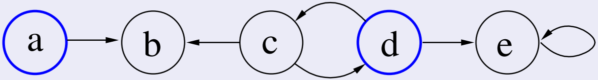

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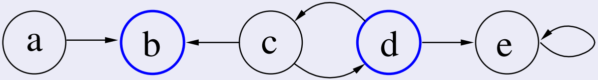

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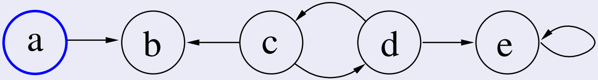

$adm(F) = \{\{a, c\}, \{a, d\}, \sout{\{b, d\}}, \{a\}, \sout{\{b\}}, \{c\}, \{d\}, \emptyset\}$

Want all defended arguments

Complete Set

Given an AF $F = (A, R)$. A set $S \subseteq A$ is complete in F, if

- S is admissible in F
- each $a \in A$ defended by S in F is contained in S
  - $a \in A$ is defended by S in F, if for each $b \in A$ with $(b, a) \in R$, there exists a $c \in S$, such that $(c, b) \in R$.

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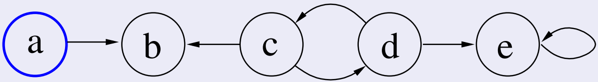

$comp(F) = \{\{a, c\}, \{a, d\}, \{a\},$ ~~$\{c\}, \{d\}, \emptyset$~~ $\}$

A skeptical approach

Grounded Extension

Given an AF $F = (A, R)$. A set $S \subseteq A$ is grounded in F, if

- S is complete in F
- for each $T \subseteq A$ complete in F, $T \not\subset S$

Proposition [Dung 95]: The grounded extension of an AF $F = (A, R)$ is given by the least fix-point of the operator $\Gamma_F : 2^A \to 2^A$, defined as $\Gamma_F(S) = \{a \in A \mid a \text{ is defended by } S \text{ in } F\}$

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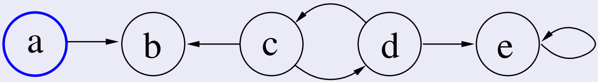


$ground(F) = \{$ ~~$\{a, c\}, \{a, d\},$~~ $\{a\}\}$

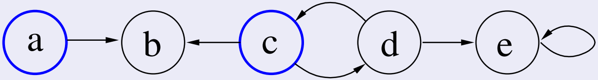
A credulous approach

Stable Extension

Given an AF $F = (A, R)$. A set $S \subseteq A$ is stable in F, if

- S is conflict-free in F
- for each $a \in A \setminus S$, there exists a $b \in S$, such that $(b, a) \in R$.

Example



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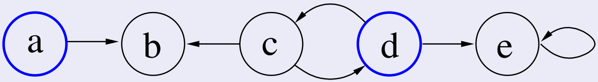

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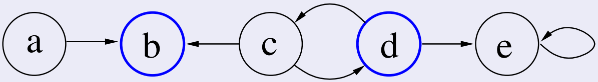

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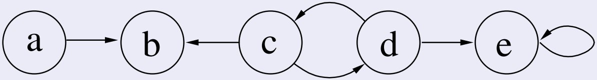

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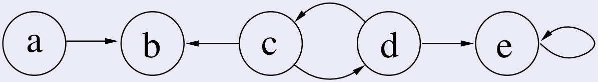
Guaranteeing existence of extensions

Preferred Extension

Given an AF $F = (A, R)$. A set $S \subseteq A$ is preferred in F, if

- S is admissible in F
- for each $T \subseteq A$ admissible in T, $S \not\subset T$

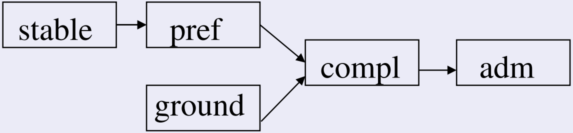
Example



$pref(F) = \{\{a, c\}, \{a, d\},$ ~~$\{a\}, \{c\}, \{d\}, \emptyset$~~ $\}$

Complexity

Relation between Semantics



Complexity

	stable	*adm*	*pref*	*comp*	*ground*
Cred	NP-c	NP-c	NP-c	NP-c	in P
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[Dimopoulos & Torres 96; Dunne & Bench-Capon 02; Coste-Marquis *et al.* 05]

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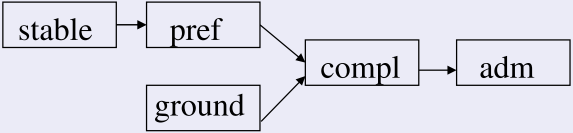

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Further results and conclusions

- AFs: simple graph representation of argumentation scenarios.
- Semantics map AFs to a collection of sets of arguments.
  - grounded: (1) accept unattacked args, (2) delete args attacked by accepted args, (3) goto 1, stop when fixpoint reached.
  - preferred: maximal conflict-free sets attacking all their attackers.
  - stable: conflict free sets attacking all unaccepted args.
- Grounded always unique, others may produce multiple extensions.
- Unlike stable extensions preferred extensions always exist.
- Grounded extension subset of each preferred (and thus each stable) extension.
- Extending an AF may change extensions nonmonotonically.
- Many other semantics have been defined.

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Restrictions of AFs

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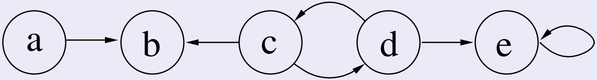

- Fixed meaning of links: attack.
- Fixed acceptance condition for args: no parent accepted.
- Want more flexibility:
  1. Links supporting arguments/positions,
  2. Nodes not accepted unless supported,
  3. Flexible means of combining attack and support.
- From *calculus of opposition* to *calculus of support and opposition*.
- Current work in our group: generalize to *Dialectical Frameworks* where each node has its own acceptance condition.

Argumentation in AI (ctd.)

Literature

- C. Chesnevar, A. Maguitman, R. Loui: *Logical models of argument*. ACM Comput. Surv. 32(4): 337-383 (2000)
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- P. Besnard, A. Hunter: *Elements of Argumentation*. The MIT Press (2008).
- G. Simari, I. Rahwan (eds.): *Argumentation in Artificial Intelligence*. Springer, 2009.