TECHNISCHE UNIVERSITÄT DRESDEN

Artificial Intelligence, Computational Logic

SEMINAR ABSTRACT ARGUMENTATION

Introduction to Formal Argumentation

Sarah Gaggl

Dresden, 17th October 2016

DRESDEN concept Exzellenz aus Wissenschaft und Kultur

Organisation

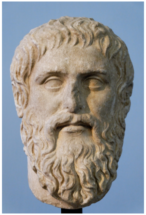
Learning Outcomes

- The students will get an overview of recent research topics within the field of abstract argumentation
- The students will be able to write a scientific article and give a scientific presentation
- The students will participate in a peer-reviewing process

Organisation:

- 3 introductory lectures
  - Lecture 1: 17.10.2016
  - Lecture 2: 24.10.2016
  - Lecture 3: 07.11.2016
- In last lecture (07.11.2016): article selection
- Students will read related literature and write a seminar paper of 4-5 pages till 9.12.2016
- Each student will review 3 seminar papers from colleagues: 12.12.2016-6.1.2017
- Revised version of seminar paper are due to 20.1.2017
- Each student will give a 20 min talk (plus 10 min discussion) about his/her article: 23.1.2017-27.1.2017
- Send the slides no later than 1 week before presentation to sarah.gaggl@tu-dresden.de for feedback

Argumentation in History



Plato's Dialectic

The dialectical method is discourse between two or more people holding different points of view about a subject, who wish to establish the truth of the matter guided by reasoned arguments.

The Republic (Plato), 348b

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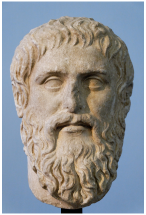

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Leibniz' Dream

"The only way to rectify our reasonings is to make them as tangible as those of the Mathematicians, so that we can find our error at a glance, and when there are disputes among persons, we can simply say: Let us calculate [calculemus], without further ado, to see who is right."

Leibniz, Gottfried Wilhelm, The Art of Discovery 1685, Wiener 51

Argumentation Nowadays

Abstract Argumentation [Dung, 1995]

- In abstract argumentation frameworks (AFs) statements (called arguments) are formulated together with a relation (attack) between them.
- Abstraction from the internal structure of the arguments.
- The conflicts between the arguments are resolved on the semantical level.

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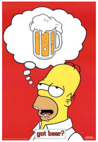

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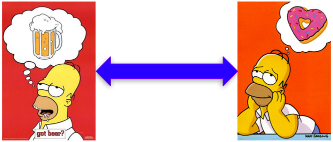

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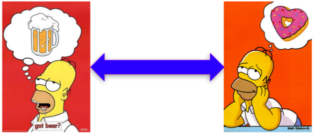

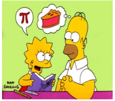

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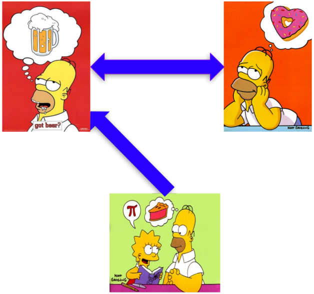

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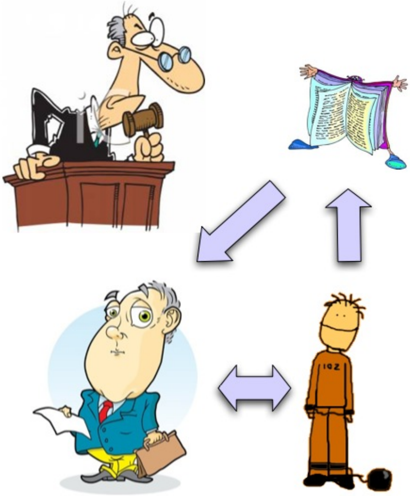
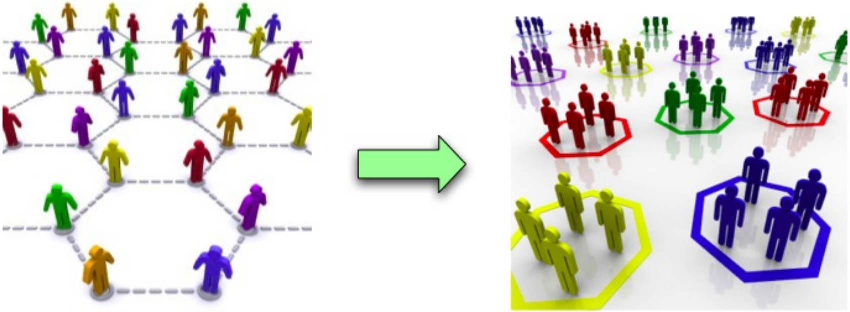
Legal Reasoning



Decision Support

Social Networks



Roadmap for the Lecture

- Introduction
- Abstract Argumentation Frameworks
  - Syntax
  - Semantics
  - Properties of Semantics
- Implementation Techniques
  - Reduction-based vs. Direct Implementations
  - Reductions to SAT
  - Reductions to ASP
- Generalizations of Abstract Argumentation Frameworks
- Students' Topics

Introduction

Argumentation:

. . . the study of processes "concerned with how assertions are proposed, discussed, and resolved in the context of issues upon which several diverging opinions may be held".

[Bench-Capon and Dunne, Argumentation in AI, AIJ 171:619-641, 2007]

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Formal Models of Argumentation are concerned with

- representation of an argument
- representation of the relationship between arguments
- solving conflicts between the arguments ("acceptability")

Introduction (ctd.)

Increasingly important area

- "Argumentation" as keyword at all major AI conferences
- dedicated conference: COMMA, TAFA workshop; and several more workshops
- specialized journal: Argument and Computation (Taylor & Francis)
- two text books:
  - Besnard, Hunter: Elements of Argumentation. MIT Press, 2008
  - Rahwan, Simari (eds.): Argumentation in Artificial Intelligence. Springer, 2009.

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Handbook of Formal Argumentation HOFA

- `http://formalargumentation.org`
- Volume 1 to appear in 2017

The Overall Process

Steps

- Starting point: knowledge-base
- Form arguments
- Identify conflicts
- Abstract from internal structure
- Resolve conflicts
- Draw conclusions

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$$\Delta = \{s, r, w, s \rightarrow \neg r, r \rightarrow \neg w, w \rightarrow \neg s\}$$

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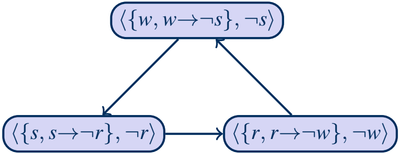

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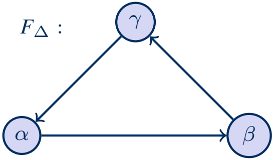

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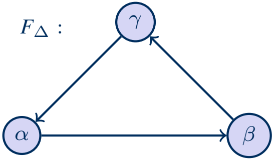

$$pref(F_\Delta) = \{\emptyset\}$$
$$stage(F_\Delta) = \{\{\alpha\}, \{\beta\}, \{\gamma\}\}$$

The Overall Process

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- Starting point: knowledge-base
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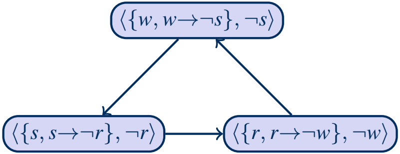

$$Cn_{pref}(F_\Delta) = Cn(\top)$$
$$Cn_{stage}(F_\Delta) = Cn(\neg r \vee \neg w \vee \neg s)$$

The Overall Process (ctd.)

Some Remarks

- Main idea dates back to Dung [1995]; has then been refined by several authors (Prakken, Gordon, Caminada, etc.)
- Separation between logical (forming arguments) and nonmonotonic reasoning ("abstract argumentation frameworks")
- Abstraction allows to compare several KR formalisms on a conceptual level ("calculus of conflict")

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Main Challenge

- All Steps in the argumentation process are, in general, intractable.
- This calls for:
  - careful complexity analysis (identification of tractable fragments)
  - re-use of established tools for implementations (reduction method)

Approaches to Form Arguments

Classical Arguments [Besnard & Hunter, 2001]

- Given is a KB (a set of propositions) Δ
- argument is a pair (Φ, α), such that $\Phi \subseteq \Delta$ is consistent, $\Phi \models \alpha$ and for no $\Psi \subset \Phi$, $\Psi \models \alpha$
- conflicts between arguments (Φ, α) and (Φ', α') arise if Φ and α' are contradicting.

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Example

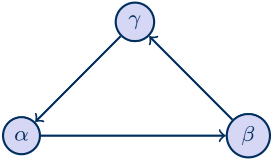
$$\langle \{s, s \rightarrow \neg r\}, \neg r \rangle \longrightarrow \langle \{r, r \rightarrow \neg w\}, \neg w \rangle$$

Other Approaches

- Arguments are trees of statements
- claims are obtained via strict and defeasible rules
- different notions of conflict: rebuttal, undercut, etc.

Dung's Abstract Argumentation Frameworks

Example



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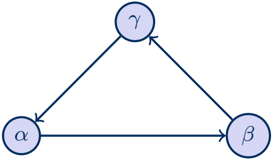

Main Properties

- Abstract from the concrete content of arguments but only consider the relation between them
- Semantics select subsets of arguments respecting certain criteria
- Simple, yet powerful, formalism
- Most active research area in the field of argumentation.
    - "plethora of semantics"

Dung's Abstract Argumentation Frameworks

Definition

An argumentation framework (AF) is a pair (A, R) where

- A is a set of arguments
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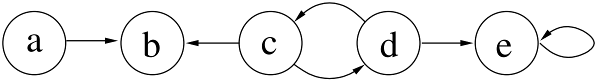
Example

$F = (\ \{a, b, c, d, e\}\ ,\ \{(a, b), (c, b), (c, d), (d, c), (d, e), (e, e)\}\ )$



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Conflict-Free Sets

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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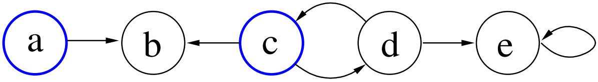

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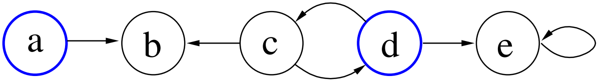

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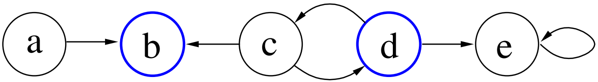

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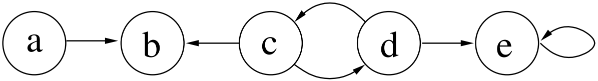

$cf(F) = \{\{a, c\}, \{a, d\}, \{b, d\}, \{a\}, \{b\}, \{c\}, \{d\}, \emptyset\}$

Basic Properties (ctd.)

Admissible Sets [Dung, 1995]

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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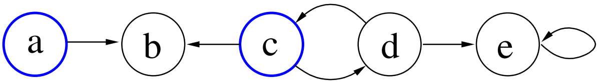

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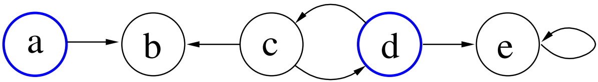

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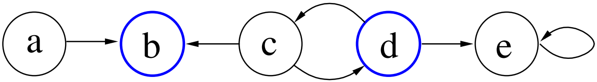

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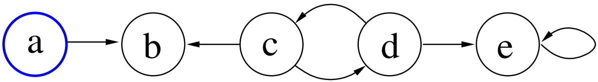

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Basic Properties (ctd.)

Dung's Fundamental Lemma

Let S be admissible in an AF F and a, a' arguments in F defended by S in F. Then,

1. $S' = S \cup \{a\}$ is admissible in F
2. a' is defended by S' in F

Semantics

Naive Extensions

Given an AF $F = (A, R)$. A set $S \subseteq A$ is a naive extension of F, if

- S is conflict-free in F
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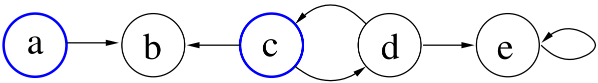

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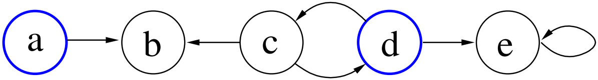

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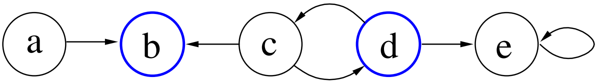

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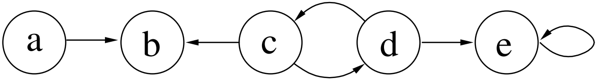

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Semantics (ctd.)

Grounded Extension [Dung, 1995]

Given an AF $F = (A, R)$. The unique grounded extension of F is defined as the outcome S of the following "algorithm":

1. put each argument $a \in A$ which is not attacked in F into S; if no such argument exists, return S;
2. remove from F all (new) arguments in S and all arguments attacked by them (together with all adjacent attacks); and continue with Step 1.

Semantics (ctd.)

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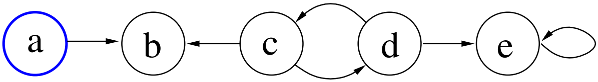
Given an AF $F = (A, R)$. The unique grounded extension of F is defined as the outcome S of the following "algorithm":

1. put each argument $a \in A$ which is not attacked in F into S; if no such argument exists, return S;
2. remove from F all (new) arguments in S and all arguments attacked by them (together with all adjacent attacks); and continue with Step 1.

Example



$ground(F) = \{\{a\}\}$

Semantics (ctd.)

Complete Extension [Dung, 1995]

Given an AF (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
    - Recall: $a \in A$ 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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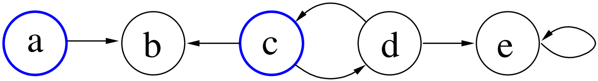

$comp(F) = \{\{a, c\},$

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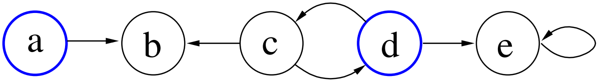

$comp(F) = \{\{a, c\}, \{a, d\},$

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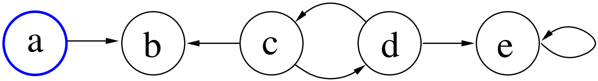

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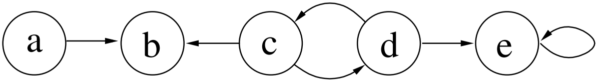

$comp(F) = \{\{a, c\}, \{a, d\}, \{a\}, \sout{\{c\}, \{d\}, \emptyset}\}$

Semantics (ctd.)

Properties of the Grounded Extension

For any AF F, the grounded extension of F is the subset-minimal complete extension of F.

Semantics (ctd.)

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Remark

Since there exists exactly one grounded extension for each AF F, we often write $\mathit{ground}(F) = S$ instead of $\mathit{ground}(F) = \{S\}$.

Semantics (ctd.)

Preferred Extensions [Dung, 1995]

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

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

Semantics (ctd.)

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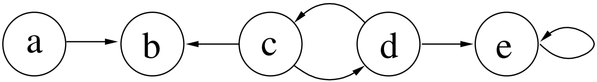

$pref(F) = \{\{a, c\}, \{a, d\}, \sout{\{a\}, \{c\}, \{d\}, \emptyset}\}$

Semantics (ctd.)

Stable Extensions [Dung, 1995]

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

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

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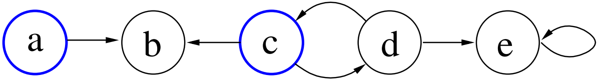

$stable(F) = \{ \{a, c\} \}$

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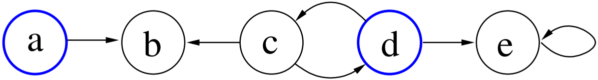

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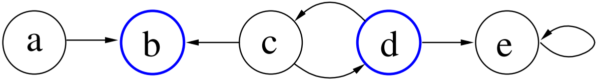

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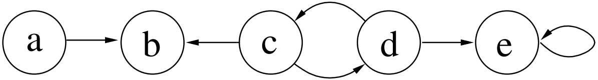

$stable(F) = \{$ ~~$\{a, c\}$~~, $\{a, d\}$, ~~$\{b, d\}$~~, ~~$\{a\}$~~, ~~$\{b\}$~~, ~~$\{c\}$~~, ~~$\{d\}$~~, ~~$\emptyset$~~, $\}$

Semantics (ctd.)

Some Relations

For any AF F the following relations hold:

1. Each stable extension of F is admissible in F
2. Each stable extension of F is also a preferred one
3. Each preferred extension of F is also a complete one

P. Baroni and M. Giacomin.
Semantics of abstract argument systems.
In Argumentation in Artificial Intelligence, pages 25–44. Springer, 2009.

T.J.M. Bench-Capon and P.E.Dunne.
Argumentation in AI,
AIJ 171:619-641, 2007

P. M. Dung.
On the acceptability of arguments and its fundamental role in nonmonotonic reasoning, logic programming and n-person games.
Artif. Intell., 77(2):321–358, 1995.