Knowledge Base Change and Abstract Dialectical Frameworks

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Motivation

- Argumentation is naturally situated in an evolving context
- Formal models of argumentation hence require change operators
- Usually argumentation frameworks (AFs) are used as the modeling language
- Abstract Dialectical Frameworks (ADFs) are a generalization, which express relations of arguments with propositional logic
- We want to study the relation between knowledge base change and ADFs
- We want to present preliminary considerations on this topic and future research directions

Argumentation Framework [Dung, 1995]

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

- A is a set of arguments
- $R \subseteq A \times A$ is a relation representing the conflicts (“attacks”)

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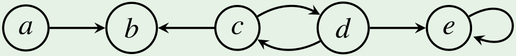

Stable Extensions [Dung, 1995]

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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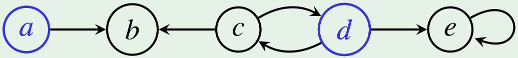

$st(F) = \{\{a, d\}\}$

Argumentation Semantics

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.

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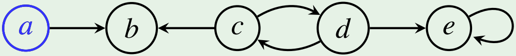

$ground(F) = \{\{a\}\}$

The Overall Process

Steps

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

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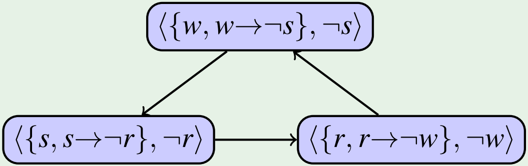

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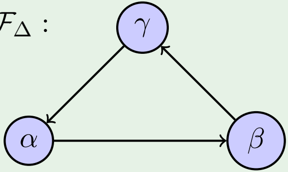

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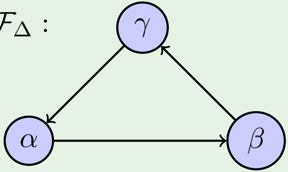

$$ground(\mathcal{F}_\Delta) = \{\emptyset\}$$

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

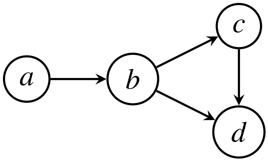
$$\begin{tikzcd}
 & \boxed{\langle \{w, w \to \neg s\}, \neg s \rangle} \arrow[dl] & \\
\boxed{\langle \{s, s \to \neg r\}, \neg r \rangle} \arrow[rr] & & \boxed{\langle \{r, r \to \neg w\}, \neg w \rangle} \arrow[ul]
\end{tikzcd}$$

$$Cn_{ground}(\mathcal{F}_\Delta) = Cn(\top)$$

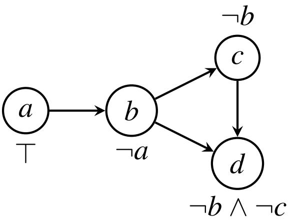
ADF Motivation

- Abstract dialectical frameworks (ADF) generalize AFs to capture general relations between arguments
- ADF remain on the abstract level as AFs
- Relationships are modeled through acceptance conditions for each argument using propositional logic
- Notions like support and collective attack can be expressed easily in ADFs
- Related approaches: [Gabbay, 2009, Weydert, 2011]

ADF Basic Idea



An Argumentation Framework



An Abstract Dialectical Framework

Abstract Dialectical Framework [Brewka and Woltran, 2010]

An abstract dialectical framework (ADF) is a pair $D = (S, C)$ where

- $S = \{s_1, ..., s_n\}$ is a finite set of arguments
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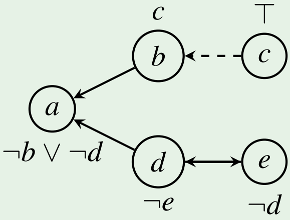

ADF Model

Given an ADF $D = (S, C)$. A set $M \subseteq S$ is a model of D if for each $s \in S$: $s \in M$ iff $C_s^M = 1$.

ADF Semantics

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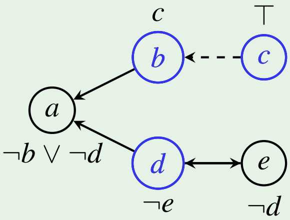

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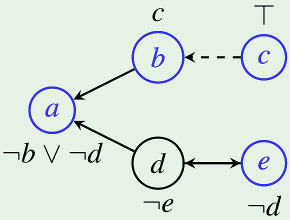

$mod(D) = \{\{b, c, d\}, \{a, b, c, e\}\}$

ADF Stable Model

Given a bipolar ADF $D = (S, C)$. A set $M \subseteq S$ is a stable model of D if it is a model and a minimal model of the reduct D^M, where

- all arguments outside of M are removed and
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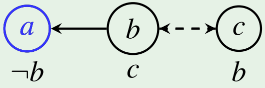

$st\_mod(D) = \{\{a\}\}$

Well-founded Model

Given an ADF $D = (S, C)$. The unique well-founded model of D is defined as the outcome A of the following “algorithm”:

1. put each argument $a \in S$ into
   - A if it has a valid acceptance condition
   - R if it has an unsatisfiable acceptance condition

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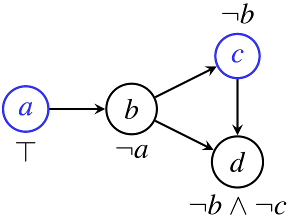
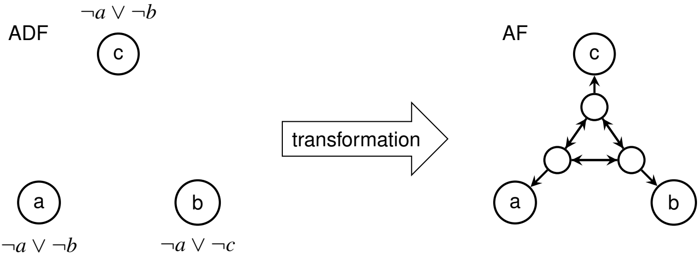


ADF as a Modeling Tool

- ADFs can be seen as a modeling tool for AFs
- Work on AFs can be shifted to ADFs, reducing auxiliary structure needs
- ADFs can then be transformed to AFs if needed ([Brewka et al., 2011])



1. Argumentation
   - Argumentation Frameworks
   - Argumentation Process
2. Abstract Dialectical Frameworks
   - Motivation
   - Semantics
3. Dynamics and ADFs
   - Dynamic Argumentation Process
   - Knowledge Base Change and ADFs
4. Future Work

Process

- Knowledge-base
- Instantiation
- Abstract Framework
- Conflict Resolution
- Conclusions

Dynamics in Argumentation

Process

- Knowledge-base
- Instantiation
- **Abstract Framework**
- Conflict Resolution
- Conclusions

- Everything in the argumentation process is potentially dynamic:
  - Knowledge bases may change over time
  - Different semantics may be applied
  - Instantiation schemes may be changed
- Here we focus on change operations on the abstract layer
- Related work, e.g.: [Cayrol et al., 2010], [Rotstein et al., 2008].

Knowledge Base Change Introduction

- Knowledge base change deals with the following question:
  - Given a knowledge base KB
  - and I, the information that led to KB
  - how to change KB if I changes?
- In our context: how to change an ADF in light of new information?
- Change operations should not introduce inconsistencies
  - Inconsistency of conclusions (rationality postulates)
  - Inconsistency of acceptance conditions
- Knowledge base change provides well studied operations for changing propositional formulae
- Overview given in: [Peppas, 2008], and for knowledge base change: [Katsuno and Mendelzon, 1991]

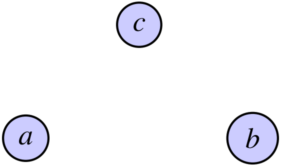
Revision Postulates (Katsuno and Mendelzon Style)

- R1 $\phi \circ \mu \models \mu$
- R2 If $\phi \wedge \mu$ is satisfiable, then $\phi \circ \mu \equiv \phi \wedge \mu$
- R3 If μ is satisfiable, then so is $\phi \circ \mu$
- R4 If $\phi_1 \equiv \phi_2$ and $\mu_1 \equiv \mu_2$, then $\phi_1 \circ \mu_1 \equiv \phi_2 \circ \mu_2$
- R5 $(\phi \circ \mu) \wedge \psi \models \phi \circ (\mu \wedge \psi)$
- R6 If $(\phi \circ \mu) \wedge \psi$ is satisfiable, then $\phi \circ (\mu \wedge \psi) \models (\phi \circ \mu) \wedge \psi$

ADF Change Example

$$\langle \{a \rightarrow b\}, a \rightarrow b \rangle$$

$$\langle \{a\}, a \rangle \qquad \langle \{\neg b\}, \neg b \rangle$$


c
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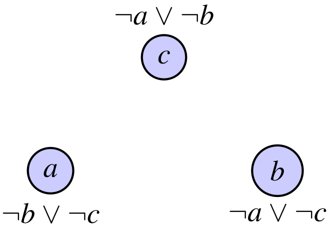
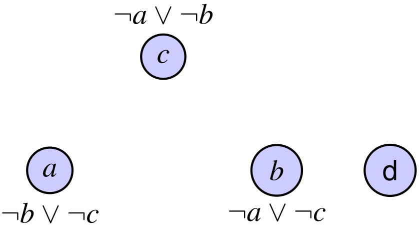


Argument Addition

- Task: We learn new information and add an argument
- Idea: Revise affected acceptance condition by revision
- Example: Add argument $\langle b, b \rangle$ by revision operator $\circ$



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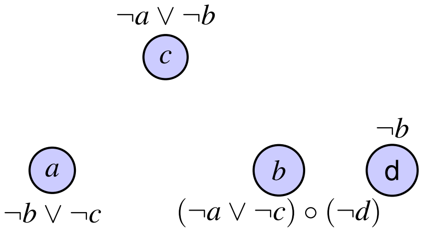

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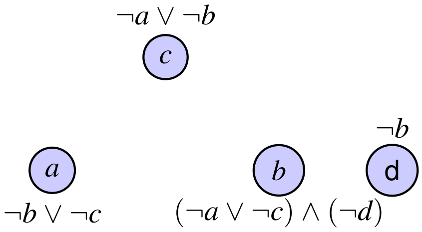

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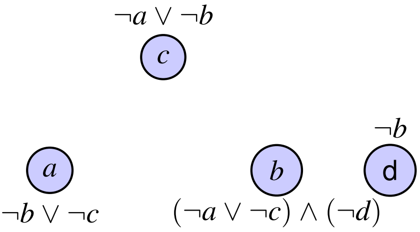
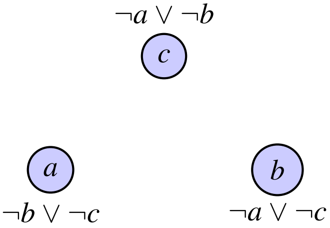


- In case of consistent revision: $\phi \circ \psi \equiv \phi \wedge \psi$
- Future work: Generalize for different instantiations and investigation of updates, e.g. change attack to support

Argument Removal

- Task: Remove arguments
- Idea: Use “forget” operator in affected acceptance conditions
- Example: Remove argument c by forget operator •



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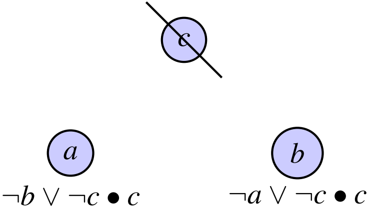

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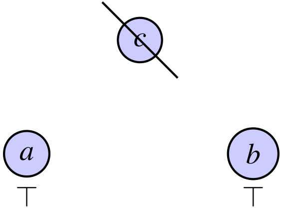

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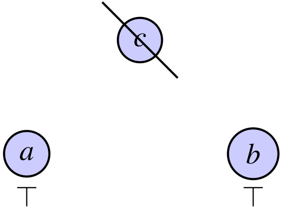

- Removal in this case does not require non-abstract knowledge
- Future work: Again generalization for other instantiation schemes is required

Future Work

- Generalization of AFs by incorporating propositional formulae eases expressing relations
- Dynamics of ADF seems to be strongly related to the field of knowledge base change
- Future work: rigorous investigation of knowledge base change operators for ADFs
- Provide change operations on ADFs for different needs
- Can we formulate postulates for ADF change as was done for knowledge base change?

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