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The Hidden Power of Abstract Argumentation Semantics

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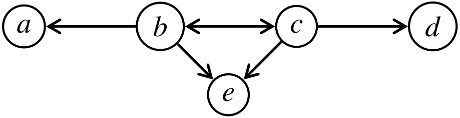
Introduction

- Abstract Argumentation Framework [Dung, 1995]:



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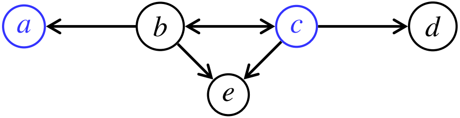

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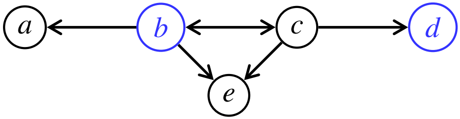

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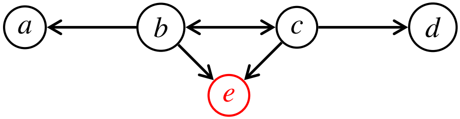

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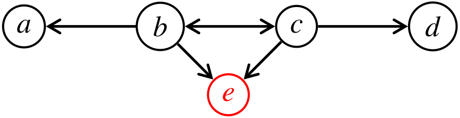

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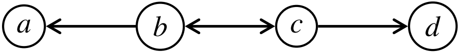

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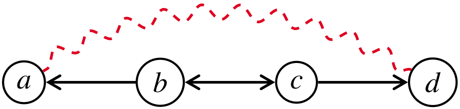

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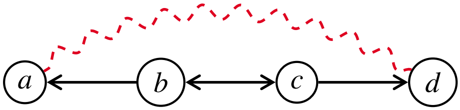

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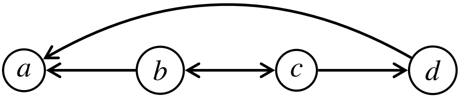

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Motivation

- Systematic comparison of argumentation semantics [Baroni and Giacomin, 2007, Dunne et al., 2014].
- Normal form.
  - Succinct representation of argumentation frameworks.
  - Minimal number of arguments $\Rightarrow$ no rejected arguments.
  - Maximal number of attacks $\Rightarrow$ no implicit conflicts.
- Belief revision in abstract argumentation [Coste-Marquis et al., 2014, Diller et al., 2015].
  - Scenarios where the use of additional (rejected) arguments is not permitted.

Outline

- Background
- Implicit Conflicts
  - Refute Explicit Conflict Conjecture [Baumann et al., 2014].
  - Conditions for explication of implicit conflicts.
- Rejected Arguments
  - Impact on expressiveness.
  - Comparison of semantics.
- Conclusion & Future work

Background

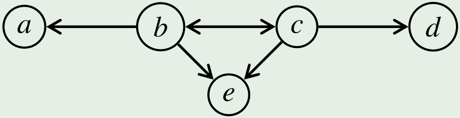
Countably infinite domain of arguments $\mathfrak{A}$.

Definition

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

- $A \subseteq \mathfrak{A}$ is a finite set of arguments and
- $R \subseteq A \times A$ is the attack relation representing conflicts.

Example



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

Background

Definition

Given an AF $F = (A, R)$, a set $S \subseteq A$ is

- naive extension if $S \in \mathit{cf}(F)$ and $\nexists T \in \mathit{cf}(F) : T \supset S$,
- stable extension if $S \in \mathit{cf}(F)$ and $S_F^+ = A$,
- stage extension if $S \in \mathit{cf}(F)$ and $\nexists T \in \mathit{cf}(F) : T_F^+ \supset S_F^+$,
- preferred extension if $S \in \mathit{adm}(F)$ and $\nexists T \in \mathit{adm}(F) : T \supset S$,
- semi-stable extension if $S \in \mathit{adm}(F)$ and $\nexists T \in \mathit{cf}(F) : T_F^+ \supset S_F^+$.

Implicit Conflicts

Definition

Given AF $F = (A, R)$, semantics σ and arguments $a, b \in A$

- a and b ($a \neq b$) are in conflict $\left|{}^{a}_{b}\right|$ for σ if $a \in \sigma(F) \Rightarrow b \notin \sigma(F)$;
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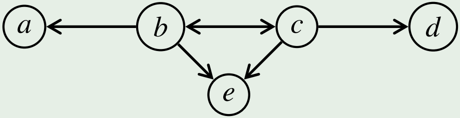

- *stb*$(F) = \{\{a, c\}, \{b, d\}\}$.
- explicit conflicts: $\left|{a \atop b}\right|$, $\left|{b \atop c}\right|$, $\left|{c \atop d}\right|$, $\left|{b \atop e}\right|$, $\left|{c \atop e}\right|$.

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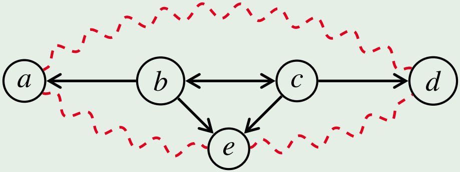

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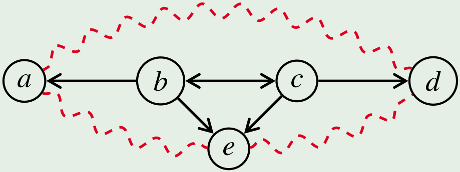

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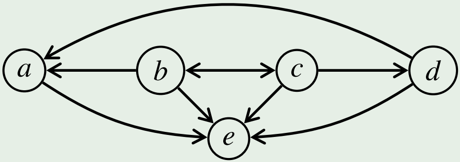

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Explicit Conflict Conjecture

For stable semantics every AF is quasi-analytic. [Baumann et al., 2014]

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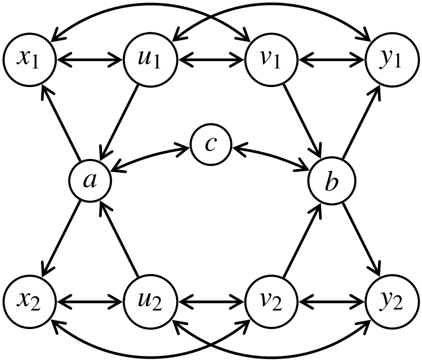

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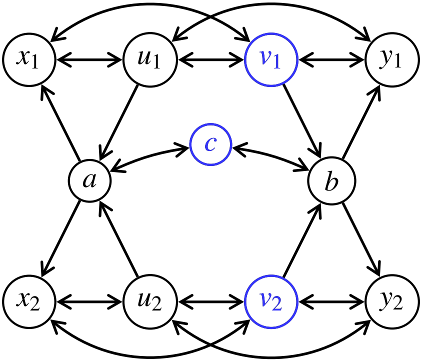

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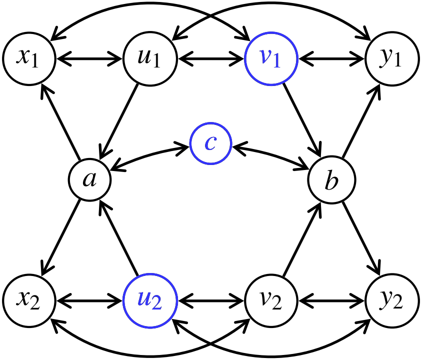

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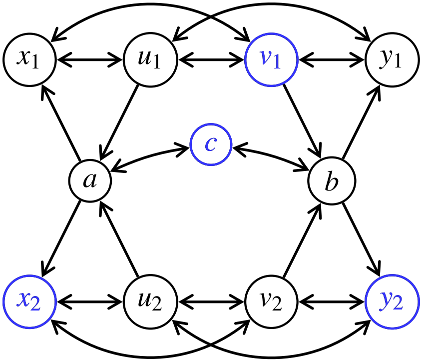

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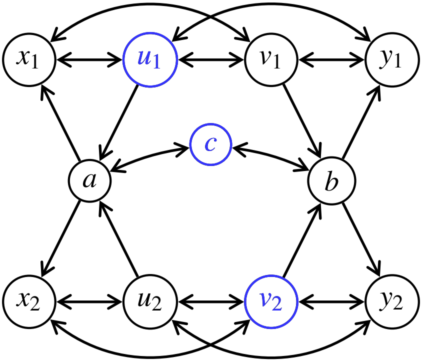

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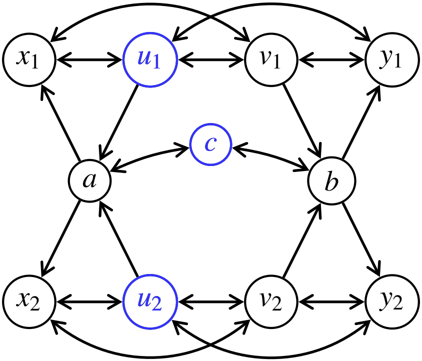

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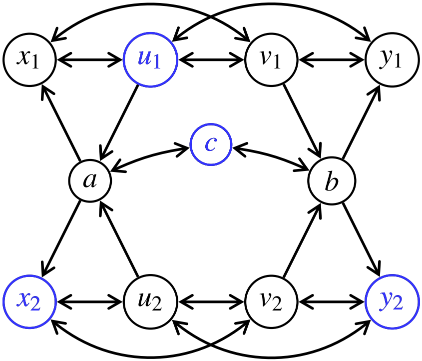

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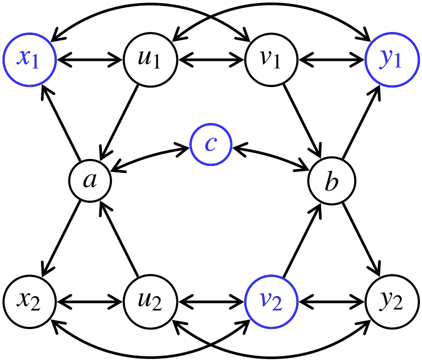

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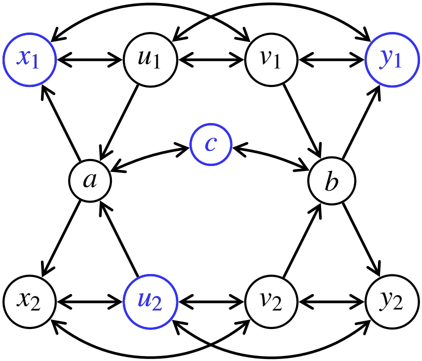

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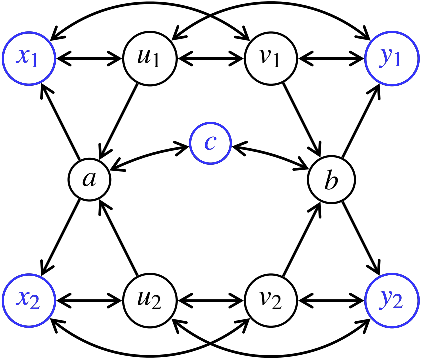

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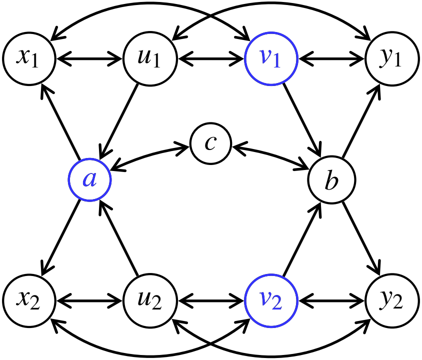

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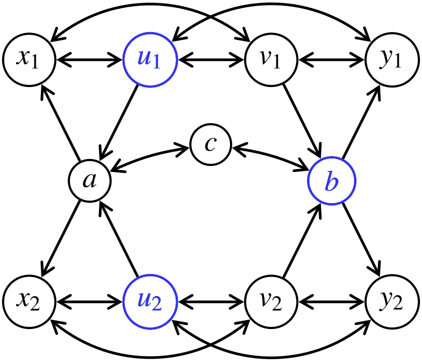

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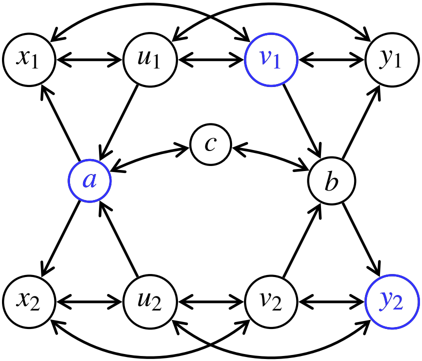

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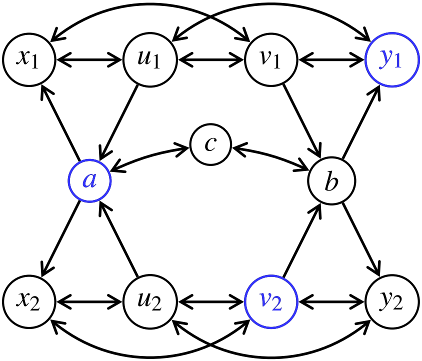

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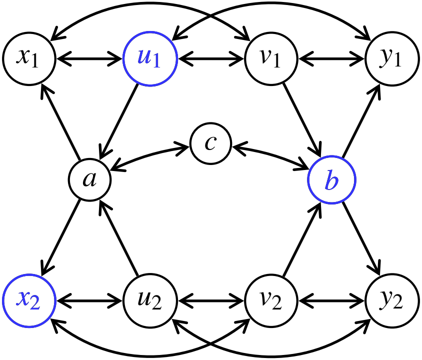

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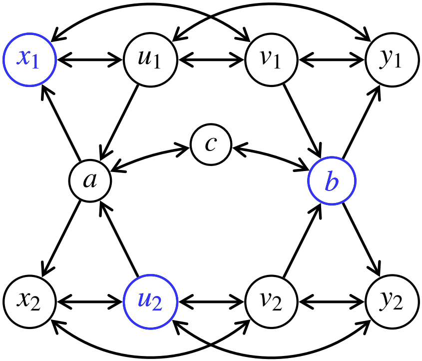

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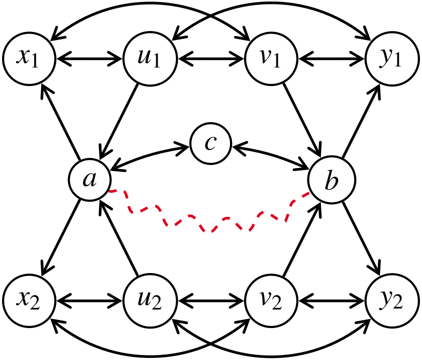

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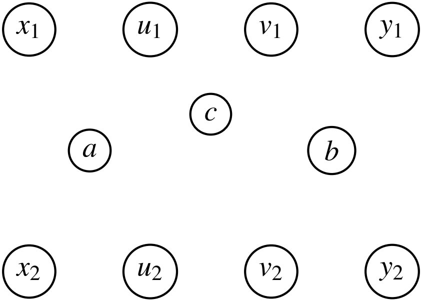

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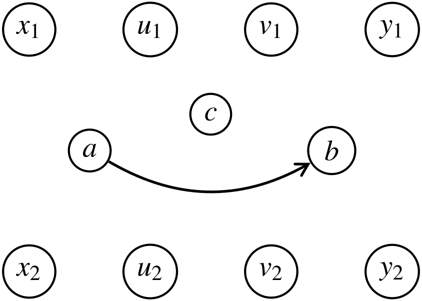

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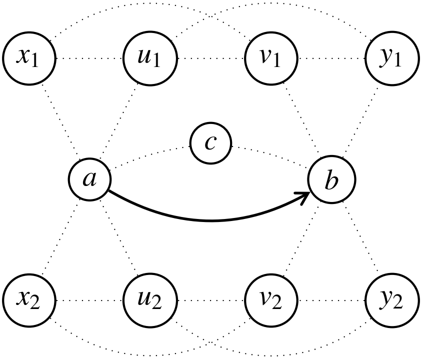

Stable extensions:

$\{\{c\} \cup M_{1i} \cup M_{2j} \mid i, j \in \{1,2,3\}, M_{i1} = \{v_i\}, M_{i2} = \{u_i\}, M_{i3} = \{x_i, y_i\}\} \cup$
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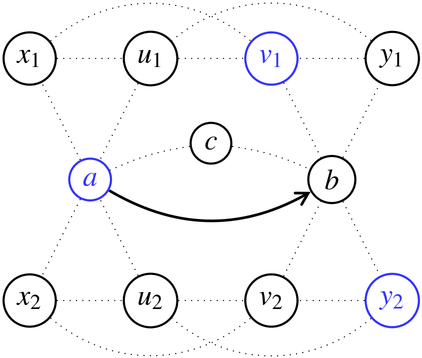

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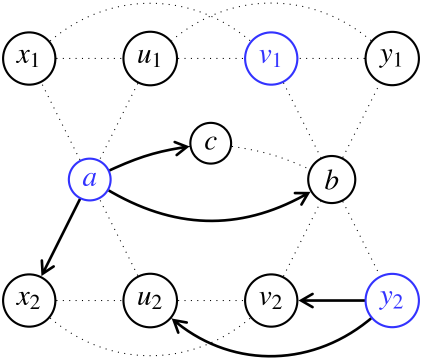

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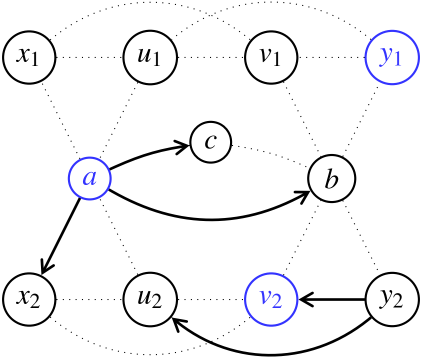

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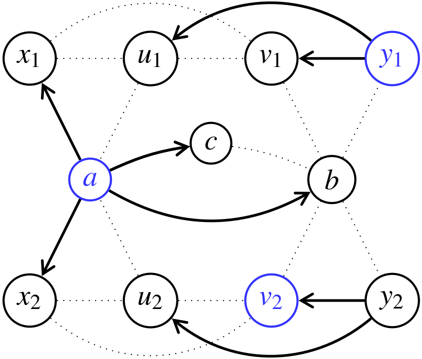

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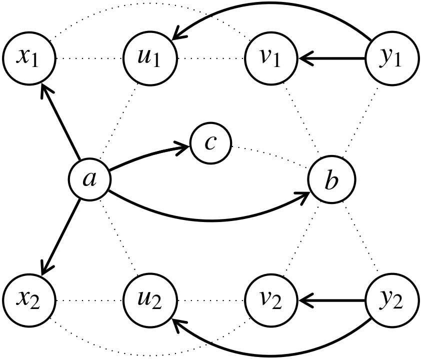

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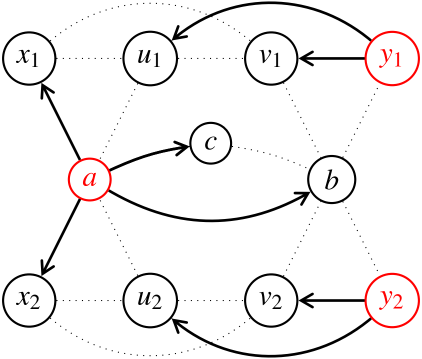

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Implicit Conflicts

Theorem

There are non-analytic AFs for stable semantics.

Implicit Conflicts

Theorem

There are non-analytic AFs for stable, preferred, semi-stable semantics.

Implicit Conflicts

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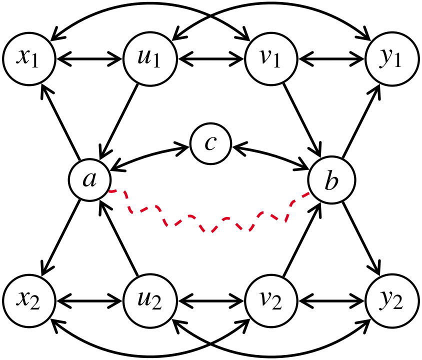
There are non-analytic AFs for stable, preferred, semi-stable semantics.

What about stage semantics?

Implicit Conflicts



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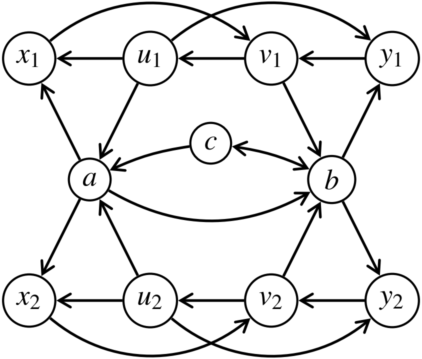

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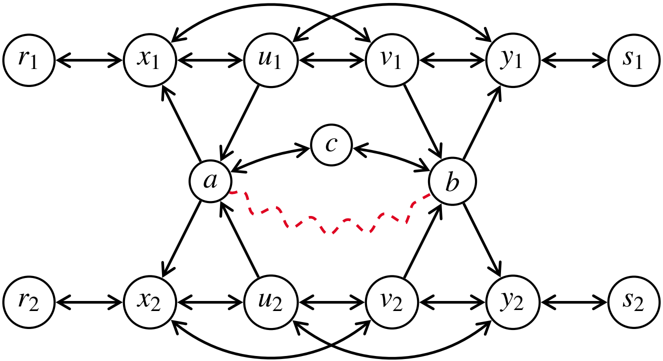
Implicit Conflicts



Implicit Conflicts

Theorem

There are non-analytic AFs for stable, preferred, semi-stable semantics.

Implicit Conflicts

Theorem

There are non-analytic AFs for stable, preferred, semi-stable and stage semantics.

Implicit Conflicts

Definition

Given AF $F = (A, R)$, semantics σ and arguments $a, b \in A$

- F is quasi-analytic for σ if there is some analytic AF $F' = (A', R')$ with $A = A'$ and $\sigma(F) = \sigma(F')$;

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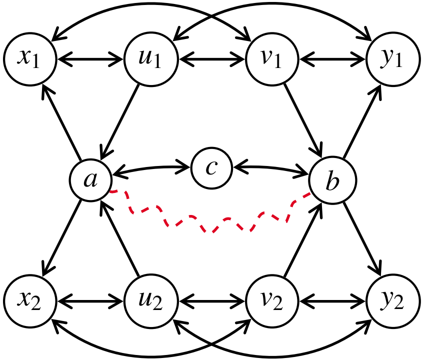
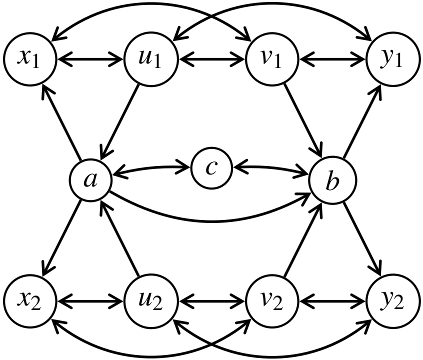
Proposition

For stable semantics and some AF $F = (A, R)$, if there is an implicit conflict $|^a_b|$ for *stb* then there is an AF $F' = (A', R')$ with *stb*$(F) =$ *stb*(F'), $|A'| = |A| + 1$, $R' \supseteq R$ and $(a, b) \in R'$.

Implicit Conflicts



Implicit Conflicts



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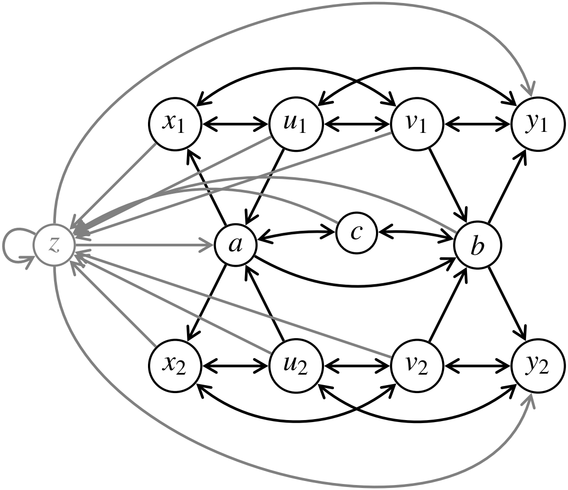

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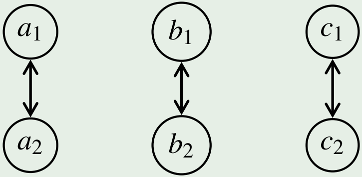
Theorem

Every AF F is quasi-analytic' for stable and stage semantics.

Note: This does not hold for preferred and semi-stable semantics.

Rejected Arguments

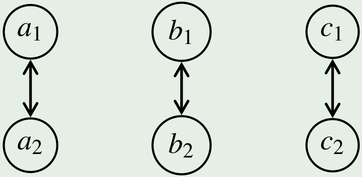
Example



- *stb*$(F) = \{\{a_i, b_j, c_k\} \mid i, j, k \in \{1, 2\}\}$.

Rejected Arguments

Example



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- Revision eliminating $\{a_2, b_2, c_2\}$.

Rejected Arguments

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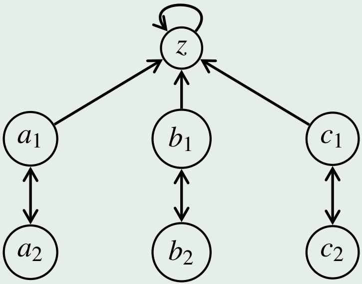

- *stb*$(F) = \{\{a_i, b_j, c_k\} \mid i, j, k \in \{1, 2\}\}$.
- Revision eliminating $\{a_2, b_2, c_2\}$.
- Possible by introduction of rejected arguments.
- Not possible without.

Rejected Arguments

Definition

Given a semantics σ, an extension-set $\mathbb{S} \subseteq 2^{\mathfrak{A}}$ is called

- σ-realizable if there exists an AF F such that $\sigma(F) = \mathbb{S}$.
- compactly σ-realizable if there exists an AF $F = (\bigcup \mathbb{S}, R)$ such that $\sigma(F) = \mathbb{S}$.

Signature: $\Sigma_\sigma = \{\sigma(F) \mid F = (A, R) \text{ is an AF}\}$.

Compact signature: $\Sigma_\sigma^c = \{\sigma(F) \mid F = (A, R) \text{ is an AF}, A = \bigcup \sigma(F)\}$.

Rejected Arguments

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Proposition [Baumann et al., 2014]

For $\sigma \in \{stb, pref, sem, stg\}$, $\Sigma^c_\sigma \subset \Sigma_\sigma$.

Rejected Arguments

Theorem [Dunne et al., 2014]

$\Sigma_{stg} = (\Sigma_{stb} \setminus \{\emptyset\}) \subset \Sigma_{pref} = \Sigma_{sem}$.

Rejected Arguments

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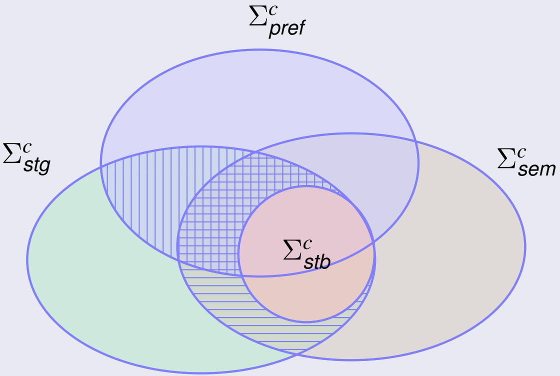
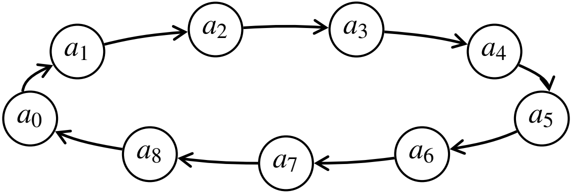
Theorem



Rejected Arguments

$\Sigma^c_{stg} \setminus (\Sigma^c_{stb} \cup \Sigma^c_{pref} \cup \Sigma^c_{sem}) \neq \emptyset$:



$stg(F) = \big\{\{a_i, a_{i\oplus 2}, a_{i\oplus 4}, a_{i\oplus 6}\} \mid 0 \leq i < 9\big\}$ with $a \oplus b = (a + b) \mod 9$.

Rejected Arguments

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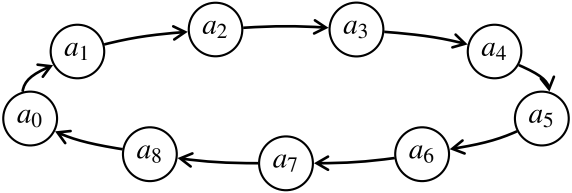

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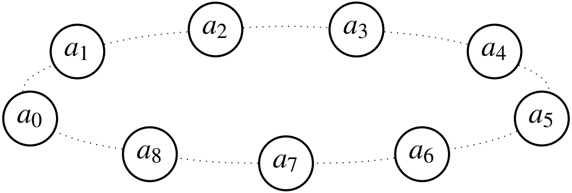

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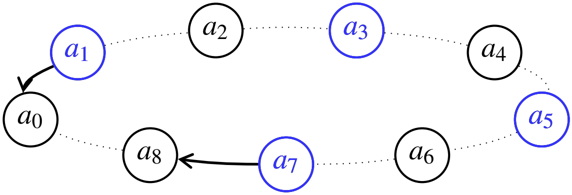

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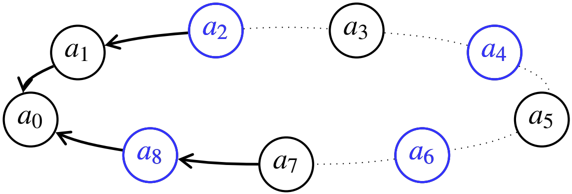

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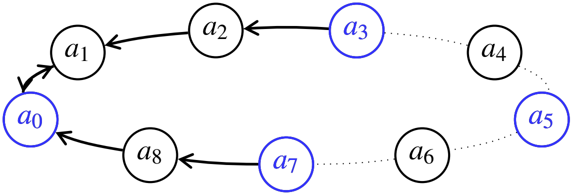

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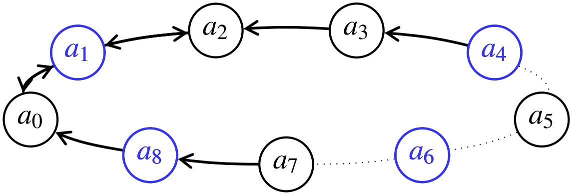

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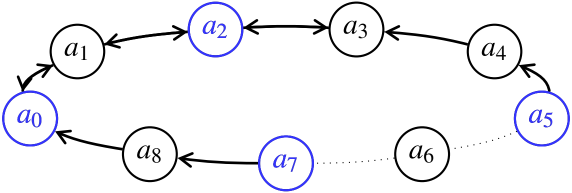

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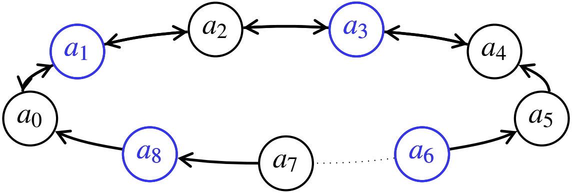

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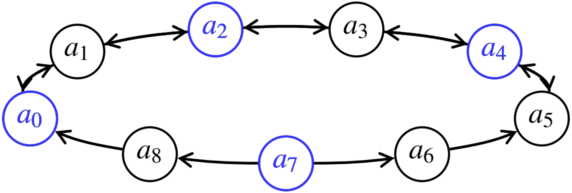

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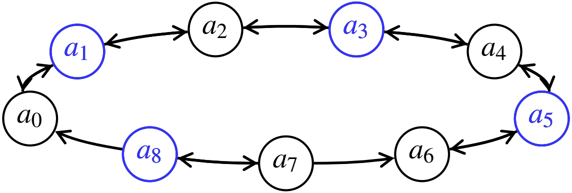

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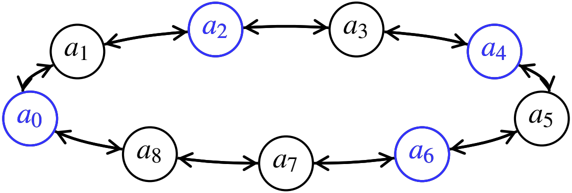

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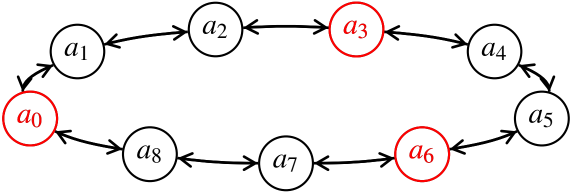

$stg(F) = \{\{a_i, a_{i\oplus 2}, a_{i\oplus 4}, a_{i\oplus 6}\} \mid 0 \leq i < 9\}$ with $a \oplus b = (a+b) \mod 9$.

$\sigma \in \{stb, pref, sem\}$: $\exists F' : \sigma(F') = stg(F)$? No.

$\sigma(F') = stg(F) \cup \{\{a_i, a_{i\oplus 3}, a_{i\oplus 6}\} \mid 0 \leq i < 3\}$.

Conclusion

Summary

- Implicit Conflicts
  - In general not explicable.
  - Possible under certain conditions.
  - For *stb* and *stg* possible with additional arguments.
- Rejected Arguments
  - Relation between semantics differs depending on the permission of rejected arguments.

Future Work

- Exact characterizations of compact signatures.
- Concrete use in implementations.
- Analysis in the context of instantiations.

References I

- Baroni, P. and Giacomin, M. (2007).
  On principle-based evaluation of extension-based argumentation semantics.
  Artif. Intell., 171(10-15):675–700.

- Baumann, R., Dvořák, W., Linsbichler, T., Strass, H., and Woltran, S. (2014).
  Compact argumentation frameworks.
  In Proc. ECAI, volume 263 of Frontiers in Artificial Intelligence and Applications, pages 69–74. IOS Press.

- Coste-Marquis, S., Konieczny, S., Mailly, J., and Marquis, P. (2014).
  On the revision of argumentation systems: minimal change of arguments statuses.
  In Proc. KR, pages 72–81.

- Diller, M., Haret, A., Linsbichler, T., Rümmele, S., and Woltran, S. (2015).
  An Extension-Based Approach to Belief Revision in Abstract Argumentation.
  In Proceedings of the 24th International Joint Conference on Artificial Intelligence, IJCAI 2015. AAAI Press / IJCAI.
  To appear.

References II

Dung, P. M. (1995).
On the acceptability of arguments and its fundamental role in nonmonotonic reasoning, logic programming and n-person games.
Artif. Intell., 77(2):321–357.

Dunne, P. E., Dvořák, W., Linsbichler, T., and Woltran, S. (2014).
Characteristics of multiple viewpoints in abstract argumentation.
In Proc. KR, pages 72–81. AAAI Press.

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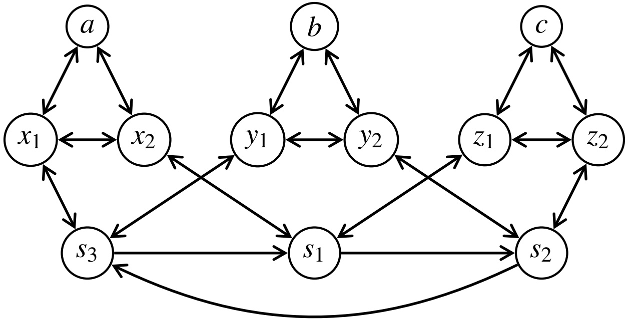
- $\sigma \in \{\mathit{stb}, \mathit{pref}, \mathit{sem}, \mathit{stg}\}$ and F is determined for σ (i.e. $\forall S \in \sigma(F)\ \exists a \in S\ \forall S' \in \sigma(F) : S' \neq S \Rightarrow a \notin S'$).

Rejected Arguments

$\Sigma^c_{stb} \setminus \Sigma^c_{pref} \neq \emptyset$:



Rejected Arguments

$(\Sigma^c_{pref} \cap \Sigma^c_{sem}) \setminus (\Sigma^c_{stb} \cup \Sigma^c_{stg}) \neq \emptyset$: