The AIDAL Project

Towards Formal Argumentation for Legal Reasoning

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Table of contents

Background: A (Very) Short Survey of Formal Argumentation

Abstract Argumentation

Dung's Abstract Argumentation Framework

Argumentation Framework (**AF** for short): $F = \langle A, R \rangle$ where

- A is a set of arguments
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  - a_4: (John) "Moreover, the other restaurants in the streets are closed."

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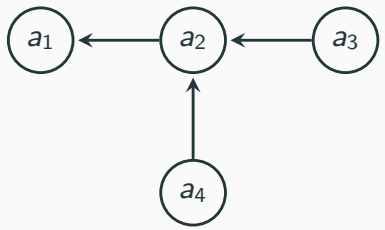

P. M. Dung: On the Acceptability of Arguments and its Fundamental Role in Nonmonotonic Reasoning, Logic Programming and n-Person Games. Artif. Intell. 77(2): 321-358 (1995)

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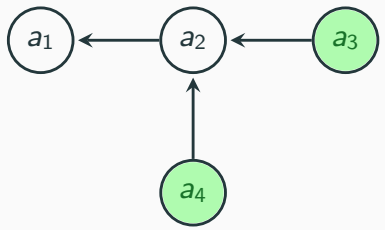

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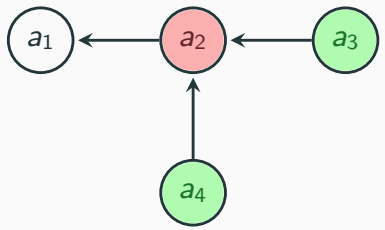

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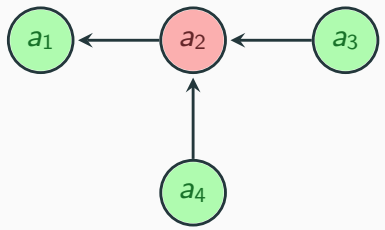

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Abstract Argumentation: Extension-based Semantics

Extension

Given $F = \langle A, R \rangle$, an extension is a set of jointly acceptable arguments

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Extension-based Semantics

Given $F = \langle A, R \rangle$, $S \subseteq A$ is

- *conflict-free* (**cf**) if there is no $a, b \in S$ s.t. $(a, b) \in R$
- *admissible* (**ad**) if $S \in \mathbf{cf}(F)$ and S defends all its elements
- *stable* (**st**) if $S \in \mathbf{cf}(F)$ and S attacks each argument in $A \setminus S$
- *complete* (**co**) if $S \in \mathbf{ad}(F)$ and S doesn't defend any argument in $A \setminus S$
- *preferred* (**pr**) if S is $\subseteq$-maximal in $\mathbf{ad}(F)$
- *grounded* (**gr**) if S is $\subseteq$-minimal in $\mathbf{co}(F)$

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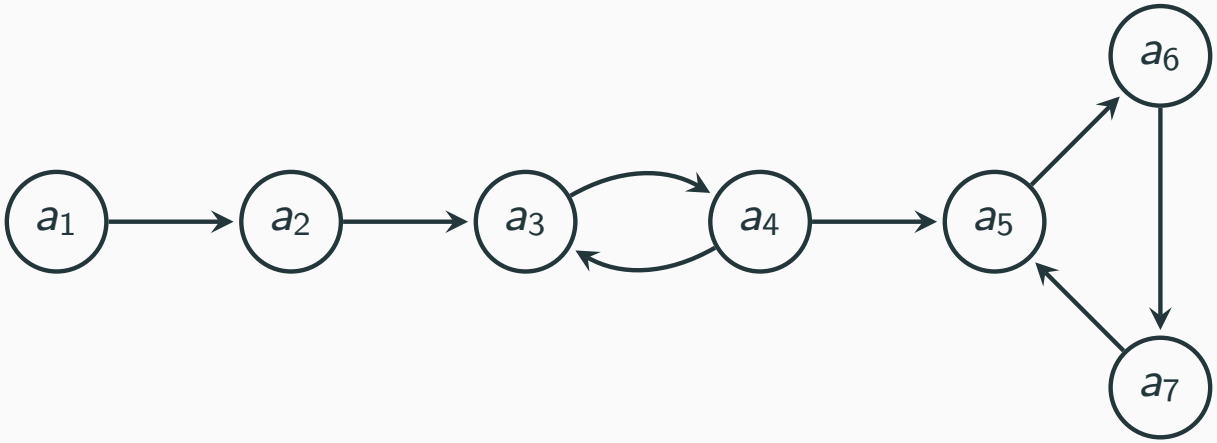
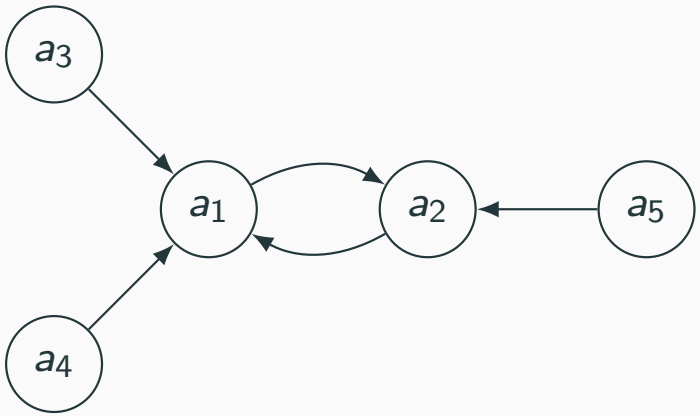
Example: Semantics Comparison



Semantics σ	σ-extensions	$cred_\sigma$	$skep_\sigma$
grounded	$\{\{a_1\}\}$	$\{a_1\}$	$\{a_1\}$
stable	$\{\{a_1, a_4, a_6\}\}$	$\{a_1, a_4, a_6\}$	$\{a_1, a_4, a_6\}$
preferred	$\{\{a_1, a_4, a_6\}, \{a_1, a_3\}\}$	$\{a_1, a_3, a_4, a_6\}$	$\{a_1\}$
complete	$\{\{a_1, a_4, a_6\}, \{a_1, a_3\}, \{a_1\}\}$	$\{a_1, a_3, a_4, a_6\}$	$\{a_1\}$

- $cred_\sigma(F) = \cup_{S \in \sigma(F)} S$: credulously accepted arguments
- $skep_\sigma(F) = \cap_{S \in \sigma(F)} S$: skeptically accepted arguments

Abstract Argumentation: Gradual Semantics



a_1 A is guilty

a_2 A is innocent

a_3 B has a motive and no alibi

a_4 A has an alibi

a_5 A has a motive

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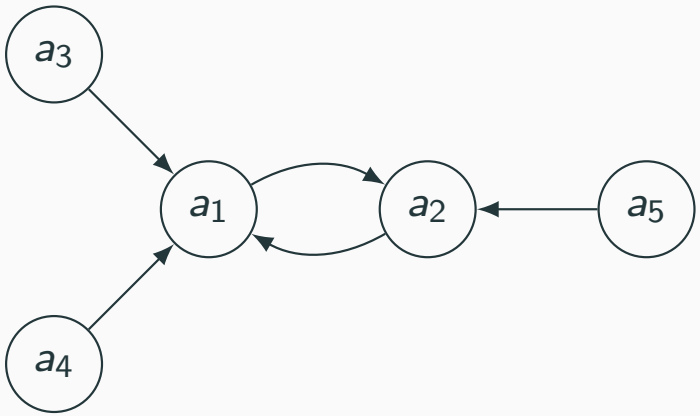

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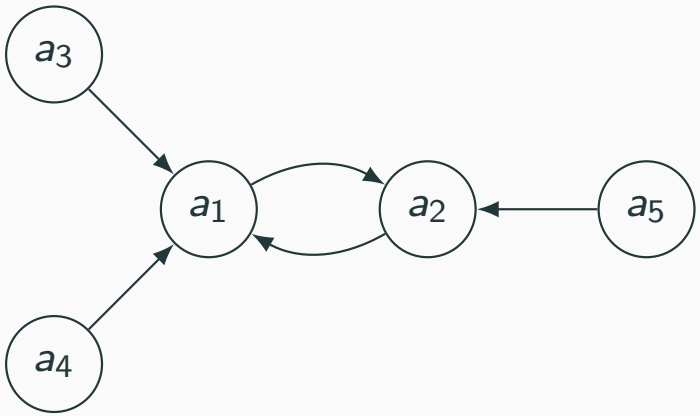

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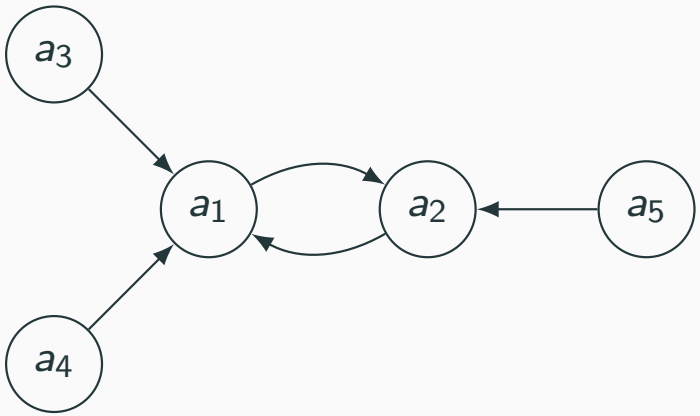

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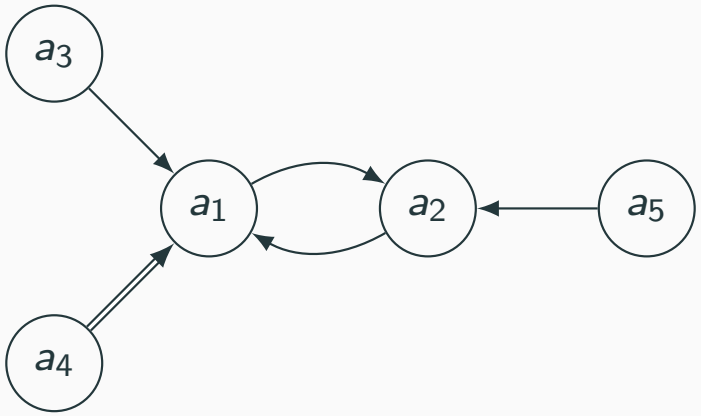
...but a_1 seems weaker than a_2

- Gradual semantics: assigns a score in $[0, 1]$ to each argument
- Example: $hcat(a) = \frac{1}{1+\sum_{(b,a)\in R} hcat(b)}$
- $hcat(a_1) \approx 0.29$, $hcat(a_2) \approx 0.43$

P. Besnard, A. Hunter:A logic-based theory of deductive arguments. Artif. Intell. 128(1-2): 203-235 (2001)

C. Cayrol, M.-C. Lagasquie-Schiex: Graduality in Argumentation. J. Artif. Intell. Res. 23: 245-297 (2005)

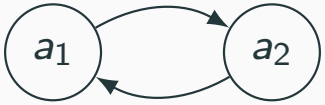
Bipolar Argumentation Frameworks



- Intuitively, a_1 should be stronger than a_2
- Many different interpretations of the notion of support
- Different if we consider extension-based or gradual semantics

Leila Amgoud, Claudette Cayrol, Marie-Christine Lagasquie-Schiex, P. Livet: On bipolarity in argumentation frameworks. Int. J. Intell. Syst. 23(10): 1062-1093 (2008)

Preference-based Argumentation Frameworks



- Additional information about preferences/priorities between arguments
- Example
  - a_1 John is innocent because his wife says he was with her at the time of the murder
  - a_2 John is guilty because there is a video of him murdering the victim

Leila Amgoud, Claudette Cayrol: A Reasoning Model Based on the Production of Acceptable Arguments. Ann. Math. Artif. Intell. 34(1-3): 197-215 (2002)

Preference-based Argumentation Frameworks

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  - $\Rightarrow$ Intuitively, a_2 is preferred to a_1 because the video is more reliable
    For computing arguments acceptability, the attack that disagrees with the preferences can be "ignored"

Leila Amgoud, Claudette Cayrol: A Reasoning Model Based on the Production of Acceptable Arguments. Ann. Math. Artif. Intell. 34(1-3): 197-215 (2002)

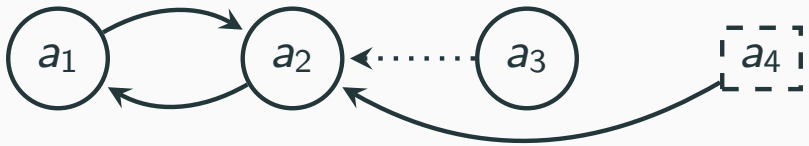
Incomplete Argumentation Framework (IAF)

$I = \langle A, A^?, R, R^? \rangle$ where

- $A, A^?$ are disjoint sets of arguments
- $R, R^?$ are disjoint sets of attacks over $A \cup A^?$

such that

- A, R are certain arguments and attacks
- $A^?, R^?$ are uncertain arguments and attacks



J.-G. Mailly: Yes, no, maybe, I don't know: Complexity and application of abstract argumentation with incomplete knowledge. Argument Comput. 13(3): 291-324 (2022)

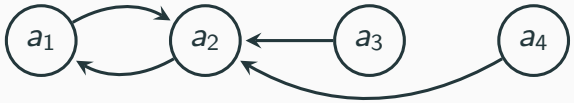
Completions of an IAF

Completions $=$ AFs compatible with the incomplete knowledge encoded in the IAF

$\simeq$ possible worlds

Possible and Necessary Reasoning

- Possible reasoning: some property is true for some completion of the IAF
- Necessary reasoning: some property is true for each completion of the IAF



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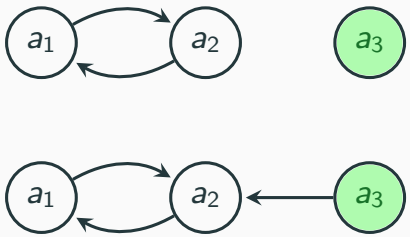

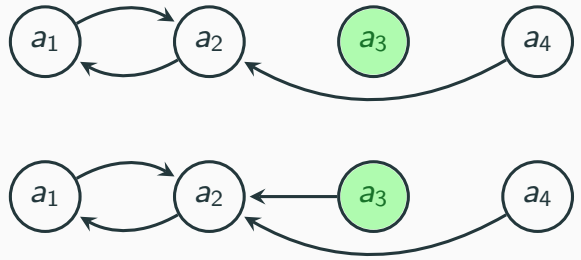

- a_3 is skeptically accepted in each completion $\rightarrow$ necessarily skeptically accepted

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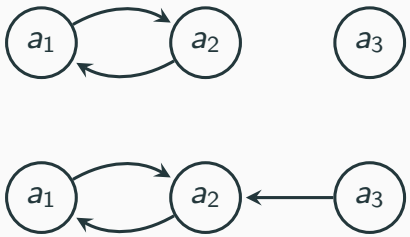

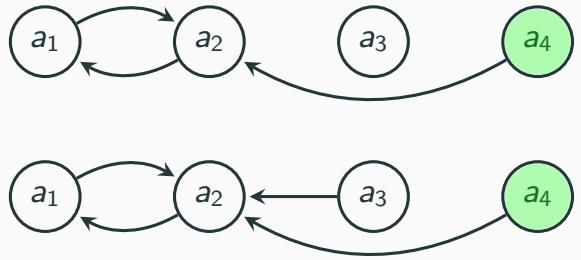

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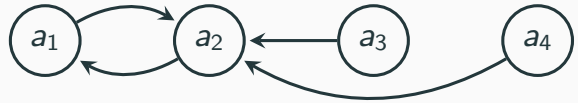

- a_3 is skeptically accepted in each completion $\rightarrow$ necessarily skeptically accepted
- a_4 is skeptically accepted in some completion $\rightarrow$ possibly skeptically accepted
- a_2 is credulously accepted in some completion $\rightarrow$ possibly credulously accepted

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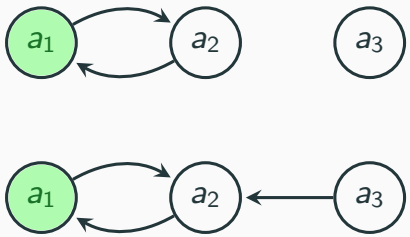

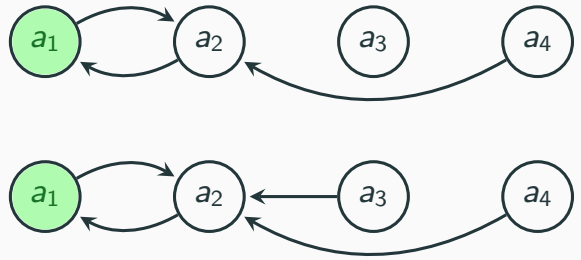

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- a_2 is credulously accepted in some completion $\rightarrow$ possibly credulously accepted
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Constrained IAFs

$cI = \langle A, A^?, R, R^?, \phi \rangle$ where

- $\langle A, A^?, R, R^? \rangle$ form an incomplete AF
- ϕ is a propositional formula expressing a constraint on "valid" completions

$$\phi = (att_{a_1,a_2} \oplus att_{a_3,a_2}) \wedge arg_{a_3}$$

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ϕ means that exactly one of the uncertain attack exists, and a_3 must exist

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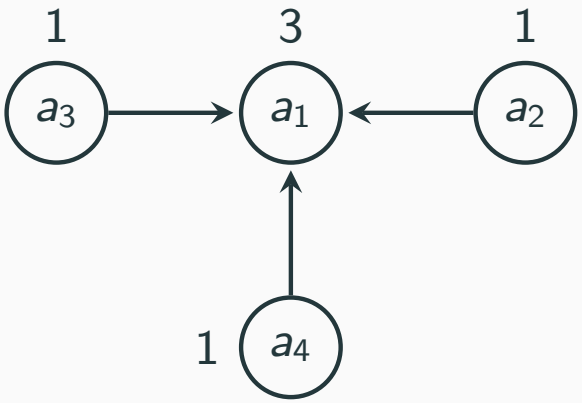
J.-G. Mailly: Constrained Incomplete Argumentation Frameworks. ECSQARU 2021: 103-116

J.-G. Mailly: Constrained Incomplete Argumentation Frameworks: Expressiveness, Complexity and Enforcement. AI Communications, 31(3): 299-322 (2024)

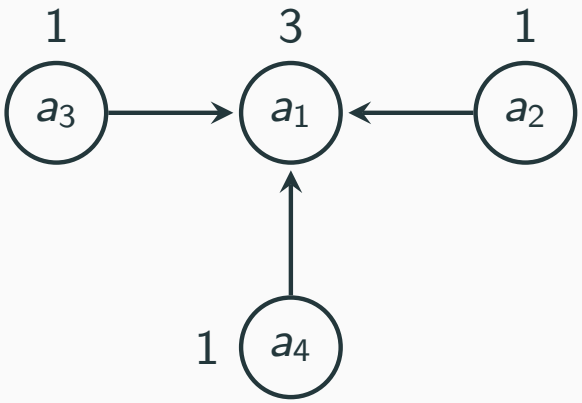
Strength-based Argumentation Frameworks



- $StrAF = \langle A, R, s \rangle$, with $s : A \to \mathbb{N}^+$

Julien Rossit, Jean-Guy Mailly, Yannis Dimopoulos, Pavlos Moraitis: United we stand: Accruals in strength-based argumentation. Argument Comput. 12(1): 87-113 (2021)

Strength-based Argumentation Frameworks



- $StrAF = \langle A, R, s \rangle$, with $s : A \to \mathbb{N}^+$

a_1 This house is great, let's buy it!

a_2 It's a bit far from my work, let's not buy it.

a_3 It doesn't have a swimming pool, let's not buy it.

a_4 It doesn't have air conditioning, let's not buy it.

Julien Rossit, Jean-Guy Mailly, Yannis Dimopoulos, Pavlos Moraitis: United we stand: Accruals in strength-based argumentation. Argument Comput. 12(1): 87-113 (2021)

Structured Argumentation... with logic or text

- Generally speaking, an argument is a (set of) reason(s) for accepting a claim
- Logical formalisms can be used to represent arguments and their relations
  - $a_1 = (\{a, b, a \wedge b \Rightarrow c\}, c)$
  - $a_2 = (\{d, d \Rightarrow \neg a\}, \neg a)$
  - a_2 attacks a_1 because its claim negates some premises of a_1
- The same kind of intuition (argument = premises supporting a claim) works with natural language arguments

  a_1 I think there will be rain today, so I will take my umbrella.

  a_2 I have see the weather forecast yesterday evening, they did not announce rain for today.
  - The claim of a_2 negates the premises of a_1

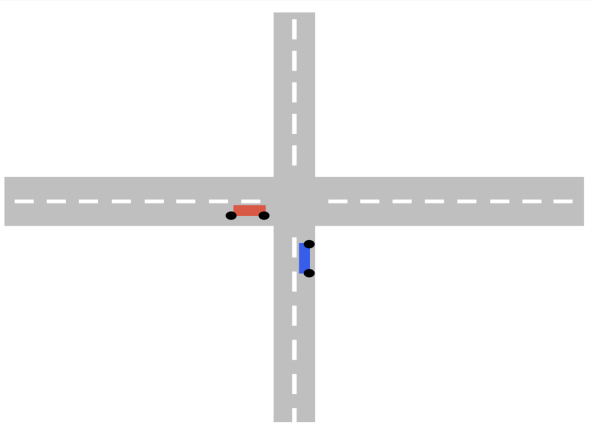
Argument Mining

- Subfield of Natural Language Processing (NLP) interested in argumentation
  - Identifying which parts of a text are premises, and claims
  - Identifying the (premises, claim) relation that make an argument
  - Identifying the (attacks or supports) relations between arguments

Elena Cabrio, Serena Villata: Five Years of Argument Mining: a Data-driven Analysis. IJCAI 2018: 5427-5433

Towards Argument-based Legal Reasoning

Context-dependent Argument-based Decision Aiding: Toy Example



Traffic Laws: Which car has the priority?

- a_1: Red car must let pass on its right side
- a_2: Blue car has a "Yield" sign
- a_3: Red car also has a "Yield" sign
- a_4: Blue car is a police car with flashing lights on

Adaptation to context is important for legal decision making:

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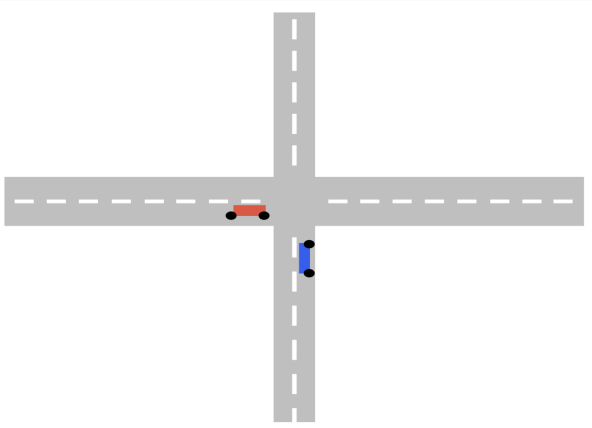

a_1

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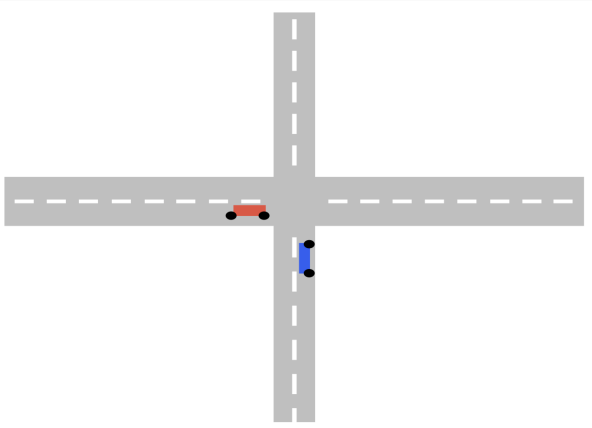
Adaptation to context is important for legal decision making:

- Default case

Context-dependent Argument-based Decision Aiding: Toy Example



Traffic Laws: Which car has the priority?

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Adaptation to context is important for legal decision making:

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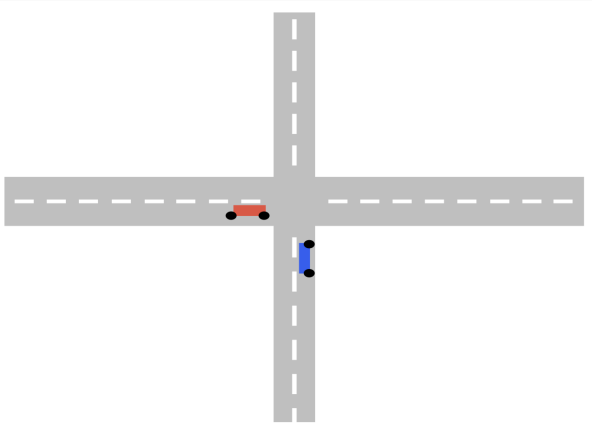

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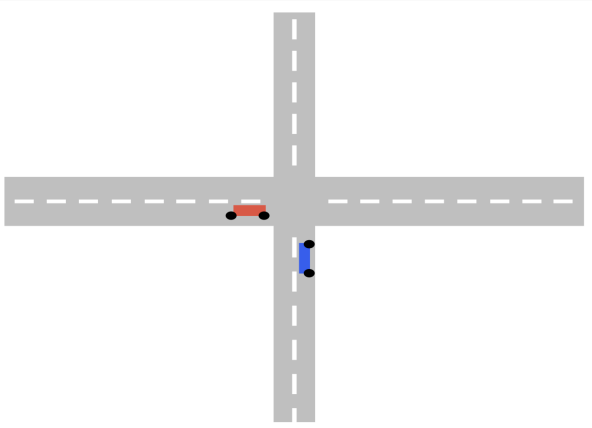

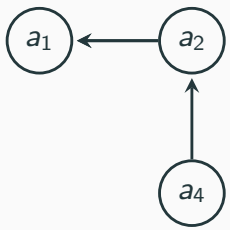

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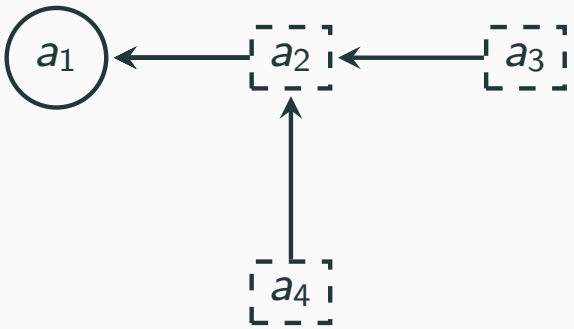
CIAFs for Context-dependent Argumentation



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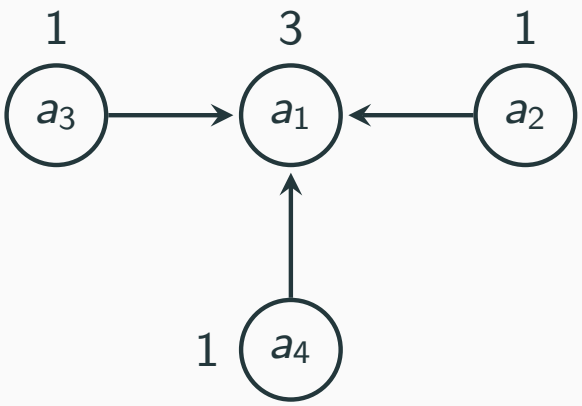
Context = constraint on completions

- Default case: $\phi = \neg arg_{a_2} \wedge \neg arg_{a_3} \wedge \neg arg_{a_4}$
- "Yield" for blue: $\phi = arg_{a_2} \wedge \neg arg_{a_3} \wedge \neg arg_{a_4}$
- "Yield" for blue and red: $\phi = arg_{a_2} \wedge arg_{a_3} \wedge \neg arg_{a_4}$
- "Yield" for blue and it is a police car: $\phi = arg_{a_2} \wedge \neg arg_{a_3} \wedge arg_{a_4}$

Arguments Strength in Legal Reasoning



a_1 John is innocent of murdering Paul.

a_2 There is a witness saying he threatened Paul.

a_3 If Paul is dead then John inherits Paul's money.

a_4 John's hair was found in the house where Paul was killed.

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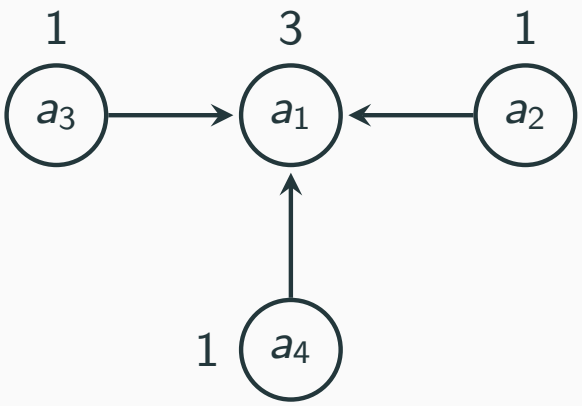

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- Using numbers is probably too "rigid" for this kind of scenario
- Defining a "qualitative" version of StrAFs makes sense to formally represent meter models of jurors reasoning

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Is it enough?

Legal reasoning may need more information than arguments and attacks

- Supports
  - Incomplete Bipolar AFs might be useful

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- Other extension-based semantics
- Gradual semantics
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Building systems requires argument mining

- From laws, justice decisions,...

Why?

Argument-based formal reasoning offers interesting features

- Practical computational approaches
- Explainability of reasoning
  - visual
  - or dialectical

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  - visual
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Why using argumentation for legal reasoning?

- Explaining the law/legal decisions to the layperson
- Guaranteeing the law-compliant behavior of autonomous systems
  - Remember the example of traffic laws and the development of autonomous cars
- Helping lawyers/judges/etc to take decisions
  - Replacing human decision by fully automated decision is **not** the goal

What's next?

- AIDAL: Artificial Intelligence, Data, Algorithms and Law

  `https://www.irit.fr/aidal/`

- Soon: AIDAL mailing list, send me an email if you want to be added

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Thanks for your attention!