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Possible Controllability of Control Argumentation Frameworks

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What's in this talk?

- Control Argumentation Frameworks = dynamics of (abstract) argumentation + (qualitative) uncertainty
- In this paper, we propose a new reasoning mode for this formalism, and study computational issues
  - Complexity
  - Logical encoding

Outline

1. Background
2. Possible Controllability
3. Conclusion

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Abstract Argumentation [Dung 95]

Argumentation Framework (AF)

$F = (A, R)$ where

- A is a set of arguments
- $R \subseteq A \times A$ represents attacks between arguments

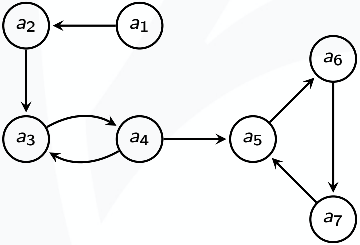
Extension Semantics

$S \subseteq A$ 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 $\mathbf{co}(F)$

Example

$F =$



- $\mathbf{gr}(F) = \{\{a_1\}\}$
- $\mathbf{st}(F) = \{\{a_1, a_4, a_6\}\}$
- $\mathbf{pr}(F) = \{\{a_1, a_4, a_6\}, \{a_1, a_3\}\}$
- $\mathbf{co}(F) = \{\{a_1, a_4, a_6\}, \{a_1, a_3\}, \{a_1\}\}$

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Control AFs [Dimopoulos, Mailly, Moraitis 2018]

Intuition

- Argumentation is an inherently dynamic process (*e.g.* debate)

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  - $\rightarrow$ some (set of) argument(s) must be credulously or skeptically accepted

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- Can the agent deal with the effects of these threats?

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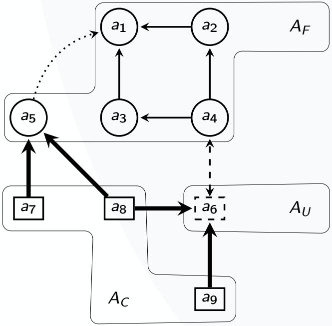
Control AF (CAF)

Generalization of Dung's framework with 3 parts:

- fixed part: certain knowledge
- uncertain part: uncertain knowledge about the environment/other agents
- control part: possible action for the agent

A Picture is Worth a Thousand Words



- Fixed part: circle arguments + plain arrows
- Uncertain part:
  - dashed arguments
  - dotted arrows
  - two-heads dashed arrows
- Control part: square arguments + bold arrows

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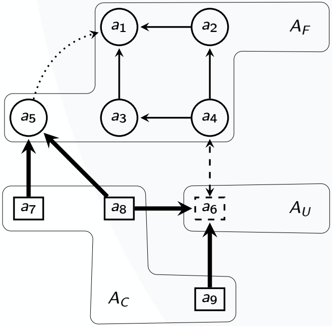

- certain knowledge: always exist

- Fixed part: circle arguments + plain arrows
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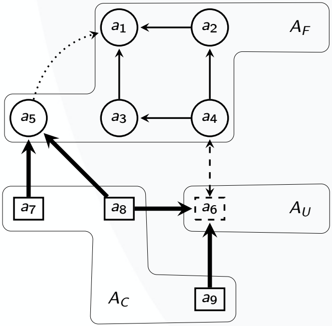

- the argument could exist, or not

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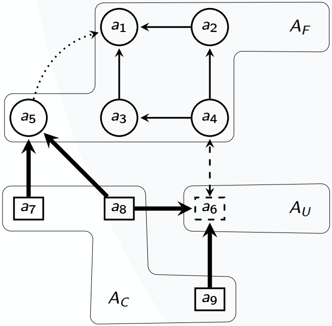

- the attack could exist, or not

- Fixed part: circle arguments + plain arrows
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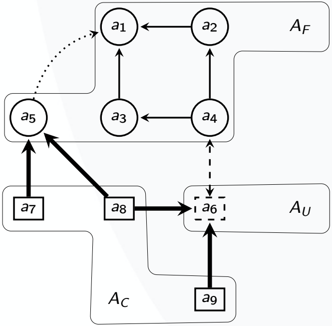

- Fixed part: circle arguments + plain arrows
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- the attack exists (if both arguments exist), but we are not sure of the direction

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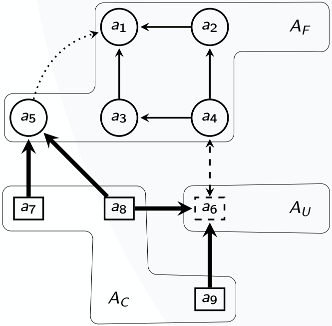

- Fixed part: circle arguments + plain arrows
- Uncertain part:
  - dashed arguments
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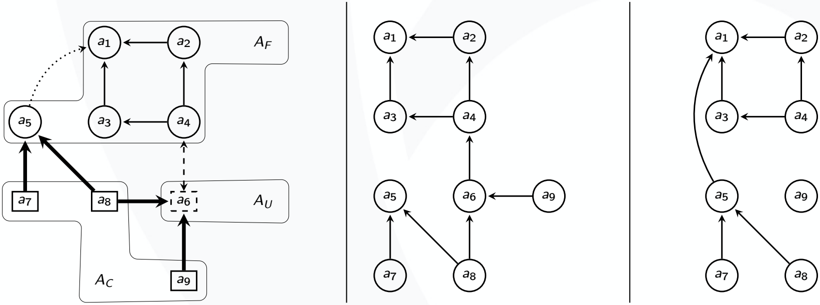
- Control part: square arguments + bold arrows
  - exist only if the agent chooses to use the arguments

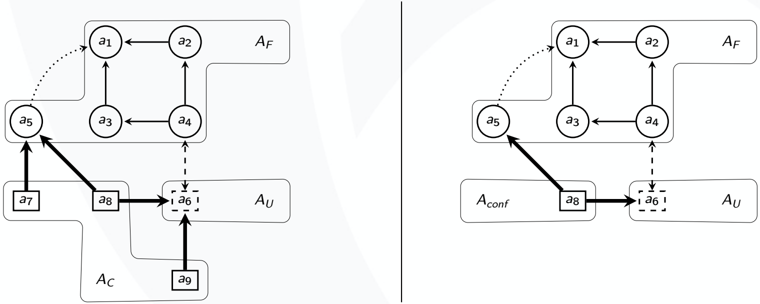
Completions

A completion is a classical AF which is "compatible" with the CAF



Controllability

- Given a target $T \subseteq A_F$, can the agent choose a configuration $A_{conf} \subseteq A_C$ s.t. T is accepted in each completion when CAF is configured by A_{conf}?



Ex.: In CAF configured by $A_{conf} = \{a_8\}$, $T = \{a_1\}$ is accepted w.r.t. each completion

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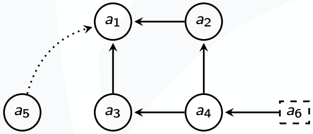
Complexity of CAFs [Niskanen, Neugebauer, Järvisalo 2020]

- Question: Given a CAF C, a target T and a semantics σ, is C credulously/skeptically controllable w.r.t. T and σ?

Semantics	Credulous	Skeptical
ad	Σ_3^P-c	trivial
co	Σ_3^P-c	NP-c
pr	Σ_3^P-c	Σ_3^P-c
st	Σ_3^P-c	Σ_2^P-c
gr	Σ_2^P-c	NP-c

Incomplete AFs [Baumeister, Neugebauer, Rothe 2018]

- AF with uncertainty about the existence of some arguments/attacks



- a_1 is not necessarily accepted (*e.g.* it is not accepted in completions where (a_5, a_1) exists)

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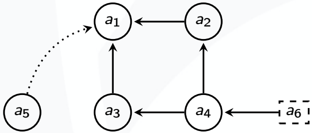

- a_1 is not necessarily accepted (*e.g.* it is not accepted in completions where (a_5, a_1) exists)
- but a_1 is possibly accepted (in the completion where neither (a_5, a_1) nor a_6 exists)

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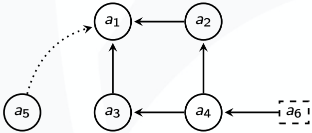

- a_1 is not necessarily accepted (*e.g.* it is not accepted in completions where (a_5, a_1) exists)
- but a_1 is possibly accepted (in the completion where neither (a_5, a_1) nor a_6 exists)
- **Question:** Does it make sense to apply the notion of possible/necessary reasoning to CAFs?

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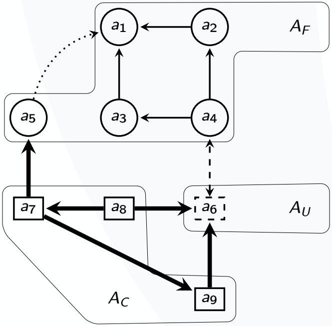
Motivation

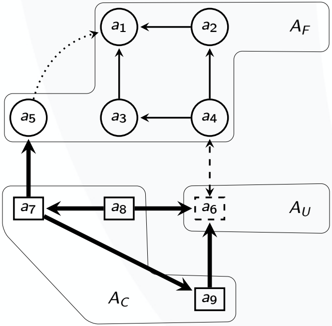
Necessary controllability may be too strong in some cases



- Not necessary skeptically controllable w.r.t. $T = \{a_1\}$
- But with $A_{conf} = a_7$, T is skeptically accepted in at least one completion

Motivation

Necessary controllability may be too strong in some cases



- Not necessary skeptically controllable w.r.t. $T = \{a_1\}$
- But with $A_{conf} = a_7$, T is skeptically accepted in at least one completion
- In some cases, it may be enough → "credulous reasoning" over completions

Definition of Possible Controllability

- Input: a CAF C, a target $T \subseteq A_F$ and a semantics σ
- Question: is there a configuration $A_{conf} \subseteq A_C$ s.t. T is credulously (resp. skeptically) accepted in at least one completion of C configured by A_{conf}

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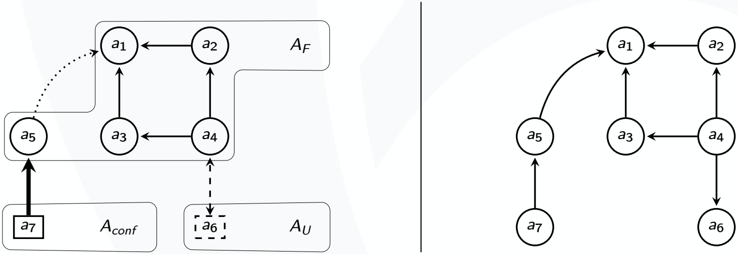
Example



Complexity

- Question: Given a CAF C, a target T and a semantics σ, is C **possibly** credulously/skeptically controllable w.r.t. T and σ?

Semantics	Credulous	Skeptical
co	NP-c	NP-c
pr	NP-c	Σ_3^P-c
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QBF Encoding for Stable Semantics

- Inspired by [Besnard and Doutre 04]: for $F = \langle A, R \rangle$

$$\phi_{\mathbf{st}}(F) = \bigwedge_{a \in A} [a \Leftrightarrow (\bigwedge_{(b,a) \in R} \neg b)]$$

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  - $att_{a,b}$ is true iff (a, b) exists
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- for a CAF C

$$\Phi_{\mathbf{st}}(C) = \bigwedge_{a \in A_F} [a \Leftrightarrow \bigwedge_{b \in \mathcal{A}} (att_{b,a} \Rightarrow \neg b)] \wedge \\ \bigwedge_{a \in A_C \cup A_U} [a \Leftrightarrow (on_a \wedge \bigwedge_{b \in \mathcal{A}} (att_{b,a} \Rightarrow \neg b))] \wedge \\ (\bigwedge_{(a,b) \in \rightarrow \cup \Rrightarrow} att_{a,b}) \wedge (\bigwedge_{(a,b) \in \rightleftarrows} att_{a,b} \vee att_{b,a}) \wedge (\bigwedge_{(a,b) \notin \mathcal{R}} \neg att_{a,b})$$

with $\mathcal{A} = A_F \cup A_C \cup A_U$, $\mathcal{R} = \rightarrow \cup \rightleftarrows \cup \dashrightarrow \cup \Rrightarrow$

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Credulous/Skeptical Acceptance

- $\Phi^{sk}_{\mathbf{st}}(C, T) = (\Phi_{\mathbf{st}}(C) \Rightarrow \bigwedge_{a \in T} a)$

$$\begin{aligned} &\exists\{on_{x_i} \mid x_i \in A_C\}\exists\{on_{x_i} \mid x_i \in A_U\} \\ &\exists\{att_{x_i,x_j} \mid (x_i, x_j) \in \dashrightarrow \cup \rightleftarrows\}\forall\{x_i \mid x_i \in \mathcal{A}\} \\ &[\Phi^{sk}_{st}(C, T) \vee (\bigvee_{(x_i,x_j)\in\rightleftarrows}(\neg att_{a_i,a_j} \wedge \neg att_{a_j,a_i}))] \end{aligned} \quad (1)$$

- $\Phi^{cr}_{\mathbf{st}}(C, T) = (\Phi_{\mathbf{st}}(C) \wedge \bigwedge_{a \in T} a)$

$$\begin{aligned} &\exists\{on_{x_i} \mid x_i \in A_C\}\exists\{on_{x_i} \mid x_i \in A_U\} \\ &\exists\{att_{x_i,x_j} \mid (x_i, x_j) \in \dashrightarrow \cup \rightleftarrows\}\exists\{x_i \mid x_i \in \mathcal{A}\} \\ &[\Phi^{cr}_{st}(C, T) \vee (\bigvee_{(x_i,x_j)\in\rightleftarrows}(\neg att_{a_i,a_j} \wedge \neg att_{a_j,a_i}))] \end{aligned} \quad (2)$$

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Summary and Future Work

- Possible controllability $\simeq$ lawyer's reasoning: he must prove that there is a possibility ($\simeq$ a completion) that his client is innocent
  Necessary controllability $\simeq$ prosecutor's reasoning: he must prove that the defendant is guilty without doubt ($\simeq$ in each completion)
- Future work:
  - Implementation and experimentation of the QBF encoding for stable semantics
  - Encoding other semantics
  - Other forms of controllability?
    - optimization issues?
    - rankings?
    - with probabilities?