Computing Skeptical Preferred Acceptance in Dynamic Argumentation Frameworks with Recursive Attack and Support Relations

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Attack-Support Argumentation Framework (ASAF)

- A general way for representing arguments and relationships between them, allowing to represent dialogues, making decisions, and handling inconsistency and uncertainty.
- Extension of AF (and BAF) with recursive attacks and "necessary" supports

Example (a simple ASAF)

$\mathtt{w_t}$: winter season

$\mathtt{w_i}$: it is windy

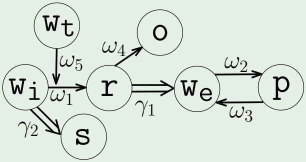
$\mathtt{r}$: it rains

$\mathtt{w_e}$: the court is wet

$\mathtt{p}$: play tennis

$\mathtt{s}$: need a sweatshirt

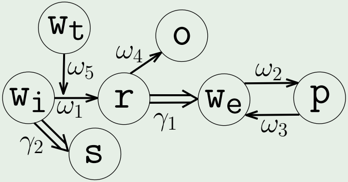
$\mathtt{o}$: tennis racket shop is open



Preferred Semantics

- Extensions also include attacks and supports that contribute to determine the set of accepted arguments.
- An element (i.e., an argument/attack/support) X is skeptically preferred accepted w.r.t. Δ (denoted as $SA_{\Delta}(X) = true$) iff it appears in every $\mathtt{pr}$-extension of Δ

Example (ASAF Δ)



Set of preferred extensions of Δ
$\{\{\mathtt{w_i}, \mathtt{r}, \gamma_1, \mathtt{s}, \mathtt{w_e}, \omega_2, \mathtt{w_t}, \omega_4, \omega_5, \gamma_2\},$ $\{\mathtt{w_i}, \mathtt{r}, \gamma_1, \mathtt{s}, \mathtt{p}, \omega_3, \mathtt{w_t}, \omega_4, \omega_5, \gamma_2\}\}$

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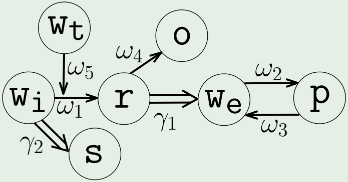

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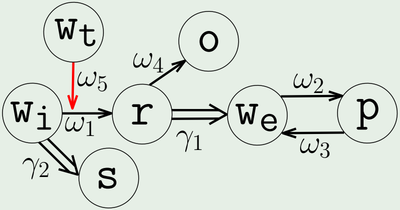
Dynamic ASAFs

- Typically an ASAF represents a temporary situation, and new arguments, attacks and supports can be added/removed to take into account new available knowledge.
- An *update* u for an ASAF Δ allow us to change Δ into an ASAF $u(\Delta)$ by adding or removing an argument, an attack, or a support.
- If E_0 is a preferred extension for Δ and $u(\Delta)$ is obtained by adding (resp. removing) the set S of isolated arguments, then a preferred extension for $u(\Delta)$ is obtained as $E = E_0 \cup S$ (resp. $E = E_0 \setminus S$).
- We focus on the addition $(+)$ (resp., deletion $(-)$) of of an attack or a support not present (resp., present) in a given ASAF.

Dynamic ASAFs

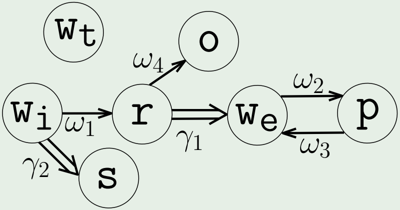
Example (update $-(\mathtt{w_t}, \omega_1)$)



Set of $\mathtt{pr}$-extensions of Δ	Set of $\mathtt{pr}$-extensions of $u(\Delta)$
$\{\{\mathtt{w_i}, \mathtt{r}, \gamma_1, \mathtt{s}, \mathtt{w_e}, \omega_2, \mathtt{w_t}, \omega_4, \omega_5, \gamma_2\},$ $\{\mathtt{w_i}, \mathtt{r}, \gamma_1, \mathtt{s}, \mathtt{p}, \omega_3, \mathtt{w_t}, \omega_4, \omega_5, \gamma_2\}\}$	?

Dynamic ASAFs

Example (update -($\mathtt{w_t}, \omega_1$))



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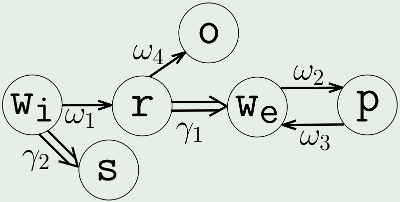
Dynamic ASAFs

Example (update $-(\mathtt{w_t}, \omega_1)$)



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Dynamic ASAFs

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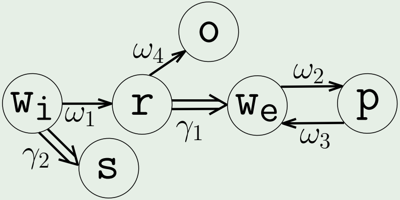

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Should we recompute $SA_u(\Delta)(\mathtt{p})$ from scratch?

Contributions

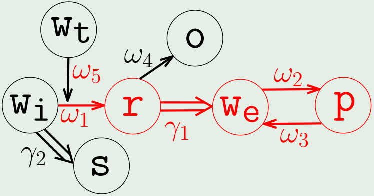
1) Given an update and a goal element, we identify a set of elements, called alterable set, whose acceptance status may change after the update.
2) We define the Proxy ASAF allowing us to compute the skeptical preferred acceptance of a goal by focusing on a restriction of the input ASAF. (containing the alterable set).
3) We introduce an incremental algorithm for computing the skeptical preferred acceptance of a goal within a dynamic ASAF.
4) We also propose a version of the algorithm that uses a translation of our problem to the AF domain.
5) Experimental analysis comparing with fastest solvers from ICCMA 2019.

Outline

Alterable set: Intuition

- *Alt*(Δ, u, G) is the set of elements whose status may change after performing update u and s.t. they may imply a change of the status of *G*.
- Informal definition: *Alt*(Δ, u, G) for $u = \pm\delta$ and *G* consists of the elements that can reach *G* from δ.

Example (*Alt*(Δ, u, G) where $G = \mathrm{p}$ and $u = -\omega_5$)



Alterable set *Alt*(Δ, u, p)	Reachable Elements
$\{\omega_5, \omega_1, \mathrm{r}, \gamma_1, \mathrm{w_e}, \omega_2, \mathrm{p}, \omega_3\}$	$\{\omega_5, \omega_1, \mathrm{r}, \omega_4, \gamma_1, \mathrm{o}, \mathrm{w_e}, \omega_2, \mathrm{p}, \omega_3\}$

Alterable set: Definition

(Alterable Set)

Let $\Delta = \langle A, \Omega, \Gamma \rangle$ be an ASAF, $u = \pm\delta$ an update, and $G \in A \cup \Omega \cup \Gamma$ a (goal) element. Let

- $Alt_0(\Delta, u, G) = \begin{cases} \emptyset & \text{if } G \notin Reach_{\Delta^u}(\delta); \\ N_{\Delta^u}(\delta) & \text{otherwise.} \end{cases}$
- $Alt_{i+1}(\Delta, u, G) = Alt_i(\Delta, u, G) \cup \{Z \mid Z \in N_{\Delta^u}(Y),\ Y \in Alt_i(\Delta, u, G), G \in Reach_{\Delta^u}(Z)\}.$

Let n be the natural number such that $Alt_n(\Delta, u, G) = Alt_{n+1}(\Delta, u, G)$. Then alterable set $Alt(\Delta, u, G)$ is $Alt_n(\Delta, u, G)$.

(Theorem 1)

Let $\Delta = \langle A, \Omega, \Gamma \rangle$ be an ASAF, u an update, $u(\Delta)$ the updated ASAF, and G a goal element in $A \cup \Omega \cup \Gamma$. If $Alt(\Delta, u, G) = \emptyset$ then $SA_{u(\Delta)}(G) = SA_{\Delta}(G)$.

Proxy ASAF

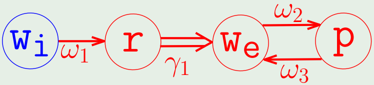
(Proxy ASAF)

Let $\Delta = \langle A, \Omega, \Gamma \rangle$ be an ASAF, $u = \pm\delta$ an update, and $G \in A \cup \Omega \cup \Gamma$ a goal element. Let $S = Alt(\Delta, u, G)$. The Proxy ASAF of Δ w.r.t u and G is $PASAF(\Delta, u, G) = u(\Delta)\downarrow_{S \cup Reach^{-1}_{u(\Delta)}(S)}$.

Example (Proxy ASAF of our example)

$PASAF(\Delta, u, \mathtt{p})$ given from the restriction of $u(\Delta)$ to:

- $S = Alt(\Delta, u, \mathtt{p}) = \{\omega_5, \omega_1, \mathtt{r}, \gamma_1, \mathtt{w_e}, \omega_2, \mathtt{p}, \omega_3\}$ +
- $Reach^{-1}_{u(\Delta)}(S) = \{\mathtt{w_i}\}$.



Proxy ASAF

Example (Proxy ASAF of our example)

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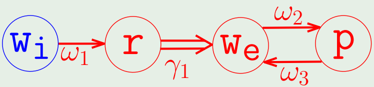
- $Reach^{-1}_{u(\Delta)}(S) = \{\mathrm{w_i}\}$.



(Theorem 2)

Let $\Delta = \langle A, \Omega, \Gamma \rangle$ be an ASAF, u an update, $u(\Delta)$ the updated ASAF, and a goal element $G \in A \cup \Omega \cup \Gamma$. If $Alt(\Delta, u, G) \neq \emptyset$ then G is skeptically preferred accepted w.r.t. $u(\Delta)$ iff it is skeptically preferred accepted w.r.t. the Proxy ASAF $PASAF(\Delta, u, G)$.

Incremental Algorithm

Algorithm 1 *ASAF-SA*$(\Delta, u, G, SA_\Delta(G)$, ASAF-Solver)

Input: ASAF $\Delta = \langle A, \Omega, \Gamma \rangle$, update u, goal $G \in A \cup \Omega \cup \Gamma$, initial skeptical preferred acceptance $SA_\Delta(G)$, function ASAF-Solver computing the skeptical preferred acceptance of a goal element for an ASAF.

Output: updated skeptically preferred acceptance of G w.r.t $u(\Delta)$.

1: Let $S = Alt(\Delta, u, G)$
2: **if** $S = \emptyset$ **then**
3: **return** $SA_\Delta(G)$;
4: Let $\Delta_P = PASAF(\Delta, u, G)$
5: **return** ASAF-Solver(G, Δ_P)

Algorithm 2: Enabling the computation at the AF level. Let ASAFtoAF be a function that takes as input an ASAF Δ and returns the corresponding AF $\langle \mathbb{A}_\Delta, \Sigma_\Delta \rangle$ [*Alfano et al, ECAI2020*]. Then, the invocation of the ASAF solver at Line 5 is replaced by AF-Solver($\overline{G}$, ASAFtoAF(Δ_P)), where AF-Solver is a function computing the skeptical preferred acceptance of a given argument w.r.t. a given AF, and $\overline{G}$ is the argument of $\langle \mathbb{A}_\Delta, \Sigma_\Delta \rangle$ corresponding to G.

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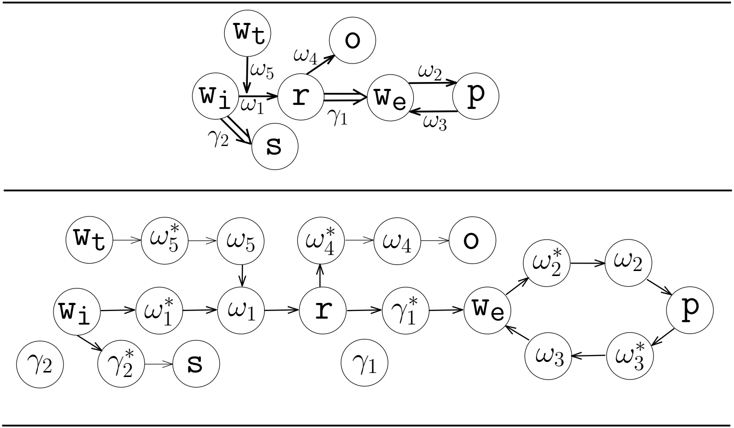
The AF for the ASAF

(AF for ASAF [Alfano et al, ECAI2020])

Let $\Delta = \langle A, \Omega, \Gamma \rangle$ be an ASAF. The *AF for* Δ is $\Lambda_\Delta = \langle \mathbb{A}_\Delta, \Sigma_\Delta \rangle$, where:

- $\mathbb{A}_\Delta = A \cup \{\, \omega, \omega^* \mid \omega \in \Omega \,\} \cup \{\, \gamma, \gamma^* \mid \gamma \in \Gamma \,\}$.
- $\Sigma_\Delta = \{\, (\mathbf{s}(\omega), \omega^*),\ (\omega^*, \omega),\ (\omega, \mathbf{t}(\omega)) \mid \omega \in \Omega \,\} \cup$
  $\{\, (\omega, \mathbf{t}(\omega)^*) \mid \omega \in \Omega, \mathbf{t}(\omega) \in \Gamma \,\} \cup$
  $\{\, (\mathbf{s}(\gamma), \gamma^*),\ (\gamma^*, \mathbf{t}(\gamma)) \mid \gamma \in \Gamma \,\} \cup$
  $\{\, (\gamma^*, \mathbf{t}(\gamma)^*) \mid \gamma \in \Gamma,\ \mathbf{t}(\gamma) \in \Gamma \,\}$.

The AF for the ASAF



ω_1 corresponds to the chain of attacks from $\mathtt{w_i}$ to $\mathtt{r}$ through ω_1 and ω_1^*
ω_5 corresponds to the attacks $(\mathtt{w_t}, \omega_5^*)$, (ω_5^*, ω_5), (ω_5, ω_1).

Outline

Methodology

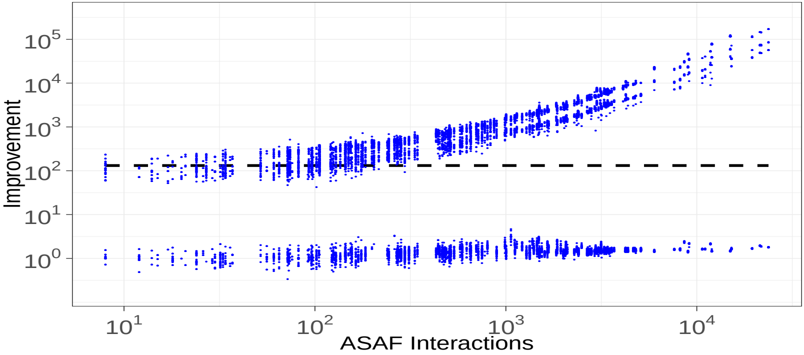
Datasets

We generated set of ASAFs from AF used as ICCMA'19 benchmarks by transforming AF's attacks into first/second/third level ASAF's attacks or supports with a given probability.

Methodology

- For each ASAF Δ in the dataset, we consider a (randomly chosen) goal element G and an update u.
- We compute $SA_{u(\Delta)}(G)$ with Alg.2.
- We compute the *improvement* of Alg. 2 over the computation from scratch (t_s / t_{A_2}).

Experimental Results



- The improvement can be either very large or limited.
- The incremental algorithm outperforms the computation from scratch.

Outline

Conclusions and future work

- We introduced a technique for the incremental computation of SPA in dynamic ASAFs
- Given the generality of the ASAF, our technique can be also applied to AFRAs and AFNs
- We identified a tighter portion of the updated ASAF to be examined for recomputing the acceptance
- Our experiments showed that the incremental technique outperforms the computation from scratch
- As future work we plan to investigate similar approaches for Recursive Argumentation Framework with Necessities (RAFN) where a support may come also from a set of arguments, as well as extending our technique to deal with other semantics.

Thank you!

... any ~~question~~ argument?