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Argumentation Frameworks with Higher-Order Attacks: Semantics and Complexity

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Introduction

Argumentation frameworks (AF) are formalisms to express argumentation problems. In Dung's one, they are expressed as directed graph in which nodes represent argument and arrow, attack relations between arguments. Higher-order frameworks, unlike Dung's one, allow to have attacks over attacks. **RAF** are such a framework (see Figures 1 and 2). Arguments are here represented by circles and attack relations by squares.



For future algorithm investigations, we adapted the notion of Dung's AF labellings for RAF. We showed the relation between structures (counterpart of extensions for RAF) and different types of structure labellings.

We studied the complexities of RAF decisions problems and shown that despite the higher expressiveness offered by them, the decision classes stay the same as Dung's AF.

Labellings for RAF

Instead of extensions (set of arguments), RAF solutions are expressed as structure: a couple of sets, one of arguments and one of attacks. As for Dung's AF, we introduced structure labellings for RAF, a couple of labellings, one for the arguments and the other one for the attacks. They are three value-based: *in* (accepted), *out* (rejected), *und* (undecidable). **Reinstament RAF labellings** are particular labellings that coïncide under some constraints to differents RAF semantics (see Tables 1 and 2).

Definition 14 (*Reinstatement RAF labelling*). Let $\Gamma = \langle A, K, s, t \rangle$ be a recursive argumentation framework and $\mathcal{L} = \langle \ell_A, \ell_K \rangle$ be a RAF labelling. \mathcal{L} is a reinstatement RAF labelling iff it satisfies the following conditions: $\forall x \in (A \cup K)$,

- $(\mathcal{L}(x) = out) \iff (\exists \alpha \in K \text{ s.t. } t(\alpha) = x, \ell_K(\alpha) = in \text{ and } \ell_A(s(\alpha)) = in)$
- $(\mathcal{L}(x) = in) \iff (\forall \alpha \in K \text{ s.t. } t(\alpha) = x, \ell_K(\alpha) = out \text{ or } \ell_A(s(\alpha)) = out)$

		RAF labellings				
		\mathcal{L}_1	\mathcal{L}_2	\mathcal{L}_3	\mathcal{L}_4	
	a	und	in	out	out	
	b	und	out	in	in	
	С	und	und	in	in	
	d	und	und	in	in	
	e	und	und	out	out	
ks	f	und	und	in	in	
Arguments or attac	g	und	in	in	out	
	h	und	und	und	und	
	α	in	in	in	in	
	β	in	in	in	in	
	γ	in	in	in	in	
	δ	und	in	out	out	
	ε	in	in	in	in	
	ζ	in	in	in	in	
	η	in	in	in	in	
	θ	und	und	out	out	
	l	und	out	out	in	
	К	in	in	in	in	
	λ	in	in	in	in	
	RAF-complete	\checkmark	\checkmark	\checkmark	\checkmark	
	RAF-grounded	\checkmark				
ics AF gs	RAF-preferred		\checkmark	\checkmark	\checkmark	
R/R/	RAF-arg-preferred		\checkmark	\checkmark		
sm(bel	RAF-stable					
Se Wj Ial	RAF-semi-stable		10	\checkmark	\checkmark	

				100

Restriction on Reinstatement	Structure semantics		
RAF labelling			
no restriction	RAF-complete		
maximal und	RAF-grounded		
minimal in	RAF-grounded		
minimal out	RAF-grounded		
maximal in	RAF-preferred		
maximal out	RAF-preferred		
empty und	RAF-stable		
minimal und	RAF-semi-stable		

Table 2: Reinstatement RAF labellings and structures semantics

 $i \checkmark j$: j is a RAF labelling corresponding to semantics i.

Table 1: RAF labellings for Figure 1

Complexities of RAF

We introduced a new **flattening** of RAF to Dung's AF (procedure called **Raf2Af)** in order to prove that it is also the case for RAF complexities.

Table 3 summarises the complexities of the credulous and skeptical acceptance problems, the verification, the existence, the non-empty existence and the uniqueness problems.

σ	$Cred_{\sigma}$	Skepσ	Ver _o	$Exists_{\sigma}$	$Exists_{\sigma}^{\neg \varnothing}$	$Unique_{\sigma}$
Co	NP-C	P- <i>c</i>	in L	trivial	NP-c	coNP-c
Gr	P-c	P- <i>c</i>	P- <i>c</i>	trivial	in L	trivial
Pr	NP-C	$\Pi_2^{\mathbb{P}}$ -c	coNP <i>-c</i>	trivial	NP-C	coNP-c
St	NP-C	coNP-c	in L	NP-C	NP-C	DP-c
Ss	$\Sigma_2^{\mathbb{P}}$ - c	$\Pi_2^{\mathbb{P}}$ -c	coNP <i>-c</i>	trivial	NP-C	in Θ_2^P

Figure 3 shows an example of flattening. For each attack two arguments are created : one, named as the attack, representing the validity of the attack, the other one the validity of both the attack and its source. For each argument, an other one is created representing the invalidity of the argument.

Same complexities as Dung's AF

Perspectives

- Algorithms for RAF argumentation problems
- Complexities of function problems
- Higher-Order bipolar argumentation framework

Table 3: Complexities for RAF decision problems

