On the Aggregation of Argumentation Frameworks

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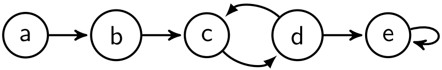
Dung's abstract argumentation framework

Definition (Dun95)

An argumentation framework is a pair AF $= \langle A, R \rangle$ where

- A is a set of arguments
- R $\subseteq$ A$\times$A is an attack relation



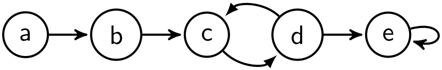
Several possible semantics σ :

- Grounded : $\mathcal{E}_{gr}$(AF) $=$ {{a}}
- Preferred : $\mathcal{E}_{pref}$(AF) $=$ {{a,c},{a,d}}
- Stable : $\mathcal{E}_{sta}$(AF) $=$ {{a,d}}
- Complete : $\mathcal{E}_{comp}$(AF) $=$ {{a,d},{a,c},{a}}

Inferences

Which arguments can be inferred from a set of extensions ?

$\mathcal{E}_{pref}(\text{AF}) = \{\{\text{a,c}\},\{\text{a,d}\}\}$



Two types of inference relations :

- Skeptical inference selects the arguments that appear in all the extensions : $sa_{pref}(\text{AF}) = \{\text{a}\}$
- Credulous inference selects the arguments that appear in at least one extension : $ca_{pref}(\text{AF}) = \{\text{a,c,d}\}$

Aggregation of argumentation frameworks

Two different approaches : properties and operators

Properties :

- P. Dunne, P. Marquis, and M. Wooldridge, *Argument aggregation : Basic axioms and complexity results* (*COMMA*'12), 2012

Aggregation methods :

- S. Coste-Marquis, C. Devred, S. Konieczny, MC. Lagasquie-Schiex, and P. Marquis, *On the merging of Dung's argumentation systems*, Artificial Intelligence, 2007
- S. Coste-Marquis, S. Konieczny, P. Marquis, and M. A. Ouali, *Selecting extensions in weighted argumentation frameworks* (COMMA'12), 2012
- A. Tohmé, G. Bodanza and G. Simari, *Aggregation of Attack Relations : A Social-Choice Theoretical Analysis of Defeasibility Criteria*, (FoIKS'08), 2008

Aim : Determine which properties are satisfied by the existing operators

Properties of aggregation function

Merging : Aggregating several AF in order to define an AF representing the social position

$$\mathbb{AF}^n \rightarrow \mathbb{AF}$$

Properties proposed by [DMW12] for the aggregation of AF :

- **Anonymity** (ANON) : The operator produces the same AF for all permutations of the same input
- **Non-triviality** (σ-SNT, σ-WNT) : The result has at least one non-empty extension
- **Decisiveness** (σ-SD, σ-WD) : The result has exactly one non-empty extension
- **Majority** (MAJ-A, σ-MAJ, ca_σ-MAJ, sa_σ-MAJ) : An entity that appears in a strict majority of AF, should be appear in the social outcome

Properties of aggregation function

- **Unanimity** (UA, σ-U, ca_σ-U, sa_σ-U) : An entity that appears in all the AF, should be appear in the social outcome
- **Closure** (CLO, AC, σ-C, ca_σ-C, sa_σ-C) : The aggregation function must not invent some entity which does not exist in the input

Other interesting property [TBS08] :

- **Positive responsiveness** (PR) : Increasing the number of agents that have an attack, should not decrease the chance for that attack to appear in the social outcome

Additional properties :

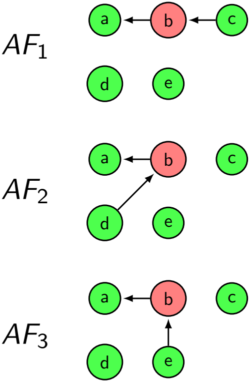
- **Identity** (A-ID, σ-ID, ca_σ-ID, sa_σ-ID) : If all the AFs in the input coincide, merging result should be identical too

Results

		[CDKLM07]		[TBS08]			
Properties		$\triangle_{de}^{\Sigma}$	$\triangle_{de}^{leximax}$	QV	FUS_{All}	$FUS_{All\text{-}NT}$	$FUS_{Maj\text{-}NT}$
Anonymity	ANON	✓	✓	×	✓	✓	✓
σ-strongly non-trivial	σ-SNT	×	×	×	×	✓	✓
σ-weakly non-trivial	σ-WNT	×	×	$\checkmark^{gr}$	×	✓	✓
σ-strongly décisive	σ-SD	×	×	×	×	×	×
σ-weakly décisive	σ-WD	×	×	$\checkmark^{gr}$	×	×	×
Unanimous attack	UA	✓	✓	×	-	-	-
σ-Unanimity	σ-U	×	×	×	×	×	×
ca_σ-Unanimity	ca_σ-U	×	×	×	×	×	×
sa_σ-Unanimity	sa_σ-U	×	×	×	×	×	×
Majority attack	MAJ-A	✓	×	×	-	-	-
σ-Majority	σ-MAJ	×	×	×	×	×	×
ca_σ-Majority	ca_σ-MAJ	×	×	×	×	×	×
sa_σ-Majority	sa_σ-MAJ	×	×	×	×	×	×
Closure	CLO	×	×	×	-	-	-
Attack Closure	AC	✓	✓	✓	-	-	-
σ-closure	σ-C	×	×	×	×	×	×
ca_σ-closure	ca_σ-C	×	×	×	×	×	×
sa_σ-closure	sa_σ-C	×	×	×	×	×	×
Identity attack	A-ID	✓	✓	×	-	-	-
σ-Identity	σ-ID	✓	✓	×	$\checkmark^{gr}$	×	×
ca_σ-Identity	ca_σ-ID	✓	✓	×	$\checkmark^{gr}$	×	×
sa_σ-Identity	sa_σ-ID	✓	✓	×	$\checkmark^{gr}$	×	×
Positive responsiveness	PR	✓	✓	✓	-	-	-

$\checkmark^{\sigma}$ means that the property is satisfied for the semantic σ

Criticism of Unanimity, Majority and Closure



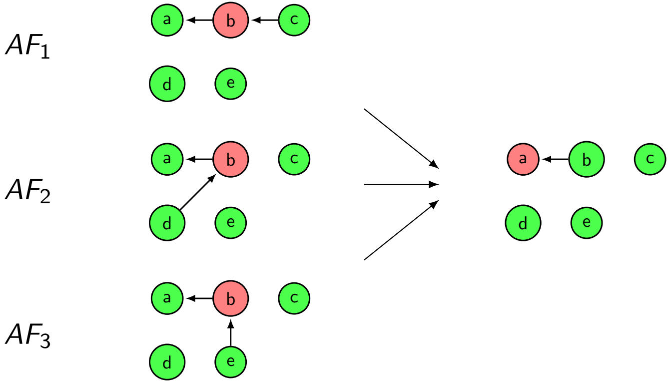
Unanimity (all the agents) :

- b attacks a

Majority (two of the three agents) :

- c does not attack b
- d does not attack b
- e does not attack b

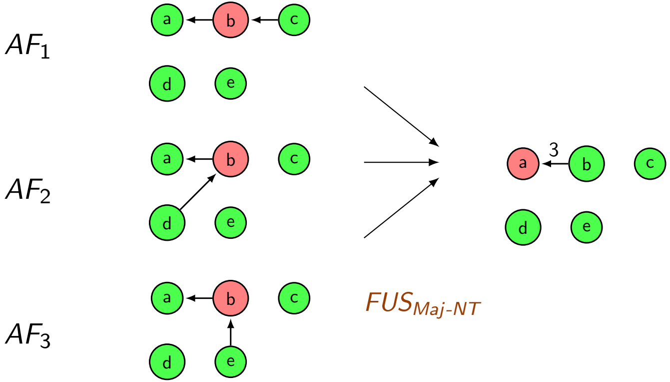
Criticism of Unanimity, Majority and Closure



$\mathcal{E}_{pref}(AF_1) = \{\{a, c, d, e\}\}$
$\mathcal{E}_{pref}(AF_2) = \{\{a, c, d, e\}\}$
$\mathcal{E}_{pref}(AF_3) = \{\{a, c, d, e\}\}$

$\mathcal{E}_{pref}(\text{AF'}) = \{\{b, c, d, e\}\}$

Criticism of Unanimity, Majority and Closure



$\mathcal{E}_{pref}(AF_1)=\mathcal{E}_{pref}(AF_2)=\mathcal{E}_{pref}(AF_3) = \{\{a, c, d, e\}\}$

$\mathcal{E}_{pref}(\text{WAF}) = \{\{b, c, d, e\}\}$

Counterexample which demonstrates that $FUS_{Maj\text{-}NT}$ contredicts the properties of Unanimity, Majority and Closure

Results without too strong properties

		[CDKLM07]		[TBS08]			
Properties		Δ^{Σ}_{de}	$\Delta^{leximax}_{de}$	QV	FUS_{All}	$FUS_{All\text{-}NT}$	$FUS_{Maj\text{-}NT}$
Anonymity	ANON	✓	✓	×	✓	✓	✓
σ-weakly non-trivial	σ-WNT	×	×	$✓^{gr}$	×	✓	✓
Unanimous Attack	UA	✓	✓	×	-	-	-
Majority Attack	MAJ-A	✓	×	×	-	-	-
Attack Closure	AC	✓	✓	✓	-	-	-
Identity Attack	A-ID	✓	✓	×	-	-	-
σ-Identity	σ-ID	✓	✓	×	$✓^{gr}$	×	×
ca_σ-Identity	ca_σ-ID	✓	✓	×	$✓^{gr}$	×	×
sa_σ-Identity	sa_σ-ID	✓	✓	×	$✓^{gr}$	×	×
Positive responsiveness	PR	✓	✓	✓	-	-	-

$✓^{\sigma}$ means that the property is satisfied for the semantic σ

- All the properties are satisfied by at least one operator
- No operator satisfies all the properties

Conclusion and Future works

Conclusion

- Few of the properties are satisfied by existing aggregation operators
- Some of the properties (coming from social choice theory) seem to be too demanding in the general case

Future works

- Definition of other aggregation methods
- Translate the properties from propositional belief merging for argumentation systems

PhD Thesis

I am in my first year of PhD Thesis as part of the french project ANR AMANDE

AMANDE

≪ **Argumentation reasoning tools for online debate platforms** ≫

- Elise Bonzon (LIPADE), Université Paris Descartes
- Sébastien Konieczny (CRIL), Université d'Artois
- Nicolas Maudet (LIP6), Université Pierre et Marie Curie, Paris

Ranked-based semantics

→ We actually study the existing ranked-based semantics and their properties

- J. Leite and J. Martins, *Social abstract argumentation* (IJCAI'11), 2011
- P. Besnard and A. Hunter, *A logic-based theory of deductive arguments*, Artificial Intelligence, 2001
- L. Amgoud and J. Ben-Naim, *Ranking-based semantics for argumentation frameworks*, (SUM'13), 2013
- C. Cayrol and M. Lagasquie-Schiex, *Graduality in argumentation*, Journal of Artificial Intelligence Research, 2005
- P. Matt and F. Toni, *A Game-Theoretic Measure of Argument Strength for Abstract Argumentation*, (JELIA'08), 2008