What can we expect from consensus decision-making?

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Outline

- we introduce the definitions of argumentation framework and semantics
- brief look at a result from graph aggregation
- we define several semantic properties
- we study the interaction of semantic properties, aggregation rules and its properties

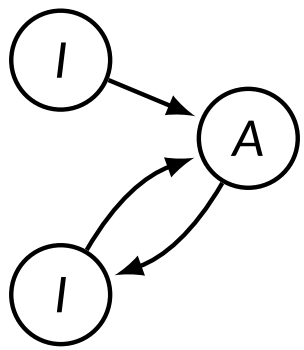
First Taste

Who should be responsible for blocking negotiation in their region.:

I My government cannot negotiate with your government because your government doesn't even recognize my government

A Your government doesn't recognize my government either

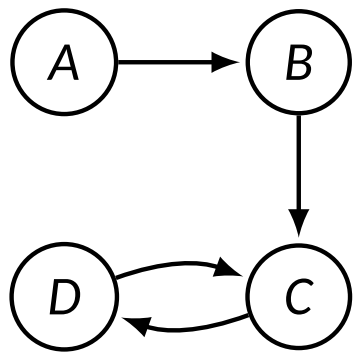
I But your government is a terrorist government



Background: Abstract Argumentation Frameworks

An abstract *argumentation framework (AF)* is a pair $AF = \langle Arg, \rightharpoonup \rangle$, where,

- Arg is a finite set of *arguments*
- $\rightharpoonup$ is an irreflexive binary *attack-relation* on Arg



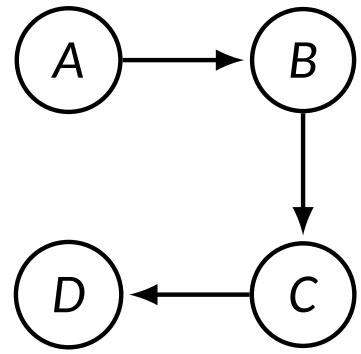
A is not attacked by any argument, B is *attacked* by A,
C, D *attack* each other.

P.M. Dung. On the Acceptability of Arguments and its Fundamental Role in NMR, LP and n-Person Games. *Artificial Intelligence*, 77(2):321–357, 1995.

Background: Conflict-Freeness and Admissibility

Given an AF, we say that $\Delta \subseteq Arg$ is:

- *conflict-free* if there exist no arguments $A, B \in \Delta$ such that $A \rightharpoonup B$
- *admissible* if it is conflict-free and defends every single one of its members



$\{A, D\}$ is conflict-free but not admissible

$\{A, C\}$ is admissible

Background: Conflict-Freeness and Admissibility

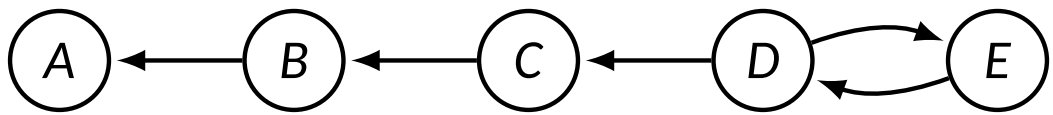
A Diesel cars should be banned from entering the city centre in order to decrease pollution.

B There are few alternatives: there are not enough charging stations around.

C Setting up more charging stations.

D In times of financial crisis, the city should not commit to spending additional money.

E Health and climate change issues are important, so the city has to spend what is needed to tackle pollution.



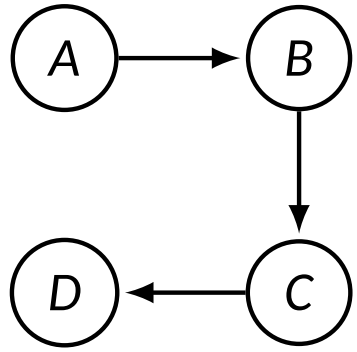
$\{E\}$,
$\{C, E\}$,
$\{A, C, E\}$ are admissible sets of AF

$\{D\}$,
$\{B, D\}$ are admissible sets of AF

Background: Preferred Extension

Given an AF, we say that $\Delta \subseteq Arg$ is:

- *a grounded extension* iff Δ is a maximal admissible set w.r.t. set inclusion (accept as more argument as possible)



$\{A\}$ is an admissible set but not a preferred extension

$\{A, C\}$ is a preferred extension

Background: Preferred Extension

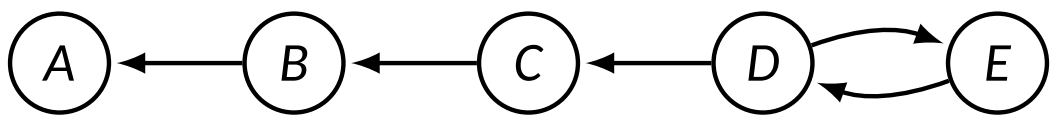
A Diesel cars should be banned from in the city centre in order to decrease pollution.

B There are few alternatives: there are not enough charging stations around.

C Set up more charging stations.

D In times of financial crisis, the city should not commit to spending additional money.

E Health and climate change issues are important, so the city has to spend what is needed to tackle pollution.

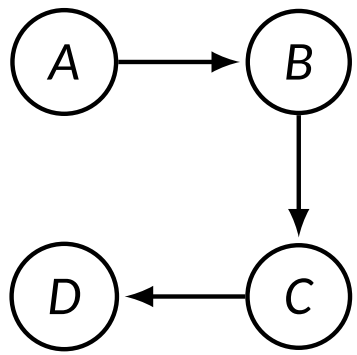


$\{A, C, E\}$, $\{B, D\}$ are the preferred extensios of AF

Background: Grounded Semantics

The *characteristic function* of AF is the function $f_{AF} : 2^{Arg} \longrightarrow 2^{Arg}$ with $f_{AF} : \Delta \mapsto \{A \in Arg \mid \Delta \text{ defends } A\}$.

The *grounded extension* of AF is the *least fixed point* of its characteristic function f_{AF}.



$$f^1_{AF}(\emptyset) = \{A\}, f^2_{AF}(\emptyset) = \{A, C\}, f^3_{AF}(\emptyset) = \{A, C\}, f^2_{AF}(\emptyset) = f^3_{AF}(\emptyset)$$

so the *grounded extension* of AF is $\{A, C\}$.

Collective Argumentation

Fix a set of *arguments*. Given n *agents* and a *profile* of attack relations $\rightharpoonup = (\rightharpoonup_1, \ldots, \rightharpoonup_n)$. How should we *aggregate* this information?

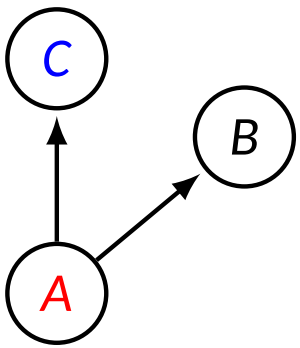
An example

Let F be the majority rule. Three figures each provide an AF on the same set of three issues:

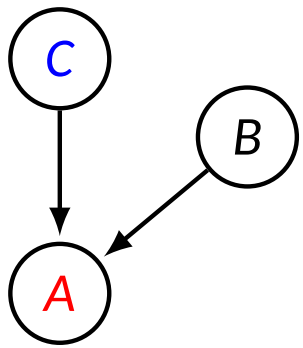
A Increasing consumption of fossil fuels.

B Preventting global warming

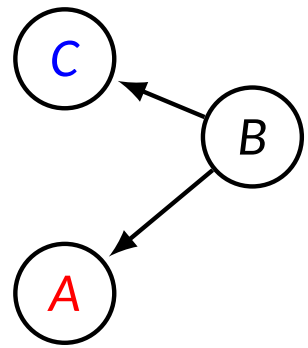
C Lowering or eliminating electric car tax



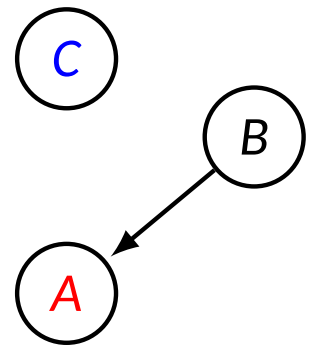
Donald Trump



Emmanuel Macron



a scientist



$F(\rightharpoonup)$

Graph Aggregation

Theorem 1 For $|Arg| \geqslant 3$, any unanimous, grounded, neutral, and independent agggegation rule F that preserves some property P that is *implicative* and *disjunctive* must be a dictatorship.

where

- *implicative*: there exist a set $Att \subseteq Arg \times Arg$ such that $[att_1, att_2, att_3 \in Arg \times Arg \backslash Att] \rightarrow [att_1 \wedge att_2 \rightarrow att_3]$
- *disjunctive*: there exist a set $Att \subseteq Arg \times Arg$ such that $[att_1, att_2 \in Arg \times Arg \backslash Att] \rightarrow [att_1 \vee att_2]$

Example:

- *Transitivity* is implicative
- *Completeness* is disjunctive
- *Connectedness* is implicative and disjunctive

Semantic Properties

What AF-properties are preserved under aggregation?

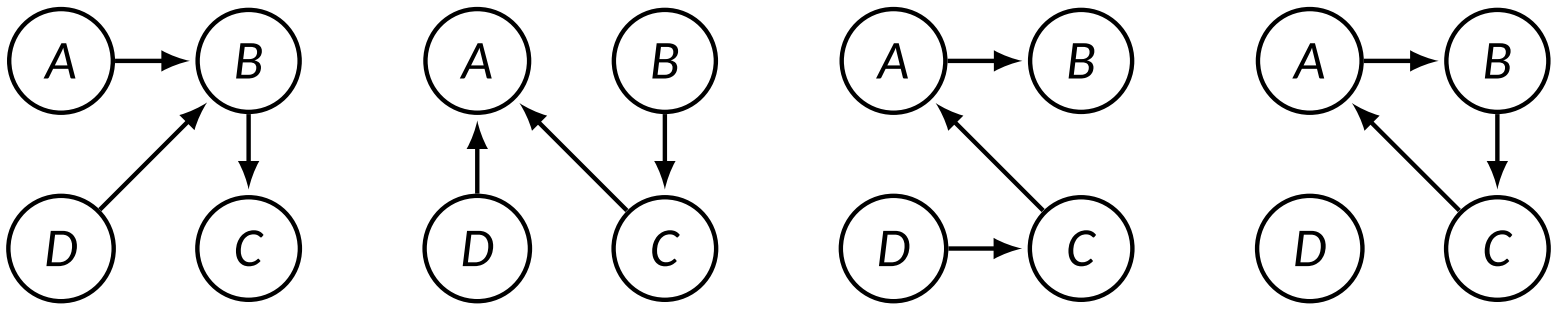
We are interested in *semantic properties* such as:

- *acyclicity*
- *nonemptiness* of the grounded extension
- $\Delta \subseteq Arg$ *being an extension* (according to a given semantics)

So, in case all agents agree on one of them being satisfied, we would like to see it preserved under aggregation.

Example

Let F be the *majority rule*. Consider the following example:



AF_1 AF_2 AF_3 $F(\rightharpoonup)$

Observations:

- *acyclicity* is not preserved
- *nonemptiness* of the grounded extension is preserved

But does the latter result hold in general?

Preservation of Conflict-Freeness

Theorem 2 Every aggregation rule F that is *grounded* preserves *conflict-freeness*.

Proof Idea

- no grounded aggregation rule would *invent* an attack between two arguments

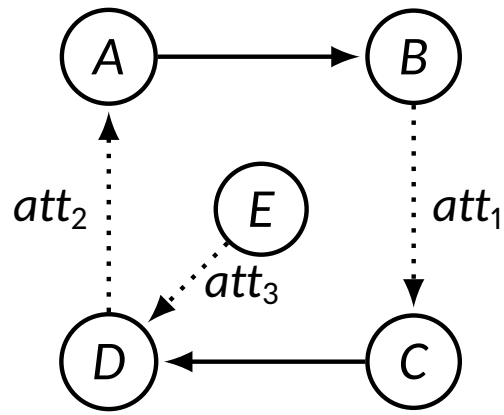
Terminology: an aggregation rule F is called *grounded* if $F(\rightarrow_1, \ldots, \rightarrow_n) \subseteq (\rightarrow_1) \cup \cdots \cup (\rightarrow_n)$ for every profile $\rightarrow$.

Preservation of Grounded Extensions

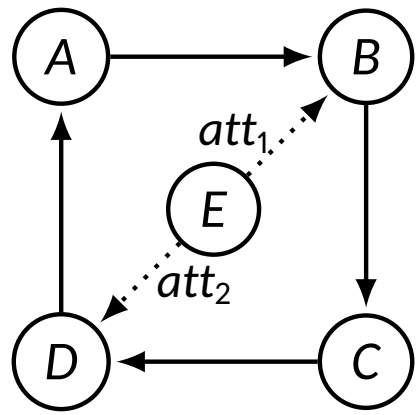
Theorem 3 For $|Arg| \geqslant 5$, any unanimous, grounded, neutral, and independent aggregation rule F that preserves *grounded extensions* must be a *dictatorship*.

Proof Idea

Being a grounded extension is a *disjunctive* and *implicative* property



Implicativeness



Disjunctiveness

- $Att = \{A \rightharpoonup B, C \rightharpoonup D\}$
- $att_1 = B \rightharpoonup C$, $att_2 = D \rightharpoonup A$, and $att_3 = E \rightharpoonup D$.
- the acceptance of att_1 and att_2 imply the acceptance of att_3

Preservation of Acyclicity

Acyclicity is associated with the existence of a *single extension*.

Theorem 4 If $|Arg| \geqslant n$, then under any neutral and independent aggregation rule F that preserves *acyclicity* at least one agent must have *veto powers*.

Proof Idea

- the proof of this theorem relies on a result for a more general property which we call k-exclusiveness
- acyclicity is a k-exclusive property

Terminology: Agent $i \in N$ has *veto powers* under aggregation rule F, if $F(\rightharpoonup) \subseteq (\rightharpoonup_i)$ for every profile $\rightharpoonup$.

Preservation Results

Property	**Rule(s)**
Argument acceptability	
(Holds for all four semantics)	dictatorships
Conflict-freeness	all grounded rules
Admissibility	nomination rule
Grounded extension	dictatorships
Stable extension	nomination rule
Coherence	dictatorships
Nonempty of the GE	veto rules
Acyclicity	veto rules

Summary

In this talk, we have:

- defined a model for aggregation of AFs
- defined desirable semantic properties of AFs
- drawn a picture of the capabilities and limitations of aggregation of AFs

Things that could be done in the future:

- study the preservation of preferred and complete extensions
- study further semantic properties of AFs, going beyond the four classical semantics
- ...