Université Toulouse 1 Capitole - IRIT

Argumentation Reasoning

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Based on a tutorial given at EASSS’17 Summer School with Jean-Guy Mailly (Univ. Paris 5 Descartes - LIPADE)
Content

An example

Abstract Argumentation Framework

Acceptability Semantics

Extended Argumentation Frameworks

Argumentation Dynamics
Arguments are used in everyday life to defend or explain a point of view
Where to eat?

Arguments are used in everyday life to defend or explain a point of view

- **John**: "I’m hungry, let’s go to this restaurant."
Where to eat?

Arguments are used in everyday life to defend or explain a point of view

- **John**: "I’m hungry, let’s go to this restaurant."
- **Yoko**: "I’ve seen on Tripadvisor that the food is bad, let’s go somewhere else."
Where to eat?

Arguments are used in everyday life to defend or explain a point of view

- **John**: "I’m hungry, let’s go to this restaurant."
- **Yoko**: "I’ve seen on Tripadvisor that the food is bad, let’s go somewhere else."
- **John**: "The Tripadvisor grades are old and there is a new chef, so it should be better now."
Where to eat?

Arguments are used in everyday life to defend or explain a point of view

- **John**: "I’m hungry, let’s go to this restaurant."
- **Yoko**: "I’ve seen on Tripadvisor that the food is bad, let’s go somewhere else."
- **John**: "The Tripadvisor grades are old and there is a new chef, so it should be better now."
- **John**: "Moreover, the other restaurants in the streets are closed."
Formally, an argument is made of a support which allows to deduce a given claim.
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I’m hungry, let’s go to this restaurant.
Conflicts between Arguments

The support (or the claim) of an argument can be incompatible with the support (or the claim) of another argument: **attack**
Conflicts between Arguments

The support (or the claim) of an argument can be incompatible with the support (or the claim) of another argument: **attack**

▶ **claim vs claim** (rebuttal): "I’m hungry, let’s go to this restaurant." vs "Its grades on Tripadvisor are bad, let’s go somewhere else."
Conflicts between Arguments

The support (or the claim) of an argument can be incompatible with the support (or the claim) of another argument: **attack**

- **claim vs claim** (rebuttal): "I’m hungry, let’s go to this restaurant." vs "Its grades on Tripadvisor are bad, let’s go somewhere else."
- **claim vs support** (undercut): "The Tripadvisor grades are old and there is a new chef, so it should be better now." vs "I’ve seen on Tripadvisor that **the food is bad**, let’s go somewhere else."
Several formalisms capture formally the nature of arguments and attacks

- Deductive argumentation [Besnard and Hunter 2008]
- Rule-based argumentation

Support and claims are represented as logical formulas or rules, then arguments and attacks are built.
CLAIM 1 While those on the far-right think that immigration threatens national identity, as well as cheapening labor and increasing dependence on welfare.

[...]

Proponents of immigration maintain that, according to Article 13 of the Universal Declaration of Human Rights, everyone has the right to leave or enter a country, along with movement within it. [...]

CLAIM 3 Some argue that the freedom of movement both within and between countries is a basic human right, and that the restrictive immigration policies, typical of nation-states, violate this human right of freedom of movement.

[...]

Immigration has been a major source of population growth and cultural change throughout much of the history of Sweden. The economic, social, and political aspects of immigration have caused controversy regarding ethnicity, economic benefits, jobs for non-immigrants, settlement patterns, impact on upward social mobility, crime, and voting behavior.

ARGUMENT A ATTACKS ARGUMENT B

SUPPORTS SCORE 0.90
SCORE 0.25
SCORE 0.07

SUPPORTS SCORE 0.81

[O] [P] [I] [R] [E] [N] [E] [N] [C] [E] [E] [2]

[O] [P] [I] [R] [E] [N] [E] [N] [C] [E] [E] [4]

[O] [P] [I] [R] [E] [N] [E] [N] [C] [E] [E] [2]

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[Lippi and Torroni 2016]
Example
Debate about reduced meat consumption

[Salliou and Thomopoulos 2018]
Content

An example

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Argumentation Dynamics
Dung’s Argumentation Framework [Dung 1995]

**Argumentation Framework** (AF for short): $F = (A, R)$ where
- $A$ is a set of arguments
- $R \subseteq A \times A$ represents attacks between arguments
Abstracting arguments and relationships

Dung’s Argumentation Framework [Dung 1995]

**Argumentation Framework** (AF for short): \( F = (A, R) \) where

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

**Example:**

- \( a_1 \): (John) "I’m hungry, let’s go to this restaurant."
- \( a_2 \): (Yoko) "I’ve seen on TripAdvisor that the food is bad, let’s go somewhere else."
- \( a_3 \): (John) "The TripAdvisor grades are old and there is a new chef, so it should be better now."
- \( a_4 \): (John) "Moreover, the other restaurants in the streets are closed."

\( F = (A, R) \) with
\[
A = \{a_1, a_2, a_3, a_4\}, \quad R = \{(a_2, a_1), (a_3, a_2), (a_4, a_2)\}
\]
Acceptability

Given an argumentation framework $F = (A, R)$:

- What is acceptable?
Given an argumentation framework $F = (A, R)$:

- What is **acceptable**?
- Intuitively:
Given an argumentation framework $F = (A, R)$:

- What is **acceptable**?
- Intuitively:

![Diagram of argumentation framework with nodes $a_1$, $a_2$, $a_3$, $a_4$.]
Given an argumentation framework $F = (A, R)$:

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Given an argumentation framework $F = (A, R)$:

- What is **acceptable**?
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Cycles: Dilemmas

- $a_1$: "I like this restaurant, let's eat here." (John)
- $a_2$: "I don’t like this restaurant, let's go somewhere else." (Yoko)
Cycles: Dilemmas

- $a_1$: "I like this restaurant, let's eat here." (John)
- $a_2$: "I don’t like this restaurant, let’s go somewhere else." (Yoko)

What can we accept?
Cycles: Paradoxes

- \( a_1 \): "John says that Paul is a liar."
- \( a_2 \): "Paul says that George is a liar."
- \( a_3 \): "George says that John is a liar."

```
What can we accept?
```

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Cycles: Paradoxes

- $a_1$: "John says that Paul is a liar."
- $a_2$: "Paul says that George is a liar."
- $a_3$: "George says that John is a liar."

What can we accept?
Content

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Argumentation Dynamics
Extension-based Semantics [Dung 1995]

- **Extension**: set of jointly acceptable arguments
  - "solution" of the debate
  - "point of view" about the situation

- A set of arguments has to satisfy some properties to be an extension: *e.g.* we don’t accept arguments $a_1$ and $a_2$ together if there is an attack between them

- **Semantics**: Function $\sigma$ which maps an AF $F$ to a set of extensions $\sigma(F)$
## Basic semantics

A set $S \subseteq A$ is

- **conflict-free (cf) w.r.t.** $F$ if $\nexists a_i, a_j \in S$ s.t. $(a_i, a_j) \in R$
- **admissible (ad) w.r.t.** $F$ if $S$ is cf and $S$ defends each $a_i \in S$ (i.e. $\forall a_i \in S, \forall a_j$ s.t. $(a_j, a_i) \in R, \exists a_k \in S$ s.t. $(a_k, a_j) \in R$)

## Classical semantics

A set $S \subseteq A$ is

- **complete (co) w.r.t.** $F$ if $S$ is ad and $S$ contains all the arguments that it defends
- **preferred (pr) w.r.t.** $F$ if $S$ is a maximal co extension (w.r.t. $\subseteq$)
- **stable (st) w.r.t.** $F$ if $S$ is cf and $S$ attacks every $a_j \in A \setminus E$
- **grounded (gr) w.r.t.** $F$ if $S$ is a minimal co extension (w.r.t. $\subseteq$)
Arguments’ Acceptance

Skeptical Acceptance
Given $F = \langle A, R \rangle$ and $\sigma$, $skep_\sigma(F) = \bigcap_{S \in \sigma(F)} S$ is the set of skeptically accepted arguments

Credulous Acceptance
Given $F = \langle A, R \rangle$ and $\sigma$, $cred_\sigma(F) = \bigcup_{S \in \sigma(F)} S$ is the set of credulously accepted arguments
Example:

\[ \{a_1, a_3, a_4\} \text{ is the unique complete (resp. preferred, stable, grounded) extension.} \]

\[ \text{This set is then also the set of}\ \textit{skeptically} \text{ and of}\ \textit{credulously} \text{ accepted arguments under these semantics.} \]
How Semantics Deal with Dilemmas

Semantics

$\sigma$-

Extensions

Cred

Skep

Grounded $\{\emptyset\}$

Stable $\{\{a_1\}, \{a_2\}\}$

Preferred $\{\{a_1\}, \{a_2\}\}$

Complete $\{\emptyset, \{a_1\}, \{a_2\}\}$

$\{a_1, a_2\}$

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How Semantics Deal with Dilemmas

<table>
<thead>
<tr>
<th>Semantics $\sigma$</th>
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<th>$skep_\sigma$</th>
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<tbody>
<tr>
<td>grounded</td>
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- $a_1$ and $a_2$ are connected with a double arrow, indicating a relationship or interaction between them.
### How Semantics Deal with Dilemmas

#### Semantics \( \sigma \)

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![Diagram](image-url)
How Semantics Deal with Dilemmas

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$\sigma$-extensions for grounded and stable semantics with $a_1$ and $a_2$. $cred_\sigma$ and $skep_\sigma$ indicate the preferred and complete extensions respectively.
How Semantics Deal with Dilemmas

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The diagram illustrates the relationship between $a_1$ and $a_2$. The table shows the $\sigma$-extensions, $\text{cred}_\sigma$, and $\text{skep}_\sigma$ for each semantics type.
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How Semantics Deal with Paradoxes

- $a_1$ → $a_2$ → $a_3$

- Stable: $\{\emptyset\}$
- Complete: $\{\emptyset\}$
- Preferred: $\{\emptyset\}$
- Grounded: $\{\emptyset\}$
- Suspect: $\{\emptyset\}$
- $\sigma$-extensions: $\emptyset$

S. Doutre | Argumentation Reasoning
How Semantics Deal with Paradoxes

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Exercise

Questions:
▶ What are the extensions under the various semantics (grounded, stable, preferred, complete)?
▶ Under each semantics, which arguments are credulously accepted? Which ones are skeptically accepted?

Need help?
⇒ [ConArg] (Web interface, to be used with the example in Appendix)

S. Doutre | Argumentation Reasoning
Questions:

- What are the extensions under the various semantics (grounded, stable, preferred, complete)?
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Need help?

⇒ [ConArg] (Web interface, to be used with the example in Appendix)
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<td>${{a_1, a_4, a_6}, {a_1, a_3}}$</td>
<td>${a_1, a_3, a_4, a_6}$</td>
<td>${a_1}$</td>
</tr>
<tr>
<td>complete</td>
<td>${{a_1, a_4, a_6}, {a_1, a_3}, {a_1}}$</td>
<td>${a_1, a_3, a_4, a_6}$</td>
<td>${a_1}$</td>
</tr>
</tbody>
</table>
Example: Semantics Comparison

<table>
<thead>
<tr>
<th>Semantics $\sigma$</th>
<th>$\sigma$-extensions</th>
<th>$\text{cred}_\sigma$</th>
<th>$\text{skep}_\sigma$</th>
</tr>
</thead>
<tbody>
<tr>
<td>grounded</td>
<td>${{a_1}}$</td>
<td>${a_1}$</td>
<td>${a_1}$</td>
</tr>
<tr>
<td>stable</td>
<td>${{a_1, a_4, a_6}}$</td>
<td>${a_1, a_4, a_6}$</td>
<td>${a_1, a_4, a_6}$</td>
</tr>
<tr>
<td>preferred</td>
<td>${{a_1, a_4, a_6}, {a_1, a_3}}$</td>
<td>${a_1, a_3, a_4, a_6}$</td>
<td>${a_1}$</td>
</tr>
<tr>
<td>complete</td>
<td>${{a_1, a_4, a_6}, {a_1, a_3}, {a_1}}$</td>
<td>${a_1, a_3, a_4, a_6}$</td>
<td>${a_1}$</td>
</tr>
</tbody>
</table>
An argumentation system is made of:

1. Argumentation framework $F$
2. Acceptability Semantics $\sigma$
3. Argument evaluation $\sigma(F)$
Other *extension-based* semantics:

- naive
- ideal
- stage
- semi-stable
- eager
- ...

See [Baroni, Caminada, Giacomin 2011]
More Semantics

Other types of semantics:

- **Labelling-based** semantics
  - Every argument is assigned a label: *in*, *out* or *undec*.
  - \( a \) is labelled *in* iff \( \forall b \) s.t. \( (b, a) \in R \), \( b \) is labelled *out*
  - \( a \) is labelled *out* iff \( \exists b \) s.t. \( (b, a) \in R \) and \( b \) is labelled *in*
  - \( a \) is labelled *undec* iff \( a \) is neither labelled *in* nor *out*
  - Several possible labellings can result.
  - Correspondence shown between labellings and extensions

\[ \Rightarrow \text{[ArgTeach]} \text{ to learn how to label (to be used with the example in Appendix)} \]
Other types of semantics:

- **Ranking-based** semantics
  - A *pre-order* on arguments is defined, instead of sets of collectively acceptable arguments.
  - The pre-order compares the acceptability of arguments.
  - The comparison may be based on the number of attacking and defending arguments, for example.

⇒ See [Bonzon, Delobelle, Konieczny, Maudet 2016] for a comparative study of ranking-based semantics
Content

An example

Abstract Argumentation Framework

Acceptability Semantics

Extended Argumentation Frameworks

Argumentation Dynamics
There are many ways to extend the expressiveness of abstract argumentation, e.g.:

- Preferences
- Support relation
- Abstract dialectical frameworks
besides conflicts between arguments, the agent has some preferences between arguments

- if $a_1$ is preferred to $a_2$, then no attack from $a_2$ to $a_1$ can succeed
besides conflicts between arguments, the agent has some preferences between arguments

if \( a_1 \) is preferred to \( a_2 \), then no attack from \( a_2 \) to \( a_1 \) can succeed

\[
PrF = \langle A, R, \leq \rangle \text{ with }
\]

\( A = \{ a_1, a_2 \} \)

\( R = \{ (a_1, a_2), (a_2, a_1) \} \)

\( a_2 \leq a_1 \) (\text{i.e.} \( a_1 \) is "better than" \( a_2 \))
besides conflicts between arguments, the agent has some preferences between arguments

- if $a_1$ is preferred to $a_2$, then no attack from $a_2$ to $a_1$ can succeed

$PrF = \langle A, R, \leq \rangle$ with

- $A = \{a_1, a_2\}$
- $R = \{(a_1, a_2), (a_2, a_1)\}$
- $a_2 \leq a_1$ (i.e. $a_1$ is "better than" $a_2$)

$F = \langle A, R \rangle$ with

- $A = \{a_1, a_2\}$
- $R = \{(a_1, a_2)\}$
preferences are not expressed over arguments, but over values assigned to arguments
preferences are not expressed over arguments, but over values assigned to arguments

\[ VAF = \langle A, R, V, val \rangle \] with

- \( A = \{a_1, a_2\} \)
- \( R = \{(a_1, a_2), (a_2, a_1)\} \)
- \( V = \{\text{env}, \text{eco}\} \)
- \( val(a_1) = \text{env}, \quad val(a_2) = \text{eco} \)
- \( \text{eco} \leq \text{env} \) (i.e. \( \text{env} \) is preferred to \( \text{eco} \))
preferences are not expressed over arguments, but over values assigned to arguments

\[ VAF = \langle A, R, V, val \rangle \] with

- \( A = \{a_1, a_2\} \)
- \( R = \{(a_1, a_2), (a_2, a_1)\} \)
- \( V = \{\text{env, eco}\} \)
- \( val(a_1) = \text{env}, val(a_2) = \text{eco} \)
- \( \text{eco} \leq \text{env} \) (i.e. env is preferred to eco)

\[ F = \langle A, R \rangle \] with

- \( A = \{a_1, a_2\} \)
- \( R = \{(a_1, a_2)\} \)
besides conflicts between arguments, there are **supports** between arguments

pure support graphs also exist (**e.g.** recommendation letter, job application,...)
besides conflicts between arguments, there are supports between arguments

pure support graphs also exist (e.g. recommendation letter, job application, ...)

Concepts like conflict-freeness and admissibility are generalized for this setting, then semantics can also be defined (see [Amgoud et al 2008] for technical details)
Abstract entities are called **statements**

- Statements can be linked together
- Each statement $s_i$ is associated with a propositional formula built on other statements $s_j$ s.t. there is a **link** from $s_j$ to $s_i$
- $s_i$ is accepted if its formula is true
- Acceptance formulas can express (collective) attacks, (collective) supports or any complex relation
Abstract entities are called **statements**

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![Diagram](http://example.com/diagram.png)
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Content

An example

Abstract Argumentation Framework

Acceptability Semantics

Extended Argumentation Frameworks

Argumentation Dynamics
The dynamics

Given:

\[ a_1 \rightarrow a_2 \rightarrow a_3 \]

the stable semantics produces as set of extensions: \( \{a_1, a_3\} \)

Consider the following constraints:

1. a new argument \( a_4 \) must be added
2. argument \( a_1 \) must be removed
3. a new attack from a new argument \( a_4 \) to argument \( a_1 \) must be added
4. the attack from \( a_1 \) to \( a_2 \) must be removed
5. \( a_2 \) must be in an acceptable set
6. there must be several acceptable sets of arguments

For each of these constraints:

- What are all the ways to enforce it?
- What are the changes implied by each of these enforcements?
Many challenging enforcement problems remain to be explored in Dung’s argumentation framework:

- **Semantic change**
  - As a result of the enforcement of a semantic constraint
  - Alone, as a means to enforce an acceptability constraint
  - Quality

- **Combination** of constraints, and of requirements on the quality of changes

- **Computational approaches**: quite recent for computing extensions, almost nothing for argumentation dynamics
Open Questions

Enforcement problems to be extended to other abstract frameworks and semantics:

- Adaptation to argumentation frameworks other than Dung’s one
- Investigation of constraints and changes in ranking-based semantics
Open Questions

Challenging problems have to be explored in **structured argumentation frameworks** as well:

- Constraints and changes in structured argumentation frameworks
  - on the **underlying structure of arguments**, with possible impacts at the graph level
  - **at the graph level**, with possible impacts on the underlying structure of arguments


[Doutre and Mailly 2018] S. Doutre and J.-G. Mailly *Constraints and


Appendix

Graph example in the Aspartix format:

\[
\begin{align*}
  \text{arg}(a_1). \\
  \text{arg}(a_2). \\
  \text{arg}(a_3). \\
  \text{arg}(a_4). \\
  \text{arg}(a_5). \\
  \text{arg}(a_6). \\
  \text{arg}(a_7). \\
  \text{att}(a_1,a_2). \\
  \text{att}(a_2,a_3). \\
  \text{att}(a_3,a_4). \\
  \text{att}(a_4,a_3). \\
  \text{att}(a_4,a_5). \\
  \text{att}(a_5,a_6). \\
  \text{att}(a_6,a_7). \\
  \text{att}(a_7,a_5).
\end{align*}
\]

⇒ Can be used in [ConArg] and [ArgTeach]