An Argumentation Framework for Decision Making

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Outline

1. ARGUGRID
2. Argumentation
3. Assumption-based argumentation framework
4. Argumentation-based decision making
5. Quantitative argumentation-based decision making
6. Conclusions & Future works
7. Questions?
ARGUmentation as a foundation for the semantic GRID

Project Aims:

- Enact the reasoning and decision making processes and negotiation required for dynamic composition of Grid resources and services into executable workflows, using argumentative agents to support grid service providers and requestors.

- Impact business and business practices by empowering grid-enabled e-business applications where multiple service requestors and providers exist.
ARGUGRID Objectives & Partners

- Provide a new model for argumentative agents populating and evolving within a trusted grid.
- Provide a new model for the specification, creation, operation and dissolution of VOs over the grid using argumentation.
- Design an architecture for the semantic grid to support argumentative agents and VOs.
- Develop a grid-based platform to support the implementation of models and architecture and assess the approach.
- Experiment with and evaluate the models, architecture and platform in the context of concrete applications for e-business.
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5 Quantitative argumentation-based decision making

6 Conclusions & Future works

7 Questions ?
Overview of argumentation

Argumentation is:
- a conceptualisation of nonmonotonic reasoning;
Overview of argumentation

Argumentation is:

- a conceptualisation of nonmonotonic reasoning;
- a process of construction and comparison of arguments for and against certain conclusions formalized by an argumentation framework [Dung 95], i.e.

- Arguments
  - abstract entities

- Attack relation

- Status of arguments
Overview of argumentation

Argumentation is:

- a conceptualisation of nonmonotonic reasoning;
- a process of construction and comparison of arguments for and against certain conclusions formalized by an argumentation logic [Prakken & Sartor 97], i.e.

- **Underlying logic**
- **Arguments**
  - abstract entities
  - logical structures
- **Attack relation**

- **Status of arguments**
Overview of argumentation

Argumentation is:

- a conceptualisation of nonmonotonic reasoning;
- a process of construction and comparison of arguments for and against certain conclusions formalized by a preference-based argumentation logic [Amgoud & Cayrol 02], i.e.

- **Underlying logic**
- **Arguments**
  - abstract entities
  - logical structures
- **Attack relation**
- **Priority relation**
- **Status of arguments**
Abstract argumentation framework

\[ \begin{array}{ccc}
\uparrow & a \rightleftharpoons b & \downarrow \\
\downarrow & c \rightleftharpoons d & \\
\end{array} \]
Abstract argumentation framework

\[ a \dashv b \quad c \dashv d \]

- \( \emptyset \) is ground;
- \( \{b, c\} \) are \( \{b, d\} \) preferred;
- \( \{b\} \) is the maximal ideal set.

**Definition ([Dung, Kowalski & Toni 06])**

A set \( X \) of arguments is:

- **admissible** iff \( X \) does not attack itself and \( X \) attacks every argument \( Y \) such that \( Y \) attacks \( X \);
- **preferred** iff \( X \) is maximally admissible;
- **complete** iff \( X \) is admissible and \( X \) contains all arguments \( x \) such that \( X \) attacks all attacks against \( x \);
- **grounded** iff \( X \) is minimally complete;
- **ideal** iff \( X \) is admissible and it is contained in every preferred sets.
Abstract argumentation framework

\[ a \rightarrow b \quad c \leftarrow d \]

- \{b, c, f\} are \{b, d, f\} preferred;
- \{b\} is the maximal ideal set and \{b\} \subset \{b, f\} \subset \{b, c, f\} \cap \{b, c, f\}

Definition ([Dung, Kowalski & Toni 06])

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\( \mathcal{L} \) a logic language

**Definition ([Prakken & Sartor 97])**

A theory \( \mathcal{T} \) is an extended logic program, i.e a finite set of rules:

\[
R : L_0 \leftarrow L_1, \ldots, L_j, \text{not } L_k, \ldots, \text{not } L_m
\]

\( \text{head}(R) = L_0 \).
\( \text{body}(R) = \{L_1, \ldots, \text{not } L_m\} \).

\( \mathcal{T} \) is an incompatibility relation amongst sentences in \( \mathcal{L} \):
- \( \mathcal{T} (b_1, \neg b_1) \) and \( \mathcal{T} (\neg b_1, b_1) \),
- \( \mathcal{T} (b_1, \text{not } b_1) \)
Argument as 'proof'

Forms of arguments:

- An **abstract entity** with an unspecified logic,
  \[ A = \text{‘Tweety flies because it’s a bird’}; \]

- A **pair** (Premises, Conclusion),
  \[ A = (\{\text{bird(Tweety), bird(X) }\rightarrow \text{fly(X)}\}, \text{fly(Tweety)}); \]

- A deduction **sequence** of rules and facts
  \[ A = (f_1(\text{Tweety}), r_1(\text{Tweety})); \]

- An inference **tree** grounded in premises;

\[
\text{fly(Tweety)}
\]

\[
\text{bird(\text{Twenty}) not penguin(\text{Twenty})}
\]
Rebutting attack conflicting conclusions:

- *Tweety flies because it is a bird;*
- *Tweety doesn’t fly because it’s a penguin.*

![Diagram showing rebutting attack](image)
Rebutting, undermining and undercutting attacks

**Undermining** attack non-provable assumptions:

- *Tweety flies because it is a bird and it is not provable that Tweety is a penguin;*
- *Tweety is a penguin.*
Rebutting, undermining and undercutting attacks

**Undercutting** attack intermediate step:

- *Tweety flies because all the birds I’ve seen fly;*
- *I’ve seen Tux, it’s a bird and it doesn’t fly.*
How to evaluate the strengths of arguments?

Some domain-independent principles of commonsense reasoning:

- the last link principle [Prakken & Sartor 97];
- the weakest link principle [Amgoud & Cayrol 02];
- the specificity principle [Simari & Loui 92].
From the defeat relation to the status of arguments

- Defeat relation focus on two arguments not on a dispute, eg
Burden of proof rather than correspondence with reality

(Declarative) Model-theoretic Semantic

Completeness  Soundness

(Procedural) Dialectical Proof Procedure
Dialectical enquiry

**Definition**

A Two-Party Immediate Respond Dispute (TPI) is defined s.a.:

- both parties are allowed to repeat PRO;
- PRO is not allowed to repeat CON;
- CON is allowed to repeat CON in a different dispute line.

\{p, r\} and \{p, s\} are preferred

![Diagram](Diagram)

\[ M_3 = \langle PRO, r, M_2 \rangle \quad M_4 = \langle CON, s, M_3 \rangle \quad M_5 = \langle PRO, r, M_4 \rangle \]

\[ M_3 = \langle PRO, s, M_2 \rangle \quad M_4 = \langle CON, r, M_3 \rangle \quad M_5 = \langle PRO, s, M_4 \rangle \]

\[ \text{CON looses} \]

**Theorem**

*Soundness and completeness of TPI for the sceptically preferred semantics.*

Maxime MORGE  MARGO
Take away argumentation technics

**Argumentation framework** is made of:
- Dialectical proof procedure
- Model-theoretic semantics
- Defeat relation
- Priority/Contradictory relation
- Arguments
- Underlying logic

**Argumentation** is a promising approach for:
- **decision-making**, *i.e.* reasoning with inconsistent information;
- **dialogue**, *i.e.* facilitating rational interaction;
- **collective decision making**, *i.e.* reach an agreement.
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An abstract argumentation framework [Dung, Kowalski & Toni 06]

- An Assumption-based argumentation framework
  \( ABF = \langle \mathcal{L}, \mathcal{R}, \mathcal{A}, \_ \rangle = \)
  - \((\mathcal{L}, \mathcal{R})\) a deductive system \(i.e.\)
    - \(\mathcal{L}\) a formal language
    - \(\mathcal{R}\) set of inference rules, eg \(p \leftarrow q, r\)
  - \(\mathcal{A}\) a set of candidate assumption
  - \(\overline{p}\) is the contrary of \(p\)

- Abstract argument \(\mathcal{A}\)
  \(\iff\) Tight deductions supported by sets of assumptions \(\mathcal{A} \vdash \alpha\).

- \(\mathcal{A}\) attacks \(\mathcal{B}\)
  \(\iff\) \(\mathcal{A} \vdash \alpha, \mathcal{B} \vdash \beta, \text{ and } \alpha = \overline{\delta} \in \mathcal{B}\).
An example of ABF

\[ ABF = \langle \mathcal{L}, \mathcal{R}, A, \_ \rangle = \]

- \( \mathcal{L} = \{ a, b, c, d, \neg a, \neg b, \neg c, \neg d \} \)
- \( \mathcal{R} = \{ a \rightarrow \neg b, a \rightarrow \neg a, b \rightarrow \neg d, \neg d \rightarrow c \} \)
- \( A = \{ a, b, c, d \} \)
- \( \overline{a} = \neg a, \overline{b} = \neg b, \overline{c} = \neg c, \overline{d} = \neg d \)

**Attack relations:**
- \{a\} attacks itself;
- \{a\} and \{b\} attack each other.

**Model-theoretic semantics:**
- \( \emptyset \) is ground;
- \{b, c\} are \{b, d\} preferred;
- \{b\} is the maximal ideal set.
Admissible beliefs derivations example

\[ ABF = \langle \mathcal{L}, \mathcal{R}, \mathcal{A}, \overline{-} \rangle = \]

- \( \mathcal{L} = \{ a, b, c, d, \overline{a}, \overline{b}, \overline{c}, \overline{d} \} \)
- \( \mathcal{R} = \{ \overline{b} \rightarrow a \rightarrow \overline{b}, \overline{a} \rightarrow d \rightarrow \overline{c} \} \)
- \( \mathcal{A} = \{ a, b, c, d \} \)
- \( \overline{a} = a, \overline{b} = b, \overline{c} = c, \overline{d} = d \)

Is \( \overline{a} \) an admissible belief?

<table>
<thead>
<tr>
<th>Proponent</th>
<th>Opponent</th>
<th>Ass support. P</th>
<th>Culprit choosen in O</th>
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<tr>
<td>{\overline{a}}</td>
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<td>{b}</td>
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<td>{}\</td>
<td>{}\</td>
<td>{b}</td>
<td>{a}</td>
</tr>
</tbody>
</table>
Credulous and Sceptical Argumentation Prolog Implementation

- Written in Prolog by Dorian Gaertner and Francesca Toni
- Available at
  http://www.doc.ic.ac.uk/~dg00/casapi.html
- The main procedure is
  `run(derivationtype, outputmode, numberofsolutions)`
  with:
    - the first argument is the type of dispute derivation, eg ab (for admissible belief);
    - the second argument determines the output mode: (s)ilent or (n)oisy.
    - the third argument indicates whether (1) or (a)ll solutions are required.
A good example is better than a long explanation

:- compile('casapi.pl').

myRule(nb,[a]).
myRule(na,[a]).
myRule(na,[b]).
myRule(nc,[d]).
myRule(nd,[c]).

myAss([a,b,c,d]).

toBeProved([na]).

contrary(na,a).
contrary(nb,b).
contrary(nc,c).
contrary(nd,d).
-------
run(ab,s,a).
FINISHED, one defence set is: [b, b]
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Outlook: Agents’ mind (WP2)

- Design
  - state-of-mind (knowledge, goals, actions)
  - qualitative priorities (probabilities, preferences, utilities)
- Argumentation-based decision-making
- Implementation
  - MARGO: a Prolog prototype
Abstract representation of the problem: influence diagram

- Moral decision (moral)
  - Life (life)
  - Propriety (prop)
    - break or leave
  - Hal's life (hlife)
  - Carla's life (cliffe)
    - dia?
    - supp?
  - Decision
    - Abstract value
    - Concrete value
Data structures and priorities: hierarchies of conflicting rules

The theory compiles:

- **goal rules** such as \( R_{012} : g_0 \leftarrow g_1, g_2 \)
- **epistemic rules** such as \( R_{012} : b_0 \leftarrow b_1, \neg b_2 \)
- **decision rules** such as \( R_{110} : g_1 \leftarrow D(a_1), b_0 \)

Different priorities for different rules:

- the priority over **goal rules** comes from preferences,
  eg \( R_1 : g_0 \leftarrow g_1 \) has priority over \( R_2 : g_0 \leftarrow g_2 \)
- the priority over **epistemic rules** comes from probabilities,
  eg \( F_1 : \text{dia} \leftarrow \) has priority over \( F_2 : \neg \text{dia} \leftarrow \)
- the priority over **decision rules** come from expected utilities,
  eg \( R_{11} : g_1 \leftarrow D(a_1), b_1 \) has priority over \( R_{12} : g_1 \leftarrow D(a_1), b_2 \)
A walk through the example

\[ F_1 : \text{dia} \leftarrow \]
\[ F_3 : \neg \text{dia} \leftarrow \]

\[ R_{22} : \text{prop} \leftarrow D(\text{leave}) \]
\[ R_{31} : \text{hlife} \leftarrow D(\text{break}) \]
\[ R_{41} : \text{clife} \leftarrow D(\text{leave}) \]
\[ R_{42} : \text{clife} \leftarrow D(\text{break}), \text{supp}, \text{dia} \]
\[ R_{21} : \text{prop} \leftarrow D(\text{break}) \]
\[ R_{32} : \text{hlife} \leftarrow D(\text{leave}) \]
\[ R_{43} : \text{clife} \leftarrow D(\text{break}), \text{dia} \]

\[ R_{012} : \text{moral} \leftarrow \text{life}, \text{prop} \]
\[ R_{134} : \text{life} \leftarrow \text{hlife}, \text{clife} \]
\[ R_{01} : \text{moral} \leftarrow \text{life} \]
\[ R_{13} : \text{life} \leftarrow \text{hlife} \]
\[ R_{02} : \text{moral} \leftarrow \text{prop} \]
\[ R_{14} : \text{life} \leftarrow \text{clife} \]
Structure of arguments: abductive tree

**Definition**

An argument $A = \langle \text{conc}, \text{premise}, \text{hyp} \rangle$ is:

1. **hypothetical**, i.e. built upon an hypothesis
   
   \[ \text{sent}(A) = \text{hyp}(A) \]
   
   \[ A = \langle D(\text{break}), \emptyset, [D(\text{break})] \rangle \text{ or } A = \langle \text{supp}, \emptyset, [\text{supp}] \rangle \]

2. **trivial**, i.e. built upon an unconditional ground statement

   \[ \text{sent}(A) = \text{premise}(A) \]
   
   \[ A = \langle \text{dia}, [\text{dia}], \emptyset \rangle \text{ or } A = \langle \neg \text{dia}, [\neg \text{dia}], \emptyset \rangle \]

3. **tree**, i.e. built upon a top rule where all literals in the body are the conclusions of subargument s.a.:

   \[ \text{sent}(A) = \bigcup_{A_i = \text{subarg}(A)} \text{sent}(A_i) \cup \text{body}(R) \]
   
   \[ \neg \mathcal{I} \left( \bigcup_i \text{sent}(A_i) \right) \text{ and } \neg (\text{conc}(A) \mathcal{I} \text{ sent}(A_i)). \]

   \[ B_1^4 = \langle \text{clife}, (D(\text{leave})), ((D(\text{leave})) \rangle \]
   
   \[ A_2^4 = \langle \text{clife}, (D(\text{break}), \text{supp}, \text{dia}), (D(\text{break}), \text{supp}) \rangle \]
   
   \[ A_3^4 = \langle \text{clife}, (D(\text{break}), \text{dia}), (D(\text{break})) \rangle. \]
Interaction: choice between different explanations

**Definition (Attack relation)**

attacks \((A, B)\) iff conc\((A)\) \(\vdash\) sent\((B)\)

\(\Rightarrow\) build homogeneous explanations:

- \(B_1^4 = \langle \text{clife}, (D(\text{leave})), ((D(\text{leave}))) \rangle\);
- \(A_2^4 = \langle \text{clife}, (D(\text{break}), \text{supp}, \text{dia}), (D(\text{break}), \text{supp}) \rangle\);
- \(A_3^4 = \langle \text{clife}, (D(\text{break}), \text{dia}), (D(\text{break})) \rangle\).
**Interaction: choice between different explanations (cont.)**

**Definition (Hypothesis size)**

1. If $A$ is a hypothetical argument, then $\text{hypsizer}(A) = 1$;
2. If $A$ is a trivial argument, then $\text{hypsizer}(A) = 0$
3. If $A$ is a tree argument then
   \[ \text{hypsizer}(A) = \sum_{A' \in \text{subarg}(A)} \text{hypsizer}(A'). \]

**Definition (Strength relation)**

$A_1$ a hypothetical argument, and $A_2, A_3$ two built arguments:

1. $A_2 \succ^A A_1$;
2. If $(\text{top}(A_2) \prec \text{top}(A_3)) \land \neg(\text{top}(A_3) \prec \text{top}(A_2))$, then $A_3 \succ^A A_2$;
3. If $(\text{top}(A_2) \sim \text{top}(A_3)) \land (\text{hypsizer}(A_2) \leq \text{hypsizer}(A_3))$, then $A_2 \succ^A A_3$;
Interaction: choice between different explanations (cont.)

Definition (Defeat relation)

A defeats B

1. attacks \((A, B)\)
2. \(\neg(B \succ^A A)\).

\[B_1^4 = \langle \text{clife}, (D(\text{leave})), ((D(\text{leave}))) \rangle;\]
\[A_2^4 = \langle \text{clife}, (D(\text{break}), \text{supp}, \text{dia}), (D(\text{break}), \text{supp}) \rangle;\]
\[A_3^4 = \langle \text{clife}, (D(\text{break}), \text{dia}), (D(\text{break})) \rangle.\]

Since

\[\text{top}(A_3^4) \prec (\text{top}(B_1^4) \sim \text{top}(A_2^4));\]
\[\text{hysize}(B_1^4) = \text{hysize}(A_3^4) = 1 \text{ and } \text{hysize}(A_2^4) = 2,\]

\(B_1^4\) defeats \(A_2^4/A_3^4\) and \(A_2^4 \succ^A A_3^4\).
Semantics: status of arguments/alternatives

Definition (Acceptability)

A set $X$ of arguments is:

- **admissible** iff $X$ does not attack itself and $X$ attacks every argument $Y$ such that $Y$ attacks $X$;
- **preferred** iff $X$ is maximally admissible;
- **ideal** iff $X$ is admissible and it is contained in every preferred sets.

The semantics is:

- either *credulous*, eg admissible;
- or *sceptical*, eg ideal, or sceptically preferred semantics.

Definition (Suggestion)

The decision $D(a_1)$ is **suggested** iff $D(a_1)$ is a hypothesis of one argument in an admissible set.
Procedure and its implementation: relax goals requirement and make hypotheses
Take away MARGO (Multicriteria ARGumentation framework for Opinion justification)

A *argumentation framework* for practical reasoning

→ **Formalization** of a decision making

- Influence diagram
  → **Abstract representation**

- Goal/Decision/Epistemic rules
  → **Specific data structures**

- Priority over epistemic/goal/decision rules
  → **Intuitions about probability/preferences/expected utilities**

- Abductive tree argument
  → **Interaction-based explanation of the decision**
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Influence diagram

- Recommended location \( (g_0) \)
- Regulation \( (g_1) \)
- Accessible \( (g_2) \)
- Taxes \( (g_3) \)
- Permit \( (g_4) \)
- Assistance \( (g_5) \)
- Sewage \( (g_6) \)
- Transport \( (g_7) \)

Decision

- Sea?
- Road?
### Epistemic/Goal/Decision theory

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<th>$c(R)$</th>
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<td>$\leftarrow$</td>
<td>$R_{012} : g_0 \leftarrow g_1, g_2$</td>
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<td>$\leftarrow$</td>
<td>$R_{01} : g_0 \leftarrow g_1$</td>
<td>$c(R_{01}) = 6/10$</td>
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<tr>
<td>$\leftarrow$</td>
<td>$R_{02} : g_0 \leftarrow g_2$</td>
<td>$c(R_{02}) = 4/10$</td>
</tr>
<tr>
<td>$\leftarrow$</td>
<td>$R_{1345} : g_1 \leftarrow g_3, g_4, g_5$</td>
<td>$c(R_{1345}) = 1$</td>
</tr>
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<td>$\leftarrow$</td>
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<td>$\leftarrow$</td>
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<td>$R_{62} : g_6 \leftarrow D(\text{pisa})$</td>
<td>$c(R_{62}) = 5/10$</td>
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<tr>
<td>$\leftarrow$</td>
<td>$R_{71}(x) : g_7 \leftarrow D(x), \text{Sea}(x)$</td>
<td>$c(R_{71}(x)) = 6/1$</td>
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<tr>
<td>$\leftarrow$</td>
<td>$R_{72}(x) : g_7 \leftarrow D(x), \text{Road}(x)$</td>
<td>$c(R_{72}(x)) = 4/1$</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>$&lt;$</th>
<th>$R$</th>
<th>$c(R)$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\leftarrow$</td>
<td>$F_1 : \text{Road(\text{pisa})}$</td>
<td>$c(F_1) = 8/10$</td>
</tr>
<tr>
<td>$\leftarrow$</td>
<td>$F_2 : \neg \text{Road(\text{pisa})}$</td>
<td>$c(F_2) = 2/10$</td>
</tr>
<tr>
<td>$\leftarrow$</td>
<td>$F_3 : \text{Sea(\text{pisa})}$</td>
<td>$c(F_3) = 7/10$</td>
</tr>
<tr>
<td>$\leftarrow$</td>
<td>$F_4 : \neg \text{Sea(\text{pisa})}$</td>
<td>$c(F_4) = 3/10$</td>
</tr>
</tbody>
</table>
**Interaction: choice between different explanations (cont.)**

### Definition (Weight)

1. if $A$ is a hypothetical argument, then $\text{wei}(A) = 1$;
2. if $A$ is trivial and built upon $F \in \mathcal{T}$, then $\text{wei}(A) = c(F)$;
3. if $A$ is a tree built upon $R \in \mathcal{T}$, then:
   - either $R$ is an epistemic rules of the form $R : B_0 \leftarrow B_1, \ldots, B_n$ with $n \geq 0$, then
     
     \[
     \text{wei}(A) = c(R) \times \prod_{i=1}^{n} \text{wei}(A_i);
     \]
   - or $R$ is a decision rules of the form $R : g \leftarrow D, B_2, \ldots, B_n$ with $n \geq 0$, then
     
     \[
     \text{wei}(A) = c(R) \times \prod_{i=1}^{n} \text{wei}(A_i);
     \]
   - otherwise $R$ is a goal rule of the form $R : g_0 \leftarrow g_1, \ldots, g_n$ with $n > 0$, then
     
     \[
     \text{wei}(A) = c(R) \times \sum_{i=1}^{n} c(R_{0i}) \times \text{wei}(A_i).
     \]
Interaction: choice between different explanations (cont.)

Definition (Strength relation)

Let $A_1$ be an hypothetical argument and $A_2, A_3$ two built arguments.

1. $A_2$ is stronger than $A_1$ (denoted $A_2 \succ^A A_1$);
2. If $(\text{top}(A_2) \sim \text{top}(A_3))$ and $(\text{hypsise}(A_2) \leq \text{hypsise}(A_3))$, then $A_2 \succ^A A_3$;
3. Else if $(\text{wei}(A_2) \geq \text{wei}(A_3))$, then $A_2 \succ^A A_3$;
Arguments

Some of the arguments supporting the transport accessibility:

- $B_7^1 = \langle g_7, (D(\text{pisa}), \text{Sea(pisa)}), (D(\text{pisa}))\rangle$;
- $B_7^2 = \langle g_7, (D(\text{pisa}), \text{Road(pisa)}), (D(\text{pisa}))\rangle$;
- $A_7^1 = \langle g_7, (D(\text{london}), \text{Sea(london)}), (D(\text{london}), \text{Sea(london)})\rangle$;
- $A_7^2 = \langle g_7, (D(\text{london}), \text{Road(london)}), (D(\text{london}), \text{Road(london)})\rangle$.

Since

- $\text{wei}(B_7^1) = 42/100$, $\text{wei}(B_7^2) = 32/100$, $\text{wei}(A_7^1) = 60/100$, and $\text{wei}(A_7^2) = 40/100$,
- $\text{hysize}(B_7^1) = \text{hysize}(B_7^2) = 1$ and $\text{hysize}(A_7^1) = \text{hysize}(A_7^2) = 2$.

$B_7^1 / B_7^2$ defeat $A_7^1 / A_7^2$ and $B_7^1$ (resp. $A_7^1$) is stronger than $B_7^2$ (resp. $A_7^2$)

$\Rightarrow$ Pisa must be selected as the best alternative to achieve $g_7$ and the best explanation is based upon the availability of sea transports.
Semantics

The admissible arguments are:

- \( A_0^1 = \langle g_0, (g_1, g_2), (D(\text{london}), \text{Sea(london)})) \rangle; \)
- \( B_2^1 = \langle g_2, (g_6, g_7), (D(pisa)) \rangle. \)

Definition (Full admissibility)

- \( A \) is fully acceptable with respect to \( S \) in \( \mathcal{T} \) (denoted \( A \in \mathcal{S}^S_A(\mathcal{T}) \)) iff \( A \) is acceptable with respect to \( S \) in \( \mathcal{T} \) and all its subarguments \( A' \) are acceptable with respect to the set of arguments and subarguments of \( S \) in \( \mathcal{T}_{\text{conc}}(A') \);
- \( S \) is fully admissible in \( \mathcal{T} \) iff \( S \) is conflict-free and \( \forall A \in S, A \in \mathcal{S}^S_{\mathcal{T}} \);

The fully admissible arguments are:

- \( A_0^2 = \langle g_0, (g_1), (D(\text{london}), \text{Sea(london)})) \rangle; \)
- \( B_2^1 = \langle g_2, (g_6, g_7), (D(pisa)) \rangle. \)
Outline

1. ARGUGRID
2. Argumentation
3. Assumption-based argumentation framework
4. Argumentation-based decision making
5. Quantitative argumentation-based decision making
6. Conclusions & Future works
7. Questions?
Outlook: Agents’ mind (WP2)

- **Design**
  - state-of-mind (*knowledge, goals, actions, plans*)
  - qualitative/quantitative priorities
  - workflow in state-of-mind

- **Implementation**
  - MARGO: a Prolog prototype

- **Application**
  - procurement/migration/EO scenarios
References

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Making Hard Decisions.

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Concrete scenarios identification & simple use cases.

P. M. Dung.
On the acceptability of arguments and its fundamental role in nonmonotonic reasoning, logic programming and n-person games.
References (cont.)

H. Prakken and G. Sartor.
Argument-based logic programming with defeasible priorities.

Phan Minh Dung, Robert A. Kowalski, Francesca Toni
Dialectic proof procedures for assumption-based, admissible argumentation

Leila Amgoud and Claudette Cayrol
A Reasoning Model Based on the Production of Acceptable Arguments

Guillermo Ricardo Simari and Ronald Prescott Loui
A Mathematical Treatment of Defeasible Reasoning and its Implementation
Brief overview

- Written in Prolog
- Available in GPL at http://margo.sourceforge.net
- Built upon CaSAPI (Credulous and Sceptical Argumentation Prolog Implementation) written by Dorian Gaertner and Francesca Toni
  http://www.doc.ic.ac.uk/~dg00/casapi.html
- The main procedure is
  admissibleArgument(+CONC, -PREMISES, -SUPPOSITIONS) with:
  - the first argument is the goal/belief of the admissible arguments ie the conclusions;
  - the second argument stands for the premises;
  - the third argument stands for the suppositions.
A good example is better than a long explanation

:- compile('./src/margo.pl').
decisionrule(r71a, g7, [d(london), sea(london)]).
decisionrule(r71b, g7, [d(pisa), sea(pisa)]).
epistemicrule(f11,road(london),[]).
epistemicrule(f12,road(pisa),[]).
epistemicpriority(f12,f11).
supposition(a11,road(london)).
supposition(a12,road(pisa)).
supposition(a21,sea(london)).
supposition(a22,sea(pisa)).
decisions([d(london), d(pisa)]).

  admissibleArgument(g7,PREMISES,SUPPOSITION) returns

PREMISES = [d(london), sea(london)]
SUPPOSITIONS = [d(london), sea(london)] ;
PREMISES = [d(pisa), sea(pisa)]
SUPPOSITIONS = [d(pisa), sea(pisa)] ;
(1) MARGO in the shell: translation in CaSAPI

%%%Define CaSAPI rules with priorities/rules
myRule(FACT, [not(del(NAME))]):- supposition(NAME, FACT).
myRule(HEAD, [not(del(NAME))][BODY]):- decisionrule(NAME, HEAD, BODY).
myRule(HEAD, [not(del(NAME))][BODY]):- goalrule(NAME, HEAD, BODY).
myRule(HEAD, [not(del(NAME))][BODY]):- epistemicrule(NAME, HEAD, BODY).
myRule(del(R1), [not(del(R2))]):- epistemicpriority(R2, R1).
myRule(del(R1), [not(del(R2))]):- decisionpriority(R2, R1).

%%%Define set of assumptions with decision/epistemic rules
myAss(Ass):- findAll(D, isDecision(D), DS),
decisionrules(DR), append(DS, DR, SUBA),
epistemicrules(ER), append(ER, SUBA, A),
incompatibilities(I), append(I, A, Ass).

%%%Define CaSAPI’s contrary with decisions/incompatibilities
contrary(d(X), d(Y)): - decisions(D), member(d(X), D), member(d(Y), D), \+ X=Y.
contrary(not(del(X)), del(X)): - !.
contrary(del(X), not(del(X))).
contrary(X, Y): - incompatibility(X, Y).
contrary(X, Y): - incompatibility(Y, X).
contrary(X, Y): - asincompatibility(Y, X).
(2) MARGO in the shell: CaSAPI meta-interpreter

Data: A problem description, a conclusion
Result: SENTENCES of an admissible argument

myAss(ASSUMPTIONS); // set the assumptions
run(ab,s,a,[CONC],ASSUMPTIONS,SENTENCES); // run CaSAPI
if no argument is found then
  while strongestrules() do
    nextstrongestrule(TOPRULE); // find one of the strongest rule
    usefulSuppositions(BODY,USL); // find minimal non-empty useful hypotheses
    append(USL,ASSUMPTIONS,NEWASSUMPTIONS);
    run(ab,s,a,[CONC],NEWASSUMPTIONS,SENTENCES); // run CaSAPI with these new assumptions
  end
end
Relax of user’s needs in CaSAPI

%goal rules
myRule(g1,[g4, g5, not(del(r145))]).
myRule(g1,[g4, not(del(r14))]).
myRule(g1,[g5, not(del(r15))]).
%decision rules
myRule(g4,[d(london), not(del(r41))]).
myRule(g4,[d(pisa), not(del(r42))]).
myRule(g5,[d(london), not(del(r51))]).
myRule(g5,[d(pisa), not(del(r52))]).
% decision priorities
myRule(del(r42),[not(del(r41))]).
myRule(del(r51),[not(del(r52))]).

contrary(d(london),d(pisa)).
contrary(d(pisa),d(london)).
contrary(not(del(X)),del(X)) :- !.
contrary(del(X),not(del(X))).

run(ab,s,a,[g1],[d(pisa), d(london),
not(del(r145)),
not(del(r51)), not(del(r52)),
not(del(r41)), not(del(r42))],X).
says No.

run(ab,s,a,[g1],[d(pisa), d(london),
not(del(r14)),
not(del(r51)), not(del(r52)),
not(del(r41)), not(del(r42))],X).
says
X = [not(del(r14)), d(london),
     not(del(r41))]

run(ab,s,a,[g1],[d(pisa), d(london),
not(del(r15)),
not(del(r51)), not(del(r52)),
not(del(r41)), not(del(r42))],X).
says
X = [not(del(r15)), d(pisa),
     not(del(r52))];
Natural relax of user’s needs in MARGO

%goal rules
goalrule(r145, g1, [g4, g5]).
goalrule(r14, g1, [g4]).
goalrule(r15, g1, [g5]).
%decision rules
decisionrule(r41, g4, [d(london)]).
decisionrule(r42, g4, [d(pisa)]).
decisionrule(r51, g5, [d(london)]).
decisionrule(r52, g5, [d(pisa)]).

%goal priority
goalpriority([[r145],[r14],[r15]]).

%decision priority
decisionpriority(r41,r42).
decisionpriority(r52,r51).

decisions([d(london), d(pisa)]).

Then argument(g1,PREMISES,SUPPOSTIONS).
PREMISES = [g4]
SUPPOSTIONS = [d(pisa)].
Hypotheses over knowledge in CaSAPI

myRule(g7, [d(london), sea(london), not(del(r71a))]).
myRule(g7, [d(pisa), sea(pisa), not(del(r71b))]).

myRule(sea(pisa), [not(del(supp1))]).
myRule(sea(pisa), [not(del(supp2))]).

contrary(d(london), d(pisa)).
contrary(d(pisa), d(london)).
contrary(not(del(X)), del(X)) :- !.
contrary(del(X), not(del(X))).

run(ab, s, a, [g7], [d(pisa), d(london),
not(del(r71a)), not(del(r71b))], X).
says No

run(ab, s, a, [g7], [d(pisa), d(london),
not(del(r71a)), not(del(r71b)),
not(del(supp1)), not(del(supp2))], X).
says
X = [d(pisa), not(del(r71b)),
not(del(supp1))] ;
X = [d(pisa), not(del(r71b)),
not(del(supp2))] ;
Natural hypotheses over knowledge in MARGO

decisionrule(r71a, g7, [d(london), sea(london)]).
decisionrule(r71b, g7, [d(pisa), sea(pisa)]).

supposition(a11,road(london)).
supposition(a12,road(pisa)).
supposition(a21,sea(london)).
supposition(a22,sea(pisa)).

decisions([d(london), d(pisa)]).

argument(g7,PREMISES,SUPPOSITIONS) says

PREMISES = [d(london), sea(london)]
SUPPOSITIONS = [d(london), sea(london)]

PREMISES = [d(pisa), sea(pisa)]
SUPPOSITIONS = [d(pisa), sea(pisa)]
Influence diagram

- Guilty?
  - Judge (jdg)
  - Punish (pu)
  - Rehabilitation (re)
  - Protection (pt)
  - Deterrence (de)
  - Prison
  - Service
  - Fine

- Drug?
- Driving?
- Alcohol?
- Mobile?
Epistemic/Goal/Decision theory

\[ R_{01} : \text{jdg} \leftarrow \text{pu}, \text{re}, \text{pt}, \neg \text{de} \]
\[ R_{02} : \text{jdg} \leftarrow \text{pu}, \text{re}, \neg \text{de} \]
\[ R_{03} : \text{jdg} \leftarrow \text{pu}, \neg \text{re}, \text{pt}, \text{de} \]
\[ R_{04} : \text{jdg} \leftarrow \text{pu}, \text{re}, \text{de} \]

\[ F_0 : \text{driving} \leftarrow \]
\[ F_1 : \text{guilty} \leftarrow \]
\[ F_2 : \text{drug} \leftarrow \]
\[ F_2' : \neg \text{drug} \leftarrow \]
\[ F_3 : \text{alcohol} \leftarrow \]
\[ F_3' : \neg \text{driving} \leftarrow \]

\[ R_{11} : \text{pu} \leftarrow \text{Prison(yes), drug, driving, guilty} \]
\[ R'_{11} : \text{pu} \leftarrow \text{Prison(yes), alcohol, driving, guilty} \]
\[ R''_{11} : \text{pu} \leftarrow \text{Prison(yes), mobile, driving, guilty} \]
\[ R_{12} : \text{pu} \leftarrow \text{Service(yes), guilty} \]
\[ R_{13} : \text{pu} \leftarrow \text{Fine(yes), not guilty} \]
\[ R_{21} : \neg \text{re} \leftarrow \text{Prison(yes), guilty} \]
\[ R_{21} : \neg \text{re} \leftarrow \text{Prison(yes), Service(yes), guilty} \]
\[ R_{21} : \neg \text{re} \leftarrow \text{Prison(yes), Service(no), guilty} \]
\[ R_{42} : \text{de} \leftarrow \text{Prison(yes), Service(yes), guilty} \]
\[ R_{42} : \text{de} \leftarrow \text{Prison(no), Service(yes), guilty} \]
Arguments

Some of the arguments concluding pu are the following:

- $A = \langle \text{re}, (\text{Prison(yes)}, \text{Service(yes)}, \text{guilty}),$ 
  $(\text{Prison(yes)}, \text{Service(yes)}) \rangle$;

- $B = \langle \neg \text{re}, (\text{Prison(yes)}, \text{guilty}),$ 
  $(\text{Prison(yes)}) \rangle$;

- $C = \langle \text{re}, (\text{Service(yes)}, \text{guilty}),$ 
  $(\text{Service(yes)}) \rangle$;

Since

- $(\text{top}(B) \sim \text{top}(C)) \prec \text{top}(A)$,

- $\text{hypo}(A) = 2$ and $\text{hypo}(B) = \text{hypo}(C) = 1$,

$A \succ^{A} B/C$.

$\Rightarrow$ Prison and community service must be selected to promote rehabilitation.