EASSS 2010

Argumentation technologies for agents and multiagent systems.

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Outline

Introduction

Digital economy

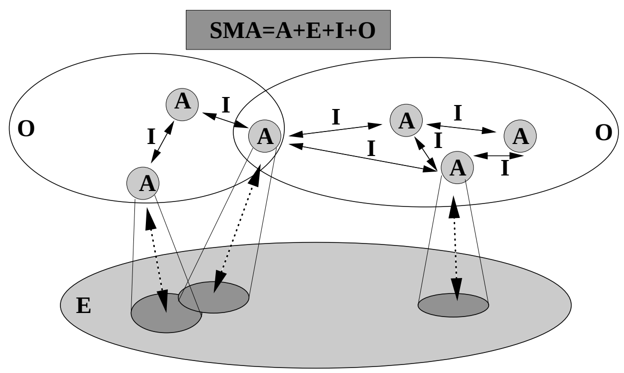
One the challenges facing society today is preparing businesses, organizations and governments for globalization, adoption of IT and the communication revolution. Policy-makers, business executives, NGO activists, academics, and ordinary citizens are increasingly concerned with the need to make their societies competitive in the emergent digital economy based on goods, services and expertise produced by electronic management processes and where partners conduct transactions through Internet and Web technologies.

- Electronic transactions through Internet and Web technologies
- Negotiations = interactions amongst parties to resolve disputes and to produce agreements e.g. in:
  - **E-procurement**, i.e. B2B purchase/provision of resources/services;
  - **E-commerce**, i.e. B2C purchase/provision of resources/services;
  - **E-health**, i.e. healthcare practices being supported by electronic processes;
  - **E-democracy**, i.e. electronic public decision processes.

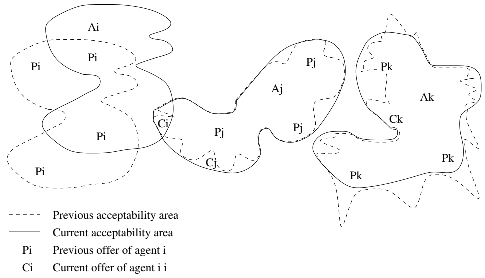
IT applications for automatic negotiation using MAS and argumentative technologies

- Negotiations are time consuming and emotionally demanding.
- ⇒ Delegate (partially) negotiations to software components responsible (helping) to reach agreements (semi-)automatically.
- Interests
  - **Reasoning and decision-making process of agents**
  - **Inter-agent negotiation process**
  - *Definition of contracts*
  - *Dispute resolution wrt agreed contracts*
- Strengths
  - Solid theoretical foundations
  - Concrete systems
  - Available technologies

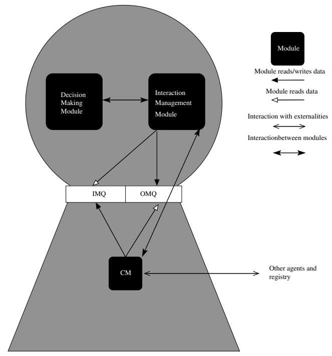
The vowels approach [Demazeau 95]



Negotiation as distributed search through a space of potential agreements [Jennings 01]



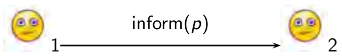
Abstract agent architecture for negotiation [Morge et al, EUMAS'07]



Analysis grid of negotiation [Müller, DAI'96]

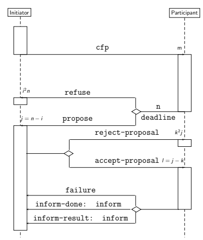
Agent communication for negotiation (`http://www.fipa.org/`)

In order to communicate, agents use an ACL (syntax/semantics/pragmatics). E.g. FIPA-ACL:



- Feasible preconditions: $B_1 p \wedge (\neg B_1(Bif_2 p \vee Uif_2 p))$
- Rational effects: $B_2 p$

Speech act theory [Searle69]



Outline

Decision-theory model

- **Decision making**= cognitive process leading to the selection of a course of action among alternatives based on estimates of the values of those alternatives (whether to get up in the morning or go back to sleep, sexual orientation, . . .).
- **Choice**= mental process of judging the merits of multiple options and selecting one of them for action.

Definition (Choice)

Let $\mathcal{A}$ be a set of alternatives. A **choice function** for $\mathcal{A}$ is a function ($\mathtt{C} : 2^{\mathcal{A}} \to 2^{\mathcal{A}}$) defined such that for all $\mathcal{B} \subseteq \mathcal{A}$:

1. $\mathtt{C}(\mathcal{B}) \subseteq \mathcal{B}$, and
2. if $B \neq \emptyset$, then $\mathtt{C}(\mathcal{B}) \neq \emptyset$.

Rational properties of choice

α) (Chernoff) If $\mathcal{B} \subseteq \mathcal{A}$ then $(\mathcal{B} \cap \mathtt{C}(\mathcal{A})) \subseteq \mathtt{C}(\mathcal{B})$

β) If $\mathcal{B} \subseteq \mathcal{A}$ and $x, y \in \mathtt{C}(\mathcal{B})$, then $x \in \mathtt{C}(\mathcal{A})$ iff $y \in \mathtt{C}(\mathcal{A})$

γ) (Expansion) $\cap_i \mathtt{C}(B_i) \subseteq \mathtt{C}(\cup_i B_i)$ whatever $B_i \subseteq \mathcal{A}$ are.

δ) (WARP) If $x, y \in \mathcal{A}$ and $x \in \mathtt{C}(\mathcal{A})$, then for all B, if $x \in B$ and $y \in \mathtt{C}(\mathcal{B})$, then $x \in \mathtt{C}(\mathcal{B})$.

ϵ) (SARP) If $x_1, x_2, \ldots, x_n \in \mathcal{A}_1$, $x_2, \ldots, x_n \in \mathcal{A}_2$, ..., $x_{n-1}, x_n \in \mathcal{A}_{n-1}$, $x_n \in \mathcal{A}_n$, and $x_1 \in \mathtt{C}(\mathcal{A}_1), x_2 \in \mathtt{C}(\mathcal{A}_2), \ldots, x_n \in \mathtt{C}(\mathcal{A}_n)$ then for all $\mathcal{B}$ with $x_1, x_2, \ldots, x_n \in \mathcal{B}$, if $x_i \in \mathtt{C}(\mathcal{B})$, $i \in \{1, \ldots, n\}$, then $x_1, x_2, \ldots, x_{i-1} \in \mathtt{C}(\mathcal{B})$.

Exercise

1. Erna is invited to an acquaintance's house for dinner. Her choice for dessert is between an apple (x), which is the last piece of fruit in the fruit basket, and nothing instead (y). Because Erna is polite, she chooses y. When she had faced a choice between an apple, nothing and an orange (z), she would have taken the apple.
   1. What is her choice $\mathtt{C}(\{x, y, z\})$?
   2. What is her choice $\mathtt{C}(\{x, y\})$?
   3. Is the property α violated ?
2. Considering the world championship of table tennis, which property reflects the following assertion ?
   1. "If the world champion of table tennis is a Chinese, then she must also be the champion in China."
   2. "If a Chinese woman is a world champion, then the champion of China must be the world champion."

Exercise (bis)

1. Let us suppose that the town's best ladies' hairdresser is also the town's best gents' hairdresser. According to the property γ, What is deduced?
2. Consider an agent who chooses to stay at a friend's house for a cup of tea (t) rather than to go home (h), but who leaves in a hurry when the friend offers a choice between tea and cocaine (c) at his next visit.
   1. What is her choice $\mathtt{C}(\{t, h\})$?
   2. What is her choice $\mathtt{C}(\{t, h, c\})$?
   3. Is the property β violated ?
   4. Is the property WARP violated ?

Preference, i.e. "penchant" about an imagined choice

Definition (Comparaison)

- ➜ A **preference relation** over $\mathcal{A}$ is a binary relation on $\mathcal{A}$ (denoted $\succ$). For all $x, y \in \mathcal{A}$, $x \succ y$ can be read "x is (strictly) preferred to y".
- ➜ An **indifference relation** over $\mathcal{A}$ is a binary relation on $\mathcal{A}$ (denoted $\simeq$). For all $x, y \in \mathcal{A}$, $x \simeq y$ can be read "x is equally preferred to y".

Definition (Properties of comparative relations)

1. **Asymmetry of preference:** if $x \succ y$, then it is not the case that $y \succ x$.
2. **Symmetry of indifference:** if $x \simeq y$, then $y \simeq x$;
3. **Reflexivity of indifference:** $x \simeq x$;
4. **Incompatibility of preference and indifference:** if $x \succ y$ then it is not the case that $x \simeq y$.

At least as preferred ...

Definition (Weak preference)

x is **weakly preferred** to y (x is at least as preferable as y) iff $x \succ y$ or $x \simeq y$

Controversial properties

Definition (Completeness)

The preference relation $\mathcal{P}$ is **complete** iff:

$$\forall x, y \in \mathcal{A} \; x\mathcal{P}y \vee y\mathcal{P}x$$

Otherwise, two alternatives x, y are **incomparable** (denoted $x \not\succeq y$) whenever the preference relation is incomplete with respect to them:

$$x \not\succeq y \text{ iff } \neg(x\mathcal{P}y) \wedge \neg(y\mathcal{P}x)$$

Definition (Transitivity)

The weak preference relation $\mathcal{P}$ is **transitive** iff:

$$\text{If } x\mathcal{P}y \text{ and } y\mathcal{P}z \text{ , then } x\mathcal{P}z$$

The preference relation $\succ$ is **acyclic** iff:

$$\forall a_1, \ldots, a_n \; \neg(a_1\mathcal{P} \ldots \mathcal{P}a_n\mathcal{P}a_1)$$

More controversial properties

- The preference relation $\mathcal{P}$ is **antisymmetric** iff:

$$\text{If } x\mathcal{P}y \text{ and } x\mathcal{P}y, \text{ then } x = y$$

- The preference relation $\mathcal{P}$ is **weakly connected** iff:

$$\forall x, y \in \mathcal{A}\ x \neq y,\ x\mathcal{P}y \vee y\mathcal{P}x$$

Name	Properties
Preorder	reflexive, transitive
Partial order	reflexive, transitive, anti-symmetric
Strict partial order	irreflexive, transitive
Total preorder	reflexive, transitive and complete
Complete ordering	reflexive, transitive, complete and anti-symmetric
Strict total order	asymmetric, transitive and weakly connected

Exercises

We consider 1000 cups of coffee ($c_0, \ldots, c_{999}$) such that the cup c_0 contains no sugar, the cup c_1 contains one grain of sugar, etc. Intuitively, $c_i \simeq c_{i+1}$ with $0 \leq i < 999$ but clearly $c_{999}\mathcal{P}c_1$. What are the (im)possible properties of the strict preference and the indifference relations ?

Exercises (bis)

Suppose now you have to choose between three boxes of Christmas ornaments. Each box contains three balls, coloured red , blue and green, respectively. They are represented by the vectors $\langle r_1, g_1, b_1\rangle$, $\langle r_2, g_2, b_2\rangle$ and $\langle r_3, g_3, b_3\rangle$.
Your preferences over the balls are as follows:
$b_1 \simeq b_2$, $g_1 \simeq g_2$, $r_1 \succ r_2$, $b_2 \simeq b_3$, $r_2 \simeq r_3$, $g_2 \succ g_3$, $r_3 \simeq r_1$, $g_3 \simeq g_1$ and $b_3 \succ b_1$.
We can deduce from these preferences your preferences between the boxes.

1. How can you compare the box # 1 and the box #2 ?
2. How can you compare the box # 2 and the box #3 ?
3. How can you compare the box # 2 and the box #3 ?
4. What are the (im)possible properties of the strict preference and the indifference relations ?

Exercises (ter)

The money pump argument. A certain stamp-collector has the following cyclic preferences with respect to three stamps (a, b and c): $a \succ b$, $b \succ c$ and $c \succ a$. We may assume that there is an amount of money, i.e. 10 cents, that she is prepared to pay for exchanging b for a, c for b, or a for c. She has a. You have c and b. How can you extract 50 cents from her?

From preferences to choice: the best choice function

- The **best choice function** for $\mathcal{A}$ built upon $\mathcal{P}$ is a function ($\mathtt{C}^b_{\mathcal{P}} : 2^{\mathcal{A}} \rightarrow 2^{\mathcal{A}}$) defined such that for all $\mathcal{B} \subseteq \mathcal{A}$:

$$\mathtt{C}^b_{\mathcal{P}}(\mathcal{B}) = \{x \in \mathcal{B} \mid \forall y \in \mathcal{B}\ x\mathcal{P}y\}$$

- The best choice function is a choice function iff $\mathcal{P}$ is complete and acyclical.
- The best choice function satisfies properties α and γ.
- The best choice function satisfies the property β iff the preference relation is transitive and complete.
- When $\mathcal{P}$ is not complete, there may not be an element that is preferred to all other elements …

From preferences to choice: the non-dominance choice

- The **non-dominance choice function** for $\mathcal{A}$ built upon $\mathcal{P}$ is a function ($\mathtt{C}^d_{\mathcal{P}} : 2^{\mathcal{A}} \leftarrow 2^{\mathcal{A}}$) defined such that for all $\mathcal{B} \subseteq \mathcal{A}$:

$$\mathtt{C}^d_{\mathcal{P}}(\mathcal{B}) = \{x \in \mathcal{B} \mid \forall y \in \mathcal{B}\ \neg(y\mathcal{P}x)\}$$

- The non-dominance choice function is a choice iff $\mathcal{P}$ is acyclical.
- The non-dominance satisfies α and γ
- The non-dominance choice function satisfies β iff $\mathcal{P}$ is transitive and complete.

Some limits

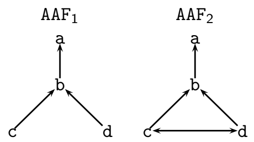
- Preference relation = a model of qualitative and ordinal model of "penchant" for comparing the satisfaction of a given agent for different alternatives allowing her to make a choice.
- The limits of this modelization are:
  - **No preference intensity**, e.g. "how much agent i is happier with x rather than y";
  - **No interpersonal comparaison** of preferences, e.g. "agent i is happier with x than agent j with y".
- $\Rightarrow$ Utility = a metric use of preferences to allow monetary compensations (cf Airau's lecture)
- ... but no explanation $\Rightarrow$ **Argumentation**

Outline

Abstract Argumentation Framework [Dung AI'95]

Definition (AAF)

An **abstract argumentation framework** is a pair $\mathtt{AAF} = \langle \mathcal{A}rg, \mathtt{attacks} \rangle$ where $\mathcal{A}rg$ is a finite set of arguments and $\mathtt{attacks} \subseteq \mathcal{A}rg \times \mathcal{A}rg$ is a binary relation over $\mathcal{A}rg$. When $(\mathtt{a}, \mathtt{b}) \in \mathtt{attacks}$, we say that a attacks b.



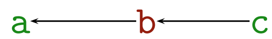
- a: if not walk then museum
- b if forecast nice then walk
- c: forecast hot
- d:
  - forecast rain ($\mathtt{AAF}_1$)
  - cold ($\mathtt{AAF}_2$)

What are the justified / rejected / undecided arguments ?

Dung's calculus of opposition

Definition (Acceptability)

An argument a is **acceptable** wrt S (denoted $\mathtt{acc}(\mathtt{a}, \mathtt{S})$) iff S attacks all the attackers of a (a fortiori if a is not attacked).

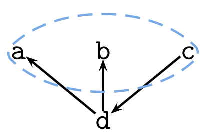


a is reinstanciated since c defends a

AAF semantics

Definition (Admissibility)

- S is **conflict-free** iff $\forall \mathtt{a}, \mathtt{b} \in \mathtt{S}$ it is not the case that a attacks b.
- S is **admissible** (denoted $\mathtt{adm}(\mathtt{S})$)iff S is conflict-free and S attacks every argument a such that a attacks some arguments in S.



Lemma (Fundamental lemma)

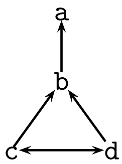
If a set of arguments S is admissible and it defends two arguments $\mathtt{a}, \mathtt{b}$, then $S \cup \{a\}$ is admissible and it defends $\mathtt{b}$.

AAF extensions

Definition (Extensions)

- S is **preferred** (denoted $\mathtt{pref}(\mathtt{S})$) iff S is maximally admissible (wrt $\subseteq$);
- S is **complete** (denoted $\mathtt{comp}(\mathtt{S})$) iff S is admissible and S contains all arguments a such that S attacks all attacks against a;
- S is **grounded** (denoted $\mathtt{gnd}(\mathtt{S})$) iff S is minimally complete (with respect to $\subseteq$).

AAF extensions: example

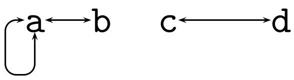


- ➜ adm(S) iff S =
- ➜ pref(S) iff S =
- ➜ comp(S) iff S =
- ➜ gnd(S) iff S =

Other AAF extensions (e.g. [Caminada'09])

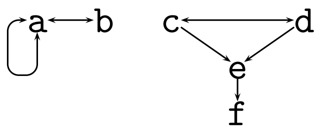
Definition (Extensions)
- ➜ S is **stable** (denoted stable(S)) iff every argument not in S is attacked by S
- ➜ S is **semi-stable** iff S is admissible and with $S \cup S^+$ is maximal
- ➜ S is **ideal** iff S is admissible and it is contained in every preferred set.

Exercises



1. Is there any ground set of arguments in this AAF ? If it is the case, which one ?
2. What is/are the preferred extension(s) of this framework ?
3. What is is the maximal ideal set of arguments ?

Exercises (bis)



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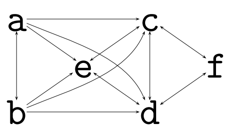
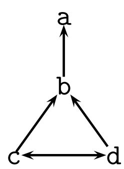
Exercises (ter)



1. Is there any ground set of arguments in this AAF ? If it is the case, which one ?
2. What is/are the preferred extension of this framework ?
3. What is is the maximal ideal set of arguments ?

Collective justification

Definition (Credulous/Sceptical arguments)
- ➜ a is credulously justified under semantics *E* iff a is in at least one *E* extension
- ➜ a is skeptically justified under semantics *E* iff a is in all *E* extensions



- ➜ a is skeptically preferred
- ➜ c and d are credulously preferred

AAF extensions: properties

Proposition (Relation between extensions)

1. *Any admissible (resp. complete) set is included in a preferred extension.*
2. *Each AAF has at least one preferred extension.*
3. *Each preferred extension is a complete extension, but not vice versa.*
4. *A preferred extension is a maximal (wrt $\subseteq$) complete extension*
5. *The ground extension is the least (wrt $\subseteq$) complete extension.*

The ground extension is the more skeptical semantics which does not necessarily coincide with the intersection of all preferred extensions.

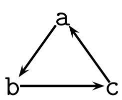
AAF extensions: computational complexity

Problem	Description	Complexity
adm(S)	Is S admissible?	$\mathcal{P}$
gnd(S)	Is S a ground extension?	$\mathcal{P}$
pref(S)	Is S a preferred extension?	co$\mathcal{NP}$-complet
stable(S)	Is S a stable extension?	$\mathcal{P}$
has-stable(AAF)	Is there a stable extension in AAF?	$\mathcal{NP}$-complet

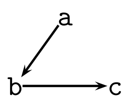
Preference-based Argumentation Framework [Amgoud & Cayrol'98]

Definition (PAF)
A *preference-based argumentation framework* is a triple PAF $= \langle \mathcal{A}rg,$ attacks $, \mathcal{P} \rangle$ where

- ➜ $\langle \mathcal{A}rg,$ attacks $\rangle$ is an abstract argumentation framework and,
- ➜ $\mathcal{P}$ is a partial pre-order over $\mathcal{A}rg$, called preference relation. When $(a, b) \in \mathcal{P}$, we say that a is preferred to b.



$a\mathcal{P}b$
$b\mathcal{P}c$

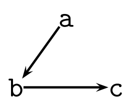


Definition (Defeats)
The *defeat relation* is a binary relation over $\mathcal{A}rg$ defined such that: def$(a, b) \Leftrightarrow$ (attacks $(a, b) \wedge (b, a) \notin \mathcal{P})$.

PAF semantics

Definition (Admissibility)

- ➜ S is **conflict-free** iff $\forall a, b \in S$ it is not the case that a defeats b.
- ➜ S is **admissible** (denoted adm(S))iff S is conflict-free and S defeats every argument a such that a defeats some arguments in S.
- ➜ ...

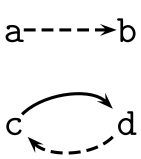


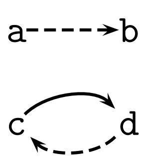
- ➜ adm(S) iff S =
- ➜ pref(S) iff S =
- ➜ comp(S) iff S =
- ➜ gnd(S) iff S =

PAF semantics: exercise

- ➜ The fact that x defeats y is depicted by a plain arrow from x to y.
- ➜ The fact that x attacks y and it is not the case that x defeats y, i.e. the unsuccessful attack, is depicted by a dashed. arrow.

What are the preferred extension of the PAF/AAF ?

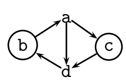




Value-based Argumentation Framework [Bench-Capon'02]

Definition (VAF)
A *value-based argumentation framework* is a tuple VAF $= \langle \mathcal{A}rg,$ attacks , V , promote $, \Pi \rangle$ where

- ➜ $\langle \mathcal{A}rg,$ attacks $\rangle$ is an abstract argumentation framework;
- ➜ V $= \{v_1, \ldots, v_t\}$ is a finite set of values;
- ➜ promote : $\mathcal{A}rg \rightarrow$ V is a function;
- ➜ $\Pi = \{\mathcal{P}_\alpha, \ldots, \mathcal{P}_\omega\}$ is a set of audiences.

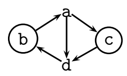


promote (b) = promote (c) = v_1
promote (a) = promote (d) = v_2
$v_1 \mathcal{P}_\alpha v_2$
$v_2 \mathcal{P}_\beta v_1$

Definition (Defeats)
The *defeat relation* for an audience α is a binary relation over $\mathcal{A}rg$ defined such that: def$_\alpha(a, b) \Leftrightarrow$ (attacks $(a, b) \wedge (b, a) \notin \mathcal{P}_\alpha)$.

VAF semantics

Definition (Acceptance)
An argument is:
- **objectively acceptable** iff it is acceptable for all audiences
- **subjectively acceptable** iff it is acceptable for some audiences.
- **indefensible** if it is acceptable for none audience.



- Objective acceptance:
- Subjective acceptance:
- Indefensibility:

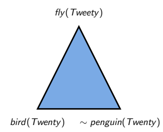
Outline

The argumentation elements [Prakken'02]

- TODO The underlying **language**, i.e. the logical language (and an associated logical consequence)
- TODO The structure of an **argument**, i.e. a proof (a sequence or a tree of inferences)
- TODO The **conflicts**, i.e. the rebuting/undermining/undercuting counter-arguments
- DONE The (argumentation-theoretic) **semantics**, i.e. with fixed-point definitions
- TODO The **procedure**, i.e. the proof theory

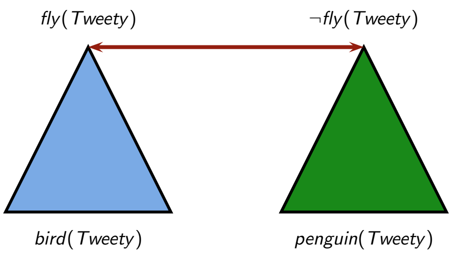
Argument as 'proof'

- An **abstract entity** with an unspecified logic,
  A='Tweety flies because it's a bird';
- A **pair** (Premises, Conclusion),
  $A = (\{bird(Tweety), bird(X) \rightarrow fly(X)\}, fly(Tweety))$;
- A deduction **sequence** of rules and facts
  $A = (f_1(Tweety), r_1(Tweety))$;
- An inference **tree** grounded in premises



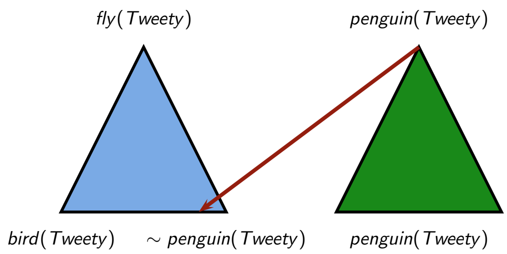
Rebutting attack conflicting conclusions

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



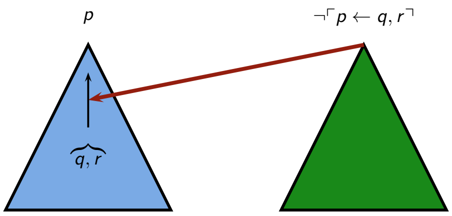
Undermining attack non-provable assumptions

- *Tweety flies because it is a bird and it seems not to be a penguin.*
- *Tweety is a penguin.*



Undercutting attack intermediate step

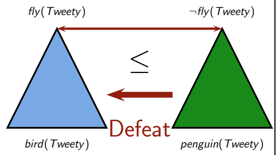
- *Tweety flies because all the birds I've seen fly.*
- *I've seen Tux, it's a bird and it doesn't fly.*



How to evaluate the strengths of arguments?

Some domain-independent principles of commonsense reasoning:

- the specificity principle [Simari & Loui 92].
- the last link principle [Prakken & Sartor 97];
- the weakest link principle [Amgoud & Cayrol 02];



The strength of an argument depends on the quality of information:

- the likelihood of beliefs;
- the preferences between goals;
- the credibility of decisions.

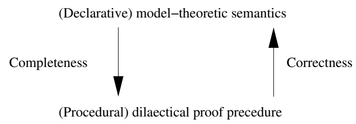
The argumentation process

4 (interleaved) steps:

1. **Construction:** generate arguments based on a knowledge base
2. **Confrontation:** see how these arguments defeat each other
3. **Evaluation:** determine which arguments can be seen as justified
4. **Conclusion:** take the conclusions of the justified arguments

The argumentation game

- Argumentation as a dialogue.
- The procedural rules which regulate the exchanges of arguments and counter-arguments.
- Argumentation can be considered as a game which is win when a thesis defends itself from adversarial thesis.
- A validator to persuade a falsificator who try to force the validator to withdraw.



Dialectical enquiry [Vreeswijk & Prakken'00]

Definition (TPI-dispute)

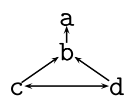
A **Two-Party Immediate Respond dispute** (TPI-dispute) is an argumentation game between Pro and Opp such that:

- both parties are allowed to repeat Pro;
- Pro is not allowed to repeat Opp;
- Opp is allowed to repeat Opp in a different dispute line (backtracking).

Theorem (Soundness/Correctness)

- *An argument is credulously preferred iff it can be proved in all TPI-dispute(s).*
- *An argument is skeptically preferred iff it is credulously preferred and all its attackers are not proved in all TPI-dispute(s).*

TPI-dispute: example



1. What are the preferred extensions of this framework ?
2. The TPI-disputes about a and b ?

Outline

3 Abstract argumentation
- Abstract Argumentation Framework
- Preference-based Argumentation Framework
- Value-based Argumentation Framework

4 Concrete argumentation system
- Principle
- The structure of arguments
- The counter-arguments
- The proof procedure

5 ABA: a concrete argumentation system
- The underlying language
- Arguments & counter-arguments
- Proof theory

Assumption-Based Argumentation [BDKT AI'97] (ABA)

Definition (ABF)
An **assumption-based argumentation framework** is a tuple $\texttt{ABF} = \langle \mathcal{L}, \mathcal{R}, \mathcal{A}sm, \mathcal{C}on \rangle$ where:

- ➜ $(\mathcal{L}, \mathcal{R})$ is a deductive system where,
  - ➜ $\mathcal{L}$ is a formal language consisting of countably many sentences,
  - ➜ $\mathcal{R}$ is a countable set of inference rules of the form r: $\alpha \leftarrow \alpha_1, \ldots, \alpha_n$ where $\alpha \in \mathcal{L}$, called the **head** of the rule (denoted $\texttt{head}(r)$), $\alpha_1, \ldots, \alpha_n \in \mathcal{L}$, called the **body** (denoted $\texttt{body}(r)$), and $n \geq 0$;
- ➜ $\mathcal{A}sm \subseteq \mathcal{L}$ is a non-empty set of **assumptions**. If $x \in \mathcal{A}sm$, then there is no inference rule in $\mathcal{R}$ such that x is the head of this rule;
- ➜ $\mathcal{C}on$: $\mathcal{A}sm \to 2^{\mathcal{L}}$ is a (total) mapping from assumptions into set of sentences in $\mathcal{L}$, i.e. their **contraries**.

ABA: the arguments and the conflicts

Definition (Argument)
An **argument** for a conclusion is a deduction of that conclusion whose premises are all assumptions. We denote an argument $\texttt{a}$ for a conclusion α supported by a set of assumptions $\texttt{A}$ simply as $\texttt{a}$: $\texttt{A} \vdash \alpha$.

Definition (Attack)
An argument $\texttt{a}$: $\texttt{A} \vdash \alpha$ **attacks** an argument $\texttt{b}$: $\texttt{B} \vdash \beta$ iff there is an assumption $x \in \texttt{B}$ such as $\alpha \in \mathcal{C}on(x)$.

ABA: example

$\texttt{ABF} = \langle \mathcal{L}, \mathcal{R}, \mathcal{A}sm, \mathcal{C}on \rangle$ where:

- ➜ $(\mathcal{L}, \mathcal{R})$ is a deductive system where,
  - ➜ $\mathcal{L} = \{\alpha, \beta, \delta, \gamma, \neg\alpha, \neg\beta, \neg\delta, \neg\gamma\}$,
  - ➜ $\mathcal{R}$ is the following set of rules,
    $\neg\alpha \leftarrow \alpha$,
    $\neg\alpha \leftarrow \beta$,
    $\neg\beta \leftarrow \alpha$,
    $\neg\gamma \leftarrow \delta$,
    $\neg\delta \leftarrow \gamma$
- ➜ $\mathcal{A}sm = \{\alpha, \beta, \gamma, \delta\}$. Notice that no assumption is the head of an inference rule in $\mathcal{R}$;
- ➜ and $\mathcal{C}on(\alpha) = \{\neg\alpha\}$, $\mathcal{C}on(\beta) = \{\neg\beta\}$, $\mathcal{C}on(\gamma) = \{\neg\gamma\}$, and $\mathcal{C}on(\delta) = \{\neg\delta\}$.

Which AAF is an abstract representation of this ABF?

ABA: exercise

$\texttt{ABF} = \langle \mathcal{L}, \mathcal{R}, \mathcal{A}sm, \mathcal{C}on \rangle$ where:

- ➜ $(\mathcal{L}, \mathcal{R})$ is a deductive system where,
  - ➜ $\mathcal{L} = \{\alpha, \beta, \delta, \gamma, \epsilon, \phi, \neg\alpha, \neg\beta, \neg\delta, \neg\gamma, \neg\epsilon, \neg\phi\}$,
  - ➜ $\mathcal{R}$ is the following set of rules,
    $\neg\alpha \leftarrow \beta$, $\neg\epsilon \leftarrow \gamma$, $\neg\beta \leftarrow \alpha$,
    $\neg\gamma \leftarrow \epsilon$, $\neg\gamma \leftarrow \alpha$, $\neg\delta \leftarrow \epsilon$,
    $\neg\delta \leftarrow \alpha$, $\neg\epsilon \leftarrow \delta$, $\neg\epsilon \leftarrow \alpha$,
    $\neg\phi \leftarrow \gamma$, $\neg\gamma \leftarrow \beta$, $\neg\gamma \leftarrow \phi$,
    $\neg\delta \leftarrow \beta$, $\neg\phi \leftarrow \delta$, $\neg\epsilon \leftarrow \beta$,
    $\neg\delta \leftarrow \phi$, $\neg\delta \leftarrow \gamma$, $\neg\gamma \leftarrow \delta$.
- ➜ $\mathcal{A}sm = \{\alpha, \beta, \gamma, \delta, \epsilon, \phi\}$. Notice that no assumption is the head of an inference rule in $\mathcal{R}$;
- ➜ and $\mathcal{C}on(\alpha) = \{\neg\alpha\}$, $\mathcal{C}on(\beta) = \{\neg\beta\}$, $\mathcal{C}on(\gamma) = \{\neg\gamma\}$, $\mathcal{C}on(\delta) = \{\neg\delta\}$, $\mathcal{C}on(\epsilon) = \{\neg\epsilon\}$ and $\mathcal{C}on(\phi) = \{\neg\phi\}$.

Which AAF is an abstract representation of this ABF?

AB-dispute: the dispute state

Definition (Dispute state)
A **dispute state** at the step $i \in \mathbb{N}$ is a tuple $DS_i = \langle \text{Pro}_i, \text{Opp}_i, A_i, C_i \rangle$:

- ➜ Pro_i represents the set of sentences of $\mathcal{L}$ held by the proponent;
- ➜ Opp_i represents the set of sentences of $\mathcal{L}$ held by the opponent;
- ➜ A_i holds the set of assumptions in $\mathcal{A}sm$ generated by the proponent in support of its belief and to defend itself against the opponent;
- ➜ C_i holds the set of assumptions in $\mathcal{A}sm$ in attacks generated by the opponent that the proponent has chosen as “culprits” to be counter-attacked.

AB-dispute: the derivation [DKT AI'06]

The **AB-dispute derivation** of the defense set A for the topic $\alpha \in L$ is is

$$\langle DS_0, \ldots, DS_i, \ldots, DS_n \rangle$$

where $DS_0 = \langle \{\alpha\}, \{\}, \{\alpha\} \cap \mathcal{A}sm, \{\} \rangle$
$DS_n = \langle \emptyset, \emptyset, A, C \rangle$ whatever the set C is
and for σ in Pro_i or one S in Opp_i:
1. $\sigma \in \mathrm{Pro}_i$ is selected by s then
1i. if $\sigma \in \mathcal{A}sm$, then

$$DS_{i+1} = \langle \mathrm{Pro}_i \setminus \{\sigma\}, \mathrm{Opp}_i \cup \{\{\sigma\} \mid x \in \mathcal{C}on(\sigma)\}, A_i, C_i \rangle$$

1ii. if $\sigma \not\in \mathcal{A}sm$, then there is an inference rule $r \in \mathcal{R}$ such that $\mathtt{head}(r) = \sigma$ and $C_i \cap \mathtt{body}(r) = \emptyset$,

$$DS_{i+1} = \langle \mathrm{Pro}_i \setminus \{\sigma\} \cup (\mathtt{body}(r) \setminus A_i), \mathrm{Opp}_i, A_i \cup (\mathcal{A}sm \cap \mathtt{body}(r)), C_i \rangle$$

2. If $S \subset \mathrm{Opp}_i$ and $\sigma \in S$ are selected by s then
2i. if $\sigma \in \mathcal{A}sm$, then
2ia. either σ is ignored,

$$DS_{i+1} = \langle \mathrm{Pro}_i, \mathrm{Opp}_i \setminus \{S\} \cup \{S \setminus \{\sigma\}\}, A_i, C_i \rangle$$

2ib. or $\sigma \not\in \mathrm{A_i}$ and $\sigma \in C_i$,

$$DS_{i+1} = \langle \mathrm{Pro}_i, \mathrm{Opp}_i \setminus \{S\}, A_i, C_i \rangle$$

2ic. or $\sigma \not\in \mathrm{A_i}$ and $\sigma \not\in \mathrm{C_i}$ and $x \in \mathcal{C}on(\sigma)$ are chosen
2ic1. if $x \not\in \mathcal{A}sm$, then

$$DS_{i+1} = \langle \mathrm{Pro}_i \cup \{x\}, \mathrm{Opp}_i \setminus \{S\}, A_i, C_i \cup \{\sigma\} \rangle$$

2ic2. if $x \in \mathcal{A}sm$ and $x \not\in \mathrm{C_i}$

$$DS_{i+1} = \langle \mathrm{Pro}_i, \mathrm{Opp}_i \setminus \{S\}, A_i \cup \{x\}, C_i \cup \{\sigma\} \rangle$$

2ii. if $\sigma \not\in \mathcal{A}sm$, then there is an inference rule $r \in \mathcal{R}$ such that $\mathtt{head}(r) = \sigma$ and $C_i \cap \mathtt{body}(r) = \emptyset$, then

$$DS_{i+1} = \langle \mathrm{Pro}_i, \mathrm{Opp}_i \setminus \{S\} \cup \{S \setminus \{\sigma\} \cup \mathtt{body}(r)\}, A_i \cup \{x\}, C_i \cup \{\sigma\} \rangle$$

AB-dispute: example

ABF $= \langle \mathcal{L}, \mathcal{R}, \mathcal{A}sm, \mathcal{C}on \rangle$ where:

- $(\mathcal{L}, \mathcal{R})$ is a deductive system where,
  - $\mathcal{L} = \{\alpha, \beta, \delta, \gamma, \neg\alpha, \neg\beta, \neg\delta, \neg\gamma\}$,
  - $\mathcal{R}$ is the following set of rules, $\neg\alpha \leftarrow \alpha$, $\neg\alpha \leftarrow \beta$, $\neg\beta \leftarrow \alpha$, $\neg\gamma \leftarrow \delta$, $\neg\delta \leftarrow \gamma$
- $\mathcal{A}sm = \{\alpha, \beta, \gamma, \delta\}$. Notice that no assumption is the head of an inference rule in $\mathcal{R}$;
- and $\mathcal{C}on(\alpha) = \{\neg\alpha\}$, $\mathcal{C}on(\beta) = \{\neg\beta\}$, $\mathcal{C}on(\gamma) = \{\neg\gamma\}$, and $\mathcal{C}on(\delta) = \{\neg\delta\}$.

The AB-dispute derivation computing the defense set for a.

AB-dispute: implementation [Gaertner & Toni'07]

CaSAPI
Credulous and Sceptical Argumentation (Prolog Implementation)
`http://www.doc.ic.ac.uk/~dg00/casapi.html`

The ABF:

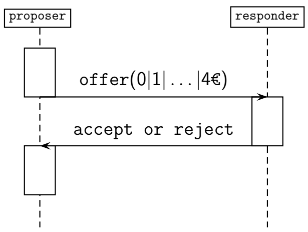
```
myRule(p,[a]).
myRule(not(a),[b]).
myRule(not(b),[c]).
contrary(a,not(a)).
contrary(b,not(b)).
contrary(c,not(c)).
```

The AB-dispute:

```
>runAB(s,a,[p], [a, b, c], D).
D = [a, c] ;
false.
```


Outline

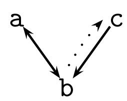
MARGO: The strategy of the proposer in the ultimatum game



- If the `responder` rejects then the `proposer` receives nothing
- The `proposer` is **altruist** if
  1. he is generous, i.e. `offer`(x) with $x > 0$;
  2. he is fair, i.e. `offer`(2);
  3. and eventually he maximize his gain, $\min_{x \in X}(x)$.

MARGO: Dung's calculus of opposition

- Three (3) arguments of the proposer:
  - a: Since I wants to be fair, I will offer 2€
  - b: Since I wants to maximize my gain, I will offer $\min_{x \in X}(x)$
  - c: Since I wants to be generous, I will offer $x > 0$€
- If the proposer is altruist:
  - a and b defeat each other
  - c defeats b but b does not defeat c



MARGO : the proposer decides an amount to offer [Morge & Mancarella ArgMAS'07]

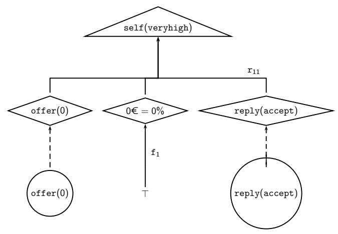
$\mathcal{L} = \mathcal{G} \cup \mathcal{D} \cup \mathcal{B}$

$\mathcal{P}sm = \{\texttt{reply(accept)}, \texttt{reply(reject)}\}$
$\texttt{offer}(x)\ \mathcal{I}\ \texttt{offer}(y)$ with $y \neq x$

$\texttt{self(veryhigh)}\mathcal{P}\texttt{self(high)}$,
$\texttt{self(high)}\mathcal{P}\texttt{self(medium)}$,
$\texttt{self(medium)}\mathcal{P}\texttt{self(low)}$, and
$\texttt{self(low)}\mathcal{P}\neg\texttt{self}(y)$ whatever y is
$\mathcal{RV} = \{\texttt{generous}, \texttt{fair}\}$

$\texttt{r}_{11}:\ \texttt{self(veryhigh)} \leftarrow \texttt{offer}(x), x = 0\%, \texttt{reply(accept)}$
...
$\texttt{r}_{14}:\ \texttt{self(low)} \leftarrow \texttt{offer}(x), x > 50\%, \texttt{reply(accept)}$
$\texttt{r}_{15}:\ \neg\texttt{self}(y) \leftarrow \texttt{offer}(x), \texttt{reply(reject)}$
$\texttt{r}_{21}:\ \texttt{fair} \leftarrow \texttt{offer}(x), x = 50\%$
$\texttt{r}_{31}:\ \neg\texttt{generous} \leftarrow \texttt{offer}(x), x = 0\%$
$\texttt{r}_{32}:\ \texttt{generous} \leftarrow \texttt{offer}(x), \neg(x = 0\%)$

MARGO: tree-like structure of arguments

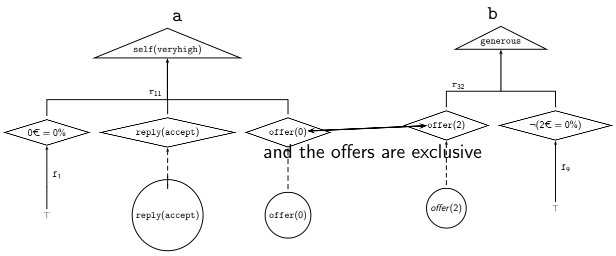


a is concluding that the economic motivation is extremely promoted since we suppose:

- that the proposer offers 0 €,
- representing 0 % of the endowment,
- the responder's reply will be an acceptance.

MARGO: managing the conflicts and the preferences

If the goals ($\texttt{self(veryhigh)}$ and $\texttt{generous}$) are not comparable



MARGO: concession-based mechanism

Definition (Preference between decisions)

We consider $\texttt{G}$, $\texttt{G}'$ two set of goals in $\mathcal{G}$ and $\texttt{D}$, $\texttt{D}'$ two set of decisions in $\mathcal{D}$. $\texttt{G}$ is **preferred** to $\texttt{G}$ (denoted $\texttt{G}\mathcal{P}\texttt{G}'$) iff

1. $\texttt{G} \supseteq \texttt{G}'$, and
2. $\forall g \in \texttt{G} \setminus \texttt{G}'$ there is no $g' \in \texttt{G}'$ such that $g'\mathcal{P}g$.

$\texttt{D}$ is **preferred** to $\texttt{D}'$ (denoted $\texttt{D}\mathcal{P}\texttt{D}'$) iff $\texttt{val}_c(\texttt{D})\mathcal{P}\texttt{val}_c(\texttt{D}')$.

Theorem (Decisions)

Let $D \subseteq \mathcal{D}$ such that it is not the case that $\mathcal{RV}\ \mathcal{P}\ \mathtt{val}_c(D)$ and $\forall D' \subseteq \mathcal{D}$ it is not the case that $\mathtt{val}_c(D')\ \mathcal{P}\ \mathtt{val}_c(D)$.
D are **acceptable decisions**.

MARGO: implementation

MARGO
Multiattribute ARGumentation framework for Opinion explanation
http://margo.sf.net

The KBase:

```
decision([offer(_)]).
rule(r11(X), self(veryhigh), [offer(X), perc(X,0), reply(accept)]).
rule(r12(X), self(high), [offer(X), perc(X,25), reply(accept)]).
rule(r13(X), self(medium), [offer(X), perc(X,50), reply(accept)]).
rule(r14(X,Y), self(low), [offer(X), perc(X,Y), isgreater(Y,50), reply(accept)]).
rule(r15(X,Y), sn(self(Y)), [offer(X), reply(reject)]).
rule(r21(X), fair, [offer(X), perc(X,50)]).
rule(r31(X), sn(generous), [offer(X), perc(X,0)]).
rule(r32(X), generous, [offer(X), sn(perc(X,0))]).
```

```
rule(f1, perc(0,0), []).
rule(f2, perc(1,25), []).
rule(f3, perc(2, 50),[]).
rule(f4, perc(3, 75), []).
rule(f5, perc(4,100), []).
rule(f6, isgreater(100,50), []).
rule(f7, isgreater(75,50), []).
rule(f8, sn(perc(1,0)), []).
rule(f9, sn(perc(2,0)), []).
rule(f10, sn(perc(3,0)), []).
rule(f11, sn(perc(4,0)), []).
presumable(reply(accept)).
presumable(reply(reject)).
sincompatibility(self(veryhigh),self(high)).
sincompatibility(self(veryhigh),self(medium)).
sincompatibility(self(veryhigh),self(low)).
sincompatibility(self(high),self(medium)).
sincompatibility(self(high),self(low)).
sincompatibility(self(medium),self(low)).
```

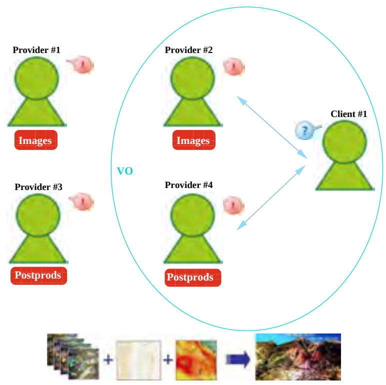
The altruism:

```
priority(self(veryhigh), self(high)).
priority(self(high), self(medium)).
priority(self(medium), self(low)).
rv([generous, fair])
```

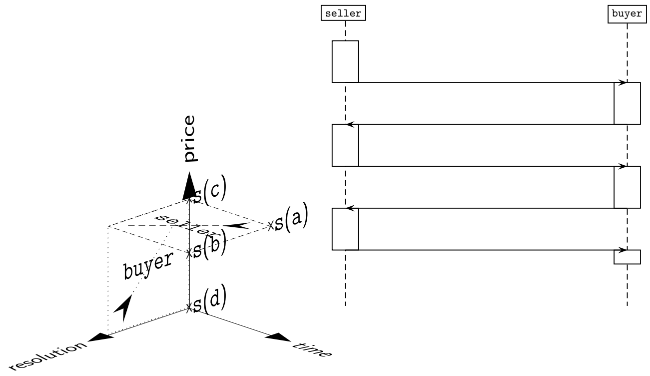
The decision:

```
>admissible([self(veryhigh), self(high), self(medium), self(low),
generous, fair],
DEFENCESET).
DEFENCESET = [ offer(2),
wn(del(r32(2))),wn(del(r21(2))), wn(del(f9)), wn(del(f3))] ;
```


MARGO: the earth observation scenario [Bromuri et al. AAMAS'10]



MARGO: the minimal concession strategy [Morge & Mancarella ArgMAS'09]



Discussion

To take away

- **Application area:** digital economy (e-procurement, e-commerce, e-health and e-democracy).
- **Research field:** Multiagent systems
  - Reasoning and decision-making process of agents with incomplete and inconsistent information, e.g. *MARGO*
  - Inter-agent negotiation process as a dialectical game, e.g. *the minimal concession strategy/protocol*
- **Scientific community:** computational model of rgumentation
  - Solid theoretical foundations, i.e. *AAF, PAF, VAF*
  - Concrete systems, e.g. *Assumption-based argumentation*
  - Available technologies, e.g. *CaSAPI/MARGO*

Research challenges for argumentation [Dix et al. 09]

- Decision making, i.e.
  - large amounts of data
  - argumentation vs. classical decision theory
  - argumentation vs. machine learning
- Autonomous agents, i.e.
  - tractability (anytime algorithm)
  - argumentation for trust (e.g. [P-A Matt et al. AAMAS'10])
- Semantic Web, i.e. handling the heterogeneity of ontologies for interoperability at the semantic level (e.g. [Morge & Routier, AO'07])
- Social network, i.e. automated tools for argument authoring

MAS & Negotiation

Yves Demazeau.
From interactions to collective behaviour in agent-based systems.
In *Proc. of the First European Conference on Cognitive Science*, pages 117–132, Saint Malo, 1995.

Jennings, N. R., Faratin, P., Lomuscio, A. R., Parsons, S., Sierra, C. and Wooldridge, M.
Automated Negotiation: Prospects, Methods and Challenges
International Journal of Group Decision and Negotiation, 10 (2). pp. 199-215.

M. Morge, J. McGinnis, S. Bromuri, F. Toni, P. Mancarella, K. Stathis.
Toward a Modular Architecture of Argumentative Agents to Compose Services.
In *Proc. of EUMAS'07*, Hammamet, Tunisia 2007

H. Jürgen Müller
Negotiation Principle
In *Foundations of distributed artificial intelligence.* G. M. P. O'Hare and N. R. Jennings, p. 211-229, John Wiley (1996).

J.R. Searle.
Speech Acts: An Essay in the Philosophy of Language.
Cambridge University Press, 1969.

Decision, Choice & Preferences

Sven Ove Hansson and Till Grune-Yanoff.
Preferences.
Standford Encyclopedia of Philosophy, 2006.
http://plato.stanford.edu/entries/preferences.

Amartya K Sen.
Choice functions and revealed preference.
Review of Economic Studies, 38(115):307–17, July 1971.

Argumentation framework

Phan Minh Dung.
On the acceptability of arguments and its fundamental role in nonmonotonic reasoning, logic programming and n-person games.
Artif. Intell., 77(2):321–357, 1995.

Martin Caminada.
On the issue of reinstatement in argumentation.
In *Proc. of the European Conference Logics in Artificial Intelligence (JELIA)*, volume 4160 of *Lecture Note in Computer Science*, pages 111–123. Springer, 2009.

Leila Amgoud and Claudette Cayrol.
On the acceptability of arguments in preference-based argumentation.
In *Proc. of the 14th Conference on Uncertainty in Artificial Intelligence (UAI)*, pages 1–7, Madison, Wisconsin, USA., 1998. Morgan Kaufmann.

T.J.M Bench-Capon.
Value based argumentation frameworks.
In *Proc. of the 2nd International Workshop on Non-Monotonic Reasoning (NMR)*, pages 444–453, 2002.

Concrete argumentation system

H. Prakken and G. Vreeswijk
Logics for defeasible argumentation.
In D. Gabbay and F. Guenthner (eds.), *Handbook of Philosophical Logic, second edition*, Vol 4, pp. 219-318. Kluwer Academic Publishers, Dordrecht, 2002.

H. Prakken and G. Sartor.
Argument-based logic programming with defeasible priorities.
Journal of Applied Non-classical Logics, 7:25–75, 1997.

Leila Amgoud and Claudette Cayrol
A Reasoning Model Based on the Production of Acceptable Arguments
Annals of Maths and AI, 34(1-3): 197-215, 2002.

Guillermo Ricardo Simari and Ronald Prescott Loui
A Mathematical Treatment of Defeasible Reasoning and its Implementation
Artif. Intell., 53(2-3):125-157, 1992.

Gerard Vreeswijk and Henry Prakken.
Credulous and sceptical argument games for preferred semantics.
In M. Ojeda-Aciego, I.P.d. Guzman, G. Brewka, and L.M. Pereira, editors, *Proc. of the 7th European Workshop on Logic for Artificial Intelligence (JELIA'2000)*, number 1919 in Lecture Notes in AI, pages 239–253. Springer Verlag, 2000.

ABA: concrete argumentation system

Bondarenko, A. Dung, P.M, Kowalski, R., Toni F.
An abstract, argumentation-theoretic approach to default reasoning.
Artif. Intell., 93(63–101), 1997.

P. M. Dung, R. A. Kowalski, and F. Toni.
Dialectic proof procedures for assumption-based, admissible argumentation.
Artif. Intell., 170(2):114–159, 2006.

Phan Minh Dung, Paolo Mancarella, and Francesca Toni.
Computing ideal sceptical argumentation.
Artifi. Intell., Special Issue on Argumentation, 171(10-15):642–674, 2007.

Dorian Gaertner and Francesca Toni.
On computing arguments and attacks in assumption-based argumentation.
IEEE Intelligent Systems, Special Issue on Argumentation Technology, 22(6):24–33, November/December 2007.

Argumentation-based decision making

Rahwan I., Ramchurn S.D., Jennings N.R., McBurney P., Parsons S., Sonenberg L.
Argumentation-based negotiation.
The Knowledge Engineering Review 18(4):343–375, 2003.

Kakas A., Moraitis P.
Argumentative-based decision-making for autonomous agents.
In Proc. of AAMAS, ACM Press, pp 883–890 (2003).

Atkinson K., Bench-Capon T., and McBurney P.
Computational representation of practical argument.
Synthese, special issue on Knowledge, Rationality and Action 152(2):157–206 (2006).

Wassila Ouerdane, Nicolas Maudet, and Alexis Tsoukias.
Arguing over actions that involve multiple criteria: A critical review.
In Springer Berlin, editor, *Proc. of the European Conference on Symbolic and Quantitative Approaches to Reasoning with Uncertainty (ECSQARU)*, volume 4724 of *Lecture Notes in Computer Science*, pages 308–319, 2007.

Amgoud L., Prade H.
Using arguments for making and explaining decisions.
Artif. Intell. 173(3-4):413–436 (2009).

MARGO: an argumentation-based engine for decision-making

F. Toni, M. Grammatikou, S. Kafetzoglou, L. Lymberopoulos, S. Papavassileiou, D. Gaertner, M. Morge, S. Bromuri, J. McGinnis, K. Stathis, V. Curcin, M. Ghanem and L. Guo.
The ArguGRID Platform: An Overview
In *Proc. of the 5th International Workshop on Grid Economics and Business Models (GECON'08)*, Las Palmas de Gran Canaria (Spain), 2008.

M. Morge and P. Mancarella.
The hedgehog and the fox. An argumentation-based decision support system.
In *Proc. of the 4th International Workshop on Argumentation in Multi-Agent Systems (ArgMAS)*, Honolulu (Hawai), 2007.

M. Morge and P. Mancarella.
Assumption-based argumentation for the minimal concession strategy.
In *Proc. of the 6th International Workshop on Argumentation in Multi-Agent Systems (ArgMAS)*, Budapest (Hungary), 2009.

S. Bromuri and V. Urovi and M. Morge and F. Toni and K. Stathis
A multi-agent system for service discovery, selection and negotiation.
In *Proc. of the 8th International Joint Conference on Autonomous Agents and Multiagent Systems (AAMAS)*, Budapest (Hungary), 2009.

Research challenges

Morge, M. and Routier, JC.
Debating over heterogeneous descriptions.
Applied Ontology, Special issue on Formal Ontology for Communicating Agents, 2(3-4), 333–349, IOS press (2007).

J. Dix, S. Parsons, H. Prakken & G. Simari
Research Challenges for Argumentation.
Computer Science - Research and Development, 23 (2009): 27–34.

Paul-Amaury Matt, Francesca Toni and Maxime Morge
Combining statistics and arguments to compute trust.
In *Proc. of the 9th International Joint Conference on Autonomous Agents and Multiagent Systems (AAMAS)*, Toronto (Canada), 2010.