Argumentation framework for practical reasoning in legal disputes*

Maxime Morge Paolo Mancarella

*Dipartimento di Informatica
Università di Pisa

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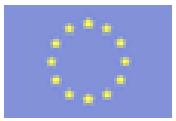

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Vagueness, indeterminacy and adversarial nature of the law with hierarchies of possibly conflicting rules

The British National Act [Sergot. 86].

- In a natural language:
  1. A person born in the UK shall be a British citizen if one of her parent is:
     a. a British citizen;
     b. settled in the UK;
  2. A newborn who is found abandonned in the UK, shall, unless the contrary is shown by 1, be deemed a British citizen.
- In a Logic Programm:
  - $r1a(X) : \text{citizen1}(X) \leftarrow \text{parent}(Y, X), \text{citizen}(Y).$
  - $r1b(X) : \text{citizen1}(X) \leftarrow \text{parent}(Y, X), \text{settled}(Y).$
  - $r2(X) : \text{citizen2}(X) \leftarrow \text{abandonned}(X), \text{not } \neg\text{citizen1}(X).$

$\Rightarrow$ Conclusion by default of **nonmonotonic** reasoning in the absence of information.

Outline

1. Motivation
2. Argumentation
3. Argumentation for practical reasoning
4. Conclusions & Future works

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1 Motivation

2 Argumentation

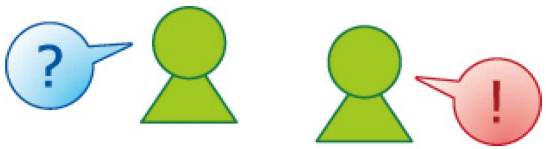
3 Argumentation for practical reasoning

4 Conclusions & Future works

Overview of argumentation

Argumentation is 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

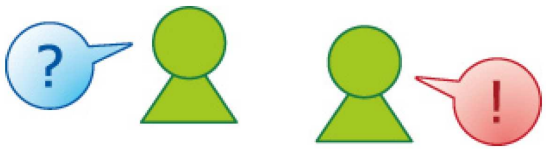


- Status of arguments
- Proof procedure

Overview of argumentation

Argumentation is 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



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Overview of argumentation

Argumentation is a process of construction and comparison of arguments for and against certain conclusions formalized by an preference-based argumentation logic [Amgoud & Cayrol 02], *i.e.* :

- Underlying logic
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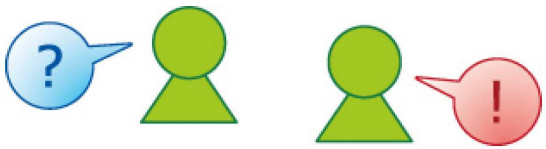
  - abstract entities
  - logical structures
- Attack relation
- Priority relation
- Status of arguments
- Proof procedure



The underlying language: statements

- $\mathcal{L}$ a logic language

Definition ([Prakken & Sartor 97])

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

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

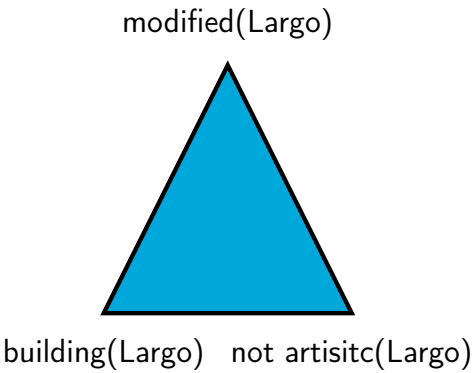
$\text{head}(R) = L_0$.
$\text{body}(R) = \{L_1, ..., \text{not } L_m\}$.

- $\mathcal{I}$ is an incompatibility relation amongst sentences in $\mathcal{L}$
  - $\mathcal{I}\,(b_1, \neg b_1)$ and $\mathcal{I}\,(\neg b_1, b_1)$,
  - $\mathcal{I}\,(b_1, \text{not } b_1)$

Argument as 'proof'

Forms of arguments:

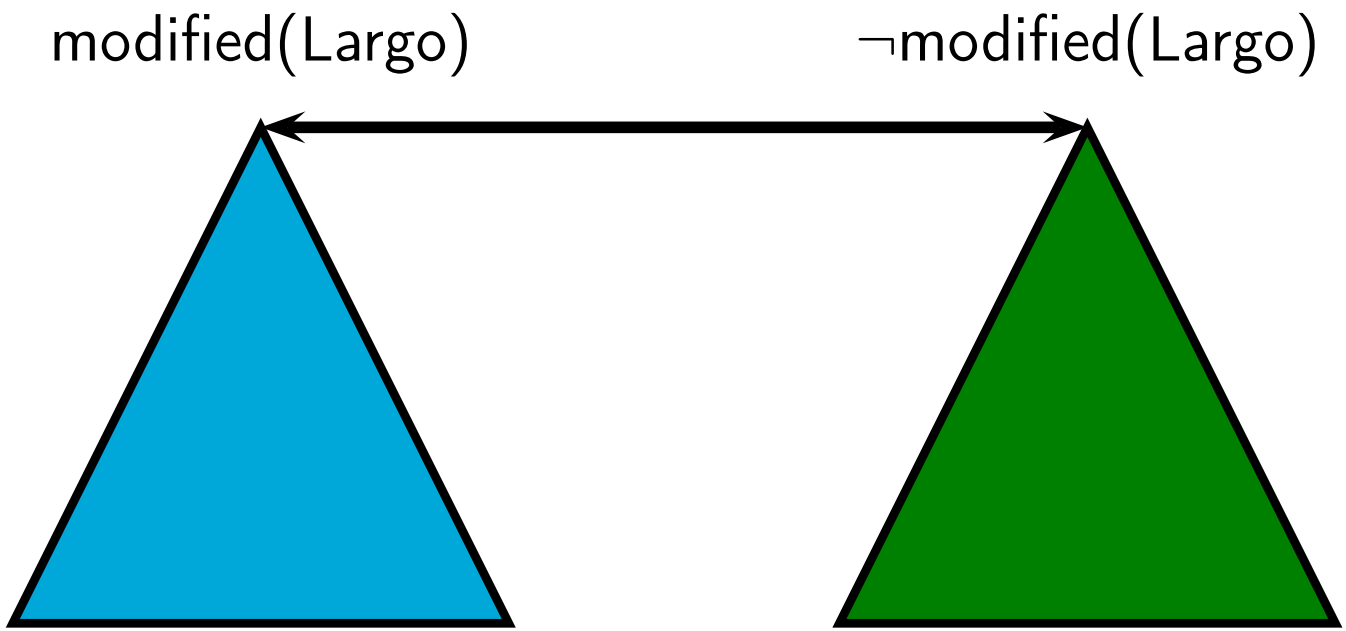
- An **abstract entity** with an unspecified logic,
  A='Largo may not be modified since it needs restructuring';
- A **pair** (Premises, Conclusion),
  $A = (\{\text{building(Largo)}, \text{building}(X) \rightarrow \text{modified}(X)\},$
  $\text{modified(Largo)})$;
- A deduction **sequence** of rules and facts
  $A = (f_1(\text{Largo}), r_1(\text{Largo}))$;
- An inference **tree** grounded in premises;



Attacks relation: rebutting, undermining and undercutting

Rebutting attack conflicting conclusions:

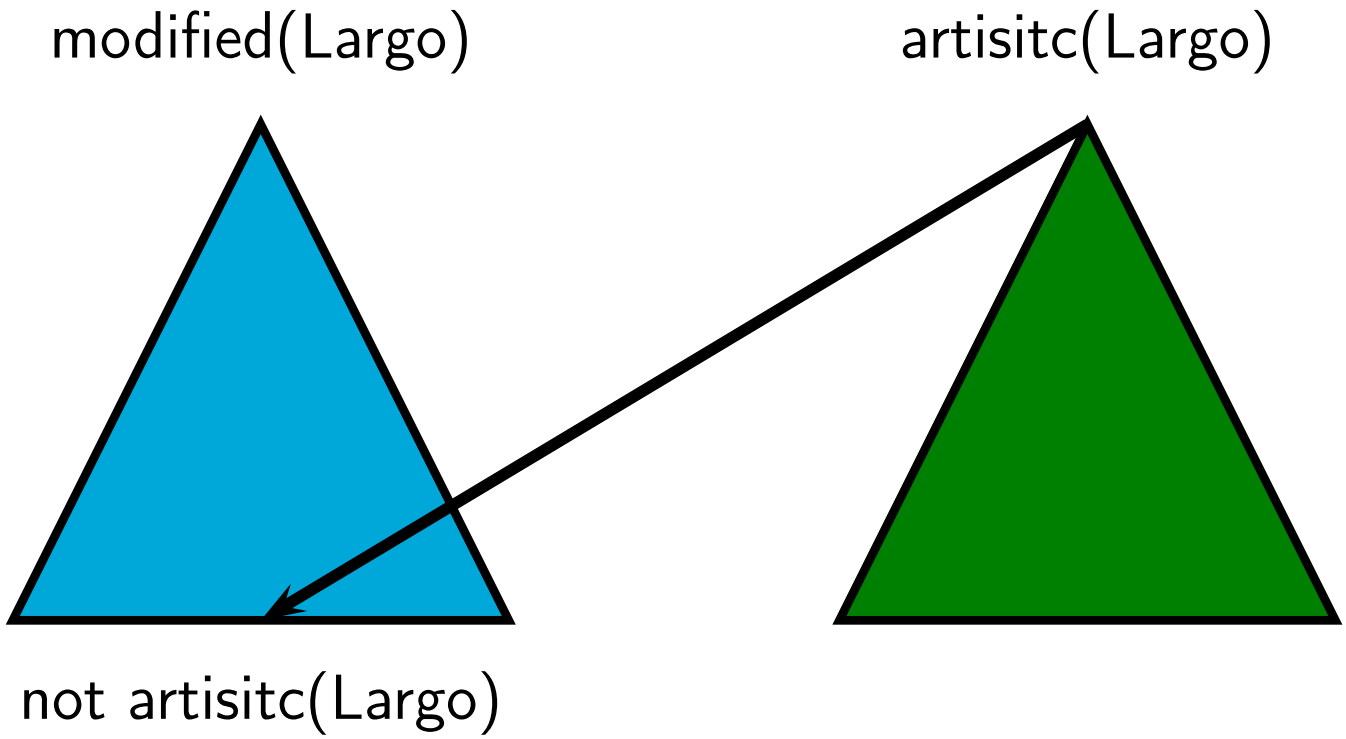
- Largo may be modified since it is a building;
- Largo may not be modified because it's artistic.



Attacks relation: rebutting, undermining and undercutting

Undermining attack non-provable assumptions:

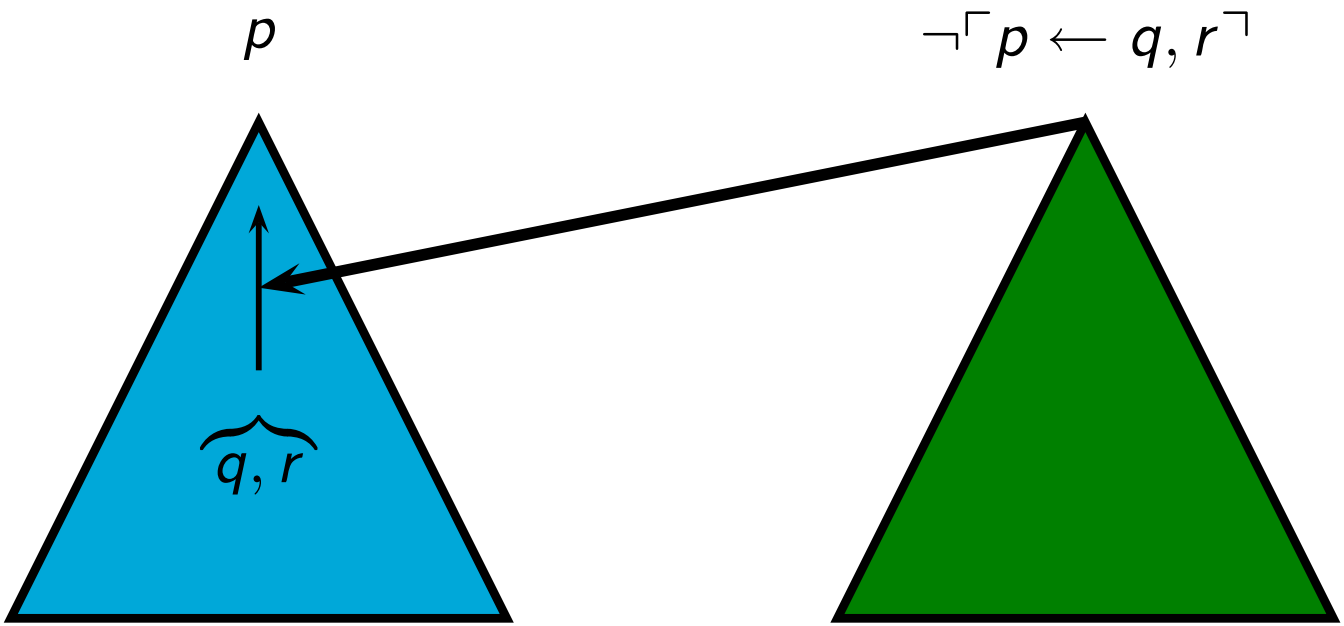
- Largo may not be modified since it is a building and it is not provable that Largo is artistic;
- Largo is artistic.



Attacks relation: rebutting, undermining and undercutting

Undercutting attack intermediate step:

- Largo may be modified because all the building must be modified;
- This law cannot applied because of the *lex superiori* principle.



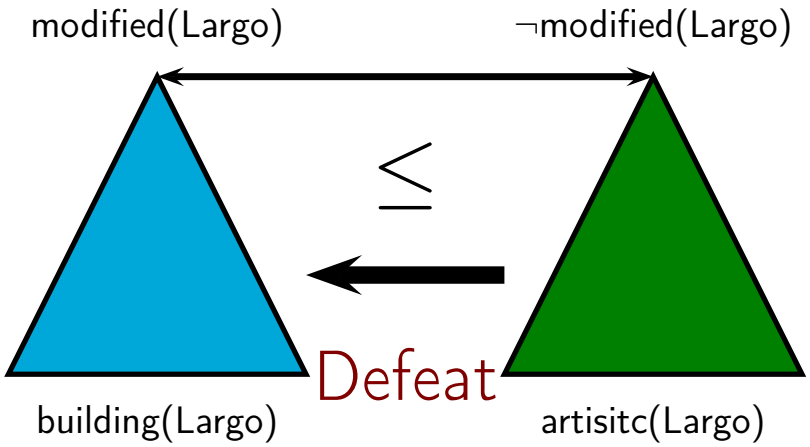
Priority relation: how to evaluate the strengths of arguments?

Law principles for reasoning:

- *lex superiori*;
- *lex posteriori*;
- *lex anteriori*;

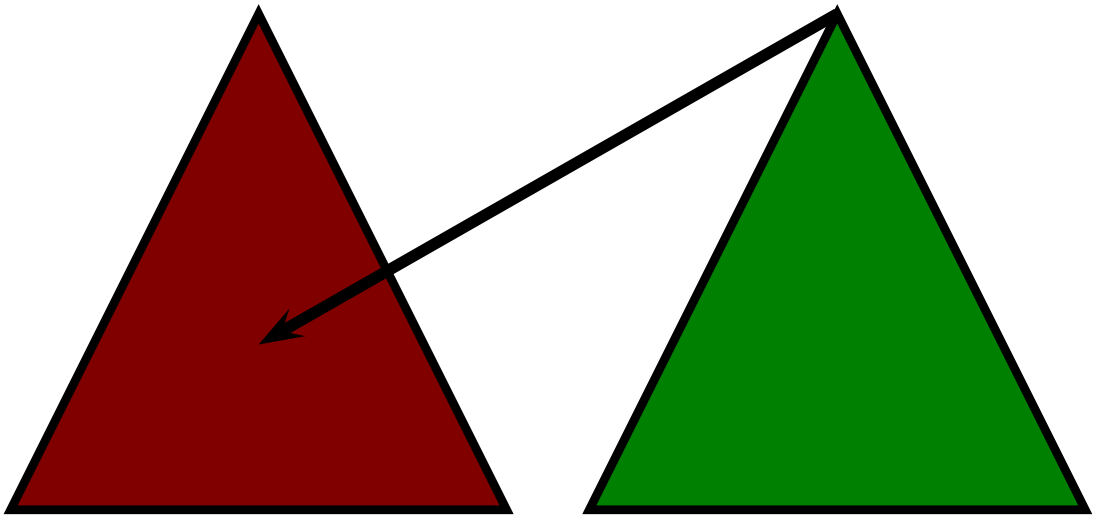
domain-independant principles of commonsense reasoning:

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



From the defeat relation to the status of arguments

- Defeat relation focus on two arguments not on a dispute, eg



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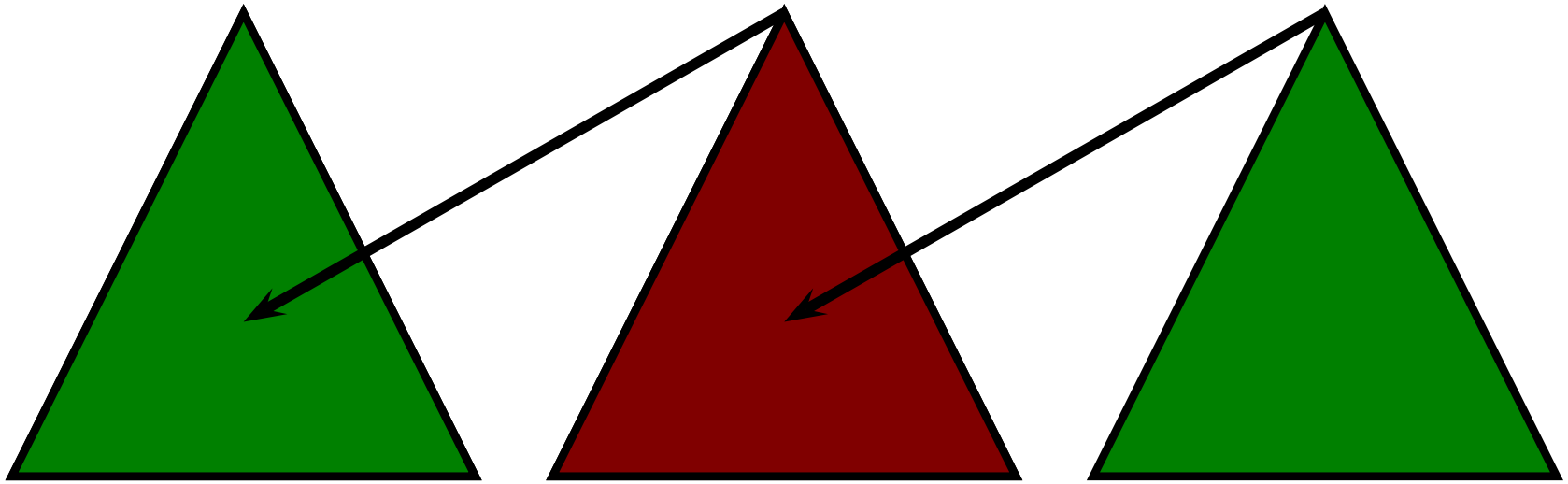
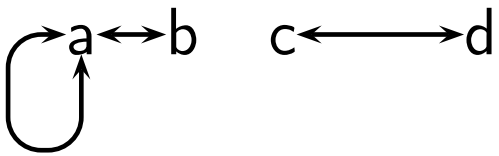


The status of arguments



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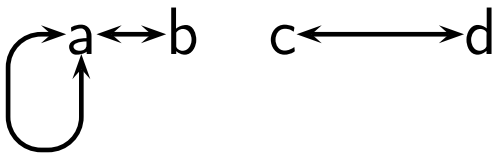


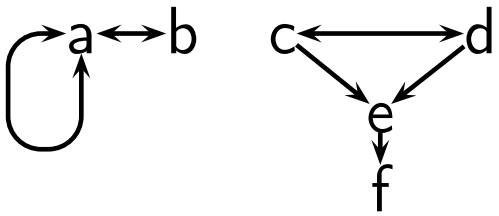
- $\emptyset$ is ground;
- $\{b, c\}$ are $\{b, d\}$ preferred;
- $\{b\}$ is the maximal ideal set.

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.

The status of arguments



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

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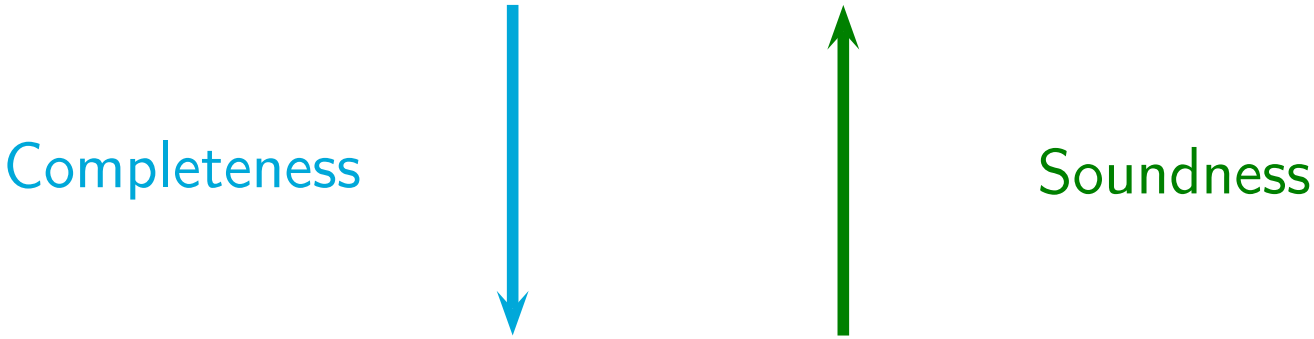
Burden of proof rather than correspondence with reality

(Declarative) Model-theoretic Semantics



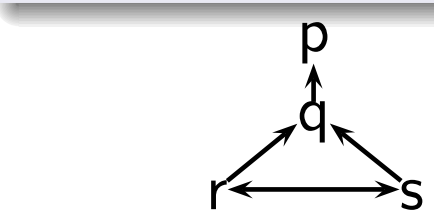
(Procedural) Dialectical Proof Procedures

Proof procedure: a dialectical enquiry

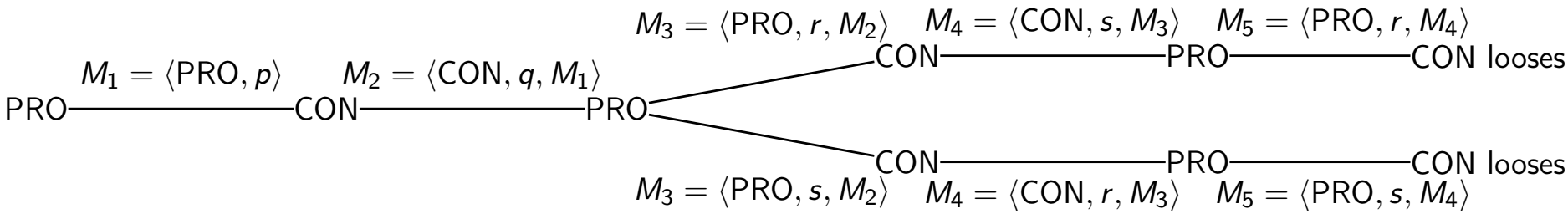
Definition

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



Theorem

Soundness and completeness of TPI for the credulous semantics.

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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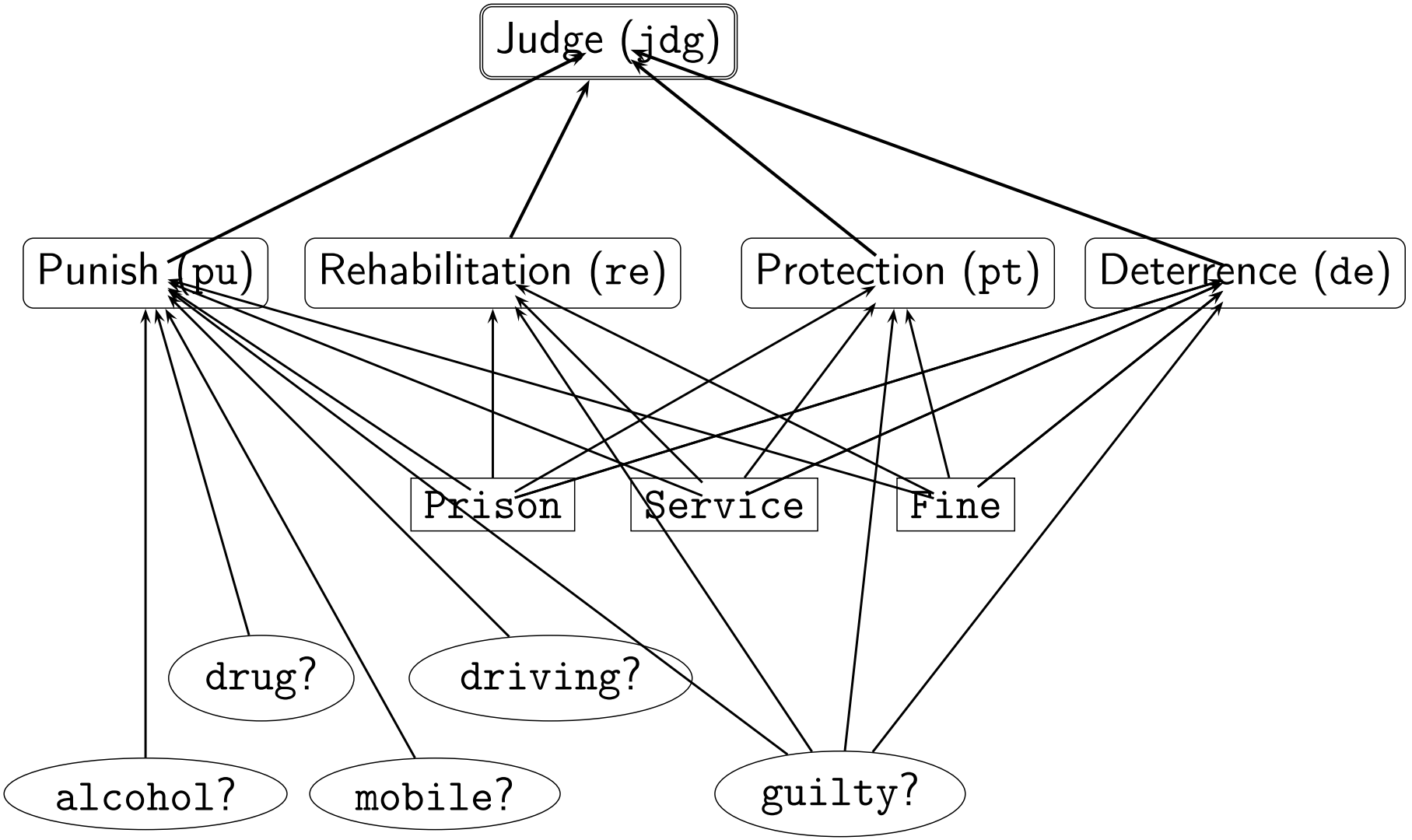
From epistemic (guilty) to practical reasoning (sentence)



Data strutures and priorities: hierarchies of conflicting rules

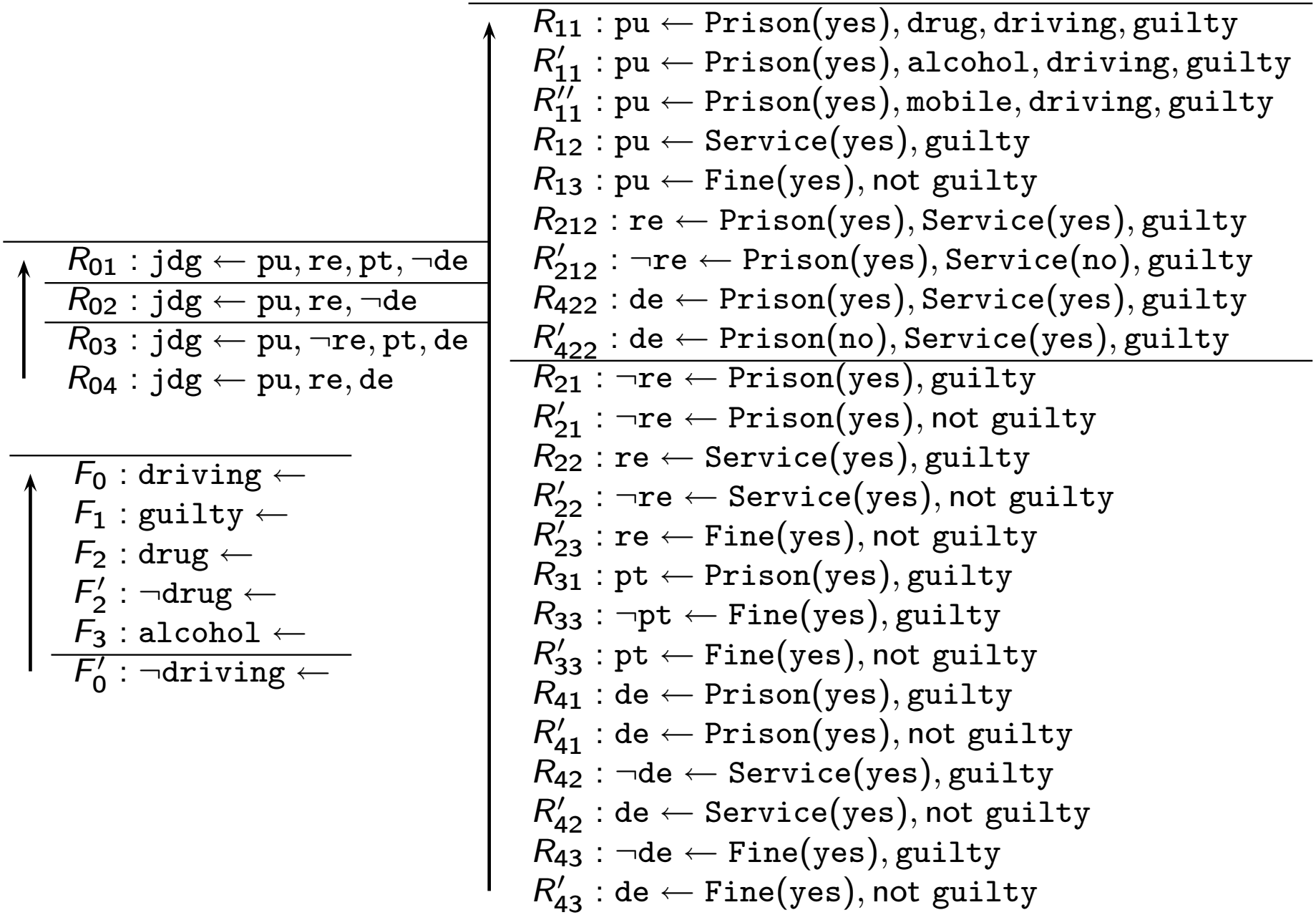
The theory compiles:

- goal rules such as $R : \texttt{jdg} \leftarrow \texttt{pu}, \texttt{re}$
- epistemic rules such as $F : \texttt{mobile} \leftarrow$
- decision rules such as $R : \texttt{pt} \leftarrow \texttt{Prison(yes)}, \texttt{guilty}, \texttt{drug}$

Different priorities for different rules:

- the priority over goal rules comes from preferences,
  eg $R_1 : \texttt{jdg} \leftarrow \texttt{re}$ has priority over $R_2 : \texttt{jdg} \leftarrow \texttt{pu}$
- the priority over epistemic rules comes from probabilities,
  eg $F_1 : \texttt{alcohol} \leftarrow$ has priority over $F_2 : \neg\texttt{alcohol} \leftarrow$
- the priority over decision rules come from expected utilities,
  eg $R_{212} : \texttt{re} \leftarrow \texttt{Service(yes)}, \texttt{Prison(yes)}, \texttt{guilty}$ has priority over $R_{21} : \neg\texttt{re} \leftarrow \texttt{Prison(yes)}, \texttt{guilty}$

Epistemic/Goal/Decision theory



Struture of arguments: abductive tree

Definition

An argument $A = \langle \texttt{conc}, \texttt{premise}, \texttt{supp} \rangle$ is:

1. **supposal**, *i.e.* built upon an hypothesis
   $\texttt{sent}(A) = \texttt{supp}(A)$
   $A = \langle \texttt{Prison(yes)}, \emptyset, [\texttt{Prison(yes)}] \rangle$ or
   $A = \langle \texttt{alcohol}, \emptyset, [\texttt{alcohol}] \rangle$
2. **trivial**, *i.e.* built upon an unconditional ground statement
   $\texttt{sent}(A) = \texttt{premise}(A)$
   $A = \langle \texttt{mobile}, [\texttt{mobile}], \emptyset \rangle$ or $A = \langle \neg\texttt{mobile}, [\neg\texttt{mobile}], \emptyset \rangle$
3. **tree**, *i.e.* built upon a top rule where all literals in the body are the conclusions of subargument.
   $B = \langle \neg\texttt{re}, (\texttt{Prison(yes)}, \texttt{guilty}), (\texttt{Prison(yes)}) \rangle$;

Interaction: choice between different explanations

Definition (Attack relation)

$\texttt{attacks}\ (A, B)$ iff $\texttt{conc}(A)\ \mathcal{I}\ \texttt{sent}(B)$

$\Rightarrow$ build homogeneous explanations:

- $A = \langle \texttt{re}, (\texttt{Prison(yes)}, \texttt{Service(yes)}, \texttt{guilty}), (\texttt{Prison(yes)}, \texttt{Service(yes)})\rangle$;
- $B = \langle \neg\texttt{re}, (\texttt{Prison(yes)}, \texttt{guilty}), (\texttt{Prison(yes)})\rangle$;
- $C = \langle \texttt{re}, (\texttt{Service(yes)}, \texttt{guilty}), (\texttt{Service(yes)})\rangle$;

Interaction: choice between different explanations (cont.)

Definition (Hypothesis size)

1. if A is a hypothetical argument, then $\texttt{suppsize}(A) = 1$;
2. if A is a trivial argument, then $\texttt{suppsize}(A) = 0$;
3. if A is a tree argument then $\texttt{suppsize}(A) = \Sigma_{A' \in \texttt{subarg}(A)} \texttt{suppsize}(A')$.

Definition (Strength relation)

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

1. $A_2 \succ^{\mathcal{A}} A_1$;
2. If $(\texttt{top}(A_2) \prec \texttt{top}(A_3)) \wedge \neg(\texttt{top}(A_3) \prec \texttt{top}(A_2))$, then $A_3 \succ^{\mathcal{A}} A_2$;
3. If $(\texttt{top}(A_2) \sim \texttt{top}(A_3)) \wedge (\texttt{suppsize}(A_2) \leq \texttt{suppsize}(A_3))$, then $A_2 \succ^{\mathcal{A}} A_3$;

Interaction: choice between different explanations (cont.)

Definition (Defeat relation)

A **defeats** B

1. $\texttt{attacks}\ (A, B)$
2. $\neg(B \succ^{\mathcal{A}} A)$.

- $A = \langle \texttt{re}, (\texttt{Prison(yes)}, \texttt{Service(yes)}, \texttt{guilty}), (\texttt{Prison(yes)}, \texttt{Service(yes)})\rangle$;
- $B = \langle \neg\texttt{re}, (\texttt{Prison(yes)}, \texttt{guilty}), (\texttt{Prison(yes)})\rangle$;
- $C = \langle \texttt{re}, (\texttt{Service(yes)}, \texttt{guilty}), (\texttt{Service(yes)})\rangle$;

Since

- $(\texttt{top}(B) \sim \texttt{top}(C)) \prec \texttt{top}(A)$,
- $\texttt{suppsize}(A) = 2$ and $\texttt{suppsize}(B) = \texttt{suppsize}(C) = 1$,

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

Semantics: status of arguments/alternatives

Definition (Acceptability)

A set X of arguments is :

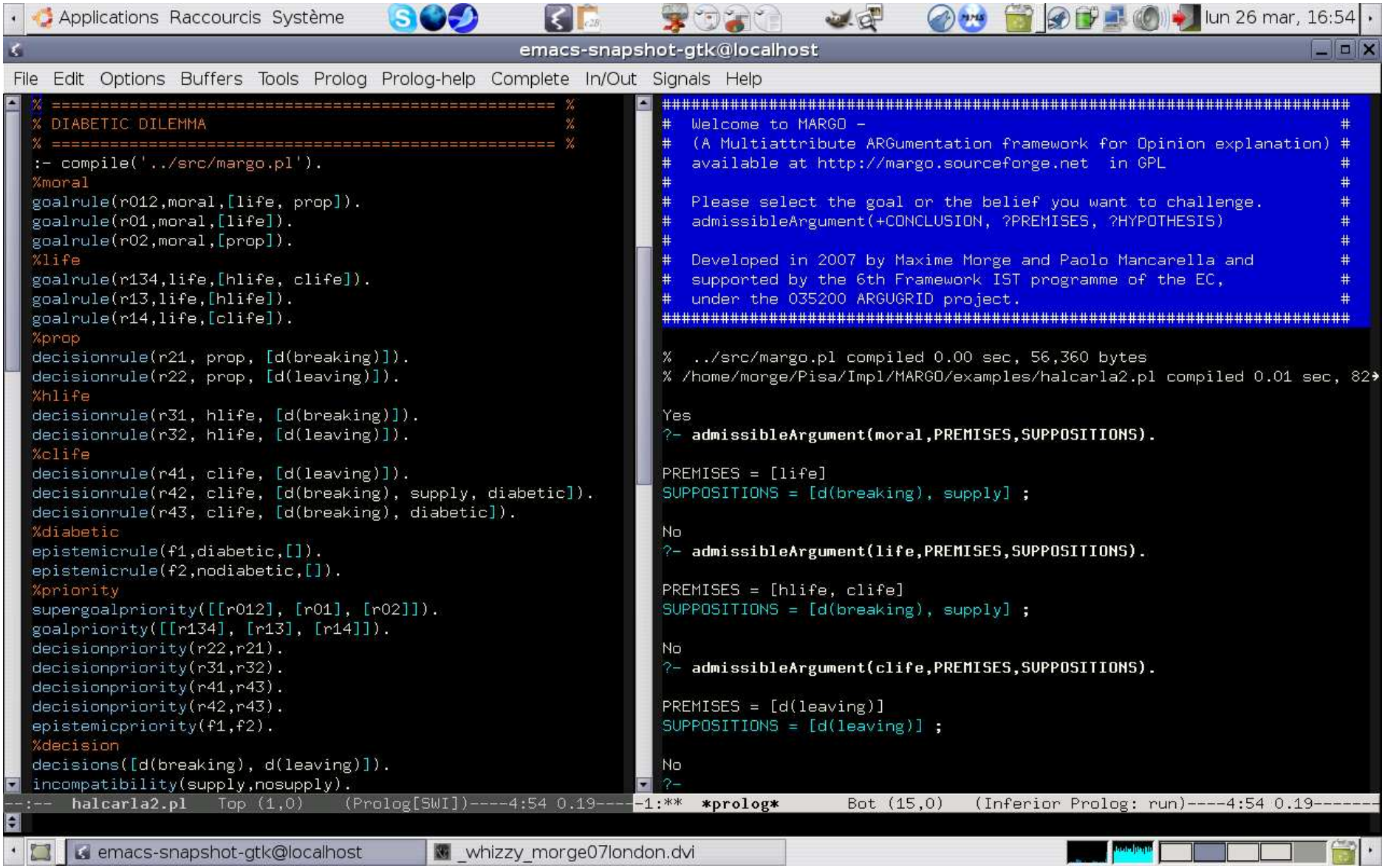
- **admissible** iff X does not attack itself and X attacks every argument Y such that Y attacks X;
- **preferred** iff X is maximally admissible;
- **ideal** iff X is admissible and it is contained in every preferred sets.

- 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 an assumption of one argument in an admissible set.

Procedure and its implementation: relax goals requirement and make assumptions



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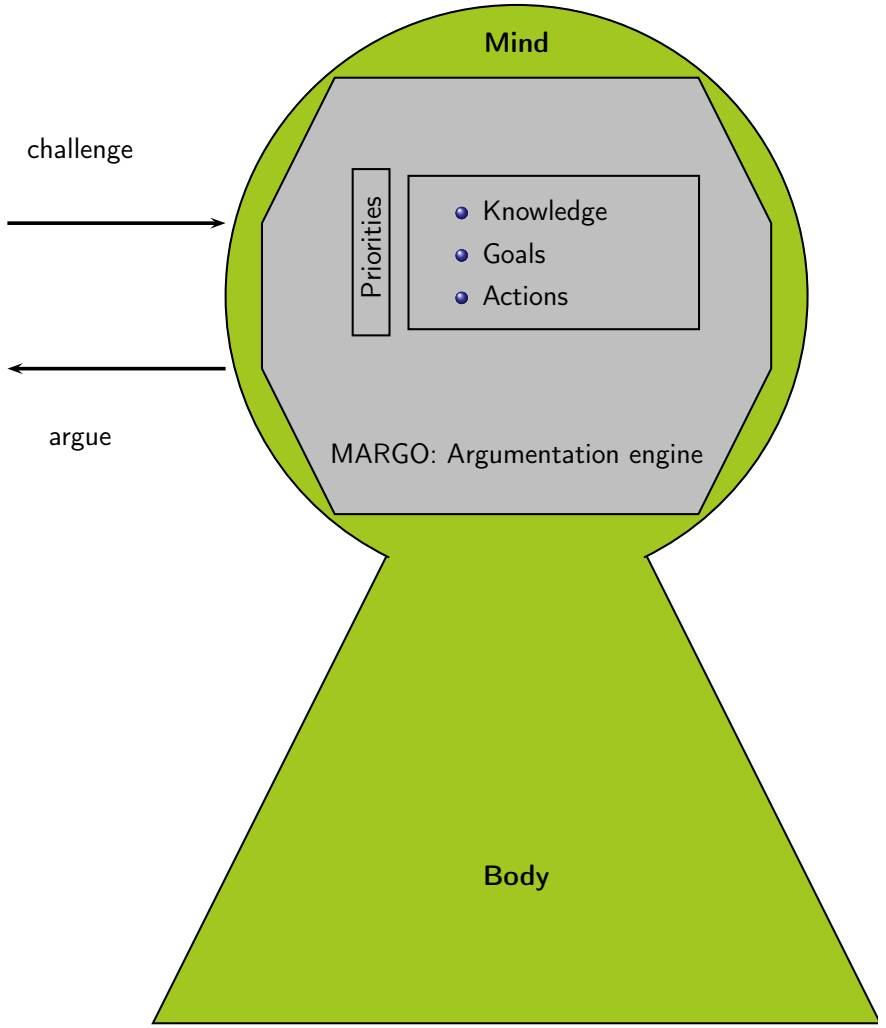
Argumentation for practical reasoning

A argumentation framework for practical reasoning
↪ *Formalization of a criminal sentencing*

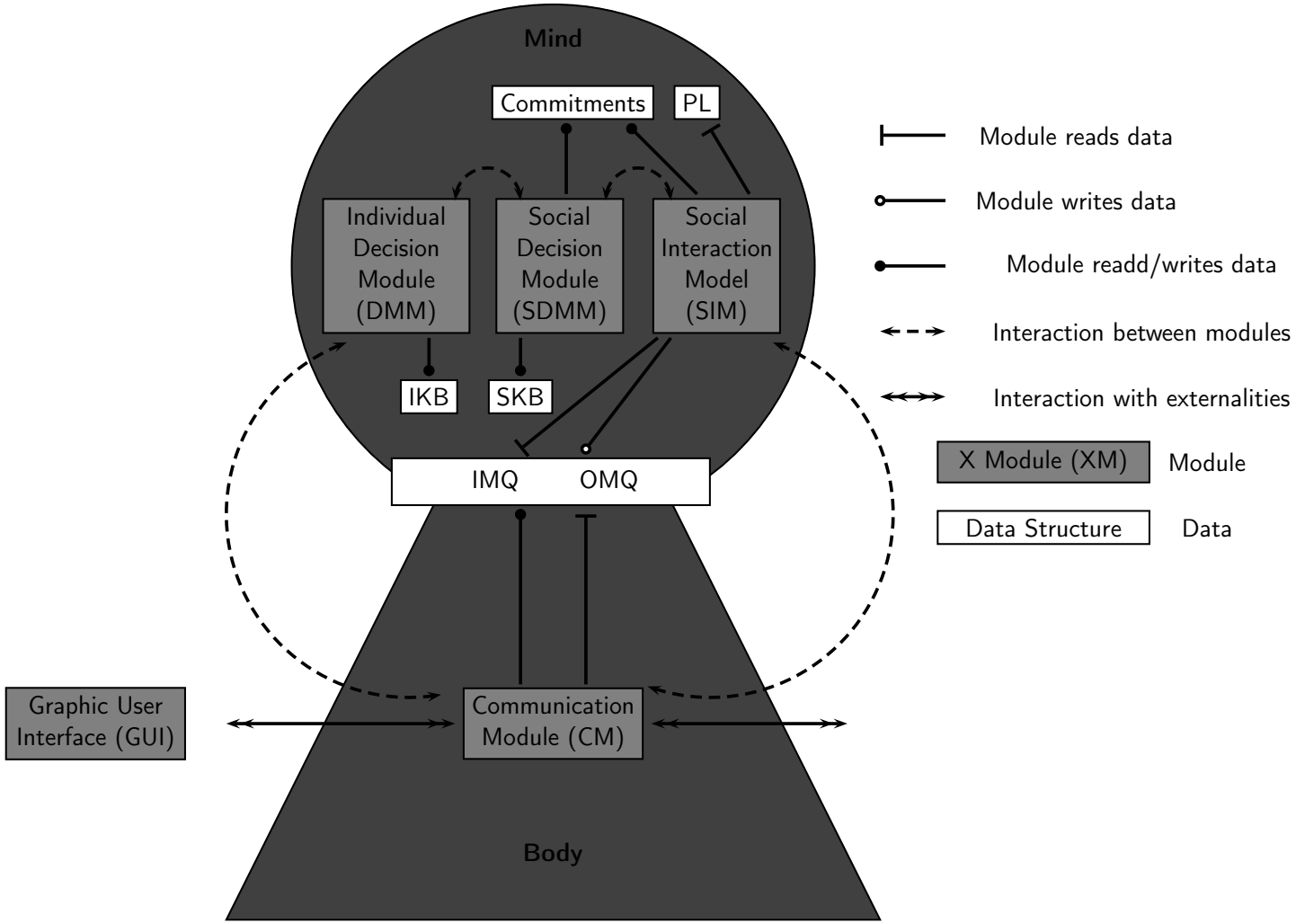
- Influence diagram
  ↪ *From epistemic to practical reasoning*
- Goal/Decision/Epistemic rules
  ↪ *Specific data structures*
- Priority over epistemic/goal/decision rules
  ↪ *Intuitions about probability/preferences/expected utilities*
- Abductive tree argument
  ↪ *Interaction-based explanation of the decision*

Practical reasoning for proactive agents

- Design
  - KGP (Knowledge, Goals, Plans) state-of-mind vs BDI
  - qualitative/quantitative priorities
- Implementation
  MARGO: a Prolog prototype
  `http://margo.sourceforge.net`



Toward an internal dialectics between the individual decision and the social decision



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