

Argumentation framework for practical reasoning in legal disputes*

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Seminar, Paris, May 2007



*supported by the Sixth Framework IST programme of the EC, under the 035200 ARGUGRID project.

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 abandoned in the UK, shall, unless the contrary is shown by 1, be deemed a British citizen.

- In a Logic Programm:

- $r1a(X) : \text{citizen1}(X) \leftarrow \text{parent}(Y, X), \text{citizen}(Y).$
- $r1b(X) : \text{citizen1}(X) \leftarrow \text{parent}(Y, X), \text{settled}(Y).$
- $r2(X) : \text{citizen2}(X) \leftarrow \text{abandoned}(X), \text{not } \neg \text{citizen1}(X).$

⇒ 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

Outline

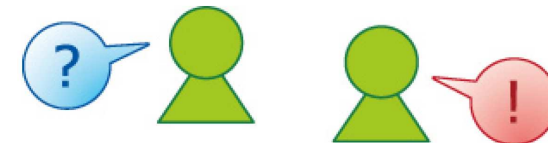
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Overview of argumentation

Argumentation is a process of construction and comparison of arguments for and against certain conclusions formalized by an **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

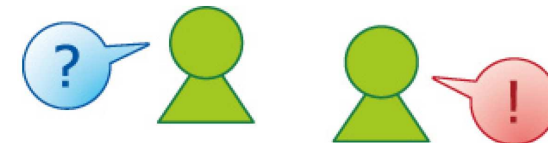


- Status of arguments
- Proof procedure

Overview of argumentation

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

- Underlying logic
- Arguments
 - 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:

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

$\text{head}(R) = L_0$.

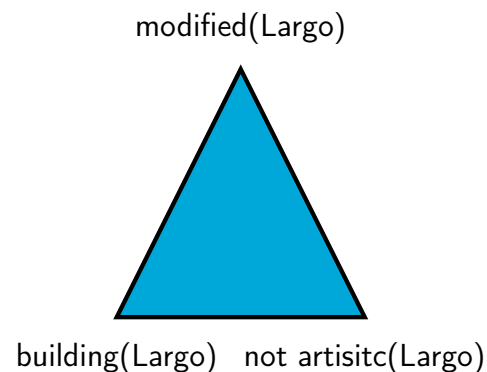
$\text{body}(R) = \{L_1, \dots, \text{not } L_m\}$.

- \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:

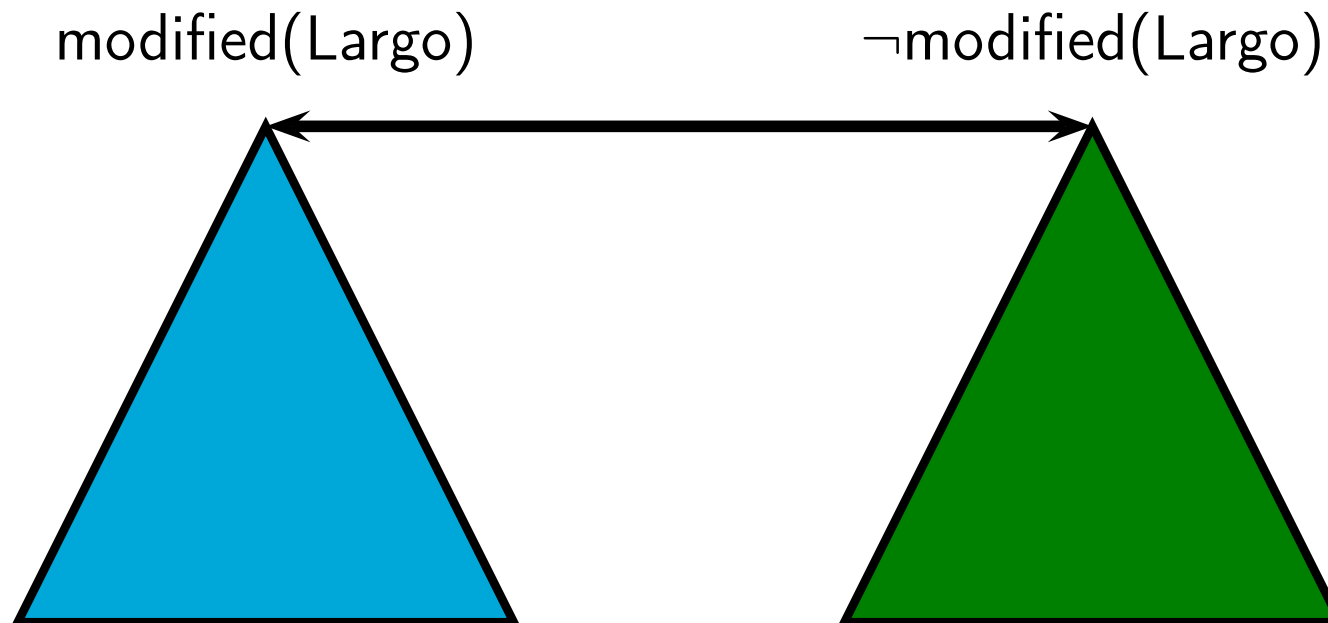
- An **abstract entity** with an unspecified logic,
 $A = \text{'Largo may not be modified since it needs restructuring'}$;
- A **pair** (Premises, Conclusion),
 $A = (\{\text{building(Largo), building}(X) \rightarrow \text{modified}(X)\}, \text{modified(Largo)})$;
- A deduction **sequence** of rules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

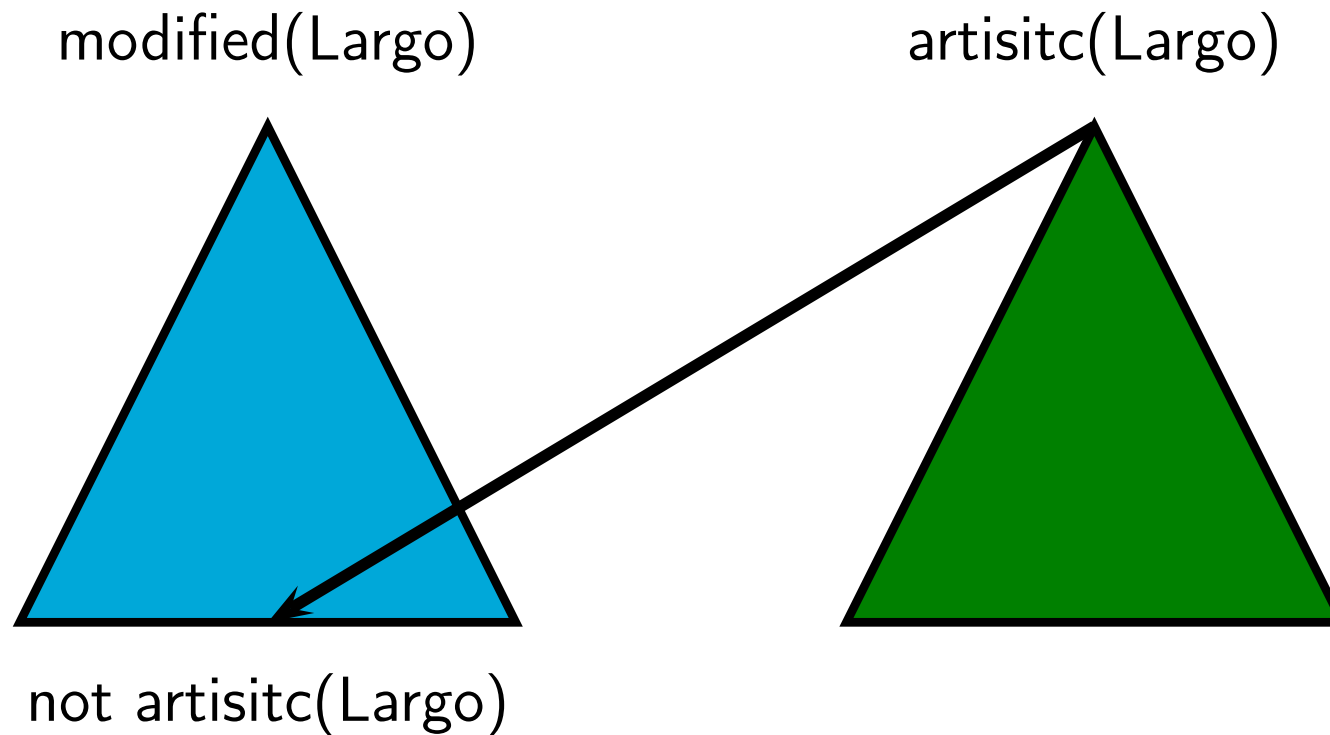
- Largo may be modified since it is a building;
- Largo may not be modified because it's artistic.



Attacks relation: rebutting, undermining and undercutting

Undermining attack non-provable assumptions:

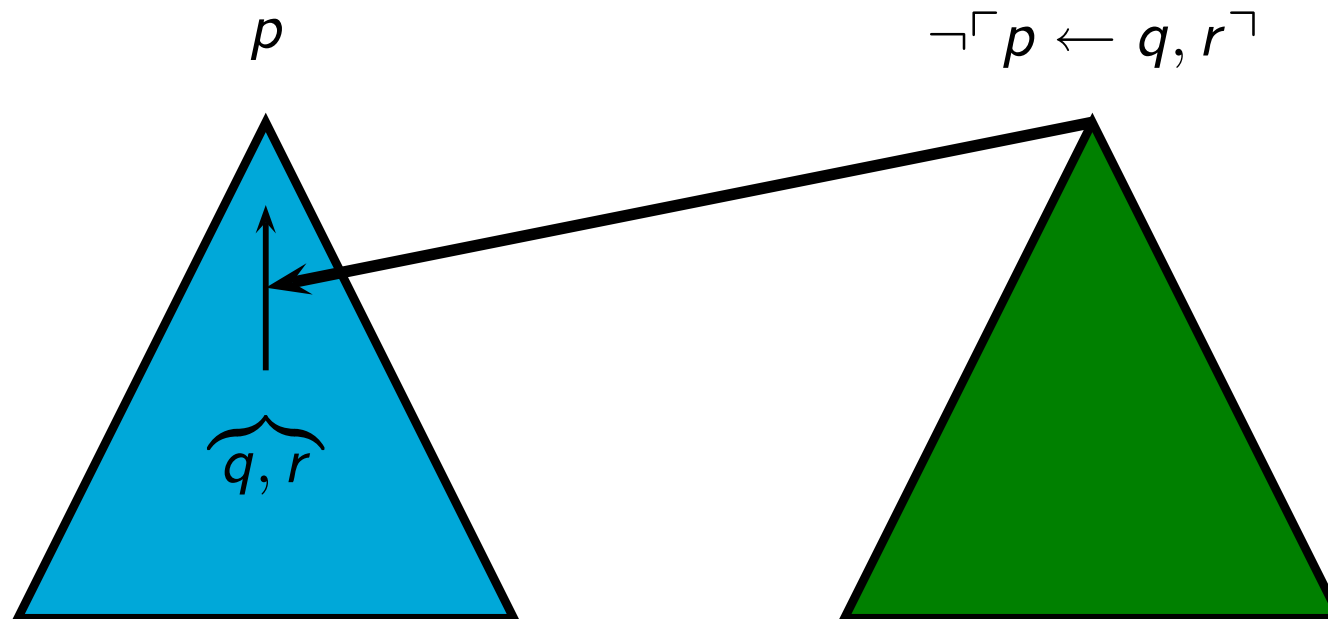
- Largo may not be modified since it is a building and it is not provable that Largo is artistic;
- Largo is artistic.



Attacks relation: rebutting, undermining and undercutting

Undercutting attack intermediate step:

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



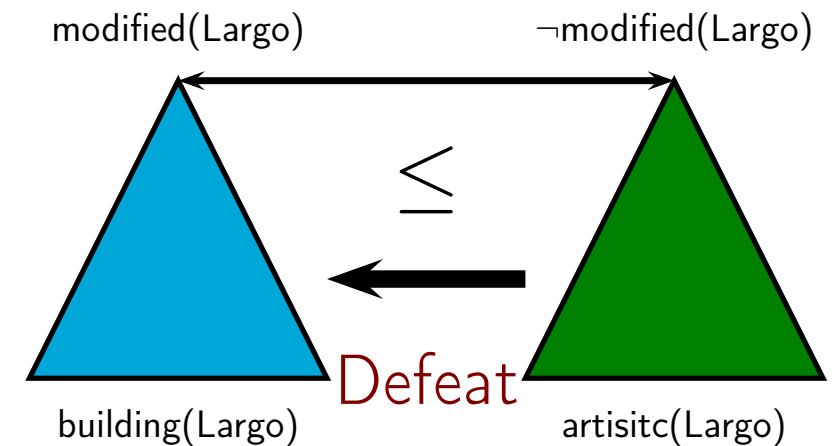
Priority relation: how to evaluate the strengths of arguments?

Law principles for reasoning:

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

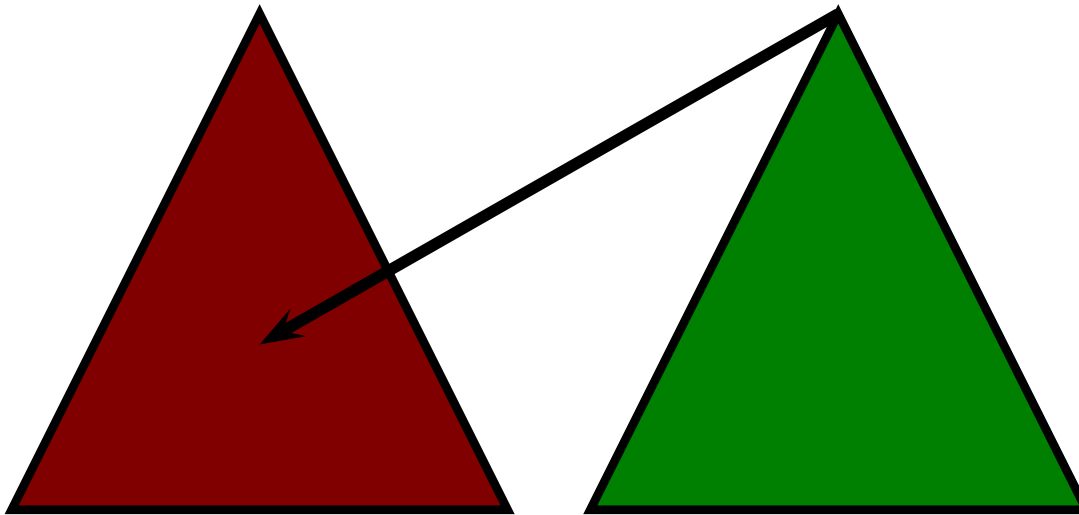
domain-independent principles of commonsense reasoning:

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



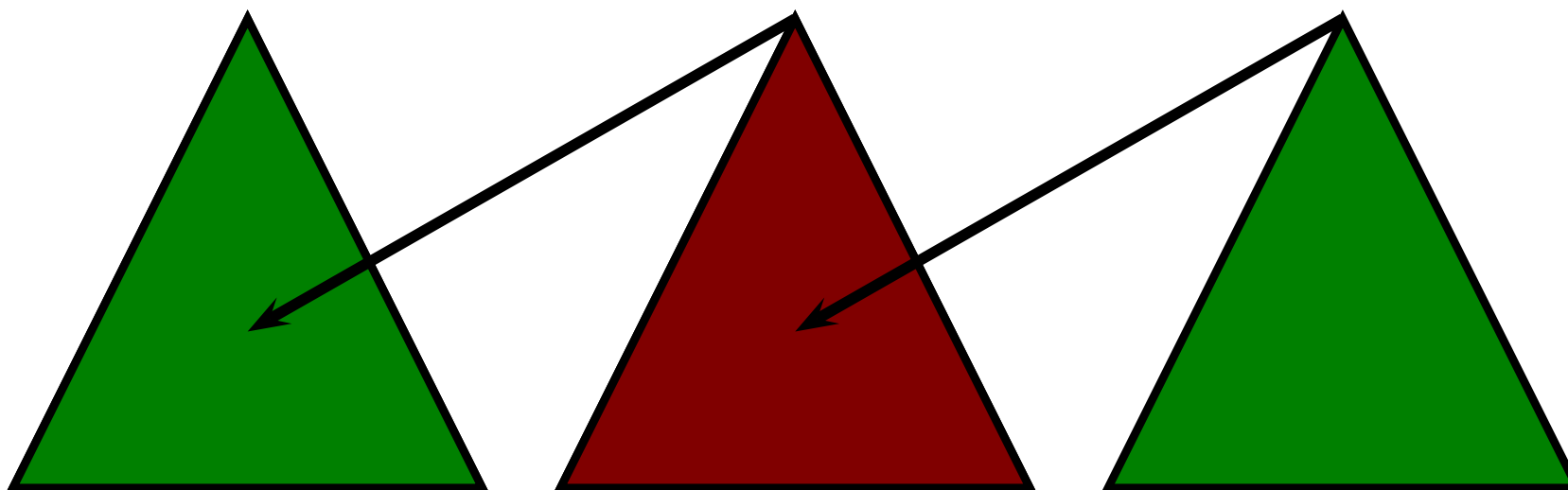
From the defeat relation to the status of arguments

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

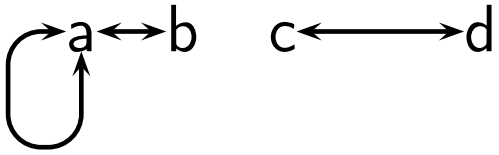


From the defeat relation to the status of arguments

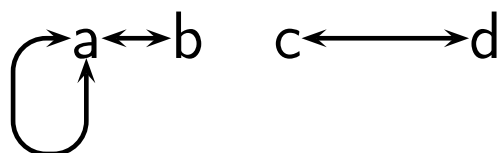
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The status of arguments



The status of arguments



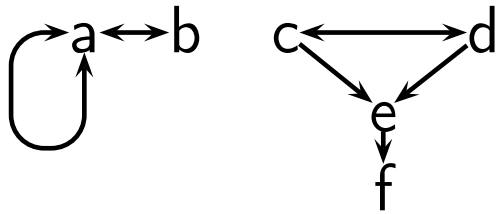
- \emptyset is ground;
- $\{b, c\}$ are $\{b, d\}$ preferred;
- $\{b\}$ is the maximal ideal set.

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 $\{b\} \subset \{b, f\} = \{b, c, f\} \cap \{b, d, f\}$

Definition ([Dung, Kowalski & Toni 06])

A set X of arguments is :

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Burden of proof rather than correspondence with reality

(Declarative) Model-theoretic Semantics

Completeness



Soundness

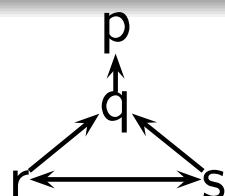
(Procedural) Dialectical Proof Procedures

Proof procedure: a dialectical enquiry

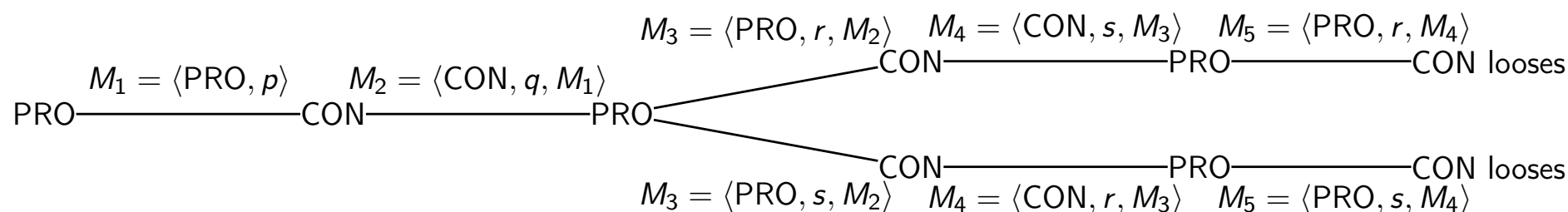
Definition

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

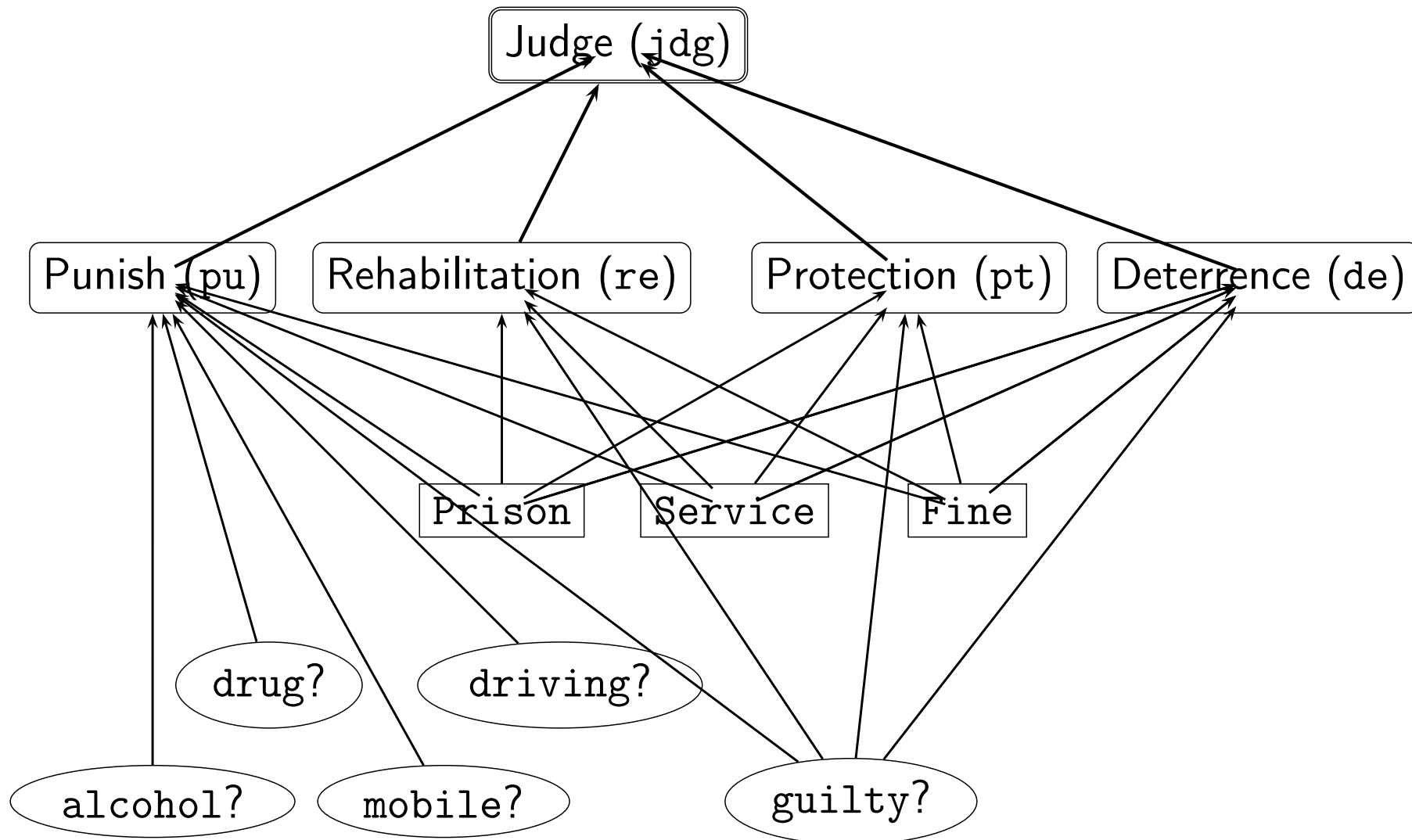
Argumentation is a promising approach for:

- 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 structures and priorities: hierarchies of conflicting rules

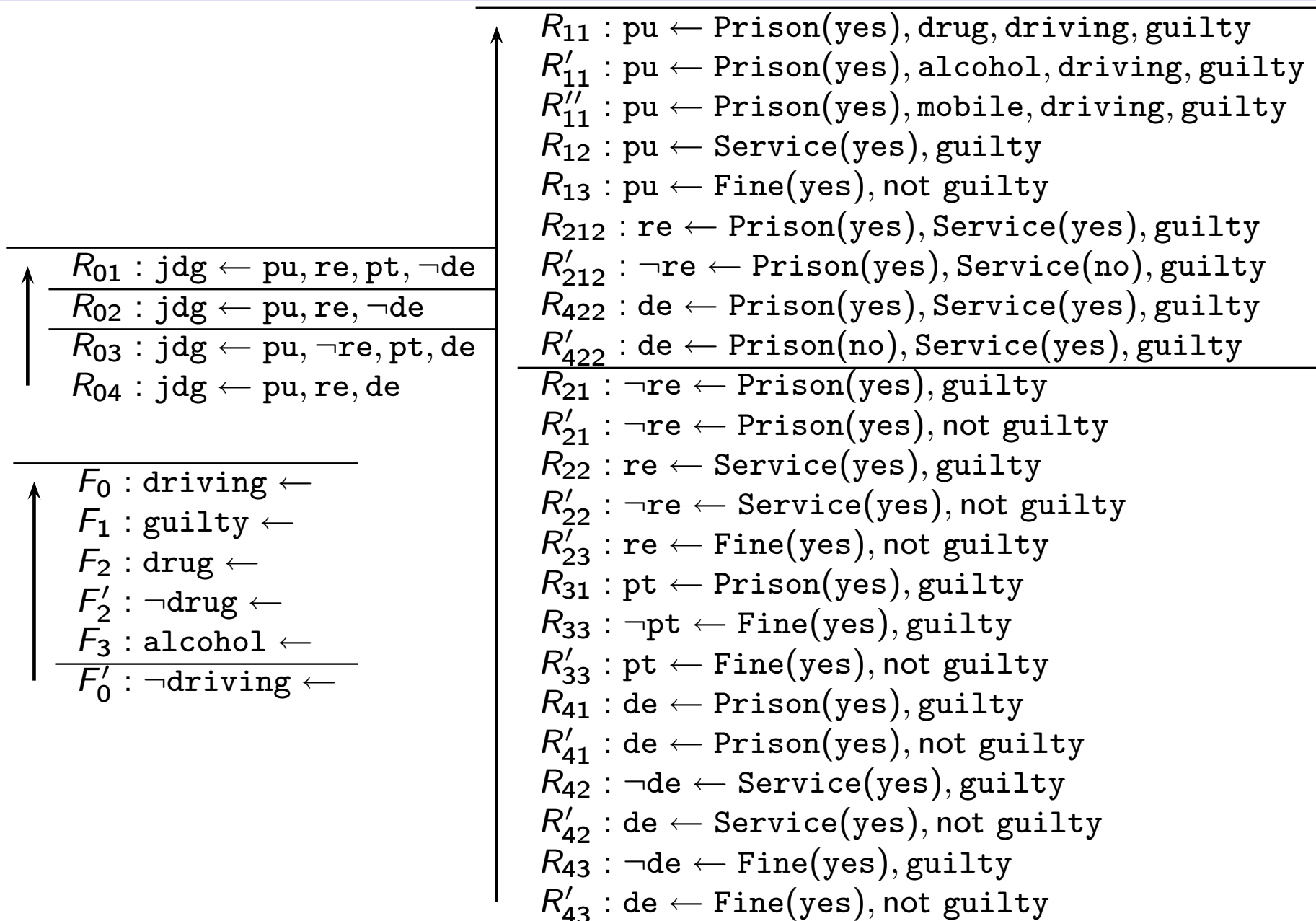
The theory compiles:

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

Different priorities for different rules:

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

Epistemic/Goal/Decision theory



Structure of arguments: abductive tree

Definition

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

- 1 **supposal**, *i.e.* built upon an hypothesis

$$\text{sent}(A) = \text{supp}(A)$$

$$A = \langle \text{Prison}(\text{yes}), \emptyset, [\text{Prison}(\text{yes})] \rangle \text{ or}$$

$$A = \langle \text{alcohol}, \emptyset, [\text{alcohol}] \rangle$$

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

$$\text{sent}(A) = \text{premise}(A)$$

$$A = \langle \text{mobile}, [\text{mobile}], \emptyset \rangle \text{ or } A = \langle \neg \text{mobile}, [\neg \text{mobile}], \emptyset \rangle$$

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

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

Interaction: choice between different explanations

Definition (Attack relation)

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

⇒ build homogeneous explanations:

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

Interaction: choice between different explanations (cont.)

Definition (Hypothesis size)

- ① if A is a hypothetical argument, then $\text{suppsize}(A) = 1$;
- ② if A is a trivial argument, then $\text{suppsize}(A) = 0$;
- ③ if A is a tree argument then

$$\text{suppsize}(A) = \sum_{A' \in \text{subarg}(A)} \text{suppsize}(A').$$

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 $(\text{top}(A_2) \prec \text{top}(A_3)) \wedge \neg(\text{top}(A_3) \prec \text{top}(A_2))$, then
 $A_3 \succ^{\mathcal{A}} A_2$;
- ③ If $(\text{top}(A_2) \sim \text{top}(A_3)) \wedge (\text{suppsize}(A_2) \leq \text{suppsize}(A_3))$,
then $A_2 \succ^{\mathcal{A}} A_3$;

Interaction: choice between different explanations (cont.)

Definition (Defeat relation)

A defeats B

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

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

Since

- $(\text{top}(B) \sim \text{top}(C)) \prec \text{top}(A)$,
 - $\text{suppsize}(A) = 2$ and $\text{suppsize}(B) = \text{suppsize}(C) = 1$,
- $A \succ^A B/C$.

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

```

File Edit Options Buffers Tools Prolog Prolog-help Complete In/Out Signals Help
% ===== %
% DIABETIC DILEMMA %
% ===== %
:- compile('../src/margo.pl').
%moral
goalrule(r012,moral,[life, prop]).
goalrule(r01,moral,[life]).
goalrule(r02,moral,[prop]).
%life
goalrule(r134,life,[hlife, clife]).
goalrule(r13,life,[hlife]).
goalrule(r14,life,[clife]).
%prop
decisionrule(r21, prop, [d(breaking)]).
decisionrule(r22, prop, [d(leaving)]).
%hlife
decisionrule(r31, hlife, [d(breaking)]).
decisionrule(r32, hlife, [d(leaving)]).
%clife
decisionrule(r41, clife, [d(leaving)]).
decisionrule(r42, clife, [d(breaking), supply, diabetic]).
decisionrule(r43, clife, [d(breaking), diabetic]).
%diabetic
epistemicrule(f1,diabetic,[]).
epistemicrule(f2,nodiabetic,[]).
%priority
supergoalpriority([[r012], [r01], [r02]]).
goalpriority([[r134], [r13], [r14]]).
decisionpriority(r22,r21).
decisionpriority(r31,r32).
decisionpriority(r41,r43).
decisionpriority(r42,r43).
epistemicpriority(f1,f2).
%decision
decisions([d(breaking), d(leaving)]).
incompatibility(supply,nosupply).

#####
# Welcome to MARGO - #
# (A Multiattribute ARGumentation framework for Opinion explanation) #
# available at http://margo.sourceforge.net in GPL #
# #
# Please select the goal or the belief you want to challenge. #
# admissibleArgument(+CONCLUSION, ?PREMISES, ?HYPOTHESIS) #
# #
# Developed in 2007 by Maxime Morge and Paolo Mancarella and #
# supported by the 6th Framework IST programme of the EC, #
# under the 035200 ARGUGRID project. #
#####

% ../src/margo.pl compiled 0.00 sec, 56,360 bytes
% /home/morge/Pisa/Impl/MARGO/examples/halcarla2.pl compiled 0.01 sec, 82

Yes
?- admissibleArgument(moral,PREMISES,SUPPOSITIONS).

PREMISES = [life]
SUPPOSITIONS = [d(breaking), supply] ;

No
?- admissibleArgument(life,PREMISES,SUPPOSITIONS).

PREMISES = [hlife, clife]
SUPPOSITIONS = [d(breaking), supply] ;

No
?- admissibleArgument(clife,PREMISES,SUPPOSITIONS).

PREMISES = [d(leaving)]
SUPPOSITIONS = [d(leaving)] ;

No
?-

```

--- halcarla2.pl Top (1,0) (Prolog[SWI])---4:54 0.19----1:** *prolog* Bot (15,0) (Inferior Prolog: run)---4:54 0.19-----

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Argumentation for practical reasoning

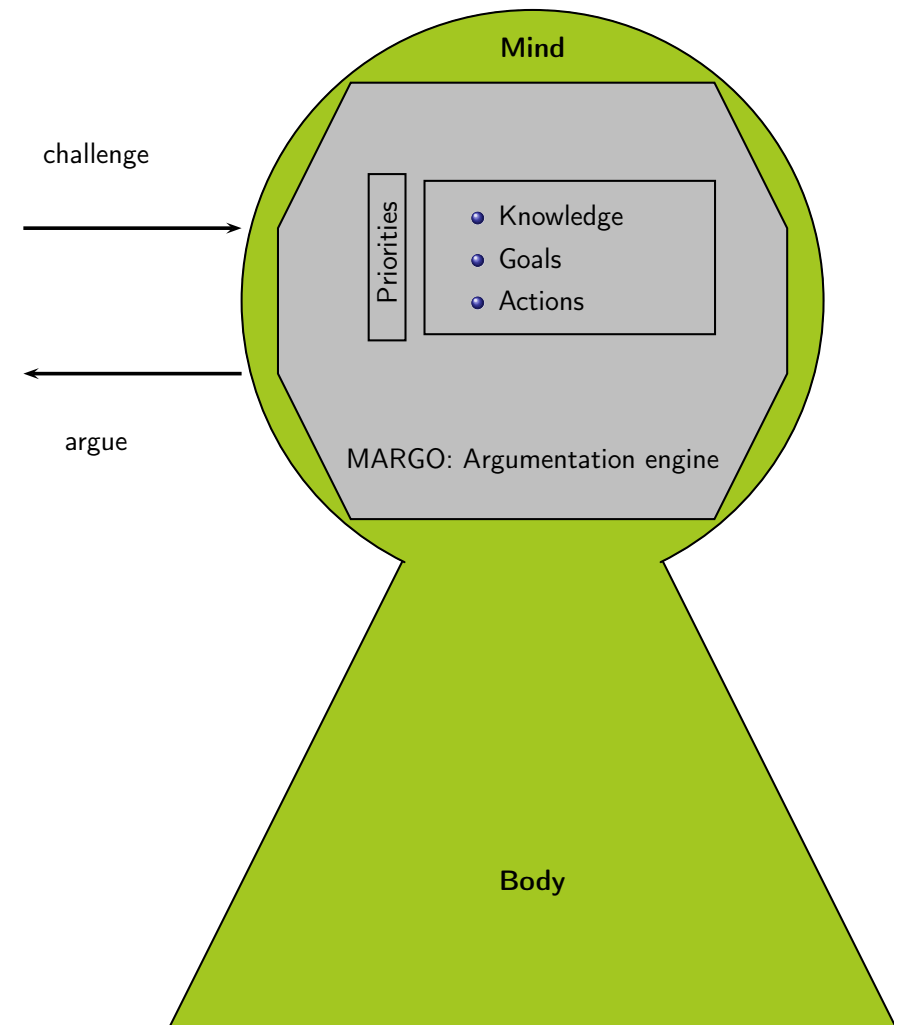
A argumentation framework for practical reasoning

↪ *Formalization of a criminal sentencing*

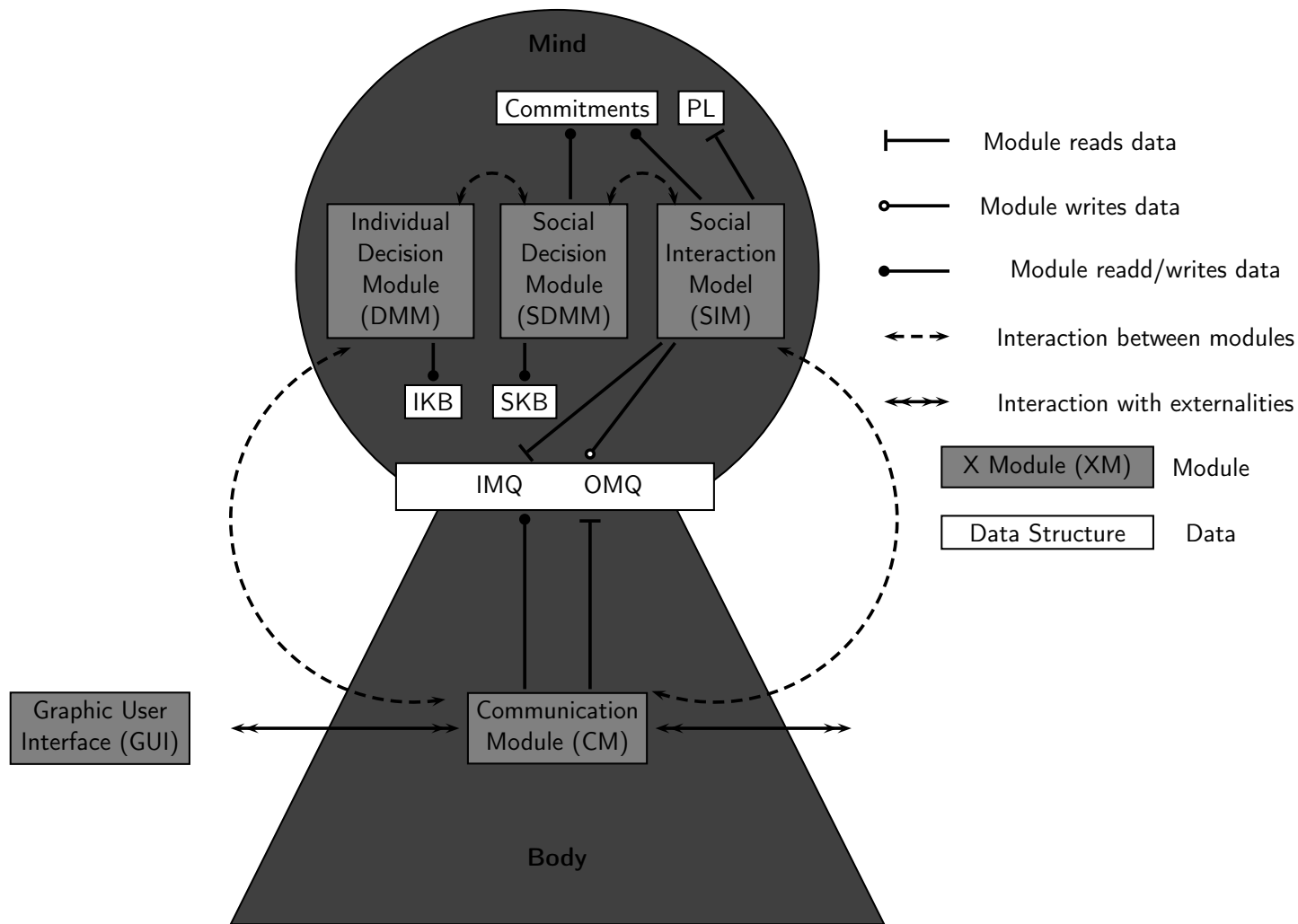
- Influence diagram
 - ↪ *From epistemic to practical reasoning*
- Goal/Decision/Epistemic rules
 - ↪ *Specific data structures*
- Priority over epistemic/goal/decision rules
 - ↪ *Intuitions about probability/preferences/expected utilities*
- Abductive tree argument
 - ↪ *Interaction-based explanation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