

# Argumentation in ARGUGRID

*Francesca Toni*

Department of Computing  
Imperial College London



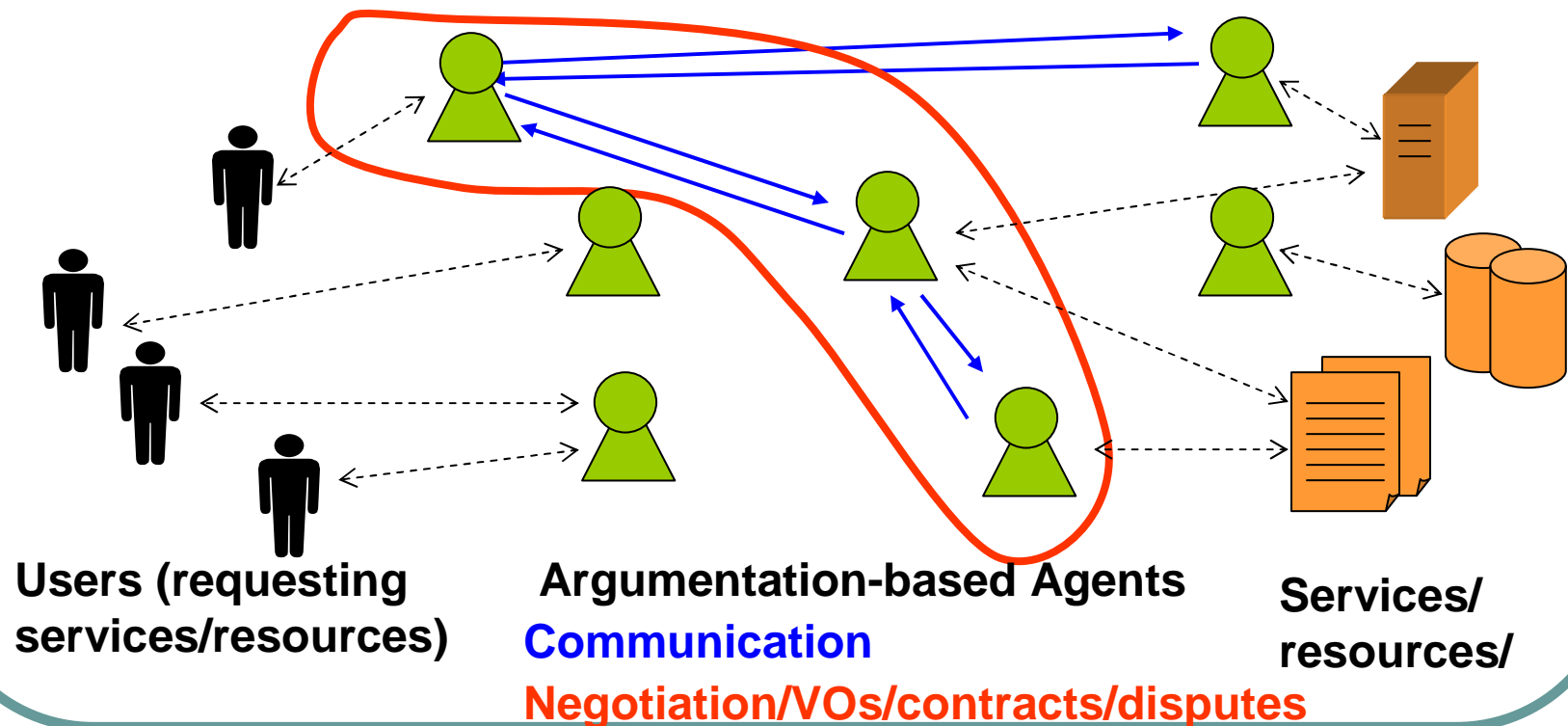
<http://www.argugrid.eu/>

# Outline

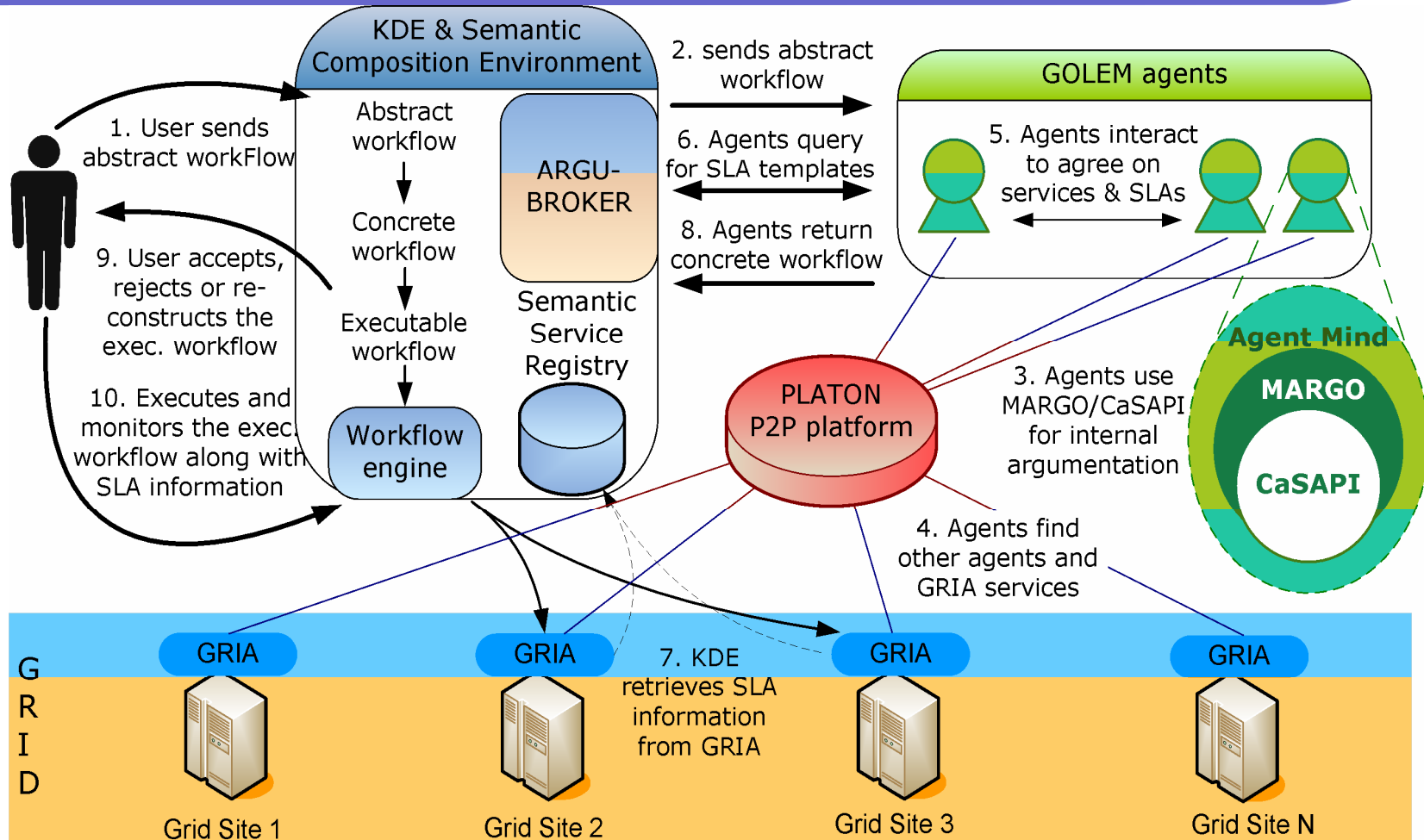
- ARGUGRID: vision, platform, (some) components, scenarios
- Argumentation for decision-making, negotiation, trust computing, dispute resolution
- Assumption-based argumentation, CaSAPI
- Decision-making and trust computing

# ARGUGRID vision

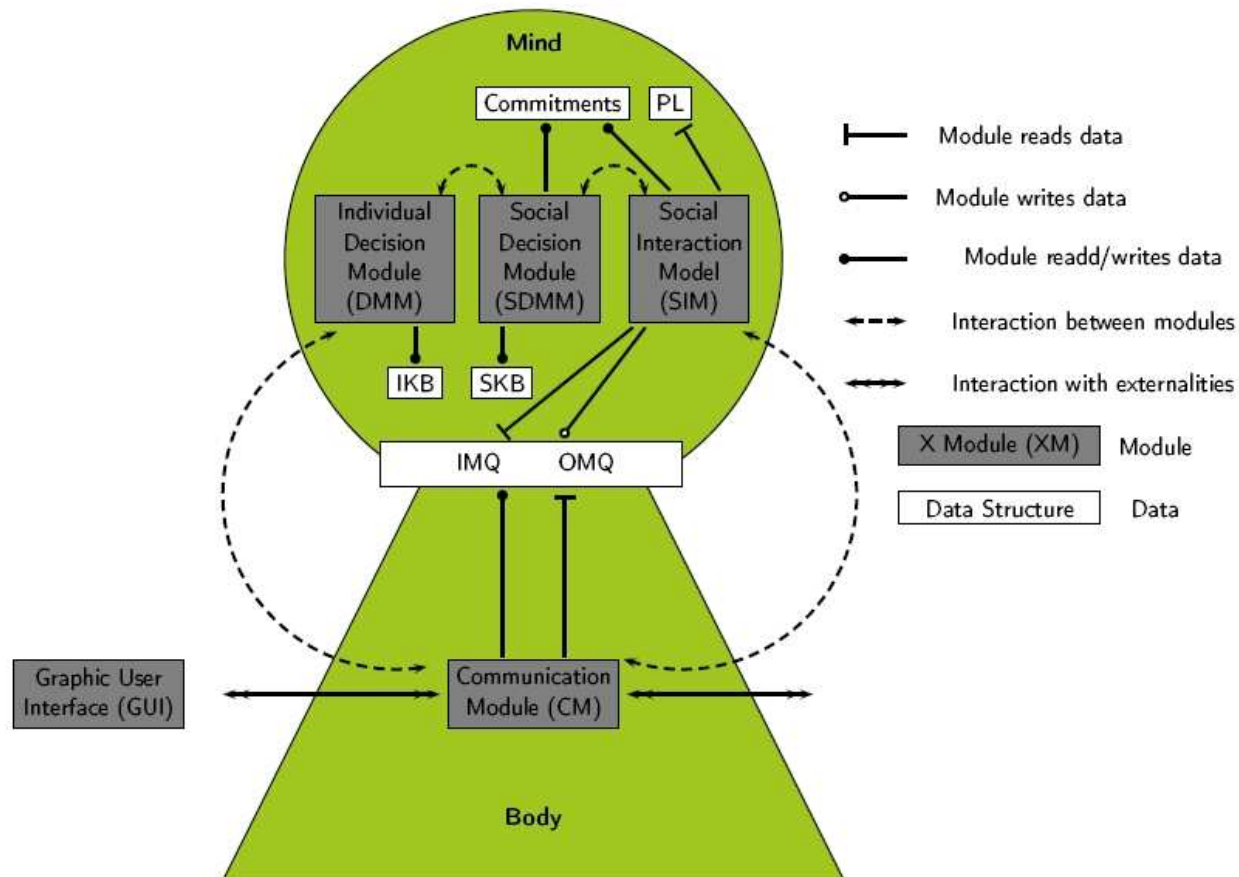
- Develop a *semantic grid/service-oriented architecture* to support applications



# ARGUGRID: the “big picture”



# An agent perspective



# Scenarios

- Business migration (**AIT – academic**)
  - Select appropriate location
  - Combine several services (constructors, suppliers etc)
- Earth observation (**GMV – industrial**)
  - Select appropriate sensors/satellites e.g. for dealing with oil spill
  - Combine sensors/satellites + other services (weather) e.g. for fire monitoring
- E-procurement (**CosmoONE – industrial**)

# The case for argumentation

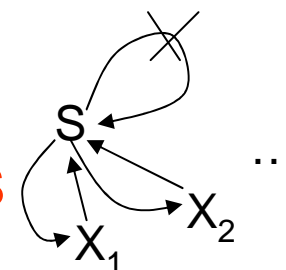
- Decision-making/practical+epistemic reasoning
  - alternative decisions, benefits and preferences, contradictory beliefs
- Negotiation
  - persuasion (rewards)
- Trust computing
  - evidence (from contracts) + statistics
- Dispute resolution (contracts)
  - default reasoning (legal doctrines)

# Outline

- ARGUGRID: vision, platform, (some) components, scenarios
- Argumentation for decision-making, negotiation, trust computing, dispute resolution
- Assumption-based argumentation, CaSAPI
- Decision-making and trust computing

# Computational argumentation

- Needed to support platform and scenarios!
- Abstract argumentation (Dung AIJ95):
  - Given framework:  $(arguments, attack)$
  - A subset  $S$  of  $arguments$  is
    - *Admissible* iff  $S$  does not attack  $S$  and  $S$  attacks each  $X$  that attacks  $S$
    - *Preferred* iff  $S$  is maximally admissible
    - *Grounded* iff  $S$  is minimal such that it contains every  $a$  such that  $S$  attacks every  $X$  that attacks  $a$
    - *Ideal* iff  $S$  is admissible and contained in each preferred set
    - ...
- Several computational mechanisms



# Pros and cons of abstract argumentation

- 👍 Many instances/applications: non-monotonic reasoning, games etc
- 👍 Intuitive “semantics”/computation: game/dispute, “last word wins”
- 👎 A lot of work to identify arguments and attacks
- 👎 Overlapping between arguments ignored

# Pros and cons of abstract argumentation

👉 A lot of work to identify arguments and attacks:

$\alpha$ : “*John is guilty because he was seen with the murder weapon by a reliable witness ....*”

$\beta$ : “*but the witness is not reliable because ....*”

👉 Overlapping between arguments ignored

$\alpha$ : “*A because B and C ....*”

$\beta$ : “*but not B because D....*”

$\gamma$ : “*but not D because C and E ....*”

# Assumption-based argumentation (ABA)

In ABA frameworks:

- *arguments* defined in terms of:
  - a **deductive system (rules)**
    - e.g. laws/regulations, policy rules, argumentation schemas
  - a set of candidate **assumptions**
    - e.g. uncertain/unsupported beliefs, decisions, “names” of rules
- *attacks* defined in terms of:
  - a notion of **contrary** of assumptions
    - e.g. Negation, alternative decisions, exceptions to rules

# ABA arguments and attacks

- *arguments* are *tight* deductions supported by sets of assumptions
- an argument  $\alpha$  *attacks* another argument  $\beta$  if the conclusion of  $\alpha$  is the contrary of one of the assumptions supporting  $\beta$

$$\alpha: A \vdash c_\alpha \quad \longrightarrow \quad \beta: B \vdash c_\beta$$
$$c_\alpha = \bar{b}, b \in B$$

e.g.  $\beta$  : "John is guilty because he was seen ...by a reliable witness ...."

$\alpha$  : "but the witness is not reliable because ...."

# Example

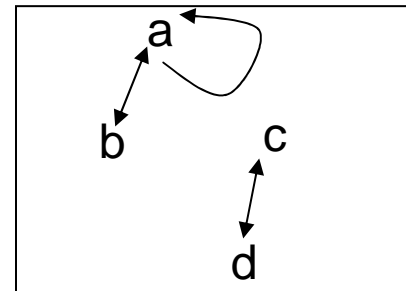
$(\mathcal{L}, \mathcal{R}, A, \bar{\cdot})$ :

- $\mathcal{L} = \{a, b, c, d, \neg a, \neg b, \neg c, \neg d\}$
- $\mathcal{R} = \{\neg a \leftarrow a; \neg a \leftarrow b; \neg b \leftarrow a; \neg c \leftarrow d; \neg d \leftarrow c\}$
- $A = \{a, b, c, d\}$
- $\bar{a} = \neg a; \bar{b} = \neg b; \bar{c} = \neg c; \bar{d} = \neg d$

$\{a\} \vdash \neg a$  attacks itself

$\{b\} \vdash \neg a$  attacks  $\{a\} \vdash \neg b$ , etc

$\{a\}$  attacks itself  
 $\{b\}$  attacks  $\{a\}$ , etc



All arguments supported by subsets of  $\{b, d\}$  and  $\{b, c\}$  are preferred

$\{b, d\}$  and  $\{b, c\}$  preferred

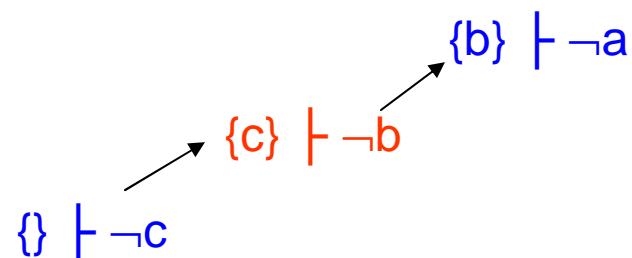
# Assumption-based argumentation: computation

- (various kinds of) dispute derivations:
  - Dispute between proponent and opponent
  - Construction of arguments/identification of attacks
  - Outcomes:
    - the initial claim is “acceptable” (e.g. preferred/admissible) or not
    - Assumptions supporting the arguments by the proponent (if acceptable)
    - Assumptions supporting arguments by the opponent and chosen by the proponent to be counter-attacked (if acceptable)

# Dispute derivations: example

- $\mathcal{R} = \{\neg a \leftarrow b; \neg b \leftarrow c; \neg c\}$
- $\bar{a} = \neg a; \bar{b} = \neg b; \bar{c} = \neg c$

Is  $\neg a$  “acceptable”?

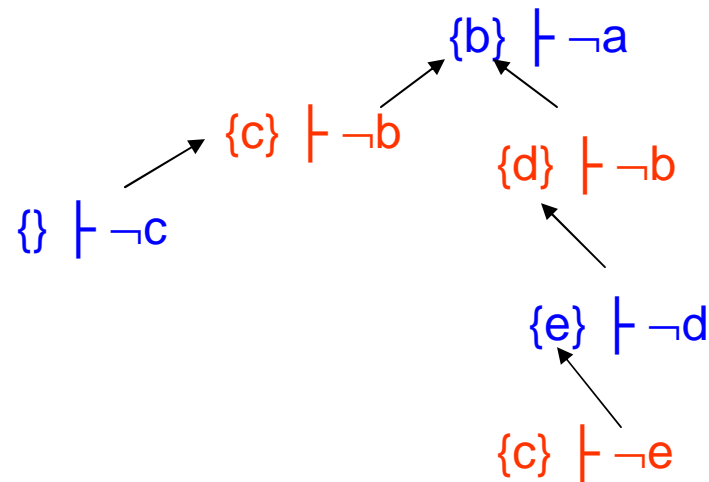


Proponent	Opponent	Assumptions supporting Proponent	Culprits chosen in Opponent
$\{\neg a\}$	$\{\}$	$\{\}$	$\{\}$
$\{b\}$	$\{\}$	$\{b\}$	$\{\}$
$\{\}$	$\{\{\neg b\}\}$	$\{b\}$	$\{\}$
$\{\}$	$\{\{c\}\}$	$\{b\}$	$\{\}$
$\{\neg c\}$	$\{\}$	$\{b\}$	$\{c\}$
$\{\}$	$\{\}$	$\{b\}$	$\{c\}$

**Yes!**

# Dispute derivations: filtering

Overlapping between arguments *not* ignored:



Filtering of culprits by culprits

Various other forms of filtering to exploit overlapping between arguments

# Assumption-based argumentation: implementation

- CaSAPI (Credulous and Sceptical Argumentation: Prolog Implementation)

<http://www.doc.ic.ac.uk/~dg00/casapi.html>

- 3 kinds of dispute derivations
  - Version 2 (assumptions)
  - Version 3 and Version 4 (assumptions and arguments)

# Demo

**Proponent:**

**Software house**



**Opponent:**

**Customer**



payment because goodJob

badJob because not(accordingToSpec)

accordingToSpec because reqA and reqB

not(reqB)!

OKreqB because e-mail



# Decision-making for e-procurement

- ABA:
  - features of product/service to purchase
  - description of (un)certain features in offers
  - links from features to business strategic benefits for the buyer

e.g.  $b1(S) \leftarrow f1(S), f3(S), f4(S)$

$f1(s1)$

$f3(s1) \leftarrow option3$

$f4(s1) \leftarrow guarantee1, clause3$

- Agent use argumentation to evaluate pros and cons of offers from different supplies, in terms of granted benefits and guarantees

e.g.  $\{option3, guarantee1, clause3\} \vdash b1(s1)$

$s1$  can challenge  $s2$  wrt  $b1$  (does  $b1(s2)$  hold?)

- CaSAPI : selects the best (dominat) offers using admissibility semantics + returns optimal contracts to user (as defence set)

e.g. if  $s2$  fails to provide  $b1(s2)$ , then  $s1$  is a better supplier and the contract returned is  $\{s1, option3, guarantee1, clause3\}$

# Decision-making and contract negotiation

- Two agents, a buyer and a seller, each using
  - an ABA describing
    - how to achieve “structural” goals (e.g. for buyer house with 2 toilets) and “contractual” goals (e.g. for buyer max £450K)
    - Uncertainties
    - Defeasible rules
  - Ranking of goals (preferences)
- Two-phase negotiation:
  1. Sceptical preferred semantics (equivalent to minmax preference for structural goals) for deciding options
  2. Negotiation protocol (of alternating offers and counter-offers) leading to agreement (using a Nash equilibrium strategy)

# Trust computing

- trust = willingness of an entity (*evaluator*) to engage in a risky relationship with another entity (*target*)
- existing approaches classified as either cognitive (based on beliefs/knowledge) or game-theoretic (subjective probability based on statistics)
- we propose a hybrid approach using both statistics, a subjective probability model and knowledge/beliefs in the form of arguments

## The evidence-based trust model (Yu & Singh 2002)

- Trust is represented by a **belief function** (imprecise subjective probability  $Bel: 2^\Omega \rightarrow [0,1]$  where  $\Omega = \{T, \neg T\}$  (2 scenarios meaning target is trustworthy/untrustworthy))
- belief function determined by **evidence mass function**  
 $m: 2^\Omega \rightarrow [0,1]$   
via  $\forall E \subseteq \Omega: Bel(E) = \sum_{X \subseteq E} m(X)$
- evaluator decides to trust iff  $Bel(\{T\}) - Bel(\{\neg T\}) \geq \rho$   
where  $\rho$  is the **cautiousness** of the evaluator
- the evidence mass function is defined as  
$$m(\emptyset) = 0, m(\{T\}) = \frac{N^+}{N}, m(\{\neg T\}) = \frac{N^-}{N}, m(\Omega) = \frac{N_?}{N}$$
- purely statistical approach to trust computing

# Extending the evidence-based trust model with argumentation

- idea: stats = past information, but also need info about present/future behavior of target
- assume given some (*forecast*) *arguments*, each argument supporting either {T} or {not T} (for or against trust)
- arguments are interpreted as justified claims for trusting or not, but justifications not infallible...
- also consider (*mitigation*) *arguments* which attack (undermine justifications for) forecast arguments...
- we model non-statistical information by an abstract argumentation framework (Dung 1995)
- can estimate the strength of arguments numerically in various ways, e.g. using admissibility, for experiments we use notion of strength (Matt & Toni 2008)

# Extending the evidence-based trust model with argumentation

we propose a new formula for calculating  $m$

$$m(\emptyset) = 0, m(\{T\}) = (1 - \varepsilon)p_A(\{T\}), m(\{\neg T\}) = (1 - \varepsilon)p_A(\{\neg T\}), m(\Omega) = \varepsilon$$

where

the **indeterminacy**  $\varepsilon = \frac{K}{K + I}$

is built from the **epistemic risk-aversion** parameter  $K = \frac{N_?}{N - N_?}$

the **argumentation-based prior**  $p_A : 2^\Omega \rightarrow [0, 1]$  is defined as

$$\forall E \subseteq \Omega : p_A(E) = \frac{1}{I} \left[ p(E) + V_A \sum_a s(a) p(E | X_a) \right]$$

where

$$I = 1 + V_A \sum_{a \in A} s_F(a) \quad (\text{total amount of information})$$

$$V_A \geq 0 \quad (\text{subjective informational value of arguments})$$

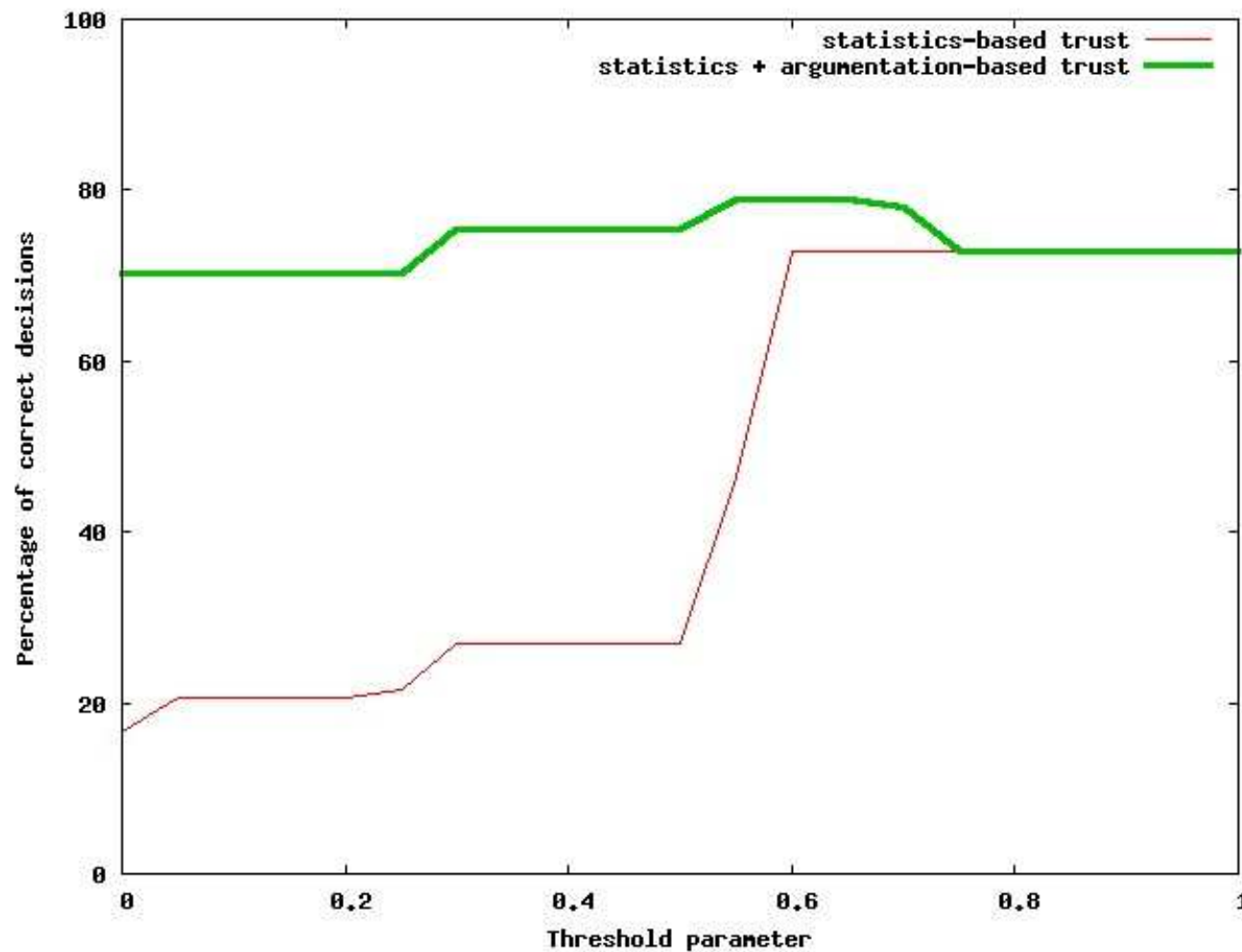
$p : \Omega \rightarrow [0, 1]$  (the **statistical prior**) is defined as

$$p(T) = \frac{N^+}{N^+ + N^-}, p(\neg T) = \frac{N^-}{N^+ + N^-}$$

# Building arguments from contracts

- we construct one belief function per dimension of trust (*Availability, Privacy, Security, Reliability*)
- One forecast argument supporting {T} if contract offered by target to evaluator has clause guaranteeing satisfying level of (A/P/S/R)
- otherwise one forecast argument supporting {not T}
- optionally one mitigation argument against the forecast of {T} if, in the past, clause was (often) violated
- one such argumentation framework per dimension, so four frameworks used per interaction
- overall decision to trust iff trust wrt all of four dimensions
- Specific choice of  $V_A \geq 0$

# Some preliminary experimentation



# Conclusions

- Argumentation tool for various (credulous and sceptical) semantics in ABA
- Deployed to support
  - decision making in agents (e-procurement in ARGUGRID)
- Argumentation-based trust computing (hybrid approach)
- Ongoing/Future
  - CaSAPI:
    - Interfaces (preferences, decisions)
    - visualisation of arguments + attacks
    - Extensions (constraints), Other applications
    - Distributed version (across agents)
  - Decision-making
    - Other notions of dominance? Uncertainty?
  - Trust
    - Further experimentation
    - Computation of contract-based arguments
  - Further applications (Medicine? Security?)