Assumption-based argumentation for epistemic and practical reasoning

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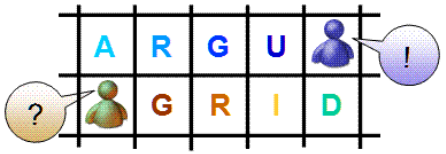

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Motivation

Assumption-based argumentation can serve as an effective

computational tool

for argumentation-based reasoning (e.g. legal epistemic and practical reasoning)

Outline

- Abstract argumentation [Dung95]
- Assumption-based argumentation [Bondarenko, Dung, Kowalski, Toni 97]
- Epistemic reasoning example
- Practical reasoning example
- Conclusions

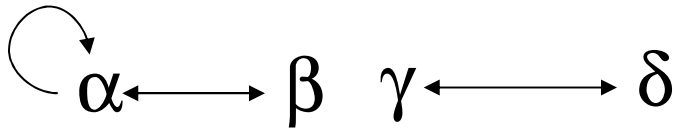
Abstract Argumentation

- Abstract argumentation framework: *(arguments,attacks)*
- Various ways to sanction when a set of arguments is “OK”, e.g.
  - a set of arguments is ***admissible*** iff
    - it does not attack itself and
    - it attacks every argument that attacks it (i.e. it “defends” itself against all attacks)

Abstract argumentation example

arguments: α; β; γ; δ

attacks:



- {}, {β}, {β, δ}, {β,γ} …. admissible

Abstract Argumentation (cntd)

Other notions of “being OK” (semantics) exist:

a set of arguments is

- *preferred* iff
  - it is maximally admissible
- *complete* iff
  - it is admissible and it contains all arguments it defends
- *grounded* iff
  - it is minimally complete
- *ideal* iff
  - it is admissible, and
  - it is a subset of every preferred set of arguments

Abstract Argumentation (cntd)

Notions of sets of arguments “being OK” lift up to notions of sentences (beliefs/properties) “being OK”: e.g.

- A sentence is admissible iff
  - *it is supported* by* an argument contained in an admissible set of arguments

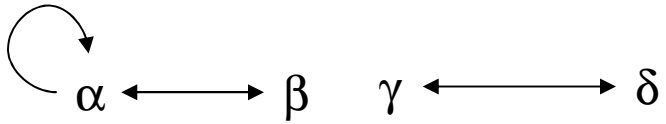
*requires framework with *(arguments,attacks,support)*

Notes on semantics

- Semantics differ in their level of scepticism, with boundaries:
  - Preferred (the most credulous)
  - Grounded (the most sceptical)

- Example: arguments: $\alpha; \beta; \gamma; \delta$

  attacks:



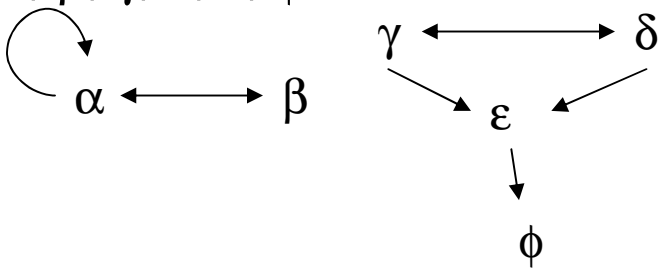
  - {} grounded
  - {β, δ} and {β,γ} preferred
  - {β} sceptical preferred (intersection of all preferred) and ideal

Notes on semantics (cntd)

- Semantics differ in their level of scepticism, with boundaries:
  - Preferred (the most credulous)
  - Grounded (the most sceptical)

- Another example: arguments: α; β; γ; δ; ε; ϕ

  attacks:



  - $\{\beta, \delta, \phi\}$ and $\{\beta, \gamma, \phi\}$ preferred
  - $\{\beta, \phi\}$ sceptical preferred
  - $\{\beta\}$ and ideal

Assumption-based argumentation

- Recall abstract argumentation framework:

  (arguments,attacks)

- In assumption-based argumentation frameworks:
  - *arguments* defined in terms of:
    - a **deductive system** (also defining *support*)
    - a set of candidate **assumptions**
  - *attacks* defined in terms of:
    - a notion of **contrary** of assumption

Assumption-based argumentation formally

- An assumption-based argumentation framework is $(\mathcal{L},\mathcal{R},A,\bar{\ })$ where
  - $(\mathcal{L},\mathcal{R})$ is a deductive system
    - $\mathcal{L}$ set of sentences
    - $\mathcal{R}$ set of inference rules $s \leftarrow s_1,\ldots,s_n$
  - $A \subseteq \mathcal{L}$ is a set of candidate assumptions
  - $\bar{a}$ is the contrary of assumption a

From assumption-based to abstract argumentation

- Given an assumption-based argumentation framework
  - arguments are *tight* deductions supported by sets of assumptions
  - an argument α attacks* another argument β if the conclusion of α is the contrary of one of the assumptions supporting β

*undermining attack – but rebuttal attack can be obtained too – [Dung,Kowalski,Toni 06] and later example

Assumption-based argumentation: example

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

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

a ├ ¬a attacks itself

b ├ ¬a attacks a ├ ¬b, etc

{a} attacks itself

{b} attacks {a}

- {} grounded
- {b,d} and {b,c} preferred
- {b} sceptical preferred and ideal

Computational counterpart for assumption-based argumentation

- Dispute derivations (between a proponent and an opponent) for computing
  - admissible sets of assumptions (AB-dispute derivations)
  - grounded sets of assumptions (GB-dispute derivations)
  - ideal sets of assumptions (IB-dispute derivations, using Fail-dispute derivations)
- Prolog implementation (CaSAPI)

AB-Dispute derivations

- $\mathcal{R}$={¬a ←a, ¬a ← b, ¬b ← a, ¬c ← d, ¬d ← c}
- ā= ¬a; $\bar{b}$= ¬b; $\bar{c}$= ¬c; $\bar{d}$= ¬d

Is ¬a an admissible belief?

Proponent	Opponent	Assumptions supporting Proponent	Culprits chosen in Opponent
{¬a}	{}	{}	{}
{b}	{}	{b}	{}
{}	{{¬b}}	{b}	{}
{}	{{a}}	{b}	{}
{¬a}	{}	{b}	{a}
{}	{}	{b}	{a}

GB-Dispute derivations

- $\mathcal{R}$={¬a ←a, ¬a ← b, ¬b ← a, ¬c ← d, ¬d ← c}
- ā= ¬a; $\bar{b}$= ¬b; $\bar{c}$= ¬c

Is ¬a a grounded belief?

Proponent	Opponent	Assumptions supporting Proponent	Culprits chosen in Opponent
{¬a}	{}	{}	{}
{b}	{}	{b}	{}
{}	{{¬b}}	{b}	{}
{}	{{a}}	{b}	{}
{¬a}	{}	{b}	{a}
….			

IS-Dispute derivations

- $\mathcal{R}$={¬a ←a, ¬a ← b, ¬b ← a, ¬c ← d, ¬d ← c}

Is ¬a an ideal belief?

Proponent	Opponent	Assumptions of Proponent	Culprits in Opponent	Sentences to Fail upon
{¬a}	{}	{}	{}	{}
{b}	{}	{b}	{}	{}
{}	{{¬b}}	{b}	{}	{}
{}	{{a}}	{b}	{}	{}
{¬a}	{}	{b}	{a}	{{a}}
{}	{}	{b}	{a}	{{a}}
{}	{}	{b}	{a}	{} (since Fail({a}))

Fail-dispute derivations

- $\mathcal{R}$={¬a ←a, ¬a ← b, ¬b ← a, ¬c ← d, ¬d ← c}

Fail({a})?

Proponent	Opponent	Assumptions of Proponent	Culprits in Opponent
{a}	{}	{a}	{}
{}	{¬a}	{a}	{}
{}	{{a},{b}}	{a}	{}
{}	{{},{b}}	{a}	{}

Epistemic reasoning: example

Example from [Prakken, Sartor 96]

- Defeasible rules:
  - r1(X): X 's exterior may not be modified if X is a protected building.
  - r2(X): X's exterior may be modified if X needs restructuring.
  - r3(X,Y): R1(X) > R2(Y) if R1(X) concerns artistic bldgs and R2(Y) concerns town planning
  - t(X,Y): R1(X) > R2(Y) if R1(X) is later than R2(Y)
- Strict rules:
  - r1(X) concerns artistic buildings; r2(X) concerns town planning
  - r2(X) is later than r1(X); r3(X,Y) is later than t(X,Y)
  - villa is a protected building and needs restructuring
- What should be believed about modifying villa's exterior?

Assumption-based argumentation for epistemic reasoning

In assumption-based argumentation
(see [Kowalski, Toni 96] – but other translations possible)

- Rules $\mathcal{R}$:

  villa 's exterior may not be modified ← not defeated(r1(villa))
  villa's exterior may be modified ← not defeated(r2(villa))
  defeated(r1(villa)) ← not defeated(t(villa,villa)), not defeated(r2(villa))
  defeated(r2(villa)) ← not defeated(r3(villa,villa)),
  not defeated(r1(villa))
  defeated(t(villa,villa)) ← not defeated(t(villa,villa)),
  not defeated(r3(villa,villa))

- Assumptions A are *not defeated(X))*, with contrary *defeated(X).*

AB-dispute derivations: *villa's exterior may not be modified*

Practical reasoning: example

Example from [Bench-Capon,Prakken 06]

- Possible decisions: *prison; fine; (community) service*
- Beliefs:

  punish ← prison
  punish ← fine
  punish ← service
  deter ← prison
  deter ← fine
  ¬ deter ← service
  rehabilitate ← service
  ¬ rehabilitate ← prison
  protect ← prison
- Which decision,
  given goals: punish, deter, rehabilitate (in some order)?

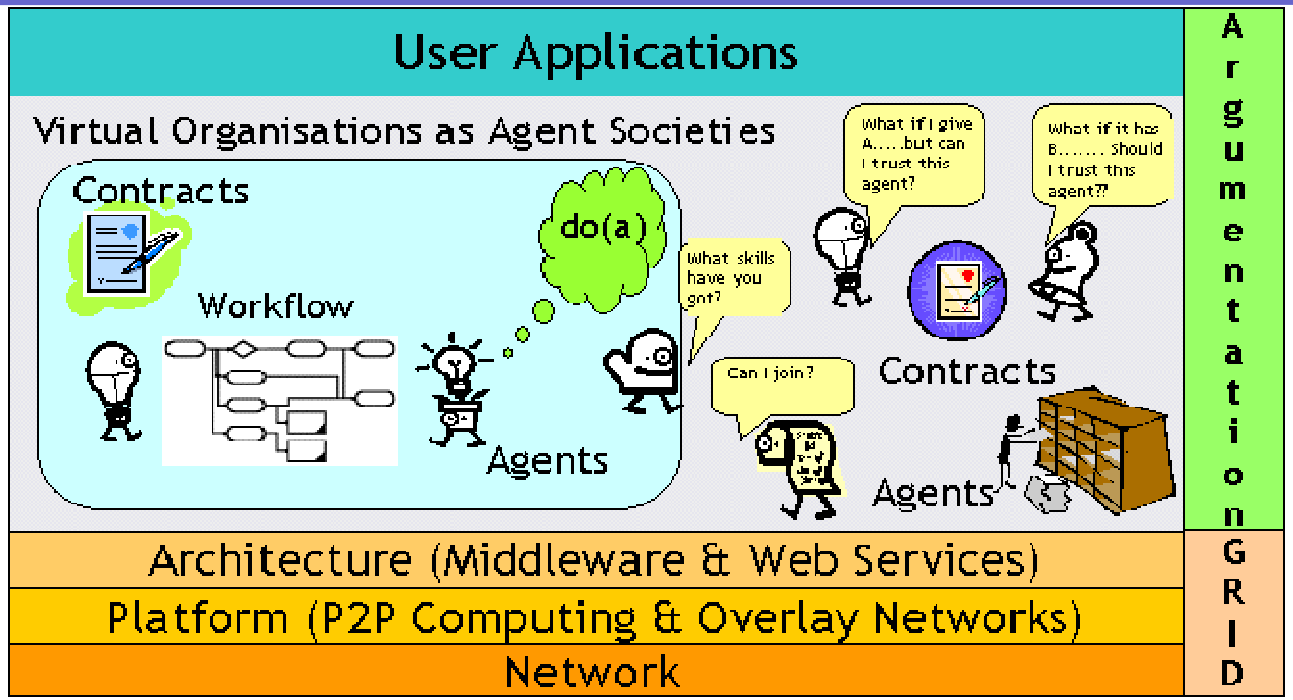
Assumption-based argumentation for practical reasoning

- A = {*prison; fine; service, a,b,c,d*}
- contrary(*prison*) = {*fine, service*} contrary(*fine*) ={*prison; service*}
  contrary(*service*)= {*prison; fine*}
  contrary(*a*)= $\neg$ *deter* contrary(*b*)=*deter*
  contrary(*c*)= $\neg$ *rehabilitate* contrary(*d*)= *rehabilitate*
- $\mathcal{R}$ consists of
  punish ← *prison*
  punish ← *fine*
  punish ← *service*
  deter ← *prison, a*
  deter ← *fine, a*
  $\neg$ *deter* ← *service, b*
  rehabilitate ← *service, c*
  $\neg$ *rehabilitate* ← *prison, d*
  protect ← *prison*
- AB-dispute derivations: given goals *punish&deter*, decision is *prison*

Conclusions

- In ARGUGRID: decisions/beliefs are about composing services over the grid for e-business applications (see later overview)
- Related work: Bench-Capon&Prakken, Prakken at COMMA 2006, Amgoud05 and more
- Ongoing work:
  - Refinement of the implementation
  - automated translation into assumption-based argumentation
  - generalised notion of contrary in assumption-based argumentation
  - preferences on goals/properties for practical reasoning
- Extensions:
  - uncertainty on events in the world
  - quantitative utilities assigned to goals

Overview of ARGUGRID www.argugrid.eu



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Goals

- Develop argumentation-based foundations for the GRID, populated by rational decision-making agents within virtual organisations.
- Incorporate argumentation models into service-centric architecture.
- Develop underlying platform using P2P computing and overlay networks.
- Validate ArguGRID by way of industrial application scenarios.