An Argumentative Model for Service-Oriented Agents
Demokritos, April 2008.

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ARGUmentation as a foundation for the semantic GRID

- Provide a new model for argumentative agents populating and evolving within a trusted grid.
- Provide a new model for the specification, creation, operation and dissolution of Virtual Organizations over the grid using argumentation.
- Design an architecture for the semantic grid to support argumentative agents and VOs.
- Develop a grid-based platform to support the implementation of models and architecture and assess the approach.
- Experiment with and evaluate the models, architecture and platform in the context of concrete applications for e-business.

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Global Picture of the ARGUGRID platform

1. Users edit an abstract Workflow
2. KDE sends GOLEM Agents the abstract workflow
3. Agents use MARGO/Cesapi for internal argumentation
4. Agents return the concrete workflow
5. Users decide to accept, reject or reconstruct the concrete Workflow
6. SCE executes the concrete Workflow
7. Users receive the final result

GOLEM Agents

P2P Network

MARGO

CaSAPI

Agent Mind

KDE & Semantic Composition Environment

Abstract Workflow

Concrete Workflow

Workflow Engine

GRID

Grid Site 1

Grid Site 2

Grid Site N

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Plan

- ARGUGRID
- Use case
- Argumentation framework for decision making
- Agents’ architecture
- Case study
- Deployment
- Conclusions
E-procurement [ARGUGRID D1.2]
## Deliberative steps for e-procurement

<table>
<thead>
<tr>
<th>step #</th>
<th>description</th>
<th>dialogue type</th>
</tr>
</thead>
<tbody>
<tr>
<td>step 1</td>
<td>find potential providers</td>
<td>information-seeking</td>
</tr>
<tr>
<td>step 2</td>
<td>get providers’ features</td>
<td>information-seeking</td>
</tr>
<tr>
<td>step 3</td>
<td>create shortlist</td>
<td>n/a</td>
</tr>
<tr>
<td>step 4</td>
<td>get services’ quotes</td>
<td>information-seeking</td>
</tr>
<tr>
<td>step 5</td>
<td>choose winner</td>
<td>n/a</td>
</tr>
<tr>
<td>step 6</td>
<td>negotiate specific terms</td>
<td>argumentation-based negotiation</td>
</tr>
</tbody>
</table>
Argumentation framework for decision making

Arguments as reasons supporting claims which can be disputed by other reasons.

1. Which service and provider?
2. The service $S_b(c)$ provided by Bob.
3. Why?
4. good_deal because of cost.
5. Why not $S_b(e)$?
6. ...
Arguments as reasons supporting claims which can be disputed by other reasons.

1. Which service and provider?
2. The service $S_b(c)$ provided by Bob.
3. Why?
4. good_deal because of cost.
5. Why not $S_b(e)$?
6. ... 

In [Morge ARGMAS 07]
- Argumentation framework and semantics by admissibility.
- Decisions are taken if supported by admissible arguments.
- Need for extensions (handle user’s representation/preferences).
- Implemented by MARGO (http://margo.sourceforge.net).
A model of multi-criteria decision problems with incomplete knowledge

- good_deal
  - supplier
    - performance
      - testimonials(p,v)
      - satisfaction(p,v)
    - previous(p,n)
  - representation
    - proposal(p,s)
    - turnover(p,t)
  - provision
    - price(s,ps)
    - warranty(s,w)
    - installation(p,i)
A decision framework is a tuple $\mathcal{D} = \langle \mathcal{L}, \text{Asm}, \mathcal{I}, \mathcal{T}, \mathcal{P} \rangle$, where:

- $\mathcal{L}$ is the **object language** which captures the statements about the decision problem;
- $\text{Asm}$, is a set of sentences in $\mathcal{L}$ which can be assumed, called **assumptions**;
- $\mathcal{I}$ is the **incompatibility relation**, i.e. a binary relation over atomic formulas which is asymmetric. It captures the mutual exclusion between the statements;
- $\mathcal{T}$ is the **theory** expressed as a set of statements in $\mathcal{L}$;
- $\mathcal{P} \subseteq \mathcal{T} \times \mathcal{T}$ is a (partial or total) preorder over $\mathcal{T}$, called the **priority** relation, which captures the uncertainty of beliefs, the priority amongst goals, and the expected utilities of the decisions.
Goal rules, decision rules, and epistemic rules

\[ \text{r}_{012} : \text{good\_deal} \leftarrow \text{supplier, provision} \]
\[ \text{r}_{01} : \text{good\_deal} \leftarrow \text{supplier} \]
\[ \text{r}_{134} : \text{supplier} \leftarrow \text{performance, representation} \]
\[ \text{r}_{256} : \text{provision} \leftarrow \text{cost}_b, \text{qos}_b \]
\[ \text{r}_{25} : \text{provision} \leftarrow \text{cost}_b \]
\[ \text{r}_{26} : \text{provision} \leftarrow \text{qos}_b \]
\[ \text{r}_{02} : \text{good\_deal} \leftarrow \text{provision} \]

\[ \text{f}_1 : \text{testimonials}(\text{Bob, high}) \leftarrow \]
\[ \text{f}_2 : \text{turnover}(\text{Bob, 5}) \leftarrow \]
\[ \text{f}_3 : \text{installation}(\text{Bob, 100}) \leftarrow \]
\[ \text{f}_4 : \text{price}(d, \text{high}) \leftarrow \]
\[ \text{f}_5 : \text{warranty}(d, \text{low}) \leftarrow \]
\[ \text{f}_6 : \text{price}(c, \text{low}) \leftarrow \]
\[ \text{f}_7 : \text{warranty}(c, \text{high}) \leftarrow \]
\[ \text{f}_8 : \text{price}(e, \text{low}) \leftarrow \]
\[ \text{f}_9 : \text{warranty}(e, \text{low}) \leftarrow \]
\[ \text{f}_{10} : \text{price}(f, \text{high}) \leftarrow \]
\[ \text{f}_{11} : \text{warranty}(f, \text{high}) \leftarrow \]

\[ \text{r}_{21}(p, s) : \text{performance} \leftarrow \text{proposal}(p, s), \text{testimonials}(p, \text{high}) \]
\[ \text{r}_{31}(p, s) : \text{representation} \leftarrow \text{proposal}(p, s), \text{turnover}(p, t), t > 2\text{M euros} \]
\[ \text{r}_{32}(p, s) : \text{representation} \leftarrow \text{proposal}(p, s), \text{installation}(p, i), i > 50 \]
\[ \text{r}_{51}(p, s) : \text{cost}_b \leftarrow \text{proposal}(p, s), \text{price}(s, \text{low}) \]
\[ \text{r}_{61}(p, s) : \text{qos}_b \leftarrow \text{proposal}(p, s), \text{warranty}(s, \text{high}) \]
Interaction between tree arguments

Argumentation framework for decision making

Arguments

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www.argugrid.eu
3 Modules for decisions, communication, and negotiation
The reasoning about the kind of services which can be provided or requested
Reasoning about the concrete instances of services which can be provided/requested
Agents' architecture

Social Interaction

Drive the communication

Information seeking dialogue

<table>
<thead>
<tr>
<th>$M_k$</th>
<th>$S_k$</th>
<th>$H_k$</th>
<th>$A_k$</th>
<th>$R_k$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$M_0$</td>
<td>Al</td>
<td>Bob</td>
<td>question($\theta, S_b(x), [\text{price}_b(x, p)]$)</td>
<td>$\theta$</td>
</tr>
<tr>
<td>$M_1$</td>
<td>Bob</td>
<td>Al</td>
<td>assert($\theta, S_b(c), [\text{price}_b(c, pc), \text{low} \leq pc \leq \text{medium}]$)</td>
<td>$M_0$</td>
</tr>
<tr>
<td>$M_2$</td>
<td>Bob</td>
<td>Al</td>
<td>assert($\theta, S_b(e), [\text{price}_b(e, pe), \text{low} \leq pe \leq \text{medium}]$)</td>
<td>$M_0$</td>
</tr>
<tr>
<td>$M_3$</td>
<td>Bob</td>
<td>Al</td>
<td>assert($\theta, S_b(d), [\text{price}_b(d, pd), \text{medium} \leq pd \leq \text{high}]$)</td>
<td>$M_0$</td>
</tr>
<tr>
<td>$M_4$</td>
<td>Bob</td>
<td>Al</td>
<td>assert($\theta, S_b(f), [\text{price}_b(f, pf), \text{medium} \leq pf \leq \text{high}]$)</td>
<td>$M_0$</td>
</tr>
</tbody>
</table>

Negotiation dialogue

<table>
<thead>
<tr>
<th>$M_k$</th>
<th>$S_k$</th>
<th>$H_k$</th>
<th>$A_k$</th>
<th>$R_k$</th>
</tr>
</thead>
<tbody>
<tr>
<td>$M_0$</td>
<td>Al</td>
<td>Bob</td>
<td>question(good_deal, $S_b(x), \emptyset$)</td>
<td>$\theta$</td>
</tr>
<tr>
<td>$M_1$</td>
<td>Bob</td>
<td>Al</td>
<td>assert(good_deal, $S_b(d), \emptyset$)</td>
<td>$M_0$</td>
</tr>
<tr>
<td>$M_2$</td>
<td>Al</td>
<td>Bob</td>
<td>assert(good_deal, $S_b(c), \emptyset$)</td>
<td>$M_1$</td>
</tr>
<tr>
<td>$M_3$</td>
<td>Bob</td>
<td>Al</td>
<td>why(good_deal, $S_b(c), \emptyset$)</td>
<td>$M_2$</td>
</tr>
<tr>
<td>$M_4$</td>
<td>Al</td>
<td>Bob</td>
<td>assert(cost$_A_1, S_b(c), \emptyset$)</td>
<td>$M_3$</td>
</tr>
<tr>
<td>$M_5$</td>
<td>Bob</td>
<td>Al</td>
<td>assert(good_deal, $S_b(e), \emptyset$)</td>
<td>$M_1$</td>
</tr>
<tr>
<td>$M_6$</td>
<td>Al</td>
<td>Bob</td>
<td>accept(good_deal, $S_b(e), \emptyset$)</td>
<td>$M_5$</td>
</tr>
</tbody>
</table>
Negotiation protocol for the requester

Corresponding pseudo-code representation:

IF receive assert(G,D,K) from interlocutor
THEN
    update commit(interlocutor,D);
    IF SDMM.evaluate(G,D,K) THEN
        send accept(G,D,K) to interlocutor;
        commit(me,D);
    ELSE IF SDMM.evaluate(G,D2,K) & D2!=D & D2=new() THEN
        send assert(G,D2,K) to interlocutor;
        commit(me,D2);
    ELSEIF send why(G,D,K) to interlocutor;
implementation of the SIM: LCC [Robertson ICLP 04]

Lightweight Coordination Calculus includes:
- a bootstrap mechanism that initiates the protocol/role/participants;
- preconditions mechanism to prompt the SDMM;
- post condition mechanism to update the commitments.

\[\begin{align*}
\text{a(requestor}(g_0, c, K), &ag_1) := \\
\text{question}(g_0, c, K) \Rightarrow \text{a(provider}(g_0, c, K), &ag_2) \text{ then } \\
\text{commit}(ag_2, [g_0, c_1, K_1]) &\leftarrow (\text{assert}(g_0, c_1, K_1) \leftarrow \text{a(provider}(g_0, c, K), &ag_2)) \text{ then } \\
\text{a(evaluator}(g_0, g_0, c_1, K_1), &ag_2) .
\end{align*}\]

\[\begin{align*}
\text{a(provider}(g_0, c, K), &ag_2) := \\
\text{question}(g_0, c, K) \leftarrow \text{a(requestor}(g_0, c, K), &ag_1) \text{ then } \\
(\text{assert}(g_0, c_1, K_1) \Rightarrow \text{a(requestor}(g_0, c, K), &ag_1)) \leftarrow \\
(\text{evaluate_contract}(g_0, c_1, K_1)) \text{ and } \\
\text{commit}(ag_2, [g_0, c_1, K_1]) \text{ then } \\
\text{a(proponent}(g_0, g_0, c_1, K_1), &ag_2) .
\end{align*}\]
Case study

Acceptability space of participants

After $M_3$

At the end

price$_b$

$S_b(d)$ × $S_b(c)$

warranty$_b$

$S_b(d)$ × $S_b(e)$

Al

Bob

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GOLEM Platform [Bromuri and Stathis EEMMAS’07]
**Take away**

- A modular approach of the agent with Knowledge, Goals, Decisions, and Priorities:
  - IDMM, agent reasoning about how to achieve its individual goals;
  - SDMM, social reasoning based on collaboration;
  - SIM, conformance to social norms of the agent society.

- In the ARGUGRID project:
  - IDMM *via* MARGO;
  - SDMM *via* MARGO;
  - SIM *via* LCC.

- The MAS platform GOLEM.

- An industrial “real-world” scenario.
References

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Demokritos, April 2008.