

Agenda

Agents — who communicates?

FIPA standards — how do they communicate?

Knowledgebase — What is the content of a message?

Problem — Why not use FIPA SL as a content language?

Using *OWL DL* as FIPA ACL content language

Example — scenario

OWL DL as a FIPA ACL content language

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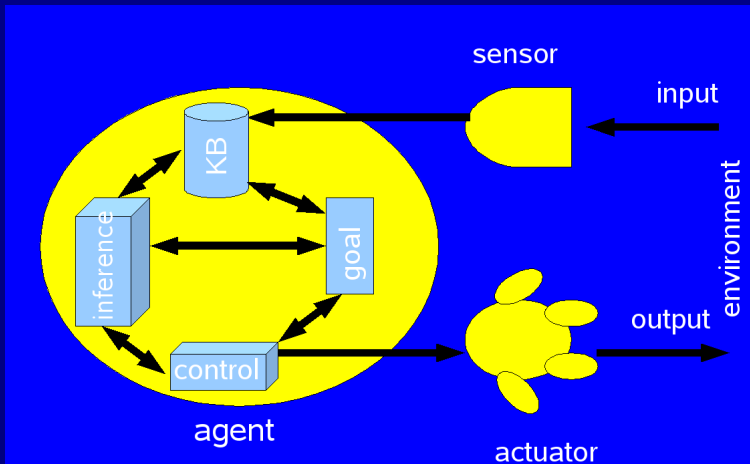
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Example — scenario

Knowledge-based agents



Knowledge-based agents II

- Sensor \Rightarrow “ear“
- Actuator \Rightarrow “mouth“
- Autonomous, rational, goal-oriented
- Knowledgebase (KB) \Rightarrow based on ontologies
- Inference engine \Rightarrow reasoner e.g. RACER
- Keep control algorithm simple
- Environment \Rightarrow Multi-Agent System (MAS)
- Specific domain given by the MAS (application)
- FIPA standard compliant (mainly)

FIPA standards

- FIPA: Foundation for Intelligent Physical Agents
- ACL: Agent Communication Language
- Standards for the ontology based communication:
 - ① FIPA message structure specification [3]
 - ② FIPA Ontology Service specification [2], which models ontology based communication in general
 - ③ FIPA SL Content Language Specification [5], which proposes a language for the content field of a message
 - ④ FIPA Communicative Act Library Specification [4] and its substandards, which define the speech act details (i.e. performatives)

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Example — scenario

A first example of a FIPA speech act (JADE)

The screenshot shows a dialog box titled "ACL Message" with two tabs: "ACLMessage" and "Envelope". The "ACLMessage" tab is active. The fields are as follows:

- Sender:** View button, followed by the text "_3199@robothron:1106/JADE".
- Receivers:** A text field containing "coordination@robothron:1106/JADE" with navigation arrows.
- Reply-to:** An empty text field.
- Communicative act:** A dropdown menu with "inform" selected.
- Content:** A text area containing the FIPA-SDL code:

```
((do (Order :has_OrderType (ProductionOrder) :ID "3199"
```
- Language:** A text field containing "fipa-sld".
- Encoding:** An empty text field.
- Ontology:** A text field containing "AttAgent".
- Protocol:** A dropdown menu with "Null" selected.
- Conversation-id:** A text field containing "coordination118671405484_1".
- In-reply-to:** An empty text field.
- Reply-with:** An empty text field.
- Reply-by:** A View button.
- User Properties:** An empty text field.

At the bottom of the dialog is an "OK" button.

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Example — scenario

Knowledgebase

- Each agent manages its own KB
- Based on formal domain ontology
- *OWL DL (SHOIN(D))*
- *T – Box* contains concepts, roles, . . .
- *A – Box* holds instances (individuals)
- Example KB:
 - Concept: „Bratwurstpizza“
 - Instance: **The** Bratwurstpizza, which I have on my plate.

Problems with FIPA specifications

- FIPA Communicative Act Library Specification [4] defines not only the speech act itself, it additionally models the content, e.g.:
 - A „Request“ speech act has an action in the content field.
 - A „Request-when“ ’ s content field holds another speech act .
- ⇒ The expressivity of such content fields easily reaches FOL (plus modal operators)
- This is a problem if an agent wants to do reasoning about such a message

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Problems with FIPA specifications II

- FIPA SL content language in general undecidable
- SL profiles are difficult to use for domain experts (domain experts vs. experts in logic)
- SL content in general not interoperable with semantic web
- Separation of the semantic of the content field difficult
⇒ Our idea is to:
- Use *OWL DL* as FIPA ACL content language

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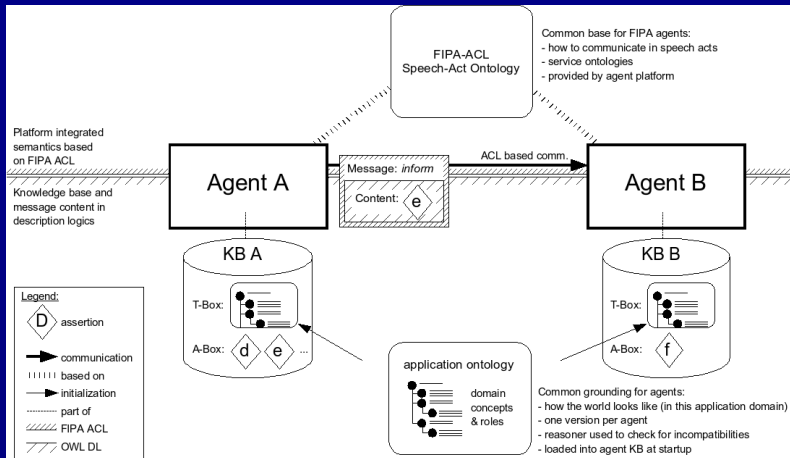
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FIPA inform message with *OWL DL* in the content field



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Complete Knowledgebase in *OWL DL*

- Two separate ontologies:
 - a) Ontology for the speech act semantic
 - b) Content ontology in *OWL DL*
- Only a few speech acts from the original specification usable
- *T – Boxes* are equal
- RACER to reason about the content semantics
- Specifications like *OWL QL* [1] are not yet accepted
⇒ Own query format (pattern based) which is restricted to *A – Box* queries

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Example — scenario

Scenario (example)

- Two KB agents communicate
- A ChefAgent (CA) that has pizzas in his *A – Box* which are deliverable
- A WaiterAgent (WA) queries types of deliverable pizzas from the CA.
- WA sends **Query-Ref**
- CA replies with **Inform**

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Example — scenario

Query-Ref speech act: FIPA conform part

```
(QUERY-REF
```

```
:sender ( agent-identifier
  :name WaiterAgent@ex.com
  :addresses (sequence http://ex.com:7780/jade))
:receiver (set (agent-identifier
  :name ChefAgent@ex.com
  :addresses (sequence http://ex.com:7781/jade)))
:content " next slide "
:language OWL-DL
:ontology http://ex.com/WaiterAgent/kb
:conversation-id WaiterAgent@ex.com12345678)
```

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Query-Ref speech act: content field

```
:content "<rdf:RDF
  xml:base=\" http://ex.com/WaiterAgent/msg1234\"
  xmlns:rdf=\" http://w3.org/1999/02/22-rdf-ns#\"
  xmlns:owl=\" http://w3.org/2002/07/owl#\" >
<owl:ontology
  rdf:about=\" http://ex.com/WaiterAgent/msg1234\"
  owl:imports=\" http://ex.com/WaiterAgent/kb\"/>
<owl:Class rdf:about=\"#AnswerSet\">
  <owl:equivalentClass>
    <owl:intersectionOf rdf:parseType=\"Collection\">
      <owl:Class
        rdf:about=\" http://co-ode.org/ontologies/
        pizza/pizza_041007.owl#Pizza\"/>
```

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Query-Ref speech act: content field II

```
<owl:Restriction >
  <owl:onProperty
    rdf:resource = \" http://co-ode.org/ontologies/
      pizza/pizza_041007.owl#hasCountryOfOrigin\" / >
  <owl:hasValue
    rdf:resource = \" http://co-ode.org/ontologies/
      pizza/pizza_041007.owl#Germany\" / >
  </owl:Restriction >
</owl:intersectionOf >
</owl:equivalentClass >
</owl:Class >
</rdf:RDF >"
```

Inform speech act: message structure

(INFORM

:sender (agent-identifier

:name ChefAgent@ex.com

:addresses (sequence http://ex.com:7781/jade))

:receiver (set (agent-identifier

:name WaiterAgent@ex.com

:addresses (sequence http://ex.com:7780/jade)))

:content " next slide "

:language OWL-DL

:ontology http://ex.com/ChefAgent/kb

:conversation-id WaiterAgent@ex.com123456789)

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Inform speech act: content field

```
: content "<rdf:RDF
xml:base=\" http://ex.com/ChefAgent/msg5678\"
xmlns:rdf=\" http://w3.org/1999/02/22-rdf-ns#\"
xmlns:owl=\" http://w3.org/2002/07/owl#\">
xmlns:wcoop=\" http://co-ode.org/ontologies/pizza/
  pizza_041007.owl#\">
<owl:ontology
  rdf:about=\" http://ex.com/ChefAgent/msg5678\"
  owl:imports=\" http://ex.com/ChefAgent/kb\"
  owl:imports=\" http://ex.com/WaiterAgent/msg1234\"/>
```

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Inform speech act: content field II

```
<wcoopp:MeatyPizza
  rdf:about=\" http://ex.com/ChefAgent/
    kb#bratwurstpizza3456\" >
  <rdf:type rdf:resource=\" http://ex.com/
    WaiterAgent/msg1234#AnswerSet\" / >
<wcoopp:hasTopping>
  <wcoopp:MeatTopping
    rdf:about=\" ex.com/ChefAgent/kb#bratwursttopping456\"
  </wcoopp:MeatTopping>
</wcoopp:hasTopping>
<wcoopp:hasBase
  rdf:resource=\" ex.com/ChefAgent/kb#base5678\" / >
```

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Example — scenario

Inform speech act: content field III

```
<wcoop:hasCountryOfOrigin  
  rdf:resource=\" http://co-ode.org/  
  ontologies/pizza/pizza_041007.owl#Germany\" / >  
</wcoop:MeatyPizza>  
</rdf:RDF>
```

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Discussion and open issues

- We introduced a proposal to easily combine FIPA ACL compliant speech acts with *OWL DL* as a content language
- Open issues:
- Conversion of all FIPA ACL speech acts in *OWL DL* (possibly by reformulation with other speech acts)
- Semantic Dialogue management with these reasonable speech acts
- Query language for *OWL DL*

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Example — scenario

Thank you,

- for the attention!
- Questions?

Literature I

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Technical Report KSL 03-14, Stanford University, Stanford,
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Literature II

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