

CHAPTER 8: AGENT COMMUNICATION

An Introduction to Multiagent Systems

<http://www.csc.liv.ac.uk/~mjw/pubs/imas/>

1 Agent Communication

- In this lecture, we cover *macro-aspects* of intelligent agent technology: those issues relating to the agent *society*, rather than the individual:
 - *communication* :
speech acts; KQML & KIF; FIPA ACL.
 - *cooperation*:
what is cooperation; prisoner's dilemma; cooperative *versus* non-cooperative encounters; the contract net.

2 Speech Acts

- Most treatments of communication in (multi-)agent systems borrow their inspiration from *speech act theory*.
- Speech act theories are *pragmatic* theories of language, i.e., theories of language *use*: they attempt to account for how language is used by people every day to achieve their goals and intentions.
- The origin of speech act theories are usually traced to Austin's 1962 book, *How to Do Things with Words*.

- Austin noticed that some utterances are rather like ‘physical actions’ that appear to *change the state of the world*.
- Paradigm examples would be:
 - declaring war;
 - christening;
 - ‘I now pronounce you man and wife’ :-)
- But more generally, *everything* we utter is uttered with the intention of satisfying some goal or intention.
- A theory of how utterances are used to achieve intentions is a speech act theory.

- Searle (1969) identified various different types of speech act:
 - *representatives*:
such as *informing*, e.g., ‘It is raining’
 - *directives*:
attempts to get the hearer to do something e.g., ‘please make the tea’
 - *commissives*:
which commit the speaker to doing something, e.g., ‘I promise to...’
 - *expressives*:
whereby a speaker expresses a mental state, e.g., ‘thank you!’
 - *declarations*:
such as declaring war or christening.

- There is some debate about whether this (or any!) typology of speech acts is appropriate.
- In general, a speech act can be seen to have two components:
 - a *performative verb*:
(e.g., request, inform, . . .)
 - *propositional content*:
(e.g., “the door is closed”)

- Consider:
 - performative = request
content = “the door is closed”
speech act = “please close the door”
 - performative = inform
content = “the door is closed”
speech act = “the door is closed!”
 - performative = inquire
content = “the door is closed”
speech act = “is the door closed?”

3 Plan Based Semantics

- How does one define the semantics of speech acts? When can one say someone has uttered, e.g., a request or an inform?
- Cohen & Perrault (1979) defined semantics of speech acts using the *precondition-delete-add* list formalism of planning research.
- Note that a speaker cannot (generally) *force* a hearer to accept some desired mental state.

- Here is their semantics for *request*:

$request(s, h, \phi)$

pre:

- s believes h can do ϕ
(you don't ask someone to do something unless you think they can do it)
- s believe h believe h can do ϕ
(you don't ask someone unless *they* believe they can do it)
- s believe s want ϕ
(you don't ask someone unless you want it!)

post:

- h believe s believe s want ϕ
(the effect is to make them aware of your desire)

4 KQML and KIF

- We now consider *agent communication languages* (ACLs) — standard formats for the exchange of messages.
- The best known ACL is KQML, developed by the ARPA knowledge sharing initiative.
KQML is comprised of two parts:
 - the knowledge query and manipulation language (KQML); and
 - the knowledge interchange format (KIF).

- KQML is an ‘outer’ language, that defines various acceptable ‘communicative verbs’, or *performatives*.

Example performatives:

- ask-if (‘is it true that...’)
 - perform (‘please perform the following action...’)
 - tell (‘it is true that...’)
 - reply (‘the answer is ...’)
- KIF is a language for expressing message *content*.

- In order to be able to communicate, agents must have agreed a common set of terms.
- A formal specification of a set of terms is known as a *ontology*.
- The knowledge sharing effort has associated with it a large effort at defining common ontologies — software tools like `ontolingua` for this purpose.

Example KQML/KIF dialogue (A)

```
A to B:  (ask-if
          (> (size chip1) (size chip2)))
B to A:  (reply true)
B to A:  (tell (= (size chip1) 20))
B to A:  (tell (= (size chip2) 18))
```

Example KQML/KIF dialogue (B)

```
(stream-about
  :sender      A
  :receiver    B
  :language    KIF
  :ontology    motors
  :reply-with  q1
  :content     m1
)
```

```
(tell
  :sender      B
  :receiver    A
  :in-reply-to q1
  :content
    (= (torque m1) (scalar 12 kgf))
)
```

Example KQML/KIF dialogue (B continued)

```
(tell
  :sender      B
  :receiver    A
  :in-reply-to q1
  :content
    (= (status m1) normal)
)
```

```
(eos
  :sender      B
  :receiver    A
  :in-reply-to q1
)
```

FIPA

- More recently, the Foundation for Intelligent Physical Agents (FIPA) started work on a program of agent standards — the centrepiece is an ACL.
- Basic structure is quite similar to KQML:
 - *performative*;
20 performative in FIPA.
 - *housekeeping*;
e.g., sender etc.
 - *content*
the actual content of the message.

- Example

```
(inform
  :sender      agent1
  :receiver    agent5
  :content     (price good200 150)
  :language    sl
  :ontology    hpl-auction
)
```

| performative | passing info | requesting info | negotiation | performing actions | error handling |
|------------------|-----------------|--------------------|-------------|-----------------------|-------------------|
| accept-proposal | | | x | | |
| agree | | | | x | |
| cancel | | x | | x | |
| cfp | | | x | | |
| confirm | x | | | | |
| disconfirm | x | | | | |
| failure | | | | | x |
| inform | x | | | | |
| inform-if | x | | | | |
| inform-ref | x | | | | |
| not-understood | | | | | x |
| propose | | | x | | |
| query-if | | x | | | |
| query-ref | | x | | | |
| refuse | | | | x | |
| reject-proposal | | | x | | |
| request | | | | x | |
| request-when | | | | x | |
| request-whenever | | | | x | |
| subscribe | | x | | | |

5 “Inform” and “Request”

- “Inform” and “Request” are the two basic performatives in FIPA. All others are *macro* definitions, defined in terms of these.
- The meaning of inform and request is defined in two parts:
 - pre-condition
what must be true in order for the speech act to succeed.
 - “rational effect”
what the sender of the message hopes to bring about.

- For the “inform” performative...

The content is a *statement*.

Pre-condition is that sender:

- holds that the content is true;
- intends that the recipient believe the content;
- does not already believe that the recipient is aware of whether content is true or not.

- For the “request” performative. . .

The content is an *action*.

Pre-condition is that sender:

- intends action content to be performed;
- believes recipient is capable of performing this action;
- does not believe that sender already intends to perform action.