LECTURE 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'
  - *commisives*:
    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 to B:  (ask-if
           (> (size chip1) (size chip2)))
B to A:  (reply true)
B to A:  (inform (= (size chip1) 20))
B to A:  (inform (= (size chip2) 18))
```

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.