CHAPTER 7: COMMUNICATING

An Introduction to Multiagent Systems

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

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.

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*.

Speech Acts: Austin

- Austin noticed that some utterances are rather like 'physical actions' that appear to *change the state of the world*.
- Paradigm example – declaring war.
- 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.

Speech Acts: Searle

- 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”)

- 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?”

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.

Plan-based Semantics for Request

$request(s, h, \phi)$

pre:

- s believes h can do ϕ
- s believe h believe h can do ϕ
- s believe s want ϕ

post:

- h believe s believe s want ϕ

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*.

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			

"Inform" and "Request"

- "Inform" and "Request" are the two basic performatives in FIPA. 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.

FIPA “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.

FIPA “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.