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.