

# LECTURE 11: AGENT COMMUNICATION

An Introduction to Multiagent Systems

CIS 716.5, Spring 2006

## 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*.

- 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;
  - naming a child;
  - ‘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 naming.

- 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?”

## 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  $\phi$   
(you don't ask someone to do something unless you think they can do it)
- $s$  believe  $h$  believe  $h$  can do  $\phi$   
(you don't ask someone unless *they* believe they can do it)
- $s$  believe  $s$  want  $\phi$   
(you don't ask someone unless you want it!)

post:

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

## 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			

## “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.

- Other performatives are:
  - `propose`  
One agent makes a proposal to another.
  - `accept-proposal`  
One agent states that it accepts a proposal made by another agent.
  - `reject-propose`  
One agent rejects a proposal previously made by another agent.
- The syntax of these is similar to that of `inform`.

## Alternative semantics

- There is a problem with the “mental state” semantics that have been proposed for the FIPA ACL.
- (This also holds for KQML).
- How do we know if an agent’s locutions conform to the specification?
- As Wooldridge pointed out, since the semantics are in terms of an agent’s internal state, we cannot *verify* compliance with the semantics laid down by FIPA.
- In practice, this means that we cannot be sure that a agent is being sincere.
- (Or, more importantly, we cannot detect if it is being insincere).

- Singh suggested a way around this.
- Rather than define the conditions on a locution in terms of an agent's mental state, base it on something external to the agent.
- Move from a “mentalistic” semantics to a *social* semantics.
- How?
- Take an agent's utterances as *commitments*.
- But what does it mean to say that “if an agent utters an `inform` then it is committing to the truth of the proposition that is the subject of the utterance”?
- Argumentation provides a solution.

## Contestability semantics

- If an agent asserts that a proposition is true, then it is committing to *defend* that proposition.
- Any asserted proposition can be contested, and the assertor will have to provide an argument that supports it.
- If every agent only asserts propositions for which it has an IN argument, and every agent only accepts propositions for which it is given an IN argument, then communication is *rational*.
- Agents can lie, but only if they have good reasons to support the untruths they tell.
- If agents lie, they run the risk of being caught out (because they have to justify what they say).

## Summary

- This lecture has discussed some aspects of communication between agents.
- It has focussed on the interpretation of locutions/performatives as speech acts, and some suggestions for what performatives one might use.
- There is much more to communication than this. . .
- . . . but this kind of thing is required as a “transport layer” to support the kinds of thing we talked about earlier.