LECTURE 11: AGENT COMMUNICATION

An Introduction to Multiagent Systems

CIS 716.5, Spring 2005

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;
  - 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?"

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)

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
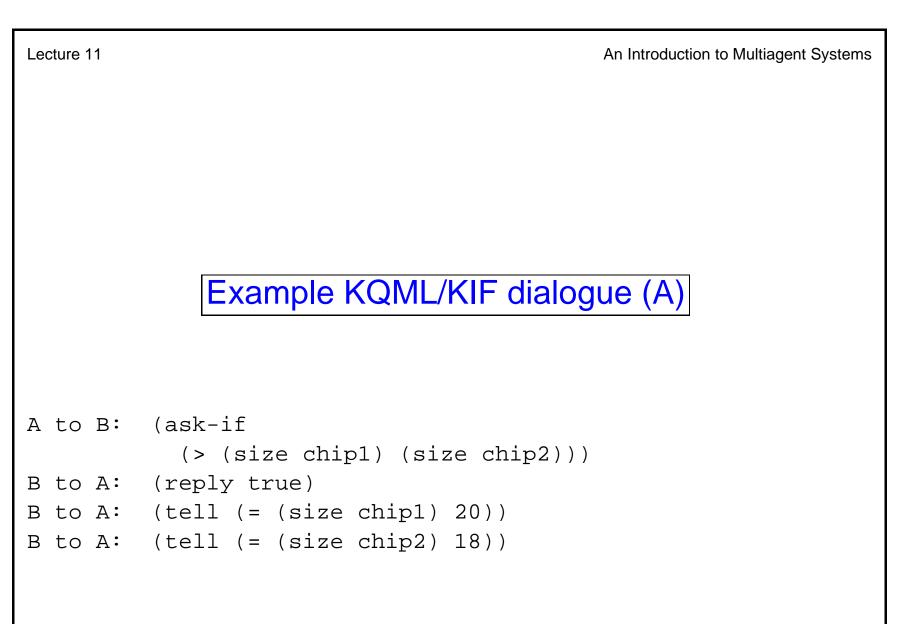 - the knowledge interchange format (KIF).

• 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 *verfiy* 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 ever 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 that this. . .

- . . . but this kind of thing is required as a "transport layer" to support the kinds of thing we talked about earlier.