

4: Agent Communication

AI6125: Multi-Agent System

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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 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

Different Aspects of Speech Acts

- From “A Dictionary of Philosophical Terms and Names”:
- “*Locutionary act*: the simple speech act of generating sounds that are linked together by grammatical conventions so as to say something meaningful. Among speakers of English, for example, ‘It is raining’ performs the locutionary act of saying that it is raining, as ‘Grablistrod zetagflx dapu’ would not.”

Different Aspects of Speech Acts

- “*Illocutionary act*: the speech act of doing something else – offering advice or taking a vow, for example – in the process of uttering meaningful language. Thus, for example, in saying ‘I will repay you this money next week,’ one typically performs the illocutionary act of making a promise.”

Different Aspects of Speech Acts

- “*Perlocutionary act*: the speech act of having an effect on those who hear a meaningful utterance. By telling a ghost story late at night, for example, one may accomplish the cruel perlocutionary act of frightening a child.”

Speech Acts

- 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 christening

Speech Acts

- 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, promise, ...)
 - *propositional content*:
(e.g., “the door is closed”)

Speech Acts

■ 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
- In other words, there is a separation between the *illocutionary act* and the *perlocutionary act*

Plan-Based Semantics

- Here is their semantics for *request*:

$request(s, h, \phi)$

pre:

- s believe 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)
 - the knowledge interchange format (KIF)

KQML and 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*

KIF – Knowledge Interchange Format

Used to state:

- Properties of things in a domain (e.g., “Noam is chairman”)
- Relationships between things in a domain (e.g., “Amnon is Yael’s boss”)
- General properties of a domain (e.g., “All students are registered for at least one course”)

KIF – Knowledge Interchange Format

- “The temperature of m1 is 83 Celsius”:
`(= (temperature m1) (scalar 83 Celsius))`
- “An object is a bachelor if the object is a man and is not married”:
`(defrelation bachelor (?x) :=
 (and (man ?x) (not (married ?x))))`
- “Any individual with the property of being a person also has the property of being a mammal”:
`(defrelation person (?x) :=> (mammal ?x))`

KQML and KIF

- In order to be able to communicate, agents must have agreed on a common set of terms
- A formal specification of a set of terms is known as an *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 centerpiece 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

FIPA

■ Example:

```
(inform  
  :sender      agent1  
  :receiver    agent5  
  :content     (price good200 150)  
  :language    sl  
  :ontology    hpl-auction  
)
```

FIPA

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

“Inform” and “Request”

- 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

“Inform” and “Request”

- 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 receiver already intends to perform action