

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.

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CHAPTER 7: COMMUNICATING

An Introduction to Multiagent Systems

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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*.

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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.

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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'
 - *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.

- 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))
)
```

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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
)
```

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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.

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• Example

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

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performative	passing info	requesting info	negotiation	performing actions	error handling
accept-proposal			x		
agree		x		x	
cancel				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				

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“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.

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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.

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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.

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