

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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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’
 - **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.

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- 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”)

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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.

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Plan-based Semantics for Request

- We now consider **agent communication languages** (ACLs) — standard formats for the exchange of messages.
- The best known ACL is KQML, developed by the ARP&A knowledge sharing initiative.
- KQML is comprised of two parts:
 - the knowledge query and manipulation language (KQML); and
 - the knowledge interchange format (KIF).

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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**.

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- KQML is an ‘outer’ language, that defines various acceptable ‘communicative verbs’, or **performatives**.
- Example performatives:

Example KQML/KIF dialogue (A)

- 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**.

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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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- 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:

Example

```
(inform
  :sender agent1
  :receiver agent5
  :content
  :language s1
  :ontology hpl-auction
)
```

the actual content of the message.

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performative	passing info	requesting info	negotiation	performing actions	error handling
accept-proposal			x	x	
agree	x	x	x	x	
cancel			x		
cfp	x	x			
confirm	x				
disconfirm					
failure				x	
inform	x				
inform-if	x				
inform-ref	x				
not-understood	x		x		x
propose					
query-if	x		x		
query-ref	x		x		
refuse			x		
reject-proposal		x	x	x	
request					
request-when			x		
request-whenever		x	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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