

**Intelligent Autonomous Agents**  
**ICS 606 / EE606**  
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**Lecture #7 – Communicating**

- Agent Communication
- Speech Acts
- KQML
- FIPA agent communication language
- References
  - Wooldridge, Ch. 6
  - Weiss, Ch. 2
  - N & R, Ch. 23, 10 & 11

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**What/Why do Agents Need to Communicate?**

- Propose a course of action
- Accept a course of action
- Reject a course of action
- Retract a course of action
- Disagree with a proposed course of action
- Counter propose a course of action

**Communication**

Goals:

- Analyze
- Describe
- Design

environments in which agents can operate effectively and interact with each other productively

**Environment-Agent Characteristics (review)**

Property	Definition
Knowable	How much of the Environment is viewable
Predictable	Results predictable? Actions always work?
Controllable	Ability to modify its environment?
Historical	Future states depend on past ones, or only current state.
Teleological	Are other parts purposeful (other agents)?
Real-time	Can environment change while I'm deciding?

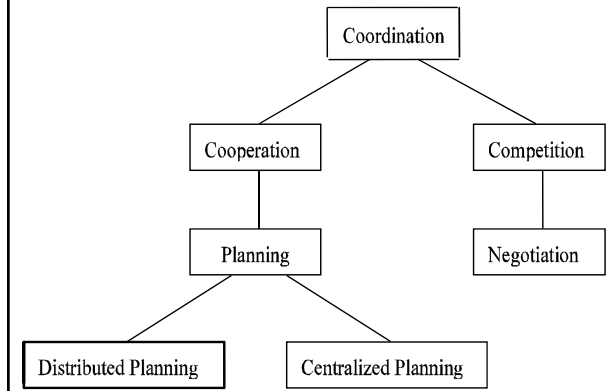
**Multi-Agent System Characteristics**

Property	Range of values
Design autonomy	Platform/language/architecture
Communication infrastructure	Shared, messages, broadcast, point-to-point, (a)synchronous
Directory services	White pages, yellow pages
Message Protocol	KQML, HTTP/HTML,..
Mediation services	Ontology-based? Transactions?
Security services	Timestamp/authentication
Remittance services	Billing/currency
Operations support	Archiving/redundancy/accounting

## Agent Communication

- **Macro-aspects** of intelligent agent technology:
- Issues relating to the agent **society**, rather than the individual:
- **Communication**
  - speech acts;
  - KQML & KIF;
  - FIPA agent communication language (ACL)
- **Cooperation**:
  - what is cooperation?
  - cooperative *versus* non-cooperative encounters
  - the contract net

## Taxonomy of Agent Communication



## Dimensions of Meaning in Agent Communication

- **Syntax** – how symbols are **structured** to form sentences [legal sentences]
- **Semantics** – what the symbols denote/mean [**meaning** of phrases]
- **Pragmatics** – how the symbols are **interpreted**

## Speech Acts

- Communication in (multi-) agent systems borrows from *speech act theory*
- Speech act theories are **pragmatic** theories of language, i.e., theories of *language use*: attempt to account for how language is used to achieve goals and intentions
- Origin of speech act theories traced to Austin's 1962 book, *How to Do Things with Words*

## Speech Acts: Austin

- Austin noticed that some utterances are rather like 'physical actions' - they appear to change the state of the world
- Paradigm examples would be:
  - declaring war
  - christening
  - 'I now pronounce you husband and wife'
- More generally, **everything is uttered to try to satisfy some goal or intention**
- A speech act theory - a theory of **how utterances are used to achieve intentions**

## Speech Acts: Searle

1969 book identified several types of speech acts

- **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”)

## Examples

- 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 someone has uttered, e.g., a request or an inform?
- Cohen & Perrault (1979, “Elements of a plan based theory of speech acts” article) defined the semantics of speech acts using the *precondition-delete-add* lists formalism of planning research.
- Note that a speaker cannot (generally) *force* a hearer to accept some desired mental state

## Plan-based Semantics for Request

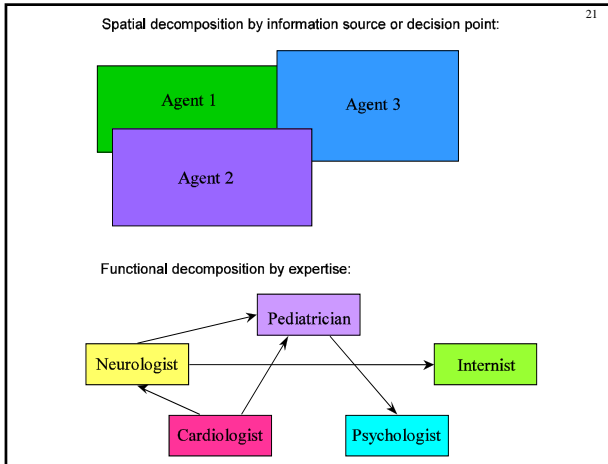
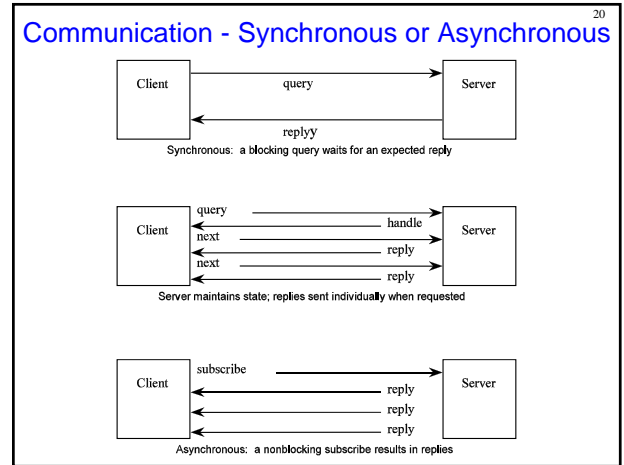
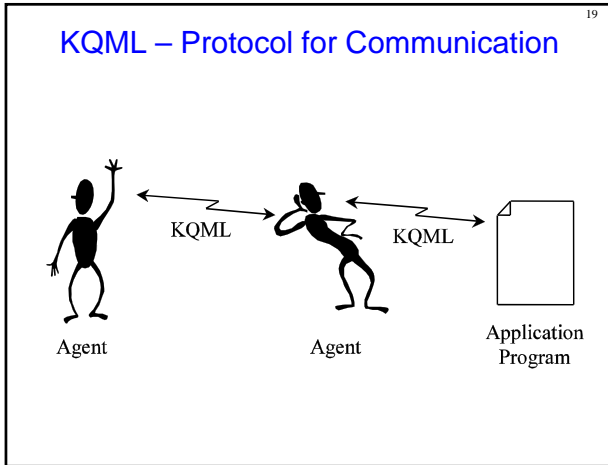
- $request(s; h; )$ 
    - $s$  = speaker
    - $h$  = listener
    - $\emptyset$  = statement
- pre:
- $s$  believes  $h$  can do  $\emptyset$
  - $s$  believe  $h$  believe  $h$  can do  $\emptyset$
  - $s$  believe  $s$  want  $\emptyset$
- post:
- $h$  believe  $s$  believe  $s$  want  $\emptyset$

## Agent Communication Languages (ACLs)

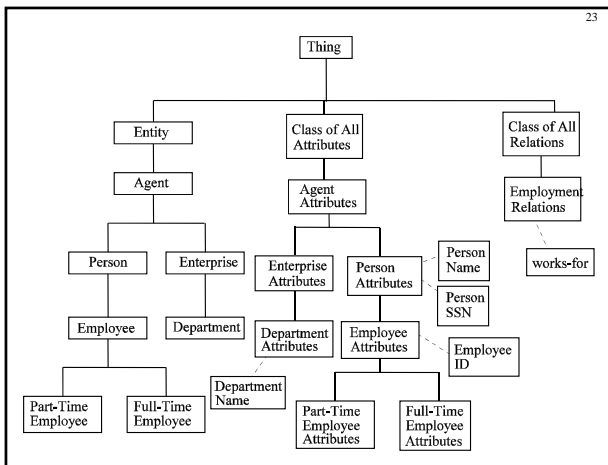
- Standard formats for the exchange of messages
- Best known is **knowledge query and manipulation language (KQML)**, developed by the ARPA knowledge sharing initiative
- KQML is comprised of two parts:
  - An outer language
  - knowledge interchange format (KIF) (internal content representation)

## KQML

- KQML is an ‘outer’ language
- Defines 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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- ### Ontologies
- To communicate, agents must agree on a **common set of terms**
  - A formal specification of a set of terms is known as an **ontology**
  - The knowledge sharing effort
    - Includes defining common ontologies
    - Created software tools like ontolingua for this purpose



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### Example KQML/KIF Dialogue (A)

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))

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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 cont)

```

(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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### Foundation for Intelligent Physical Agents

FIPA – started a program of agent standards, the centerpiece is an ACL

Now a standards group of IEEE

Basic structure is quite similar to KQML:

- *performative*
  - 20 performatives 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
)

```

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			

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### Inform and Request

“Inform” and “Request” are the two basic performatives in FIPA.

- All others are defined in terms of these
- The meaning of inform and request is defined in two parts:
  1. **pre-condition** what must be true in order for the speech act to succeed
  2. **“rational effect”** what the sender of the message hopes to bring about

### Inform Performative

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- 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

### Request Performative

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- 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
- Like the Precondition in planning  
Precondition/Add/Delete list

### Summary

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### Questions

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