UNIT 3: Agent Communications

Agent Communications

- ■ We now deal with macro-aspects of intelligent agent technology: those aspects related to the society of agents rather than to the individual agent.

- ■ communication; speech acts; KQML & KIF; FIPA ACLs

- ■ what is cooperation? the prisoner's dilemma, cooperative and non-cooperative encounters; the network of contracts

Computational Infrastructure

- Communication Protocols (PC): allow exchanging and understanding messages (infrastructure)
- Interaction Protocols (IP): establish conversations (structured exchanges of messages)
- How to create PC and PI?

Speech acts

- The main inspiration for the treatment of multiagent communication is based on the speech act theory
- Speech act theories are pragmatic theories, that is, theories of language usage: they try to determine how people use language to achieve their intentions and goals.
- The origin of speech record theories can be traced back to Austin's 1962 book How to Do Things with Words.

Speech acts

- JL Austin (1911-1960) noted that some pronunciations were like "physical actions" in that they seemed to imply a change in the state of the world.
- Paradigmatic examples could be:
  - Declare war
  - Christianity
  - I pronounce you husband and wife' :-)
- But generally, everything we utter is done with the intention of satisfying some goal or intention.
- Speech act theory is a theory of how utterances are used to achieve intentions.

Fundamental aspects of the Speech Act Theory

■ Act of locution: physical sounds of the speaker.

■ Act of illocution: meaning of the sound for the speaker.

■ Act of perlocution: the intended action as a consequence of the locution.

Speech Acts

Searle (1969) identified several different types of speech acts:

- **representative**: such as reporting, for example, 'it is raining'

- **directives**: attempts to get the listener to do something, e.g., 'heat my milk'

- **commissive**: that commit the speaker to do something, e.g., 'I promise you that... '

- **expressive**: by which the speaker expresses a state of mind, e.g., 'thank you!
'

- **declarative**: such as declaring a war or Christianity

Speech acts

- It is not clear whether reaching this level of detail in speech act theory is useful or simply convenient.
- However, in general, a speech act can be seen as consisting of two components:
  - a performative verb:
    (e.g., ask, inform, promise, …)
  - propositional content:
    (e.g., "the door is closed")

For example,
- performative = request
- content = "the door is closed"
- speech act = "please close the door"

- performative = informative
- content = "the door is closed"
- speech act = "the door is closed!"

- performative = question
- content = "the door is closed"
- speech act = "is the door closed?"

Based plans semantics

- How to define the semantics of speech acts? How can a receiver distinguish between a request and information?

- The sender cannot (generally) force the receiver to accept some desired state of mind.

- In other words, there is a separation between the acts of illocution and perlocution.

- Here is the semantics for request: request(s, h, φ)
  pre:
  s believes h can do φ (don't ask anyone to do a task you think they can't do)
  s believes h believes h can do φ (don't ask anyone to do a task if you think they don't think they can do it)
  s believes s wants φ (you don't ask anyone for something you don't want)
- post:
  h believe s believe s want φ (the effect is to make the listener "aware" of your desire)

KQML and KIF

- Consider agent communication languages (ACLs) — standard message exchange formats
- The best known ACL is KQML, developed at the ARPA Knowledge Sharing Initiative (KSE)
- KQML is made up of two parts:
  - ❏ The Knowledge Manipulation and Query Language (KQML)
  - ❏ The Knowledge Exchange Format (KIF)

- KQML is the 'output' language, the one that defines the various "verbs of communication" 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 the language to express the content of the message

KQML communication options
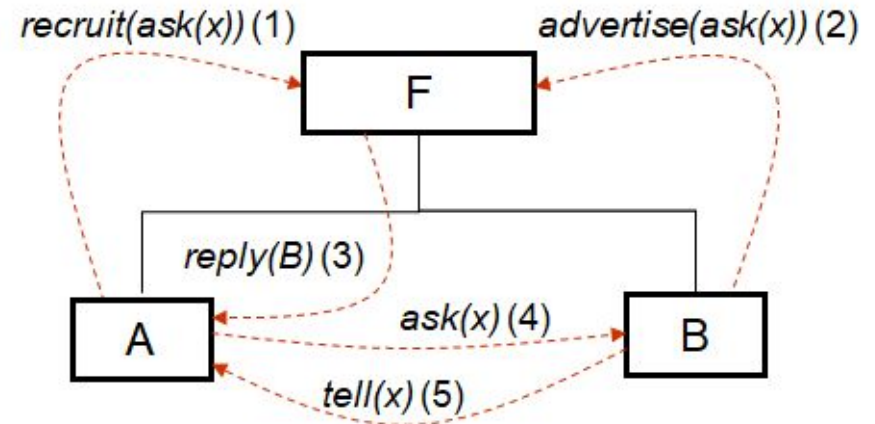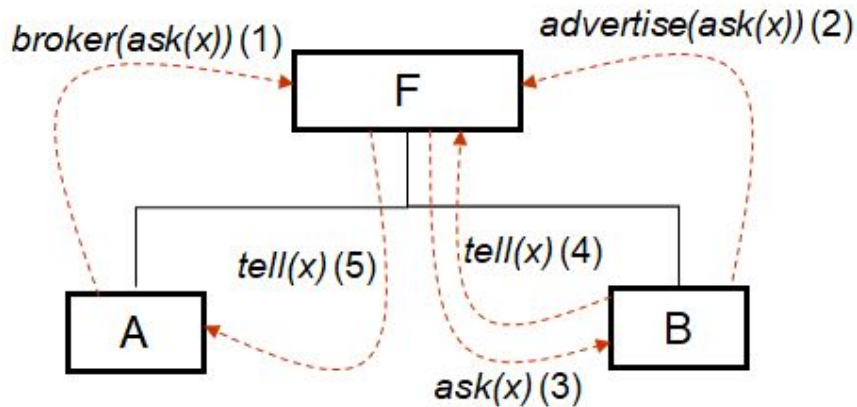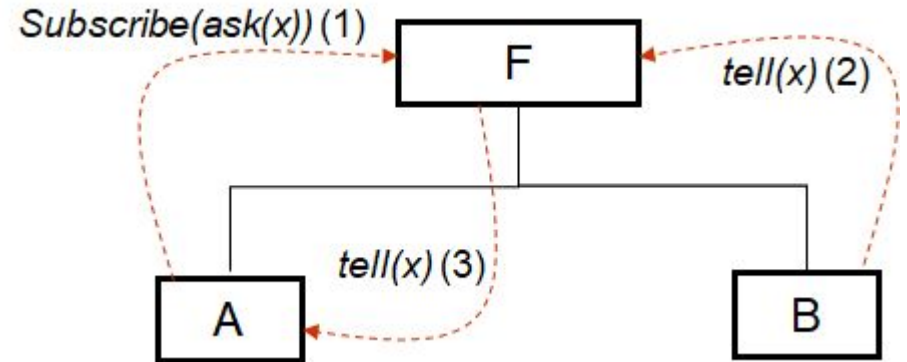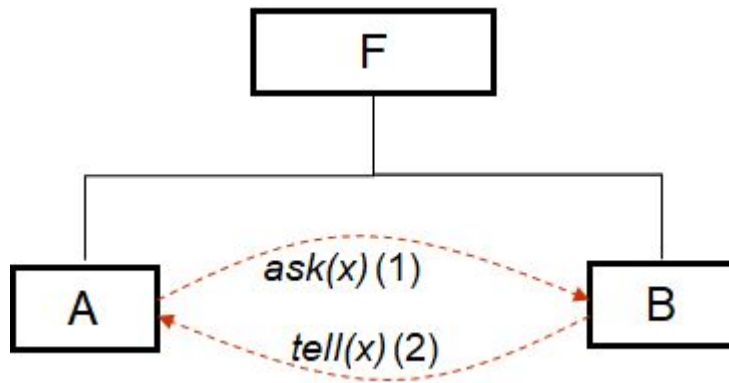
Mensajes KQML

Answer 1
info

(ask-one
    :content (price(ibm, Model, Cost))
    :receiver store
    :language Prolog
    :ontology InfSupplies)

(ask-all
    :content (price(ibm, Model, Cost))
    :receiver store
    :language Prolog
    :ontology InfSupplies)

Answer all
infos

Answer 1 by 1
sinc.

(stream-all
    :content (price(ibm, Model, Cost))
    :receiver store
    :language Prolog
    :ontology InfSupplies)

Answer 1 by 1
using
discard, *next*,
rest

(standby
    :content (stream-all
        :content (price(ibm, Model, Cost)))
    :receiver store
    :language Prolog
    :ontology InfSupplies)

KIF – Knowledge Interchange Format

- It is used to establish:

  - The properties of things in a domain (e.g., "Ana is a lady")

  - Relationships between things in a domain (e.g., "Maria is Ana's boss")

  - General properties of a domain (e.g., "All students are enrolled in at least one course")

- "The temperature of m1 is 83 Celsius":

    (= (temperature m1) (scale 83 Celsius))

- "An object is a bachelor if the object is male and 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

- Agents for the purpose of being able to communicate must agree on the set of terms available

- An ontology is the formal specification of that set of terms

- The KSE has invested a great deal of effort in defining such ontologies — software tools like ontolingua

- KQML/KIF dialog example

```
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))
```

KQML problems

- too many performative

- standalone implementation

- Transport mechanisms not defined

- Semantics defined in natural language

- Does not have commissives

FIPA

- More recently (1996), the Foundation for Intelligent Physical Agents (FIPA) started an agent standards program whose main component is an ACL

  - ❏ FIPA has been officially accepted by the IEEE at its 11th standards committee on June 8, 2005.
  - ❏ FIPA Mission: The promotion of technologies and interoperability specifications that facilitate interaction between intelligent agent systems in today's commercial and industrial environments.

- Main Specifications:
  - ❏ Agent Message Transport
  - ❏ agent-management
  - ❏ Agent Communication
  - ❏ Agent-based Applications
  - ❏ Abstract Architecture

FIPA specifications
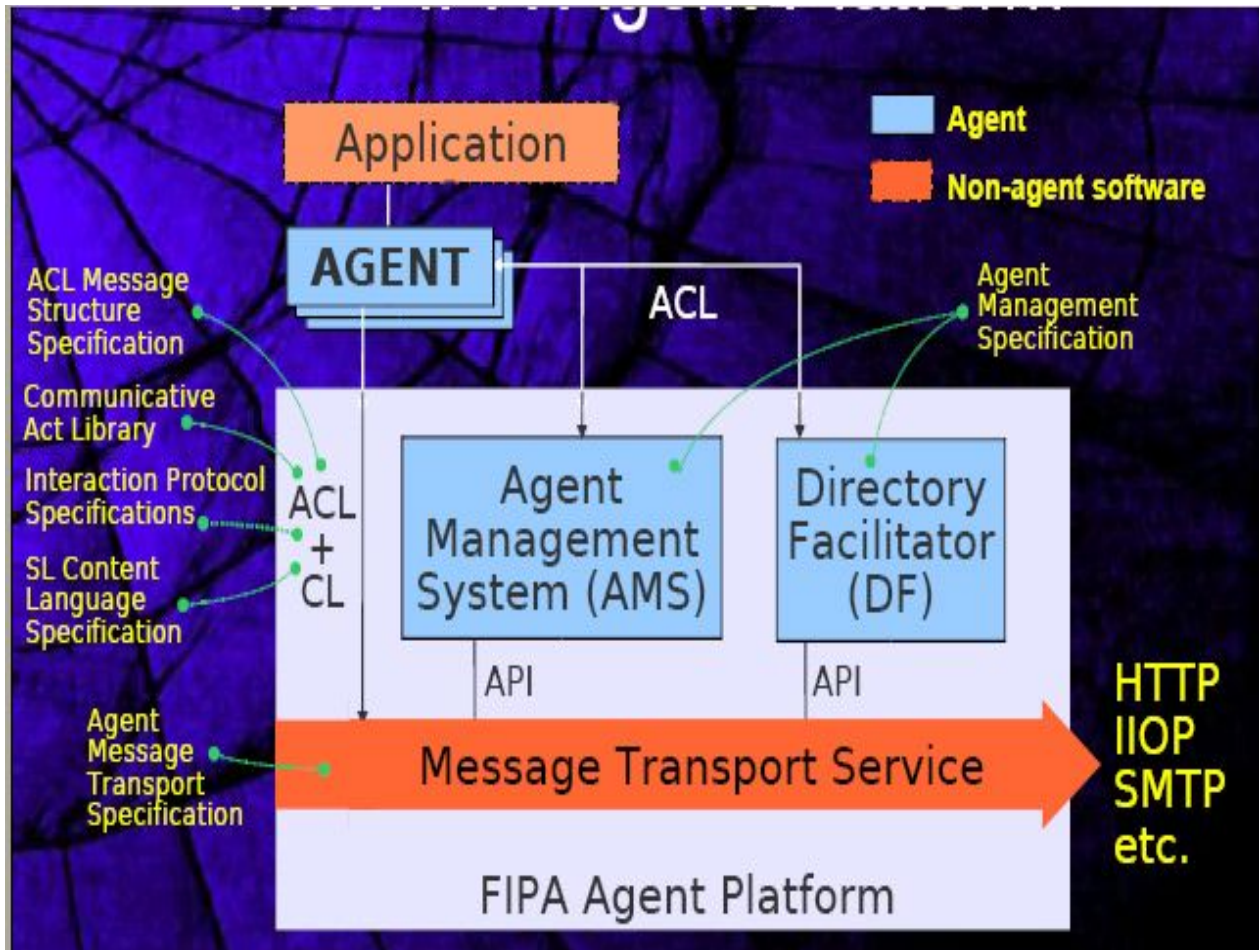
FIPA ACL

- FIPA Agent Communication Language (FIPA ACL)
  - ❑ FIPA-ACL is composed of:
    - FIPA Communicative Act Library (CAL)
    - FIPA Content Language Library (CLL)
    - FIPA Interaction Protocol Library (IPL)

Parameter	Category of Parameters
performative	Type of communicative acts
sender	Participant in communication
receiver	Participant in communication
reply-to	Participant in communication
content	Content of message
language	Description of Content
encoding	Description of Content
ontology	Description of Content
protocol	Control of conversation
conversation-id	Control of conversation
reply-with	Control of conversation
in-reply-to	Control of conversation
reply-by	Control of conversation

FIPA ACL

- The basic structure is quite similar to KQML:
- performative
        20 performatives at FIPA
- Sender data
        e.g., sender, etc.
- contents
        the actual content of the message
- ■
- Ejemplo:

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

Performative message type FIPA CAL

Protocolo FIPA IPL

Contenido

Lenguaje de Contenido FIPA CCL

Identificador Ontología

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 two basic performatives in FIPA. All the others are defined based on these. They are the primitives.*
- *The meaning of inform and request is defined in two parts:*
  - *pre-condition*
    which must be true for the speech act to work
  - *"rational effect"*
    what the sender of the message expects to be done

- For the informative performative…
- The content is a sentence.
- The Pre-condition is that the sender:
  - Keep the content true
  - Try to have the receiver create the content
  - Do not believe that the receiver has a formed idea about whether or not the content is true

"Inform" and "Request"

- For the performative request...
  Content is an action.
   The Pre-condition is that the sender:
    - Try to get the action done
    - Believe that the receiver is capable of performing this action
    - Don't think the receiver was already going to execute it anyway