University of Msila

FACULTY OF MATHEMATICS AND INFORMATICS

DEPARTMENT OF COMPUTER SCIENCE

Interaction and communication between agents

Introduction

- **Why do agents interact?**
- Agents interact with each other and with the environment Interactions enable the acquisition, sharing and exchange of distributed knowledge
- Interactions are based on communication modes and respect interaction and coordination protocols.

Interaction between agents

- **Definition**
- **Interaction:** The dynamic linking of two or more agents through a set of reciprocal actions.
- Interaction occurs as soon as an agent's own dynamics are disrupted by the influences of othersInteracting agent
- **Types of interaction**
  - **Direct interaction:** by sending messages

    1. **Point-to-point mode:** the agent sending the message knows and specifies the address of the recipient agent(s). This type of communication is generally the most widely used by cognitive agents.

    2. **Broadcast mode:** the message is sent to all agents in the system. This type of transmission is widely used in dynamic and reactive agent systems. In fact, this generally involves messaging: a specialized agent manages as many queues as there are recipients, and each agent can process the first message in its queue.

Interaction between agents

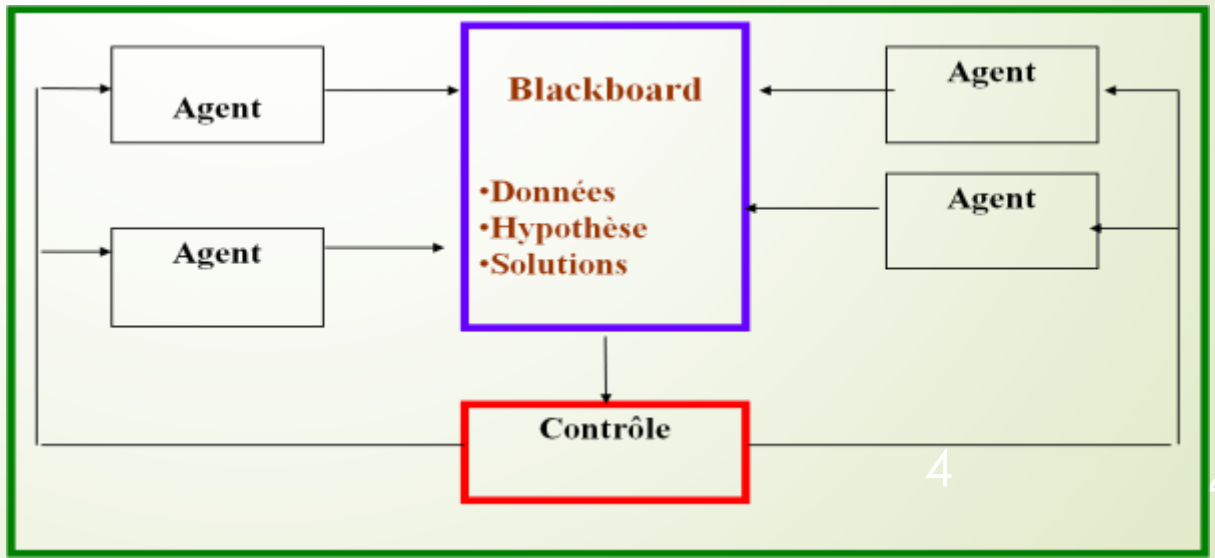
- **Indirect interaction**

  1.by signal propagation : An agent emits a signal that is transmitted to the environment;

  2.By Traces :an agent drops "radioactive bits", thus making traces an agent follows a trace and decreases the trace until it disappears.

  Example: Ants, for example, communicate by depositing pheromones behind them, so that other ants can follow the trail to food or the colony as required.

  3.by Blackboard (knowledge base)Several agents deposit and collect objects or information in a dedicated part of the environment. This common area (shared memory) is called "Blackboard".



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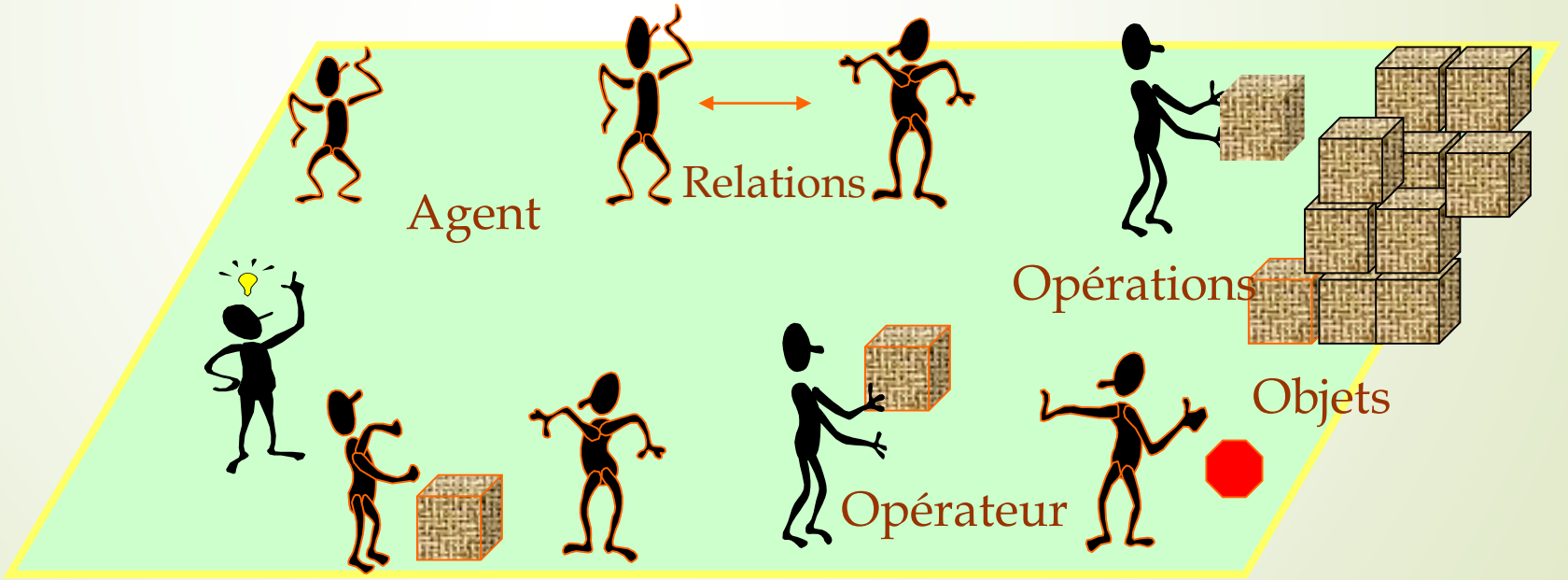
Communication between agents

- An agent can take part in a dialogue either passively or actively.
- A passive agent must accept and answer questions from other agents.
- An active agent must propose and send questions.
- In a dialogue, agents alternate between active and passive roles, exchanging a series of messages according to precise protocols: **coordination, cooperation and negotiation protocols**.



Different forms of interaction between agents

- **Cooperation** Cooperation is the most widely studied general form of interaction in M.A.S.

1. **Cooperation by sharing tasks and results,** with the possibility of locally taking into account the plans of others.
2. **Command:** a superior agent "A" breaks down the problem into sub-problems, which he distributes among the other agents "**Xi**". These solve the problem and send the partial solutions back to "A".
3. **Call for tenders:** "A" breaks down the problem into sub-problems and distributes the list. Each agent "**Xi**" wishing to solve one of the sub-problems sends an offer; "**A**" chooses from these and distributes the sub-problems. The system then works in command mode.
4. **Competition:** In competition mode, "**A**" breaks down and distributes the list of sub-problems in the same way as in bidding mode. Each "**Xi**" agent solves one or more sub-problems and sends the corresponding results to "**A**", who in turn sorts the results.

Different forms of interaction between agents

- **Conflict resolution**

  Cooperative agents need to avoid conflictual situations as much as possible to solve a problem. To do this, they may need to coordinate their solutions.

- **Coordination**

  Agents work on problems whose solutions are useful to other agents. Their work must therefore be coordinated over time.
  Coordination enables agents to consider all tasks and avoid duplicating work.
  The coordination of actions is linked to planning and conflict resolution, as it is at this level that the actions (plans) of other agents are taken into account.

Two types of coordination can be distinguished:

1. **coordination due to hindrance:** (navigation problem: agents must coordinate their navigation plans to avoid each other).
2. **coordination due to assistance:** (handling: in a multi-robot environment, agents must synchronize their actions to be able to act efficiently and transport an object).

Different forms of interaction between agents

- **Negotiation**

The activities of agents in a distributed system are often interdependent , leading to conflicts.
To resolve them, agents' points of view must be considered and negotiated, and decision mechanisms must be used to determine which goals the system should focus on.

- Negotiation is characterized by :
  - A small number of agents involved in the process.
  - A minimal protocol of actions: proposing, evaluating, modifying and accepting or rejecting a solution.
- The problem of negotiation does not necessarily consist in finding a compromise, but can extend to modifying the beliefs of other agents in order to make a point of view prevail.

Direct communication between agents

- Based on Agent Communication Languages (**ACLs**)
- ACLs can communicate propositions, rules and actions, not just objects without associated semantics.
- An ACL message describes a desired state in a declarative language and is not a simple method invocation.
- ACLs are based on BDI theory: BDI agents try to communicate their BDI states and modify the BDI states of other agents.
- ACLs are based on Speech Act Theory.

Direct communication between agents

Structure Générique d'un Message

Numéro Message : Chaque message a un numéro d'identification.

Agent Expéditeur : Nom de l'agent expéditeur

Agent Destinataire :

Nature :

Type : Type de message (urgent, prioritaire, normal)

Etat : Etat du message (traité, non-traité).

Contenu : Corps du message.

Date : Date d'envoi du message.

Communication language

Any multi-agent language is represented by a data structure comprising the fields :

- Sender
- Receiver
- Language used: language in which the real message is written
- Message content: the actual message that is the subject of the communication
- Ontology: the vocabulary in a given domain so that agents can understand each other Set of definitions concerning the message

There are 02 standards:

KQML
FIPA-ACL

KQML -Knowledge Query and Manipulation Language

- **KQML:** A high-level message-oriented communication language and information exchange protocol that is independent of content syntax (KIF, SQL, Prolog, etc.) and application ontology.

- **KQML:**
- **Several performatives(36)**
- **Message: Content Language (Java, XML, etc.)**
- **Performative**
- **Ontology**

Un message KQML comporte 8 champs :

```
( performatif-name
      :sender
      :receiver
      :reply-with
      :in-reply-to
      :language
      :ontology
      :content
)
```

KQML -Knowledge Query and Manipulation Language

- A few performatives

E : l'agent émetteur
R : l'agent récepteur
C : le contenu du message
BVC : la base virtuelle de connaissances (connaissances attribuées par chaque agent aux autres agents)

ask-one : *E veut que seulement R réponde à sa question C*
ask-if : *E veut savoir si la réponse à la question précisée en C se trouve dans la BVC de R*
tell : *E affirme au R que C est dans la BVC de E*
broadcast : *E veut que R transmette à son tour la performative à toutes ses connexions*
error : *E considère le message précédent de R comme mal formé*
sorry : *R ne peut pas fournir plus d'information*

KQML -Knowledge Query and Manipulation Language

- **Example of KQML**
- Agent A1 asks agent A2 the price of a Nokia-6100 cell phone, and A2 replies:

```
(ask-one
      :sender A1
      :receiver A2
      :content (val (prix Nokia-6100))
      :language KIF
      :ontology portables
)
(tell
      :sender A2
      :receiver A1
      :content (=(prix Nokia-6100) (scalar 290 Euro))
      :language KIF
      :ontology portables
)
```

- KQML and FIPA-ACL have the same message syntax

FIPA-ACL
Foundation for Intelligent Physical Agents, 1996

- FIPA goal = to provide a specification that enables maximum interoperability between heterogeneous software agents
- FIPA ACL : Syntax similar to KQML.
- Set of predefined messages that any agent must be able to process to process:

  - **not-understood**: Predefined message used by an agent that receives a message it cannot understand. Every agent must be able to process such a message.

  - Administration and facilitation primitives outside the ACL

  -These are defined in the content

FIPA-ACL

Performative	*: Type de l'acte de communication*
sender	*: l'émetteur du message*
receiver	*: le destinataire du message*
reply-to	*: participant à l'acte de communication*
content	*: le contenu du message (l'information transportée par la performative)*
language	*: le langage dans lequel le contenu est représenté*
ontology	*: le nom de l'ontologie utilisé pour donner un sens aux termes utilisés dans le content*
conversation-id	*: identificateur de la conversation*
reply-with	*: identificateur unique du message, en vue d'une référence ultérieure*
in-reply-to	*: référence à un message auquel l'agent est entrain de répondre (précisé par l'attribut reply-with de l'émetteur)*
reply-by	*: impose un délai pour la réponse*

FIPA-ACL

- *Example*

```
(inform
        :sender Agent1
        :receiver Agent2
        :content (price (good2) 150)
        :in-reply-to round-1
        : reply-with bid03
        : language S1
        :ontology hp-auction
        :reply-by 10
        :protocol offer
        :conversation-id conv-1
)
```

FIPA-ACL

- **FIPA performative category**
- **Information**

  query_if, query_ref, sunscribe, inform, inform_if, inform_ref, confirm, disconfirm, not_understood

- **Error handling**

  not-understood, failure

- **Negotiation**

  cfp(Call for proposal), propose, accept_proposal, reject_proposal

FIPA-ACL: The 20 performatives

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			

FIPA interaction protocols

- **Protocols & Convesations**
- **Protocol:** a protocol provides a set of behavioral rules to be followed by an agent involved in the protocol.

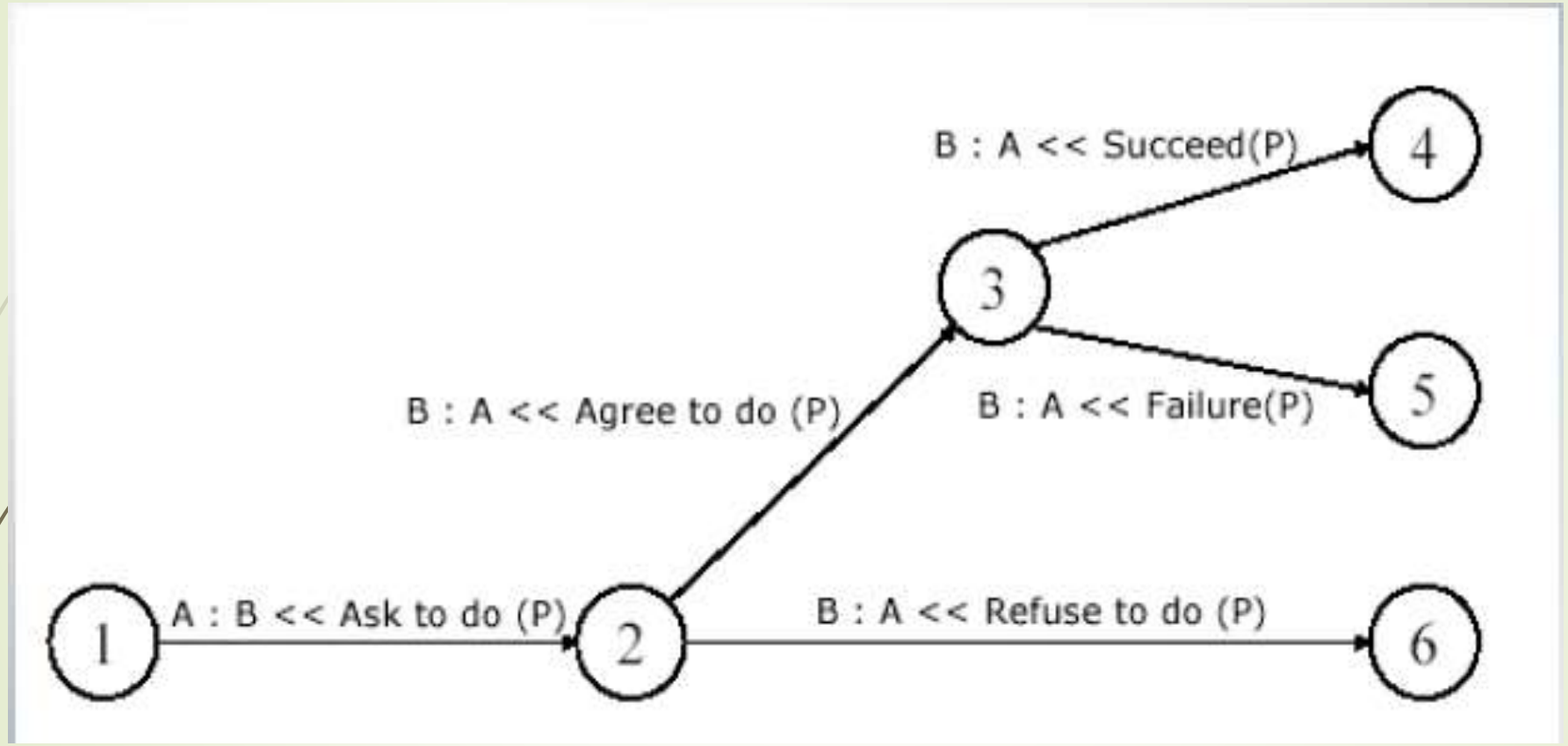
- A protocol specifies who can say what to whom, and the possible reactions to what is said.
- **Conversation:** sequence of messages exchanged between several agents, conforming to a protocol. These are occurrences of the protocol used.

FIPA interaction protocols

- Protocols & Conventions

- Interaction protocols = enable agents to have conversations (structured exchange of messages).
- Interaction protocols explicitly describe the conversational sequences involved in communications between agents.
- They represent a common conversational pattern used to execute a task.
- Based on communication acts
- Different acts at different stages of the conversation, restriction of possible acts;
- Acts act on the agent's mental state, on the continuation of the conversation.

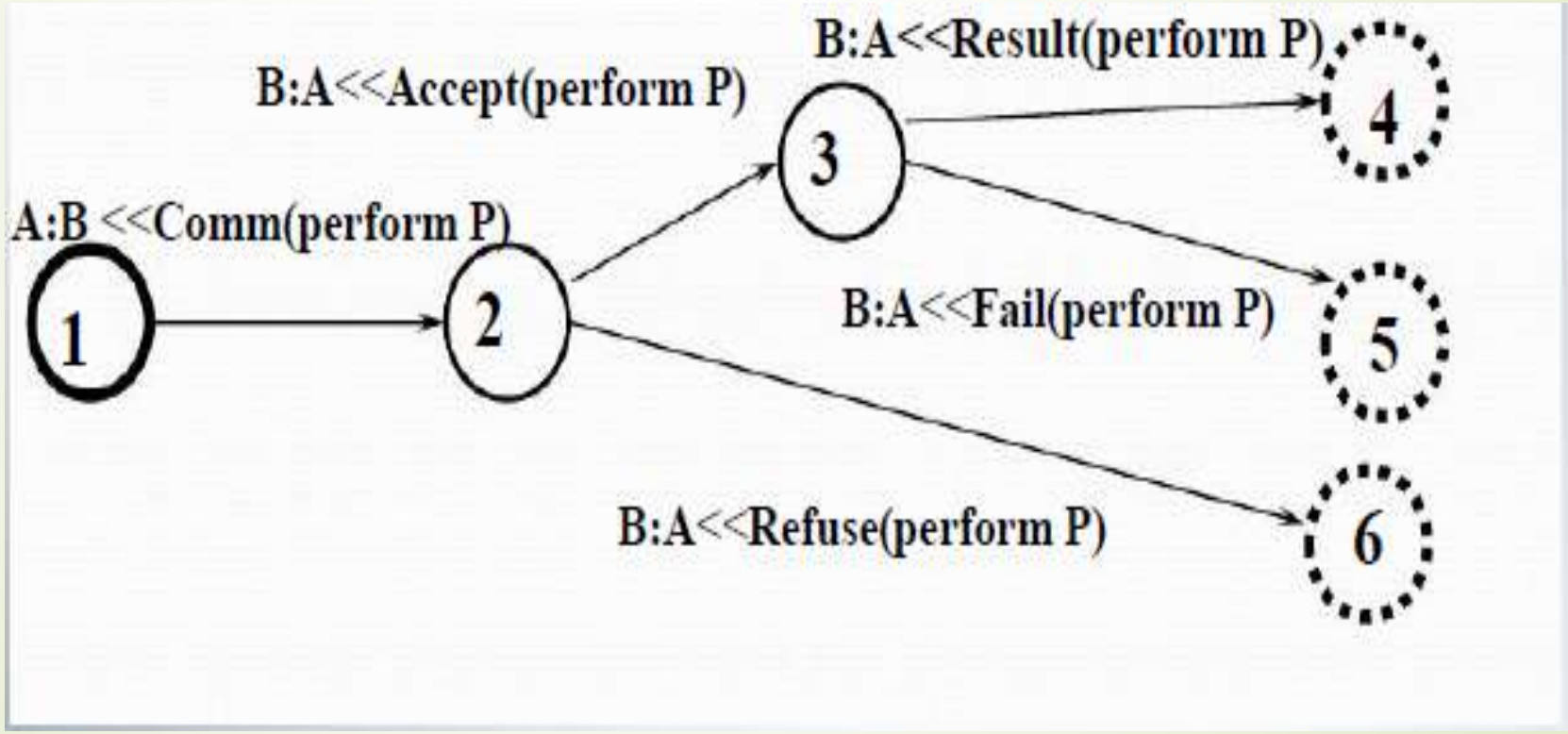
FIPA interaction protocols



Interaction Protocol Modeling

- **Finite-state automata**

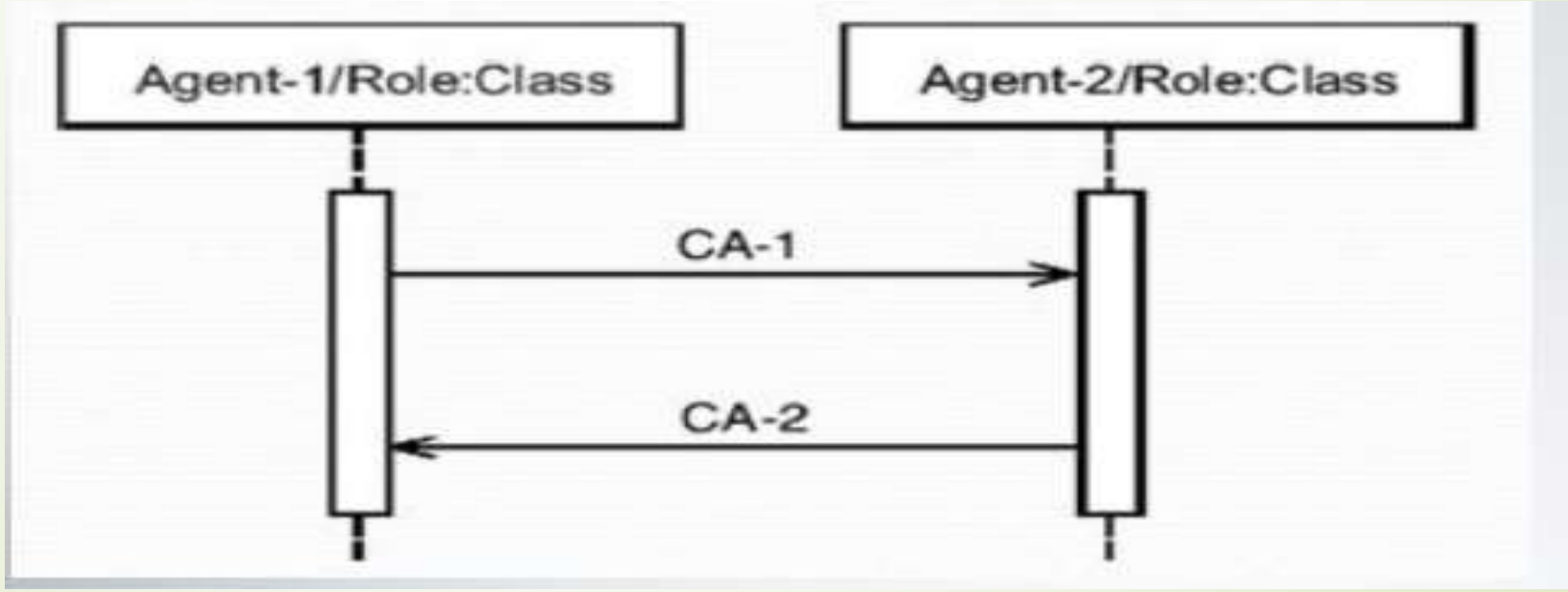
Description of a conversation by a sequence of states linked by transitions (interactions between agents).



Interaction Protocol Modeling

- **AUML (Agent UML)**

Agent interactions can be represented in the UML standard using sequence diagrams



Interaction Protocol Modeling

- **Petri nets**

Oriented graph with two types of nodes:

places and transitions

- A **transition** is activated if all P input places in **T** have tokens.
- **Places** internal state of the agent,
- Message in progress,
- **Transitions Synchronization** due to message reception
- Action application **conditions**.

Interaction Protocol Modeling

- Example of a RoP: request to do something