

Cooperation in Multi-Agent System

Basics of cooperation

1. Cooperation is the practice of working in common with mutually agreed-upon goals and possibly methods, instead of working separately in competition, and in the success of one is dependent and contingent upon the success of another.

Basics of cooperation

2. When agents are working together, it is important to make a distinction between two types of agents

(i) **Benevolent agents**- If the system is being "owned" by single entity then the whole system in a cooperative environment, can be designed in such way that agents help each other whenever asked (if possible).

(ii) **Self-interested agents** - Self-interested agents does not mean that they want to cause harm to other agents or that they care only about themselves. It means that it follows its interest as represented by a utility function (representing the agent's own preferences).

Basics of cooperation

3. Task Sharing and Result Sharing mode in cooperative environment

- Two main modes of cooperative problem solving,
 - **Task sharing** : components of a task are distributed to various agents
 - **Result sharing** : information (partial results, etc.) is distributed

Basics of cooperation

4. An AI Agent communication comes into two as discussed below,
- 1.Low-level communication, where in there are simple signals, traces, and low-level languages.
 - 2.High-level communication , where in there are cognitive agents and mostly seen as international systems.

Basics of cooperation

- Communication in multi-agent systems is more than simple communication that implies interaction among various agents in the system.
- There are two types of protocols for agent communication.
 - First category is of communication protocols that enables agents to exchange and understand messages.
 - Whereas second category is that of interaction protocols that enable agents to have conversations that is exchanges of messages.

Blackboard system – a technique for communication in cooperation mode

- (i) It is one of the first scheme introduced for cooperative problem solving.
- (ii) It was Introduced in a system called HEARSAY-II (1975, Carnegie Mellon) as results sharing via shared data structure called Blackboard(BB).
- (iii) Multiple agents can read and write to BB.
- (iv) Agents can write partial solutions to BB.
- (v) BB can be structured into hierarchy
- (vi) Problems associated with BB
 - Mutual exclusion of access to the BB is required as it can result into bottleneck.
 - Working with BB can't be a concurrent activity.

Contract Net-Cooperative agent protocol

1. Contract net is well known task-sharing protocol for task allocation.
 - The contract net protocol is an interaction protocol for cooperative problem solving among agents.
 - It is modeled on the contract allocation mechanism used by businesses to govern the exchange of goods and services.
 - It is an approach to distributed problem solving, focusing on task distribution in which the task distribution viewed as a kind contract negotiation.
2. In contract net terminology an agent wanting a task solved is called the manager, agents that might be able to solve the task called potential contractors.

3. Contact net process takes place in below 5 phases

- i.) Recognition – In this stage, an agent recognizes it has a problem it wants help with. The agent has a goal, either, realizes it cannot achieve the goal in isolation and does not have capability (no plan for it) or realizes it would prefer not to achieve the goal in isolation (typically because of solution quality, deadline, etc).
- ii) Announcement – In this stage, the agent with the task sends out an announcement of the task which includes a specifications of the task to be achieved specification must encode the description of task itself (maybe executable) with any constraints (e.g., “bids must be submitted by...”). The announcement is then broadcasted.

3. Contact net process takes place in below 5 phases (contd.,)

iii) Bidding – Agents that receive the announcement decide for themselves whether they wish to bid for the task. The factors that agents consider for themselves to go for the task are, agent must decide whether it is capable of expediting task, whether agent can guarantee quality constraints & price information (if relevant). If they do choose to bid, then they submit a tender (completely specified offer).

iv) Awarding – The agent that sent task announcement must choose between bids & decide who to “award the contract” to. The result of this process is communicated to all agents that submitted a bid.

v) Expediting – The successful contractor then expedites the task. While working it the task may get sub-contracting (eventually using contract net again).

4. Four phases to solution in cooperative problem solving, as seen in contract Net are as follows,

- i) Problem Decomposition
- ii) Sub-problem distribution
- iii) Sub-problem solution
- iv) Answer synthesis

5. Types of messages in contract net communication

- Task announcement messages, with the following slots,
 - Eligibility specification
 - Task abstraction
 - Bid specification
 - Expiration time
- Bid (following the Bid specification)
- Award
- Intern report (on progress)
- Final report (including result description)
- Termination message (if manager wants to terminate contract)