Practical exercise of AI2-MAS-IMAS 2012/2013

Multi-agent systems are a particularly interesting alternative to be applied in distributed systems, in which the different elements act autonomously and they must communicate and coordinate in order to achieve a common task.

This practical exercise includes tasks such as fishing and selling negotiation activities. It consists of a system which includes agents that require communication, negotiation and acting activities. Basically, it consists of a map which simulates a sea and contains ports, fishing boats and groups of fishes.

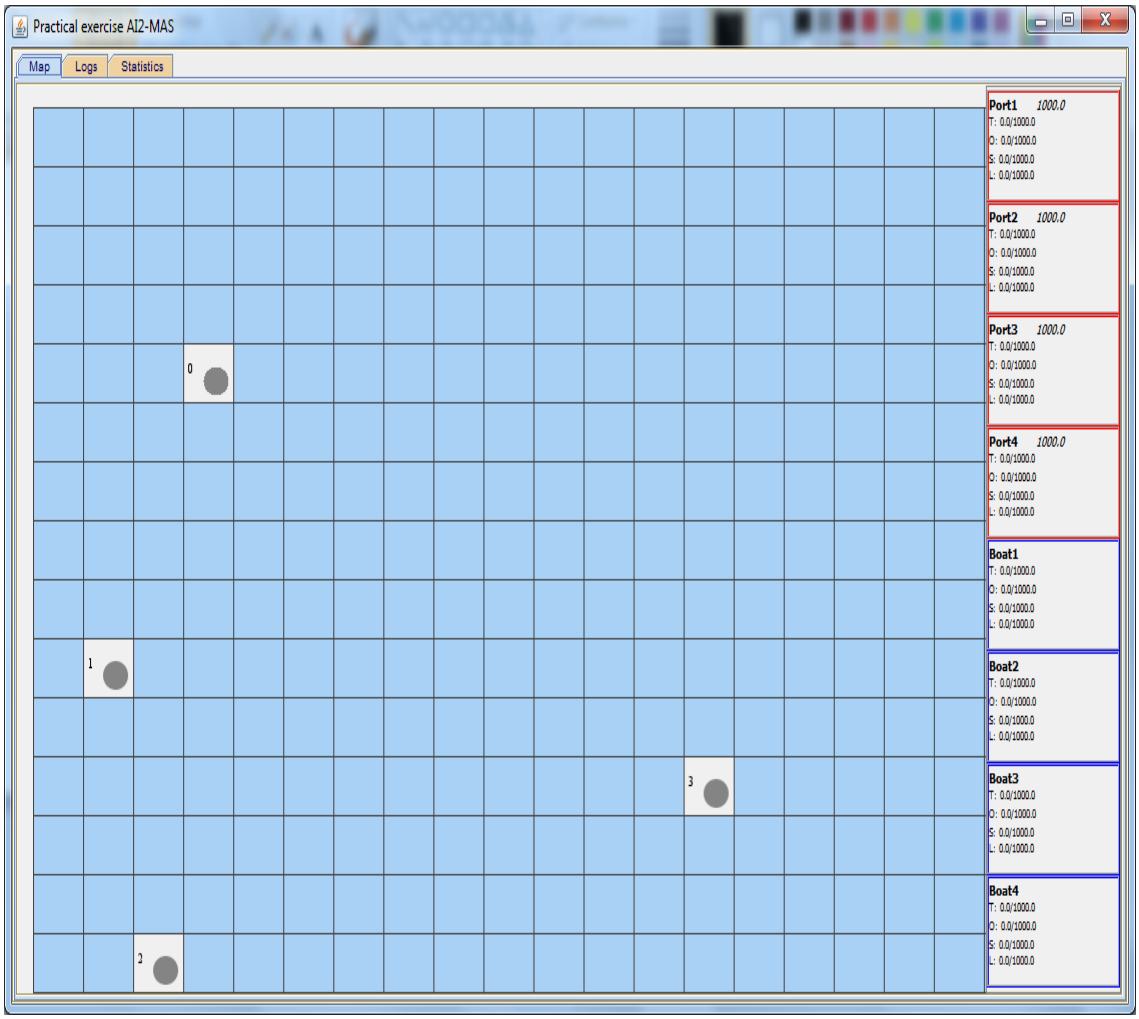

Fig. Map Example

The practice consists in the development of optimal coordination procedures between the fishing boats to capture different types of seafood and the creation of negotiation procedures to sell the captured seafood to the different ports available. The goal is to fill all the ports deposits using an established amount of money available for each port. The timeline of the practice to develop these tasks is defined as follows:

- Turn: Equivalent to a movement. On each turn the fishing boats and seafood groups can move one cell in the map.
- Fishing phase: Represents the start of a new fishing turn. On each new fishing phase the elements in the map are randomly placed (including fishing boats and seafood groups). The

initial position of the elements is detailed below. A fishing phase ends once all the seafood groups are captured by the fishing boats or if they have exited the map.
- Negotiation phase: After five fishing phases a negotiation between the ports and the fishing boats starts.

The practice session will consist in a total of 5 negotiation phases which includes a total of 25 fishing phases. After 5 negotiation phases, the simulation stops.

1. Elements of the map

1.1 Seafood groups

Seafood groups represent a set of seafood of the same type. A particular seafood group will be displayed in a cell of the map.
There are 4 different types of seafood available in the map with its respective color that represents a group of each in the map (a group represents a cell):

1. Tuna: Green
2. Octopus: Violet
3. Lobster: Orange
4. Shrimp: Red

On each fishing phase, there will be 5 random seafood groups in the map. Each group will have a random quantity of kilograms of the seafood [10 to 20 kg] and when it's captured surrounded by 4 boats, this quantity will be split between the 4 boats. The split of seafood can be performed equally between the boats. In case that the equal split cannot be performed for a certain boat (for example, its deposit almost full and the quantity corresponding to that boat exceeds the maximum), the remaining part of the seafood that cannot be added to the deposit can be split among the other boats. In case that this is not possible and the remaining seafood cannot be accepted for the boats group, the remaining kgs of seafood will be wasted. Note that the seafood groups may leave the map, in this case the boats of the boat group will not fill the deposit during this fishing phase.

A group will be in constant movement around the map, one cell movement per turn in either horizontal or vertical way following a constant direction.

In general terms, the seafood groups consist of the following initial information:

- Map Position in coordinates x, y
- Seafood type
- Quantity (kgs)
- Movement direction (up, down, left or right)

Each seafood type has a minimum and maximum cost **per kilogram**:

1. Tuna: 1,00 – 2, 00 euros
2. Octopus: 2,00 – 3,00 euros
3. Lobster: 1,50 – 2,50 euros
4. Shrimp: 3,00 – 5 euros

1.2 Fishing boats

Fishing boats agents have to capture the seafood and sell it to the available ports. There will be 20 fishing boats that have each one 4 deposits for the 4 different types of seafood, with a maximum quantity of **10**

kg per deposit (in total a fishing boat can load up to 40 kg). Each boats group needs to stop the seafood group. This task is performed by setting a boat besides the seafood group. In order to start fishing, all the members of the boats group must surround the seafood group and start the split of kilograms of the seafood.

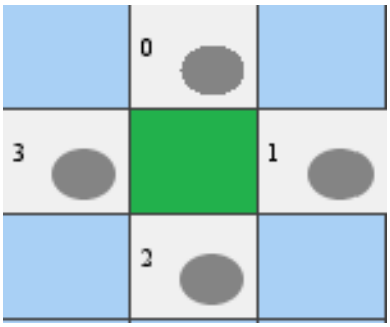

Fig. Example of a boat group surrounding a seafood group

The fishing boats consist of the map position in coordinates (x, y) as initial information only. However, during the practical exercise, the fishing boats will consist of the following information:

- Map position in coordinates x, y
- Four deposits information
- Movement direction
- List of coalition boats

1.3 Ports

Port agents will make offers to the fishing boats in order to fill their deposits. There will be in total 6 ports in the map. Each port will contain 4 deposits (one for each type of seafood) that will contain up to 100 kilograms per deposit. It means that a port may have up to 400 kg of seafood in total. After 5 fishing phases, a negotiation will be opened by each port. Each port will have different negotiation strategies:

1. Steady deposit: Always keep balanced the 4 deposits
2. Minimum offer range: Always offer minimum prices ranges
3. Expensive seafood priority: Always fill the most expensive seafood as a priority
4. Cheap seafood priority: Always fill the cheapest seafood as a priority
5. Offer medium prices range: Always offer the medium price ranges based on the minimum and maximum prices.
6. Offer maximum prices and lowering: Always start offering high prices and lower them during the fishing session.

Each port will have 1.000,00 euros in order to fill their deposits. The students must make sure that depending on the strategy of each port, the port can fill all their deposits with this amount. It's important to take into account that when a port and a fishing boat make a deal, the port must take all the seafood of the fishing boat. This means that a boat can only sell its food to a port in a given negotiation phase, but the ports have no limits to buy seafood of several fishing boats.
The specific negotiation technique between the ports and the fishing boats has to be decided by each practice group. The only constraint in the negotiation is that a boat can only sell all its product to a particular port, but the ports can buy from any quantity of boats depending on their own strategy.

1.4 Collisions

Initially, collisions between the elements in the map are not considered. In a cell you can set several boats, but the cell must show visually the boats on it. However, the management of collisions can be decided by each practice group

2. Architecture

In any implementation of this type of simulation, there has to be a **Coordinator_agent** which centralizes the orders to be executed in each turn. This Coordinator_Agent knows the changes that dynamically happen in the map (e.g., movement of the fishing boats and seafood groups). In order to simulate and control what is happening, there is also a **Central_agent** which executes orders to update the state of the world. This agent is the one that, in a nutshell, keeps the state of the map and shows it using a graphical interface. Below, a basic architecture for the practice is shown. It must be changed by the practice group to add more agents (for example, coordinators) and communication possibilities if the group considers that this modification (or modifications) will improve the performance of the practical exercise.

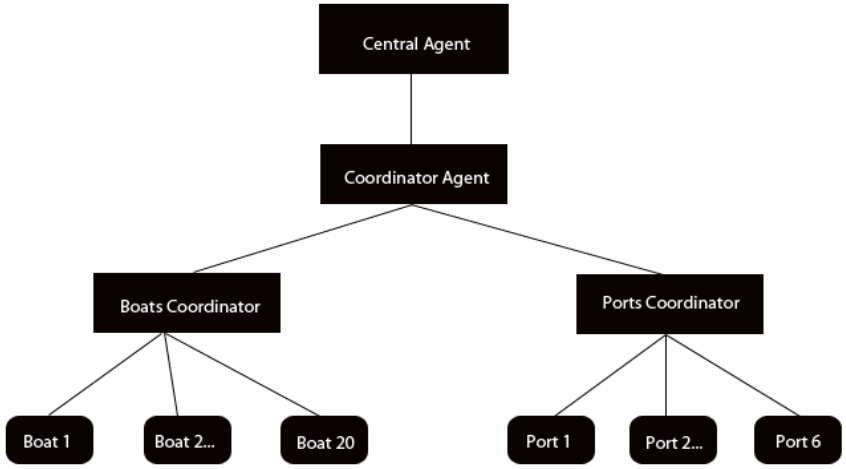

Fig. Basic Architecture.

2.1 Information flow

As it can be observed in the previous figure, there are different agents involved in the fishing activities. In order to show more clearly how the system works and which role is played by each actor, we describe the basic steps of the functioning:

- Initially, the Central_Agent loads the configuration of the map from a file. This configuration contains information about the map size (by default: 20 x 20 matrix), the quantity of fishing boats, groups of seafood, ports and their money available. The information of the type of strategy per port (6 in ports in total) is set in the file. The quantity of boats must be set to 20 and the groups of seafood are set to 5, all as constants.

- The boats communicate with each other in other to form dynamically groups in each fishing round. This dynamic distribution of the boats in fishing groups cannot be decided in a centralized way by any particular agent, such as a Boats_Coordinator.

- The boats and ports agents send an OK message to their coordinator saying that everything is correct and that the simulation is ready to start. These coordinators send an acknowledgement to the Coordinator_Agent and this message is resent to the Central_Agent. At this point, everybody is ready to start.

- On each turn, each Boat_Agent will "think" the strategy to follow. This desire is transmitted to the Coordinator_Agent, which receives all the proposals and transmits them to the Central_Agent. The Central_Agent, in concrete periods of time (turns) waits for the Coordinator_Agent to send a list with all these movements or actions of the fishing boats. If there is none, the list is empty.

- Each Boat_Agent communicates and coordinate with each member of the boat group to capture a particular seafood group. When a group finished fishing, paint the boat of the color of the captured seafood to show the boats that already finished fishing. Once all the boats of a certain group reach the fishing positions, each Boat_Agent of the group finishes its turn and waits for the other boats groups to finish.

- Once the Boats_Coordinator receives the notifications that all the boat groups have fished, a new fishing phase will restart setting randomly the positions of the new seafood groups and the fishing boats. After 5 fishing phases, instead of restarting a new fishing phase, the turn will be conceded to the negotiation phase between the boats and ports.

- When the negotiation phase starts, each port prepares prices for each seafood. The negotiation strategy of each port and the prices given by each port must be taken into account for the negotiations procedures between the boats and the ports. Some conflicts must be avoided when negotiating, for example, two ports cannot accept seafood from the same boat. The Ports_Coordinator will send the final result of the negotiations to the Boats_Coordinator.

- Update the information of the ports and boats with their respective data on the panel located at the right part of the interface. When boats finished fishing, update the boat data about the units of seafood they have as well as for the ports once a negotiation is finished, including the remaining money they have.

- Restart the fishing phase or open a negotiation phase. After 5 negotiation phases, the simulation ends.

This process is basically divided into two stages: initialization and simulation. The *initialization* is used to place all the agents in their corresponding position and initialize the knowledge they must keep. The *simulation*, which works using synchronous turns, is used to keep changing the positions and states of the agents.

The Central Agent will keep some statistics and a log of the executed tasks in order to evaluate the work of the different actors. Once the number of turns specified in the configuration file is reached, the simulation finishes and the statistics are shown in the Statistics tab. The statistics that you may use for this purpose are:

- Average number of turns taken by the boats to capture seafood groups
- Percentage of seafood groups captured by fishing boats
- Best strategies for the ports negotiations (considering relation money / fill of deposits)

You can apply other statistics to analyze the practical exercise.