A Design and Preliminary Evaluation of Hierarchical Organizational Behaviour Modelling Architecture

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1 Introduction

In the field of large scale multi-agent based simulations, such as war game simulations for defence or disaster simulations, a simulation program has to control huge numbers of entities such as soldiers, rescues, civilians or a variety of vehicles which are expected to run autonomously. However, since the current multi-agent schemes are not enough powerful to achieve fully autonomous agents required for training simulation systems for war game or disaster simulations, human support at runtime is required. Such human is called a response cell, and many response cells are required for large scale simulation in order to control the behaviour of hundreds of entities by input their routes, movement or actions in details. Same situation happens for scenario preparation, as the simulation scale grows, the effort of scenario input increases drastically, which becomes a critical issue.

Therefore, new methods are required to reduce the number of response cells, or the increase of the efficiency of scenario input. For instance, in a conventional method, response cells have to provide all required information for all entities. Our proposal is based on the idea to introduce such mechanism that response cells provide only macroscopic inputs, such as the objective of the entities, and the system expand them to microscopic orders or commands. However, when the number of entities becomes huge, even providing macroscopic inputs is also difficult by the limited number of response cells.

In order to solve the above problems, we propose the architecture for hierarchical organizational behaviour modelling (HOBM). Using HOBM, entities are structured as organization, and they behave by the orders given by the leaders. Leaders gather information reported from their members, and they give orders to their members. Moreover, a leader is also a member of a super leader, and a super leader is also a member of the boss, and so on, this hierarchical architecture ensures the scalability of this model. By introducing HOBM, the efficiency of scenario input may be increased at preparation phase, and also we can reduce the number of response cells at run time.

In this paper, we will describe the overview of our proposed HOBM, and also a preliminary evaluation results are shown.

2 HOBM Architecture

An organization can be defined as a set of members, and a member belong to a sub-group of an organization which has one leader. A leader is a member of another sub-group, and a this sub-group has a super leader. This hierarchical structure is composed recursively (Fig. 1). As the figure shows, top of the organization is called the boss, and all the members of this organization behaves based on the common objective of the boss.

In previous research, “Group Model (GM)” is proposed and focused for group behaviour modelling, and it is applied to crowd models for evacuation [1, 2, 3]. However, in GM, groups are considered to be uniform, and mass of entities behaves as groups, but the behaviour models of all are equal. In the research of [2], it employs leaders for efficient building evacuation, but since the leaders are not hierarchically organized, it is not scalable.

On the other hand, our proposed HOBM architecture is based on the idea that organization is hierarchically structured, and the role of each level of hierarchy is different. Moreover, the hierarchical structure of HOBM is recursively organized, it can be applicable to large scale real-world organizational behaviour modelling.

As the Fig. 1 shows, the objective of the organization is shared by the highest leader (the boss), super leaders and leaders. Therefore, those leaders give commands to their subordinate to achieve the objective, by deriving concrete orders such as move, sense, act or others from a more general objective. In order that those leaders derive concrete orders, members give report to their leader. In the same way, leaders give report to their super leaders, and super leaders give report to the boss.

In [2], it employs leaders and leaders teach information of the environment to the members, but leaders have to own complete information of the environment at runtime, and members do not give reports to their leader, and this point is different from our method. In HOBM, reports from subordinates are the essential to the leader’s decision process.

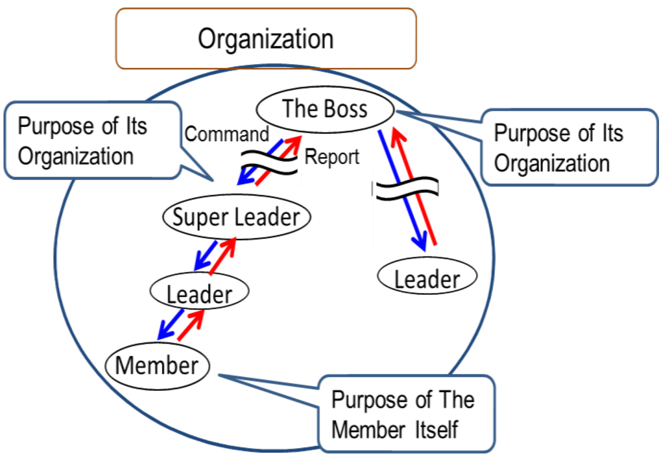

Fig. 1. Organization

2.1 Objectives and Commands

Each level of leaders, including super leaders or the boss have their objectives, and they are spread to their subordinates through commands. Commands are generated in a manner that an objective is break down to more concrete commands. Therefore, all members of the organization share the same objectives. The command to the boss is given from outside of the organization, but it’s usually given as a scenario by a person who executes that simulation.

2.2 Information Feedback

Members of an organization communicate each other through their leader. Subordinates of organization give the information to their leader through reports (Fig. 1), and the information includes environment, detected other agent, and their own status. The leaders derive decision using this information given from the subordinates.

2.3 Recursive Structure

The proposed HOBM architecture is inherently recursive structured. Therefore, as the Fig. 1 shows, the relation between leader and member is same as that between leader and super leader, and super leader and a boss. It means that we can able to express a small platoon model, to a huge legion model. As the size of an organization increases, by increasing the level of recursion, we can ensure the scalability of this HOBM.

3 Preliminary Evaluation of HOBM

In order to show the effectiveness of HOBM, we have built a prototype system which simulates a simple evacuation model shown in Fig. 2. We have used "Artisoc" which is a tool to model and simulate multi agent simulations.

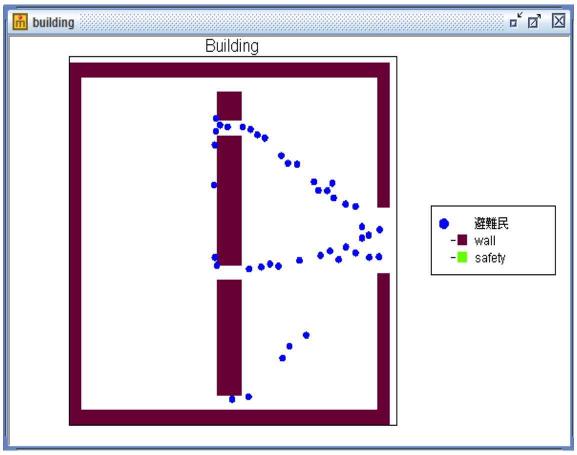

Fig. 2. A Screenshot of Evacuation Simulation for a Preliminary Evaluation

3.1 Experimentation

In this evacuation model, we assume that entities escape from a building, which has several evacuation routes.

The building has walls and paths, and the routes of evacuees are blocked by walls. The rule of evacuees' movement is ruled by Helbing's equation[1] which are characterised that they receive forces from walls and other evacuees.

Although all evacuees would like to escape toward the exit of the building, information that they can get is limited, since their length of eye sight differs. In this preliminary experiment, the length of the building is 50m and the eye sight length of evacuees is 2m. Parameters of the test are shown in Table 1.

In this experimentation, each evacuee's own behaviour model is very simple. They run toward the exit and if they bump into wall, they follow wall by right-hand or left-hand rule until the end of the wall.

We evaluated and compared two cases. One is with a leader, and the other is without a leader. In both of the cases, number of evacuees in the simulations is 50.

In the case with a leader, subordinates send their sight information to their leader and the leader make crowd map which is shown in Fig.3. In order that the leader tries to avoid collision of evacuates, the leader refers to the map and sends a command to his subordinate to move to the less crowded direction. When they do not get commands from the leader, evacuees decide to move only by their own information.

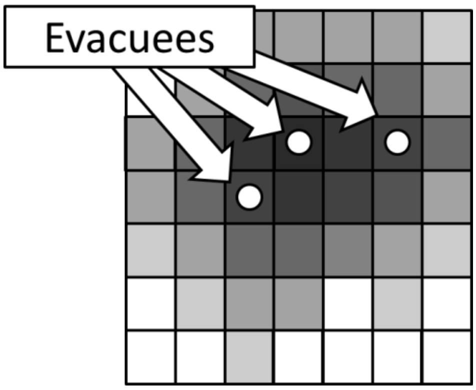

Fig. 3. Crowd Map

3.2 Result of the Experimentation

The result of the experimentation is shown in Table 2. In the table, the number of iterations that all or half evacuees completed their evacuation is shown. We ran the test cases in 20 times and the averages are shown in Table 2.

As the table shows, result of the case 1 (with leader) is better than that of the case 2 (without leader). It implies the effectiveness of the leadership.

Table 1. Parameters of the Test

Length of Building	50m
Radius of Each Evacuee	0.4m
Length of Eye Sight	2m
Width of Paths	2m
Number of Evacuee	50
Number of Trials of the Simulation	20

Table 2. Result of the Test

	Average Iterations of All Evacuees Evacuation	Average Iterations of Half Evacuees Evacuation
Without Leader	1119	740
With Leader	1101	722

4 Conclusion

We proposed the HOBM architecture, a new method which is applicable to modelling hierarchical organizational modelling for a large scale simulation. Our preliminary evaluation result implies that the effectiveness of the leader which sends commands to the subordinates and receives information by reports for their decision making. In this preliminary result, we have not showed the effectiveness of this recursive structure, and this is our future work. We also need to evaluate this using more complex scenario and larger scale problem, to show the effectiveness of this method to the real world problems.

References

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