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An Integrative Self-Organization Mechanism in a Distributed Agent Network

K.Pandikumar, R.Anjugam, V.Bhavani
Dhanalakshmi College of Engineering, Chennai, Tamilnadu, India

ABSTRACT

Self-organisation provides a suitable concept for developing self-managed composite distributed systems, such as grid computing and sensor networks. In this paper, an integrative self-organisation mechanism is proposed. Unlike current related studies, which propose only a single principle of self-organisation, this mechanism synthesises the three principles of self-organisation: cloning/spawning, resource exchange and relation adaptation. Based on this mechanism, an agent can separately generate new agents, when it is overloaded, exchange resources with other agents if necessary, and modify relations with other agents to achieve a better agent network structure. In this way, agents can adjust to active environments. The proposed mechanism is evaluated through an evaluation with three other approaches, each of which represents up to date search in each of the three self-organisation principles. Experimental results display that the future mechanism outperforms the three approaches in terms of the profit of individual agents and the entire agent network, the load-balancing along with agents and the time use to finish a simulation run.
Keywords: Distributed multi-agent system, self-organisation, support learning

I. INTRODUCTION

Complex distributed systems are attractive more and more common. With their ever-increasing exponential complexity in deployment, operation, management and maintenance, it is highly desirable that these systems should be independent and be capable of self-management. Self-managed systems can save work time of being managers and are able to adapt to environmental changes and make sure their own survivability. In addition, in a dynamic environment, it is almost impossible to use a still design time generated system structure for able problem solving. Now self-organisation has been employed in many multipart distributed systems, such as deliver network management, computer networks security management, sensor and communication networks management and evolvable manufacturing assembly system growth, in order to advance their freedom and effectiveness. Self-organisation is usually defined as "the mechanism or the process enabling the system to change its organisation with no clear external command during its execution time. Any self-organising multi-agent systems should have the following three properties:

1. No external control: The entire edition processes should live initiated internally and these process can change only the inside state of the system.
2. Dynamic and continuous operation: The system is normal to evolve as time progresses, and the self-organisation process should be nonstop.
3. No central control: The self-establishment process should be operated only through local interactions of individual mechanism in the system without centralised direction.

The self-organising spread systems can continuously and autonomously fix and reschedule their organisational structures, without any external control, so as to adapt to green changes. A multi-agent system is composed of some intelligent agents, and individual agents may perform different roles. For the design of self-organising multi-agent systems, alive three basic principles of self-organising multi-agent systems, although they did not provide real approaches to realise any one of the three principles:
-Cloning/Spawning: Agents within the system will generate new causes to take part of their work load once they are overloaded.

-Resource exchange: Agents can exchange skills or supply, if necessary, between each other to increase autonomy.
-Relation adaptation: Agents should be able to create new explicit relations between agents in order to remove the middle-agents.

In this paper, we present an integrative self-organisation means which combines the three basic principles together. The proposed self-organisation means is devised in an agent network, where each agent is nonstop connected with some other agents, called neighbours, and each agent can speak only with its neighbours. In addition, this paper focuses on a cooperative agent network, where agents together exploit their overall income rather than a self-seeking agent network, where each agent tries to exploit only its own profit.

II. METHODS AND MATERIAL

A. Proposed System

In this paper, the self-organisation means is designed in an agent network. Thus, it is necessary to define a model. The sort include the number of agents in the network, the neighbours of each agent, the task and store types in the system, and the capital mad by each agent. A task type defines the required resource type and the quantity of resources of this type.

Additionally, a task type also dictates the task benefit, the task check time and the task most waiting time by being executed. The term "task most waiting time" is used instead of "limit," because it is nameless when a task will arrive at the agent network. However, once a task arrives at the network, the deadline of the task can be easily planned using the task arrival time plus the task maximum waiting time. At each time step, a task arrives at the agent network with a picky probability, and is given to a randomly selected agent. Then, this agent starts the task allocation process, which will be described later. In addition, each task also has a service time, an end time and a corresponding benefit. Instead, it is on the advance of an integrative self-organisation mechanism in multi-agent systems for optimising the efficiency of task close.

B. Evaluation Indices Of The Model

Three evaluation indices are introduced these include cost, benefit and profit of an agent and the agent network.

Cost Calculation

The cost of the network consists of six parts: message cost, addition cost consumed by agents to complete the assigned tasks, running cost for maintain tasks and resources, management cost for maintain relations with other agents, resource transfer cost and relation version cost.

Benefit Calculation

The benefit obtained by an agent depends on how many tasks are completed by that agent. When the task is successfully done by an agent, this agent can obtain this benefit. The benefit of the network is the sum of the profit that all the agents gain in the network.

$$Benefit_{NET} = \sum_{i=1}^{A} benefit(a_i)$$

Where benefit (a_i) is the benefit that agent a_i obtains for successfully completing tasks, and then $Benefit_{NET}$ is derived by summing up all the agents' benefits in the network.

3.3 Profit Calculation

The aim of this is near maximise the profit of the agent network. Of line it is difficult to sum up indices with changed units. For example, $Comm_{NET}$ is measured as the number of tokens, while $Comp_{NET}$ is slow as the number of time steps. In this paper, the profit of the network, $Profit_{NET}$, does not have a specific unit. $Profit_{NET}$ Is used to show the general state of an agent network. To sum up these indices, coefficients are used, which involve message coefficients and management coefficients, to equilibrium the values of such indices to the same size.

$$Profit_{NET}=Benefit_{NET} - Comm_{NET} - Comp_{NET} - \sum_{i=1}^{A}(cost_i^1 + cost_i^2 + cost_i^{RT} + cost_I^{RA})$$

Where $cost_i^{RT}$and $cost_i^{RA}$ represent the resource transfer cost and the relation adaptation cost, respectively, incurred by agenta_i.

C. The Integrative Self-Organization Mechanism

This mechanism consists of three components: cloning/spawning, resource exchange and relation adaptation. Each of them is explained as below.

Cloning/Spawning

When an agent is overloaded, it will make a new agent to take division of its load. The agent has two options: cloning or spawn a new agent. Therefore, when an agent has too many tasks in the waiting list, these tasks not only incur managing cost but also face the risk of not being ended on time. When this happens, the agent is considered "loaded" Specifically, for an individual agent, spawning is triggered when it cannot finish the assigned tasks on time. The original agent then assigns tasks to these spawned beginner agents. A spawn agent is a subordinate of the original agent and a spawned agent cannot establish relations with other agents. When the spawned agent remainder in an idle status for a pre-defined period and no more such tasks need to be completed, it will raise itself to save the original agent's relation management cost. Cloning happens when an agent has too many neighbours, which means that the agent has a heavy slide for control relations with other agents. In this situation, to avoid possible letter blocking the agent clones a new manager, and assigns half of its neighbours to the cloned agent. The cloned agent has the same resources as the original agent has, and maintains a examine relation with the original agent.

Resource Exchange

As agents gain running cost for maintain their resources. Hence, for a single agent, when a resource has not been used for a long time, the agent will move the resource to a near agent, which needs this resource. Since this paper considers a joint agent network, an agent directly gives its unused resource to another agent. A policy search algorithm is devised to handle the resource transfer problem. A policy of an agent is a chance distribution over the agent's available actions.

Relation Adaptation

The relation adaptation algorithm is based on past information of individual agents. Specially, agents use the information regarding before task allocation processes to evaluate their relations with other agents. We develop a multi-agent Q-learn algorithm to begin the relation adaptation problem. For example, at a time step, an agent wants to transfer a resource to one of its neighbours, but at the same time, this agent is overloaded and has to clone it. However, the original agent is transferring one of its incomes to a neighbour, so a conflict arises.

III. RESULTS AND DISCUSSION

Experiment and Analysis

To the best of our knowledge, there does not exist a means, which combine the three self-organisation principles together: cloning/spawning, resource exchange and relation adaptation, we select the most efficient approach from each of the three research areas for comparison.

(1) Central. This is an ideal centralised task share approach, in which there is an external omniscient central boss that maintains in rank about all the agents and tasks in the network. The central boss is able to interact with all the agents in the complex with no cost.

(2) Hybrid Model. If an agent is load it spawn a new agent to handle part of its load. Then, if the task is too big and cannot be completed by a single agent, the task has to be separated into small tasks, one or some of which be assign to the newly spawned agent. This proceed is referred to as cloning.

(3) MAL-Allocation. For resource exchange, we choose an efficient approach from the area of resource allocation research. Which includes two multi-agent learning functions for task allocation and transfer? Although Zhang et al.'s work is not the latest work in the resource allocation research area, based on our investigation, it is the best one suitable for resource exchange, as their work was developed in a cooperative and distributed environment and the transferred tasks did not need to be returned to the original agents.

(4) K-Adapt. For relation edition, we opt for the latest and the most able approach, K-Adapt. Which utilises a meta-reasoning approach to adapt the relation between two agents?

a) Experimental Setup

In this testing, the agent inter links in the task allocation network are generate using the Small World system, where most neighbours of an agent are connected to each other. The approach opens in deals with only one type of relation between agents in the network. We thus modify the approach to contain multiple relations by randomly changing the relation between two near agents. In addition, in order to control the total of resources that an agent can have, a parameter called supply probability (RP) is employed. A task is created by randomly generate the required supply type and the amount of resources of that resource type. The benefit of a task is simply as double as the amount of profits required to complete the task.

IV. CONCLUSION

This paper introduced an integrative self-organisation means, which combines the three principles of self-organisation: cloning/spawning, store exchange and Relation adaptation. Through combining the benefits of the three principles, our mechanism outperforms state-of-the art approaches, each of which focused on only a single principle. We also gave an example about the potential application of the proposed device In the future, the analysis of the type of system generate by the proposed self-organisation device will be a motivating research area. In this paper, it is assumed that each agent has an identical power to complete tasks. Agents with higher capacity could complete tasks faster than those with lower capacity. This is another aspect of our future work. We also intend to improve and evaluate our machine in an open location where agents can join and leave freely and new types of resources may be with introduced into the location.

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