Organizations learning mechanism in the cyber society ecology system: an agent-based simulation

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Abstract

In this paper, we try to focus on the cyber society ecology system, which is a naturally occurring complex system to a certain stage of networks economic development. Based on the multi-agent simulation methodology, this paper analyses adaptive learning among organizations of cyber society ecology system, and then designs interaction rules of agents and simulation parameters, and finally the simulation results are analysed.

Keywords: Cyber Society Ecology System, Adaptive Learning, Agent-Based Simulation

1 Introduction

The Cyber Society is a new social form derived from the emergence of computer and Internet technology, which serves as the representatives of the information technology. From the ecology perspective, some scholars proposed the concept of "Cyber Society Ecosystem" [1]. The ecosystem of cyber society is a whole within a certain time and space, consisting of various ecological groups, resources and environment in the cyber society, which is a naturally occurring complex system to a certain stage of networks economic development [2]. Comprehensively understanding the feature of the cyber society ecosystem, revealing its internal evolution mechanism has an important theoretical and practical significance for promoting rapid development of the internet [3]. This paper, based on complex adaptive system theory and ecology theory, uses agent-based modelling and simulation method to study organizations learning mechanism in the cyber society ecology system, so as to propose a new direction for understanding and studying the formation and evolution of cyber society ecosystem. There are many agents in the cyber society, such as the internet users and the virtual enterprise etc. These are parts of the cyber society ecosystem, as the biological organisms in the biological ecosystem, which makes the cyber society ecosystem having the same adaptive evolution process as the biological systems.

The structure of the paper is as follows: section 2 analyses the theory and methodology; section 3 introduces the model and simulation process; section 4 analyses the simulation results; and section 5 discusses the conclusions.

2 Theory and methodology

2.1 CAS THEORY

The complex adaptive system theory is proposed by Holland [4], who is one of the members of SFI School, which is focus on studying complex science. Its core idea is "Adaptability creating Complexity" that the evolution of system benefited from the "living" agent. In order to adapt to the environment or to win the right to survive, agents will adjust their behaviours constantly according to the external environment and other agents [5].Complex adaptive system theory provides a new perspective to explore the complexity of organization such as the evolution of the cyber society ecosystem.

2.2 AGENT-BASED SIMULATION IN SOCIAL AND ORGANIZATIONAL THEORY

Generally speaking, the social and economic phenomena have complex and dynamic characteristics. These lead to the conclusion that traditional tools, such as mathematics and experimental techniques etc., often do not provide adequate descriptions or explanations of these complex phenomena. While the computer-based simulation method, especially the agent-based simulation, has a unique advantage in exploring the complex and dynamic organizational and social phenomena, the method has been widely used in the past few years and earned a wide acceptance [6, 7]. Agent-based simulation takes the systems' macro-phenomena as the results of interactions within the micro-level actions [7]. By defining the agents and their interactions rules, as well as their environments, simulation models can reveal some mechanisms of these macro-phenomena, and may even be used for theory

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discovery and hypothesis generation. In conclusion, agent-based simulation is an effective method to study the 'emergence' of macro level phenomena from micro level actions [7]. Consequently, this paper studies the adaptive learning among organizations of cyber society ecosystem by using agent-based simulation methodology.

2.3 THE CYBER SOCIETY ECOSYSTEM AS CAS

The cyber society ecosystem exchanges massive information, matter and energy with external system, and lies in a non-equilibrium status. The exchanging process is complex adaptive process which is from disorder to order, and then from one order to another order. The cyber society ecosystem will transmit information to internal system through a feedback mechanism, and evolve by the driven force in the internal system. The cyber society ecosystem acquires the ability to adapt to the environment by self-organization and restructuring. Consequently, the cyber society ecosystem is a representative complex adaptive system, which ties the elements of the network society and constraints spontaneous formation.

3 Model Design and Simulation

3.1 MODEL ASSUMPTIONS

In order to simplify the analysis, we need to statement some assumptions and confirm the simulation model boundary. The assumptions of the simulation model are followed:

(1)The agents of the simulation model are the organizations of cyber society ecology. We premise that the organizations are homogeneous in the cyber society ecology.

(2)The agents are bounded rationality. The agents cannot find the optimal decision in the beginning. They only have limit knowledge, and improve their decision through constantly continuous learning.

(3)Using random values to replace the parameters, which cannot be measured and the information, which cannot be estimated accurately [8].

3.2 DEFINING THE AGENT AND IT'S ATTRIBUTE

The agents in the model are the abstract of virtual organization, and have following attributes:

(1)Cyber Society Space. Cyber Society Space is the position of organizations or agent in the grid, separately locates the expression through X-axis and the Y-axis.

(2)Boundary Value. Boundary value reflects the intensity degree of mutual learning among virtual organizations in the cyber society ecosystem. The higher the boundary value is, the greater the degree of mutual learning. The value is 0 that means there is not learning relationship from each other.

(3) Agent's Degree. Agent's Degree is the number of edges, which the agent owns in the position. The more the number, the more linkages between the agent and other agents, otherwise there is less relationships.

(4) Absorption Capability. Absorptive capability is the agent's ability to access knowledge in his location by learning from the agents in other locations. The stronger absorptive capability is, the greater acquiring knowledge, and vice versa. Absorption capability is measured by the absorption capability coefficient in the simulation model.

(5) Knowledge Stock. Knowledge stock reflects the knowledge quantity, which the agent has in this location. The more the knowledge stock is, the higher the learning probability.

3.3 ADAPTIVE LEARNING PROCESS OF AGENT

Adaptive learning process of the cyber society organization is the process to exchange knowledge among members. From the multi-agent system perspective, we regard the members of cyber society ecosystem as the agents of system, and then the learning process of the system is the flow of knowledge between the agents. The essential process of knowledge flowing is that the agents transfer knowledge to their "neighbouring agent", and then these neighbouring agents transfer knowledge to their "neighbouring agent" too. Under circumstance, the flowing of knowledge will occur on the network, which is composed of by neighbouring agents. This network has shown significant characteristics of small-world networks. Therefore, this paper analysed the adaptive learning process of the members of cyber society ecological system according to the relevant outcomes of the small world network theory.

According to the characteristics of small-world networks, we mapped the agents as the node of network, and used (N=i, i=1,2,3,…,n) to stand for the set of agents in the cyber society ecosystem. The N includes a series of channels of knowledge flowing, and each channel is connected to two or more network nodes, which express the learning relationship among the agents. General speaking, for the agent i which is belong to N, has ki boundaries that connected to other agents, and we call the ki agent as the neighbouring agents of agent i. We use the set of N(G,i) to stand for all the neighbours of agent i. That's to say, if agent j is belong to N(G,i), the agent j is the neighbours of agent i and the node i and j will become a boundary. The value of boundary reflects the strength of the degree of connection between agents. The value of boundary is larger, and the degree of connection between agents is stronger. If the value is zero, it represents that there are no learning connection between agent i and agent j. The degree of the node indicates the number of boundaries of the agent i.

The learning rule is the system randomly selected an agent k from the small word network N. Then the agent k gain the set of neighbour N(G,k) by the boundary value. In each period, the agent k searches for each neighbour, and compares the size of each neighbour knowledge stock with it owns. If the neighbouring agent's j knowledge about one type is more than the agent's k what's more, the agent j's absorption capability is the most of all the neighbouring agents, the agent k will learn this type knowledge from the agent j. The value of Absorption capability determines the size of the knowledge acquired in the network.

3.4 IMPLEMENTATION OF SIMULATION

Swarm is the widely used agent-based simulation platform, so we realize this simulation program under the Swarm-2.2-java and the jdk1.6.0_10 development package. The main program documents include Enterprise.java, CyerSocietySpace.java, Adaptivelearning Mechanism.java, ModelSwar-m.java, ObserverSwarm. -java, StartSimulation. java and so on.

3.5 VERIFICATION AND VALIDATION OF THE SIMULATION MODEL

Before running the model, we need to test the program. The testing procedure includes validation and a detailed verification process [9]. The way verification is perceived and deployed depends on the model design methodology and the paradigm utilized for its representation [10]. For the purpose of model validation, we have opted to analyse each agent separately and verify to what extent the results of the experiments correspond to real world data [10]. This paper adopts the unit testing method for verification of the program.

The testing results verify our assumptions. According to the model proposed by Sargent [11], we test the validation according to four components: conceptual model validity, computerized model verification, operational validity, and data validity. The results show that the model's output is very close to the real world. These results indicate that the model's response accuracy is within an acceptable range for its intended purpose and therefore the model is valid.

4 Analysis of the Simulation Result

4.1 MODEL INITIALIZING

In order to make the simulation results reasonable, we should initialize the variables which we statement at the simulation experiment beginning. The generation of small world network is based on the WS model, which is proposed by Watts and Strogatz [12]. According to Watts and Strogatz 's point, we may get small world network by denoting the reconnection probability whose value is 0.01. Through a number of tests of the model, we repeated modifications and corrections for the program, and obtained the reasonable value of the related parameters. The interface of initializing parameters is following:

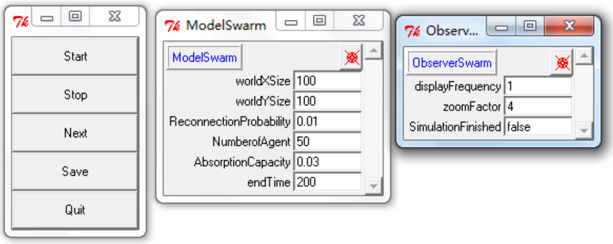

FIGURE 1 The Interface of Initializing Parameters

4.2 ANALYSIS OF THE SIMULATION RESULT

From simulation schedule 1 to 100, the change in the distribution of cyer society space and the learning net are following:

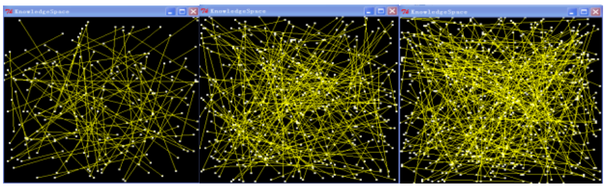

FIGURE 2 Adaptive Learning Network

The Figure2 shows the complicated knowledge flow network forming through long practical learning among interior organizations in the cyber society ecosystem system. With the simulation time going on, the knowledge flow network is becoming more and more complex. The line among agents represents the relevance of knowledge flowing. The more the lines, the more the knowledge are absorbed. By adjusting model parameters, when setting the knowledge stocks value is very high we can find the following findings as shown below. Adjusting the various parameters, we obtain the following simulation results:

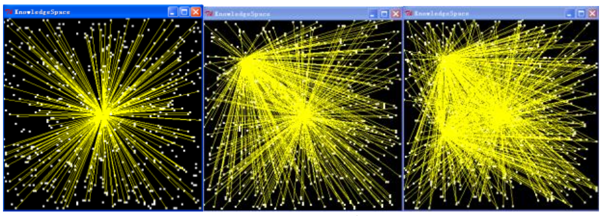

FIGURE 3 The Concentration of Adaptive Learning

The above Figure3 shows when the agent's knowledge stocks in the cyber society ecosystem system is higher, the adaptive learning network presents centre salient features, and learning among agents appears agents keeping higher knowledge stores flow and spread outwards.

The simulation results did just preliminary finish the simulation on learning process and knowledge flowing among organizational members in the cyber society ecosystem system. The problems of relevance about how to measure knowledge flow still need to further research and develop.

5 Conclusion and Discussion

This paper, using agent-based simulation, studied learning process of organization in the cyber society ecology from the complex adaptive system perspective. Through analysis of the simulation result, we draw the following conclusions:

(1) The cyber society ecology system is a complex adaptive system, and has complex adaptive characters. Its complexity is reflected in the structure of cyber society ecology system. The structure of cyber society ecology system includes internet users, virtual enterprises and so on. They all have initiative and adaptive, like biological organisms in the biological ecosystem.

(2) Adaptive learning among internal organizations in the cyber society ecology is an important driving force for the evolution of the cyber society ecology system. Adaptive learning spurs the cyber social to develop.

(3) The network group with subjective initiative, such as internet users and virtual enterprises etc., are part of organisms in all elements of the cyber society ecology system, as living organisms in the biological ecosystem. This makes the formation for the self- organization process possible in the cyber society ecology system like the biological system.

These results are helpful in understanding the adaptive learning process among agents in the cyber society ecology system, and make a base for continued modelling and simulation of the cyber society ecology system evolution.

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