

Ecosystem as an Autopoietic System

Considering Relationship between Ecology and Society based on Luhmann's Theory

Miyuko Naruse

Faculty of Policy Management, Keio University

Takashi Iba

Faculty of Policy Management, Keio University

Abstract

The objective of this paper is to propose a new framework to understand the relationship between ecology and society. For the purpose, we try to build the theory of “ecosystem” as an autopoietic system, based on the concept of “autopoiesis” and social system theory. The concept of “autopoiesis” was originally proposed by H. Maturana and F. Varela as a concept to describe living system and nervous system in biology. Autopoietic system is defined as a unity whose organization is defined by a particular network of production processes of elements, and has three features: self-reference, boundary reproduction, and element as momentary operation.

N. Luhmann abstracted the concept of autopoiesis from biology and improved it as an general concept, and built a novel theory that society is autopoietic system in sociology. In the theory, society is defined as the nexus of communication, and the system can reproduces communication by communication. Mind of human is also considered as an autopoietic system, which is the nexus of consciousness, and the system can reproduces consciousness by consciousness. Since his aim was to build a general theory of society ⁽¹⁾, he mentioned the ecological communication in our society (Luhmann, 1986). In his analysis, however, ecology is not treated as a “system” but just as phenomena on the side of “environment” of social system. It is inevitable because his theory is a “social” theory, not a theory for world as a whole.

In this paper, we focus on the self-organizing feature of ecology, and try to define ecosystem as an autopoietic system in order to understanding the relationship between ecosystem and social system. Framework, system element, operation, and media are described, comparing the economic system, which is one of the functional system in social system theory.

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1 Introduction

The concern over the environmental issues has been increasing. For a recent instance, Al Gore, who appealed the environmental protection, received the Nobel prize for peace in 2007. Mass media also gave big concern to 13th Conference of the Parties (COP13) and reported it everyday. On the other hand, economic growth is still the major objective in modern society. In order to get in the harmony with economic growth and environmental protection, we have to look into the relationship between ecosystem and social system.

From the academic viewpoint, current problem is that the methods, concepts and theories are separated in each disciplines. Many studies have proved the specific fact of ecosystem and made the efficient approaches to the particular issue in ecosystem. Although these approaches are efficient, the problem seems to lie in that the division of those studies. Some scientists, like G. E. Linkens, who is known for the studies of acid rain in North America, complain that the method and ideas of the studies became too specialized (Kress and Barrett, 2001). It is difficult to get the comprehensive view of environmental issues, but still necessary. Therefore the trans-disciplinary framework to understand the fundamental relationship between nature and society is required.

Under the situation, we build new theory that can be connected to social theories in this paper, which is based on the concept of “Autopoiesis”. In general, ecosystem is defined as “the wholeness of the certain part which including the animals and the environment”(Ezaki, 2007). Then the analysis focuses on certain area, like the river, the swamp, the tideland and the wood, and makes it easy for us to understand ecosystem. In this paper, however, we treat ecosystem as a whole and discuss the substance circulation of all the plants and animals, in order to promote to understand ecosystem comprehensively⁽²⁾. For the purpose, we build the theory of ecosystem based on the concept of autopoiesis and social system theory (Figure 1). In the following sections, we review the concept and theory at first, and then propose our framework.

2 Background

2.1 Concept of Autopoiesis

The concept of “Autopoiesis” was proposed by the Chilean biologist Humberto Maturana and Francisco Varela (Maturana and Varela, 1972). They explains an autopoietic system as a unity whose organization is defined by a particular network of production processes of elements, not by the components themselves or their static relations. Summarizing the concept of autopoiesis, there are three features: element as momentary operation, boundary reproduction, and self-reference (Figure 2).

The first target of the autopoiesis theory at that time is the “life”, the living

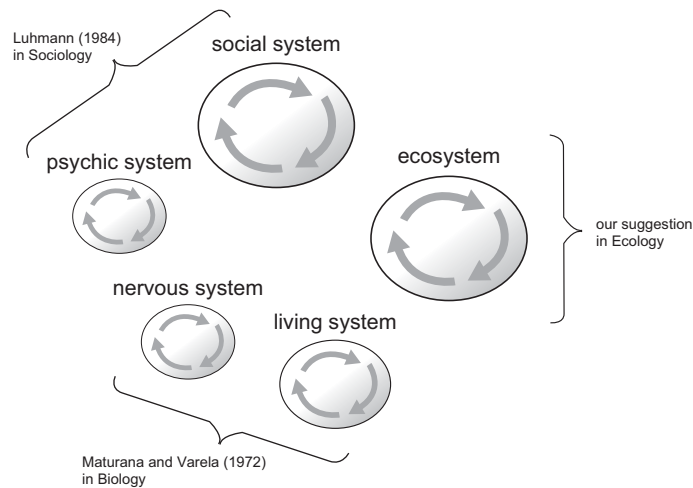


Figure 1: Various Autopoietic Systems and Proposed System

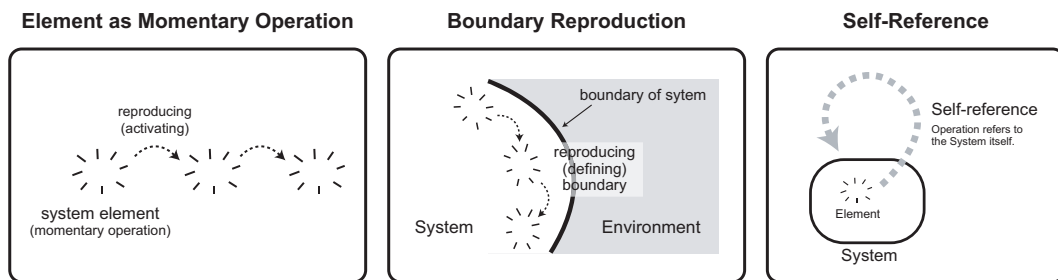


Figure 2: Three features of autopoietic system: element as momentary operation, boundary reproduction, and self-reference

system⁽³⁾. That was a challenge to think life as an autopoietic system. Before that, living system was observed as a machine, which just breathes oxygen and exhausts carbon dioxide. Living system, however, is not a simple machine, so the idea of autopoiesis is useful to look at them from the different angle. Second major target of the autopoiesis theory is “society”, which Niklas Luhmann, German sociologist, applied the theory into sociology, as we will mention below (Luhmann, 1984).

2.2 Social System Theory

Niklas Luhmann suggests new framework for understanding society that society is an autopoietic system, in other word, society is the nexus of communication. He insists that the element of the society is communication, not actor nor action. It is important to consider the freedom and autonomy of individuals, because the individuals must lose the freedom and autonomy, if the individuals would be just

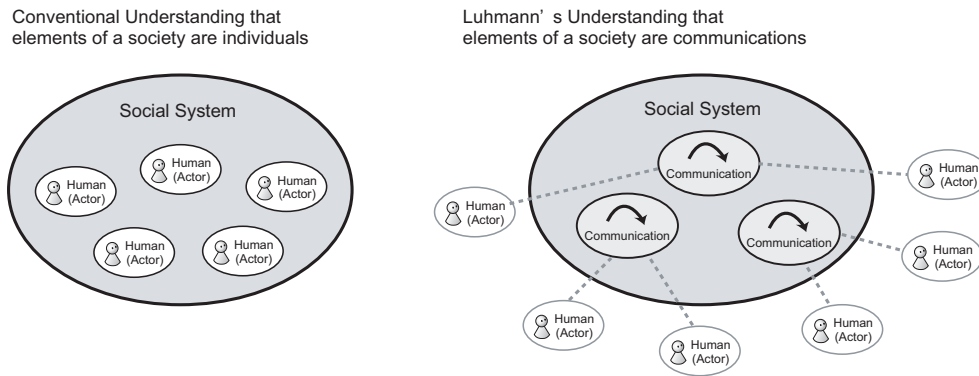


Figure 3: Understanding of the elements of society

parts of the society. In order to get over this kind of problem, he focus on the emergent system at the social level, and consider the fundamental element at that revel, which cannot be reduced into actor or action at the individual level (Figure 3).

The key concept of his theory is as follows. Society is autopoietic system, which is the nexus of communication, and the system can reproduces communication only by communication (Figure 4). Communication can have no duration because of momentary operation, so it must be reproduced constantly. From the viewpoint of operation, social system is a closed system. It means that it cannot receive communication from outside of the system, and also cannot give communication away to outside. In addition, mind of human is also autopoietic system, which he called “psychic system”. Psychic system is the nexus of consciousness, and the system reproduces consciousness by consciousness (Figure 5). Consciousness can have no duration because of momentary operation, so it must be reproduced constantly. From the viewpoint of operation, psychic system is a closed system. It means that it cannot receive consciousness from outside of the system, and also cannot give consciousness away to outside. Psychic systems are mutually inaccessible, therefore communication is necessary.

Luhmann applied his theory into a wide variety of social phenomena, including economy, law, politics, art, religion, education, science, mess media, family, and so on. Since his aim was to build a general theory of society, he mentioned the ecological communication in modern society. In his analysis, however, ecology is not treated as a “system” but just as phenomena on the side of “environment” of social system. It is inevitable because his theory is a “social” theory, not a theory for world as a whole. Then in the context of the social system theory, our approach in this paper can be considered as an extension of the social system theory into the area of nature. It will helps us to think the ecology and society at the same time and at the same stage.

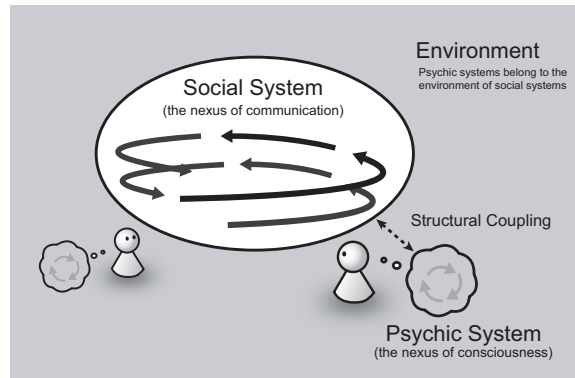


Figure 4: Social system as nexus of communication

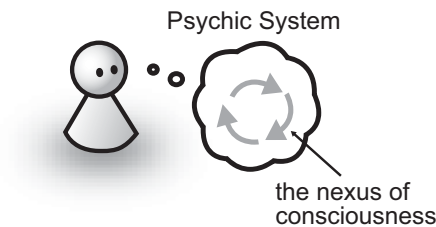


Figure 5: Psychic system as nexus of consciousness

3 Overview of Ecosystem as an Autopoietic System

Now we would like to show the overview of our proposed theory that ecosystem is defined as an autopoietic system. As well as Luhmann's theory, elements of ecosystem should be considered a momentary operation, not but individuals. Here we name the operation "substantial transference" (Figure 6).

Then ecosystem is emerged as an autopoietic system, which a unity whose organization is defined by a particular network of production processes of food chain and the substances transference (Figure 7). In the ecosystem, the producers convert inorganic compounds to organic ones, the consumers use them and decomposers change them to minerals and gas. It is clear that the ecosystem would be destroyed if the circulation stopped. All the living things get the substance from outside and maintain their lives. Although all actors do their best to keep their lives without the consciousness of parts of ecosystem, consequently their operation make the ecosystem.

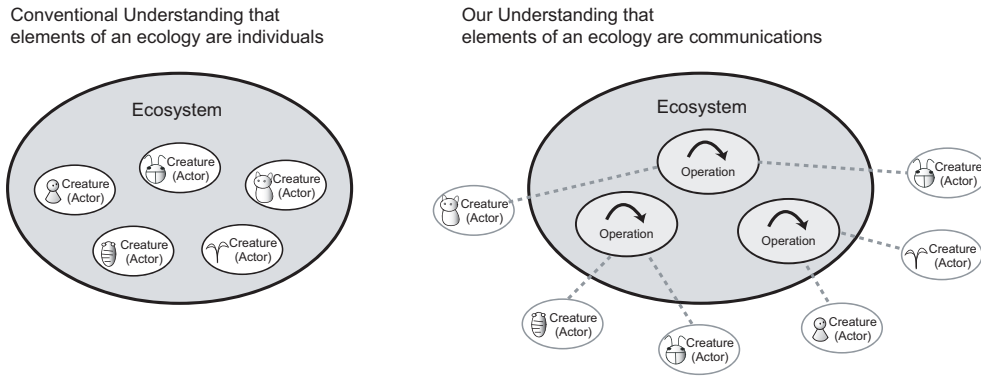


Figure 6: Understanding of the elements of ecology

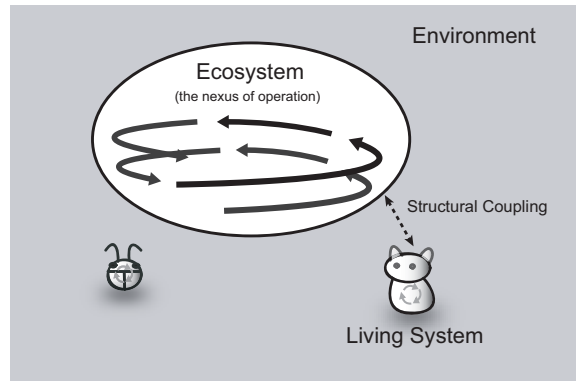


Figure 7: Ecosystem as nexus of ecological operation

4 Building a Theory of Ecosystem

Now we define some terms clearly to explain the ecosystem as an autopoietic system. For the purpose, we refer to the theory of economic system, which is one of the functional system of society (Luhmann, 1988), because ecosystem is similar to economic system, such as limited resources, competitions, evolution, irreversible time and so on. Note that an element of economic system is a kind of communication, named “payment”, and an economic system is realized by the nexus of payment. As we mention above, in our theory, the element of ecosystem is operation, named “substantial transference”, and ecosystem is realized by the nexus of the operation. Therefore it seems to be able to understand the operation of ecosystem by analogy from the payment of ecosystem.

Table 1 shows the list of the key terms of ecosystem and economic system. The items for comparison are element, three-part selection of operation, actor, code, and symbolically generalized communication media. Since we have already explained the element, we explain the latter items in the following section,

Table 1: The key terms of ecosystem and economic system

	Ecosystem	Economic System
Element	Operation (Substantial Transference)	Communication (Payment)
Three-Part Selection	Food/ Ingestion/ Digestion	Information/ Utterance/ Understanding
Result	Assimilation/Elimination	Acceptance/Reject
Actor	Creature	Person
Code	Biologically-Beneficial/ Non-Biologically-Beneficial	Payment/ Non-Payment
Symbolically Generalized Media	Affordance	Currency

4.1 Three-Part Selection in Operation

As Luhmann proposed, communication is a process of mutual selection. He insists that communication must be viewed not as two-part process like a conventional metaphor, but as three-part selection process (Luhmann, 1984). The conventional metaphor of communication is based on the concept of “transference”. In the metaphor, a sender passes a message (information) to a receiver, then the information moves from the sender to the receiver (Figure 8). Luhmann pointed out the limitation in this perspective because the idea is prepossessed with existence of information, and there is a concern that the information transferred between sender and receiver is thought to be the same one. Luhmann claim that this perspective misses to understand the nature of communication⁽⁴⁾.

Luhmann offers to consider the communication as a process of three-part selection; selection of “information”, selection of “utterance”, and selection of “understanding” (Figure 9). First, about the selection of “information”, there are enormous amount of sources to select as information. For example, if you meet a person, he/she has a lot of sources to select as information, such as his/her sayings, facial expressions, attitude, hair style, smell, atmosphere, and so on. No one can get all sources for information, and we have to focus on some sources. This means the selection of “information”. The selection of “information” is done by referring to the environment, and it is called “other-reference”. Second, about the selection of “utterance”, there are also many ways of expressing the information. If you look at the person and got the information, that means you used the visual representation. If you get information from e-mails or letters, you use the written words. If you get the information from his / her voice, you use the phonetic representation. The way of talking, such as cynically or playfully, is also related to the selection of “utterance”. The selection of “utterance” is done by referring to the system which the commu-

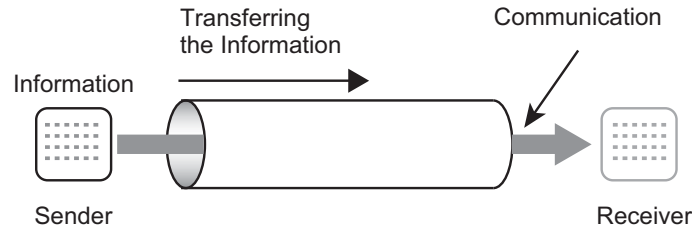


Figure 8: Conventional metaphor of communication

nication belong to, and it is called “self-reference”. Third, about the selection of “understanding”, people have to understand what the information which is uttered. They select the meaning in the context of the nexus of communication. These selections of “information”, “utterance”, and “understanding” occurs together at the same time, therefore it can be said that communication is emergent phenomenon (5).

Next, let us consider the three-part selection of the operation in ecosystem. In this paper, we propose the three-part selection as the selection of “food”, “ingestion”, and “digestion” (Figure 10). First, about the selection of “food”, there are enormous amount of sources to select as food (6). We here mention all kind of nutrient for all the creatures here. For plants the nutrition will be the vitamins and the minerals. Second, about the selection of “ingestion”, there are also many ways of ingesting the food (7). For the ingestion, creatures take something into their bodies, however they have not changed it to their body materials yet. They just have take into their body. There are some options for ingestion, and most of the creatures take in (eat) the materials of food from their mouth, but some creatures take in (absorb) the materials from their skin. Also some creatures take in substances from their legs or arms. Third, about the selection of “digestion”, creatures have to digest what the food which is ingested (8). The digestion means the change of the materials to their own body parts. So that they can use those materials for energy, growth, etc. Here is also selection according to the situation. It is clear that all the food we eat cannot be changed to our body. Some of the nutrition taken in, the others will not be absorbed.

These three stages have common characteristics. They are contingency and the reduction. The choices are contingency, and the selection is the reduction of contingency. The definition of contingency is “a possible event or occurrence or result” or “the event that may or may not happen”. Contingent state is not necessary, but it is not unpredictable. The information could have been another, transfer and understanding could have been too. Nutrient can be another factor, inclusion can be another way, and absorption can be different. Despite this kind of contingency, creature can do the operation. That is the reduction of contingency, which is the work for create operation.

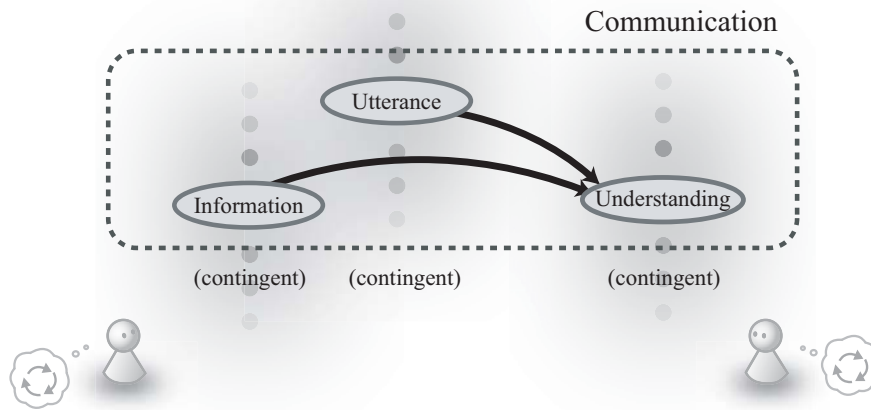


Figure 9: Three-part selection of communication in social system

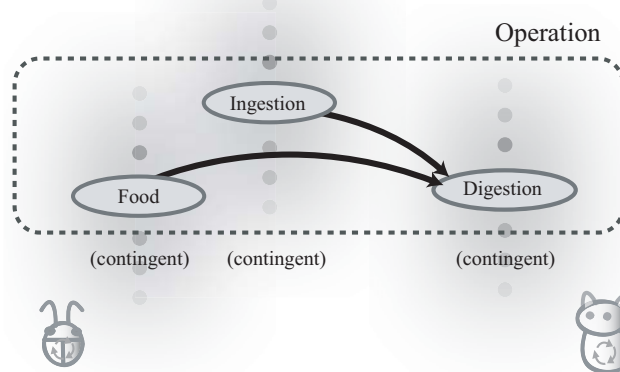


Figure 10: Three-part selection of operation in ecosystem

4.2 Result of Operation

In social system, the selection of “understanding” does not mean the acceptance of the communication. The actor can reject the specific meaning of communication instead of acceptance. For example, the person was waving his / her hand. Even if he/she wanted to say hello to you, you were sleepy and did not want to move, then you would ignore him/her. Therefore we should take care of the difference between “understanding” in the communication and “acceptance” of the actor. Thus communication is said to change the difference between “information” and “utterance” to either-or between “acceptance” or “rejection”.

That will also happen to the operation in ecosystem. In ecosystem, the selection of “digestion” does not mean the assimilation of the ingredient. The creature can eliminate the specific ingredient instead of assimilation. Even if the creature digests the substances into the body, it does not mean the assimilation. Therefore we

should take care of the difference between “digestion” in the ecological operation and “assimilation” of the creature. Thus ecological operation is said to change the difference between “food” and “ingestion” to either-or between “assimilation” or “elimination” (9).

4.3 Code for Operation

Inside of social system, there are many functional systems. Each functional system has a code; the affirmations and the denials. There are no other codes except those. In society there are a lot of words to explain the opposite concepts, just like firm and solid, good and bad, high and low, etc. It is troublesome to use such different kinds of words each time because the exception will be occurred. There are some materials which is not firm but not solid either. You don't need to look for two words with opposite meaning. What you have to do is pick up one word with a concept and make the denial word from it.

In Luhmann's theory, the code of Economic system is “payment” / “non-payment”. Each system uses their codes and distinguish the communication whether it belong to their system or not. In our theory, the code of ecosystem is “biologically-beneficial” / “non-biologically-beneficial”. Ecosystem use the code and distinguish the operation whether it belong to the system or not.

4.4 Symbolically-Generalized Media for Supporting Operation

Since there is uncertainty for realizing communication, it is intrinsically difficult that the nexus of communication is realized. However, in reality, some kind of evolutionary achievement, called “media”, support for communication to overcome the uncertainty. In the social system theory, Luhmann suggested some media such as “love”, “power”, and “currency” as the symbolically-generalized media for communication. These media activate the motivation of people for participating in communication, and bring the successful results of accepting the meaning of communication.

Then, what is the media for supporting the operation and the motivation to participate in ecosystem? We now focus on the concept from perceptual psychology. Creatures know certain things implicitly when they are born, which is known as “instinct” or “embodied knowledge”, for example, they have a sensor to search their target food and some specific functions of the body to catch and eat them. Some scientists insist that the order of material environment have afford creatures to act. The embodied mechanism into the environment is called “affordance”(Gibson, 1979) in perceptual psychology. The affordance would be embodied in color, smell, figure, or texture of the materials, which has been achieved by co-evolution of the creatures and environment. The affordance can be worked as media for supporting the realization of operation in ecosystem.

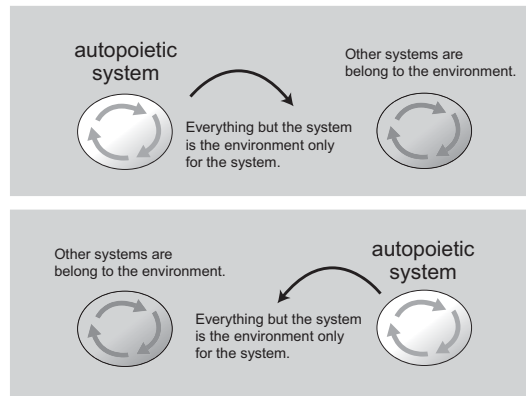


Figure 11: Systems which are located in their environment each other

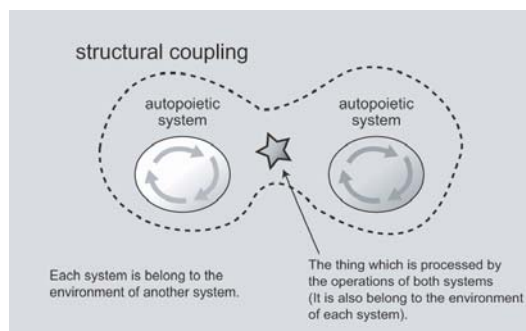


Figure 12: Structural Coupling of Autopoietic Systems

5 Discussion: Structural Coupling of Ecosystem and Social System

The relationship between function systems can be described with the concept of “structural coupling” in the autopoietic system theory (Figure 11 and 12). For example, social system and psychic system are structurally coupled with the medium of “language”⁽¹⁰⁾. Economic system and political system are also structurally coupled with the media of “tax” and “national budget”, and economic system and law system is coupled with the media of “contracts” and “property right”.

Think about this kind of relationship between ecosystem and social system, we have to consider the structural coupling of them.

6 Conclusion

In this paper we propose the theory of “ecosystem” as an autopoietic system, based on the concept of “autopoiesis” and social system theory, in order build a new

framework to understand the relationship between ecology and society. Considering ecosystem as an autopoietic system leads us to the possibility of the well-ordered unified understandings. We hope this framework will contribute to make an effective understanding of the ecology and society.

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Notes

- (1) Actually, Luhmann applied his theory into a wide variety of social phenomena, including economy, law, politics, art, religion, education, science, mass media, family, and so on. These applications prove that his theory is applicable to a lot of social phenomena.
- (2) There are some ideas to understand an ecosystem based on cybernetics, instead of autopoiesis. For example, most famous theory is GAIA hypothesis, where James Lovelock proposed the vision to consider the earth as a life (Lovelock, 1979; Lovelock, 1989).
- (3) Maturana and Varela also proposed their own perspectives of the society based on the concept of autopoiesis (Maturana and Varela, 1972).
- (4) The same kind of criticism to the perspective had been done by W. J. Ong (Ong, 1982).
- (5) Note that, in the social system theory, the selectivity does not mean to select from given choices, rather it means to create choices by itself at the same time. As Luhmann states that “Communication grasps *something* out of the actual referential horizon that it itself constitutes and leaves *other things* a side.” (Luhmann, 1984, p.140).
- (6) The term “food” means “Material, usually of plant or animal origin, that contains or consists of essential body nutrients, such as carbohydrates, fats, proteins, vitamins, or minerals, and is ingested and assimilated by an organism to produce energy, stimulate growth, and maintain life.” (Soukhanov, 1992). This term is sometimes used to mean “Something that nourishes or sustains in a way suggestive of physical nourishment” such as “food for thought”, so the term seems to be related to “information”.
- (7) The term “ingestion” means “To take into the body by the mouth for digestion or absorption” (Soukhanov, 1992). The synonym of the term is “eat”, “consume”, “devour”. The position to use the term is reversed from that of “utterance”, however the meaning of the term can be considered to be related to “utterance”.
- (8) The term “digestion” means (1a) “The process by which food is converted into substances that can be absorbed and assimilated by the body. It is accomplished in the alimentary canal by the mechanical and enzymatic breakdown of foods into simpler chemical compounds.” (Soukhanov, 1992), (1b) “The result of this process”, and (1c) “The ability to digest food” (Soukhanov, 1992). It also means (2) “The process of decomposing organic matter in sewage by bacteria” (Soukhanov, 1992), or (3) “Assimilation of ideas or information; understanding” (Soukhanov, 1992). From the last meaning, the term seems to be related to “understanding”.

- (9) The term “assimilation” means (1a) “To consume and incorporate nutrients into the body after digestion.” (Soukhanov, 1992), (1b) “To transform (food) into living tissue by the process of anabolism; metabolize constructively.” (Soukhanov, 1992). It also means (2) “To incorporate and absorb into the mind” (Soukhanov, 1992), so the term seems to be related to “acceptance” of the actor.
- (10) One of the media of coupling between consciousness and communication is “language”, which is distinguished by the use of signs. The language is a means of communication and also of thinking, as Luhmann noticed that “linguistically formed thoughts play a part in the autopoiesis of consciousness, help to produce it” (Luhmann, 1984).

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* This paper is for Fourth Joint Japan-North America Mathematical Sociology Conference, May, 2008. (Contact Us: E-mail to Corresponding Author, Takashi Iba at iba@sfc.keio.ac.jp)