

A Collaborative Tool for Modeling and Simulating Social Complex Systems

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Abstract

The goal of this research is to develop tools and method for collaborative thinking about social complex systems with computer simulation. The tools proposed in this paper help modelers to develop a simulation program just by drawing model diagrams in the modeling language. We also explore a new method for collaborative modeling conducted by two modelers, which we call “pair modeling”. We take up comments by modelers and discuss what happens in pair modeling, applying social system theory. As a conclusion, we suggest that pair modeling is effective method for collaborative thinking, which is essentially different from single modeling.

1 Introduction

In a complex society we live in today, it becomes important to increase one’s thinking power to understand the complex phenomena, which is difficult to understand intuitively because of their complex consequence. In the complex society, it is also required to collaborate with others in order to solve social problems. However, the thinking and collaboration are not automatically realized, thus we should consider a tool and method for them. In this paper, we focus on social simulation as a tool for collaborative thinking. Modeling a society and simulating the model will give us a chance to understand a society’s mechanism and gain new perspective (Figure 1).

In this paper, we propose tools and method for collaborative thinking about social complex systems with computer simulation. Then, we take up the comments by modelers in order to show the effectiveness of our proposed tools and method. Finally, we discuss the method in detail, applying social system theory.

2 Background

As a beginning, we will examine the concept of complex systems. There is no shared defi-

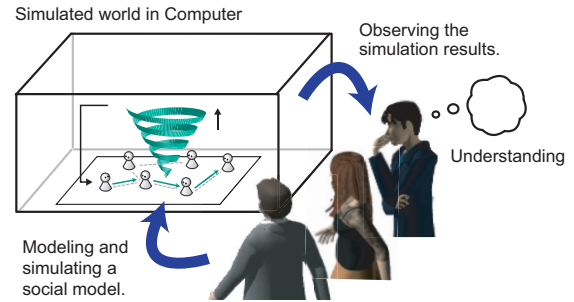


Figure 1: Collaborative thinking about social phenomena with computer simulation

nition of complex systems among the scientists, but we can say that the definition is able to be summarized in two ways as follows: In a broad sense, the complex system means that the system has the components where each component changes the internal states by mutually interacting with the other components. In addition, in a strict sense, the complex system means the system where the rules of each component’s behavior are changed dynamically during the simulation. Many researchers and we almost agree that the agent-based model (multi-agent model) is suitable for studying social complex systems.

Based on the background, we proposed the model framework for agent-based model, which we call “PlatBox foundation model” (Iba, 2004; Iba, 2006). The framework defines the set of concepts for modeling societies, consisting five major elements: “Agent”, “Relation”, “Behavior”, “Goods”, and “Information”. “Agent” object is defined to describe an autonomous actor who does an action. The relation between agents will be described by “Relation” object. The behavior of the agent is defined as “Behavior” object, which is described as a state machine that is a system which changes the state when the event is received. “Goods” can be defined as material / immaterial things which are possessed by Agents in order to be used or to be exchanged with other agents. The information which is possessed by Goods or Agents is defined as “Information” in the model.

3 Tools for Collaborative Thinking

In order to support making the simulation models with the proposed framework, we propose tools for modeling and simulating social complex systems: “PlatBox Simulator” and “Component Builder”. PlatBox Simulator is a software platform to execute and to analyze the agent-based social simulations. It is developed to realize an extensible software application with the component-based architecture. The modeler can obtain the simulation environment which suits the needs, only if he/she sets necessary model components into the platform.

Component Builder is the tool for designing the model component plugged into PlatBox Simulator. With using the tool, a modeler can develop a simulation program just by drawing model diagrams in the modeling language¹. As a result, the modeler comes to be able to make the simulation as long as they have little skills of programming. Moreover, the modeler can make and change their model promptly, and then can give priority to the trial and error in modeling and the analysis of the consequences.

Component Builder consists of five designers and a composer: “Model Designer” for modeling the static view of the simulation (Figure 2), “Behavior Designer” for modeling the behavior of agents, “Action Designer” for describing details of actions of behavior (Figure 3), “Activity Designer” and “Communication Designer” for conceptual modeling, and “World Composer” for setting the initial state of the simulation world (Figure 4). They are the tools to generate the program code just by making the diagram and setting the parameters with a graphical user interface (Aoyama et al., 2004).

4 An Example of Modeling

As an example of a simulation model built with Component Builder and PlatBox Simulator, we introduce “Movie Theater Model” here.

4.1 Model Overview

The movie theater we focused is independent theater that shows films like art films instead of

¹From the viewpoint of software engineering, our approach is based on the emerging development process, which is driven by modeling: “Model-Driven Development” (Iba et al., 2004). We can use the high-level language for development, instead of writing in the lower-level language, i.e. program code. Note that the modeling language used on Component Builder is Unified Modeling Language (UML).

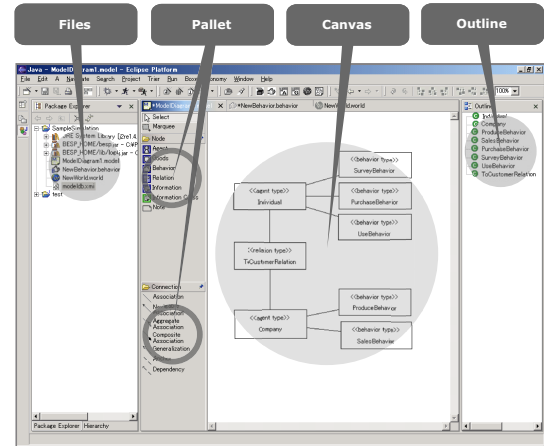


Figure 2: Model Designer of Component Builder

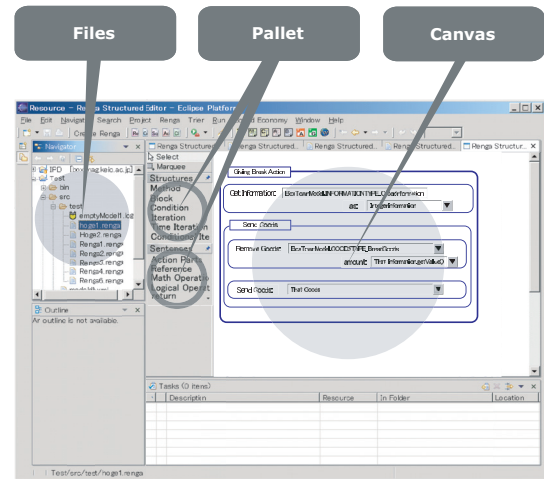


Figure 3: Action Designer of Component Builder

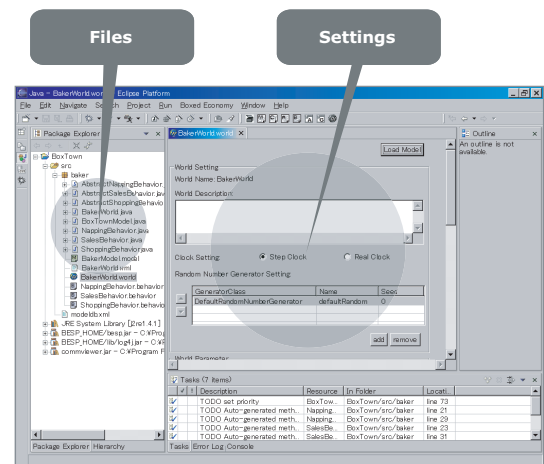


Figure 4: World Composer of Component Builder

major films. Due to its small market and resource for advertising, word-of-mouth marketing becomes essential to the theaters. Therefore, the purpose of simulating and analyzing “Movie Theater Model” is to find the most efficient method of advertising using word-of-mouth marketing.

4.2 Model Description

In this model, there are two agents: “Movie Theater” and “Customer” (Figure 5). Movie Theater agent has “Advertising Behavior”, and Customer agent has “Chatting Behavior”. The relation from Movie Theater agent to Customer agent is “Advertising Target Relation”, and the relation among the Customer agents is “Friend Relation”. The information which these agents send and memorize is “Movie Information”.

Based on these elements, the simulation steps are as follows. First, Movie Theater agent randomly selects a numbers of Customer agents, and then links an Advertising Target Relation. Second, Movie Theater agent makes Movie Information, Third, Movie Theater agent sends Movie Information to selected Customer agents. Forth, Each Customer agent sends Movie Information to Customer agents with Friend Relation. Then, repeat Step.4.

In modeling on Component Builder, we draw the statechart diagram and action block diagram in order to describe the flow of the simulation. There is no space to show all diagrams in this paper, so we take only two diagrams as examples (Figure 6, 7).

4.3 Code Generation and Simulation

After generating the program code from the diagrams, the simulation will be executed on Plat-Box Simulator (Figure 8). We can observe the process of information becoming widespread, changing the initial settings.

In this case, we draw 5 diagrams, which are a class diagram, two statechart diagrams, and two action block diagrams, and set 1 world-setting. From the diagrams and settings, Component Builder generate 1043 lines program. The breakdown of code size is shown in Table 1.

5 Method for Collaborative Thinking

In this paper, we propose “Pair Modeling” which is a collaborative modeling conducted by two modelers. This way of modeling is the applica-

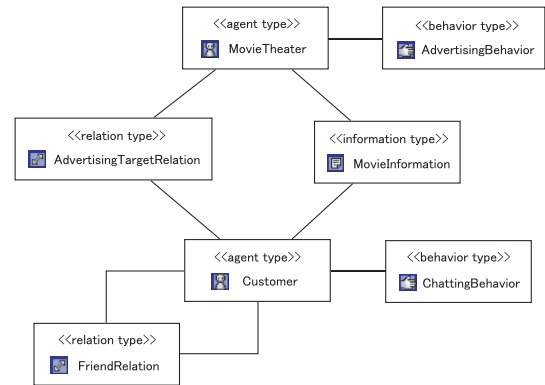


Figure 5: Class diagram (Movie Theater Model)

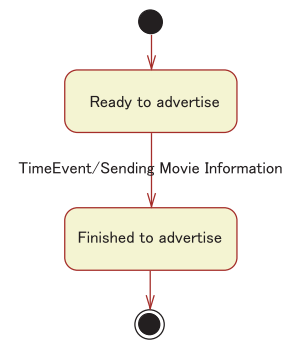


Figure 6: Statechart diagram of Advertising Behavior (Movie Theater Model)

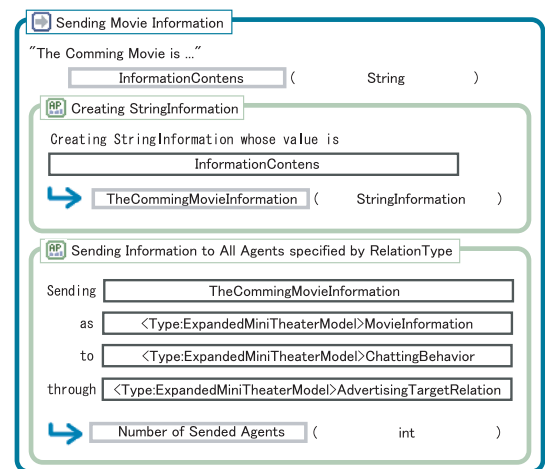


Figure 7: Action block diagram of a part of action in Advertising Behavior (Movie Theater Model)

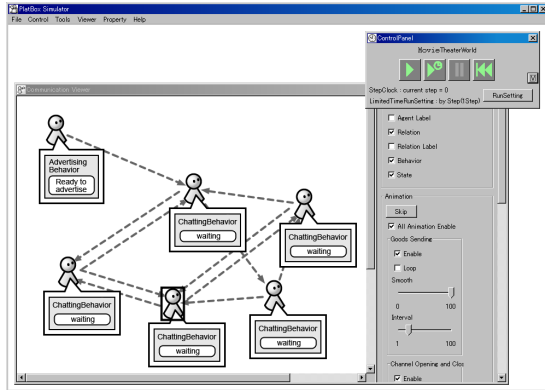


Figure 8: Simulating Movie Theater Model on PlatBox Simulator

tion of “Pair Programming” in software development (Williams and Kessler, 2003).

5.1 Pair Modeling

Generally speaking, modeling is considered as a work done in alone by facing a computer screen. Comparing to this, in pair modeling, two modelers use the same computer at the same time, and conduct modeling by communicating with each other. To share the role in pair modeling, it is divided into two parts called “Driver” and “Navigator” after the manner of pair programming. Driver draws a model by computer using keyboard and mouse. Navigator operates whole modeling by grasping the modeling strategy and pointing out the next step watching driver’s work from a side. These two roles are switched to one another in a certain time period. The time length of the period is varied in each occasion, it could be a certain period of time or it could be an extemporizing switch by saying phrases such as “Can I do this part?” or “Let me do this part.”

Pair modeling is considered to improve the quality of a model and productivity of modeling more than usual modeling which two modelers make different models separately and put them into one. Along with this research, the study of

Table 1: Amount of the diagrams and program code of Movie Theater Model

Tool	Diagram	generated code
Model	1 diagram	82 lines
Behavior	2 diagram	184 lines
Action	2 diagram	305 lines
World	1 setting	472 lines



Figure 9: Pair Modeling on laptop PC

the effect of pair programming in software development help this. In pair programming, it is already known that it produces higher quality model than to give two separate works to each of them (Williams and Kessler, 2003). The point is, two of them make up their weak part with the process of making a model, and by doing so it generates the multiplier effect. Later we shall discuss it in details.

5.2 Pair Modeling with Tools

In what form should our proposed tools be used to increase the effectiveness of pair modeling? Here are three possibilities.

First, there is a pair modeling using a laptop computer (Figure 9). This form would likely be the most common method, allowing many modelers to work anywhere without any special preparation. However, due to the size of the screen, a diagram and letters can be hard to see by the others.

Second, there is a pair modeling using a big screen. By doing so, model diagrams and letters can be seen easier, allowing smooth pair modeling. However, a big screen must be prepared and the screen would be likely to limit the working environment.

Third, there is a pair modeling using a tablet PC (Figure 10). As a merit for using a tablet PC would be the fact that intuitive modeling becomes possible using a pen. A characteristic of modeling using Component Builder is that it uses model diagrams and visual language instead of implementation by programming language. Therefore, there would be little problem about inputting the characters using a pen on tablet PC. By preparing two pens, either of the pair can be the “driver” according to the situa-



Figure 10: Pair Modeling on tablet PC

tion, allowing to cooperating easier. It, however, can only be done if there is a tablet PC. If not, it cannot be done.

6 Some Experiences: Pair Modeling with Component Builder

In my laboratory, there are some research projects that build simulation models by pair-modeling. Here, we would like to show some comments given by the modelers about the process of pair modeling, the advantage / disadvantage, and the tool. Figure 11 shows the comments in the case of beginner-beginner pairing, where they build the network simulation. Figure 12 shows the comments in the case of expert-beginner pairing, where they build the financial market simulation. Figure 13 shows the comments in the case of expert-expert pairing. According to these comments, it is likely that the method of pair modeling is effective for collaborative thinking, although the measurement and evaluation is a task for the future.

7 Discussion

We shall discuss what happens in pair modeling in detail. The question here is whether there is

a substantial difference between single modeling and pair modeling. Our answer is that pair modeling is essentially different from single modeling.

On the theoretical side, we think that social system theory is of value to our analysis here. So, in the rest part of this paper, we would like to consider what happens in pair modeling, applying social system theory. The theory we applied here is autopoietic theory proposed by the sociologist Niklas Luhmann (Luhmann, 1984). In the first place, we illustrate an overview of social system theory, especially as it relates to communication, and then we consider what happens in pair modeling with using the theory.

7.1 Social System Theory

Luhmann's theory is based on the concept of "autopoietic system". Autopoietic system means that "the elements of the system are produced within the network of the system's elements, that is, through recursions" (Luhmann, 1995). With using this concept, Luhmann suggests that the communication is the element of social system and the system reproduces itself², although an actor or action is considered as the element in the conventional sociology.

According to Luhmann, a thinking of human being is autopoietic system, which he called "psychic system". Psychic system is the nexus of consciousness, and the system reproduces consciousness by consciousness. Consciousness can have no duration, 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.

On the other hand, society is autopoietic system, which he called "social system". Social system is the nexus of communication, and the system reproduces communication by communication. Communication can have no duration, 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.

²Luhmann applied his theory into a wide variety of social phenomena, including economy, law, politics, art, religion, education, science, mass media, family, and so on. The applications show that his theory is applicable to a lot of social phenomena.

Modeler A (Beginner)

- Process

"In pair modeling, we first talked about the progress we've made so far, and then we set our goal that is achievable in that day. We did the modeling little by little as we were making sure that it's going right. When a trouble came up, we went back to where it was over and over again. We got a help from some experts when we really didn't have any idea of what to do after we organized what the problem really was."

- Advantage and disadvantage

"I think the advantage of doing pair modeling is that it helps me to organize many things in my mind as I try to explain my idea to my partner. Also, by doing pair modeling, I was able to get an idea from my partner that I wouldn't come up with. What's good about pair modeling is that I can talk with my partner as much as I want till I really understand what it is since there are only two of us, and we can make up our weak points each other. I thought the disadvantage of pair modeling is that if one sticks to an idea, that stops the whole modeling process, and in that situation, pair modeling is not the one. "

"It was harder than I expected to do pair modeling with a pair of two beginners. Well, even though we were beginners, I thought it was interesting when I learned something throughout the process of pair modeling by trial and error. Another thing is that it had something to my motivation. Doing modeling with my partner, he asked me to do the best what I could do so I also had some responsibility to it, and I was able to work hard for his respect."

- Component Builder

"I think it was impossible to do modeling all by myself without Component Builder since I had no knowledge or skill of computer programming at all. If it were pair modeling, it might not be impossible to do modeling but still it would be really hard. Even if I manage to complete the modeling somehow, my contribution to the modeling will be little."

Modeler B (Beginner)

- Advantage

"We both were beginners, so we did modeling by trial and error, and every time one of us made a progress, we showed each other's work and talked about it. We also shared one computer to exchange our idea. I thought I could get more things such as new idea and my mistakes from it because we were able to talk about it in pair modeling. Also in pair modeling, the thing is that I didn't have to feel alone because there were two. I'm proud that beginners like two of us achieved to complete the model, and now I really have a feeling that if it weren't two of us, it was unable to do it."

- Component Builder

"I think the good thing of Component Builder is that we can communicate with each other by drawing model diagrams with it, not by writing a computer program."

Figure 11: Modelers' comments in the case of beginner-beginner pairing

According to Luhmann, communication is defined as the synthesis of three selections: "information", "utterance", and "understanding". Note that communication is not just sending of a message, and understanding is indispensable for communication. Then there must be at least two people, in a word, communication is an emergent unity on social level. Thus communication cannot be reduced into action of individuals like methodological individualism.

In summary, there are psychic systems and social systems as autopoietic systems in the real world. Psychic system reproduces itself by reproducing consciousness, and social system re-

produces itself by reproducing communications. Psychic systems belong to the environment of social systems, however social systems are not composed of psychic systems. Luhmann pointed out that "Consciousness is enlisted in the reproduction of communication, and communication in the reproduction of consciousness *without fusing the two*" (Luhmann, 1984).

For coupling of these different types of system, the form of "media" is considered. 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,

Modeler C (Expert)

- Advantage and disadvantage

"I think the advantage of pair modeling is that we were able to bring what we wanted to analyze into focus as we making a model. As a result, the length of the time of making and reproducing a model has gotten shorter, and that brought us higher quality model in a shorter time than to do it by oneself. But I think if you have a clear idea of a model then you better do it by yourself because pair modeling takes more time and cost."

- Component Builder

"I think it was easy to talk about a phenomenon we wanted to analyze and to make a model of it with model diagrams by Component Builder. If this were a pair programming by writing programming source code, we might be able to discuss the actual process of it but I don't think we were able to have a discussion that would make what we wanted to analyze clear. Also using Component Builder, the time cycle of "designing, building, and experimenting" has been speeded up, as a result, I think we managed to speed up re-building and re-executing a model."

Modeler D (Beginner)

- Advantage

"I think by doing pair modeling, the work efficiency has been improved since I was able to get notices in every step, and that led me to the right way. I could ask even a small question every time that came up in my mind randomly. I kept having a good tense throughout the pair modeling since I had a partner and I got the tasks done better than to do it just by myself."

- Component Builder

"I say, to develop a model based on diagrams using Component Builder is very practical. For us, a model diagram is some kind of common language and by using it, we were able to share one's understandings of the model to others smoothly."

Figure 12: Modelers' comments in the case of expert-beginner pairing

Modeler E (Expert)

- Advantage and disadvantage

"I guess the advantages of pair modeling are that to keep our motivation higher, set specific goal, and set precise working procedure. The disadvantage is that if our schedule doesn't match, then the progress of the work downs a lot since there are only two."

"I don't think I wasn't able to complete making a model if I were alone. Rather than that, I think the pair modeling had something to do to our mental such as to keep our motivation higher, and if there are two, the work progresses surely. At this point, we tend to finish up our work just in between two of us so that I think it's better to have some review from others, not only to review in the pair."

- Component Builder

I think to develop a model based on diagrams using Component Builder was really useful. But, if you are familiar with UML, then you are able to do modeling till certain level without this tool."

Figure 13: Modelers' comments in the case of expert-expert pairing

as Luhmann noticed that “linguistically formed thoughts play a part in the autopoiesis of consciousness, help to produce it”(Luhmann, 1984).

7.2 Pair Modeling as a Social System

Now we explain the method of modeling with using social system theory. In the situation of single modeling, the modeler makes a model by the nexus of consciousness as psychic system (Figure 14). On the other hand, in the situation of pair modeling, the modelers make a model by the nexus of communication as social system (Figure 15), in addition to each modeler’s making by the nexus of consciousness as psychic system.

The important thing, in pair modeling, is that two modelers have to communicate with each other besides “externalizing” a model on a computer which they have in their mind, and understanding it by watching the model. For instance, hands typing on a keyboard suddenly stops if one starts to think about what he/she is doing or why he/she is at a stand still. Then his/her partner starts to wonder why. So one would say “What happens?” or “What was the variable?”, and the other one would respond to it saying “Let’s find out what it is.” and those communication continue. In the process of modeling, the modelers use the several languages as media: natural language, Unified Modeling Language (UML), and Action Block Language (ABL), and occasionally programming language.

Now we understand theoretically that pair modeling is not only an activity of thinking but also an activity of collaboration on social level³.

8 Conclusion

In this paper, we proposed tools and method for collaborative thinking about social complex systems with computer simulation. The tools are open to the public on <http://www.platbox.org/>. Creating tools and method for collaborative thinking with computer simulation is an oversized project for our members to complete. We would like to realize it by collaborating with many researchers in various fields. Please contact us, if you are interested in our challenge.

³Luhmann pointed out that there are three types of social system: “interactional”, “organizational”, and “societal”. In our view, pair-modeling is interactional social system, because of involving people being physically present together.

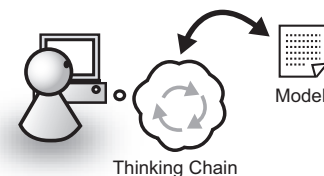


Figure 14: System analysis of single modeling

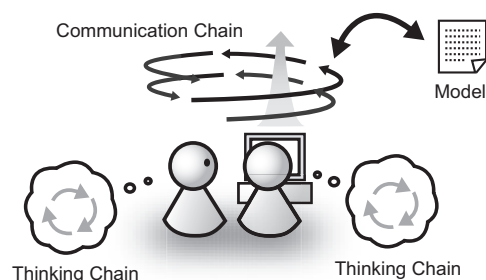


Figure 15: System analysis of pair modeling

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