Boxed Economy Simulation Platform for Agent-Based Economic and Social Modeling

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1 Introduction

The recent advancement of agent-based modeling and simulation has been revolutionizing the social sciences, and the expectations are rising in social sciences. In the current state in the study of simulating agent- based economic models, however, there are some problems, as follows, that need to be resolved: (1) absence of integrated environment to support a whole research process, (2) difficulty in reusing program components of model, (3) entry barrier of programming, and (4) difficulty in securing the software quality of simulation. These problems did not become serious too much up to now, because the models were small-scale and for experimental use. It becomes, however, indispensable to resolve these existing problems, as the simulations come to be used practically in social science and policy analysis. In this paper, we propose concrete solutions to resolve the problems in the study of simulating agent-based economic models.

2 Background

In the last some years, several languages, frameworks and tools for agent-based simulations have been proposed. For example, "Swarm Simulation System", which seems to be the most famous and to be used, provides the class library (Objective-C language and Java language) for the simulation of complex adaptive systems[1]. "MAML" (Multi-Agent Modelling Language) which is macro language for Swarm makes programming more easily than original Swarm[2]. As well as Swarm, "RePast" (REcursive Porous Agent Simulation Toolkit) provides the class library (Java language) to make the multiagent model[3]. "Ascape" provides the framework (Java language), and it is said that the amount of the code description can be less than that of Swarm and RePast[4].

These support systems try to solve the problem with a necessary support to the model builder who has a little (or, no) experience of the computer programming. As the solution, those systems assist the model builders to write programs by providing a general library and framework, and in fact these systems are useful for the reduction of programming.

These systems, however, support for the model builders to build the agent-based model including the molecular interaction or the ecosystem, but not to build the economic or social model directly. In the social scientific viewpoint, it is necessary to share some basis, for example, the scheme for modeling, terms, and description method.

Moreover, these systems do not support to share the simulation models among two or more researchers, although they support for the model builders to construct the simulation alone. In order to support such a cumulative research process, the design rule for the model by which perpetuity and the reusability of the model are considered



Figure 1: Screenshot and Structure of Boxed Economy Simulation Platform

becomes indispensable. The design rule enables us to divide the model into some piece of modules, which can be reused.

3 Our Approach

3.1 Boxed Economy Simulation Platform (BESP)

We would like to propose a sharable basis for agent-based economic simulations, which we call "Boxed Economy Simulation Platform" (BESP). BESP is a software platform to make, to execute, and to analyze the agent-based economic simulations¹ (Figure 1). BESP is designed to realize an extensible software application with componentbased architecture. The user can obtain the simulation environment which suits the needs, only if he/she sets necessary components into the platform. There are two kinds of components built into the platform: that is "model component" and "presentation component". The model component is a software component that implements the model which the user wants to simulate. The model component is made based on the "Boxed Economy Foundation Model", which is mentioned later. The presentation component is a software component for the user interface to operate and to visualize the simulation, and the output into the file. The simulation is executed by setting up the economic model as the model components and the user interface as the presentation components in BESP.

Model components and presentation components are independent each other, communicating indirectly by sending and receiving the events through BESP. Therefore, the user simulates his/her original economic model with existing presentation components even if he/she makes only the model components. In contrast, the user makes his/her original user interface as presentation components that do not specialize in a specific economic model.

From the viewpoint of software program, BESP is multi-platform software which is implemented in object-orientated Java language. BESP is executable on Java Virtual Machine regardless of the operating system. In a word, BESP is executed quite similarly even if the users are using a different computer environment. Moreover, the users who are using different computer environments can share the components, because the component for BESP does not depend on the computer environment in which it is made.

¹Boxed Economy Simulation Platform (BESP) is able to be downloaded freely from our web page (*http://www.boxed-economy.org/*). Or please contact us by E-mail to *box-designers@crew.sfc.keio.ac.jp*.



Figure 2: Basic design of Boxed Economy Foundation Model (UML class diagram[7])

3.2 Boxed Economy Foundation Model

In BESP, "Boxed Economy Foundation Model" is provided as a framework of the model component, which is specializing in agent-based model of economic society. The foundation model is an abstraction of the structure of the real economic society by classifying and relating with Object-Oriented analysis ²(Figure 2).

The user can adopt the policy of modeling provided in the foundation model as a reference when modeling. Moreover, the user does not have to care about details by how those elements are actually executed on the computer. The user describe his/her model only by using the vocabulary in the foundation model, such as "Goods" or "Channel". It can be said that the concept which the foundation model provides is simpler and easier than operating the program directly.

The foundation model also enables us to share and reuse the model components among the model builders, because the granularity and the policy of modeling will be equal if the model components are made based on the foundation model. In addition, efficient communications among model builders become possible because they can use the name of model elements in the foundation model as a vocabulary.

4 What does BESP Bring to Us?

4.1 Providing Integrated Environment for Seamless Research Process

BESP provides the integrated environment by which a whole research process is executed on only a piece of software platform. As a result, the automatic execution with changing the initial settings and to check the behavior of the consequence becomes possible, because all processes are executed on a set of software platform. In addition, systematic management of the models and the programs becomes also possible with the software platform.

4.2 Supporting for Reusing Components

BESP provides the setup to reuse the program components of the models by Boxed Economy Foundation Model and the model components. Reusing the model compo-

 $^{^{2}}$ Figure 2 shows only the simple diagram of Boxed Economy Foundation Model. See our paper[5] for more detail class diagram and explanations.



Figure 3: Model Component Builder and Model Composer for building model

nents is realized by the foundation model specialized in the domain of agent-based economic models. In addition, the tools to visualize and analyze the simulation results can be shared as well as the model components, because they are built as the reusable component.

4.3 Breaking Through the Entry Barrier of Programming

BESP provides the setup by which the programming to make the simulation is greatly reduced. As a result, the user comes to be able to make the simulation as long as they have the basic skills of programming, they do not have to make the design and the implementation concerning the structure which make the programming more difficult. Moreover, the user can make and change their simulation promptly, and then can give priority to the analysis of the consequences.

The reduction of the programming is supported by the following three manners. First, many programs that is necessary to simulate an agent-based economic model are already implemented in the body of BESP. Second, the tools which support to make the simulation programs are provided as presentation components³. Third, model components and presentation components can be reused, and then the user decreases the amount of the programming if a part of the model which they want to use has already been made. The component-based development, by which simulations are made only by combining and setting the component, becomes possible if the cumulating the model components is enhanced in the future. Thus, many of entry barriers from the social scientist are removed.

4.4 Supporting for Securing the Software Quality of Simulation

BESP provides the setup to secure the software quality of simulation without enlarging the load to the user. It narrows the range to make the verification, which is the inspection to the correct coding from the model to the computer program. The narrowing the range results from the reduction of the programming, which has been described above.

³ "BESP Model Component Builder" and "BESP Model Composer" are provided with BESP. These are components to generate the simulation program automatically just by making the state chart diagram and setting the model with a graphical user interface (Fgure 3).

First, each user only has to check the part newly implemented by himself / herself, because the programs provided by BESP are already tested. Second, The user released from a deliberate check on the program if they use the supporting tools, such as "Model Component Builder" and "Model Composer", because human errors at the programming are eliminated by generating the program automatically with these tools⁴. Third, the range of verification is narrowed if they reuse the model components, which have already been tested.

5 Conclusion

In this paper, we discussed how "Boxed Economy Simulation Platform" (BESP) resolves the existing problems in the study of simulating agent-based economic and social models. The tool is used for resolving the following problems in study of agent-based economic models: (1) absence of integrated environment to support a whole research process, (2) difficulty in reusing program components of model, (3) entry barrier of programming, and (4) difficulty in securing the software quality of simulation.

The existing problems are resolved by BESP in the following manners: (1) the integrated environment to consistently support the research process is provided, (2) reusing the program components of models is supported by the Boxed Economy Foundation Model and the model components, (3) programming by user is greatly reduced in BESP, where the tool supports for modeling and implementation of simulation, and reusing of components, (4) the software quality of simulation is improved without enlarging the load to users, because the programming human errors are decreased by BESP, where most of programs for simulation are prepared in BESP.

Creating the foundation for the social simulation researches is an oversized project for our members to complete. We would like to realize this by collaborating with many researchers in various fields. Please contact us on *http://www.boxed-economy.org/*, if you are interested in the challenge.

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⁴It is pointed out that the code generator can describe the code by 10000 times early, and can decrease the error to 1/1000 compared with the human even if the performance is the lowest[8].