**Boxed Economy Foundation Model**

for agent-based economic/social simulation

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**The gap**

- The area of agent-based economic/social modeling and simulation has two natures
- These two areas had been trying two merge, but they are not enough confluent yet.
The gap

We need the well-defined primitive terms and framework to describe the society by agent-based approach.

We need the system to implement and manage the complex and dynamic social simulations efficiently.
The gap

Boxed Economy Project

Model framework  Simulation Platform
Boxed Economy Project

Introduction Video!

Agenda

1. Boxed Economy Foundation Model
2. Understanding BEFM with an Example
3. BEFM to Simulation Platform
4. The Road Ahead
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Main Class Diagram of Boxed Economy Foundation Model

- a model framework which has a tight focus to human economy/society.
Let’s run through some details of Boxed Economy Foundation Model!

**World and Entity**

World is defined as an environment in which Entity are placed. Note that the classes defined as Entity are Agent, Goods, Information, Behavior and Needs. Only one instance of World would be created in each simulation model.
**Clock**

**Clock** is defined as the class to manage the flow of time in the model, during the execution of the simulation. **Agent** acts by the passage of the time of **Clock**. Each model, actually each instance of **World**, holds only one instance of **Clock**. In BEFM, it is not defined how to implement the model of time yet. Therefore, the model builder will determine in which form time would be implemented such as "year/month/day/hour/minute/second" or discrete integer.

**TimeOfDay** is defined to describe a point of time in the model. **Clock** holds the instance of **TimeOfDay** as a present time. **Time** is defined as the difference between two points of **TimeOfDay**. We can also calculate **TimeOfDay** by adding **Time** to **TimeOfDay** or subtracting **Time** from **TimeOfDay**.

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**Location**

**Location** is the class to describe a spatial position in the model. The spatial position of **Agents** and **Goods** would be described with using **Location**, and their migration and transportation can be described by changing the values of **Location**. In BEFM, a concrete implementation of **Location** is not defined yet. Therefore the model builder makes a choice of implementation, such as two-dimensional lattice space, three-dimensional Euclidean space, or even implementing no space in the model at all.

**Direction** and **Distance** are the classes which shows the relationship of two points of **Location**. In addition, **Region** is defined to be composed of two or more **Locations**, and **Area** is defined as the spatial size of **Region**.
**Goods**

Goods can be defined as material / unmaterial thing which is possessed by Agent in order to use by himself/herself, or to exchange with other agents. For instance, the objects modeled as Goods can be automobile, oil, corn, financial stock, right of land, books, advertisings, diaries, memorandum, water, voice, noises, garbage, money, and so on.

Goods can be specified by the kind, the quality, and the amount by using GoodsKind, GoodsQuality, and GoodsQuantity. Goods have Location in order to describe where it is. In addition, Goods often holds Information describing various contents. For instance, a newspaper can be modeled as an object that the newspaper article (as Information) is printed on a paper (as Goods), and a conversation can be modeled as an object which contents (as Information) is conveyed on the voice (as unmaterial and transient Goods).

**Information**

The Information which accompanied by Goods and stored in the Agent are defined as Information. Information will never exist alone, and be always held by Goods or InformationManager of Agent. Information held in InformationManager is the information stored in the Agent internally, for example it can be described as ”memory” and ”genetic information” in the real world.

Information holds InformationContents which can be copied. The classes which would be defined as InformationContents are RelationInformationContents, ChannelInformationContents, NeedsInformationContents, GoodsInformationContents, BehaviorInformationContents, GoodsQuantity, GoodsKind, GoodsQuality, Location, NeedsStateDifference, Time, and TimeOfDay.
Agent

Agent is defined to describe an autonomous actor who does the economic activity. Each individuals and social groups such as corporation, government, family, school, regional community, and country are all dealt as an Agent in the model. In the model, Agent exists as a more specific class: Individual or SocialGroup. Individual and SocialGroup inherit all the characteristics of Agent. Agent possesses more than one Behavior, Information, Relation, and Goods. Agent holds and manages them by each manager: BehaviorManager, InformationManager, RelationManager and GoodsManager. In addition, only Individual possesses Needs, and manages it by NeedsManager.

Behavior

The behavior of the agent is defined as Behavior. Various activities such as decision-making, production, trade and communication, are described by Behavior of Agent. Two or more Behavior can be managed in parallel inside an Agent. In BEFM, the internal state is given to each behavior, and the internal state is dynamically changed respectively. Behavior is defined as a state machine, which is a system that changes the state when the event is received. Behavior holds more than one instance of BehaviorState, and a present state as currentState.
State Transition of Behavior and Some kinds of Events

Behavior changes the state by receiving an event which means the stimulus from outside. There are three kinds of Event in BEFM: ChannelEvent, ClockEvent, and NeedsEvent. ChannelEvent is an event sent from Channel. It holds Goods and delivers them to the listener behavior. NeedsEvent is an event sent when Needs becomes to a certain state. ClockEvent is an event sent when time passes on Clock. It holds TimeOfDay and delivers it to the listener. Each Event is sent from the object implemented the EventDispacher to the object implemented the EventListener.

Needs

Needs is hold only by Individual, and activates the Behavior of the Individual. Needs holds two or more NeedsStates. The needs holds the state which becomes a target as targetNeedsState and the state which becomes a present state as currentNeedsState. The difference in two states is NeedsStateDifference, which represents the strength of Needs. Needs is able to is patch NeedsEvent to Behavior if necessary. Needs is a model element which moves dynamically by the time passage (reception of ClockEvent).
An agent in a model usually has some kind of relationship with other agents rather than being isolated. In BEFM, the situation of a fact that a certain agent knows other agents will be described by Relation. By using Relation, for example, friends, family and employment can be described. Relation is an object by which two Agents are connected with the direction. Relation is managed by Agents through RelationManager.

When an agent communicates with others, Channel will be established between the Behaviors of the agents based on Relation. Note that Channel does not connect between Agents but connects between Behaviors.

All communications between Behaviors will be abstracted as a deal of Goods through Channel. First, Channel is used to exchange Goods, such as commodities, contents of the conversation, and money, between Behaviors of Agents. Secondly, the cooperation of Behavior inside Agent is also done by exchanging Goods on Channel. By the abstraction, it is possible not only to standardize the model expression but also to raise the independency of the model components of Behavior.
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A Simple Example:
“The corporation replies the request sent by the individual.”

Static View

World

“SampleWorld”

Agent

SocialGroup

“CellTypeLocation”

Relation

“reply”

“request”

“GlobalClock”

Clock

Location

Individual

“Mr. Customer”

Goods

“The Kind Corporation”
A Simple Example:
“The corporation replies the request sent by the individual.”

“Mr. Customer”
“SendRequestBehavior”
“CollectGoodsBehavior”
“SendBackBehavior”

“GlobalClock”

“the channel to the corporation”
“the channel to the sender”

“Goods”

“reply”

“SendBackBehavior”

“The Kind Corporation”

“Mr. Customer”

“SendRequestBehavior”
“CollectGoodsBehavior”
A Simple Example:

“The corporation replies the request sent by the individual.”

State Transition View

“A Simple Example: 

“The corporation replies the request sent by the individual.”

“Mr. Customer”

“The Kind Corporation”

A Simple Example:

“The corporation replies the request sent by the individual.”

State Transition View
A Simple Example:
“The corporation replies the request sent by the individual.”

State Transition View

A Simple Example:
“Mr. Customer”
CollectGoodsBehavior
ChannelEvent
waiting for goods to receive
PutGoodsIntoManager
SendBackBehavior
ChannelEvent
waiting for the request
CreateGoods
ready to reply
SendBackGoodsToLastSender

The Kind Corporation

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Boxed Economy Simulation Platform (BESP)

- An integrated environment to make, execute, and analyze the agent-based social simulations.
- Implemented in Java language.
- The source code and detail specification are opened to the public.

BESP and Boxed Economy Foundation Model

BESP is designed to realize an extensible software application with component-based architecture. The user can obtain the simulation model and environment which suit the needs, only if he/she sets necessary components into the platform.
### Support to Build the Behavior Components

**Behavior Component**

BESP Model Component Builder generates the java program code, just by making the state chart diagram and setting the model with a graphical user interface.

### Support to Compose the Simulation Models

**BESP Model Composer**

BESP Model Composer is a tool (presentation component) to compose and set the model which wants to be simulated by graphical user interface.
Sharing Components based on Boxed Economy Foundation Model

Boxed Economy Foundation Model provides the design of the software architecture of social simulation for sharing and reusing the model components among the simulation builders, so that it will accelerate the P2P sharing of the models and components. It keeps the components on track by defining the rule for designing the components developed in the future.

The role of Model Framework

- Frame of reference for recognizing the target world
- Vocabulary for describing the model
- Code for communications among the model builders
The role of Model Framework

- Design of the software architecture of social simulation
- Bridge to the specific simulation platform

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Boxed Economy Project is a student research group!

Keio University, Japan
Graduate School of Media and Governance
Faculty of Environmental Information
Fund-Supported partly by Fujita Institute of Future Management Research, Japan

Project Leader
Takashi Iba
He is Ph.D Candidate on Graduate School of Media and Governance at Keio University. Now he is also assistant professor at Chiba University of Commerce. His research interests are social simulation methodology and complex systems.

Dr. Yoshiyasu Takefuji
He is tenured professor on faculty of environmental information at Keio University. His research interests focus on neural computing and hyperspectral computing.

Dr. Heizo Takenaka
He was tenured professor on faculty of Policy Management at Keio University. Today, He is Minister of State for Economic and Fiscal Policy, and Minister of State for IT Policy, Cabinet Office since 2001.

Project Members
Yoshihide Chubachi
Kohei Kato
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Kanichio Kamihashi
Yuu Yamada
Harumi Morikubo
You Nagami
Masaharu Hikone

Preparation and Launch of Boxed Economy Project

Studies market simulations
(Takashi Iba’s Master thesis)
• Winner-Take-All phenomena in Format Competition of Video Cassette Recorder (VHS vs. Beta)
• Bubble and Crashed at Stock Market
• Wrote the book “Introduction to Complex Systems” (in Japanese)

Started the project called “In-The-Box” project to build a basis for sharing the simulation.
• Started the working group to make an agent-based simulation of entire economy.
• As a result, we came to realize that the economy is too complex to build from a scratch.
• Reaffirmed importance of component and framework.

Started new project called Boxed Economy Project.
• Designed the Initial version of Boxed Economy Foundation Model.
• Analyzed and Designed by Object-Oriented approach.
• Applied Unified Modeling Language (UML).
Research & Development of Boxed Economy Project

- Improved the initial version of Boxed Economy Foundation Model.
- Prototyping of Boxed Economy Simulation Platform
  - Building Component by Java Beans
  - Implementing the improved initial version of BEFM

- Developed the initial version of Boxed Economy Simulation Platform
  - Applying Design Patterns
  - Introducing Rational Unified Process (RUP)
  - Use-case driven development
  - Introducing Extreme Programming (XP)
  - Pair programming
  - Unit test

**Aug. 2001 - Dec. 2001**
- Refactoring the initial version.
- Developed Boxed Economy Simulation Platform (ver. 1.0)
  - Model Composer
  - Model Component Builder
  - Some Presentation Components
  - Applying Design Patterns, RUP, and XP

The Road Ahead, Boxed Economy Project

**Aug. 2002 -**
- Refactoring and Improving BESP and BEFM, then releasing version 1.
- Remaking "BESP Model Component Builder" as more user-friendly presentation component.
- Preparing some more presentation component to visualize, analyze, control, and report to database.
- Especially, Implementing the presentation component to support for managing large number of experiments.
- Translating the documents and comment at source into English
- Making the on-line materials to understand how to use.
- Simulating some sample models on BESP
- Exploring Design Patterns originally for Agent-based Social Modeling with BEFM
Boxed Economy Foundation Model
for agent-based economic/social simulation

Welcome!!!

If you are getting interesting in our projects and software, Please E-mail to
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