Project for New-Type Simulators **Working Paper Series**

Working Paper No.13

Simulating the Classical International System:

A Model of Balance-of-Power System

Built on the Agent Based Simulator (ABS)

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Introduction

Computer technology advances rapidly, and it has benefited various aspects of human activities. The study of international relations is no exception. When Stuart Bremer and Michael Mihalka attempted to build their first refined computer simulation model of the classical balance-of-power about 20 years ago or Eiji Danno and Akihiko Tanaka rebuilt the advanced version of Bremer-Mihalka model 10 years ago[1], the limited technology prevented them from doing more extensive and detailed research, though their discoveries about the mechanism of the balance-of-power system are very interesting. For example, when Danno and Tanaka simulated their model, they had to use the large-scale computer at the university and, even using such a system, it took very long time to run the model and they could not utilize GUI (Graphical User Interface). In addition, it was also very difficult for many social scientists --- the inexperienced in computer --- to use the user-unfriendly computer system in those days. Recent technological progress has changed these conditions drastically. The processing ability has being improved radically and the more massive calculation has become possible.

In addition to this technological change, more scientists have been paying attention to the new, at least recently noticed, methodology. In the traditional scientific research, two types of methodologies have been taken as normal. One is the inductive (or positive) methodology and the other is the deductive (or theoretical) methodology. In the inductive way, the most important research is the observation or the analysis of the observed data. On the other hand, in the deductive way, the equivalent activity is the logical reasoning or analyses from the general proposition. Contrary to these traditional methodologies, in the recently noticed “third” way, the experiments are carried out in the *computer* and we might call this third methodology “abductive”. Moreover, though there are various types of computer simulations, the scientists, influenced by the distinctive research advance of *complexity*, have been more interested in the Multi-Agent type of simulation.

Considering these changes of the situation, we decided to build a new computer simulator for the social scientists --- the purpose of making it possible that the social scientists build their own model without any computer specialists’ help. The name of the

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[1] Stuart A. Bremer and Michael Mihalka, ”Machiavelli in Machina: Or Politics Among Hexagons,” in Karl W. Deutsch,ed., *Problems of World Modeling* (Boston: Ballinger, 1977). Eiji Danno and Akihiko Tanaka, ”The Stability of International System,” in Yoshinobu Yamamoto and Akihiko Tanaka eds., *Senso to Kokusai Shisutemu* (*War and International System*)(Tokyo: University of Tokyo Press.1991).

simulator is *Agent Based Simulator (ABS)*[2] and in this paper we attempts to make Danno-Tanaka model with this new simulator.

This paper consists of two sections. The first section describes the simulation rules of Danno-Tanaka model. The second section introduces the ABS version of Danno-Tanaka model. The main purpose of this paper is to introduce our new simulator. The analysis of the data collected through the simulation is to be done elsewhere.

The simulation rules of the Danno-Tanaka model

This section describes the basic simulation loop. At first, the initialization of the parameters is necessary. The model has eight parameters --- initial power average, initial power standard deviation, misperception average, misperception standard deviation, contingency in war, basic war cost, reparations, and harvest. The meaning of each parameter will be clarified later.

The agent is to be called the state throughout this paper simply because our model is the balance-of-power system. The interaction between states in the simulation model is described as *a turn* and each turn consists of eight phases. A turn is a process in which a state might wage war or give up the intention; if war breaks, the winner will get the new territories from the loser and the loser will be ruined if it lose all the territory. Reiterating these turns, finally only one state can exist in the international system and then the game is over. Figure 1 shows the flow of a game.

[2] About *Agent based Simulator*, see http://www2.kke.co.jp.

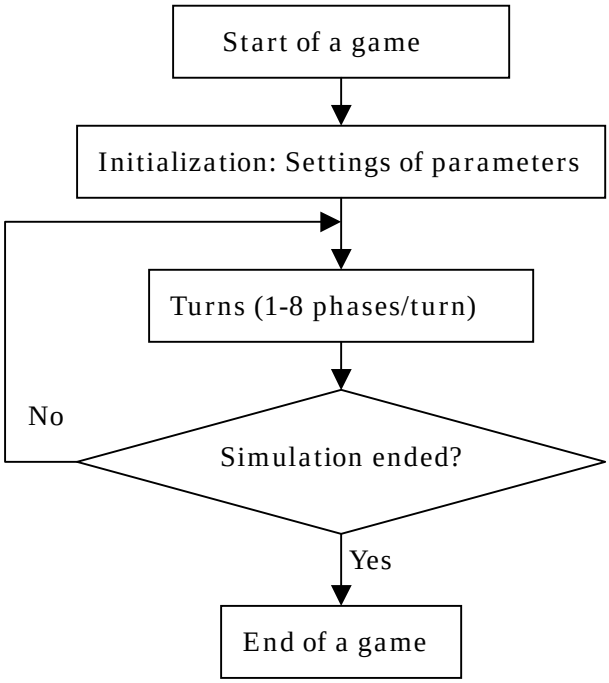

Figure 1. Cycle of a game

Turns

Figure 2 shows the flow of each turn.

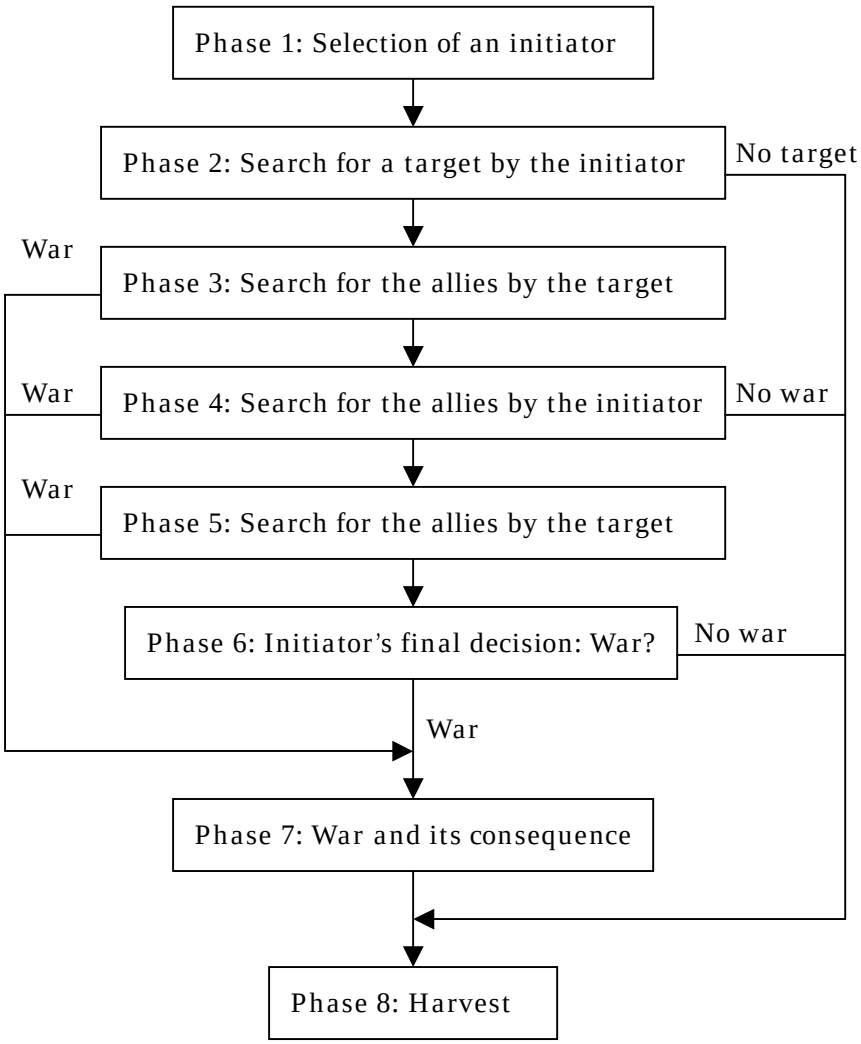

Figure 2. A turn of the simulation

(a) The first phase --- the selection of the initiator

In this phase, the initiator --- who intends to wage war --- is chosen. The selection is to be done according to the random numbers weighted by states' power proportion. This rule means that the more powerful state is inclined to wage war than the less one, but there still remains the possibility that even the weakest state intends to wage war.

(b) The second phase --- the selection of the target

In this phase, the initiator selects the target to attack. The initiator evaluates the power of the contiguous states and decides to attack the state whose power is less than its own. If the initiator is superior to more than two states, it selects the weakest one. As the initiator's evaluation includes the misperception, there is a possibility that the initiator makes the mistake of selecting the more powerful state than itself. If the initiator perceives all contiguous states more powerful, it cannot attack any states and the process goes to the eighth phase.

(c) The third phase --- the response of the target

The target has to decide whether it fight with the initiator alone or form the alliance. At first, the target evaluates the power of the initiator and if it perceives the initiator less powerful, then it decides to wage war by itself and the process goes to the seventh phase.

On the other hand, if the target perceives the initiator more powerful, it decides to form the defensive alliance. The target evaluates the states surrounding the initiator and asks these states to join the alliance according to the alliance formation rules.

The alliance formation rules

Condition 1: Exclude the state if the state had already joined the other alliance.

Condition 2: The ally must be contiguous to the enemy.

Condition 3: The total power of the allied states must be greater than the total power of the allied enemies.

Condition 4: The minimal alliance satisfying the Conditions 1 – 3

Each asked state evaluates powers of the target state, other asked states, and the initiator. If the state perceives the total defensive power more powerful than the initiator, it decides to join the alliance.

When the alliance formation rules cannot be satisfied or any states do not decide to join, the effort to form the alliance fails and the process goes to the seventh phase. If even one state comes to join, then the process goes to the fourth phase.

(d) The fourth phase --- the response of the initiator

Once the defensive alliance is to be formed, the initiator compares it's own power with the allied enemy's power. If the initiator perceives itself superior, it wages war --- the process goes to the seventh phase.

On the other hand, if the initiator perceives the allied forces more powerful, it begins to form its own alliance according to the same formation rules as the defensive one. If the formation rules cannot be satisfied or any asked states do not decide to join, then the initiator gives up the attack and the process goes to the eighth phase.

Once any asked states join the offensive alliance, the initiator evaluates the formed alliance. If the initiator perceives the alliance more powerful, the process goes to the fifth phase; otherwise the initiator gives up the attack and the process goes to the eighth phase.

(e) The fifth phase --- the final response of the target

The target compares its own alliance with the offensive alliance. If the target perceives the defensive more powerful, the process goes to the seventh phase and the war breaks out. If the target perceives the offensive more powerful, it tries to strengthen its own alliance according to the same rules as in the third phase. If its effort is to be successful and new states join the defensive alliance, the process goes to the sixth phase; otherwise the process goes to the seventh phase and the war breaks out.

(f) The sixth phase --- the final decision of the initiator

The initiator evaluates the strengthened defensive alliance. If it perceives the defensive more powerful, it gives up the attack and the process goes to the eighth phase; otherwise the process goes to the seventh phase and the war breaks out.

(g) The seventh phase

The consequence of the war depends on the *true* total power of both the defensive and the offensive, and the contingency --- fortunate or unfortunate of the time. Comparing the defensive power with the offensive multiplied by normal random number (average: 1.0, standard deviation: indicated as the parameter), the side of the greater power becomes the winner. This means that if the power difference between the two sides is slight, the luck brings the

reversion of the situation.

The next thing to be considered is the cost of the war. In this model the war costs all participant states. The war cost is calculated by the following formulas. The power of each participant after the war is $Pw - Pw*WC$ (*Pw*: a state's power).

$$WC = (1 - \frac{PB - 0.5}{0.5}) * BWC$$

(WC: The Rate of War Cost, PB: The Rate of Power Balance, BWC: Basic War Cost)

$$PB = \frac{TPV}{TPV + TPD}$$

(TPV: The total power of the victorious states, TPD: The total power of the defeated states)

These formulas satisfy the following assumptions.

Assumption (a): The war cost depends on the severity of the war.

Assumption (b): The more balanced the power of the two sides, the severer the war becomes.

There are also the reparations after the war. Each defeated state has to pay the reparations, which are calculated by the state power multiplied by the reparations rate (a parameter). The winners distribute the reparations in proportion to their power.

In Addition to the reparations, the defeated state must cede its territories to the victorious state.

Restriction (a): Only the leader of the defeated alliance cedes its territories.

Assumption (c): The number of the ceded territories depends on the severity of the war.

Assumption (d): A state territories must be continuous, not separated

by the other states.

If a state loses all its territories, the state is to be considered ruined.

(h) The eighth phase: harvest

Whether the war occurs or not, the existing states at the end of a turn get new power in proportion to their territories. Each territories have it's own *land power* and the new power is calculated by the land power multiplied by the harvest rate (a parameter).

Parameters and the selection of rules

As we have said, this simulation model has eight parameters. Now, the meanings of these parameters are explained. Tabale1 shows an example of parameter settings.

Parameter	Value
Initial power: average	10.00
: standard deviation	1.67 / 3.33 / 6.67
Power misperception: average	1.00
: standard deviation	0.10 / 0.20 / 0.40
Contingency: standard deviation	0.20
Basic war cost	0.10
Reparations	0.10
Harvest	0.03

Table 1 Settings of parameters

(1,2) The initial power: average and standard deviation

At the beginning of a game, this parameter indicates the normal random number by which the land power of each territory is distributed. At the same time, these land power become the initial power of the states occupying the territory. Therefore, the larger the standard deviation becomes, the less equal the distribution of power among states becomes.

(3,4) The power misperception: average and standard deviation

This parameter indicates how accurate states perceive the power of

the other states. If the misperception becomes larger, the state overestimates or underestimates the power of the other states.

(5) Contingency

This parameter means the “fortune” of the time. The larger the standard deviation becomes, the more the consequence of the war depends on the contingency.

(6) The basic war cost

As we said, the war cost is calculated by this parameter (see above formulas).

(7) Reparations

This is the rate at which the defeated states pay reparations to the victorious states.

(8) Harvest

After a turn, each state gets the land power from their territories.

In addition to these parameters, this simulation model has the qualitative variations.

(a) The rule of the decision-making

In this variation, we have two types of decision-making: “the risk-taking” and “the risk-averse”. In this simulation, if the turns include the sixth phase, the state may be the risk-averter or otherwise the risk-taker.

(b) The rule of the state-identification

This rule also has two types: “the state-identification” and “the state-indifference”. If “identification” turns on, each state perceives the power of other states differently. State A might overestimates the power of State B, but underestimates State C. On the other hand, if “identification” turns off (that is, “indifference” on), states perceive all other states at the same rate of misperception. If State A overestimates State B, then it overestimates State C as well.

(c) The rule of the perception-reshuffle

One type is “perception-reshuffle” and the other is “ perception-consistence”. If the reshuffle turns on, at the beginning of every turn simulator generates the new normal random number for the parameter of the misperception. On the other hand, if the consistence turns on, states keep the same misperception until the end of the game.

ABS version of the Danno-Tanaka model

In this section, we show the ABS version of Danno-Tanaka model. As we said, this paper does not aim at analyzing the simulation data, but shows how graphically this new simulator realizes the old simulation model that could not be run with GUI completely.

Figure 3 is the screen of the ABS version of Danno-Tanaka model (not run). Using “Control Panel”, the parameters can be set without any difficult operations.

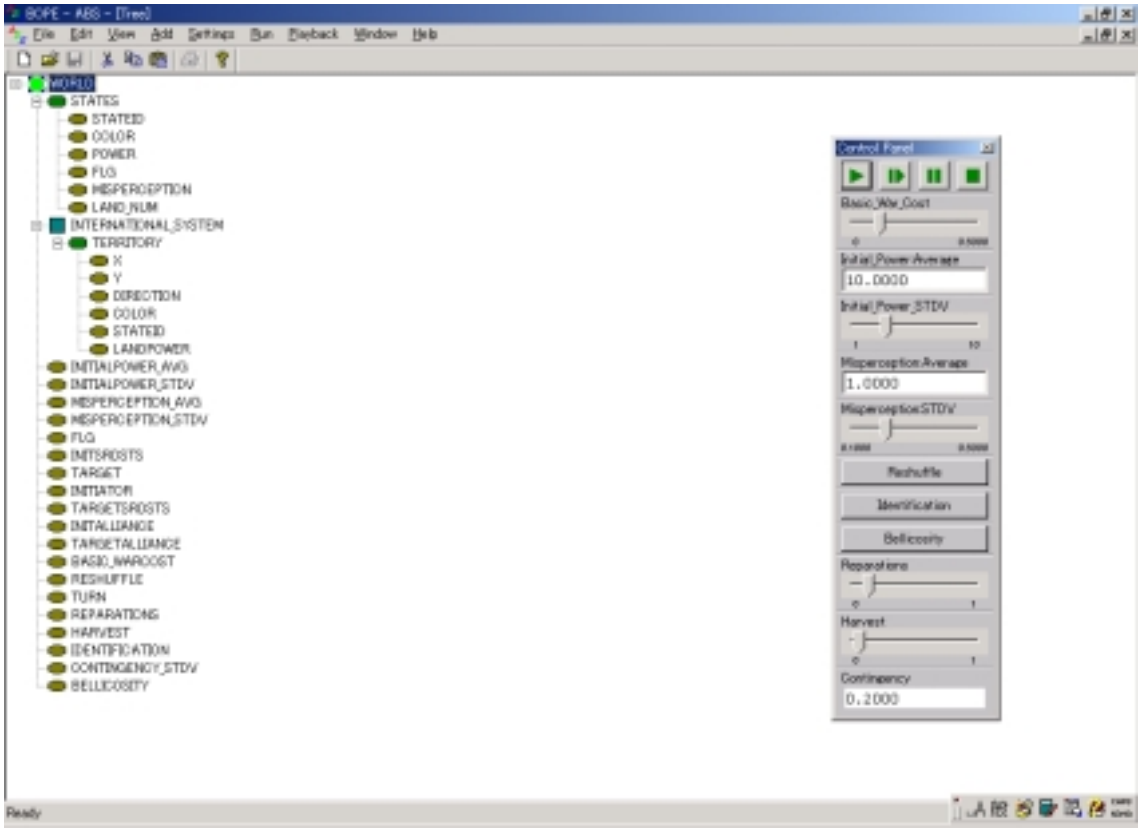

Figure 3. The screen of ABS (not run)

Figure 4 is the initial picture of this model. 98 states exit in the virtual

international system.

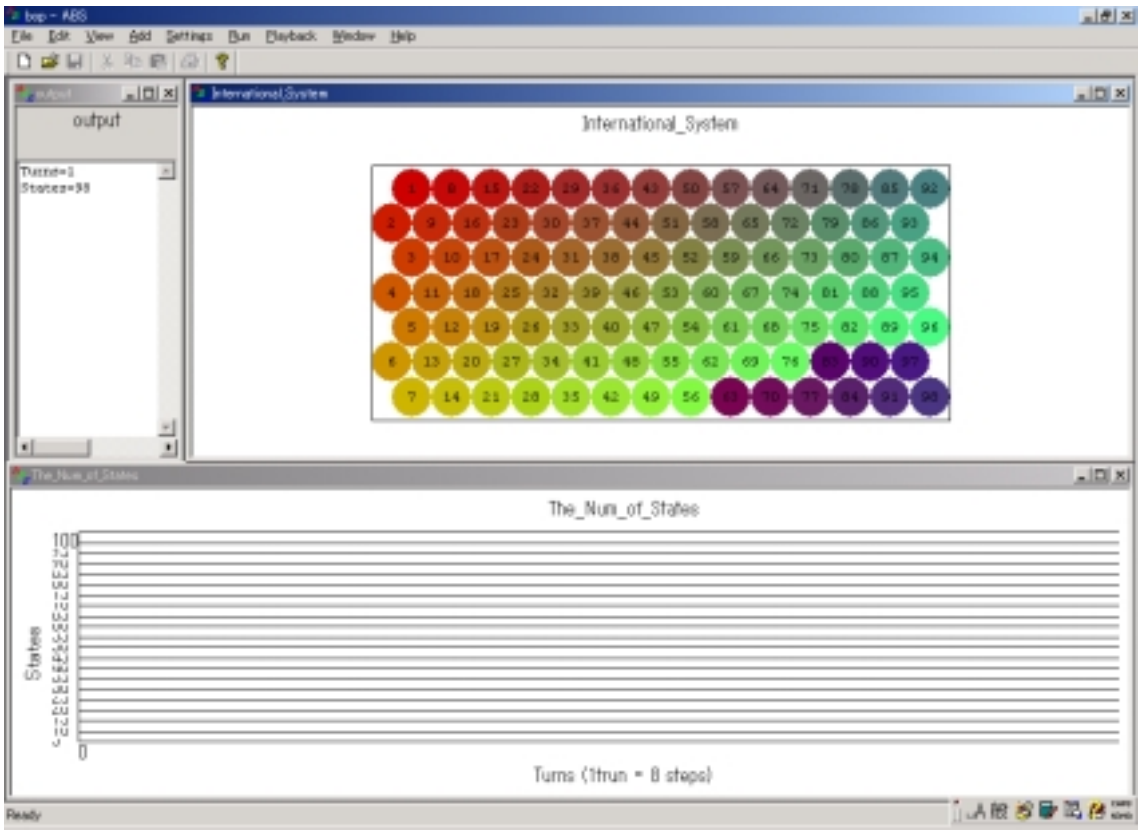

Figure 4. the initial picture of Danno-Tanaka model

The following figures show each phase of the Danno-Tanaka Model.

At Phase 1, the initiator is selected. In this case, state no.3 was chosen and became red.

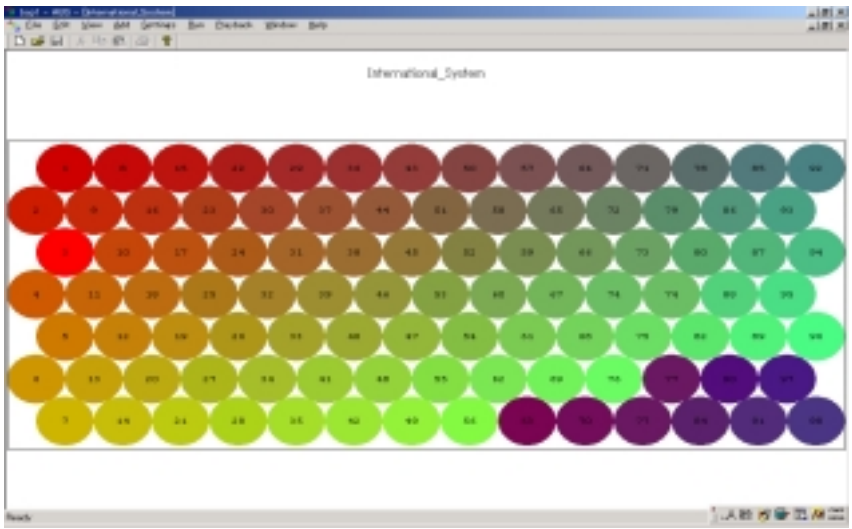

Figure 5. A picture of Phase 1

At Phase 2, the initiator chooses its target. In this case, state no.2 was the chosen target and became green.

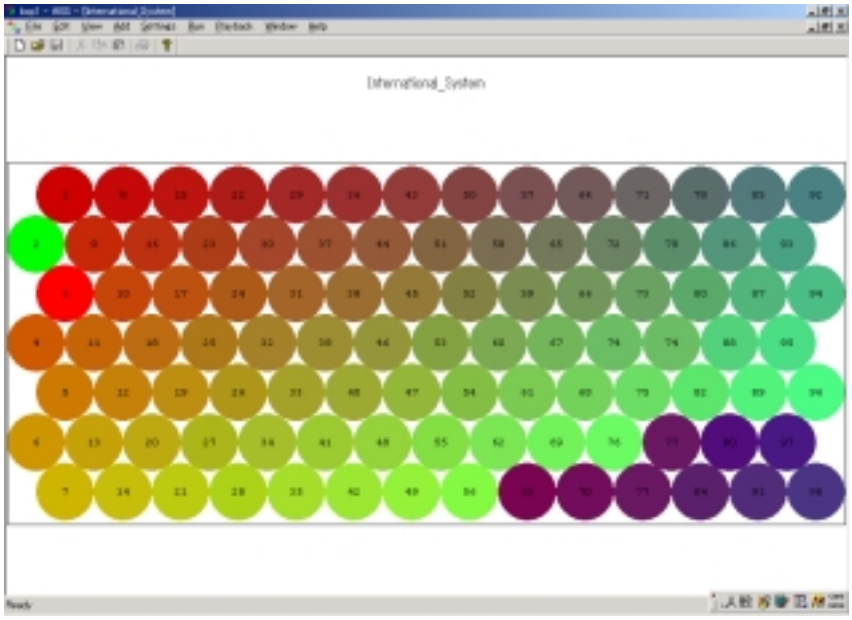

Figure 6. A picture of phase 2

At Phase 3, the target searches for the states that would join its alliance. In this case, state no.4 joined the alliance with the target.

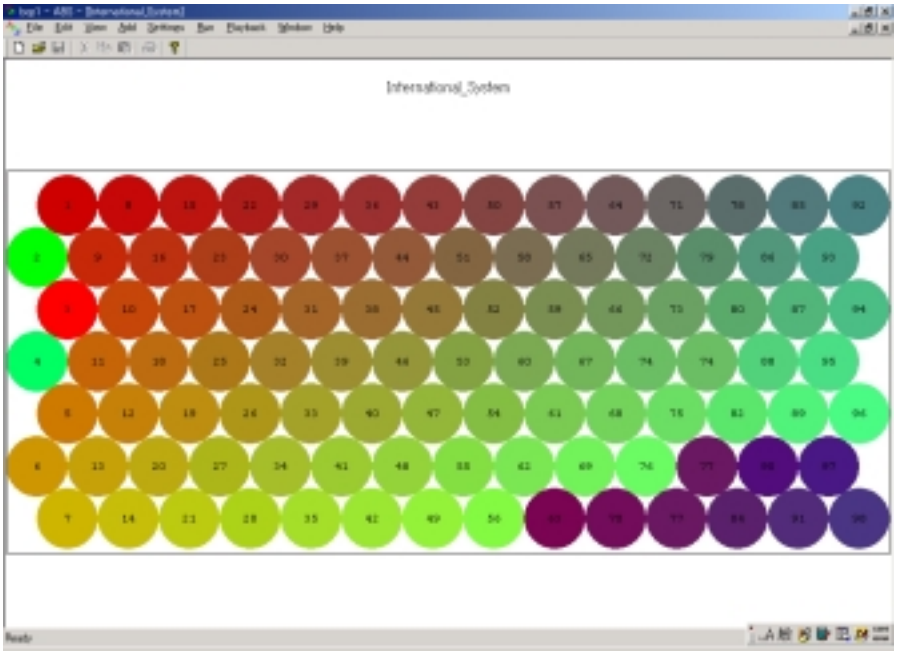

Figure 7. A picture of Phase 3

At turn, the initiator searches for its own allies in Phase 4. In this case, state no.1 joined the alliance with the initiator.

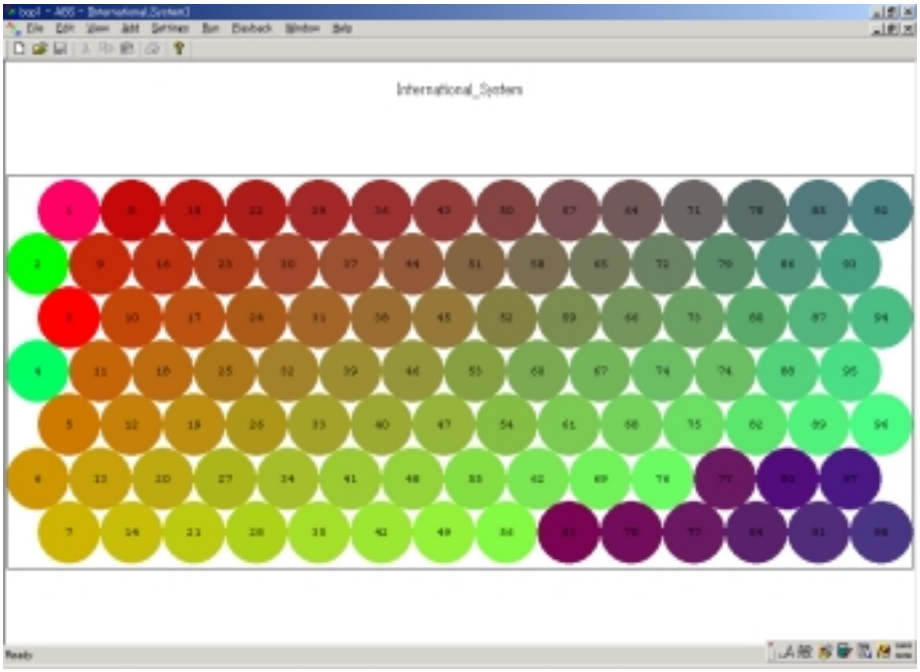

Figure 8. A picture of Phase 4

After Phase 4, the target intends to search for its allies again. In this case, state no.9 and 10 joined the alliance.

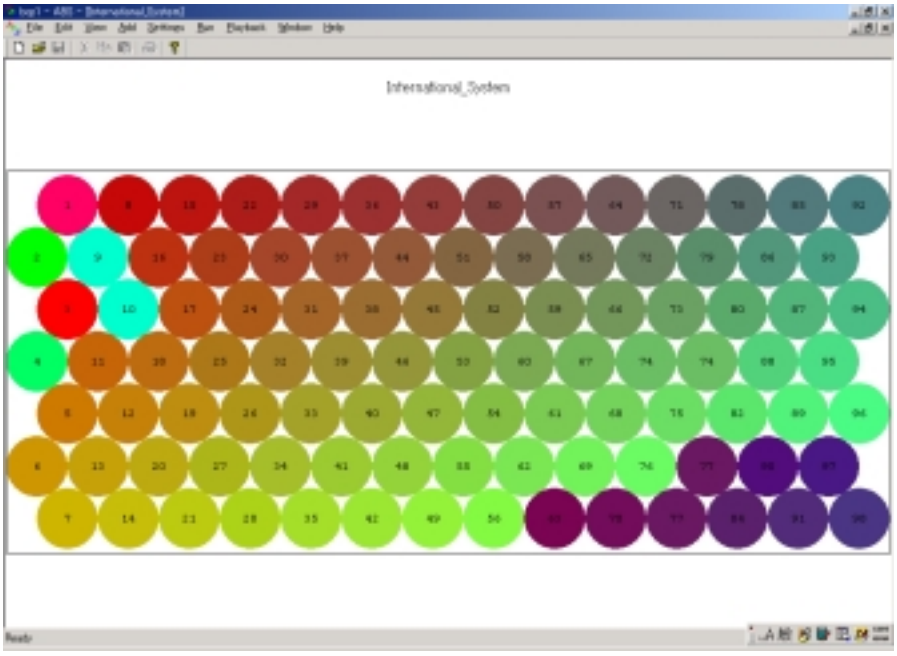

Figure 9. A picture of Phase 5

At Phase 6, the initiator considers whether it should attack the strengthened target alliance or not. If the initiator decides to attack, the phase goes to Phase 7 and war breaks out; otherwise the phase goes to Phase 8 and war is avoided. In this case, the initiator decided to make war and the phase went to Phase 7.

At Phase 7, the target alliance won against the initiator alliance. The initiator demised and the initiator's territory was annexed to the target.

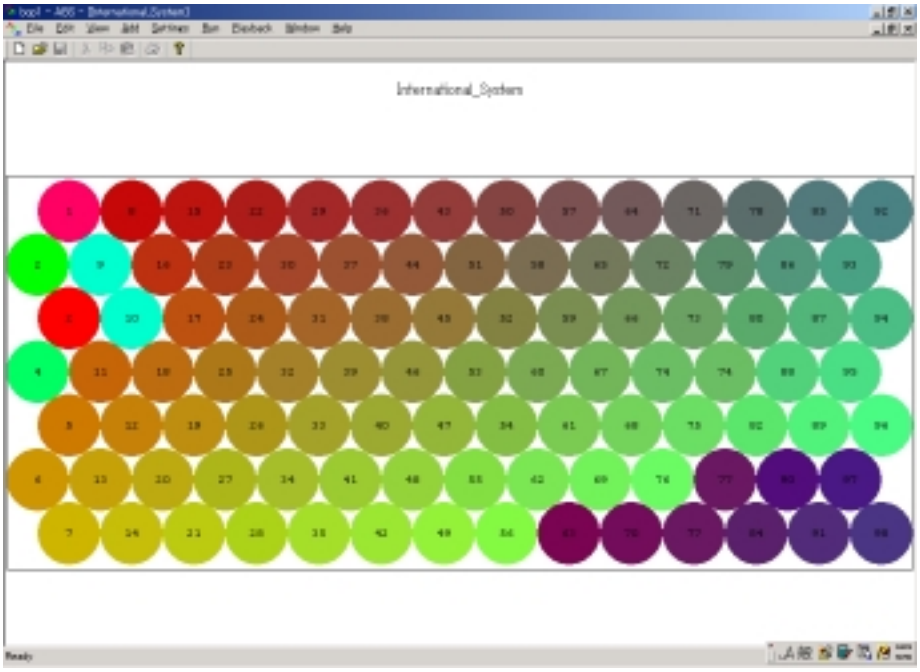

Figure 10. A picture of Phase 7

Figure 11 shows that State no.90 survived the interaction of the states after 733 turns.

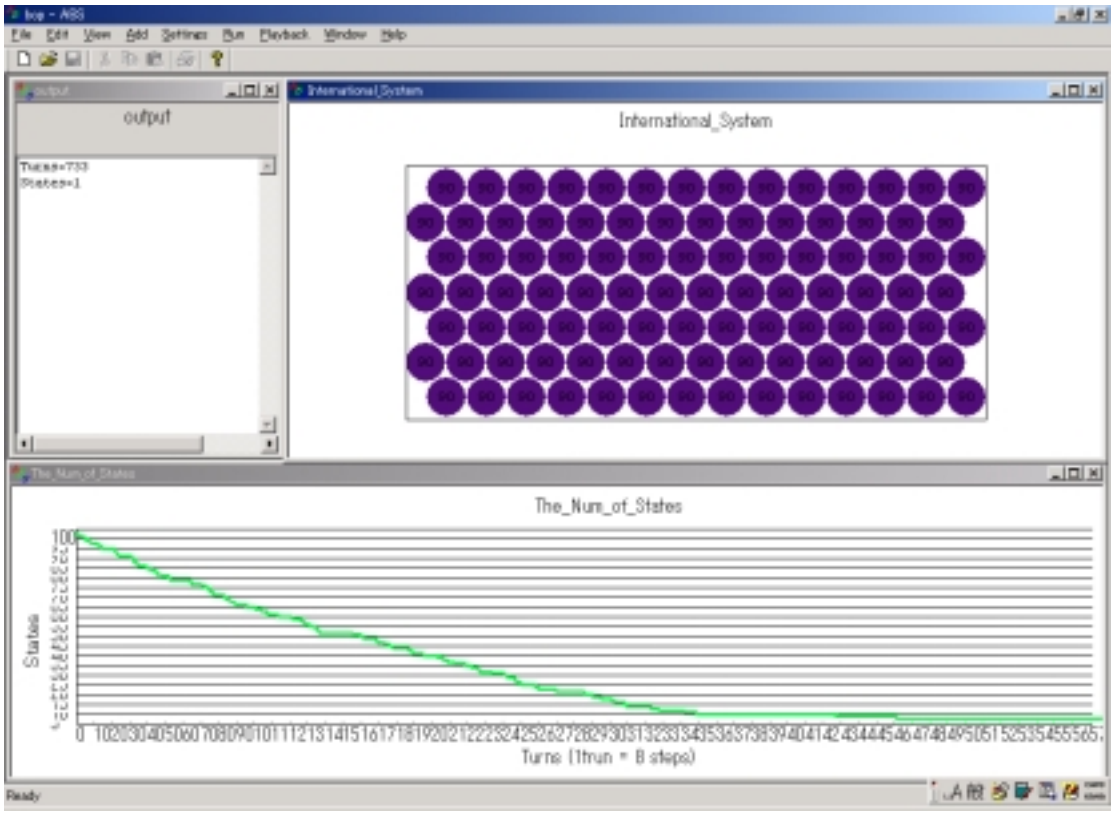

Figure 11. The end of a game

Conclusion

Using ABS simulator, the complex model as Bremer-Mihalka or Danno-Tanaka can be built much easier than using the old tools or simulators specialized in natural science. This simulator, we believe, will develop the new methodology of international relations and encourage the social scientists to discover new findings that would not otherwise ever be noticed.

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