Parrondo's Paradox Based Strategies in the Serious Game of RTGS using Forest Fire Model

Saiful Bukhori[1], Mochamad Hariadi[2], I Ketut Eddy Purnama[3], and Mauridhi Hery Purnomo[4]
[1]Information System Department, Jember University, Indonesia
[2,3,4]Electrical Engineering Department, Sepuluh Nopember Institute of Technology, Indonesia

Abstract: *This research proposed parrondo's paradox strategies in the serious game of Real Time Gross Settlement (RTGS) using forest fire model, which develop the existence of the parrondo paradox and applied in serious game of RTGS system as switching in the settlement process. The settlement process, that our proposed at this paper, is managed by clearing house. The mechanism at clearing house is a transmitter client sends a message of transaction through transmitter bank, that having canal at clearing house, then continue to receiver client through receiver bank by using forest fire model. When settlement process done by one transmitter bank (process A), the probability of increase Net Worth (NW) is p. When settlement process done by more than one transmitter bank (process B), we have introduced the probabilities of a self-transition in each state, that is, if the capital is a multiple of three we have a probability r_1 of remaining in the same state, whereas if the capital is not a multiple of three then the probability is r_2. We will turn to the random alternation of process A and B with probability γ. This will be named as process AB. Examination result of process A change in net worth trend to decrease, process B trend to decrease and process AB that switches randomly between process A and process B trend to increase net worth. Simulation of parrondo's paradox based strategies in the serious game RTGS using star logo by randomize process A and process B so distribution net worth lot in the bank that has wealth in intermediate level, total money and total loan trend to rise, total saving loan trend to rise but total wallets trend to decrease.*

Keywords: *Parrondo paradox, RTGS, forest fire model, net worth.*

Received December 23, 2010; accepted May 24, 2011; published online August 5, 2012

1. Introduction

Parrondo's paradox in game theory has been described as a losing strategy that wins. The main idea of Parrondo's paradox is that two individually losing games can be combined to win via periodic or random strategy. There has been a lot of research on Parrondo's games after the first published paper, giving birth to new games such as history dependent games [15].

The original Parrondo's games are made up of two games, namely game A and game B. The definition of both games A and B are as follows. At each discrete time step n, either game A or B will be played. The algorithm or pattern utilized to decide which game to be played at each discrete time step *n* is defined as the switching strategy.

In the previous studies complex switching based on random and chaotic strategies have been used to improve the final gain in the classical Parrondo's paradox problem [2], in this research the parrondo paradox strategies is used for switching in the settlement process at serious game Real Time Gross Settlement (RTGS) using forest fire model.

RTGS is a system that streamlines the settlement of large-value transactions between banks and other financial institutions [5]. Instead of moving physical amounts of cash, the banks transfer funds electronically. When one bank transfers money to another, the funds are immediately credited to the second bank and debited to the first. In general, the settlement of interbank funds transfers can be based on the transfer of balances on the books of a central bank [4]. The possibilities of the payment processing, when the sending bank does not have sufficient covering funds in its central bank account, are rejected, centrally queued and settled with central bank credit [4].

In RTGS systems, queues are most commonly generated when sending banks do not have sufficient covering funds in their central bank account. If the queued transfers did not settle, the receiving bank could face a liquidity problem. Particularly if this occurred close to the end of the day, it might then be difficult for the bank to raise the liquidity it needed from alternative sources [8]. Base on this problem some researchers try to increase liquidities value at critical conditions.

An agent-based model of crisis simulation for a simplified RTGS is presented by Arciero *et al.* [1]. The model's predictions approximated the macro-features of reality, shown the sequential effects of an unexpected negative shock affecting a participant. But this research had not analyzed the behaviour of fixed point in critical state that was influence the stability. The theory of Self-Organized Criticality (SOC) is concerned with a large class of complex systems that are described by simple power laws [9]. The main characteristics of these systems are: 1). Self-similar or fractal spatial behaviour, 2). Self-similar temporal behaviour resulting in 1/f noise and 3). Unpredictability and intermittent behaviour [9]. So the complex behaviour in these systems is rather nicely structured. Indeed, self-similar behaviour can be described by simple power laws. We call this kind of complex behaviour critical because of its resemblance with the behaviour of a system in thermo dynamical equilibrium at a second order phase transition, i.e., at a critical point. The abundance, the nature and importance of systems where this kind of complexity is found or supposed are so impressive that we have to regard critical behaviour. In RTGS system, critical points are happened in two positions that are where banks at a bankruptcy region and consideration of asset productivity. In this research we propose parrondo's paradox strategies in the serious game RTGS using forest fire model.

The forest fire model of Bak *et al.* [3] is a simple probabilistic cellular automaton with complex behavior that mimics the spreading of fires in a forest. The forest is modeled as a square region of side L with a regular lattice of L^2 cells or sites which represent trees. A cell can have three states: 1). A living tree, 2). A tree on fire and 3). A dead tree.

The rest of this paper is organized as follows: The theoretical consideration that supports the implementation method is described in section 2. The proposed model for parrondo's paradox based strategies in the serious game of RTGS using forest fire model is discussed in section 3. Section 4 gives the parrondo's paradox based strategies in the serious game of RTGS using forest fire model analysis. Finally conclusions are given in section 5.

2. Fundamental Theory

In this part is described the theory that support of parrondo's paradox based strategies in the serious game of RTGS using forest fire model. These theories are parrondo paradox, serious game, forest fire model and mechanism of RTGS.

2.1. Parrondo Paradox

Parrondo's paradox in game theory has been described as a losing strategy that wins. It is named after its creator, Spanish physicist Juan Parrondo, who discovered the paradox in 1996. A more explanatory description is: Given two games, each with a higher probability of losing than winning, it is possible to construct a winning strategy by playing the games alternately.

The original form of the game is shown with biased coins. game *A* contains biased coin with the win probability of p and game B is described as follows: If the current capital is multiple of then the win probability is p_1, otherwise the win probability is p_2. A convenient parameterization can be introduced if we require to controlling the three probabilities p, p_1, p_2 via a biasing parameter ε [11].

Parrondo's paradox is used extensively in game theory and its application in engineering, population dynamics, financial risk, etc. In this research parrondo's paradox is used as switching strategy in settlement process of RTGS using forest fire model.

2.2. Serious Game

A serious game is a game designed for a primary purpose other than pure entertainment. The 'serious' adjective is generally pretended to refer to products used by industries like defence, education, scientific exploration, health care, emergency management, city planning, engineering, religion, and politics [16]. In this research serious game is used to simulate the mechanism of settlement process in RTGS System.

Serious games are designed for the purpose of solving a problem. Although, serious games can be entertaining, their main purpose is to train, investigate, or advertise. Sometimes a game will deliberately sacrifice fun and entertainment in order to make a serious point. Whereas video game genres are classified by game play, serious games are not a game genre but a category of games with different purposes. This category includes educational games, political games, or evangelical games [6]. The category of serious games for training is also known as 'game-learning'. In this research, the main purpose of serious game is detecting the critical condition in RTGS system and manages them.

There are four levels of serious games: observe experiment, collaborate, and manage [10]. First, an observe game implies that the interaction with the virtual model is limited to watching the behaviour of a virtual system with a predetermined set of parameters. Second, an experiment game implies an observe game plus the interaction that can change parameters to produce a predicted result and then observe the simulated results. Comparisons can be made between predicted and simulated to understand the dynamic of the model. Further, comparisons can be made between the simulated results and actual observations in the real world to improve the validity of the model. Third, collaborate game implies an experiment game plus multiple persons can simultaneously interact with the model. The social interaction adds new dimensions in coordination and collaboration. The assumption is that the resulting quality will be better if many individuals can collaborate together within an effective environment. Fourth, a manage game implies a collaborate game plus the interaction can change parameters, not only in the virtual system, but also to control the real system. Comparisons of the simulated versus actual behaviour can be used to manage the real system toward desirable goals. The essential aspects of any complex system (such as a settlement process in this research) can be modelled as a serious game in a virtual world. One can observe the current state of the system, experiment with different strategies, collaborate on team efforts, and even manage processes within the system.

2.3. Forest Fire Model

Forest fire model is the probabilistic cellular automata that follow rules motivated by forest fire and growth. A cellular automaton consists of a number of cells organized in the form of a lattice [14]. In the forest fire model, the rules are as follows, at each step [7]:

1. A burning tree becomes an empty site.
2. A tree becomes a burning tree if at least one of its nearest neighbors is burning.
3. At an empty site, a tree grows with probability *p*.
4. A tree without a burning nearest neighbor becomes a burning tree with probability *f*.

At the start of this model, we will see trees growing uncontrollably. After a while, lightening strikes will start fires. The fires will spread, destroying trees in big swaths. Behind the fires, new trees will grow up again. If we have *p* growth and *p* burn set at the right levels, we should see clusters of trees develop and burn. Otherwise, we just get random distributions of empty, tree and burning cells.

2.4. Real Time Gross Settlement

In modern exchange economies, the smooth functioning of economic activity is heavily dependent on the reliability and the efficiency of payment systems. Cash transactions are steadily diminishing; consumers and firms generally settle their obligations through banks or other financial intermediaries, by means of instruments such as checks, money orders and electronic transfers [8]. The intermediaries themselves initiate numerous payment flows for their own treasury operations or for other reasons. The basic functioning of RTGS environment is shown in Figure 1 [5].

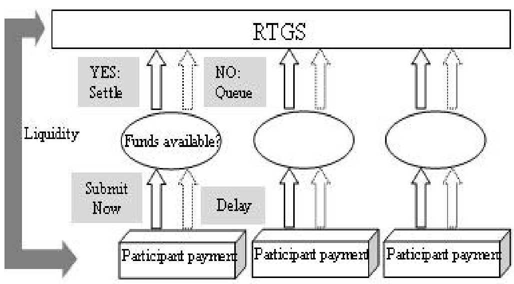

Figure 1. Basic functioning of an RTGS environment.

Transaction mechanism in RTGS as shown in Figure 1 started with remitting participant orders the payment transaction to centre of management of RTGS system in central bank for settlement process. Payment information will be continued automatically and electronics to receiver participant if settlement process run success. Success or failure of settlement process depends on sufficiency of sending bank balance value in central bank. This condition is caused of system RTGS only allowing participant credit other participant. If it was the rule of the game, hence RTGS participant bank must know the sufficiency of balance in central bank.

According to the actual and expected availability of each category of resources, banks make the strategic decision as whether to submit a payment promptly or delay it, thus affecting the overall time pattern of flows in the RTGS. In this respect, banks continuously face a trade-off between liquidity costs and delay costs. By releasing payments timely, banks satisfy customer and counterparty needs and benefit from a sound reputation, but they can incur high liquidity costs insofar as they need to borrow from the money market or the central bank. On the other hand, banks can play on the dynamics of the money market more effectively by choosing to delay payments, at the expense of increased systemic risk and reputation uncertainty [8].

3. The Proposed of Model

In general, The mechanism of RTGS transaction is done by the way of remitting participant sends a message of payment transaction to centre of management RTGS system located at central bank for settlement process. The settlement process, that our proposed at this paper, is managed by clearing house.

The mechanism at clearing house is a transmitter client sends a message of transaction through transmitter bank, that having canal at clearing house, then continue to receiver client through receiver bank as shown in Figure 2.

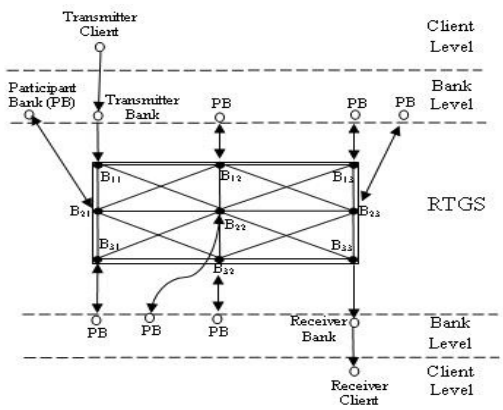

Figure 2. Development of RTGS using clearing house.

In general, settlement process depends on sufficiency of remitting bank account balance in central bank. Assess sufficiency at this research is fulfilled from other banks, that are participant bank at clearing house. Decision of accomplishment from some other banks depends on information of agents on the clearing house.

This research adopts the decentralization paradigm for modelling activity network system. The principal component of this system are adaptive agents consisting of five agents that are saving agent, reserves agent, loan agent, deposit agent and money transfer agent as shown in Figure 3.

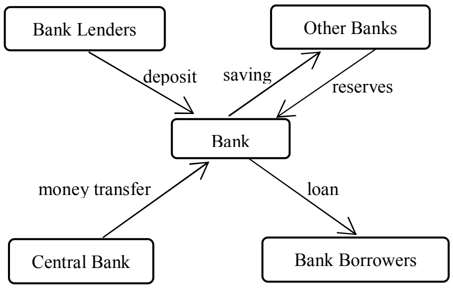

Figure 3 Decision of bank based on 5 agent information.

Saving agent give information concerning advantage that saving his money to other banks based on health analysis two banks. Reserves agent give information of advantage that taking reserve his money in other bank based on health analysis two banks. Loan agents give information concerning advantage that loan his money to other bank based on health analysis two banks. Money transfer agents give information concerning advantage that applies the deposit in central bank. Deposit agent give information concerning advantage that borrowing some money from other banks based on health analysis two banks.

Decision from five agents has consequence in the Net Worth (NW) value: increased, decreased or permanent (doesn't form networks) as shown in Figure 4.

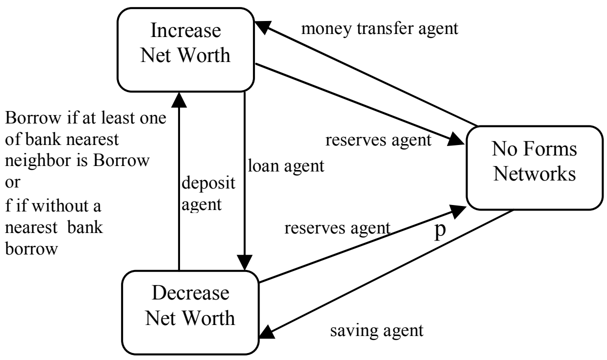

Figure 4. State diagram of RTGS system.

The *NW* of a bank if it does not declare bankruptcy is the value of its assets (*A*) , Initial reserve holding (*M*) and Payment due from other banks (*DF*) minus its liabilities Initial level of deposits (*C*) and Payment due to other banks (*DT*) as shown in equation 1 [13].

$$NW=A+DF+M-C-DT \tag{1}$$

Note that NW at time zero is $NW_0=A-C$, which we assume to be positive. If a bank declares bankruptcy, its net worth is given by α times its assets, minus α times its deposit liabilities, minus β times its interbank liabilities or net due $ND=DT-DF$ as shown in equation 2 [13].

$$NW = \alpha_{(asset)} - \alpha_{(deposit)} - \beta_{(net\ due\text{-}tos)} \tag{2}$$

$$NW=\alpha(A - C) - \beta(ND) \tag{3}$$

where $1>\alpha>\beta>0$. In other words, the cost of bankruptcy procedures diminishes the value of a bank's assets, but it also allows the bank to partially shift priority away from other banks participating in the payments network. Under this assumption, bankruptcy disproportionately punishes holders of interbank claims, implying that bankruptcy is attempting option for banks with a large net debt position relative to their capital [13].

Under RTGS, the net worth of the bank at any point during the day is the difference between original net worth and the level of liquidity penalty paid for reserves so far during the day. Recall that the total amount of reserves purchased as of time t is given by $L_{(t)}$. Hence the total liquidation penalty paid as of time *t* is given as shown in equation 4:

$$\pi(t)=\alpha_{max}L_{(t)} - A_1 \tag{4}$$

(A_1 is a portion of *A* held as bonds) Thus if asset liquidation exceed A_1, loan must be liquidated at a loss and bank's net worth is diminished. NW as of time *t* as shown in equation 5:

$$NW_{(t)}=A-C- \pi(t) \tag{5}$$

Bankruptcy can occur if $NW_{(t)}$ is driven to zero, which will occur as shown in equation 6 [13].

$$L_{(t)}=L^*=\lambda^{-1}(A-C)+A_1 \tag{6}$$

Note that under our assumptions $NW_{(t)}$ is non increasing so there is no chance that a zero net-worth bank can be bailed out of bankruptcy. If asset value were stochastic, then attempting to continue would have option value, so the analysis would be considerably more complicated.

4. Settlement Process Analysis

When settlement process done by one transmitter bank (Process *A*), the probability of increase *NW* is *p*, the probability of remaining with the same capital will be denoted as *r*, and the probability of decrease *NW* is $q=1-r-p$ as shown in Figure 5.

Following the same reasoning as Harmer *et al.* [12], we will calculate the probability *f* that our capital reaches zero in a finite number of plays, supposing that initially we have a given capital of *j* units.

a. $f_j=1$ for all $j\geq 0$, and so the process is either no forms networks or decrease net worth one.

b. $fj<1$ for all $j>0$, in which case the process can be increase net worth one because there is a certain probability that our capital can grow undefinetly.

We are looking for the set of numbers fj that correspond to the minimal non- negative solution of the equation as shown in equation 7:

$$f_j = p . f_{j+1} + r . f_j + q . f_{j-1} \tag{7}$$

with the boundary condition as shown in equation 8:

$$f_0 = 1 \tag{8}$$

with rearrange equation 7 can be written in the form as shown in equation 9:

$$f_j=p/(1-r) . f_{j+1} + q/(1-r) . f_{j-1} \tag{9}$$

the solution of equation 9 for the initial condition equation 8 is shown in equation 10:

$$f_j = A . [((1-p-r)/p)^j - 1]+1 \tag{10}$$

where A is a constant. We can therefore see that the new process A is increase NW as shown in equation 11:

$$(1-p-r)/p<1 \tag{11}$$

decrease NW as shown in equation 12:

$$(1-p-r)/p>1 \tag{12}$$

no forms networks as shown in equation 13:

$$(1-p-r)/p=1 \tag{13}$$

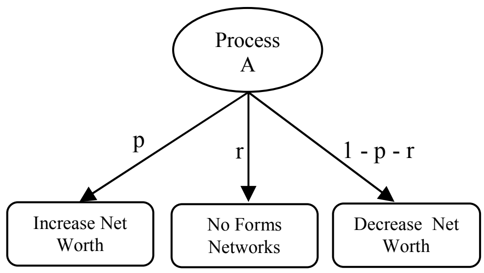

Figure 5. Probability tree of process A.

When settlement process done by more than one transmitter bank (process B), like process A, we have introduced the probabilities of a self-transition in each state, that is, if the capital is a multiple of three we have a probability r_1 of remaining in the same state, whereas if the capital is not a multiple of three then the probability is r_2 as shown in Figure 6.

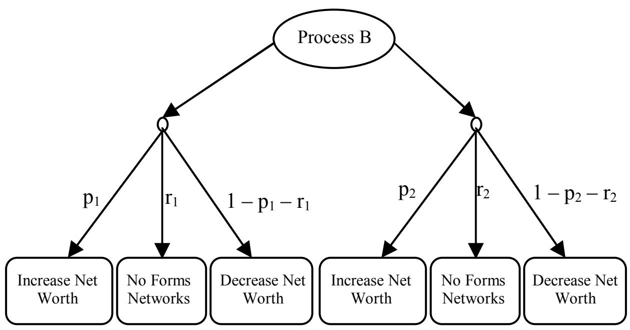

Figure 6. Probability tree of process B.

The rest of the probabilities will follow the same notation as in the original process B, so we have the following scheme:

$$\begin{aligned} &mod\ (capital,3) = 0 \text{ -> } p_1, r_1, q_1 \\ &mod\ (capital,3) \neq 0 \text{ -> } p_2, r_2, q_2 \end{aligned} \tag{14}$$

We will follow reasoning as Harmer *et al.* [12], but this time for process B. Let g_j be the probability that the capital will reach the zeroth state in a finite number of plays, supposing an initial capital of j units.

a. $g_j=1$ for all $j\geq0$, so process B is either no forms networks or decrease net worth one, or
b. $g_j<1$ for all $j>0$, in which case the process B can be increase net worth one because there is a certain probability that our capital can grow indefinitely.

The following set of recurrence equations must be solved:

$$\begin{aligned} &g_{3j}=p_1 . g_{3j+1} + r_1 . g_{3j} + (1-p_1-r_1) . g_{3j-1} \quad j \geq 1 \\ &g_{3j+1}=p_2 . g_{3j+2} + r_2 . g_{3j+1} + (1-p_2-r_2) . g_{3j} \quad j \geq 0 \\ &g_{3j+2}=p_2 . g_{3j+3} + r_2 . g_{3j+2} + (1-p_2-r_2) . g_{3j+1} \quad j \geq 1 \end{aligned} \tag{15}$$

Eliminating terms g_{3j}, g_{3j+1}, g_{3j+2} from equation 15, we get equation 16:

$$\begin{aligned} &[p_1p_2^2 + (1-p_1-r_1)(1-p_2-r_2)^2] . g_{3j} = X \\ &X = p_1p_2^2 . g_{3j+3} + (1-p_1-r_1)(1-p_2-r_2)^2 . g_{3j-3} \end{aligned} \tag{16}$$

Considering the same boundary condition as in process A, $g_0=1$, the last equation has a general solution of the form equation 17:

$$g_{3j} = B[((((1-p_1-r_1)(1-p_2-r_2)^2) / p_1p_2)^2)^j - 1] + 1 \tag{17}$$

It can be verified that the same solution as 17 will be obtained for g_{3j+1} and g_{3j+2}, leading to the same condition for the probabilities of the process as with process A, process B will be increasing NW one if:

$$((1-p_1-r_1)(1-p_2-r_2)^2) / p_1p_2^2 <1 \tag{18}$$

decrease NW one if:

$$((1-p_1-r_1)(1-p_2-r_2)^2) / p_1p_2^2>1 \tag{19}$$

and no form network if:

$$((1-p_1-r_1)(1-p_2-r_2)^2) / p_1p_2^2=1 \tag{20}$$

Now we will turn to the random alternation of process A and B with probability γ. This will be named as process AB. For this process AB we have the following probabilities:

a. If the capital is a multiple of three:

$$\begin{aligned} &p_1' = \gamma . p + (1 - \gamma) . p_1 \\ &r_1' = \gamma . r + (1 - \gamma) . r_1 \end{aligned} \tag{21}$$

b. If the capital is not multiple of three:

$$\begin{aligned} &p_2' = \gamma . p + (1 - \gamma) . p_2 \\ &r_2' = \gamma . r + (1 - \gamma) . r_2 \end{aligned} \tag{22}$$

Using the new probabilities p_1', r_1', p_2', r_2' instead of p_1, r_1, p_2, r_2. Eventually, we obtain that process AB will be Increase NW one if:

$$((1-p_1'-r_1')\,(1-p_2'-r_2')^2)/p_1 p_2'^2 < 1 \tag{23}$$

decrease *NW* one if:

$$((1-p_1'-r_1')\,(1-p_2'-r_2')^2)/p_1'p_2'^2 > 1 \tag{24}$$

no form network if:

$$((1-p_1'-r_1')\,(1-p_2'-r_2')^2)/p_1'p_2'^2 = 1 \tag{25}$$

Examination result of process *A* change in net worth applies number of trials=1000, process *A* probability of increase net worth 0.5–e, epsilon(e)=0.005, $NW_{(0)}$=100 as shown in Figure 7. The graph in the illustration on Figure 7 shows that net worth trend to decrease.

Figure 7. Process *A* change in net worth.

Process *B* change in net worth applies number of trials=1000, process *B* probability of increase net worth (in modulus base=0)=1/10, process *B* probability of increase net worth (in modulus base≠0)=¾, modulus base=3, epsilon(e)=0.005, $NW_{(0)}$=100 as shown in Figure 8. The graph in the illustration on Figure 8 shows that net worth trend to decrease.

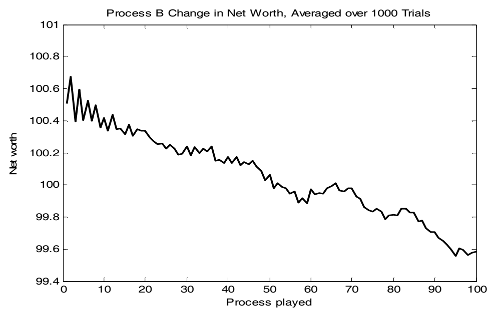

Figure 8. Process *B* change in net worth.

Figure 9 shows the result of a parrondo's paradox based strategies in the serious game of RTGS using forest fire model simulation applies number of trials=1000, process *A* probability of increase net worth 0.5–e, process *B* probability of increase net worth (in modulus base=0)=1/10, process *B* probability of increase net worth (in modulus base≠0)=¾, modulus base=3, epsilon(e)=0.005, $NW_{(0)}$=100. Process *A* and process *B* are both decrease net worth as shown in Figures 7 and 8. A process that switches randomly between process *A* and process *B* trend to increase net worth.

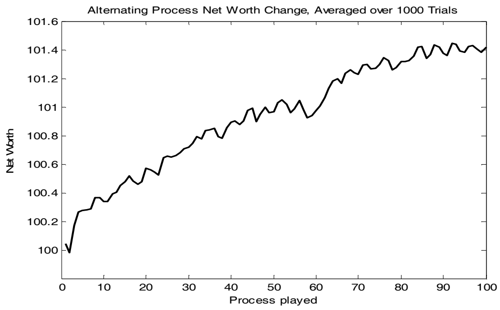

Figure 9. Process *AB* change in net worth.

Simulation of parrondo's paradox based strategies in the serious game RTGS using star logo applies money total 450 in clearing house then done settlement process so distribution net worth lot in the bank that has wealth in intermediate level as shown in histogram Figure 10.

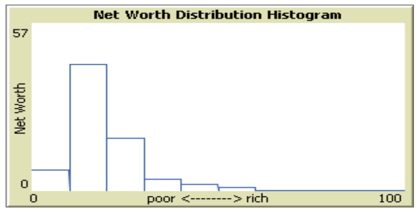

Figure 10. Net worth distribution histogram.

Money total and loan total bank that in pursuance of process settlement by using process *AB* as shown in Figure 11. In this figure shown that total money and total loan trend to rise.

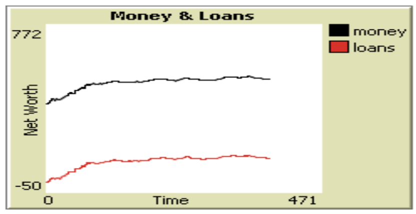

Figure 11. Money total and loan total in RTGS.

Saving total and wallets total bank that in pursuance of process settlement by using process *AB* as shown in Figure 12. In this figure show that total saving loan trend to rise but total wallets trend to decrease.

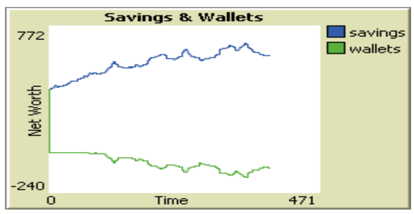

Figure 12. Saving and Wallets in RTGS.

5. Conclusions

The graph in the illustration of process *A*, change in net worth trend to decrease. The graph in the illustration of process *B*, change in net worth trend to decrease. A process that switches randomly between process *A* and process *B* trend to increase net worth. Simulation of parrondo's paradox based strategies in the serious game RTGS using star logo by randomize process *A* and process *B* so distribution net worth lot in the bank that has wealth in intermediate level.

Money total and loan total bank that in pursuance of process settlement by using switches randomly between process *A* and process *B* show that total money and total loan trend to rise. Saving total and wallets total bank that in pursuance of process settlement by using switches randomly between process *A* and process *B* show that total saving loan trend to rise but total wallets trend to decrease.

References

[1] Arciero L., Biancotti C., D'Aurizio L., and Impenna C., "Exploring Agent-Based Methods for the Analysis of Payment Systems: A Crisis Model for Starlogo TNG," *Journal of Artificial Societies and Social Simulation*, vol. 12, no. 12, available at: http://jasss.soc.surrey.ac.uk/12/1/2.html, last visited 2009.

[2] Arena P., Fazzino S., Fortuna L., and Maniscalco P., "Game Theory and Non-Linear Dynamics: The Parrondo Paradox Case Study," *Chaos, Solitons and Fractals*, vol. 17, no. 2-3, pp. 545-555, 2003.

[3] Bak P., Chen K., and Tang C., "A Forest-Fire Model and Some Thoughts on Turbulence," *Physics Letters A*, vol. 147, no. 5-6, pp. 297-300, 1990.

[4] Bank for International Settlement, "Real Time Gross Settlement System," *Technical Report*, International Financial Risk Institute, 2007.

[5] Committee on Payment and Settlement Systems, "New Developments in Large-Value Payment Systems," *Technical Report*, BANK for International Settlements, available at: http://www.bis.org/press/p050509a.htm, last visited 2005.

[6] Derryberry A., "Serious games: Online Games for Learning," available at: http://www.adobe.com/resources/elearning/pdfs/ serious_games_wp.pdf, last visited 2007.

[7] Drossel B. and Schwabl F., "Self-Organized Critical Forest-Fire Model," *Physical Review Letters*, vol. 69, no. 11, pp. 1629-1632, 1992.

[8] Emmons W., "Interbank Netting Agreements and the Distribution of Bank Default Risk," *Working Paper Series*, The Federal Reserve Bank of St. Louis, 1995.

[9] Frank D., "Sandpile Models on Fractal Lattices," *PhD Thesis*, Linburgs Universitair Centrum, 2001.

[10] Hackathorn R., "Serious Games in Virtual Worlds: The Future of Enterprise Business Intelligence," available at: http://www.b-eye-network.co.uk/view-articles/4163, last visited 2007.

[11] Harmer G. and Abbott D., "Parrondo's Paradox," *Statistical Science*, vol. 14, no. 2, pp. 206-213, 1999.

[12] Harmer G., Abbott D., and Taylor P., "The Paradox of Parrondo's Games," *Proceedings of the Royal Society A456*, vol. 456, no. 1994, pp. 247-259, 2000.

[13] Kahn C. and Roberds W., "Payment System Settlement and Bank Incentives," *The Wharton Financial Institutions Center*, vol. 11, no. 4, pp. 845-870, 1998.

[14] Kiran S. and Ramesh B., "Identification of Promoter Region in Genomic DNA using Cellular Automata Based Text Clustering," *The International Arab Journal of Information Technology*, vol. 7, no. 1, pp. 9-16, 2010.

[15] Parrondo J., Harmer G., and Abbott D., "New Paradoxical Games Based on Brownian Ratchets," *Physical Review Letters*, vol. 85, no. 24, pp. 5226-5229, 2000.

[16] Richard N., "Serious Games Get Really Serious," available at: http://www.elearningage.co.uk, last visited 2005.

Saiful Bukhori received his BS degree in electrical engineering from Brawijaya University, Indonesia in 1993 and MSc degree in computer from Institute of Technology Sepuluh Nopember, Indonesia in 2003, respectively. He joined Electrical Engineering Department in Jember University since 2003. His current research interest's include artificial intelligence and game technology. He is currently pursuing the PhD degree at the ITS. Indonesia since 2008.

Mochamad Hariadi received his BE degree in Electrical Engineering Department of Sepuluh Nopember Institute of Technology, Indonesia, in 1995. He received both MSc and PhD degrees in Graduate School of Information Science Tohoku University Japan, in 2003 and 2006 respectively. Currently, he is the staff of Electrical Engineering Department of Sepuluh Nopember Institute of Technology Indonesia. He is the project leader in joint research with PREDICT JICA project Japan and WINDS project Japan. His research interest include video and image processing, data mining and intelligent system. He is a member of IEEE, and member of IEICE.

I Ketut Eddy Purnama received his BE degree in Electrical Engineering Department of Sepuluh Nopember Institute of Technology, Indonesia, in 1994, MT degree from Bandung Institute of Technology, Indonesia in 1999 and his PhD degree from University of Groningen. Currently, he is staff member of Electrical Engineering Department of Sepuluh Nopember Institute of Technology Indonesia. His current research interests include biomedical engineering, image processing, data mining and intelligent system.

Mauridhi Heri Purnomo received his BS degree from Institute of Technology Sepuluh Nopember, Indonesia in 1985, MS and PhD degrees from Osaka City University, Osaka, Japan in 1995, and 1997, respectively. He has joined ITS in 1985. Has been a professor since 2004. His current research interests include intelligent system applications an electric power systems operation, control and management. He is a member of IEEE.