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INTELLIGENT AGENT FOR SERIOUS GAME OF REAL TIME GROSS SETTLEMENT USING FOREST FIRE MODEL

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ABSTRACT

The goal of the intelligent agent in this research is fulfill the settlement process in Real Time Gross Settlement (RTGS). The RTGS system is a payment settlement process for individual processing of payments in an electronic system for gross settlement in real time. Settlement process in this research 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 continues to receiver client through receiver bank by using forest fire model. This process is influenced by behavior of four agents (saving agent, reserves agent, loan agent and deposit agent). The result of this research indicates that the highest fluctuation of the agents that influence to increase the Net worth (*NW*) (4% to 96%) and fluctuation of the agents that influence to decrease the *NW* (2% to 94%) take place in the smallest probability ($p = 0.1$). While the most limited fluctuation of the agents that influence to increase the *NW* (35% to 60%) and fluctuation of the agents that influence to decrease the *NW* (40% to 60%) take place in the highest probability ($p = 0.9$). In the serious game of RTGS, this probability is used to determine optimal transaction and influence to stability in the RTGS system.

Keywords: *Intelligent agent, forest fire model, Real Time Gross Settlement, clearing house*

1. INTRODUCTION

Intelligent agent is an autonomous entity, which observes and acts upon an environment and directs its activity towards achieving goals [Russell and Norvig, 2003]. Intelligent agents may also learn or use knowledge to achieve their goals. They may be very simple or very complex. Intelligent agents in artificial intelligence are closely related to agents in many interdisciplinary socio-cognitive modeling and computer social simulations. In this research intelligent agent applied in serious game RTGS for finishing settlement process.

RTGS is a system that streamlines the settlement of large-value transactions between banks and other financial institutions. 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 [Committee on Payment and Settlement Systems, 2005]. The possibilities of payment processing, when the sending banks does not have sufficient covering funds in its central bank account, are rejected, centrally queued and settled with central bank credit [Committees at the Bank for International Settlement, 2007]. 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. Base on this problem some researchers try to increase liquidities value at critical conditions.

Agent-based model of crisis simulation for a simplified RTGS is presented by Luca at al [Arciero, et al., 2009]. 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 behavior of fixed point in critical state that influences on the stability.

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The theory of Self-Organized Criticality (SOC) is concerned with a large class of complex systems that are described by simple power laws. The main characteristics of these systems are: (1) Self-similar or fractal spatial behavior, (2) Self-similar temporal behavior resulting in *1/f* noise and (3) Unpredictability and intermittent behavior [Frank, 2001]. So the complex behavior in these systems is rather nicely structured. Indeed, self-similar behavior can be described by simple power laws. 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 behavior. In RTGS system, critical points are take place in two positions that are in bankruptcy region and consideration of asset productivity. The system in equilibrium a control parameter has to be fine-tuned to a specific value in order to make the system critical [Frank, 2001].

The rest of this paper is organized as follows. The materials that support the implementation are described in section 2. The proposed model for forest fire model is discussed in section 3. Section 4 gives the results and discussion. Finally conclusions are given in section 5.

2. THEORETICAL CONSIDERATION

In this part is described the theory that support of intelligent agent for serious game of Real Time Gross Settlement (RTGS) using forest fire model. These theories are forest fire model, intelligent agent, serious game and mechanism of RTGS.

2.1. FOREST FIRE MODEL

Forest fire model is any of a number of dynamical systems displaying self-organized criticality [Pruessner and Jeldtoft-Jensen, 2002]. The model is defined as a cellular automaton on a grid with L^d cells. L is the side length of the grid and d is its dimension. A cell can be empty, occupied by a tree, or burning [Drossel, and Schwabl, 1992]. The controlling parameter of the model is p/f which gives the average number of trees planted between two lightning strikes [Zinck and Grimm, 2009].

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 [Grassberger, 2002].

2.2. INTELLIGENT AGENT

Agent-based models are an instance of the wider class of connectionist models. This class includes such diverse models as classifier systems, cellular automata, hyper cycle models and neural networks [Gilbert and Terna, 2000]. All connectionist models share the idea that interactions between a large numbers of micro-elements give rise to complex macro phenomena. In particular, the elements of agent-based models may be quite complex and intelligent on their own. On the contrary, other connectionist models tend to make use of simpler elements and to constrain their interactions to a greater extent [Boero et al., 2004]. The vast majority of connectionist models of industrial districts are agent- based models. However, there are also a few models based on cellular automata, hyper cycles and neural networks. Thus, a brief introduction to these branches of the connectionist family may be in order. Nevertheless, agent-based models are expected to monopolize the scene of connectionist models of industrial districts. Thus, the following scheme illustrates cellular automata.

Cellular automata are composed by a set of elements in an ordered space, usually a plane, that change their state according to the state attained by the elements in their neighborhood. In general, the neighborhood is either defined as the four or the eight closest neighbors [Boero et al., 2004]. Roughly speaking, cellular automata may be seen as agent based models whose agents are constrained to communicate with a fixed subset of other agents and, most importantly, the state of whose agents does not depend on their own past state. Typically, cellular automata are good at describing diffusion phenomena such as growth of cities, economic behavior and sand piles cascades. In this research intelligent agent is an autonomous entity which observes and acts upon banks in RTGS system and directs its activity towards of asset productivity but also make sure to not in bankruptcy.

2.3. 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 defense, education, scientific exploration, health care, emergency management, city planning, engineering, religion, and politics [Adam, E, 2009]. In this research serious game is used to simulate the mechanism of

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settlement process in RTGS system using forest fire model.

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. This category includes educational games and advergames, political games, or evangelical games [Derryberry, 2007]. The category of serious games for training is also known as 'game-learning'. In this research, the main purpose of serious game is to detect the critical condition in RTGS system and manage them with SOC using forest fire model.

There are four levels of serious games: observe game, experiment game, collaborate game, and manage game [Hackathorn, 2007]. First, an observe game implies that the interaction with the virtual model is limited to watching the behavior 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, 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 behavior 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 modeled 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.

2.4. MECHANISM OF RTGS

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 [Committees at the Bank for International Settlement, 2007]. The intermediaries themselves initiate numerous payment flows for their own treasury operations or for other reasons. The basic functioning of RTGS environment as shown in Figure 1 [Arciero, et al., 2009].

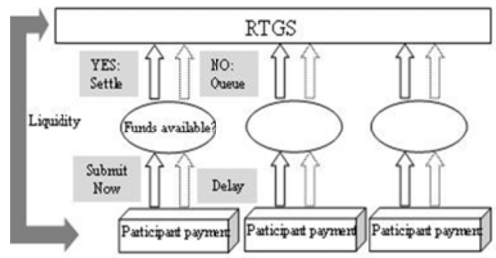

FIGURE 1. BASIC TRANSACTION IN RTGS

Transaction mechanism in RTGS as shown in Figure 1 is 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 to receiver participant if settlement process is run success. Success or failure of settlement process depends on sufficiency of sending bank balance value in central bank. This condition is caused of RTGS system 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 resource, 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. 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 [Committee on Payment and Settlement Systems, 2005].

3. THE PROPOSED FOREST FIRE MODEL FOR RTGS

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

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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. In general, settlement process depends on sufficiency of remitting bank account balance in central bank. Assess sufficiency at this research is fulfilled by 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.

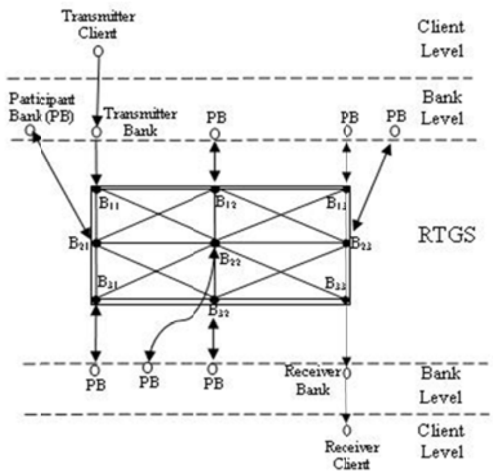

Figure 2. Development of rtgs with clearing house

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

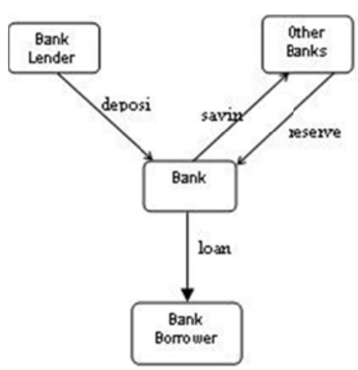

Figure 3. Decision of bank based on 4 agent information

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 agent gives information concerning advantage that loan his money to other bank based on health analysis two banks. Deposit agent give information concerning advantage that borrowing some money from other banks based on health analysis two banks.

Decision from four agents has consequence in the net worth (*NW*) value: increased, decreased or permanent. At the beginning of each time step, a participant bank (cell as shown in figure 4) has a *NW* and a bank, which will do settlement process, forms activity network with the neighbor banks for fulfill a settlement process with forest fire model as shown in Figure 5, Figure 6, Figure 7, Figure 8.

2	2	1	2	2	1	2	2	2	2
2	1	2	1	1	2	1	1	1	2
1	3	3	3	3	3	3	3	3	1
1	2	1	1	2	1	2	1	2	2
2	1	2	2	1	2	3	2	1	1
2	2	1	2	2	1	2	2	2	2
1	1	2	1	1	2	1	1	1	2
2	2	2	2	2	2	2	2	2	1
1	2	1	1	2	1	1	1	2	1
2	1	2	2	1	2	2	2	1	1

Figure 4. Settlement process using forest fire mode in step 1

2	2	1	2	2	1	2	2	2	2
2	1	2	1	1	2	1	1	1	2
1	3	3	3	3	3	3	3	3	1
1	2	1	1	2	1	2	1	2	2
2	1	2	2	1	2	3	2	1	1
2	2	1	2	2	1	2	2	2	2
1	1	2	1	1	2	1	1	1	2
2	2	2	2	2	2	2	2	2	1
1	2	1	1	2	1	1	1	2	1
2	1	2	2	1	2	2	2	1	1

Figure 5. Settlement process using forest fire model in step 2

2	2	1	2	2	1	2	2	2	2
2	1	2	1	1	2	1	1	1	2
1	3	3	3	3	3	3	3	3	1
1	2	1	1	2	1	2	1	2	2
2	1	2	2	1	2	3	2	1	1
2	2	1	2	2	1	2	2	2	2
1	1	2	1	1	2	1	1	1	2
2	2	2	2	2	2	2	2	2	1
1	2	1	1	2	1	1	1	2	1
2	1	2	2	1	2	2	2	1	1

Figure 6. Settlement process using forest fire model in step 3

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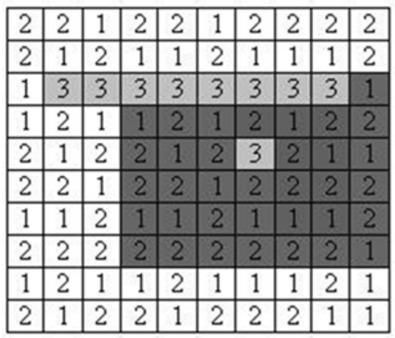

Figure 7. Settlement process using forest fire model in step 4

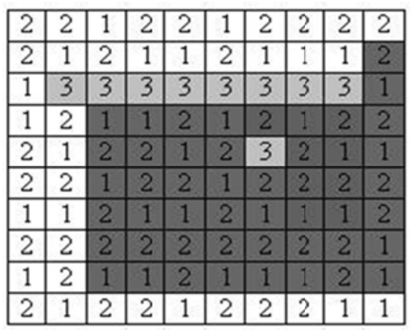

Figure 8. Settlement process using forest fire model in step 5

The rules govern movement of the bank which will do settlement process. A bank's decision to take deposits or make loans for the operation of the financial system, including settlement process, is made on the basis of profit maximization. On the other hand, Central bank as peacemaker of monetary stability obliges public bank to fulfill minimum capital. 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 Eq. (1) [Kahn and Roberds, 1998].

$$NW = A + DF + M - C - DT \quad (1)$$

Note that *NW* at time zero is simply $NW_0 = A - C$, which we assume to be positive. If a bank declares bankruptcy, its *NW* is given by α times its assets, minus α times its deposit liabilities, minus β times its interbank liabilities or net due-tos $ND = DT - DF$ as shown in Eq. (2) [Kahn and Roberds, 1998].

$$NW = \alpha(assets) - \alpha(deposit) - \beta(netdue - tos) \quad (2)$$

$$NW = \alpha(A - C) - \beta(ND) \quad (3)$$

Note α and β are $1>\alpha>\beta>0$. 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 [Committees at the Bank for International Settlement, 2007].

Under RTGS, the *NW* of the bank at any point during the day is the difference between original *NW* 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 Eq. (4).

$$\pi_{(t)} = \alpha_{\max} L_{(t)} - A_{1,0} \quad (4)$$

(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 *NW* is diminished. *NW* as of time *t* as shown in Eq. (5).

$$NW_{(t)} = A - C - \pi_{(t)} \quad (5)$$

Bankruptcy can occur if $NW_{(t)}$ is driven to zero, which will occur as shown in Eq. (6).[Kahn and Roberds, 1998].

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

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. RESULTS AND DISCUSSION

A cell in this research, which represents a bank, can be in three states (1) doesn't form activity network for process settlement, (2) bank decreases the *NW* that is influenced by saving and loan agent larger ones or (3) cell that show bank increases the *NW* that is influenced by deposit and reverse agent.

Behavior of agents using probability 0.1 show that productivity (influenced by agents that are increase the *NW* and agents that are decrease the *NW*) take place in $t = 10$ to $t = 50$, meanwhile in another *t* ($t = 0$ to $t = 10$, and $t \geq 50$) doesn't formed activity network. The fluctuation of the agents that influence to increase the *NW* is between 4% and 96%. The fluctuation of the agents that

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influence to decrease *NW* is between 2% and 94% as shown in Figure 9.

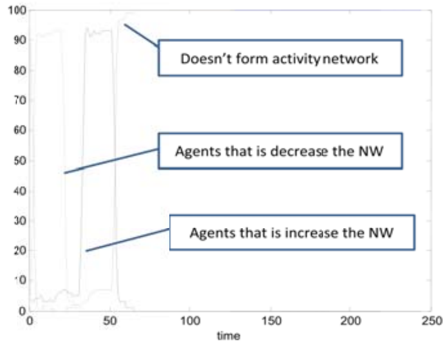

Figure 9. Behavior of agent using probability 0.1

Productivity that influenced by agents that influence to increase the *NW* and agents that influence to decrease the *NW* using probability 0.5 take place in $t = 0$ to $t = 100$. The state that no formed activity network only take place in $t = 50$ by $NW = 35\%$. The fluctuation of the agents that influence to increase the *NW* is between 8% and 95%. The fluctuation of the agents that influence to decrease *NW* is between 5% and 80% as shown in Figure 10.

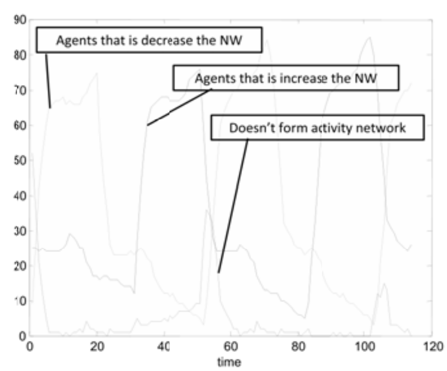

Figure 10. Behavior of agent using probability 0.5

Productivity that influenced by agents that influence to increase the *NW* and agents that influence to decrease the *NW* using probability 0.9 take place in $t = 0$ to $t = 100$. The state that no formed activity network only take place in $t = 50$ by $NW = 15\%$. The fluctuation of the agents that influence to increase the *NW* is between 35% and 60%. The fluctuation of the agents that influence to decrease *NW* is between 40% and 60% as shown in Figure 11. For other probability begins 0.1 up to 0.9 as shown in table. 1.

The result of simulation using Net Logo, Flow of fund in the RTGS, especially in clearinghouse by using forest fire model, using probability 0.7, is shown in Figure 12. In this figure indicate that by using probability 0.7, flow of fund is finished in step 150 for keep a net worth in RTGS System on stability.

Figure 11. Behavior of agent using probability 0.9

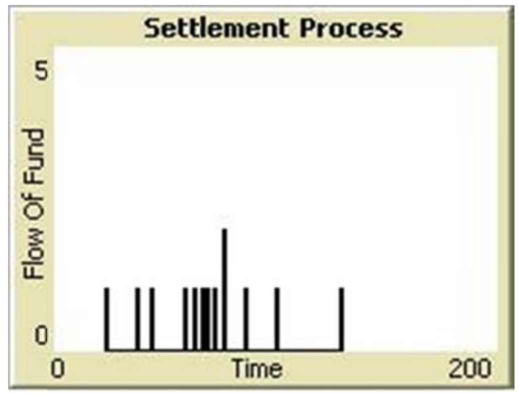

Figure 12. Settlement process

The efficiency of liquidity and productivity by using probability 0.7 with 15 banks transaction is shown in Figure 13.

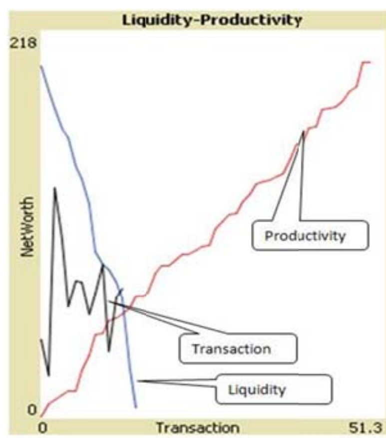

Figure 13. Efficiency in liquidity and productivity

5. CONCLUSION

The results of this research are settlement process in serious game RTGS using forest fire model indicate that productivity that influenced by agents that influence to increase the *NW* and agents that influence to decrease the *NW* using probability $p = 0.1$, $p = 0.2$ and $p = 0.3$ only take place in $t = 10$ to

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$t = 50$, in another time ($t = 0$ to $t = 10$, and $t \geq 50$) doesn't formed activity network, meanwhile the productivity that influenced by agents that influence to increase the *NW* and agents that influence to decrease the *NW* using probability $p > 0.3$ take place in $t = 0$ to $t = 100$. The highest fluctuation of the agents that influence to increase the Net worth (*NW*) (4% to 96%) and fluctuation of the agents that influence to decrease the *NW* (2% to 94%) take place in the smallest probability ($p = 0.1$). While the most limited fluctuation of the agents that influence to increase the *NW* (35% to 60%) and fluctuation of the agents that influence to decrease the *NW* (40% to 60%) take place in the highest probability ($p = 0.9$). In the serious game of RTGS, this probability is used to determine optimal transaction (productivity - liquidity) and influence to stability in the RTGS system. Flow of fund in the RTGS, especially in clearinghouse by using forest fire model can be used to detect the stability of RTGS system. The efficiency of liquidity and productivity can be organized with probability to detect how many banks should be invited to cooperate to finish the settlement process.

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Table 1. Behavior of agent

Probability	Time	Influence of the agent (%) Increase Net Worth	Decrease Net worth	Doesn't Form Activity Network
0.1	0	3	2	95
	20	4	94	2
	40	96	2	2
	60	4	0	96
	80	0	0	100
	100	0	0	100
0.2	0	8	8	84
	20	5	92	3
	40	92	0	8
	60	3	0	97
	80	0	0	100
	100	0	0	100
0.3	0	10	10	80
	20	8	90	2
	40	90	2	8
	60	8	0	92
	80	0	0	100
	100	0	0	100
0.4	0	15	20	65
	20	25	70	5
	40	70	22	8
	60	15	80	5
	80	15	80	5
	100	80	15	5
0.5	0	25	20	55
	20	20	75	5
	40	80	12	8
	60	25	75	0
	80	8	80	2
	100	95	5	0
0.6	0	35	30	35
	20	40	60	0
	40	60	35	5
	60	35	60	5
	80	45	45	10
	100	70	30	0
0.7	0	30	25	35
	20	30	65	5
	40	65	25	10
	60	35	35	30
	80	15	80	5
	100	75	20	5
0.8	0	35	30	35
	20	40	60	0
	40	55	40	5
	60	40	55	5
	80	35	55	10
	100	60	35	5
0.9	0	35	50	15
	20	44	48	8
	40	50	40	10
	60	40	60	0
	80	60	40	0
	100	50	45	5