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UPGRADED CELLULAR AUTOMATA BASED GROUP-WORK INTERACTION SIMULATION

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ABSTRACT

The simulation of group-work interaction is significant for Chinese enterprise organizational management. As a result, a cellular-automata based simulation model is put forward. The number of cells is specified equal to the one of group members. Group members consist of working-hard members and social ones, or regular ones and irregular ones. Time delay and information distortion are taken into account in the model. Work includes various degrees of hard and soft work. The model is coded into Group-Work Interaction System by Visual Basic 6.0. The validation of the system is conducted by choosing the group of adjustable parameters to achieve the optimal match of group members with their work resulting in good group behavior and high work efficiency. Many rules and related phenomena are discussed and analyzed in validation, as well as the implication of the system and further works are offered in the end.

1 INTRODUCTION

Human and work are two different basic components in an enterprise. The former usually exists in the form of groups, such as workers in workshops, employees of developments, R&D teams etc. The latter appears in workflows or tasks, including ones requiring technical skills (the process of work pieces, the research and development of product, etc.) and the others requiring social skills (marketing, negotiations, etc.). Human backgrounds and local customs both have much effect on working performance. On the other hand, different work asks for different human behavior, for an example, in the country such as China in which relationships and faces are emphasized workers may complete their jobs well only if they have social skills of getting along well with others. The interactions among group members and the ones between group members and work are all simple locally, while states generated by the interactions exhibit complicated emergency (Hu and Xia 2005). Therefore, there are three study paths in organizational management of enterprises, including workflow optimization (work), human group behavior (human), and human-things interaction (human and work) (Robbins, Coulter, and Kotze 1997). Most researchers in western countries use the first two paths. The organizational management of Chinese enterprises should be explored in the third path, i.e. to study group-work interaction in the background of Chinese organizational management, because relationships are so popular and important in China and other backgrounds and customs different from ones of western countries.

Cellular Automata (CA) is a useful tool for exploration of group behavior. It is firstly proposed in the end of 1940' (Neumann and Burks 1966). The first application of CA was in natural science and then in the simulation of group's emergent behavior in behavior and social science, including the simulation of human migration, change of ideas and cooperation relationships by CA (Hegselmann and Flache 1998). CA can be seen as a type of socio-matrix used to predict changes within a group, which comes to two conclusions: 1) behavior of group members can be determined by values within the matrix; and 2) the process of making friends can be simulated (Klüver and Stoica 2003). In the study of stock market, CA is used to analyze what reasons influence investors' behavior (Wei et al. 2003). The multi-agent simulation system – Swarm developed from CA is applied for simulation of holistic emergent behavior of complex system in the domains of economics, biology, ecology and other cross disciplines of traditional social and natural sciences (Terna 1998).

Although CA is widely used for the research of complex systems in the domain of social science. However, there are still limitations for current CA models. Firstly, time delay is not included. When the changes of a cell's neighbors or the environment which have effect on cellular happen, the evolution of cell's states or cells' movement will take place at once without any time delay. However, time delay is a common phenomenon in real world. A person won't respond to influences by environment immediately but consider for a period of time and then act. Secondly, information distortion is not taken into count. When

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a piece of information is disseminated in a crowd, the content of the information will be gradually distorted with the increase in times of information transmission, which leads to a result that the initial influence of member A on member B will be reduced gradually and even distorted with the increase in times of influence of member B on member C, member C on member D and etc. It is a common social phenomenon in reality. Last but not least, behavior mutation is not considered. Every cell's state responds to every member's behavior. The transitions of cells' states are driven by local rules which reflect members' behavioral principles. However, there are always so-called abnormal subgroups composed of few group members not obeying the principles (Boudreau 2004). The state transitions of cells on behalf the members should also be described as mutational ones inconsistent with local rules.

Time delay is one of the important reasons resulting in systematic complexity. Information distortion in dissemination is a familiar phenomenon in reality. Behavior mutation often takes place too. Therefore, we should take them into account when modelling with CA.

In this thesis, we will put forward a simulation system based on CA with a trial to avoid its limitations. Users of the system can set cellular scale freely according to group scale of the object simulated and see group behavioral and work state both displayed in grids as well as in tables of statistic data. We will introduce the CA model the system based on and its validation. The thesis will be closed with the conclusion and implication of the research.

2 MODELLING

Characteristics and influencing factors of an object simulated are simplified in CA. i.e. the behavior of cells is regarded consistent with each other without particularity; the main factors affecting the states of cells are their neighbors. However, employees behave in various ways in the process of group-work interaction, including being absorbed in one's own work without caring about others', being good at getting along well with others, or the mixed form of the two ways. The employee's behavior is influenced not only by their neighbors, but also by the state of their own work, i.e. work state.

The objects modeled below are regarded as a system composed of the group, work and the interaction of them, i.e. a group-work system. Group members are classified into working-hard and social ones; the work is classified into hard work and soft one as well. Hard work must be chiefly completed with technical ability and soft work be done with social communication ability. Here, the group's behavior is measured by "working-hard degree", and the work state is measured by "working efficiency".

In group-work system, there are relationships within the group and interaction of the group and work, which are detailed as follows:

(a) Relationships inside a group. Groups of an organization is situated in a certain social field. Every group member attracted by a core gravitation of the field prefers to acting in the same way as the majority which called herd behavior (Lewin 1951). Every member will weigh whether it is worth for one to acting in the way of herd behavior before taking any action. The difference of weighing between the members of formal and informal organizations is that the former weigh on economic benefits and the latter do on social ones, and it is a process of benefit weighing, in which members will consult with and exert influence on each other and time delay is produced (Prien, Rasheed, and Kotulic 1995) . The consulting and influence will lose its original meanings with the advance of the clock, which is referred to the generation of information distortion. A few members show particular interests, and act in the way not conforming to general rules during the process, which can be regarded as behavioral mutation. As a result of the reasons described above, group behavior exhibits distinct complexity, i.e. emergency and volatility (Vallacher and Nowak 1997).

(b) Interaction of the group and work. The behavior of different members has different effect on different work. For an example, working members have little effect on social work. On the other hand, work state also has effect on group behavior in turn. For an example, if work is completed successfully in a shortcut such as social relationship, the social members will be encouraged greatly and review their experience to enhance the degree of their hard work in the future, while the working members will be beaten so that decrease they decrease the degree in the future.

To model the system described above, we should analyze it from its input, output and structure. The input includes group scale, member property, complexity factors (time delay, information distortion, irregular members) and work characteristic etc., while the output comprises group behavior, work state. The structure refers to interactions among group members and between group members and work.

2.1 The basic CA model

A basic CA model can be described with a grid board as Figure 1. How many cells are set in the grid board depends on how large scale of objects modeled will be simulated, such as 20 times 20 or 100 times 100. Every cell is neighbored by several cells. In a CA model, there are several types of neighborhoods. The neighborhood illustrated in Figure 1 is called the Moore Neighborhood template (Bastien and Michel 1998) in which a black cell in the center is surrounded by 8 grey neighbors.

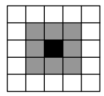

Figure 1: Moore neighborhood template

Two aspects are included in A basic CA model:

(a). States of cells. Every state of cells represents a state of an element of the object modeled such as a group member's behavioral state. Different states can be illustrated in different colors, such as 3 colors like black, white and grey responding to 3 states like buying, standing and selling respectively in the simulation of stock investors' behavior (Wei et al. 2003).

(b). Local rules. They are the rules of a state transmitting to another state. They are called local rules because the evolution of a cell is mainly influenced by its neighbors' states. The rules should be designed oriented to different objects with some other factors are taken into account but neighbors sometimes.

The simulation of a CA model is discrete and all cells' states are transmitted at the same time according to transition rules. The approach put forward in this paper will take into account time delay, information distortion and irregular members in state transition based on a basic CA model.

2.2 Variables

There are three variables to take into consideration: group states, work state and systematic performance.

Let $S_{(i,j)}(t)$ be the state of the cell which located in (i,j) of the grid board in time step t. $S_{(i,j)}(t)=\{x|\ 0 \le x \le 1\}$, which means that the member's working-hard degree will be very large illustrated in black when $S_{(i,j)}(t)$ is equal to 1, and be very little illustrated in white when $S_{(i,j)}(t)$ is equal to 0. The state of the member's neighbor is marked by $S_{(i,j)L}(t)$.

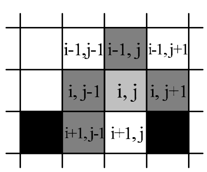

Figure 2: The CA model

As illustrated in Figure 2, the grayish cell is the cell (i,j) and its neighbors' location are all marked out among which the cells $(i\text{-}1,j\text{-}1)$, $(i\text{-}1,j\text{+}1)$ and $(i\text{+}1,j)$ are in white, the cells $(i\text{-}1,j)$, $(i,j\text{-}1)$, $(i,j\text{+}1)$ and $(i\text{+}1,j\text{-}1)$ are in dark grey, and the cell $(i\text{+}1,j\text{+}1)$ is in black. The state of every cell responds to its behavior.

Let $P_{(i,j)}$, $P_{(i,j)L}$ respectively be types of cell (i,j) and its neighbor, $P_{(i,j)}$ or $P_{(i,j)L}=\{y|\ 0 \le y \le 1\}$, which means that the member marked by cell (i,j) is the one of working type when y=1, and is the one of social type when y=0.

Let MP be work characteristic. $MP=\{z|\ 0 \le z \le 1\}$. It means that the work is a hard one when MP =1 and a soft one when MP =0. $M(t)$ is the work state in time step t. $M(t)=\{z|\ 0 \le z \le 1\}$. It means that the efficiency on work is very high when $M(t)$ = 1 shown in black and very low when $M(t)$ = 0 shown in white.

Let $S(t)$ be the average level of group behavior in the whole in time step t and n^2 be the number of members. $S(t)$ can be computed as follows.

$$S(t) = \frac{1}{n^2} \sum_{i=1}^{n} \sum_{j=1}^{n} \frac{S_{(i,j)}(t)}{255} \tag{1}$$

Let $E(t)$ be the difference among members in time step t and n^2 be the number of members. Smaller $E(t)$ means less difference. $E(t)$ can be computed as follows.

$$E(t) = \frac{1}{n^2} \sum_{i=1}^{n} \sum_{j=1}^{n} \sum_{L} \frac{|S_{(i,j)}(t) - S_{(i,j)L}(t)|}{8} \tag{2}$$

2.3 Local rules

There are General evolving rules of group behavior and work state involved in the model, the rules and their revised versions are detailed respectively below.

Firstly, for General evolving rules of group behavior, the behavior (state) of a certain member (cell) in a certain time step is influenced by many factors including his/her (its) behavior in last time step, his/her (its) neighbors' behavior (state), his/her (its) property, characteristic and state of the work. The casual relationship among the variables is: $S_{(i,j)}(t+1) = F(S_{(i,j)}(t), S_{(i,j)L}(t), P_{(i,j)}, MP, M(t))$. The general rule is given as follows:

If $(P_{(i,j)} \ge 0.5$ and $MP \ge 0.5)$ or $(P_{(i,j)} < 0.5$ and $MP < 0.5)$ then

$$S_{(i,j)}(t+1) = S_{(i,j)}(t) + \sum_{k=1}^{m} \frac{S_{(i,j)L}(t)_k - S_{(i,j)}(t)}{m} + (1-\lambda) * (M(t) - M(t-1)) \tag{3}$$

Else

$$S_{(i,j)}(t+1) = S_{(i,j)}(t) + \sum_{k=1}^{m} \frac{S_{(i,j)L}(t)_k - S_{(i,j)}(t)}{m} \tag{4}$$

End if

Where, $S_{(i,j)}(0)$ is the original state of group members. m is the number of his/her neighbors, the types of which are the same as his/hers. λ is an adjustable parameter of behavior ($\lambda \in \{0, 0.1, 0.5, 0.9\}$).

The set of λ is to make the simulation system more consistent with real world (the group and environment) in validation.

Equation (3) suggests that when the member's property is consistent with work characteristic, the member's behavior will be affected not only by his neighbors' behavior, but also by work state in next time step, i.e. that increase(decrease) of working efficiency has positive (negative) effect on the member's behavior. Equation (4) suggests that when the member's property is inconsistent with the characteristic of the work, the member's behavior is only influenced by his neighbors' behavior, i.e. group behavior emulates naturally.

Because the maximum and minimum RGB values of the colors are 255 and 0 respectively, we add following rules for Equation (3) and (4).

```
If S(i,j) (t+1) > 255 then
    S(i,j) (t+1) = 255
ElseIf S(i,j) (t+1) < 0 then
    S(i,j) (t+1) = 0
End if
```

Secondly, for general evolving rules of work state, let $\Delta S(t+1) = S(t+1) - S(t)$, $\Delta E(t+1) = E(t+1) - E(t)$, and the $\Delta S(t+1)$ and $\Delta E(t+1)$ are linked by $M(t+1)$ with casual relationships as illustrated in Figure 3 ($\omega \in \{-,0,+\}$).

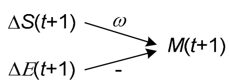

Figure 3: The casualty bridged by $M(t+1)$

The value of ω is given and $M(t+1)$ is calculated under 3 conditions listed as follows.

```
If (ΔS(t+1) >0 or (ΔS(t+1) > 0 and ΔE(t+1) > 0)) and ω= "-" Then
```

$$M(t+1) = M(t) - (1-\tau) * |\Delta S(t+1)| \quad (5)$$

```
Elseif ΔS (t+1) > 0 and ΔE(t+1) < 0 and ω= "+" Then
```

$$M(t+1) = M(t) + (1-\tau) * |\Delta S(t+1)| \quad (6)$$

```
Elseif ΔS(t+1) = 0 or ΔE(t+1) = 0 Then
```

$$M(t+1) = M(t) \quad (7)$$

```
End If
```

Where, τ is an adjustable parameter of working rules, $\tau \in \{0.1, 0.2, \ldots, 0.9\}$, and it can be tuned up or down to make the simulation system more consistent with real world (the group , work and environment) in validation.

Let $DM(t)$ be the variation ratio, and its calculation is as follows:

$$DM(t+1) = (M(t+1) - M(t)) / M(t+1) \quad (8)$$

Lastly, for revisions of general evolving rules above, if time delay and information distortion are both taken into account, general rules should be revised. The behavior of corresponding cells of irregular members won't change according to Equation (3) and (4).

(a) Revisions based on time delay. The behavioral response of a certain cell will change from $S_{(i,j)}(t)$ to a stable value $S_{(i,j)}(t+1)$ (See Equation (3) and (4)) when it is affected by its neighbors and work state. A hypothesis is given here that the response time step is 1 if there is no time delay in the process, i.e. the response takes place immediately (See Figure 4a), 2 if time delay is short (See Figure 4b), and 3 if long (See Figure 4c).

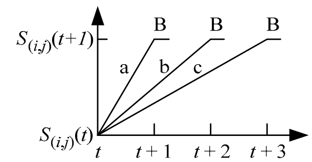

Figure 4: The response of causal variable B

Thus, Equation (3) and (4) is revised to Equation (9) and (10) when time delay is short and long respectively according to the hypothesis.

$$S_{(i,j)}(t+1) = S_{(i,j)}(t+1)/2 \quad (9)$$

$$S_{(i,j)}(t+1) = S_{(i,j)}(t+1)/3 \quad (10)$$

(b) Revisions based on information distortion. The fact that information is distorted during its dissemination can be described that the influence among cells and between cells and work state will be weaker gradually with the advance of time, and the influence of group behavior on work state will be weaker too. Let α be the weakening degree of the influence, $\alpha = \{q \mid 0 \le q \le 1\}$. The change of α is illustrated in Figure 5, in which T is time step, α is 1 in time step t, and then becomes smaller until it is 0 in time step $t+r$, the value of r depends on the situations.

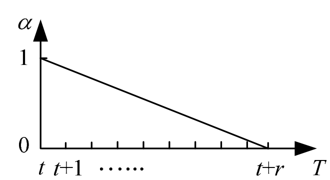

Figure 5: The change of α

r is given a great integer value L in this paper, α is given as follows.

```
For t = 1 to L
  α = 1 - t / L
Next t
```

Thus, Equation (3) and (4) need modifying as follows.

$$S_{(i,j)}(t+1) = \alpha * S_{(i,j)}(t+1) \quad (11)$$

(c) Cells' states of irregular members. Let the behavior of irregular members in every time step, i.e. $S_{(i,j)}(t+1)$, be a random of which the distribution is U(0,1). Thus,

$$S_{(i,j)}(t+1) = \text{rand}() \quad (12)$$

3 SYSTEM

The model described above is coded by Visual Basic 6.0 and Group-Work Interaction Simulation System (GWISS) is developed, and its user interface is illustrated in Figure 6.

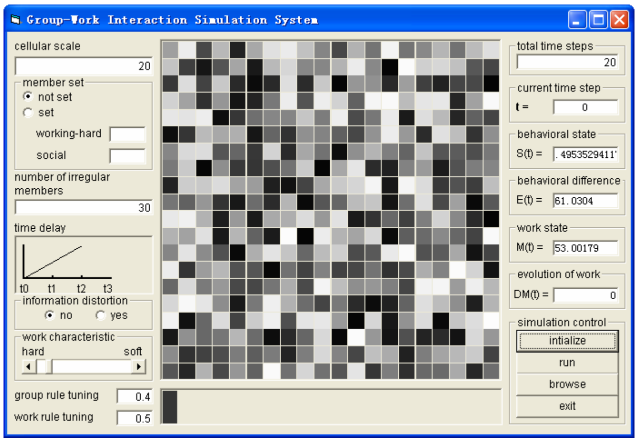

Figure 6: The user interface of GWISS when the cellular scale is 20*20

The cellular scale of GWISS can be set freely by one's willingness. "cellular scale" n =20 (See Figure 6) means that there are 400 (20*20) cells involved in the simulation. "no set" in "member set" means that the number of working-hard members or social ones is generated randomly. "set" means that the numbers of 2 types of members should be input into the textbox respectively and the sum of the them should be 100*100. "number of irregular members" refers to the number of irregular members whose behavior vary according to Equation (12). In "time delay", if there is no time delay in the mutual influence among members, the influence value of a cell on its neighbors will reach the maximum in next time step (t_1) (See Figure 4a); If there is time delay, two situations will be considered here: if time delay is short, the influence value will reach the maximum in time step t_2; if time delay is long, the influence value will reach the maximum in time step t_3 (See Figure 4c). "no" in "information distortion" means that the mutual influence among members and between members and work will remain not weakened, while "yes" means that the influence will become weaker and weaker. "group rules tuning" and "working rules tuning" are filled in with values of λ and τ respectively. "total time steps" will be filled in with the value of total time steps of the simulation. "current time step" will display the current time step in the simulation. $S(t)$, $E(t)$, $M(t)$ and $DM(t)$ will display group behavioral state, behavioral difference among group members, work state and variation ratio of work state. In the middle, the change of cells' colors in the picture box shows the evolution of group behavioral state of which value is initiated randomly by the system. The progress bar shows the evolution of work state $M(t)$ of which value is also initiated randomly by the system.

4 VALIDATION

The validation of a model is a process of comparing the input and output of the model and the ones of a real system to ensure the former consistent with the later. According to types of a model, the ways to validate of a model can be classified into 2 kinds: basic (quantitative) validation and qualitative one (Dijkum, Detombe, and Kuijk 1999). The quantitative validation will be used if the input and output data of the system can be collected, however, the data in this paper can not. Thus the qualitative validation is used here.

Firstly, it is necessary to design several naive experimental scenarios, i.e. the groups of naive input data, and set all groups constituted by λ and τ.

Secondly, every experimental scenario will be run for each group of (λ, τ) and produce results.

At last, the input and output data are compared with social phenomena or common knowledge, of which the ones most consistent with or near to the phenomena or knowledge will be chosen and the group of (λ, τ) that the data respond to should be the best group which makes validate the model well.

4.1 Simulation experiments and related analysis

The naive experimental scenarios are designed as illustrated in Table 1.For every scenario, simulation is run for different groups of (λ, τ) to find the one which can describe the object simulated best. There are 9 groups of (λ, τ) in this paper:(λ, τ)= {(0.1, 0.1), (0.1, 0.5), (0.1, 0.9), (0.5, 0.1), (0.5, 0.5), (0.5, 0.9), (0.9, 0.1), (0.9, 0.5), (0.9, 0.9)}, which are numbered as group 1, group 2, …, group 9.

Table 1: Naive experimental scenarios designed for simulation of work-group interaction when cellular scale is 20*20.

Scenario	MP	IM	TD	ID	WC
1	not set	0	no	no	not set
2	not set	0	long	no	not set
3	not set	0	no	yes	not set
4	set, all social	0	no	no	soft
5	set, as all working-hard	0	no	no	soft

Where: MP is Member Property, IM is Irregular members, TD is Time Delay, ID is Information Distortion, WC is Working Characteristic.

Every scenario ends its simulation in time step 15, i.e. *t*=15. The simulation results of scenario 1 are illustrated in Figure 7, in which the evolutions of *S*(*t*), *E*(*t*), *M*(*t*) and *DM*(*t*) are illustrated in Figure 8.

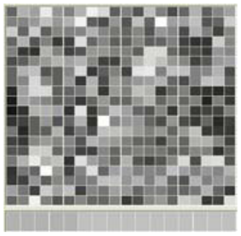

Figure 7: The simulation result of Scenario 1 when *t*=15

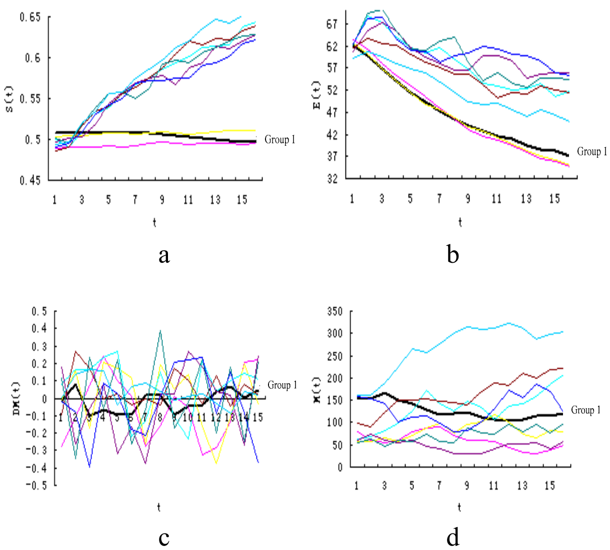

Figure 8: The change of variables in Scenario 1

- Scenario 1: member property is not set, i.e. the number of working-hard members is equal to the one of social members; work characteristic is not set, i.e. the work has a half hard and soft characteristic; there are no irregular members; there is no time delay or information distortion. In such a case, the natural evolution of group behavior should be smooth according to common knowledge. So group 1, 2, and 4 are both good as illustrated in Figure 8a, which is also proved in Figure 8b. All the 3 groups make group behavioral difference decrease gradually and gently. Because of slow evolution of group behavior above, work state should also evolve gently. In Figure 8c, group 1 results in most gentle evolution of work state, which fluctuates in the lest degree (See Figure 8d). Thus, group 1 is the best one for Scenario 1.

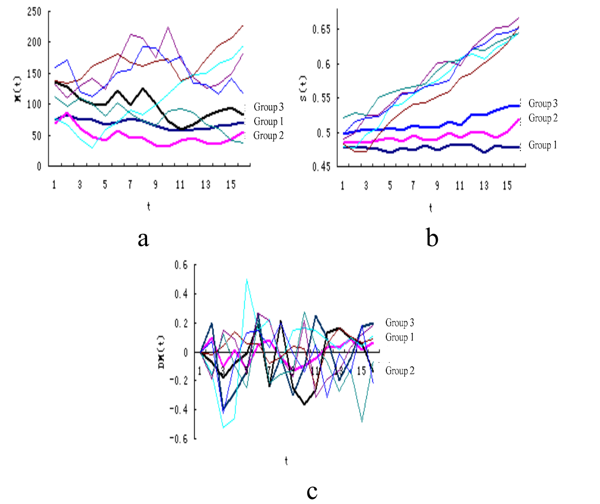

Figure 9: The results of Scenario 2

- Scenario 2: It is from Scenario 1 with time delay turned into "long". According to "Bullwhip Effect" in Complex System, time delay mainly answers for the fluctuation of system behavior. As illustrated in Figure 9a, group 1, 2 and 3 increase variation of group behavior in extent during the process of the behavior's fluctuation compared with Scenario 1. With the advance of time clock, the fluctuation becomes more drastic. The results of Scenario 2 is consistent with the phenomenon of "Bullwhip Effect". So group 1, 2, and 3 are better ones. It suggests that group 2 and 3 are better in Figure 9a. Work state fluctuates more dramatically due to the influence from group behavior's fluctuation, which accords with the logic of common knowledge. Furthermore, group 3 is the best

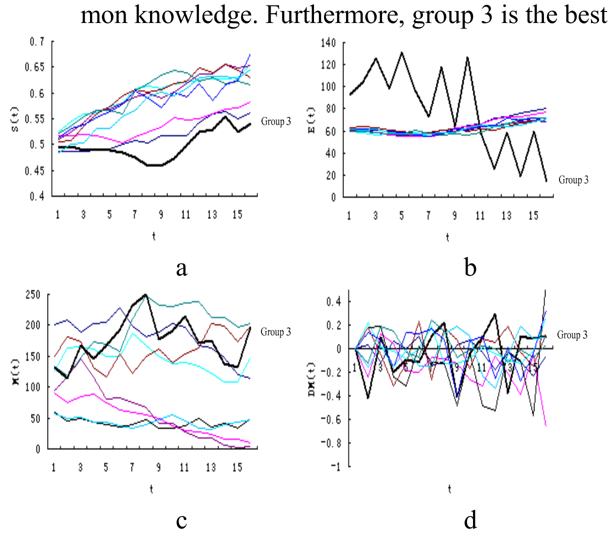

Figure 10: The results of Scenario 3

one as illustrated in Figure 9c because it results in more drastic fluctuation of work state. Thus, group 3 is the best one for Scenario 2.

- Scenario 3: It is from Scenario 1 with information distortion turned into "yes". According to common knowledge information distortion among members and between members and work will result in uncertainty of members' behavior and work state. From Figure 10a we can not decide which group is the one resulting in uncertain group behavior because of little difference among all the curves, but group 3 brings more drastic fluctuation of behavioral difference among members as illustrated in Figure 10b. From Figure 10c which group results in uncertainty of work state is not seen and curves of work state fluctuates in little extent, among which the difference is also little, but group 3 causes drastic fluctuation of work state seen from Figure 10d. Thus, group 3 is the best one for Scenario 3.

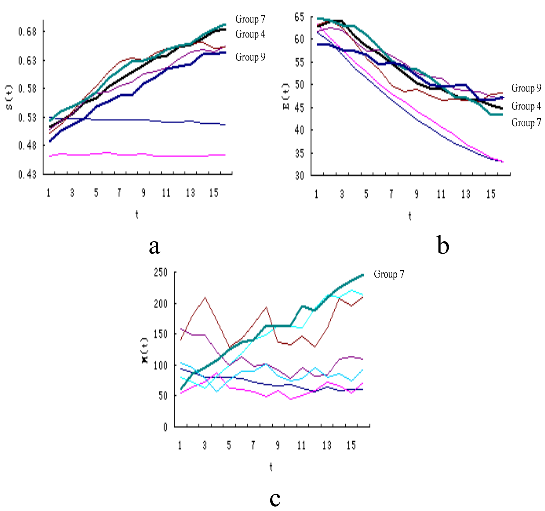

Figure 11: The results of Scenario 4

- Scenario 4: It is assumed in Scenario 4 that members are all social ones and the work is fully soft one. In such a condition people are well matched with work. Group behavior will evolve toward the direction of being better, and work state is getting better and better at the same time. Seen form Figure 11a, group 7, 4 and 9 drive the evolution of group behavior toward ideal direction, while the other groups have no such effect and show downward trends. No conclusion is arrived at from Figure 11b because the cures all exhibit downward trends. As illustrated in Figure 7, group 7 results in the increase of work state at all time

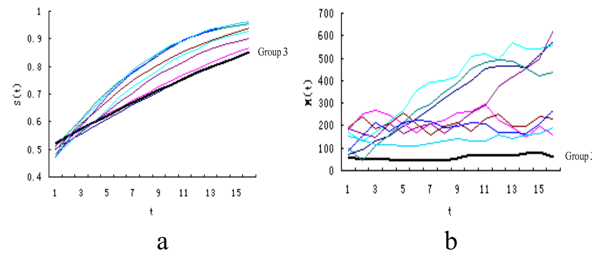

Figure 12: The results of Scenario 5

steps, which proves that group 7 is the best one for Scenario 4.

- **Scenario 5**: It is assumed in Scenario 5 that members are all working-hard types and the work is fully soft. In such condition people are not matched with work, and then group behavior will evolve not well, and work state will not be better at the same time according to common knowledge. As illustrated in Figure 12b, group 3 results in the bad trend, which can not be seen in Figure 12a. But the fluctuation caused by group 3 is in the lest trend. Thus, group 3 is the best one for Scenario 5.

4.2 Discussions

Simulation experiments have been made for Scenario 1-4 in Table 4 with cellular scale expanded to 50*50 and ended when $t = 15$. The results of variables are recorded in Figure 13, and the analysis is detailed as follows.

- **Scenario 1**: The evolution of group behavior is still fluctuating gently. But the fluctuation (See Figure 13a) are more frequent than the one under the scale of 20*20 in some time steps (See Figure 8a), and it is the same with work state (See Figure 8c and 13c). Thus, it is concluded that the expansion of cellular scale has no effect on the simulation results in section 4.6.
- **Scenario 2**: The fluctuation of the evolution of group behavior still appears (See Figure 13a), and shows more a drastic trend than the one under the scale of 20*20 (See Figure 9a) in some time steps. But the evolution of work state shows a trend of increase, which is much different from the one illustrated in Figure 9b. Thus, it is concluded that the expansion of cellular scale has not any effect on group behavior, but it influences work state.
- **Scenario 3**: There is great difference between the evolution of group behavior in Scenario 3 (See Figure 13b) and the one under the scale of 20*20 (See Figure 10a), and it is the same with the difference between behavioral difference under 2 scales (See Figure 13b and 10b). The evolution difference of the work state between the cases of 2 scales is little (See Figure 13c and 10c). It is concluded that whatever scale of a group-work sys-

tem has not any obvious laws in its behavioral evolution when there exists information distortion.

- **Scenario 4**: The evolution of variables in Scenario 4 is basically consistent with the one under the scale of 20*20. It is concluded that the evolution of group behavior and work state are note affected by group scale when member property is matched with work characteristic.

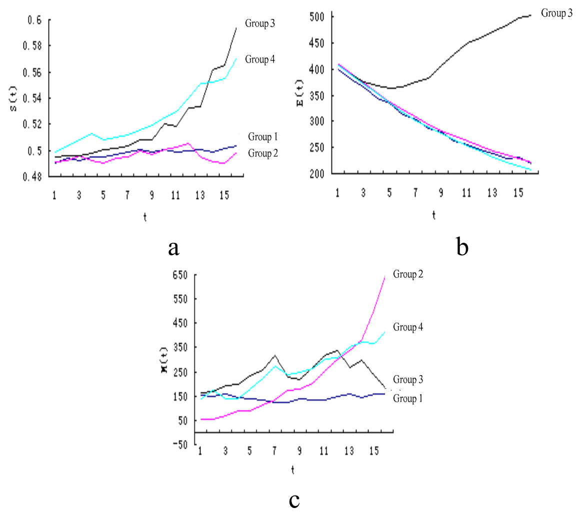

Figure 13: The results of Scenario 1-4 when cellular scale is 50*50)

The conclusions are reached from the validation of the system above as following:

(a) To adjust the groups of (λ, τ) can make group-work interaction model more consistent with real phenomena or common knowledge, which is the validation of the model in this paper.
(b) The validation is not affected by group scale basically.
(c) Time delay has great effect on the validation.

5 CONCLUSIONS

The group behavior has direct effect on working efficiency, and working efficiency also has effect on group behavior conversely. It is a process of interaction of them. Group behavior, working efficiency and their interaction co-evolve continuously. A simulation model of group-work interaction is designed based on CA and a system based on the model is developed by Visual Basic 6.0. The cellular scale of the system can be set freely. The members are classified into two types including working-hard and social ones. The number of irregular members of the group can also be set. The causes resulting in complexity of a real system including time delay and information distortion are taken into account in the system. The work is also classified into 2 types including hard one and soft one according to its characteristic. Group rules tuning parameter λ and work rules tuning parameter τ are both included in the design of the system to validate the simulation model and make it reveal real world as more rightly as possible.

Five naive experimental scenarios show the validation of the model and we find that the group scale has little effect on the validation, but the validation is difficult when there is information distortion in group-work system.

With the expansion of cellular scale (when and after it is bigger than 50*50), the speed of the simulation slows down rapidly, which is known as one of the bugs in development of the system and made every scenario (See Table 1, section 4.7 and 5.6) run only once in this paper and not many times to acquire the conclusions. In addition, the conclusions pointed out above are reached by observation with naked eye on statistic pictures of the simulation results. What other more precise methods can be used in the analysis? Can we apply the system for exploration of group-work interaction? All these need further study.

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