Int j simul model 14 (2015) 1, 134-144
ISSN 1726-4529 Original scientific paper

SIMULATION OF CONFLICT CONTAGION IN CUSTOMER COLLABORATIVE PRODUCT INNOVATION

Su, J. F.*; Yang, Y.*; Yang, T.*; Zhang, X. F.* & Liu, L.**
* State Key Laboratory of Mechanical Transmissions, Chongqing University, Chongqing, China
** Guangxi University of Chinese Medicine, Nanning, China
E-Mail: jiafu.su@hotmail.com, yuyang@cqu.edu.cn

Abstract
Customer collaborative product innovation (CCPI) is a novel pattern of new product development (NPD) to integrate customers and their knowledge as the main innovative agents and resources. In CCPI, conflict is an intrinsic and inevitable phenomenon. Conflict contagion, however, is a neglected but crucial issue for the CCPI conflict management. In order to study the mechanism and process of CCPI conflict contagion, this paper uses the idea of SIS epidemic propagation as reference, and develops a Conflict-SIS (C-SIS) model through adopting the cellular automata (CA) method and the SIS epidemic model. Based on the C-SIS model, we simulate the process of CCPI conflict contagion, and verify the influence of different setting and factors on the conflict spreading trend. The simulation result well reflects the conflict contagion characteristics of real CCPI system.
(Received, processed and accepted by the Chinese Representative Office.)

Key Words: Customer Collaborative Product Innovation, Conflict, Conflict Contagion, Cellular Automata, Conflict-SIS Model

1. INTRODUCTION

New product development (NPD) nowadays involves more and greater challenges than ever in face of the dramatic-changing economic environment. Firms today work closely with customers and acquire inspiration and knowledge from them. Under this situation, customer collaborative product innovation (CCPI) has been an imperative and popular strategy of NPD. As one of the major streams of open innovation [1], CCPI integrates both the internal innovation actors (e.g. designers and experts) and the external innovation partners (e.g. customers and users) facing the open environment, and regards customers and their knowledge as the main innovative agents and resources integrating into NPD [2]. Today, increasing numbers of researchers have proposed that CCPI can improve the performance of NPD, reduce the effort and cost for implementing NPD [3].

However, considering the internal innovation actors and external innovation customers differ in role, orientation, goal, culture and technology belief, conflict inevitably becomes an intrinsic and natural phenomenon in CCPI. A broad spectrum of scholars has recognized that conflicts launch important effects on organizational performance [4, 5]. But, most of the conflict management articles are restricted to the intra-organizational level [6]; little research on the conflict management in CCPI (an across-organizational collaborative innovative strategy) exists. In addition, CCPI conflict is a multidimensional, dynamic and evolutionary phenomenon, which can broadcast and spread throughout the organization [7], therefore conflict contagion is an intrinsic and inevitable process in CCPI. However, few researchers study the dynamic mechanism and process of conflict contagion in CCPI. CCPI conflict contagion denotes the mechanism of conflict spreading and evolution over time and CCPI system. The study of conflict contagion can help researchers and practitioners to better identify CCPI conflict contagion situations and adopt the conflict management strategies suitable for the specific conflict contagion level, ultimately better manage the conflict. In this paper, we seek to develop a quantitative model to excavate and characterize the process of CCPI conflict contagion and the factors affecting the conflict contagion.

The remainder of this paper is arranged as follows. Firstly, a sketch of the theoretical basis surrounding the concepts of CCPI, CCPI conflicts and conflicts contagion is presented. Afterward, section 3 proposes a model to study the conflict contagion. In section 4, based on the presented model, the simulation of the conflict contagion is given. Finally, the conclusion and future study are given in the last section.

2. LITERATURE REVIEW

2.1 Customer collaborative product innovation (CCPI)

The successful product innovations depend on the deep-going understanding of customers' needs and developing products to satisfy those needs [8]. Among these customers, the lead users can present strong needs, which will become general in a marketplace months or years in the future [3]. Yang Yu et al. stated that CCPI is a novel pattern of NPD which can make full use of the asymmetry of knowledge structure and innovation skills between customers (especially the lead users) and professional designers [9]. Therefore, CCPI can be seen as a natural evolution from the lead-user method [10]. In several product industries, such as athletic footwear, equipment for extreme sports, and surgical equipment, customers and their knowledge have been the important resource of product innovation [11]. To sum up, as a vertical collaborative product innovation pattern, CCPI allows companies to obtain much more new insights and knowledge about new technologies, markets, and process improvements from their customers [12, 13], and has a significant effect on NPD performance [2].

2.2 CCPI conflict

Most studies have paid much attention on the positive side of CCPI, such as motivation for collaboration [14], collaborative innovation organization pattern [15] and technology [16], and innovative knowledge management [17]. However, there are little research addressing on the management of conflict, which is a potential threat to weaken the collaborative relationship and the CCPI performance. As a kind of social phenomenon, conflicts are everywhere, and conflict management has been a significant issue studied in all fields. Rahim stated that social members, with different goals, may have incompatible working-relationships, and then conflicts would be inevitably induced [18]. Klein [19] stated that conflicts are incompatible reactions between two (or more) collaborative members with different objectives. Hinds and Mortensen [20] classified conflicts into relationship conflicts and task conflicts in the geographically distributed teams. Klein [21] and Slimani et al. [22] proposed that conflicts are commonly existing in the collaborative design process. In CCPI, because the CCPI members likely differ in their culture, languages, goals and technology beliefs, along with the rigorous NPD cost-time constraint, which will unavoidably give rise to the conflict. In a sense, the process of NPD is also a process where conflicts occur, spread and disappear continuously. In this paper, we define that there is a CCPI conflict appearing when two or more propositions, orientations, and ideas cannot co-exist at the same time in the same CCPI space. Furthermore, we will focus on excavating the evolution process of conflict contagion over time in CCPI.

2.3 CCPI conflict contagion

CCPI conflict is a multidimensional, dynamic and evolutionary process. In CCPI, an understanding of the dynamic characteristics of conflicts and the process of conflicts contagion is indispensable. However, most of the prior literatures focus on the static levels of conflict, ignoring the dynamic characteristic of conflict that might spread over time and space

[23]. In a recent study, Jehn et al. stated that conflicts are contagious in team, and the conflicting contagion may have multidimensional levels, including the dyadic level, partial level and full level [23]. In this paper, we define the CCPI conflict contagion level as the number of CCPI members behaviourally engaged in a certain conflict. Furthermore, we define that the CCPI conflict behaviour is an individual's behavioural reaction to the involvement in a certain conflict. And, the conflict behaviour can be regarded as the sign that a team member is involved in a certain conflict. For a CCPI system, it would have low conflict contagion level, when only a few members are behaviourally involved in the conflict, but it would stay at high conflict contagion level if numerous members are behaviourally involved in the conflict. To sum up, CCPI conflict contagion is the mechanism describing the progression and evolution of a conflict in CCPI over time, and it involves from just a few members to the entire CCPI members.

Conflict contagion depends on the incompatibility and independence among the CCPI members to some extent [6, 24]. Gelfand et al. stated that conflict contagion can be seen as a consequence of universal human traits (intergroup preference and out-group hostility), and suggested conflict contagion is much more likely occurring in collectivistic than individualistic groups [25]. Barsade's research indicated that a positive or negative emotion contagion may influence the spread of group conflicts [26]. Jehn et al. suggested three mechanisms, coalition formation, emotional contagion, and protection of individual and team interests, stimulate the conflict contagion occurring, and assumed that the three mechanisms run independently of each other. Furthermore, they proposed a series of factors which can affect the speed and extent of conflict contagion [7]. However, the above all literatures focused almost on the macro conflict contagion process, the result of conflict contagion and the influence factors of conflict contagion. Few researches have placed the emphases on the micro operational process of conflict contagion, which may have much more practical significance on the management of conflict contagion. Therefore, based on the above research status quo, this paper will focus on examining the micro-process of CCPI conflict contagion. Wherein, from a perspective of micro-mechanism, we will use the idea of epidemic spreading as reference, and adopt the cellular automata (CA for short) [27-29], a complexity science research method, to study the evolutionary process of CCPI conflict contagion.

3. THE CCPI CONFLICT CONTAGION MODEL

3.1 The description of CCPI conflict contagion process

For the CCPI system of our research, we assume that it adopts the pattern of geographically distributed visual teams to support the collaborative members (e.g. the intra-designers and customers) to implement the collaborative product innovation. Furthermore, the CCPI system opposes a stable collaborative relationship, thus there are existing close relationships among the collaborative teams and members.

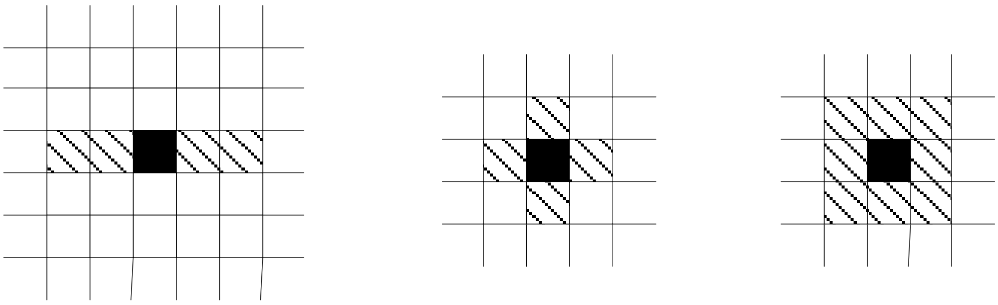
In this work, we suppose that, in a central-position team of CCPI system, there a certain task or relationship-related conflict occurs among the team members. The conflict can diffuse within the central team, and escape into its neighbouring teams. Considering the members' response to the CCPI conflict, we use the SIS epidemic model for reference [30, 31], and classify the CCPI members into two groups: the S (susceptible) group, representing the portion of the members that has not been affected by the conflict, but can be infected in case of contacting with conflict-involved members; the I (infected) group, corresponding to the group of members already involved by the conflict and who can transmit the conflict to the S group. In the process of CCPI conflict contagion, the individuals of S group are mainly infected the conflict by the inter-team members, meanwhile they can also be affected by the members of the neighbour teams. Moreover, concerning the certain conflict, the CCPI team will take measures to address it. Therefore, the conflict-infected individuals can regain the susceptible state with a certain probability.

In this paper, based on the above description of CCPI conflict contagion, we aim to study the conflict contagion level at each time point, and recreate the process of CCPI conflict.

3.2 Review of cellular automata

CA are the set of models of dynamical systems, where space and time are discrete and interactions of localized CA can cause a global change. CA have been extensively adopted to simulate complex systems, such as population dynamics [32], wildfire spreading [33], epidemic propagation [34], and innovation diffusion [35]. These works show that complex systems can be effectively simulated with simple CA local transition rules. Conflict contagion is a dynamic and complex process. Therefore, in this paper, we try to use the CA model as a new perspective to study the conflict contagion.

Bi-dimensional CA are formed by a finite number of identical objects called cells. Each cell is endowed with a state which changes in discrete steps of time according to a local transition rule. Structurally, CA are composed of lattice space, finite state set, neighbourhood and transition function, which is defined by the 4-uplet (C, Q, V, F). Wherein, C is the lattice space. Q is the finite state set, which contains the values taken as the cell's state at each time step. As a cell neighbourhood, it refers to a set of cells which affect the evolution of the central cell. For one-dimensional CA, the neighbourhood V usually be determined by a radius r: a cell, whose distance from central cell is within r, can be defined as the neighbourhood of central cell (see Fig. 1 a). As for the two-dimensional CA, the definition of neighbourhood is more complex. While, the most common types of neighbourhood are Von Neumann neighbourhood and Moore neighbourhood (see Figs. 1 b and 1 c).



a) Elementary cellular automata b) Von Neumann neighbourhood c) Moore neighbourhood

Figure 1: The typical CA neighbourhood.

At last, F is the local transition rule, which governs the CA evolution and determines how cells change their states depending on their neighbourhood in time. F may be denoted by a matrix, an analytic function, or a set of transmit rules. The transition function F may be considered as the mapping:

$$S_{V_C}^{t-1} \to S_c^t$$
$$S_c^t = F\left(S_{V_C}^{t-1}\right) \quad (1)$$

where, $S_{V_C}^{t-1}$ stands for the state of the neighbourhood of the cell c at the time $t-1$, and S_c^t is the state of the cell c at the time t.

3.3 The model of CCPI conflict contagion

CA have been extensively used to stimulate complex systems, especially in the field of epidemic propagation [34, 36-38]. As discussed above, CCPI conflict contagion is a dynamic and complex social and organizational phenomenon, and the study on it is a key to the success of CCPI. For CCPI conflict contagion, it shares lots of common points with SIS epidemic propagation. In CCPI, the conflict-involved members may transmit the conflict viewpoints, emotion and behaviour to other team members, and lead other members to engage in the conflict also, that is "infecting" conflicts, and gradually form the alliances or opposing camps, affecting far more members. Meanwhile, a conflict-involved individual can also walk away from the conflict, or settle it with a certain probability that is "regaining healthy", via updating conflict management strategies or adopting more effective conflict management measures. Therefore, based on the above analysis, we try to adopt the CA method, which is commonly applied to the study of epidemic propagation, to study the mechanism and process of CCPI conflict contagion.

We introduce the bi-dimensional CA model to stimulate the process of CCPI conflict contagion. The CA model is defined by a 4-uplet (C, Q, V, F), where C is the lattice space, Q is the finite state set, V is the neighbourhood and F is the transition rule. In this paper, combining the SIS epidemic model, we have a name for the CA model: the Conflict–SIS model, C-SIS for short.

Based on the four elements of cellular automata, coupled with the organizational operating mode of CCPI and the propagation characteristics of CCPI conflict, the C-SIS model is built as follow:

Lattice space C: we set up C as a two-dimensional cellular space, with $n \times n$ cells, denoted by C^2, and every cell in C^2 is denoted by $c(i,j)$. Thus, the C^2 can be denoted by:

$$C^2 = \{(i,j), 1 \le i \le n, 1 \le j \le n\} \tag{2}$$

Conventionally, when a CA model is designed to simulate a spreading or diffusion phenomenon, the study objects are assumed to be distributed into the cellular space, and each cell stands for an object. However, in CCPI, the collaborative members mainly take the pattern of virtual teams or virtual alliances to launch the collaborative work [15]. Thus, the conventional CA distribution mode cannot accurately reflect the real operation mode of CCPI system. In this paper, we propose that a CCPI team, instead of only one member, is assumed to be distributed into the cellular space, that is, each cell stands for a CCPI team. Based on this, different cells will have different number of members, and among the different cells, there are existing certain "across cell" traversal or mobility possibilities.

Finite state set Q : based on the above definition of cellular space, the state of each cell is denoted by the fraction of the number of members which are conflict-susceptible or conflict-infected. Let $S^t_{c(i,j)}$ be the portion of the conflict-susceptible members of the cell $c(i,j)$ at time t; and set $I^t_{c(i,j)}$ be the portion of the conflict-infected members of the cell $c(i,j)$ at time t. Wherein, we assume that the population of each cell is constant. Therefore, there does exist the following relation:

$$S^t_{c(i,j)} + I^t_{c(i,j)} = 1 \tag{3}$$

Furthermore, considering the $S^t_{c(i,j)}$ and $I^t_{c(i,j)}$ may be a irrational number, we will define the finite state set $Q = N \times N$, where:

$$N = (0.00, 0.01, 0.02, \ldots, 0.99, 1.00) \tag{4}$$

And, set $DS^t_{c(i,j)}$ and $DI^t_{c(i,j)}$ be the suitable rationalizations of the $S^t_{c(i,j)}$ and $I^t_{c(i,j)}$. Consequently, the rationalization used is:

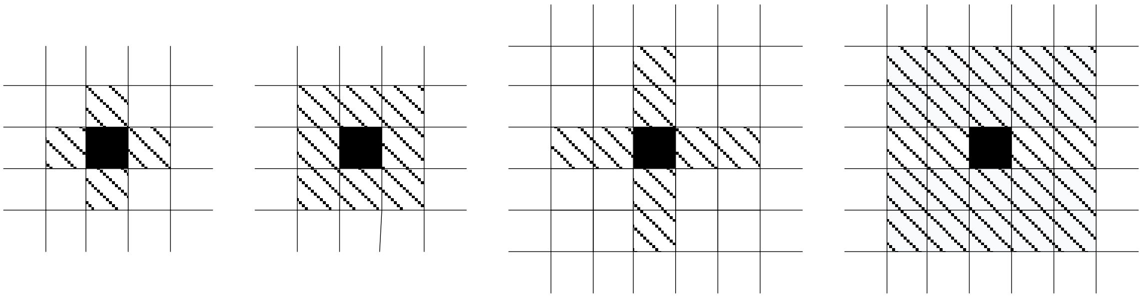
$$DS^t_{c(i,j)} = \frac{\left[100.S^t_{c(i,j)}\right]}{100}, \quad DI^t_{c(i,j)} = 1 - DS^t_{c(i,j)} \tag{5}$$

where, $[x]$ is the nearest integer to x. And then, the state of the cell $c(i,j)$ can be denoted by the two-upset $s^t_{c(i,j)} = (DS^t_{c(i,j)}, DI^t_{c(i,j)}) \in Q$.

Neighbourhood V*:* in this work, we define $V = \{(\alpha_k, \beta_k), 1 \le k \le n\}$ for the finite set of indices denoting the neighbourhood of each cell, which stands for the cells' mutual interaction of CCPI organizational structure, such the neighbourhood of the cell $c(i,j)$ can be denoted by:

$$V_{c(i,j)} = \{(i+\alpha_1, j+\beta_1), \dots, (i+\alpha_i, j+\beta_i), \dots, (i+\alpha_n, j+\beta_n)\} \quad (6)$$

The conventional bi-dimensional CA model mainly adopts two types of neighbourhood: Von Neumann neighbourhood and Moore neighbourhood. In this work, in order to better stimulate the mutual interaction among the objects, we extend the two classical types of neighbourhood. As shown in Fig. 2:



a) 1×1 b) 1×1 c) 2×2 d) 2×2

Figure 2: The typical CA neighbourhoods and their extend forms.

Where, the Fig. 3 a is the classical Von Neumann neighbourhood, and the Fig. 3 b is the classical Moore neighbourhood. We define the Fig. 3 c for 2×2 extended-Von Neumann neighbourhood and the Fig. 3 d for 2×2 extended-Moore neighbourhood. The extended neighbourhood suggests the greater mutual interaction among the cells.

Local transition function F: in the process of CCPI conflict contagion, each "healthy" (nonconflict-involved) member is susceptible of being infected with certain conflict through contact with "sick" (conflict-involved) ones (inter-team or intra-team). Meanwhile, within the conflict-infectious period, the conflict-involved individual can recover and return the S group again with a certain possibility. For the C-SIS model, the main goal is to obtain the $S_{c(i,j)}^t$ and $I_{c(i,j)}^t$. Based on the mechanism and process of "infecting conflict" and "regaining healthy" of CCPI conflict, the local transition function F is shown as the following:

$$S_{c(i,j)}^t = S_{c(i,j)}^{t-1} + \varepsilon \cdot I_{c(i,j)}^t - \nu \cdot \lambda_{In} \cdot S_{c(i,j)}^{t-1} \cdot I_{c(i,j)}^{t-1} - S_{c(i,j)}^{t-1} \cdot \sum_{(\alpha,\beta)\in V} \frac{N_{i+\alpha,j+\beta}}{N_{ij}} \cdot \mu_{\alpha\beta}^{ij} \cdot I_{c(i+\alpha,j+\beta)}^{t-1} \quad (7)$$

$$I_{c(i,j)}^t = (1-\varepsilon) \cdot I_{c(i,j)}^t + \nu \cdot \lambda_{In} \cdot S_{c(i,j)}^{t-1} \cdot I_{c(i,j)}^{t-1} + S_{c(i,j)}^{t-1} \cdot \sum_{(\alpha,\beta)\in V} \frac{N_{i+\alpha,j+\beta}}{N_{ij}} \cdot \mu_{\alpha\beta}^{ij} \cdot I_{c(i+\alpha,j+\beta)}^{t-1} \quad (8)$$

where, the parameter $\varepsilon \in [0,1]$ is the recovery rate, which is the portion of the conflict–involved members recovered from the conflict at each time step. $\nu \in [0,1]$ is the virulence of the certain conflict, and $\lambda_{In} \in [0,1]$ is the contact rate of team members in the cell $c(i,j)$. In the CCPI system, the collaborative partners (e.g. the designers and customers) are embedded in a stable cooperation relationship with the pattern of virtual teams, and there is existing the personal relationship and working relationship among the CCPI members. Therefore, the conflicts can travel across CCPI teams with a certain possibly $\mu_{\alpha\beta}^{ij}$, and the parameter $\mu_{\alpha\beta}^{ij}$ is defined as the across cell virulence of the conflict, which can be denoted as: $\mu_{\alpha\beta}^{ij} = \nu.\lambda_{Out}.c_{\alpha\beta}^{ij}$, where $c_{\alpha\beta}^{ij}$ stands for the connection factor between the central cell $c(i,j)$ and its neighbor cell $c(i+\alpha, j+\beta)$ and λ_{Out} is the contact rate of CCPI members across between the cell $c(i,j)$ and its neighbourhood.

Eq. (9) shows that $S_{c(i,j)}^t$, the portion of nonconflict-involved members of the cell $c(i,j)$ at time t, is produced by the portion of healthy members which have not been infected by the conflict (first part of the equation), the portion of conflict-infected members which have been recovered from the conflict at time $t-1$ (second part of the equation), and the decreased portion of healthy individuals which have been infected by the sick individuals at time $t-1$

in the same cell (third part of the equation). What is more, some healthy members of the cell $c(i,j)$ can be infected by the sick ones of neighbor cells which have travelled to the cell $c(i,j)$. In the same way, Eq. (10) can be given the corresponding interpretation.

As mentioned above, the healthy member of a certain cell can be infected by the sick members of his/her cell, or by the sick ones of the neighbour cells, that is, the CCPI conflict can travel across cells to spread. For the across cells conflicts, there must exist certain connection factor $c_{\alpha\beta}^{ij}$ among the cells to allow the conflict to spread. In this work, based on the different level of work closeness among CCPI teams, we will consider four levels of connections intensity:

$$c_{\alpha\beta}^{ij} = \begin{cases} 1 & \text{if there is an extremely close relationship between the cells} \\ 0.6 & \text{if there is a close relationship between the cells} \\ 0.3 & \text{if there is a relatively close relationship between the cells} \\ 0 & \text{if there is no relationship between the cells} \end{cases} \quad (9)$$

4. SIMULATION

For the simulation of CCPI conflicts contagion, we define that the cellular space (CCPI organization) is formed by a two-dimensional array of 21×21 cells (CCPI teams). Obviously, for the CCPI organizations, they may not have so many CCPI teams. Here, we set up a large enough cellular space with abundant cells, making the simulation suit for the more complex CCPI organizations. With the same consideration, the population of each cell is set as a constant, which is $N_{c(i,j)} = 50$. In the initial state, suppose that only the central cell $c(11,11)$ possess the conflict-involved members, and its state $s_{c(11,,11)} = (0.6, 0.4)$, that is, at $t = 0$, there are 30 nonconflict-involved members and 20 conflict-involved members in the cell $c(11,11)$.

We firstly focus on the influence of the neighbourhood acting on the CCPI conflict contagion, here, the parameters are set as following: $\varepsilon = 0.4$, $\nu = 0.5$, $\lambda_{In} = 0.8$, $\lambda_{Out} = 0.4$, $c_{\alpha\beta}^{ij} = 1$, for every cell $c(i,j)$. The simulation with Von Neumann neighbourhood, Moore neighbourhood and their 2×2 extended forms are shown in Fig. 3.

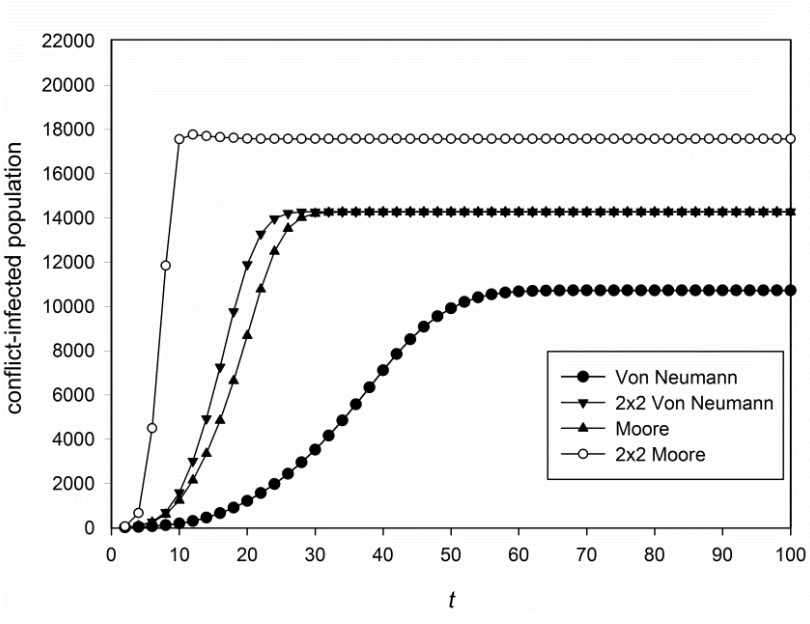


Figure 3: Simulation of task conflict-infected population for different type of neighbourhood.

In Fig. 3, arranging from Von Neumann neighbourhood to Moore neighbourhood, a cell is affected by more neighbourhoods, and its infected probability also increases. Moreover, with the order of neighbourhood increasing, the conflict infected level also increases. The results show that the cell mutual interaction of CCPI organizational structure exerts a significant influence on the CCPI conflict contagion.

Next, we investigate the impact of the relationship of cells, the $c_{\alpha\beta}^{ij}$, on the conflict contagion. Adopting the Von Neumann neighbourhood, we propose the parameters as following: $\varepsilon = 0.2,\ \nu = 0.5,\ \lambda_{In} = 0.8,\ \lambda_{Out} = 0.4$, for every cell $c(i,j)$. The simulation with different values of $c_{\alpha\beta}^{ij}$ is shown in Fig. 5, where the curve *Col 1 Col 2 Col 3 Col 4* describe separately $c_1 = 0.2,\ c_2 = 0.5,\ c_3 = 0.8,\ c_4 = 0.4$.

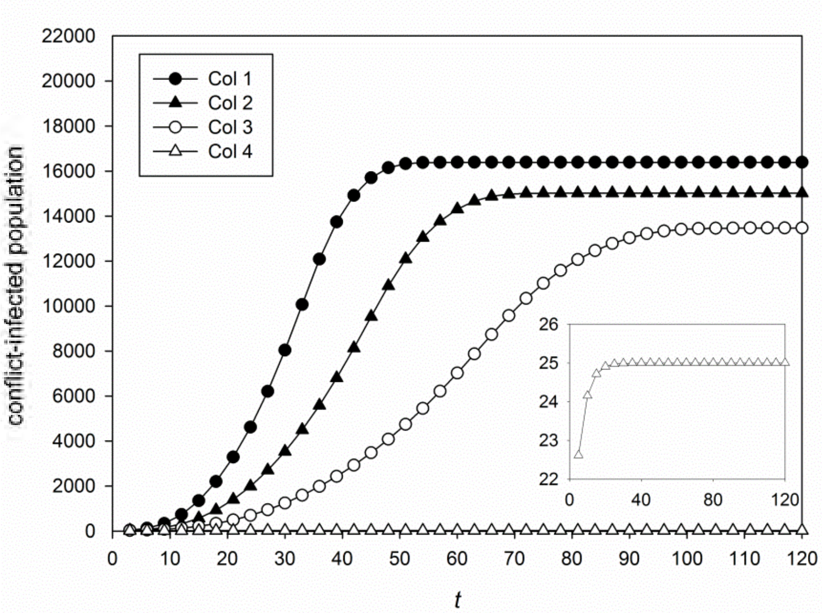


Figure 4: Simulation of task conflict-infected population for different values of $c_{\alpha\beta}^{ij}$.

In Fig. 4, we can see that, with the $c_{\alpha\beta}^{ij}$ increasing, the relationship between the CCPI teams becomes closer, and more members are becoming conflict-infected. It shows that the relationship between the CCPI teams is prone to promote the propagation of CCPI conflict.

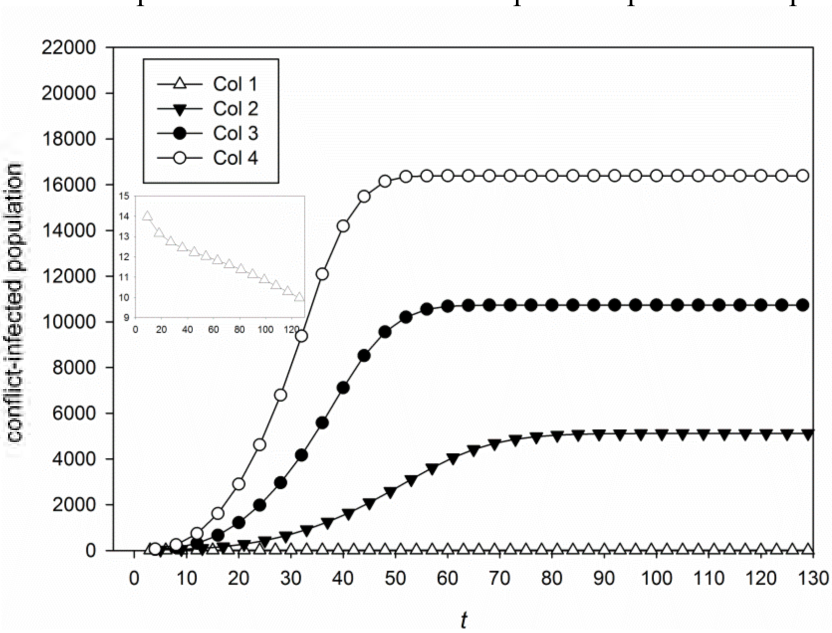


Figure 5: Simulation of task conflict-infected population for different values of ε.

Finally, we examine how the inter-team conflict resolution mechanism, the ε, affects the conflict escalation. Selecting the Von Neumann neighbourhood, and setting up the parameters: $\nu = 0.5$, $\lambda_{In} = 0.8$, $\lambda_{Out} = 0.4$, $c_{\alpha\beta}^{ij} = 1$, for every cell $c(i,j)$, we obtain the simulation with different values of ε shown in Fig. 5, where the curve *Col 1 Col 2 Col 3 Col 4* describe separately $\varepsilon = 0.8$, $\varepsilon = 0.6$, $\varepsilon = 0.4$, $\varepsilon = 0.2$.

In Fig. 5, we can obtain that there is a strong negative correlation between the ε and the final figure of conflict-infected population. And, the result shows that the inter-team conflict resolution mechanism can sever to inhibit and slow down the conflict contagion.

5. CONCLUSION

In this paper, the C-SIS model is developed to study CCPI conflict contagion, simulating and reappearing the process of CCPI conflict spreading. Through setting different parameter values of C-SIS model, we simulate the influence of the following factors, including the cell mutual interaction of CCPI organizational structure, the relationship between CCPI teams and the intra-team conflict resolution mechanism, on the propagation trend of CCPI conflict, obtaining the regularities of the above factors affecting CCPI conflict contagion.

The simulation results with artificial parameters seem to well agree with the expected process of the real CCPI conflict contagion. Therefore, the C-SIS model can serve to study the real CCPI conflict contagion against the real data to a certain extent. Our future work will focus on simulating the conflict of real CCPI system, via further ameliorating the model and using the real data of the CCPI system. By providing a new perspective and method on the CCPI conflict contagion, we hope to shed lights on the explanation of the mechanism of CCPI conflict contagion and the prediction of the trend of conflict spreading from a point of microcosmic individual interactions, and open a door for researchers and practitioners to better understand the dynamics of CCPI conflict and better manage CCPI conflict.

REFERENCES

[1] Lichtenthaler, U. (2011). Open innovation: past research, current debates, and future directions, *Academy of Management Perspectives*, Vol. 25, No. 1, 75-93, doi:10.5465/AMP.2011.59198451

[2] Thomke, S.; Von Hippel, E. (2002). Customers as innovators: a new way to create value, *Harvard Business Review,* Vol. 80, No. 4, 74-81

[3] Von Hippel, E. (1986). Lead users: a source of novel product concepts, *Management Science*, Vol. 32, No. 7, 791-805, doi:10.1287/mnsc.32.7.791

[4] Alper, S.; Tjosvold, D.; Law, K. S.. (2000). Conflict management, efficacy, and performance in organizational teams, *Personnel Psychology*, Vol. 53, No 3, 625-642, doi:10.1111/j.1744-6570.2000.tb00216.x

[5] Martínez-Moreno, E.; Gonzalez-Navarro, P.; Zornoza, A.; Ripoli, P. (2009). Relationship, task and process conflicts on team performance: The moderating role of communication media, *International Journal of Conflict Management*, Vol. 20, No. 3, 251-268, doi:10.1108/10444060910974876

[6] Lam, P. K.; Chin, K. S.; Pun, K. F. (2007). Managing conflict in collaborative new product development: a supplier perspective, *International Journal of Quality & Reliability Management*, Vol. 24, No. 9, 891-907, doi:10.1108/02656710710826171

[7] Jehn, K.; Rispens, S.; Jonsen, K.; Greer, L. (2013). Conflict contagion: a temporal perspective on the development of conflict within teams, *International Journal of Conflict Management*, Vol. 24, No. 4, 352-373, doi:10.1108/IJCMA-05-2011-0039

[8] Hauser, J.; Tellis, G. J.; Griffin, A. (2006). Research on innovation: a review and agenda for marketing science, *Marketing Science*, Vol. 25, No. 6, 687-717, doi:10.1287/mksc.1050.0144

[9] Surowiecki, J. (2005). *The Wisdom of Crowds*, Random House LLC, New York

[10] Von Hippel, E. (2007). *The Sources of Innovation*, Springer, Berlin

[11] Greer, C. R.; Lei, D. (2012). Collaborative innovation with customers: a review of the literature and suggestions for future research, *International Journal of Management Reviews*, Vol. 14, No. 1, 63-84, doi:10.1111/j.1468-2370.2011.00310.x
[12] Prahalad, C. K.; Ramaswamy, V. (2000). Co-opting customer competence, *Harvard Business Review*, Vol. 78, No. 1, 79-90
[13] Whitley, R. (2002). Developing innovative competences: the role of institutional frameworks, *Industrial and Corporate Change*, Vol. 11, No. 3, 497-528, doi:10.1093/icc/11.3.497
[14] Von Hippel, E. (2009). *Democratizing Innovation*, MIT Press, Massachusetts
[15] Yang, Y.; Guo, B.; Yin, S.; Wang, W.-L.; Zhang, X.-D. (2008). Connotation, theory framework and application of customer collaborative innovation, *Computer Integrated Manufacturing Systems*, Vol. 14, No. 5, 944-950
[16] Leon, N. (2009). The future of computer-aided innovation, *Computers in Industry,* Vol. 60, No. 8, 539-550, doi:10.1016/j.compind.2009.05.010
[17] Pals, N.; Steen, M. G. D.; Langley, D. J.; Kort, J. (2008). Three approaches to take the user perspective into account during new product design, *International Journal of Innovation Management*, Vol. 12, No. 3, 275-294, doi:10.1142/S1363919608002023
[18] Rahim, M. A. (2011). *Managing Conflict in Organizations*, Transaction Publishers, New Brunswick
[19] Klein, M. (2000). Towards a systematic repository of knowledge about managing collaborative design conflicts, Gero, J. S. (ed.), *Artificial Intelligence in Design '00*, Springer, 129-146, doi:10.1007/978-94-011-4154-3_7
[20] Hinds, P. J.; Mortensen, M. (2005). Understanding conflict in geographically distributed teams: the moderating effects of shared identity, shared context, and spontaneous communication, *Organization Science*, Vol. 16, No. 3, 290-307, doi:10.1287/orsc.1050.0122
[21] Klein, M. (1991). Supporting conflict resolution in cooperative design systems, *IEEE Transactions on Systems, Man and Cybernetics,* Vol. 21, No. 6, 1379-1390, doi:10.1109/21.135683
[22] Slimani, K.; Ferreira Da Silva, C.; Medini, L.; Ghodous, P. (2006). Conflict mitigation in collaborative design, *International Journal of Production Research*, Vol. 44, No. 9, 1681-1702, doi:10.1080/00207540500445198
[23] Jehn, K. A.; Mannix, E. A. (2001). The dynamic nature of conflict: a longitudinal study of intragroup conflict and group performance, *Academy of Management Journal*, Vol. 44, No. 2, 238-251, doi:10.2307/3069453
[24] Cohen, S. G.; Bailey, D. E. (1997). What makes teams work: group effectiveness research from the shop floor to the executive suite, *Journal of Management*, Vol. 23, No. 3, 239-290, doi:10.1016/s0149-2063(97)90034-9
[25] Gelfand, M.; Shteynberg, G.; Lee, T.; Lun, J.; Lyons, S.; Bell, C.; Chiao, J. Y.; Bruss, C. B.; Al Dabbagh, M.; Aycan, Z.; Abdel-Latif, A.-H.; Dagher, M.; Khashan, H.; Soomro, N. (2012). The cultural contagion of conflict, *Philosophical Transactions of the Royal Society B*, Vol. 367, No. 1589, 692-703, doi:10.1098/rstb.2011.0304
[26] Barsade, S. G. (2002). The ripple effect: emotional contagion and its influence on group behavior, *Administrative Science Quarterly*, Vol. 47, No. 4, 644-675, doi:10.2307/3094912
[27] Willox, R.; Grammaticos, B.; Carstea, A. S.; Ramani, A. (2003). Epidemic dynamics: discrete-time and cellular automaton models, *Physica A: Statistical Mechanics and its Applications*, Vol. 328, No. 1-2, 13-22, doi:10.1016/s0378-4371(03)00552-1
[28] Wolfram, S. (1984). Cellular automata as models of complexity, *Nature*, Vol. 311, No. 5985, 419-424, doi:10.1038/311419a0
[29] Wolfram, S. (1986). *Theory and Applications of Cellular Automata*, World Scientific, Singapore
[30] Van den Driessche, P.; Watmough, J. (2000). A simple SIS epidemic model with a backward bifurcation, *Journal of Mathematical Biology*, Vol. 40, No. 6, 525-540, doi:10.1007/s002850000032
[31] Allen, L .J. S.; Burgin, A. M. (2000). Comparison of deterministic and stochastic SIS and SIR models in discrete time, *Mathematical Biosciences*, Vol. 163, No. 1, 1-33, doi:10.1016/s0025-5564(99)00047-4

[32] Couclelis, H. (1988). Of mice and men: what rodent populations can teach us about complex spatial dynamics, *Environment and Planning A*, Vol. 20, No. 1, 99-109, doi:10.1068/a200099
[33] Karafyllidis, I.; Thanailakis, A. (1997). A model for predicting forest fire spreading using cellular automata, *Ecological Modelling*, Vol. 99, No. 1, 87-97, doi:10.1016/s0304-3800(96)01942-4
[34] White, S. H.; del Rey, A. M.; Sánchez, G. R. (2007). Modeling epidemics using cellular automata, *Applied Mathematics and Computation*, Vol. 186, No. 1, 193-202, doi:10.1016/j.amc.2006.06.126
[35] Boccara, N.; Fukś, H. (1999). Modeling diffusion of innovations with probabilistic cellular automata, Delorme, M.; Mazoyer, J. (eds.), *Cellular Automata*, Springer, Dordrecht, 263-277, doi:10.1007/978-94-015-9153-9_9
[36] Fuentes, M. A.; Kuperman, M. N. (1999). Cellular automata and epidemiological models with spatial dependence, *Physica A: Statistical Mechanics and its Applications*, Vol. 267, No. 3-4, 471-486, doi:10.1016/s0378-4371(99)00027-8
[37] Rousseau, G.; Giorgini, B.; Livi, R.; Chate, H. (1997). Dynamical phases in a cellular automaton model for epidemic propagation, *Physica D: Nonlinear Phenomena*, Vol. 103, No. 1-4, 554-563, doi:10.1016/s0167-2789(96)00285-0
[38] Sirakoulis, G. C.; Karafyllidis, I.; Thanailakis, A. (2000). A cellular automaton model for the effects of population movement and vaccination on epidemic propagation, *Ecological Modelling*, Vol. 133, No. 3, 209-223, doi:10.1016/s0304-3800(00)00294-5