A Study on the Knowledge Diffusion of Communities of Practice Based on the Weighted Small-world Network

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***Abstract*—Communities of practices (Cops) can improve organizational performance by effectively promoting knowledge diffusion, and recently they were receiving increasing attention from organizations in abroad. The aim of our study was to further explore how to cultivate and support Communities of practice. According to some literatures, we first studied what is the most important influencing factor of knowledge diffusion in the communities of practice. On the basis of the weighted small-world network, we made a study on the knowledge diffusion network of communities of practice, and proposed to use characteristic relationship length and clustering coefficient of community members to token knowledge diffusion frequency and centralization respectively, and elaborated the relationship between them and knowledge diffusion of community. We found that, a relatively small characteristic relationship length and a relatively big clustering coefficient can make knowledge diffusion frequency and centralization maintain in a moderately big level in the communities of practice, which can promote effectively knowledge diffusion and then increase overall knowledge level of community, and provided some useful theoretical guidance for organizations to cultivate and support communities of practice.**

***Index Terms*—weighted small-world network; communities of practice; knowledge diffusion; knowledge diffusion frequency; knowledge diffusion centralization**

I. INTRODUCTION

In the 21st century, the era of knowledge economy has come in. Nowadays, information and knowledge are considered as the main driving forces for the development of economic and social value (Prahalad and Hamel, 1990; Zuboff, 1996). Drucker (1993) explicitly hold that the most valuable assets of the enterprises are their knowledge and knowledge workers. Knowledge has become a crucial factor of economic growing. Knowledge dissemination in network environment has not only happened in physical space, but also more taken place in "logic space", and then presents an effect of knowledge diffusion [1]. The capacity of promoting knowledge flowing, disseminating and diffusing among an organization has kept in touch with organizational competitive advantage and is being concerned by increasing organizations. About knowledge diffusion, Grant (1996) believed that, because of the "exclusiveness" of knowledge, therefore, firstly, open willingness and ability is necessary and then effective operation of knowledge diffusion can run smoothly. Secondly, the channels of knowledge diffusion are crucial. The activities of knowledge diffusion need some appropriate channels and then can go well. For instance, knowledge networks, information channels, cooperation networks, and so on. Thirdly, the core involved in knowledge diffusion is people, so the owners and recipients of knowledge must own certain willingness.

Communities of practice (Cops) were thought that they are new organizational forms, can complement existing organization structure, active sharing, learning and updating of knowledge in depth [2]. Communities of practice can facilitate knowledge diffusion among members and then transfer individual knowledge into organizational knowledge, which is the aim of organizational knowledge management just right. The support to communities of practice can promote organizational knowledge sharing, diffusion and innovation, and help organizations deal with unstructured problems and share knowledge outside of the traditional structural boundaries, and then effectively strengthen organizational performance [3]. In light of strong diffusion ability of Cops, recently, in order to reach the goal of serving for organizations, a great number of organizations began to try to strengthen the intervention and control for communities of practice. However, due to the specificity of Cops, organizational effort cannot get good outcomes and even become counterproductive. Therefore, how to cultivate and support community to boost knowledge diffusion more effectively has become the organizational concerned focus. Currently, some scholars begin to make

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a study about this aspect, however, the prior current studies has some shortages: (1) in China, some scholars focus too much on the influence of members' characteristics (such as personality) to the knowledge dissemination (e.g., literatures [4,5,6]), and yet ignore that member's behavior is embedded in the relational network of community; (2) some scholars often emphasis too much on the experiential and qualitative discussion and elaboration (e.g., literatures [7,4,8,9]), thus there is almost no study about constructing mathematical model to conduct analysis in depth; (3) community members form a communication network, for the network, network structure has a crucial influence on the network's function, but there is almost no study about network structure of communities of practice.

Communities of practice are informal interpersonal networks which are consisted of various members. Human's social characteristic shows that communities of practice own the characteristics of social network. In communities of practice, members are not only "economic man", but also "social man". So, we wanted to know whether relational network of members had a crucial effect on knowledge diffusion in communities of practice. And, if so, what was the best relational network structure which can effectively promote knowledge diffusion of Cops? Recently, small-world network theory has developed rapidly, and has open up a brand-new research idea for academia to study social networks and their structure. To generate answer to above questions, section 2 of this paper further introduce the concept and characteristics of communities of practice. Following an elaboration of small-world network and its applications in section 3, and section 4 uses weighted small-world network to research knowledge diffusion network of Cops, where we used characteristic relationship length and relationship clustering coefficient of community members to token knowledge diffusion frequency and centralization respectively. Section 5 discusses the results of research and gets so useful implications. By our study, we found that, knowledge diffusion frequency and centralization should kept in a moderate level in the communities of practice, which can promote effectively knowledge diffusion of community, and provided some useful theoretical guidance for organizations to cultivate and support communities of practice.

II. COMMUNITIES OF PRACTICE

A. The concept of communities of practice

Communities of practice were proposed first by Brown & Duguid, Lave and Wenger respectively, and were used to narrowly define as the informal working group [10]. Generally, Communities of practice are considered as that, in order to raise work efficiency and understand the work more deeply, bounding together to exchange and help with each other, forming common interest and goals, and having common wish to share knowledge and experience, hence members who owned specialty can establish an informal network organization on the basis of the foundation of work and practice [7].

B. The characteristics of communities of practice

In fact, Cops lies widely in the organizations, and they have different names in different organizations. For instance, HP's "Learning Communities", Xerox's "Family Groups", British Petroleum's "Peer Groups", and IBM Global Service's "Knowledge Network" [11]. Because the forming situation of community is different and community members are various, communities of practice have a lot of special characteristics [12]:

1) The scale of community is big or small.

Some communities of practice are small. Maybe they only contain several experts, but their relationship is close. However, some other communities of practice consist of hundreds of people. The large scale community usually is divided into several small communities according to geographic areas or discussion topics, which can easily encourage all the members to participate in community positively.

2) The existing period of community is long or short.

The development of community would need some time, but the lifetime of Cops differs greatly from each other. Some existed for several centuries, such as the violin makers club and some other artisans club, where skill was from generation to generation. However, some other clubs, for instance, COBOL programmers club, whose lifetime was relatively short.

3) Communities of practice are centralized or decentralized.

Sharing practice needs periodical mutual exchange, so, many communities naturally born among the people who worked or lived in the same place. However, locating a place is not the necessary condition. As new technology develops rapidly, the distribution range has become very extensive in many communities.

4) The background is same or different among community members.

Some communities of practice are consists of people who come from the same discipline or function. While some other communities gather people of different background together. For example, a community consists of people who come from different function departments, but all these people involve the same customers or people of a certain country. Members whose backgrounds are same or different can also band together closely.

5) Communities of practice are inner or cross-department in a company.

Community can totally exist in the inner of business units, and can also cross the boundary of departments. Specially, some communities even cross the boundaries of organizations.

6) The emergence of communities of practice is a spontaneous or intentional.

The emergence of many communities of practice did not encounter intervention of any organizations. Because members need each other and hope to learn from each other, so they band together spontaneously. In some other examples, some organizations intentionally develop special communities to manage organizational required ability. A community is spontaneous or intentional, which cannot show the formal extent.

TABLE I. THE DIFFERENCE AMONG COMMUNITIES OF PRACTICE, FORMAL WORKING GROUP, PROJECT TEAM AND FORMAL NETWORK

	Purpose	Members	Cohesion	Duration
Communities of practice	Improving members' ability, creating and exchanging knowledge	Joining voluntarily	Being full of passion, promise and identity about community experience	Maintaining as long as there is interest
Formal working group	Providing products or service	Everybody who reports to group leader	Work needs and common goals	Until the next reorganization
Project team	Completing specific tasks	Designated by the senior manager	Project progress and the final goal	Until the end of the project
Informal network	Collecting and transmitting business information	Friends and business partners	Needing mutually	Keeping as long as there is reason of contact

Sourcing: Communities of practice-the organizational frontier, Etienne C. Wenger, 2000

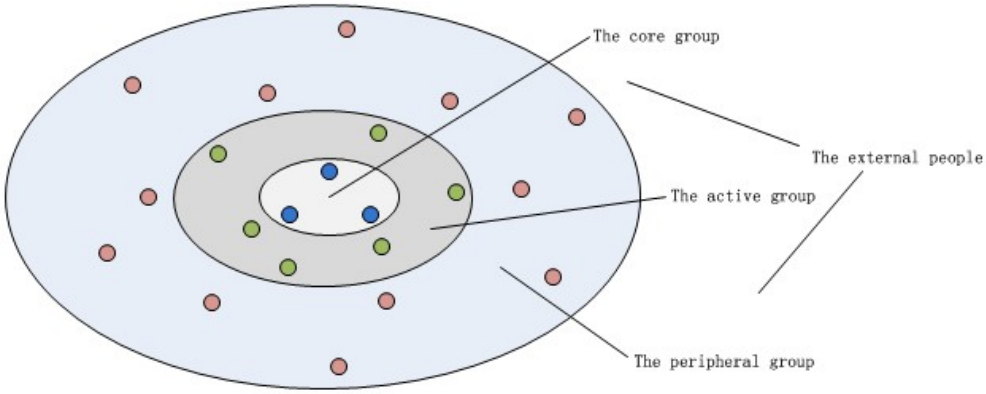

Figure 1. The members structure of communities of practice

To sum up, compared with formal working group, project team, and informal network, communities of practice are different. Table I shows the difference.

The biggest difference between communities of practice and formal organizations (i.e. work groups, project teams) is that communities have informal interpersonal network. Moreover, informal interpersonal network can easily cross stiff boundary and become an effective tool to achieve firm's strategy [13]. Cops can play a crucial role in driving strategy, starting new lines of business, solving problems quickly, etc [2].

C. The member structure of communities of practice

Because community members have varying interest about community, from the participation extent, community members can be divided into three levels [11, 13]. As shown in the Figure 1, the core group members of community are the supporters and coordinators. They contact with the other members, encourage people to take part in community, seek topics for community, get in touch with the outside world, and keep community's stability and vitality, etc. The core members are the heart of community, and they will have most of leading work on community's shoulders when community is mature. Outside the core group, there is an active group. The active members participate in meeting regularly, and sometimes engage in community forums, but their participation extent is below the participation extent of core group members. Most of members locate in the peripheral group, and they almost do not take part in community activities. The peripheral members only stand on the sidelines, watching the interaction between the core group and active group. Outside the three main levels, some people are around this community, including customers, suppliers and "knowledge neighbors", and they are not insiders, but they are interest in community.

III. SMALL-WORLD NETWORK AND ITS APPLICATION

About the small world phenomenon, the earliest study originates from Milgram's famous small world experiment in the 1960s. After social surveys, Milgram concluded that any two people's distance is six on earth [14], which is the famous "six degree of separation". The research was groundbreaking in that it suggested that human society is a small world type network characterized by short path lengths. In order to examine the idea of "six degree of separation", people then had done some small world experiments, like, movie cooperation network (Kevin Bacon game), mathematicians' cooperation network (Erdős number), etc. In 1998, based on the research foundation of regular and random network, Watts and Strogatz proposed the famous small-world network model [15] (called WS small-world network model), which reflected the "small-world" characteristic of complex network. WS small-world network is a regular network with a certain random, and it can rewire from the regular network to the random network by adjusting the parameter. As shown in Figure 2 [15], this model's rewiring procedure is following: 1) starting from a ring lattice with n vertices and k edges per vertex (keeping $n >> k >> ln(n) >> 1$, which can guarantees a random graph will be connected); 2) rewiring each edge at random probability p to reconnect to a vertex chosen uniformly at random over the entire

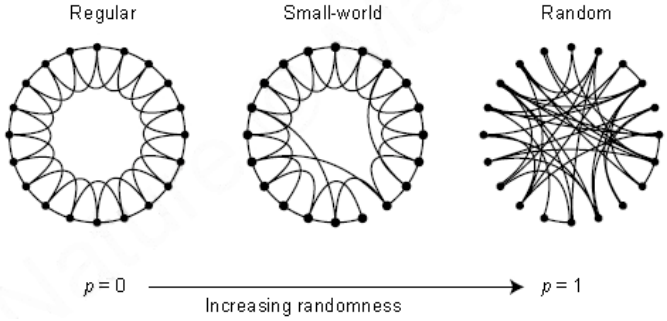

Figure 2. Random rewiring procedure for interpolating between a regular ring lattice and a random network [15]

ring. This construction can 'tune' the graph between regularity ($p=0$) and disorder ($p=1$). Based on the above construction, the rewired network has not only small-world's characteristics of random network, but also the big concentration coefficient's characteristics of regular network. To test the small-world phenomenon, Watts and Strogatz computed L (characteristic path length) and C (clustering coefficient) for the collaboration graph of actors in feature films, the electrical power grid of the western United States, and the neural network of the nematode worm C. *elegans*. And they found that all three graphs are small-world networks (Table II summarizes the results). In fact, these three networks stood for three different networks respectively: social network, artificial network, and biological network. Later, a large number of empirical results [16, 17, 18], showed that these two characteristics are the most common attributes of the actual networks. Compared with regular and random network, WS network model coincides with actual networks well, consequently, it were applied extensively in Internet control [16], AIDS prediction of disseminating [19], dynamic research of protein network [20] and other fields.

TABLE II. EMPIRICAL EXAMPLES OF SMALL-WORLD NETWORKS

	L(actual)	L(random)	C(actual)	C(random)
Film actors	3.65	2.99	0.79	0.00027
Power grid	18.7	12.4	0.080	0.005
C. *elegans*	2.65	2.25	0.28	0.05

Sourcing: collective dynamics of small-world networks, Watts D J, Strogatz S H., 1998

IV. USE WEIGHTED SMALL-WORLD NETWORK TO ANALYSIS KNOWLEDGE DIFFUSION OF COMMUNITY

In this section, we firstly built a knowledge diffusion network model of communities of practice, and then used weighted small-world network to analysis knowledge diffusion of community.

A. Build the knowledge diffusion network model of communities of practice

Based on the self-organizing and informal characteristics of Cops, members are groups of people who own shared expertise and passion about a kind of career. By establishing contacts with others, community members meet with each other regularly or irregularly, focusing on the problems directly related to their work to communicate, learn, and share the knowledge or experience creatively and freely with each other[1,21], which can promote knowledge diffusion of community. Members are both knowledge providers and recipients, naturally, the incentive mechanism of community is that all the members are willing to contribute knowledge to each other and get knowledge from each other [22]. Members who contribute knowledge to other don't require an immediate return, but on the basis of a long-term consideration, and hope to obtain needed knowledge from other members in future [22]. It makes members be full of trust, generate duty of contributing knowledge to others, and appreciate other members' participation, identification and contribution. For this informal knowledge exchange among individuals, what is the deep-seated root cause? Garnovetter hold that exchange behavior among individuals is often embedded in the structure of social relation [23]. Blau pointed out that, social exchange is different from classic economic exchange and endows both of the two exchange sides with "non-specific" obligations which do not need to be ensured previously, accordingly, only social exchange but not absolute economic exchange can enable people to give birth to duty, appreciation, and trust[24]. Deroian figured out that, knowledge diffusion is a process of every potential individual from the unbalanced state to the balanced state based on the social network [25]. So, it can be seen that, the essence of knowledge diffusion among community members is a social exchange, according to the embeddedness theory [26], and it embedded in the social relation network of members in depth. Knowledge diffusion is a process of knowledge communication and learning, more close relation among members more strong willingness of knowledge diffusion, so communication becomes frequent and then knowledge can easily diffuse among members. At the same time, knowledge diffusion is good for members to strengthen the trust relationship further and form the more close relation. Therefore, we insisted that the knowledge diffusion network of communities of practice is set up on the relation network of members.

Small-world network model proposed by Watts and Strogaze is a no direction and weight network, and only reflects the existence of edges between nodes but cannot describe the degree of close relationship between the nodes, so it has a large number of constraint conditions in studying social networks. Consequently, we used weighted small-world network to analysis knowledge

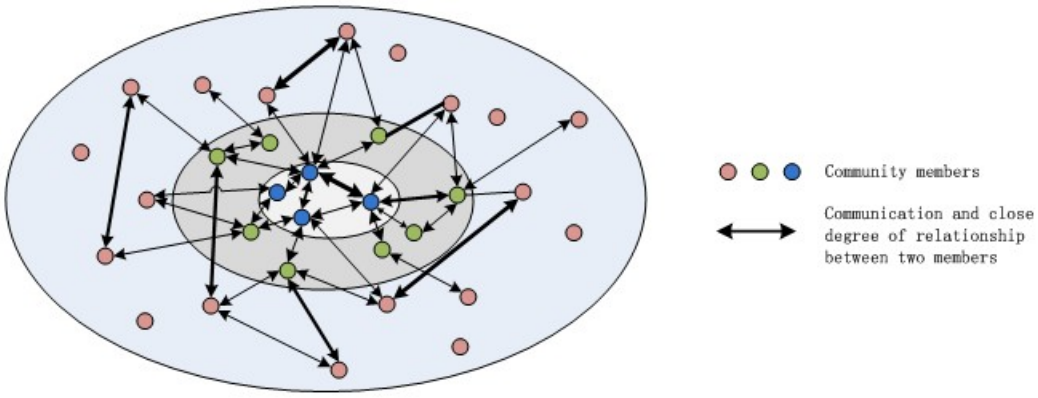

Figure 3. The knowledge diffusion network of communities of practice

diffusion network of communities of practice. As shown in Figure 3, considering knowledge sharing network of communities of practice, we assumed nodes are community members, links (or edges) are the communication among members, and then the thickness of a link is the close degree of relation (namely, social distance, such as trust, knowledge background and similarity of interests and hobbies, etc.) between two members. So, we can use some characteristic of weighted small-world network to describe and analysis knowledge diffusion network in communities of practice. Graph theory is the natural framework for the exact mathematical treatment of networks and, formally, a network can be represented as a graph. So we defined this knowledge diffusion network as undirected graph $G=(N,\Phi,W)$, which consist of three sets N, Φ and W. $N=(n_1,n_2,...,n_N)$ is the members set, $\Phi=(l_1,l_2,...,l_K)$ is the communication set, and $W=(\omega_1,\omega_2,...,\omega_K)$ is the relationship weight set (namely, the close degree of relationship). i and j are defined as arbitrary two members in the set N, and it is obvious that they have a link if two members communicate with each other and then the edge has a weight based on the close degree of relation between the two members. Obviously, it means $l_{ij}=1$ and then $\omega_{ij}>0$ if members i,j have communication, similarly, it signifies $l_{ij}=0$ and then $\omega_{ij}=0$ if members i,j have no communication. It shows that members i,j have a very close relation when ω_{ij} is close to positive infinity ($\omega_{ij}\to+\infty$), vice versa.

B. Characteristic relationship length and knowledge sharing frequency of communities of practice

In the model of WS small-world network, Watts and Strogatz proposed the concept of characteristic path length [15], which can describe the aggregate characteristics of network and is defined as the numbers of edges in the shortest path between two nodes, averaged all pairs of nodes:

$$L(G)=\frac{1}{\mathrm{N(N-1)}}\sum_{i,j\in N,i\neq j}d_{ij} \tag{1}$$

Where d_{ij} denotes the minimum number of edges between two nodes. Correspondingly, in the knowledge diffusion network of communities of practice, we can use ε_{ij} to denote the shortest relationship distance of arbitrary two members i and j (on the base of the number ω_{ij}, ε_{ij} can be calculated by Dijkstra algorithm [27]). As a result of, characteristic relationship length of knowledge diffusion network in community can be defined as:

$$L_{CoP}(G)=\frac{1}{\mathrm{N(N-1)}}\sum_{i,j\in N,i\neq j}\varepsilon_{ij} \tag{2}$$

When the amount of members remain unchanged in the community, closer relation among members means smaller ε_{ij}, the shorter characteristic relationship length and then the stronger willingness of knowledge diffusion. As a result, the more likely it is that members can communicate easily, the cost of knowledge disseminating is low and knowledge can easily transmit from one member to another member. Finally, the effect of knowledge diffusion among communities of practice is better. Latora and Marchiori assumed that the efficiency in the communication between node i and j is inversely proportional to the shortest distance d_{ij} if every node sends information along the network [28]. The shorter characteristic relationship length means the closer members relationship, the stronger willingness of knowledge diffusion and then more exchange, which is good for knowledge diffusion. Accordingly, we hold that, knowledge diffusion frequency among communities of practice is inversely proportional to the characteristic relation length. Then we can get knowledge sharing frequency:

$$F_{CoP}(G)=\frac{1}{\frac{1}{\mathrm{N(N-1)}}\sum_{i,j\in N,i\neq j}\varepsilon_{ij}} \tag{3}$$

As the Eq. (3) shown, when the amount of members remains unchanged in community, reducing the relationship distance among members (namely, shortening the characteristic relationship length) can improve knowledge diffusion frequency.

C. Clustering coefficient and knowledge diffusion centralization of communities of practice

There are many circles of friends or acquaintances in social networks. Such as your friends relation network, two of your friends maybe are friend, this attribute is called clustering feature of network. In the WS small-

world network model, Watts and Strogatz used clustering coefficient [15] to describe local characteristics of network and measure whether or not there are relatively steady sub systems. For node i, its local clustering coefficient is defined as:

$$C_i(G) = \frac{\#\text{ of edges in } G_i}{\text{maximum possible } \#\text{ of edges in } G_i} = \frac{2E_i}{k_i(k_i-1)} \quad (4)$$

Where G_i is the sub graph of neighbors of i, and k_i is the number of neighbors of node i. Then at most $k_i(k_i-1)/2$ edges can exist in G_i, this occurring when the sub graph G_i completely connected (every neighbor of i is connected to every other neighbors). G_i denotes the fraction of these allowable edges that actually exist, and the clustering coefficient $C(G)$ of graph G is defined as the average of G_i over all the nodes i of G:

$$C(G) = \frac{1}{N}\sum_{i\in N} C_i(G) = \frac{1}{N}\sum_{i\in N}\frac{2E_i}{k_i(k_i-1)} \quad (5)$$

Correspondingly, for the weighted network, taking into the account weights of all the triangular edges, Onnela et al. [29] proposed a weighted clustering coefficient, which replaced the number of triangle E_i in Eq. (5) with sum of triangle intensities as:

$$\tilde{c}_i = \frac{2}{k_i(k_i-1)}\sum_{j,k}\left(\varpi_{ij}\varpi_{jk}\varpi_{ki}\right)^{1/3} \quad (6)$$

Where ϖ_{ij} is the normalized weight of the edge between vertices i and j, which is calculated by dividing ω_{ij} by the largest weight in the network $\varpi_{ij} = \omega_{ij}/\max(\omega_{ij})$.

Therefore, the whole network clustering coefficient was calculated as the average of $\tilde{c}$ of each vertex [29]:

$$\tilde{c} = \frac{1}{N}\sum_i \tilde{c}_i \quad (7)$$

From Onnela et al.'s study, we can know that they accurately depicted close degree of neighboring nodes' contact of weighted network.

In the knowledge diffusion network of communities of practice, based on the cost of knowledge diffusion, community members lean to exchange and share knowledge with their neighbors (like circles of friends and acquaintances in social networks), which can not only promote knowledge diffusion among neighbors but also enhance neighbors' communication and strengthen neighbors' close degree of relationship. Naturally, they will often communicate with each other and share knowledge, and form knowledge diffusion cliques. Communication centralization measure reflects the extent to which interactions are concentrated in one or a small number of team members rather than distributed equally among all members, they occupy the central position in communication network if some members' link ratio is high[30]. Similar with communication centralization, there is also centralized tendency in knowledge diffusion network in community. Here, we based on the concept of centralization and used knowledge diffusion centralization to reflect the extent to which knowledge diffusion is concentrated in one or a small number of group members rather than distributed equally among all. The closer relationship in cliques, the more centralized knowledge diffusion, consequently, the whole knowledge diffusion network's clustering coefficient becomes bigger. It can be seen that, the average knowledge diffusion centralization and clustering coefficient of community is synchronous growth. Hence, according to the relationship weight of community members, we can use whole clustering coefficient of weighted network to token average knowledge diffusion centralization of community:

$$C_{CoP}(G) = \frac{1}{n}\sum_{i\in N}\left(\frac{2}{k_i(k_i-1)}\sum_{j,k\in N}\left(\varpi_{ij}\varpi_{jk}\varpi_{ki}\right)^{1/3}\right) \quad (8)$$

As the Eq. (8) shown, when the amount of members remains unchanged in community, constructing close relationship and enhancing communication for community members and their neighbors(namely, $\sum_{j,k\in N}\left(\varpi_{ij}\varpi_{jk}\varpi_{ki}\right)^{1/3}$ becomes big), can increase local and average knowledge diffusion centralization of community.

V. Discussions and Implications

For the knowledge diffusion network of communities of practice, in order to improve members' knowledge level, it is obvious that biggish knowledge diffusion frequency and centralization is necessary, but, is the bigger knowledge frequency and centralization better? Next, we will discuss the impact of knowledge diffusion frequency and centralization to communities of practice in depth, and hope to obtain some useful inspiration.

A. The influence of knowledge diffusion frequency to communities of practice

With regard to the knowledge diffusion network, communication frequency will be over frequent if characteristic relationship length is too small, naturally, which causes knowledge diffusion frequency is excessively frequent. Though high knowledge diffusion frequency is good for members to absorb knowledge from the other member, this also causes that all the members' knowledge become similar and uniform. As a result, members' thoughts and ideas are serious homogeneity, and members can not develop their potential to innovate knowledge, finally, which leads to prevent members from diffuse knowledge further. When Leenders et al. did a research on the innovation of new product development (NPD) teams, they found that team creativity requires a moderate frequency of communication, and it disadvantage team innovation if frequency is very high or low [30]. When Cowan and Jonard made a study on the network structure and knowledge diffusion by simulation technology, they constructed a network of agents and interaction rules, and found that the steady-state level of average knowledge is maximal when the network structure is a small world (that is, when most connections are local, but roughly 10 percent of them are long distance)[31], which also shows that the relatively small characteristic path length is beneficial for knowledge diffusion in the agents network. Hu Feng et al. built up a network model of knowledge diffusion and made a simulation, and they also hold that the network whose average distance is relatively small

can effectively improve knowledge diffusion efficiency [1]. Accordingly, we concluded that characteristic relationship length of communities of practice should keep in a lesser level to maintain knowledge diffusion frequency in a biggish level relatively, so that which can be good for knowledge diffusion of community.

B. The influence of knowledge diffusion centralization to communities of practice

It means that, there are a large number of cliques which own close relationship and frequent exchange and then compose a strong relation network if the average knowledge diffusion centralization of community. According to the theory of strong relation's advantage [32], even though cliques can help members to share, diffuse knowledge, and improve their knowledge level quickly, members' knowledge also becomes similar and homogenous among a clique and the relational network structure of cliques' members becomes over rigid. Therefore, members among a clique can not only immediately share external and heterogeneous knowledge, but also exclude other clique's members, and then it does harm to disseminate the new knowledge and ideas. As a result, obviously, it causes prohibit members of community from diffusing knowledge further. In terms of the theory of weak ties' advantage [33], this clique needs to establish relation with other cliques and then get new and heterogeneous knowledge. Hennessey et al. argued that the high communication centralization of team is bad for team innovation [34]. By agents simulation about network structure and knowledge diffusion, Cowan and Jonard found that the steady-state level of average knowledge is maximal when the network structure is a small world (that is, when most connections are local, but roughly 10 percent of them are long distance) [31], which also shows that the relatively big clustering coefficient is beneficial for knowledge diffusion in the agents network. By building up a network model of knowledge diffusion and making a simulation, Hu Feng et al. also hold that the network whose average distance is relatively small can effectively improve knowledge diffusion efficiency [1]. Therefore, we concluded that the whole clustering coefficient of communities of practice should keep in a biggish level to maintain the average knowledge diffusion centralization in a biggish plane relatively, so that which can be good for knowledge diffusion of community.

C. The implications of cultivate and support communities of practice

Based on the analysis above, communities of practice should have relatively biggish knowledge diffusion frequency and centralization (namely, the lesser characteristic relationship length and biggish clustering coefficient), which is beneficial for knowledge diffusion of community. That is to say, there are some cliques in community, and members of a clique should keep strong link while there are some weak ties among cliques. Thereby, keep community in a certain loose organizational structure [35], which can promote knowledge diffusion of community.

Combined with the small-world network theory, when knowledge diffusion frequency is too high or too low, organizations can regulate characteristic relationship length of community and then archive the goal of promoting knowledge diffusion by adding or breaking keys of network. For example, increasing (or reducing) the funds and place support for the community, enhancing (or weakening) communication to control close degree of relationship among members, adding (or removing) some members into (or from) the community, and so on. When knowledge diffusion centralization is too high or too low, organizations can regulate clustering coefficient to archive the goal of promoting knowledge diffusion by adding or breaking keys [17] of network. Such as, cultivating (or hindering) the form of cliques, enhancing (or weakening) members' communication and relation among a clique, enhancing (or weakening)cliques' relationship and exchange to regulate close degree of relationship, and so on.

However, due to specificity of communities, you can't tug on a cornstalk to make it grow faster or taller, and you shouldn't yank a marigold out of the ground to see if it has roots [1], excessive controlling and intervening is likely to result in the demise of community itself [31]. Consequently, organizations should insist moderate principle when they try to cultivate or support communities of practice by taking some treatments.

VI. CONCLUSIONS AND LIMITATIONS

From the relation network of community members, based on the weighted small-world network, we studied the knowledge diffusion network of communities of practice, proposed to use characteristic relationship length and clustering coefficient of community members to token knowledge diffusion frequency and centralization respectively, found that knowledge diffusion frequency and centralization should keep in a moderate level (namely, characteristic relationship length should remain in a relatively small level while clustering coefficient should maintain in a relatively big level in the communities of practice), and provided some useful theoretical guidance with organizations to cultivate and support communities of practice. This study has a few inherent limitations. First, we only addressed how does network structure of relationship influence knowledge diffusion of community on the basis of the mathematical model, and there was no simulation work to support our study. Second, in fact, characteristic relationship length and clustering coefficient may have a mutual influence, which can lead to that knowledge diffusion centralization and knowledge diffusion frequency have a mutual effect, however, we did not consider this point.

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REFERENCES

[1] Hu Feng, Zhang Li. The model and implications of knowledge diffusion network [J]. Journal of the China

Society for Scientific and Technical Information, 2006, 25(1): 109-114
[2] Wenger, E., Snyder, W. Communities of practice: the organizational frontier [J]. Harvard Business Review, 2000, 78(1): 39-45.
[3] Lesser, E.L. & Storck, J. (2001) Communities of practice and organizational performance. IBM Systems Journal, 40(4), 831-841.
[4] Shi Wendian, Luo Zhao, Yuan Xianxue. The Influence of Self-efficacy of Members of Practice Communities on Knowledge Transmission Process and Effect [J]. Psychological Science, 2007, 30(1): 92-95.
[5] Luo Zhao, Shi Wendian. The Influence of members of Cop's Face on Knowledge Transmission [J]. Chinese Journal of Applied Psychological, 2007, 13(3): 264-270.
[6] Shi Wendian, Luozhao, Yuan Xianxue. The Influence of the Members of CoP's Achievement Motivation on Knowledge Transmission [J]. Psychological Science, 2008, 31(1): 100-104.
[7] Chen Jianhua. The new trends of knowledge management: Confirm and support communities of practice [J]. Foreign Economies & Management, 2001, 23(6): 34-37.
[8] Lesser, E.L. & Storck, J. (2001) Communities of practice and organizational performance. IBM Systems Journal, 40(4), 831-841.
[9] M. Thompson, Structural and epistemic parameters in communities of practice [J]. Organization Sci 16 (2005) (2), pp. 151–164.
[10] John Seely Borwn and Paul Duguid. Organizational Learning and Communities of Practice: Toward a Unified View of Working Learning, and Innovation [J]. Organization Science, 1991, (2).
[11] P. Gongla, C. R. Rizzuto. Evolving communities of practice: IBM global services experience.IBM Systems Journal, 2001, 40.
[12] Wenger E. et al. Communities of practice: the guildlines of knowledge management in the learning organizations [M]. Beijing: Mechanical industry press, 2003.9.
[13] Zhihong Li, Jun Li, Research on Factors Influencing Knowledge Transfer and Managerial Mechanisms in the Community of Practice [J]. Library and Information Service, 2008, 52(12): 35-38.
[14] Milgram S. The small world problem [J]. Psychology Today, May 1967, 60-67.
[15] Watts D J, Strogatz S H. Collective dynamics of small-world networks [J]. Nature, 1998, 393(4): 440- 442
[16] Newman M E J. The structure and function of complex networks [J]. S IAM Review, 2003, 45: 167-256.
[17] Albert R, Barabási A L. Statistical mechanics of complex networks [J]. Review s of Modern Physics, 2002, 74 (January): 47-97.
[18] Boccaletti S, Latora V, Moreno Y, Chavez M, Hwang DU. Complex networks: structure and dynamics [J]. Phys Rep. 2006, 424:175–308.
[19] Liljeros F, Edling C R, Amaral L A N, et al. The web of human sexual contacts [J]. Nature, 2001, 411(6840):907-908.
[20] Jeong H, Tombor B, Albert R, et al. The large-scale organization of metabolic networks [J]. Nature, 2001, 407(6804): 651- 654.
[21] Wenger E. Communities of Practice, Learning, Meaning, and Identity [M]. New York: Cambridge University Press, 1998.
[22] Huang Guang-Wei. Study on the knowledge innovation mechanisms of communities of practice [J]. Sci-Tech Information Development & Economy, 2007, 17(6): 184-186.
[23] Garnovetter M. Economic action and social structure: The problem of embeddedness [J]. American of Sociology, 1985, 91: 481-510.
[24] Blau P. Exchange and power in social life [M]. New York: JohnWiley & Sons, 1964
[25] Deroian F. Formation of Social Networks and Diffusion of Innovations [J]. Research Policy, 2002; 31 (5).
[26] Polanyi, K., 1957. The economy as instituted process. In: Polanyi, K., Arensberg, C.M., Pearson, H.W. (Eds.), Trade and Markets in the Early Empires. Free Press, Glencoe, IL, pp. 243-270.
[27] M.E.J. Newman, Scientific collaboration networks: II. Shortest paths, weighted networks, and centrality [J]. Phys. Rev. E64 (2001)016132.
[28] Latora V, MarchioriM. Economic small-world behavior in weighted networks [Z]. arXiv: cond-mat/0204089 v2 12 Nov 2002.
[29] J.-P. Onnela, J. Saramaki, J. Kertesz, K. Kaski, Intensity and coherence of motifs in weighted complex networks [J]. Phys. Rev. E 72 (2005) 065103.
[30] Leenders R Th A J, van Engelen JoM L, Kratzer J. Virtuality, communication, and new product team creativity: A social network perspective [J]. J Eng Technol Manage, 2003, 20: 69—92.
[31] Cowan R, Jonard N. Network structure and the diffusion of knowledge [J]. Journal of Economic Dynamics & Control, 2004, 28 (8): 1557—1575.
[32] Bian, Y.J. Bring strong ties back in: Indirect ties, network bridges, and job searches in China [J]. American Sociological Reviews, 1997, 62：366-385.
[33] Granovetter, Mark. The Strength of Weak Ties [J]. American Journal of Sociology. 1973, 78: 1360-80.
[34] Hennessey B A, Amabile TM. The conditions of creativity [A]. In: WestM A, Farr J L (Eds). Innovation and creativity at work [M]. Chichester: Wiley, 1990, 11—38.
[35] M. Thompson, Structural and epistemic parameters in communities of practice [J]. Organization Sci 16 (2005) (2), pp. 151–164

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