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Research on Social Q&A Community Knowledge Transfer Model Based on Follow Relationship Network

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Abstract
Social Q&A community is the focus of knowledge sharing and knowledge acquisition in the Internet era. The study of user group and community structure of social Q&A community is helpful to discover its model of knowledge transfer and the characteristics of the user group. Based on the study of relevant literature and social Q&A community characteristics, we build social relationships network model and use the method of social network analysis to study user groups. Finally, we find the user characteristics and behavior pattern. Furthermore, we analyze the knowledge transfer model of social Q&A community.

Key words: Social Q&A community; Scaling-free; Centrality; Knowledge transfer model

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INTRODUCTION
Recently, the social Q&A community has a strong footprint in the world, which gradually developing into an important place for online users to share and gain knowledge. Social Q&A community is an important direction for the development of online communities. The in-depth study of knowledge transfer model in communities is good for improving the efficiency of knowledge dissemination and promoting the sharing of knowledge.

Szulanski (2000) proposed four stages of knowledge transfer. Based that, Liu considered the knowledge transfer in virtual community as a dynamic process, which includes a series of the sharing willness of knowledge owners, establishment of links with the knowledge recipients, acceptance of new knowledge by the knowledge recipients and applied to the specific field (Liu et al., 2015). The literature indicated the network environment and the existence of common interests in the virtual community provide a suitable channel and environment for knowledge transfer. And some researches (Tortoriello, Reagans, & McEvily, 2012; Levin & Cross, 2004) showed in the process of knowledge transfer, strong social relationships make a greater understanding among members. The intensity of connection among members makes it easier for members to accept each other's knowledge. Therefore, finding the user group with common interests and strong connection is useful to analyze the transfer model among users.

Xu et al. (2015) emphasized network structure information contains a lot of useful information. First of all, it can directly reflect the user through the establishment of friendships, which constitutes the physical basis of communication information exchange in the network; secondly, research oriented network structure can prove human social behavior, such as "rich club phenomenon", and to help people discover new rules of social behavior, such as social groups in the community aggregation phenomenon. Lastly, due to the fact that network structure is the carrier of information transmission among social network individuals, the study of user knowledge transfer related to users' behaviors such as publishing and transmitting text content greatly depends on the deep understanding of network structure.

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In conclusion, we can measure the connection among users by establishment of the social friendship network to study users' behaviors character. Based on this, we can use the social network analysis method to find the user group with strong connection, which is the key to mine user's knowledge transfer model. It is worth mentioning that this paper discusses knowledge exchange among members in virtual communities, namely knowledge transfer at the individual level, which is equivalent to knowledge transfer among individual members in the organization.

1. SOCIAL NETWORK STRUCTURE CHARACTERISTICS

Social network structure analysis (Fang, Jia, & Han, 2015) is analyzed to the distribution of node degree, the connection closely degree of users relationship and the importance of someone sending messages to all other users through statistical analysis method. Social network structure modeling is aimed at the characteristics of social network. We use structural modeling to study the mechanism of generating these characteristics, in order to deeply understand the inherent rules and essential characteristics of social network.

1.1 The Scaling-Free Characteristics

In recent years, scholars have done a lot of research on the structural characteristics of social networks. In the analysis of the structural characteristics of social networks, a large number of studies have verified the common characteristics of various social networks with complex networks, such as the characteristics of six degree separation, small world, scale-free, power-law distribution and structural robustness. Dodds et al. (2003) verified the "six degree separation" and the small world model on a directed network with sixty thousand nodes. Golder et al. (2007) studied the online social network Facebook, which found the numbers of friend is a median of 144 and a mean value of 179.53. Aggarwal et al. (2010) considered in-degree in directed graph as a factor of popularity, and found the popularity also obeys the power law distribution.

Follow relationship is the only and the most important way to characterize identity relationship in Q&A community. Because the users' behaviour of quiz, answer, thanks and agree do not meet with characteristics of direct interaction and long-term in social network (Song, 2015; Zhao, n.d.). In this paper, we study the distribution of follow degree in order to show the distribution of the overall user influence in the community.

1.2 User Centrality in Social Network

The centrality tendency of network is of great significance to the prediction of network structure evolution, virus marketing and information dissemination.

Centrality is equivalent to the concept of "power" in sociology, which is an important tool for the analysis of the central position of individuals or organizations in the field of network analysis. Bavelas [12] first studied the formal features of the centrality, verifying that the more the actor is in the center of the network, the greater its influence. Coleman and other scholars found that the speed of new drug transmission is related to the centrality and density of the network, but there are many problems in how to quantify the centrality. Then other scholars had carried out researches and given many central concepts and calculation methods.

2. THE CHARACTERISTICS OF COHESION AND KNOWLEDGE TRANSFER IN SOCIAL NETWORKS

Cohesion is one of the important characteristics of the social network. The phenomenon of "Birds of a feather flock together" in reality mapping onto virtue networks is one by one group. Members in these groups to flock together because of similar interest, hobbies, and values. The spread of information is more occurring among these groups, so it is necessary to analyze the "substructure" existing in the network (Freeman, 1979). The method of cohesion subgroup analysis in social network analysis is to study how to divide the actors into various cliques (or subgroups). Erickson[14], Friedkin (1980) and Collins (1988) pointed out that social cohesion plays an important role in society. Friedkin (1980) used network cohesion as an explanatory variable to study how all members of the group reach consensus.

Knowledge dissemination is a research object in many fields. Zhang (2013) proposed that in the new media environment the elements of knowledge dissemination appeared with new forms. The role of disseminators and recipients can transform. Knowledge dissemination content because of application of new media technology became more abundant. It has been expanded to the news, entertainment, life and education. In the field of management, knowledge transfer and knowledge dissemination have the same meaning. Most scholars regard knowledge transfer as an important part of knowledge management, and the efficiency of knowledge transfer directly affects the goal of knowledge management (Li, 2008).

Knowledge transfer among members is an important way of knowledge transfer in social networks. The model can be obtained by analyzing the network structure of the user's following and followed. Therefore, this paper first studies the network structure of social Q&A community to obtain user centrality and its cohesive subgroup, and finally studies the knowledge transfer model of social Q&A community through the characteristics of cohesive subgroup.

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3. THE RESEARCH OBJECT AND SIGFINICANCE

The object in our research is Zhihu.com, which is of the best development atmosphere at present in China. After ten years of development, the website has emerged in a large number of high-quality knowledge. How to spread this knowledge in the largest range is known to almost present problem to be solved. Choosing Zhihu.com as the research object because it has been accumulated a large number of user group, which will help to fully discover the user's knowledge transfer model, so as to provide decision-making basis for the social Q&A community to effectively spread knowledge accumulated.

4. METHOD

4.1 Model Establishment

Based on user communication in Q&A community, we established a directed network, which considered responders in *a* topic as a node set $U=\{u_1,u_2,\ldots, u_n\}$. The follow relationship among responders is the side $E=\{e_1,e_2, \ldots, e_m\}$. The relationship matrix $A=\{(a_{ij})\}$ represented the relationship between follower and followee. If the user u_i followed the user u_j, then the a_{ij}=1, otherwise a_{ij}=0. *A* is a two valued matrix and

$$a_{ij}=\begin{cases}1, \text{If the user } ui \text{ followed the user } uj\\ 0, \qquad\qquad \text{otherwise}\end{cases}. \quad (1)$$

4.2 Research Method

4.2.1 The Characteristic of Scale-Free

The characteristic of scale-free means that the degree of the network obeys the power law distribution, which can be expressed as :

$$P(k)=k^{-\gamma}. \quad (2)$$

$P(k)$ represents the proportion of nodes in which the network is moderately *K* in the whole network, which is a power law exponent.

4.2.2 The Characteristic of Centrality

Centrality is an indicator to measure the importance of a node. The commonly indicators of centrality are point centrality, betweenness centrality and closeness centrality.

Professor Freeman's researches on centrality has been widely recognized by the University of California-Irvine. The following concepts and methods on centrality are based on Professor Freeman's classic articles[13] and related literature.

4.2.2.1 Point Centrality

In the same network, point centrality is also called the absolute point centrality, which is recorded as $C_{AD}(x)$. Its calculating method is to statistic the number of point degree. That is

$C_{AD}(x)$ = in-degree of node x+ out-degree of node x. (3)

4.2.2.2 Betweenness Centrality

Professor Freeman proposed that if an actor is between member-pairs, then its degree is generally low. These nodes usually play an important intermediary role, and in the center of the network, so we need to compute the betweenness centrality of nodes. We can describe the intermediary ability of node with "intermediate proportion", which is defined as: The number of geodesic line of any two nodes via node *i* proported the number of geodesic line of any two nodes. The formula is expressed as:

$$C_{AB_i}=\sum_j^n\sum_k^n b_{jk}(i)\ ,\ j\neq k\neq i \ or\ j<k\ , \quad (4)$$

$$b_{jk}(i)=\frac{g_{jk}(i)}{g_{jk}}\ . \quad (5)$$

4.2.2.3 Closeness Centrality

Closeness centrality, also called overall centrality, is a measure of the proximity of an actor to other actors. Closeness centrality is a measure that is not controlled by others. The closeness centrality between nodes and other nodes is calculated by their geodesic distance. The formula expression is as follows:

$C_{AP_i}^{-1}=\sum_{j=1}^{n} d_{ij}$, d_{ij} is geodesic distance between node *i* and node *j* (6)

The "-1" power expressed the greater of nodes' closeness centrality, the more not the core point of the network. It can be seen that the farthest distance from the center nodes is also the weakest in information resources, rights, prestige and influence.

4.2.2.4 Point Centralization

Point centralization was described the centrality of overall network, which is recorded as *C*. And it was calculated by:

$$C=\frac{\sum_{i=1}^{n}(C_{\max}-C_i)}{\max\sum_{i=1}^{n}(C_{\max}-C_i)}\ . \quad (7)$$

4.3 Block Model

Block model was the method of position level, which was different from the individual level (Wasserman & Faust1994). A block corresponds to a submatrix of the initial matrix. If the value of a block is 1. It is called 1-block. A value of 0 corresponds to a 0- block. Block model is a simplified representation of 1-ary relation and multi-ary relation network, which are used to represent the overall structure of the network.

Block model method used the CONCOR method to carry out the aggregation subgroup analysis, which is an iterative correlation convergence method. The correlation matrix C1 is calculated through the Pearson product-moment correlation coefficient to calculate the correlation coefficient of the matrix rows (or columns). Then the correlation matrix C2 was to calculate the correlation coefficient of the matrix rows (or columns) by the same method. In turn, the correlation coefficient of the correlation coefficient… is obtained. The matrix, after

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multiple iterations, uses attribute graphs to represent the degree of equivalence of the structure between positions and marked the network members of positions.

The density of the network was considered as the critical value. If density value of blocks was greater than or equaled to the critical value, the matrix value of corresponding position were 1. Otherwise, the matrix value of corresponding position was 0. Finally, a matrix consisting of 1- block and 0- block was obtained.

5. EXPERIMENT

Experimental data consisted of two parts: user behavior data, including answer_num, agree_num, thanks_num, follower_num and followee_num, and the follow data including followers and followees from the answer users on a topic of computer science.

First, the basic statistics of the user's behavior data are carried out, as shown in Table 1.

Table 1
The Basic Statistics of the User's Behavior Data

	Followee_num	Follower_num	Answer_num	Agree_num	Thanks_num
mean	176.28	3,620.01	68.94	3,858.42	865.26
median	67.00	112.00	17.00	96.00	28.00
standard deviation	565.886	22,978.928	225.869	21,951.834	4,627.734

According to the statistics, mean of all indicators are greater than the median and the standard deviations are so big, which indicates that a number of answer_num, agree_num, thanks_num, follower_num and followee_num are low, only a small part of the users are far more than other users.

Intuitively, there are only a few nodes that are very large, which are connected with many other points, while most nodes are characterized by minimal degree, which is in line with the scale-free feature of social networks. Based on the focus of this article on the follow network in social Q&A community, we focus on the scale-free nature of the network.

5.1 The Result of Scale-Free Characteristic Research

User behavior in social Q&A community includes ask, answer, agree, thanks, and follow. The relevant literature indicated that several conditions of social network are direct interaction of multi-user, long-term interaction and simultaneity. Ask and answer do not refer to the proponents or responders. They ask questions because of needs. Respondents respond to questions because of community motivation and personal prestige. There is no direct interaction between the proponent and respondent in most time. There is a direct interaction between agree and answer behavior, but it does not have the long-term nature. And follow behavior is of the characteristics of direct interaction and long-term. Therefore, the follow network in social Q&A community is a social network.

We used SPSS22.0 to make statistics on a total of 26,161 follow data to show the quantity distribution characteristics, showed as Figure 1.

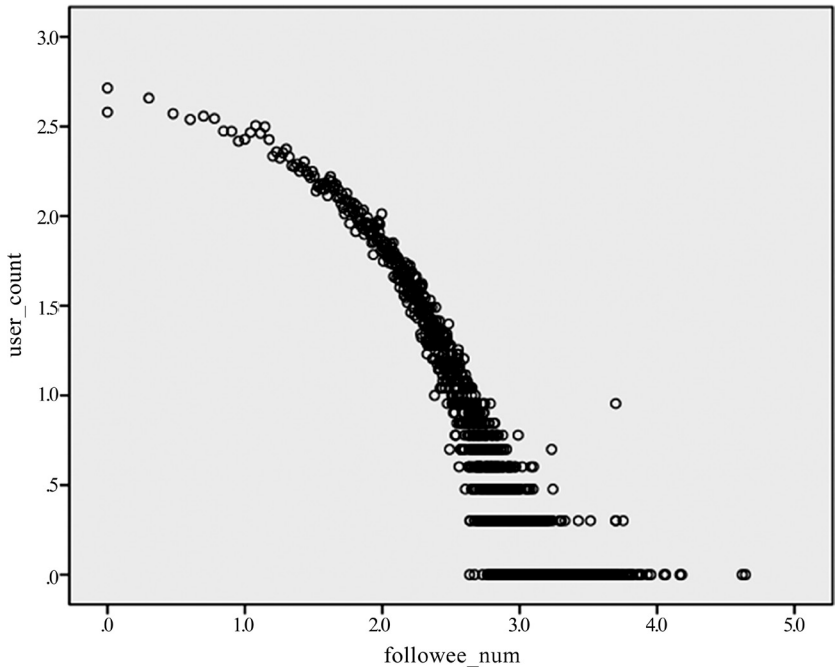

Figure 1
The Follow Data Distribution in Zhihu.com(The Data Is Processed by log10)

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We also fitted the follow data. Table 2 showed the result of linear function fitting, which emphasized the initial data obey a power distribution with a power law exponent -1.202.

Therefore, follow network in social Q&A community is a scale-free network with power law exponent power law exponent 1.202.

Table 2
The Fitting Result of Follow Data

Independent variable	Goodness of fit (R)	Parameter evaluation	
		Constant	b1
Followee_num	0.866	4.035	-1.202

5.2 The Result of Centrality Research

5.2.1 Overall Centrality Analysis

Based on the research result of chapter3.1, we knew there are a few nodes with huge degrees. In Zhihu.com, if the followees had information dynamics, these dynamic information will be pushed to the followers, thereby affecting the followers. Based on this setting, we studied the centrality of the follow network.

We assumed more agreeble numbers one user gaining, more prestige he owning, and more likely in the network center. So, we selected 366 users whose agree numbers are more than fifty thousand in the topic "investigative problem" to analyze. Figure 2 showed the 366 users' attention network.

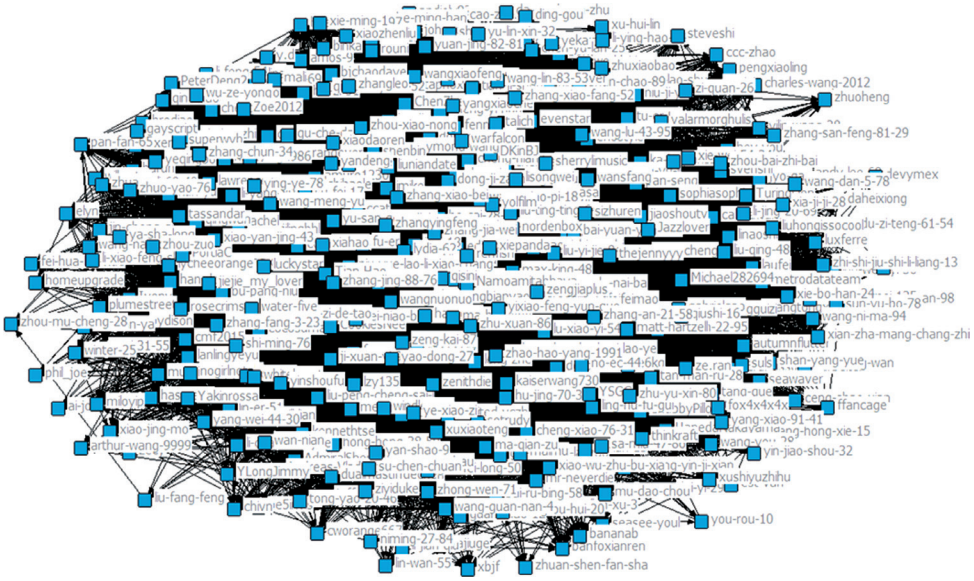

Figure 2
The Follow Relationship Model G of Zhihu.com

In view of the sample data, the structural indexes of the network map are calculated using the social network method. The results are shown in Table 3.

Table 3
The Structural Indexes in Follow Network G

Index	Value
Nodes	366
Network density	0.197,3
Average degee	144.028
Accessibility	Any two nodes can be reachable
Average path	1.855
Point centralization	0.635
Betweenness centralization	0.037,5

The network contains 366 nodes, the overall network density is 0.197,3, the average point degree is 144.028, and the average shortest path is 1.855. It can be seen that the network connection is relatively close. Compared with the six degree separation theory, the average path of the network was about 2. That is, any two nodes can be connected through an intermediate node, which indicated that there is a shorter reachable path between the users with high prestige. In addition, the point centralization of network is 0.635, and betweenness centralization is 0.037,5. It also indicated that the network has a higher connectivity and a few node had strong mediator.

5.2.2 Individual Centrality Analysis

We calculated point centrality, betweenness centrality and closeness centrality of all users and showed top 13 users in Tables 4, 5, 6.

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Table 4
The Top 13 Users of Point Centrality

User	Point centrality	Rank
miaomiaomiao	462	1
liangbianyao	450	2
jun-mo-52	431	3
jixin	407	4
namoamitabhaya	394	5
lydia-62	377	6
qisini	362	7
edison-chen-8612	354	8
renfish	335	9
li-ao-wen	324	10
cai-tong	322	11
e-mo-de-nai-ba	322	12
fu-er	319	13

Table 5
The Top 13 Users of Betweenness Centrality

User	Betweenness centrality	Rank
miaomiaomiao	5,273.514	1
liangbianyao	4,840.207	2
jixin	3,469.129	3
lydia-62	2,095.915	4
jun-mo-52	1,956.495	5
e-mo-de-nai-ba	1,929.528	6
yixiao-feng-yun-guo	1,605.877	7
li-ao-wen	1,554.835	8
bo-cai-28-7	1,510.530	9
cai-tong	1,449.204	10
renfish	1,431.029	11
fu-er	1,396.649	12
han-qing	1,300.825	13

Table 6
The Top 13 Users of Closeness Centrality

User	Closeness centrality	Rank
Namoamitabhaya	920	1
jun-mo-52	929	2
qisini	937	3
edison-chen-8612	998	4
miaomiaomiao	1,010	5
renfish	1,039	6
lydia-62	1,045	7
ji-le-18	1,060	8
NicolasYu	1,069	9
liu-ting-ting-64	1,074	10
liangbianyao	1,076	11
li-ao-wen	1,076	12
Jixin	1,088	13

We find that some users have high point centrality, betweenness centrality and low closeness centrality, such as miaomiaomiao, liangbianyao, jixin, jun-mo-52, renfish, li-ao-wen and lydia-62. They have strong information dissemination potential and intermediation. Low closeness centrality indicated the independence of these users. These users are most influential in network G.

5.3 The Result of Cohesive Subgroups Research

We conducted cohesive subgroups analysis of follow relationship about 366 members in Zhihu community. Table 7 shows the cohesive subgroups density of the follow relationship, and the corresponding subgroup members tree are shown in Figure 3.

Table 7
Cohesive Subgroups Density Matrix

	Subgroup 1	Subgroup 2	Subgroup 3	Subgroup 4
Subgroup 1	0.249	0.148	0.18	0.155
Subgroup 2	0.198	0.219	0.454	0.241
Subgroup 3	0.068	0.106	0.289	0.086
Subgroup 4	0.055	0.045	0.072	0.067

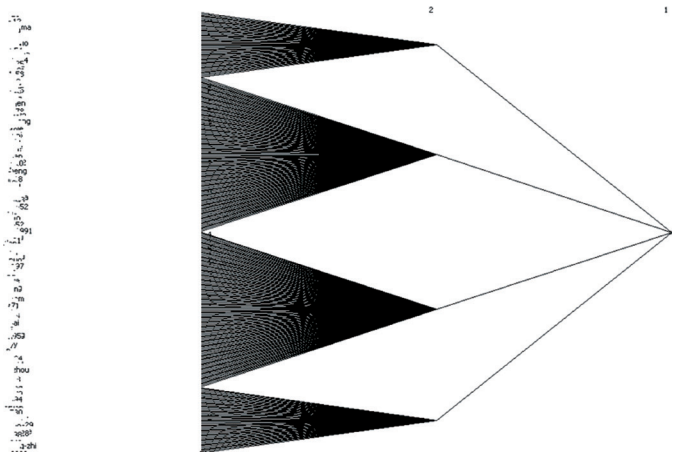

Figure 3
Cohesive Subgroup Members Tree

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Based on block model method, we get the 0-1 cohesive subgroups density matrix as Table 8.

Table 8
0-1 Cohesive Subgroups Density Matrix

	Subgroup 1	Subgroup 2	Subgroup 3	Subgroup 4
Subgroup 1	1	0	0	0
Subgroup 2	1	1	1	1
Subgroup 3	0	0	1	0
Subgroup 4	0	0	0	0

5.4 The User Knowledge Transfer Model in Social Q&A Community

Wang Kaiming and Wan Junkang proposed two kinds of knowledge transfer mechanisms: interpersonal transfer and transfer based on media or knowledge repository (Wang & Wan, 1994). Based on this, we think social Q&A community mainly includes two knowledge transfer mechanisms: interpersonal transfer (user follow) and transfer based on topics (topic concerns). Interpersonal transfer is that users follow on other users, and the community will push the followees' dynamics to the followers. Users will receive dynamic information of followees on the login page, so as to achieve the transfer and diffusion effect of users' knowledge. Transfer based on the topic is the process of obtaining topics' dynamic information by concerning topics. This paper focuses on the former, and therefore focuses on the analysis of interpersonal transfer model.

The base model of interpersonal transfer in social Q&A community shows as Figure 4. Figure 5 shows the overall knowledge transfer structure.

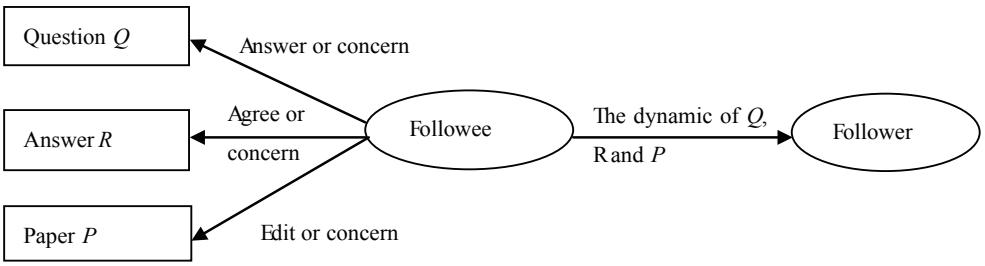

Figure 4
The Base Model of Interpersonal Transfer in Social Q&A Community

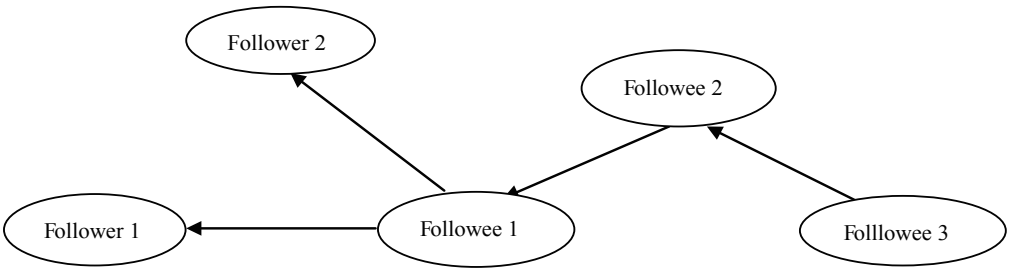

Figure 5
Overall Knowledge Transfer Line Structure in Social Q&A Community

Knowledge transfer in virtual communities includes a series of links from knowledge owners' willingness to share, connection with knowledge recipients, to knowledge recipients accepting new knowledge and appling them to specific areas. Users are willing to use community to acquire and share knowledge, which indicates knowledge owners' willingness to share. Users will absorb and apply new knowledge according to their own knowledge needs, which is uncontrollable. Therefore, how to establish a link between knowledge owners and knowledge recipients is the key to the knowledge transfer of social Q&A community. Based on this, we summarize the knowledge transfer patterns based on the results of the cohesive subgroup analysis on following relationship in social Q&A community.

5.4.1 Single Center Mode

We find that subgroup 1 has only one central high member "e-mo-de-nai-ba". He has high point centrality, betweenness centrality and low closeness centrality (ranking 24).

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From the result of social network analysis, he has strong information dissemination ability in social Q&A community. Other members in subgroup often need to acquires knowledge from him or via him. He is the knowledge source and intermediary.

In this pattern, the members involved are around the center to acquire knowledge or to answer, concern and agree questions. This model is more conducive to the discussion and answer topics deeply, which is more conducive to the emergence and innovation of knowledge. This knowledge transfer model exists in social Q&A community anywhere, forming the base of other models.

5.4.2 Intermediary Model

In subgroup 3, we find that there are some members with higher centrality, including liangbianyao, Jixin, fu-er and cai-tong. bo-cai-28-7 and Han-qing have higher betweenness centrality. All these users have shown high betweenness centrality and subgroups have more members. Some groups taking liangbianyao, Jixin, fu-er and cai-tong as single center are connected to each other by bo-cai-28-7 and Han-qing, and this subgroup has higher connection density, so called intermediary model.

Intermediary model is based on single center model, which is beneficial to the diversity of topics and problems. This model of knowledge transfer generally revolves in the emergence of knowledge around a number of different field topics, knowledge transfer in a wider range and more efficient. Therefore, there are more than two center points. Subgroup members can acquire more knowledge via center points and answer, agree, and concern to topics. Group connection density in this knowledge transfer model is higher than a single center model, and the number of members is more.

5.4.3 Multi-Center Model

From Tables 8 and 9, we can find that there are many members in subgroup 2, and the matrix blocks of other subgroups and subgroups 2 are 1- block. That is, the connection density of other subgroups and subgroup 2 is higher, because there are many high centrality users in the subgroup. These users have many fans. Apart from fans of the subgroup 2, most of the other subgroup members are fans of these high centrality members. So it's called multi-center model.

Table 9
Members With High Centrality Distribution. (1 in Brackets Represents High Point Centrality, 2 Represents High Betweenness Centrality, 3 Represents High Closeness Centrality)

Subgroup 1	Subgroup 2	Subgroup 3
yixiao-feng-yun-guo(2) e-mo-de-nai-ba(1,2)	NicolasYu(3) liu-ting-ting-64(3) ji-le-18(3) Namoamitabhaya(1,3) qisini(1,3) edison-chen-8612(1,3) renfish(1,2,3) li-ao-wen(1,2,3) lydia-62(1,2,3) miaomiaomiao(1,2,3) jun-mo-52(1,2,3)	bo-cai-28-7(2) han-qing(2) fu-er(1,2) cai-tong(1,2) jixin(1,2,3) liangbianyao(1,2,3)

This pattern collaborates single center model and intermediary model to connect all members of the community. These center members enable fans to easily acquire knowledge from other center members by interconnecting each other, so that all knowledge can be transferred to the whole community in the largest range.

This kind of model and intermediary model together cover the entire community, because there are many opinion leaders and excellent intermediary user. They follow each other or contact with related topics to form knowledge transfer channels. Their sharing knowledge transfer to the large number of users in the community through these channels, so that the whole community of users can quickly access to the knowledge required.

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