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The diffusion of online knowledge transfer network and substructure measure

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ABSTRACT

Through the analysis of network structure and network nodes, we get the recognition of online knowledge transmission mode. Just according to the judgment of the network structure, we cannot reach the aim of enlarging the transmission range. To judge the transfer state and to formulate the specific communication strategy are the fundamental.

KEYWORDS

Knowledge transfer; Network distribution; BBS; Transfer mode.

INTRODUCTION

In the field of network communication, the most intuitive view is that the removals (or protection) a small number of key nodes can achieve the purpose of destroying the whole network (Lazaro, 2005)[1]. But this kind of decision-making process is based on the complete mastery of the network structure. But in fact, we always don't know the network structure completely, so we can't achieve the purpose of collapse the network through the removal of a small number key nodes (Romualdo, 2001)[2]. Another situation is that the hub nodes in the network is obviously, but simply remove the nodes can't enlarge the transmission range. Network transmission characteristics determine that the network structure is just one of the necessary conditions in realizing network communication purpose and node communication state identification is also indispensable.

This paper is organized as follows. The second part introduces the knowledge transfer network. The third part measures the equivalence of the networks' subgroup structure. The conclusions are given in section 4.

KNOWLEDGE TRANSFER NETWORK

Community structure

We take the real forum records of certain enterprise's BBS as the analytical master of the knowledge transfer network in this paper. This online knowledge transfer network is made up of posting individuals which connected with each other. We use $N = \{1, 2, \cdots i, \cdots n\}$ to denote the individuals in the online knowledge transfer network. Individuals' line directions are decided by reply posting direction.

There are directed edges from i to $j_1, j_2, j_3, \cdots$, after i sends the placard and $j_1, j_2, j_3, \cdots$ reply to i. And there are k edges from i to others,or the node i's out-degree is k, if k individuals reply to i. In the same way, if i replies to other k' individuals, i's in-degree is k'. If we don't explain specially, the degree which we mentioned in this text is out-degree. Therefore, the online knowledge transfer network is a directed graph. Let $P(k)$ be the degree distribution, which means the scale of individuals, whose degree is k ($0 < k < n$).

Network layer diffusion

Suppose that the network N is constituted by some particular communities. Inside the community, individuals would carry on a certain kind of knowledge (or information, culture, behavior. etc, this text mentions together as 'knowledge') through the form of posting.

When knowledge A comes into the network, the state of individual i is $s_i \in (0,1,2)$. If i doesn't get knowledge A, we say $s_i = 0$,and define i as susceptible. If i gets knowledge A, and gets the meaning of spread, we say $s_i = 1$,and define i as infective. If i gets knowledge A, but doesn't get the meaning of spread, we say $s_i = 2$,and define i as recover. Therefore, the online knowledge transfer problem can be regarded as the distribution problem based on SIR model.

Select a node i as the key node, namely $s_i = 1$, i has the knowledge A and has the knowledge transfer intention i to distribute knowledge in the form of posting. Supposed that, node j_{11} gets the knowledge A, after j_{11} replies i. But node j_{11} thinks that knowledge A doesn't get enough timeliness and refuses to transfer again. Therefore j_{11} is recovered, and $s_i = 2$. Supposed that, node j_{12} gets the knowledge A, replies i, and transfers the knowledge A again. Therefore j_{12} is infected, and $s_i = 1$. Thus, we get the layer diffusion mechanism in Figure 1.

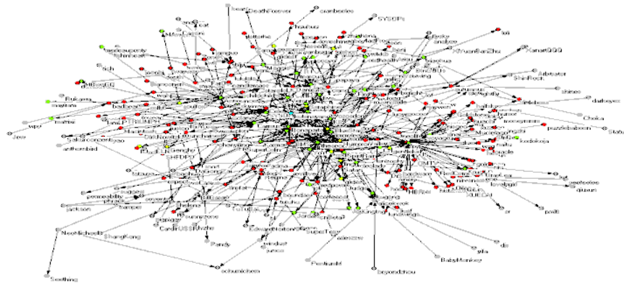

Figure 1 : The on-line knowledge transfer network layer transfer mechanism （■ : Key nodes ■ : Level-1 nodes ■ : Level-2 nodes ■ : Level-3 nodes)

The network individual's distribution condition always converts along with the time among the suspected, the infected and the recovered. If an ignorant communicates with a spreader, the ignorant turns into a spreader in probability σ . Distribution process usually ends in the forgetting mechanism (Darr,1995)[3],or ends in the state that the spreader thinks the knowledge has already lost the seasoning worth (Dunia， 2008)[4]. Hence, spreaders will gradually convert into recovers. We denote the invert rate as υ , and denote the transmission coefficient as $\lambda = \sigma/\upsilon$.

MEASUREMENT OF THE NETWORKS' COHESIVE SUBGROUP STRUCTURE

The original data source is so big. In order to do fine analysis, we choose the Ministry of finance innovation department and the risk management department. The two departments' BBS interaction record is the main analysis content in the analysis process. The reason to select the two departments is that the two departments are related closely to the day-to-day operations which are easy to show regularity and easy to avoid the statistical error.

In order to analyze more convenient, in the analysis below, the data will be referred as advice-4 and advice-5. The data used in the article is the two value data. After the composition analysis, we find the "weak composition" analysis result is not ideal, so we need to do further analysis.

Faction analysis

"Faction" refers to the maximum complete subgraph which contains at least three points and builds on the basis of reciprocity

Using UCINET software, we get the faction analysis results of advice-4 and advice-5:

There are 9 factions in advice-4(TABLE 1):

TABLE 1 : Similarity matrix of advice-4 (part data)

Subgroup	Number	Node	Clustering coefficient
Clique 1	4	Announcer chenyiling spdf SpiritRain	3.00
Clique 2	3	smallcai spdf SpiritRain	2.00
Clique 3	3	shingo lululala SpiritRain	2.00
Clique 4	3	lululala SpiritRain NeoMichael	2.00
Clique 5	3	Liusf qoiooo SpiritRain	1.00
Clique 6	3	Announcer iwo Saraphine	0.25
Clique 7	3	spdf pker Humorous	1.50
Clique 8	4	Announcer chenyiling spdf Humorous	3.00
Clique 9	3	smallcai spdf Humorous	2.00

According to TABLE 1, we can see Clique 1 and Clique 8 which have the highest clustering coefficient with 4 members, and Clique 6 which has the minimum coefficient of 0.25. In this network, some individuals repeated in different factions, and some others are free from factions. According to TABLE 1, we can get the faction overlap graphs of advice-4(Figure 2). The faction overlapping number of individual SPDF, SpiritRain, MPC is 5,that is to say these individuals maintain close knowledge transfer relationship with 5/9 individuals of this network. Rood, pLTF, blessedareye do not appear in any faction, and not actively involved in the knowledge transfer activities. According to TABLE 1 and Figure 2, SPDF, SpiritRain, MPC are not only appearing in many factions, but also shared members in several biggest factions. So they are the core members of the network, and we can get the faction overlapping figure of the advice-5(Figure 3).

Block model analysis

"Block model" is a kind of cohesion subgroup analysis method according to the density between internal and external members of subgroup. It can discriminate the nodes according to the structural information（White， 1976)[6]. There are six kinds of methods of building block model: the completely fitting method, standard method, standard method, 1-block method, a- density index method, standard method and the maximum average standard method (Wasserman, 1994)[7]. Among them, the- density index method is relatively common, and it always take the average a density of the network as the critical value (Liu Jun, 2009)[5].

Subgroup analysis

First, we partition the actors of advice-4. The network is divided into subgroups which do not overlap and get the subgroup distribution (Figure 4) and subgroups density matrix of advice-4(Figure 5). In subgroup 2, there is only one isolated node. Delete it, and do block model analysis again. We get the subgroup distribution (Figure 6) and subgroups density matrix of advice-5(Figure 7) which divide the network into 8 subgroups.

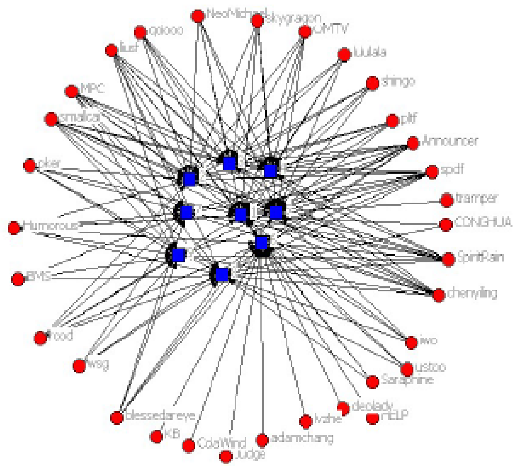

Figure 2 : Faction overlap of advice-4

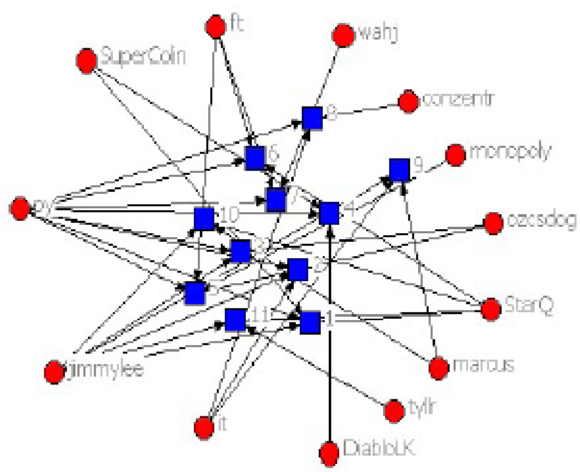

Figure 3 : Faction overlap of advice-5

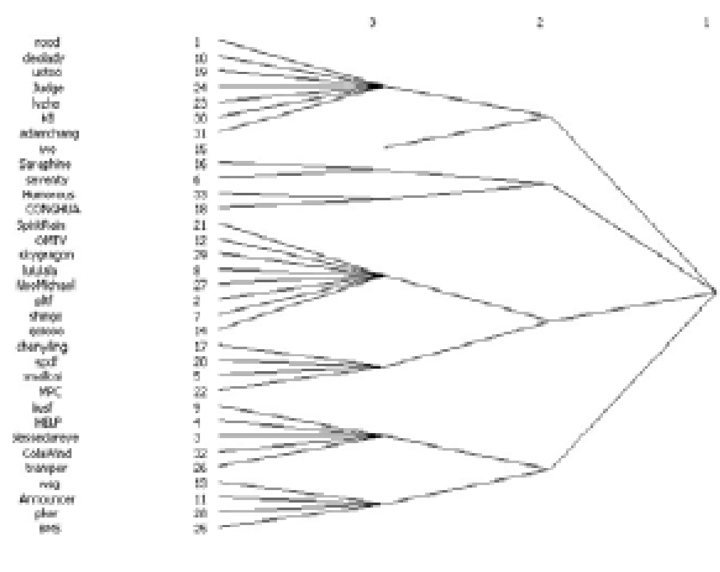

Figure 4 : Subgroup distribution of advice-4

Density Matrix

	1	2	3	4	5	6	7	8
1	0.000	0.000	0.571	0.000	0.000	0.071	0.000	0.000
2	0.000		0.500	0.000	0.000	0.000	0.800	0.500
3	0.571	0.500	0.000	0.000	0.000	0.000	0.000	0.125
4	0.000	0.000	0.000	0.000	0.000	0.625	0.200	0.500
5	0.000	0.000	0.000	0.000	0.321	0.125	0.100	0.031
6	0.071	0.000	0.000	0.625	0.125	0.333	0.000	0.188
7	0.000	0.800	0.000	0.200	0.100	0.000	0.000	0.000
8	0.000	0.500	0.125	0.500	0.031	0.188	0.000	0.000

R-squared - 0.320

Figure 5 : Subgroups density matrix of advice-4

To divide the advice-5 into not overlap subgroups, we can get an isolated node dogx. If we remove this node, the network still cannot present subgroup distribution complete, even in the presence of isolated nodes more. A conclusion can be drawn that advice-5's condensation is lower which is divided into 8 non-overlapping subgroups.

Position analysis

The main purpose of position analysis is the description of subgroup's position and the exploration of the information sending relationships among the subgroups. Remove the isolated nodes of the subgroup's density matrix, and do position analysis according to Burt (1976)[8].

According to block matrix model, we get the following results of advice-4:

Subgroups1, 2, 4 and 5 get the flattery position, namely internal members get much more relationship with other members than their own internal members. Subgroup 3 gets the isolated position, even if it contacts with subgroup 8. it contact with the outside world is very little. Subgroup 6 and 8 get the leading position, which not only receive but also send information. Members in these networks get close relationship with others and the two groups get the highest density.

In addition, from the former measure results of the two subgroups, we can see spdf, SpiritRain, MPC are the core characters in the network which participate more overlap factions in the network. So, there are network opinion leaders in these two groups which are the small groups with high cohesion.

According to block matrix model, we get the following results of advice-5:

Subgroup 1, 4 and 7 get the flattery position which receive less external information. Subgroup 2 and 6 get the leading position which get many core members of the network according to the centrality measuring results. The subgroup densities were 0.667 and 1, which were higher than the overall network density 0.2157. So, the relationship of the network is much closer. The opinion leaders may exist in these subgroups which play the important role in the knowledge transfer behavior. Subgroup 3 and 5 get the isolated position, which almost don't contact with external environment except for the occasional receives from other subgroups of information outside. Subgroup 8 gets the agent position which not only gets but also sends information. There are almost no connections in the internal network.

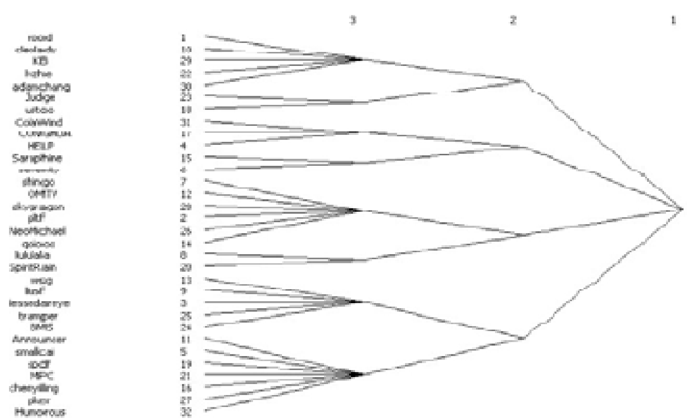

Figure 6 : Subgroup distribution of advice-4 (Release the point)

Density Matrix

	1	2	3	4	5	6	7	8
1	0.000	0.000	0.000	0.500	0.000	0.000	0.000	0.029
2	0.000	0.000	0.000	0.750	0.000	0.000	0.000	0.071
3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.048
4	0.500	0.750	0.000	0.000	0.000	0.000	0.000	0.071
5	0.000	0.000	0.000	0.000	0.000	0.667	0.100	0.000
6	0.000	0.000	0.000	0.000	0.667	1.000	0.100	0.357
7	0.000	0.000	0.000	0.000	0.100	0.100	0.000	0.114
8	0.029	0.071	0.048	0.071	0.000	0.357	0.114	0.524

R-squared = 0.382

Figure 7 : Subgroups density matrix of advice-4 (Release the point)

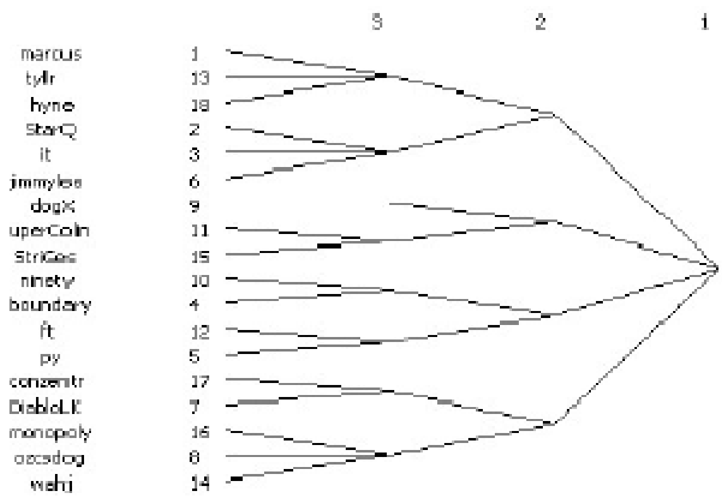

Figure 8 : Subgroup distribution of advice-5

Density Matrix

	1	2	3	4	5	6	7	8
1	0.000	0.667	0.000	0.000	0.000	0.000	0.000	0.000
2	0.667	0.667	0.000	0.500	0.000	0.667	0.167	0.111
3	0.000	0.000		0.000	0.000	0.000	0.500	0.000
4	0.000	0.500	0.000	0.000	0.250	0.250	0.250	0.000
5	0.000	0.000	0.000	0.250	0.000	0.000	0.000	0.333
6	0.000	0.667	0.000	0.250	0.000	1.000	0.500	1.000
7	0.000	0.167	0.500	0.250	0.000	0.500	0.000	0.000
8	0.000	0.111	0.000	0.000	0.333	1.000	0.000	0.333

R-squared = 0.499

Figure 9 : Subgroups density matrix of advice-5

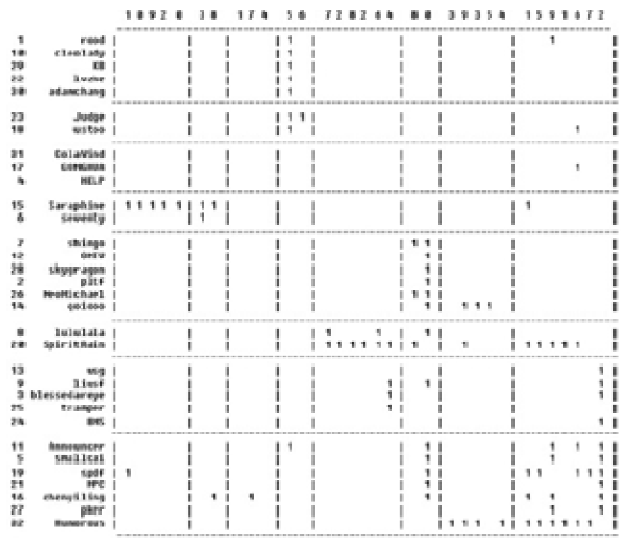

Figure 10 : Block matrix of advice-4 (Release the isolated node)

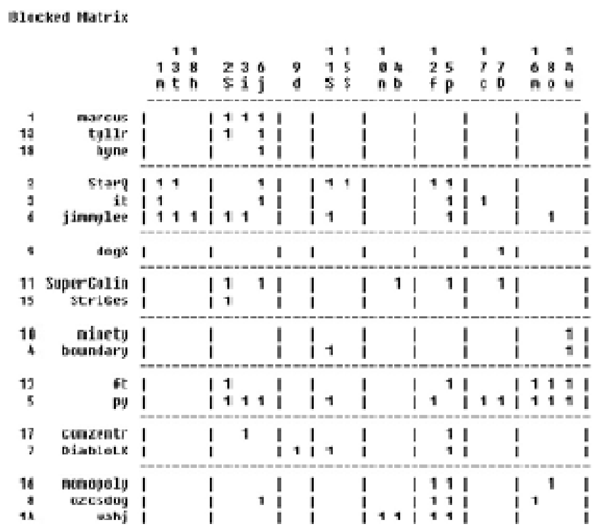

Figure 11 : Block matrix of advice-5 (Release the isolated node)

	1	2	3	4	5	6	7	8
1	0	0	0	1	0	0	0	0
2	0	0	0	1	0	0	0	0
3	0	0	0	0	0	0	0	0
4	1	1	0	0	0	0	0	0
5	0	0	0	0	0	1	1	0
6	0	0	0	0	1	1	1	1
7	0	0	0	0	1	1	0	1
8	0	0	0	0	0	1	1	1

Figure 12 : Cohesive subgroups matrix of advice-4 (Release the node)

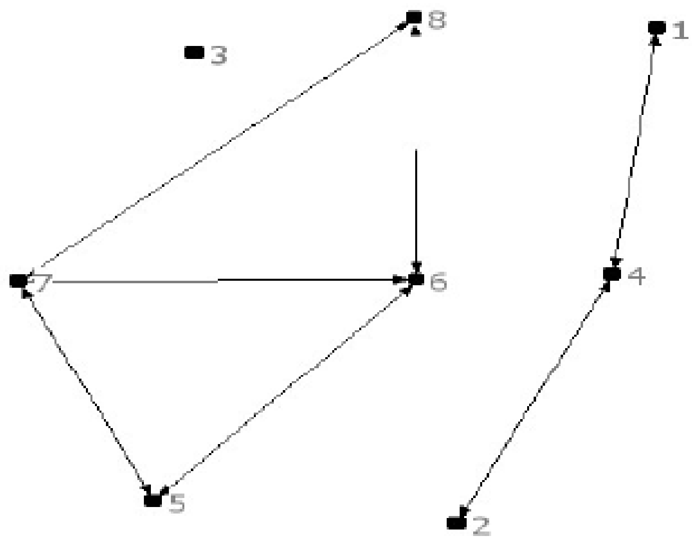

Figure 13 : Simplified subgroup graph of advice-4 (Release the node)

Image matrix analysis

According to a- density image method, we can get the image matrix. The whole network density of advice-4 is 0.0985. So we can release the node and turn the subgroup density matrix into image matrix.

	1	2	3	4	5	6	7	8
1	0	1	0	0	0	0	0	0
2	1	1	0	1	0	1	0	0
3	0	0	0	0	0	0	1	0
4	0	1	0	0	1	1	1	0
5	0	0	0	1	0	0	0	0
6	0	1	0	1	0	1	1	1
7	0	0	1	1	0	1	0	0
8	0	0	0	0	1	1	0	1

Figure 14 : Cohesive subgroups matrix of advice-5

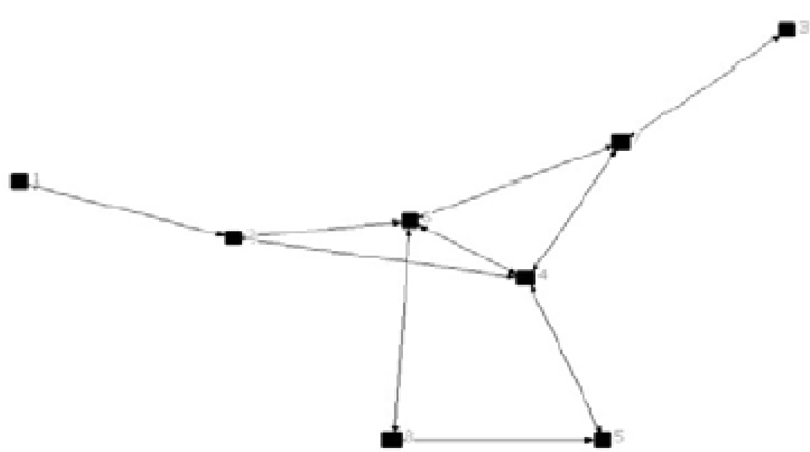

Figure 15 : Simplified subgroup graph of advice-5

If the value in density matrix is bigger than the network's density, we can replace it by 1. Otherwise replace it by 0. So, we can get imagine matrix Figure 12, and draw it as the simplified subgroup graph Figure 13. The density of advice-5 is 0.2157. Using the same method, we can get the imagine matrix (Figure 14) and the subgroup graph (Figure 15).

In advice-4, subgroup 7 and 6 get the bridge positions which connect subgroup 5 and 8. The analysis result is consistent with the the block model analysis result. In group 6, there are much more connections. So, subgroup 7gets the broker position and subgroup 6 gets the first position. In advice-5, subgroup 4 takes the broker role between subgroup 2, 5 and 7. Subgroup 6 takes the broker role between subgroup 2, 7 and 8. At the same time, there are much more links in the subgroup 6, so the subgroup 6 gets the occupy position. From the above analysis, we can see the network nodes' position occupied in the overall network structure is very import, as well as the affiliation relationship between the subgroups.

In view of the different network communication condition, we can get the different network communication strategies. Take advice-5 for example, through in the block model analysis, we get isolated node dogx. If we release the isolated node, we cannot make the remaining work nodes effectively. So, we need to activate and use effective, in order to maintain the whole network cohesion purposes.

CONCLUSIONS

Through the analysis of actual data, we identified the network structure and node transmission status in the online knowledge transfer network, and derived the online knowledge transfer online communication network. The study found that the structure of network and network communication status are important to promote network communication. If we want to promote the network transmission efficiency, we should put much more attention to the identify the nodes state, activation of specific nodes and the effective protection of such nodes

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