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Analysis of topology and propagation characteristics based on high close network

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ABSTRACT

Social network research is an important aspect of the complex systems science. In this paper, network of relationships with students on campus is introduced as the research object, through empirical research, data processing, a relationship based on empirical data matrix is established, and the build students' network model is built, network topology characteristics is analyzed. Finally, the experiments prove that the proposed model construction algorithms and methods are feasible.

Keywords: Social network, Topological characteristic, Network characteristic, Distribution

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INTRODUCTION

Social network refers to the relationship collection formed by the actors in the society. A social network is composed of multiple nodes (representing the social actors) and collection composed of the directed or undirected attachment between each node (representing the relationship between actors) [1]. Interaction between individual members forms a relatively stable relationship of system, social network focus on the interaction between people and the contact, so social interaction will influence people's social behavior, and this interaction include friends, school mates, business partner, racial beliefs and so on. Social network analysis has many unique aspects compared with traditional social analysis method, but the most unique one is its research perspective. It focus on research of the formation mechanism of the social structure and presented some social phenomenon from the perspective of social relations. The social structure also shows its diversity, economic or political structure, maybe behavior structure [2].

Social network concluded that interaction between actors can't be independent. Interaction between research should be considered before social network take "relationship" as the unit[3], and structure viewed as relationship architecture between the actors change the rule and the internal structure mechanism based on relational data analysis of the social network structure (rather than the traditional social attribute data), and it is in turn mining analysis relationship analysis between the essence of the social phenomenon[4]。

Campus network is a special social relation network for its mass, reliable empirical data acquisition. Studying the relationship between campus students network can effectively explained some universal phenomena of the social network , dig deeper into the campus students with the mathematical relationship between the social network at the same time, and extended to various types of small group, for example, make quantitative analysis, implemental measures and evaluation on issues such as learning attitude influence each other in the education of primary and middle school students of the same class, fighting actively around all kinds of inner enterprise or other organizations, spread positive energy and so on .

NETWORK BASIC CONCEPT

Network[5]

Based on graph theory, a network G can be expressed as a simple compose of nodes and edges, denoted as $G=(\mathrm{V(G)},\mathrm{E(G)})$, $V(G)$ and $E(G)$ are the point set of network and the edge set respectively. An edge used to connect the node *i* and *j*($i, j \in \mathrm{V(G)}$)can be called (i,j) or (j,i). Given N nodes of network G，it can be only expressed as a adjacency matrix A[6]： $A=(a_{ij})_{N\times N}$， where

$$a_{\mathrm{ij}}=\begin{cases}1 & \text{Edge between node } i \text{ and } j\\ 0 & \text{No edge between node } i \text{ and } j\end{cases}$$

Path [7]

Given a network G, If two non-adjacent nodes can be connected from node *i* to node *j* through a sequence containing *m* edges ($(i,s_1),(s_1,s_2),\cdots,(s_{m-1},j)\in \mathrm{E(G)}$), *m* edges are not repeated and the corresponding nodes also dose not repeated, then the set of *m* edges is called as a path between *i* and *j*, *m* is the length of the path. The set of edges is a path between *i* and *j*, where *n* is the length of path. In general, there are many paths between *i* and *j*. The shortest length of path is called as the shortest path. The length is called as the distance, and it is denoted as d_{ij}. For directed network, there is a path of length *n* between *i* and *j* if the *n* edges in the sequence $((i,s_1),(s_1,s_2),\cdots,(s_{m-1},j)\in \mathrm{E(G)})$ of each edge have the same direction for directed network. There is a path of length *n* between *i* and *j* if there are different direction of edges. The length of path is the sum of *n* edge weights.

Average path length [7]

As defined above, for an undirected and unweighted network, the distance between *i* and *j* in network is defined as the shortest path edges connecting two nodes. Thus it extends a definition of describing the average path length of overall properties of network, the average distance between any two nodes in the network is the average path length of the network, which can be expressed as :

$$L=\frac{1}{\frac{1}{2}N(N+1)}\sum_{i\geq j}d_{ij} \qquad (1)$$

Where N is the number of network nodes.

Degree and degree distribution

The degree k_i of node *i* is the number of edges connecting directly to node *i*. The average degree of all nodes is called the average degree of network, denoted as k_i. Degree of a node is divided into out-degree and in-degree in directed network. The out-degree of a node means the number of edges from the node pointing to other nodes connecting with the node, while the in-degree of a node means the number of edges pointing to the node connecting with other nodes. Distribution of nodes in the network represents a distribution function, showing the probability of selecting an arbitrary node of degree *k*, that is the number of nodes of degree *k* in the network accounts for the proportion of the total number of network nodes.

Degree Centrality[8]

Degree centrality is the definition of centricity in the basis of degree, considering the centrality of nodes is expressed by the degree of nodes. The expression of degree centrality is:

$$DC_i=\sum_{j\in\Gamma(i)}A_{ij} \qquad (2)$$

Degree centrality indicates the intensity of the node directly connecting with other nodes in the network. The greater intensity, the stronger importance it is. It is often used to simply measure the most important central figure of organization. People's position with highly centrality should be important in the organization.

Comparison of Network Topology Feature

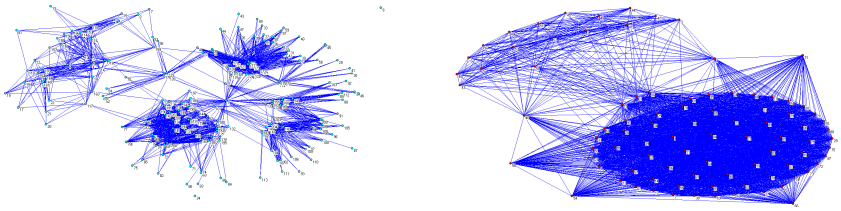
The indexes of network properties reveal network topology characteristic from different angles, the same node may show the diversity characteristics in the network, the characteristic nature of the network nodes can be exactly depicted by this diversity, The comparison of five concepts about network topology characteristic as following table1.

Table 1: The comparison of topological characteristics

No.	Property	Implication	Comparison and expansion
1	Degree	Edges numbers used to connected directly with other nodes	Reflects the relationship between the network node and others. Nodes with high degree for network influence the connectivity and traversal step number, but also to consider the position of the node in the network
2	Clustering coefficient	The existence probability of connection between the two connection nodes in the network	Large clustering coefficient of node means compact connection groups in the network with the node as the center
3	K-core	Reflects the nodes position in a closely connected group	The greater k, the network has the very close group
4	Betweenness centrality	The proportion of the shortest path to a node in the all path	Reflects the key position of the nodes in the network. The greater betweenness centrality illustrate that the node has the shortest path, and the more important.
5	Closeness centrality	The reciprocal of the average distance of a node to the other	The bigger the centricity illustrate that node to other nodes in the network distance is smaller. The close to the central node has small traversal steps

ANALYZE NETWORK CHARACTERISTIC

The relation network of 91 students can be constructed based on relation matrix as shown in Fig.1. Fig.1 (a) is a two-dimensional network diagram including course and student. Fig.1 (b) is only a one-dimensional network diagram of student, which reflects a phenomenon that classmate relationships are established between students because of selecting the same course.



(*a*) two-dimensional network diagram (*b*) one-dimensional network diagram

Fig.1: Network diagram of 91 students

According to the definition of network, characteristic value related to network is calculated, where the average path length is 1.30354, diameter is 2 (node 1-node 90). Since this research network has close relationship that can be obtained a single value of topological characteristic cannot be comprehensively reflect the importance of a certain node in the network. Therefore it needs to comprehensively analyze degree, clustering coefficient, K core, betweenness centrality and closeness centrality. Comparison results are shown in Fig.2 below by calculating degree, clustering coefficient, Kernel, betweenness centrality and closeness centrality of student network.

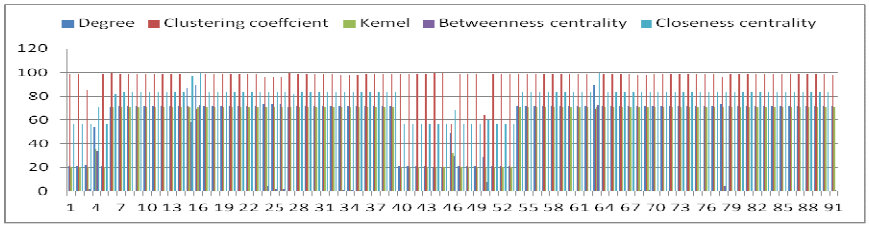


Fig.2: comprehensive comparison bar chart of topological property

Histogram fully reflects the correlation of characteristic values. As observed in histogram 4, topology characteristic values of network of 15th, 16th and 63th node in students have the big fluctuation change. There is also an obvious fluctuation of topology characteristic values in 4th, 6th and 50th. The degree, K core, betweenness centrality and closeness centrality of these nodes are bigger than other nodes, while clustering coefficient is obviously smaller than other nodes. The values illustrate that their existence has a great impact on network obviously smaller than other nodes. The values illustrate that their existence has a great impact on network connectivity and traversal times. The phenomenon that clustering coefficient is smaller illustrates the fact that node 15, 16, 63 is the three classmates with

same professional collecting data. They have elective relationship with several college students, while other college students do not necessarily exist this relationship.

ANALYSIS OF KEY NODE

According to the analysis of network characteristics, three key nodes are 15, 16 and 63. The topology characteristic values are shown in Fig.3 below after removing the three key nodes.:

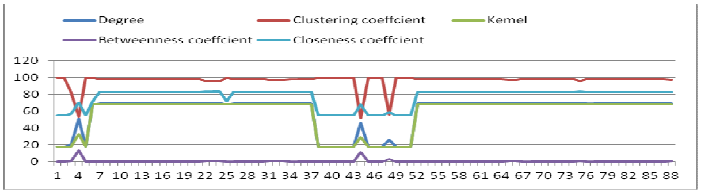


Fig.3: The change of the network topology value after removing the key nodes

Fig.3 shows clustering coefficient of some nodes present a reverse relationship with other nodes; that is other characteristic values are obviously larger than other nodes when clustering coefficient is smaller. The reason is that student elective network contains four college students. The student elective network is formed based on course selection between them so that it is very important for those students choosing course of other college, which have a direct impact on the close connection of network. The nodes of betweenness centrality and closeness centrality are larger than other node. However, those students belonging to different college having connection with most of nodes in the network may not have connection, which results in lower clustering coefficient of nodes corresponding to the students, presenting a reverse relationship of "your little older than me, you big ego" between closeness centrality and betweenness centrality.

SIMULATION ANALYSIS

The threshold is set to 0.6 after removing key node of 15, 16 and 63. The average is obtained by transmitting 100 times each node. The comparison of spread frequency between complete network and network of removing node is shown as Fig.4.

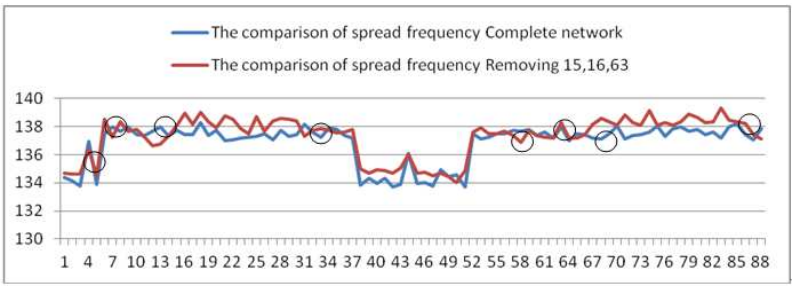


Fig.4: Transmission Comparison between complete network and removing node number network

As observed in figure 9, traversal steps of removing node network are bigger than complete network, but the difference is not too much. The reason is that network itself is more intensive. Though network removes three key nodes, impact of its transmission is not great. Traversal steps of removing node network also reflect an important characteristic of dense network. Instead traversal steps in complete network for some node are smaller in the circle of the figure. The reason why this phenomenon appears is the use of random number. In a word, these features provide us a way to study all sorts of small social groups in depth, play a positive role of the organization and avoid the spread of negative emotion and behaviour.

CONCLUSION

Taking students as the object of empirical study, this paper establishes the network channels based on students' understanding of course, through the design algorithm of data processing, automatic processing of empirical data research, get matrix extraction algorithm from design relationship, finally have 91 students relationship matrix. Based on relationship matrix generation network diagram, obtain the corresponding network topology characteristic, and launched a topology characteristic comparison and the analysis of propagation characteristics in view of the high close relation of network. The conclusions are as following:

(1) Network topology characteristics cannot fully reflect the importance of nodes, in the analysis. It requires comprehensive network topology characteristics to determine the status of nodes;
(2) The key node contributing to the spread of the network nodes reflect less Closed with high degrees of the network, obvious change needs to be removed a few key node transmission at the same time;
(3) Data processing to studying results is as important as social network researching data. The data processing in this paper proved to be feasible based on interactive algorithm framework of multiple system.

Transmission Characteristics is as important as topology characteristics in social network research. The next step is focused on deep analysis of transmission efficiency, and obtains the mathematical relationship between the transmission efficiency and network topology characteristics.

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