OVERVIEW ON THE STRUCTURE AND INFORMATION DIFFUSION OF THE ONLINE SOCIAL NETWORKS

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ABSTRACT

With the rapid and widespread popularity of the WEB2.0, there are various forms of online social network with interactive features based on WEB2.0 are generating, such as Facebook, renren.com, microblog, Wikipedia, etc.. Online social network can provide people a platform unrestricted in geographical, time, resources, and position, this make it easier for people to comunicate with each other in various fields, and online social networks also have important influence on realistic society. The research on network structure and information diffusion of the online social networks is hotspot. Network structure contain the key person or ID mining ,the recommendation based on the relations. Through analysing the network structure of the nodes and key node in online social network researchers can grasp the relationship of the nodes, and that is an important mean to know the public opinions, decide network advertising strategy, find critical or important person. The study of the online social network information diffusion focus on dynamics modeling of diffusion, searching information source and portraying information diffusion path, maximizing and minimizing the information dissemination, and so on; through studying information dissemination on the online social network, people can forecast and intervention the effect of the information diffusion, which can guide information dissemination in the favorable direction. This paper reviews the network structure and information dissemination of online social network, and the two aspects of the major research methods are compared and analyzed.

Keywords: *Online Social Networks, Network Structure, Information Difussion*

1. INTRODUCTION

With the development of the computer and WEB2.0, people's interact has undergone a tremendous change compared with the traditional form of communication. In the traditional society, Information interaction is restrained by geography, time, status, and other factors while online social networks available to people only need to rely on computer and network to carry out unlimited interactive virtual social platform. Now it has become the means of widespread interpersonal communication, for example: FaceBook, Wikipedia, Renren network, QQ, etc. Through the social networks, people can share information, explore the topics of collaborative editing, chat and so on, covering the areas of politics, military, economics, culture and others. Although online social network is a virtual one, it has the tremendous force on politics and economics in the real world, which is shown in the cases of interaction of network public opinion and proper delivery of online advertising with less input but rapid product sales. Study online social network is of great significance for safeguarding the country's political stability and economic and cultural development.

Social networks (SN) refers to a network of relationships between individuals in society because of some form of contact, which consists of a collection by the individuals within the network. In the network, the individuals may be a reality one as well as a virtual one, such as individuals, groups or Web network ID number; the relationship between the individuals can also be real or abstract, such as relatives or friends in the Network. Based on the characteristics of the social network, researchers generally use the Figure as a tool to model the social network, the nodes in the graph to represent the figure of the individual in the social network and the edge to represent the relationship of the individual in the social network.

Online social network is the virtual community network based on the Internet technology. Online social network structure is determined by Web nodes and the relationships between the nodes all together. Node is formed by the Web registered user

or ID and the relations between the nodes are generally existing in the form of Web links.

2. OVERVIEW OF THE RESEARCH OF THE SOCIAL NETWORK STRUCTURE

Network focused on the excavation of key nodes. By analyzing the network structure, people can understand the social network node relationship. The research on the network structure is the analysis and prediction of network public opinions, making network advertisement strategy and excavating important means.

Online social networks have their own network structure, whose structure is composed of the relationship between the nodes and the evolution of relations. Common social networks are online social networks, online communities, online media network, real-time communication network, online encyclopedia network, etc. Their corresponding networks are Facebook, blog of web of science, video sharing website YouTube, QQ and Wikipedia. The relationship of the social networks and the nodes in the real-time communication network is not directed while the relationships between the network nodes of online communities, online media and online encyclopedia are directed. It is common that the graph is employed to describe the social network. We define the graph as $G=<V,E,L,W>$, in which V represents the nodes set in the network; E is the relations between the nodes set, namely the network side; L is used to mark the node attributes collection; W is to mark the set of node relation attributes. This section will elaborate the network structure from two aspects of social network node and the relationship structure.

2.1. The Research Of The Nodes Of Network Structure

Node is a social network entity element. It is the information producer in online social network, the information transmission in the network and the information consumer of network. The node is also the bridge between the online social network and social network and connects the interactions between the virtue network and the real network. The node's research mainly concentrates on the node discovery, evaluation and application, including the node ranking, key node discovery and application.

2.1. 1.Study on the node ranking

Node ranking is widely used, for example in a social network, through the node ranking, we put the

advertising to the top influencial node and will obtain better advertising effects at lower cost.

To rank the node, the first step is to model the network in graph. The node ordering is mainly directed against an application scene, establish the center node to fit the scene through the center of node scheduling. Node centrality can be seen as the distance between the node and other nodes and with the specified attribute node number bigger, the node's centrality degree is bigger. Centrality can portray degrees of importance of a node. The shorter the distances from the node to the others, the more important it will be in the social network. In 1977 Freeman proposed betweenness centrality to measure centrality [1]. Betweenness reflects the times when a node was passed through as the shortest path to communicate, that is, Betweenness Centrality can reflect the average distance from one node to the other. And the higher Betweenness Centrality will show the node appeared frequently in the shortest path, thus more likely to be employed by other nodes communication, so the node is more important and with high Centrality. In 1978 Freeman summarized his prior research of social network node centrality and put forward two measures of node centrality index Closeness Centralityand the degree of centrality , Degree centrality indicates the number of edges in the graph: in indirected graph, degree is used to show the frequency of contact the node; in the directed graph, in-degree indicates the numbers of nodes ,which actively contact he node.

Closeness Centrality can be seen as the average distance from the certain node to the other nodes, more higher Closeness Centrality, more shorter distance from the node to the others and more tense with more higher centrality. The two thesises provide the calculating methods of the three indexes [2]. Wasserman used Degree Centrality to evaluate the numbers of nodes to communicate directly with the other nodes, with the numbers more larger and the Degree Centrality of the nodes more higher indicating its more powerful influences [3]. Table-1 show the comparision of the above-mentioned measurement of centrality indexes.

Table 1:Measure Of Centrality Indexes Comparison

measure of centrality index	advantage	defect	application area
Betweenness Centrality	Mesure node intermediary role	Mesure node itself insufficient	Search bridging node
Closeness Centrality	Mesure average communi--cation distancenode of a node with others in networks	Not care the relation between the nodes	Search the nodes that communi--cate with other less costly
Degree Centrality	Describe the popular of a node in networks	Care the node itself insufficient	Search the key nodes

According to the node centrality and its measure index, in 1998 Page and the others proposed the famous PageRank algorithm, which is used for web page nodes in order of importance, and successfully applied to create the Google search engine [4]-[5]. The famous PageRank algorithm mainly employs Markov random walk model. In order to make the webpage corresponding with random walk model, particles forward in the model, direct link structure of the webpage with jump probability of this webpage was successfully converted to particles forwardprobability. Because of the different webpage nodes with different center degree and influence, the webpage nodes in a Markov random walk model may obtain different click probability. In general, the main idea of the PageRank is to rank the page nodes according to their click probability. Besides PageRank algorithm, HITS algorithm is also to rank the nodes. But their differences are the latter is to seek key nodes。The main idea of HITS algorithm is to set hubness and authority attribute for webpage nodes: if the authority is better, then the hubness between the nodes will be better.Through transferring between the nodes, interatively change the values for hubness and authority and rank the nodes according to the values [6]. The two algorithms are ranking the nodes in accordance with the linking structure of the nodes, without stressing more associated information of the node. The variants of PageRank algorithm mainly improved in the node-related information, for example, in accordance with the topic, the nodes are sorted [7]-

[12]. HITS algorithm variants is also improving itself by adding attributes to the node [13]-[14].

Node ranking algorithms and ranking algorithm has been researched adequately and applied widely. These algorithms mainly rely on node centrality and network structure to rank the nodes. It is rare to see those research of node ranking concerned with the data information. However, the related research is of great importance to the prediction and analysis of public opinion ,because some information itself has a strong communication ability.Semi-Supervised PageRank algorithm proposed by Bin Gao is using Markov random walk model to excavate the node according to the multidimensional attributes [15]. RoleSim method proposed by RuoMing Jin and others is used to rank the similar nodes [16].

PageRank algorithm and HITS algorithm are very effective for node ranking according to a single attribute of the nodes in the network, but the application of the current node ranking need to be according to node multidimensional attributes; therefore, the joint ranking according to multidimensional attributes in recent years will be the future hotspot research of network node ranking.

Traditional online social network is homogeneous networks, namely the nodes in the network with the same meaning, such as node all indicating people or thing. In recent years, heterogeneous network appeared different with homogeneous networks and develops very quickly. In the heterogeneous network, nodes can be of different classification, for example some node indicating people while others thing. there are big difference between Heterogeneous network node ranking and homogeneous one. This is because the attribute between the nodes is not comparable, therefore, along with the wide application of heterogeneous network, the node ranking research will gradually get attention.

2.1. 1.Research on the key node

It is of significant importance to social politics and economy to discover Key node and annotate it. For example, after the study has identified the key points in the network, we put the information on these points and will make the rapid dissemination of information. The key nodes have the maximized effects in the transmission of information, thought and influence, but it is a NP problem [17], the optimization problem, to find a k most influential critical nodes in social network.So the excavating of the key nodes are generally using a specific method to find or label nodes in the specific domain. Freeman used node centrality to mine the key node

[2], which is the more common method, node ranking methods such as [4]-[14], PageRank algorithm and HITS algorithm and the two algorithms can also be used for excavating key nodes. Table-2 show the comparision of the PageRank algorithm and HITS algorithm.

Table 2:mining the key nodes ways comparison

algorithm	Algorithm idea	Advantage and defect	application area
PageRank algorithms	According to the different degrees of different nodes, get the transition probability of the node by the Markov model ,then mining key nodes according to the transition probability	Care the nodes have high degree centrality, but the lows can not find	The nodes have high degree centrality can find quickly
HITS algorithms	Set hubness and authority for every node,and then compute the relationship by the two attribute of the nodes	Care the nodes have high hubness and authority , but not care the centrality	Search the nodes that have high quality quickly

The application of Key node is also a research hotspot in recent years, for example, the search of the key group or people in the society according to the application of key node mining [18]. In 2001 Domingos and Richardson studied on how to expand the influence of the products in the market and put forward the perspective of taking the market as a social network, using nonlinear probability model to determine the node transmission power, and labeling those nodes as key nodes. They think that some node in a social network has strong communication ability and model the market with the final Markov random field [19].

In 2002, on the basis of the market in 2001, they modeled the market and further used the linear probability model to decide the node transmission power, to reduce the computational cost of the judgement of node transmission power [20]. They carried out pioneering exploration in the research of online social networks to maximize information dissemination. Later at the ACM KDD conference, such related research in this area constantly improved [21]-[22], wherein the mining of k-effectors active node problemwas firstly proposed by Lappas, maximizing the information in the network through the active node while at the same time proving it is a NP problem to find the most active K node, and no approximation algorithms available. Then they put forward dynamic algorithm an improved dynamic programming algorithm to find the active node [21], but the question proposed by chen and others is how to make the information in online social networks influence maximize, then they proposed the use of greedy algorithm to find the key node and maximize the extended information through the key nodes as much as possible and proved the algorithm was validated [22].

Similar with node ranking, the key nodes are more common in the mining research of a homogeneous network, but for the mining requires of the heterogeneous network , the researchers need to pay more attention .

3. THE RESEARCH OF COMMUNITY RELATIONS STRUCTURE

For an online social network, The links between the nodes, message flow and the familiar possibility can be relationship structure. Relations in the diagram are shown as the edge. If the relationship between the nodes exists, the graph edges related with the edge map is a determined side; if the relationship between the nodes only exists with a certain probability, the the graph edges corresponding with its relation is an uncertain boundary.

Associations between structural aspects of the research is mainly focused on the community segmentation and mining. The studies of mass segmentation and mining began in the early stage and these studies were based on graph structure in which graph partitioning for complete subgraph is a complete NP problem and has already been proved [23], but still many researchers put forward some exploratory algorithm for graph partitioning and community division to solve the problem, for example, an earlier Kernighan and Lin who proposed the heuristic algorithm, which is used to map segmentation, thus making the communication

between the segmentation graph is less, while the node communication in the sub-graph is more frequent. This algorithm can provide the theory basis for the parallel processing mechanism and is mainly divided into two stages, first using the aggregation method to split and generate subgraphs to use edge cost reduction principle to readjust the sub-graphs [24].Later Newman proposed to employ betweenness centrality for mass segmentation and mining, which first used to map division, then recalculated edge weight with Betweenness Centrality and in the end adjust the subgraph [25] Kumer and the others researched the structures of online social network and its evolution, and for the first time put forward the evaluation method of structure and evolution force [26]. In recent years the study is more targeted, for example, to research how to search for community in the dynamic and large-scale social network [27]. Some of the recent researches focus on certain aspects of the effects of the community attributes on social network structure [28] and the functions of the societies in the online social network information dissemination or safety role [29]-[31].

Community structure functions the role of enlarging and reducing the information transmission, so studying of the community structure can control or guide the dissemination of information. The community structure of heterogeneous network, online social networks, and the mutual mapping of the real social network structure should be concerned.

4. SUMMARY OF INFORMATION DIFFUSION RESEARCH

It is of significant importance to research information dissemination in today. For example: the influences of rumours transmission in the network on the stability of the society, dissemination of the breaking news, the influence of advertisement on the product sales, literature transmission on book sales, collaborative editing of encyclopedic problems [32]-[34]. Although the spread of information on social networks will produce various forms of questions, overall the present study is mainly concerned with how to make the information in online social networks to maximize and minimize the transmission [35]. Although the form of information dissemination varies, the information communication model, communication drive force and mode of transmission on social networks is very similar.

Information transmission in the online social network is a complex network transmission case, and propagation model and transmission dynamics

in complex networks in this field has been a long history and produced a lot of research results. Early in the 1927 Kermark presented SIR model, which is used to study the epidemic transmission mode. Wherein S represents a vulnerable state, I infection status, R removed state. The model was used for the study of infectious disease, and later this model is applied more and more extensively, even for information propagation in networks. For information on the online social networks in the propagation process, I indicates node already in the information state; S shows the state where node is not getting the information, but it will easily get the information from other I state node; R indicates I node no longer diffuse information to other nodes. The situation of a node can be S->I->S or S->I->R, which can well explain the computer virus propagation in networks.However, with the constant change of the forms of information, social network development makes the network node heterogeneity, which makes the information in different nodes perform in different meanings and forms in transmission, so SIS or SIR models can no longer explain well new information dissemination; therefore, in recent years many scholars study the propagation characteristics of the information in online social network, model, network structure and characteristics.

The transmission of information in the online social network has a very close relationship with online social network features. In 1999 Faloutsos M,etc. has found that Internet has a power-law distribution characteristics through the study of Internet [36]. In recent years researchers researched the famous Facebook, MySpace, YouTube and Flickr online social network and proved that online social networks possess the properties of power-law distribution, aggregation, small world [37]-[39].At the same time, researchers have proposed the information dissemination of online social network and the epidemic spreading in the real world share the same mode [39].

i)In recent years, the research of the information dissemination in the online social network mainly focused on information propagation path network and source derivation; the characteristics of network information transmission in heterogeneous society, the transmission cycle, the discovery and prediction of topic conversion; maximization and minimization of the effects of the information in online social network.

Derive information sources through the research of the information dissemination process in online social networks and describe the information

transmission network structure [40]-[43], in which Adar and Adamci earlier researched the drawing method of the links, through which, dissemination of information passed through [40]; Leskovec,etc. studied the information propagation path and its hierarchical structure [41]-[42]; Gomez_Rodriguez,etc. worked out a highly efficient algorithm NETINF to detect information communication path layer network structure, and derive the information source [43].

ii)It is significant for social and political stability and economic development to track down the topics and ideas of online social networks. Jure Leskovec and others divided the online social network topics into the mainstream media and blogs and made a quantitative research of the probability of topics in different media (for example, news media, blogs) and the transmission time of topics in different medium, which shows, through a large amount of data, that most of the topics are from the mainstream with the average transmission time of only about 2.5 hours; only a few topics from a blog, and from the blog to the mainstream media [44].

iii)In recent time, David Kempe,etc. studied the maximum impact of the information in online social networks [45]; Ceren Budak and others researched the minimization of the effects[46]. The two study groups all agreed that information influence is diffused by a number of highly influential node.The maximum is to influence the higher node dissemination of information while to minimize to limit higher node for the dissemination of information, but the optimal search for influential K node is a NP problem [45]-[46]. David Kempe proposed the natural greedy algorithm based on hill climbing strategy with the forthcoming Domingos and Richardson introducing the linear threshold information dissemination model and independent cascade information dissemination model [47]-[48], which is the influential node algorithm to find the optimum K [45]. Ceren Budak,etc. Proposed forecast hill climbing algorithm to predict and label the online social network node state, and use hill climbing algorithm to find out the highly influential nodes. The experiment proved their method has higher efficiency and more accurate identification ability [46].

At present, information dissemination research mainly concentrates on the transmission power, transmission model and information expansion and limitation. The researchers have studied the information source and information communication path, but overall it is still insufficient. The Information will change in the spreading process as well as expanding or minimizing. The researches of information change, the position where broadening or narrowing happens, its path and the forecasting of the changing trend are inadequate and will be attach great importance.

5. CONCLUSION

The online social network is an important platform for information diffusion and interpersonal communication. Different topics can be exchanged and ideas and viewpoints can be shared among different groups of people in different regions in the online social network, which makes the people's points about political and economic can spread quickly. It is very important for the social stability and commodity promotion, etc..

The current research on the network structure and the information diffusion of the online social networks is mainly focused on nodes ranking, the key nodes mining and its dynamics and influence of the information diffusionin in the homogeneous networks.

Research on network structure in a heterogeneous network still more inadequate, and the solution to the problem in the homogeneous network inability to use in a heterogeneous network. Therefore,more research on the network structure in the heterogeneity online social network are needed in the future , mainly include the following content.

Nodes in the heterogeneous networks represent different species, and the property of different species is incomparable. So, further study on heterogeneous network is needed, including:

i)nodes ranking in heterogeneous network.

ii)standard of the key nodes and the mining method for that in heterogeneous network.Define and the mining method of the communities in heterogeneous network

iii)And we should pay attention to the studying of the information diffusion as the following:

Mutual influence between the online social network and the real society, then the model and assessment of the influence.

Finding the source nodes at which information content changed, or information expanded and reduced, or the path of information diffusion and forecasting diffusion trend.

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