Personal Influence on the Spreading of Information: A Network Based Study

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Abstract - *Understanding the ability of nodes in spreading information in complex networks is an important area of research in the study of social network. Usually, a node with higher number of connections and greater interaction weights becomes more important in a network. But, the spreading ability of a node not only depends on degree of the node and weights of its interactions but also on the interest of the person who handle the information. In this paper we propose a new method to determine the nodes importance giving emphasis the mood or interest of the spreaders.*

Keywords — *Complex networks, Influential nodes, m-Ranking, Personal variations in spreading.*

I. Introduction

For the last several years, there has been intense research activity in studying the system of complex systems. Complex systems in various fields can be modeled as complex networks of interacting elements and their interactions. Such networks are modeled using graphs in which nodes denote interacting elements and their interactions denote links. These types of modeling are used in Social, Economical, Psychological, Financial and Biological systems. If we want to study a network, we should know its topology. A specific area of interest in the study of social network is the analysis of spreading of information. In this process the nodes play an important role and the degree of its ability to spread information is calculated in terms of the number of connections each node has to its neighbors. Various studies have been conducted to rank the nodes according to their importance in the dynamics of information spreading system. After finding these influential nodes, we can design methods either for boosting spreading of valuable information or to hinder propagation of negative information. For finding important nodes in unweighted networks various centrality measures such as Degree, Closeness, Betweenness, k-shell, Neighborhood Coreness, Extended Neighborhood Coreness etc. are being widely used. These measures are proved to be effective only in certain context. In 1978, Freeman[2] proposed the Degree, Closeness and Betweenness centralities.

In 2010, Kitsak et. al. put forward a fast node ranking method called k-shell (k- core) decomposition[4, 5, 6] for large networks. This method assigns an index k_s to each node, that is representative of the location of the node in the network, according to its importance. Nodes with high values of the k_s are located in the center or core of the network and nodes with low values of k_s lies in the periphery of the network. This way, the network is described by a layered structure, giving the hierarchy of its nodes.

In 2013 k-shell decomposition method was improved by An Zeng et. al. by proposing a new method named Mixed Degree Decomposition[1]. In 2014, Joonhyun et. al. proposed two methods, namely Neighborhood Coreness(C_{nc}) [3] and extended neighborhood coreness(C_{nc+}) [3]. The basic idea of neighborhood coreness is that a spreader node with more connections to nodes located in the core of the network is more powerful.

Closeness centrality of a node i is defined as the inverse of sum of all geodesic distance multiplied by $(n-1)$. This can be expressed as $CC(i)=\dfrac{1}{(n-1)\sum_{i\neq j} d_{ij}}$, where d_{ij} is the geodesic distance between nodes i and j and n is the total number of nodes in the network. Clearly, the larger the closeness is, the more central the node is.

The betweenness centrality of a node I is defined as $BC(i) = \sum_{i \neq s, i \neq t, s \neq t} \frac{g_{st}^{i}}{g_{st}}$, where g_{st} is the number of geodesic paths between nodes *s* and *t* and g_{st}^{i} is the number of geodesic paths between *s* and *t* passing through *i.*

In the methods so far discussed, ranking of nodes depends only on degrees of the focused nodes. It may adversely affect the ranking of nodes in some cases. As a rectification to this problem, in 2017 Reji Kumar et. al. suggested a new ranking method named m-Ranking[7] of nodes. In this method degrees of all nodes are considered to rank nodes of a network. Total power of each node is calculated using the formula

$$T(i) = d_i^{(0)} + \frac{1}{\beta}\sum d_i^{(1)} + \frac{1}{\beta^2}\sum d_i^{(2)} + \frac{1}{\beta^3}\sum d_i^{(3)} + \ldots \quad , \tag{1}$$

where $\beta \succ 1$ is a parameter. Here, $d_i^{(0)}$ is the degree of the node I and $\sum d_i^{(j)}$ is the sum of the degrees of the nodes j away from node i. All the aforementioned methods are devised on the over simplified assumption that all nodes in a network spread information with equal probability. But it is an indisputable fact that each piece of information is passed from one person to another only based on stringent personal assessment. In the following section we further improve the existing models by incorporating the assumption that the nature and content of each piece of information can affect the spreading effectiveness of the nodes.

II. EFFECTS OF PERSONAL VARIATIONS

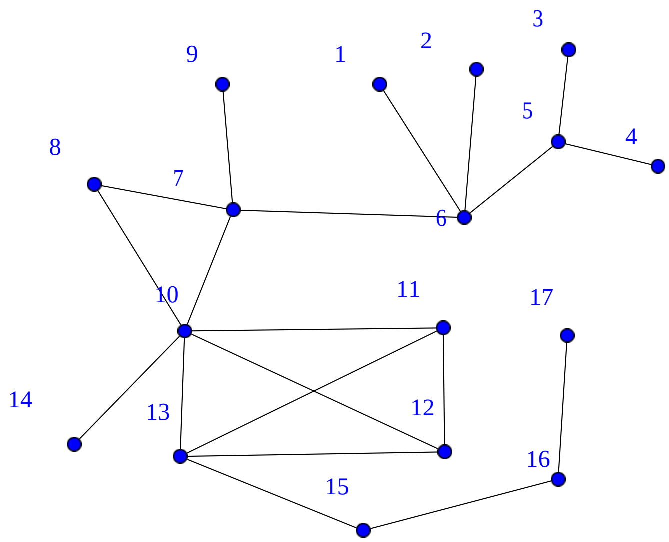
A personal variation in spreading process is effected by defining a fuzzy function on the set all nodes in the underlying graph. It is universally accepted that fuzzy function values (varying in the interval [0,1]) can represent varying states of mind[8]. In the new model a fuzzy function $f : V \to [0,1]$, such that a node which is fully interested to spread must get the value 1 and a node in just opposite state must get 0. All the intermediate states are represented by a suitably selected fuzzy value. Even though a node in a network has maximum connections with other nodes, it importance in the spreading will go down in the ranking, as its fuzzy value tends to zero. In some cases a set of nodes having relatively smaller degree can go up in the ranking only due to its special interest in spreading information.

This argument is illustrated with the help of a sample network and two sets of fuzzy values selected in a suitable way. To calculate rank of each node we use the following formula to find total power of each node.

$$T(i) = f(i)d_i^{(0)} + \frac{1}{\beta}\sum_{v \in V_1} f(v)d(v) + \frac{1}{\beta^2}\sum_{v \in V_2} f(v)d(v) + \ldots \tag{2}$$

where $f(v)$ is the fuzzy value of the node *v*. V_j is the set of nodes at a distance j away from node i. $d(v)$ is the degree of the node *v*. $\beta > 1$ is a parameter.

The following network contains 17 nodes. The ranks of the nodes are calculated using equation (2) and tabulated below.



Node(i)	$f_1(i)$	$T_1(i)$	*Rank*	$f_2(i)$	$T_2(i)$	*Rank*
1	0.2	4.13	13	1.0	3.69	10
2	0.4	4.28	12	0.9	3.61	11
3	0.3	2.90	16	1.0	3.23	15
4	0.4	2.98	15	0.8	3.08	16
5	0.5	5.36	10	0.6	4.96	5
6	0.7	7.96	7	0.4	5.88	2
7	0.9	9.88	3	0.5	5.91	1
8	0.5	8.62	6	0.6	5.28	4
9	0.2	4.46	11	1.0	3.24	14
10	1.0	12.7	1	0.1	5.53	3
11	0.8	9.49	4	0.3	4.10	8
12	0.6	9.19	5	0.4	4.25	7
13	0.7	9.98	2	0.1	4.36	6
14	0.3	6.62	8	0.7	3.29	13
15	0.4	5.85	9	0.5	3.72	9
16	0.3	3.45	14	0.8	3.43	12
17	0.2	1.87	17	1.0	2.46	17

The nodes of the network are assigned two different sets of fuzzy values as given in the above Table. The highest degree node in the network is 10, which has rank 1, when f(v) = 1 in the first case and rank 3, when f (v) = 0.1. This shows that the ranking method depends on fuzzy functional value also.

III. CONCLUSIONS

In this paper we have seen how individual difference when accounted in the form of interest in the spreading information affects the whole spreading process. In practical situations we face the difficulty of measuring the level of interest of spreaders specific to the information. But avoiding such valuable factors may affect the overall assessment. Developing some suitable strategy to measure the attitude of individuals is an interesting challenge and also a guiding point to the future research.

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