FUNDAMENTAL ANALYSIS METHODS OF SOCIAL NETWORKS

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Abstract: This study makes a survey of the main methods of social networks' analysis. We are going to underline the fact that starting with the 1970s, the combinatorial theories of graphs have known a rapid development on the basis of computer processing power, whereas the analysis of social networks as structures of communication has turned into an interdisciplinary specialty. As a conclusion, the comprehension of human understanding based on the analysis of the social networks implies the convergent use of a conceptual language belonging to the theory of communication. It also means to resort to mathematical methods in order to formalize various theories, as well as the systematic analysis of the empirical data.

Keywords: social network analysis, computer processing, conceptual language, theory of communication

1. On the analysis of social networks

The study of social networks centres on the one hand around the totality of a person's relations, that shape the so-called global networks, and on the other hand o the personal or egocentric relations of an individual. The analysis of an egocentric relation starts from an individual and analyzes its personal and social environment. When it comes to the analysis of an egocentric network, the emphasis is laid on the social relations built by one single individual. The analysis of social networks focuses on the discovery of models used for the social interactions between people (Freeman, 1979; Freeman, 2004; Morozan, Enache & Purice, 2012). The social structures become thus noticeable, whereas the movements and contacts of an individual are not accidental anymore. On the contrary, they follow a pre established model.

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If somebody were able to distance himself enough from people's lives, so that he perceived each man as a small moving point, he would come to the conclusion that people do not make friends of one another accidentally. Some of them are together out of habit, others meet often, whereas some others never meet. People's life would thus turn into a behavioural pattern governed by rules.

The analysis of social networks offers us a precise way of defining the important social concepts, a theoretical alternative to the hypotheses concerning the independent social actants, a framework meant to test the theories on the structured social relations.

The methods related to the analysis of social networks provide and regulate the indicators concerned with the measurement of the social structural properties that could not be otherwise described than in metaphorical terms. Such phrases as accumulation of relations, social role, social position, group, clique, popularity, isolation, prestige, etc. have been mathematically defined by the discipline called the analysis of social relations.

There is a series of social essential indicators within the analysis of social networks:

i. the network's dimension (in the big organizations, there are subgroups that provide the direct communication between each of their members);

ii. the network's density;

iii. the degree of connectivity;

iv. the accessibilty to each of the actants;

v. the distance between the actants (the time necessary to convey the information);

vi. the number of mutual relations in comparison to the transitive ones.

Those who play the role of communicating bridge and of intermediaries between other actants, who are not in direct contact with one another, are also important. The analysis of a network's structure takes into account the groups, the clans, cliques and factions that coexist inside it. Cosmopolitan individuals, that are part of several subgroups, can act as communicating bridges in order to avoid the conflicts between the subgroups that compete for resources and to provide communication.

The explicit mathematical settlement of the structural properties, starting from an agreement on the formal definitions, makes researchers offer clear definitions of the social concepts and facilitate the development of various models that can be tested. Furthermore, the analysis of networks allows for the measurement of the structures and systems that are almost

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impossible to describe in the absence of the relational concepts, offering at the same time the possibility to test the hypotheses concerned with these structural properties (Wasserman & Faust, 1994).

The analysis of the contemporary social networks originates in three main branches:

1. the analysts in the field of sociometry, that used to study the small groups, have registered important technical progresses, by the methods of graphs theory;
2. Harvard researchers of the 1930s, that have explored the models concerning the interpersonal relations and cliques' development;
3. the anthropologists in Manchester, that have investigated, making use of the branches mentioned above, the structure related to the relations of a "community" within the tribal and village societies.

These three branches have been reunited between 1960-1970 at Harvard, where the analysis of the contemporary social networks has been improved.

In the 1930s, in the United States of America, a group of German emigrants influenced by Wolfgang Kohler's gestalt theory (gestalt – shape) were developing their activity in the field of cognitive science and social psychology. Their work has generated a considerable number of researches on the sociometric issues and group dynamics. Using lab methods and case studies, they have investigated the group's structure, as well as the flow of ideas and information inside the group. The anthropologists and sociologists from Harvard University have developed some of the ideas belonging to the British social anthropologists (Radcliffe-Brown), making important studies on factories and communities, studies that have emphasized the importance of the informal and interpersonal relations within the social systems.

2. Moreno's contribution

Sociometry stands for a way of measuring, (establishing) the degree of blood relationship, communication and similarity between people. The measuring of similarity is useful not only for the evaluation of the behaviour inside the groups, but also for the change management.

The first study of sociometry has been led between 1932-1938, at New York, by Jacob Levy Moreno. A useful definition of sociometry is the one that sees it as a methodology for the discovery of the energy vectors in the interpersonal relations specific to a group.

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Sociometry relies on the fact that people make choices in their interpersonal relations. When more people join together, they make choices related to the seat they are going to occupy, the persons they are going to sit next to, to whom they consider to be their friends or enemies, to the most important person in the group, who is rejected and who must be isolated. These are facts of life, even if the choice is motivated or not, articulated or just expressive, rational or irrational. These choices must not be justified as long as they are spontaneous and in accordance with the self of the one that makes the choice. Sociometry points out the models on the basis of which the individuals team with one other within a group with a view to achieving the same goal.

Jacob Moreno's studies originated in the therapeutic approach of the interpersonal relations, reflecting his medical training and psychiatric practice in Vienna. His aim, comprehensively expanded upon in an important book (Moreno, 1949) and the basis of the journal Sociometry (founded in 1937), was to investigate how the psychological well being affects the structural characteristics of what he used to call 'social configurations.' These configurations are made up of the concrete models of the interpersonal choices, attraction, repulsion, friendship, or other relations people are involved in and which represent the basis on which the social aggregates on a large scale – such as economy and the state – are sustained in time. Moreno' preoccupation for the interpersonal configurations on a small scale and the social aggregates on a large scale represents a very clear expression of the main ideas of the German classical ideology, especially of those developed by Weber, Toennies and Simmel.

Moreno's main innovation was the development of the sociogram as a means of representing the formal properties of the social configurations (Moreno, 1960). Moreover, it could be represented in similar diagrams to those who develop their activity in the field of social geometry, with the individuals represented by points and the social relations between them by lines.

Before Moreno, researchers were talking about the "cobweb"of connections, about the "social intertexture," and occasionally, about "networks" of relations. However, nobody has tried to systematize this metaphor in an analytical diagram.

For Moreno, the social configurations had clear and visible structures, while the plotting of these structures in a sociogram allowed a researcher to visualize the channels by means of which the information circulates from one person to another, or by which an individual could influence another one. According to Moreno, the sociogram allows the researchers to identify the

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isolated leaders and individuals, reveal the asymmetry and reciprocity and represent the chains of connection. One of his main sociometric concepts was that of the sociometric "star," the addressee of the numerous and frequent choices made by the others, and that implicitly holds a popular and leadership position. For Moreno, the concept of "star" leads to the simple visualization of the image concerned with the relations between the group's members (Scott, 2011).

3. The description of a graph and of its component elements

The analysts of the social networks make use of two mathematical tools in order to interpret the information concerned with the models of the relations between the social actants: the graphs and the matrices (Hanneman & Riddle, 2005).

Graphs are essential for a formal description of the social networks. The theory of graphs represents a branch of Mathematics that social sciences have quickly adopted in their set of tools. A graph (graphic) is a finite set of points, highest points or knots connected between them by links called limits or arches (Batagelj, 2003). We are talking here about a diagram that describes the relations between certain variables (points).

Formally speaking, a simple graph is made up of a set of top points of a triangle and the sets of pairs that make the connections between these tops called lines or edges of a triangle.
Two knots are adjacent if they are connected by a single line.

A circuit is a way that ends where it begins.

A loop is a curve that joins a top to itself, a round circuit on a single side between two points.

A road stands for a sequence of consecutive steps that make the connection between two knots, a road that must be traversed in order to cross a graph.

The degree of a mathematical edge is given by the number of relations that end in that particular edge (top). A knot is isolated (it has a zero degree) if it is not somehow connected to the other knots (Degenne & Forse, 1994).

A graph is complete if for each pair of knots, there is at least one arch. A complete graph is the one where each point is connected by a link to the other points. A graph is linked if there is a connection between each possible pair of knots. The connected incomplete graphs are made up of subgraphs, completely connected.

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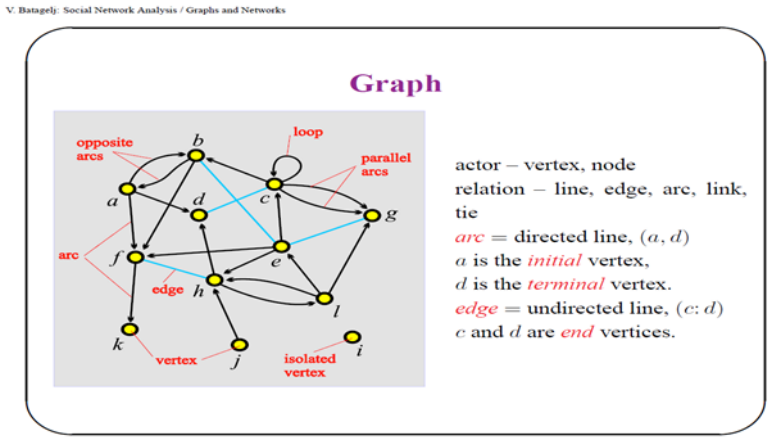

The sociogram

There is a multitude of different types of graphs. The bar, pie, linear and trends graphs are called graphs and/ or graphics. The analysis of networks mainly uses a type of graphic that consists of points or knots to represent the actants and the lines or edges (limits). When the sociologists have borrowed from the mathematicians this model of graphical representation, they have redefined it "sociograms."

The variations on the theme of sociograms are numerous, but they all have a common characteristic – the use of circles labelled for each actant in the population described and of segments of lines between the pairs of actants in order to represent the existence of a connection between them.

For example:

Let us suppose that we are interested in noticing who is interested in whom in a social group made up of Bob, Carol, Ted and Alice. We will start by considereing each actant to be a knot with a label (sometimes these labels are specified in circles or frames).

In figure 2, we have 4 knots without any connections between them.

Figure 2

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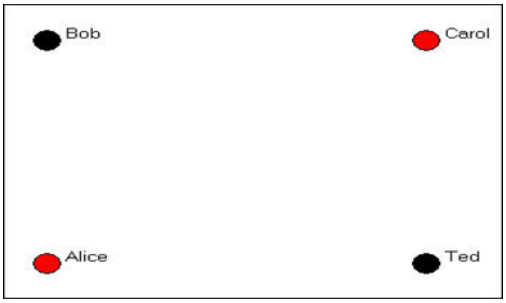

In this example, we have also represented an attribute of each actant, by colouring the knots (black for men and red for women). The colours, shadows or various forms or shapes are often used to represent attributes of knots. We have gathered the data on the friendship relations, by asking each member of the group (in private and confidentially) whom they consider to be their "close friend" of a list containing all the other members. Each of the four members had the possibility to choose 1, 2, 3 friends or none. Consequently, Bob chose Carol and Ted, but not Alice; Carol chose only Ted; Ted chose Bob, Carol and Alice; Alice chose only Ted. We have represented these pieces of information by drawing an arrow from the person who chose to ythe person chosen, as it is shown in the image below.

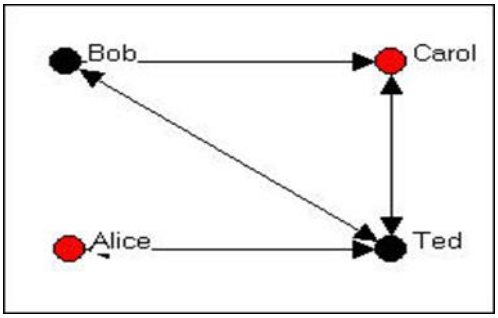

Figure 3

In order to diminish the visual confusion, we have used a double edged arrow in order to describe a relation od reciprocity between two knots.

Let us suppose that we also taken into account the second type of relationship – if the individuals have in common a marriage relation. In our example, Bob and Carol are husband and wife, Ted and Alice are. We can also represent this type of powerful relations by means of a graph, as in the figure below.

Figure 4 The graph of marital relations

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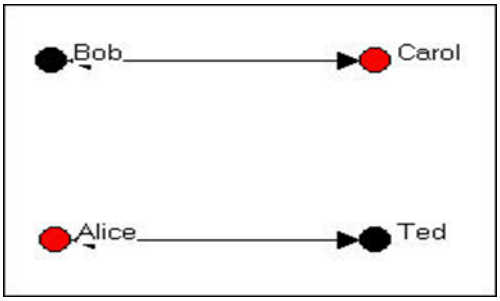

4. Methods of graphs analysis

The analysis of social networks aims at measuring the relations and information flows between people, groups, organizations, computers and other entities that process the pieces of information and knowledge.

The analysis of social networks offers a visual (graphical) and mathematical analysis of interhuman relationships. Management consultants use this method to analyze the organizational network. One way of understanding the networks is to evaluate the location of each actant within the network. Location measurement involves the discovery of a knot's degree of centrality (its importance and prominence). This can be very different from its positioning, (location) in the hierarchy or flowchart of an organization. Two knots are connected if they discuss regularly or if they interact in some way or another.

There are three usual methods of measuring the degree of centrality within a network: the degrees, the connectivity and closeness.

• The degrees – the number of direct connections (links) that a certain knot has with other knots in the network generate the degree of that knot. The more direct connections a knot has, the more active it is. The most important connections are those directed towards the actants that would otherwise remain isolated within the network (Dumitru, Avram & Siminică, 2015). Generally speaking, most of them are connected to those in their immediate neighbourhood, to their group of friends (the cliques).

• Connectivity (communication bridges) – those who play the role of a broker between two important groups belonging to a network have a powerful role within the organization, but they also stand for vulnerable points of the network that can block up the circulation of information flows (Stănescu, 2015).

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- Closeness – the knots that discover the shortest ways to the others and are thus closer to any other knot in the network have a privileged position, as they can monitor the information flows, having a bird's eye view on what really happens inside the network (Watts, 2003; Watts, 2004; Teodorescu & Bușu, 2015).
- Those who go beyond the borders – the knots that make the connection between different groups, being situated at the border between them, can be very good innovators, as they have access to the ideas and information that circulate in both groups (Negrea, 2014; Voinea, 2014). They are able to combine different ideas and knowledge in different places in order to create new products and services.
- The peripheral players – those that are to be found at the periphery of the networks are considered less important. However, they can be found in the center of their own networks, that we do not have in view during our study, and provide for a connection with them. They are actually resources of fresh information, that cannot be found inside that network (Scott, 2000).
- Network centralization – the relation between the centralities of the component knots can say a lot of things on the overall structure of a network. A very centralized network is dominated by very few knots that are positioned centrally. If these knots are eliminated or affected, the network will disintegrate rapidly into several groups that are not connected between them (Bačík, Mihal & Fedorko, 2015). The knots positioned right in the center can be weak points. The weakly centralized networks better face the attacks coming from outside the network or the accidents and they do not collapse quickly.

The analysis of networks data focuses on the actants (the knots) and the relations between them (connections, links) (Prell, 2011; Gioroceanu, 2015). The chosen sample is generally an organization whose behaviour is similar to a network, the object of study being represented by the relations established between all the actants that are part of the same network (family, class, school, company, community, organization, club, district).

Networks analysts see the individuals as being included in multiple networks of relations, that are in their turn part of other networks built according to the model of some multimodal structures (Budică & Dumitru-Traistaru, 2015). The social actants have resources, energy, time and limited cognitive capacities, which also restricts the number of powerful relations that they can cultivate and maintain.

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Snowball method: the analysis can start with a focal actant, that is asked to list all his connections with other actants in the network. Afterwards, all the nominated actants are asked to do the same thing. Generally speaking, the analysis of social networks implies a complete census of all the actants and of the connections between them within a/several networks (Vlăduțescu, 2013; Badea, 2014; Smarandache & Vlăduțescu, 2014).

The egocentric networks focus only on the connections (vicinities) of an individual, of his personal (local) contacts network. This information is useful for the comprehension of the effect that the networks have on an individual, but not for the understanding of the network (Pitiriciu & Topală, 2011).

From among the relations measuring systems, we can mention:

- the binary system: the existence of a connection between two actants (1) or the absence of a connection between them (0).
- the multiple system, with a gradual scale according to the emotional intensity of the connection: the best friend (2), a good friend (1).
- the grouped system, according to the feelings we have for the persons we are connected to: persons we do not like (-1), neutral persons (0), persons I like (1).
- according to the frequency of the communication between the individuals (daily, weekly, monthly, occasionally).

5. Conclusion

The formal mathematical methods used to represent the analyzed data (matrices, graphs, sociograms) allow for their computerized processing. Generally, we do not find all the possible connections between the members of a network. The phenomenon is known as structural holes (voids). The better connected individuals are also better informed, influential, but also more influenced by the others. There are homogenous networks from the point of view of the degree of knots connection, as well as other networks where there is a small elite of central, well connected persons and a large mass of relatively isolated actants. The differences related to degree of connection are relevant for the order and hierarchy specific to the group.

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