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## Social Network Analysis shed light on a study case, a typical company with NodeXL

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**Abstract.** The interest in social network has extended to different disciplines, such as Computer Science. This approach brings Social Network Analysis (SNA) as the study of social structure in different environments, like companies. For this reason, the present paper highlights basic network information like graphs using actors and relations, and important concepts related to companies like hierarchy. Finally, to obtain a practical approach of SNA, we describe the company as a sociometric experiment using NodeXL to verify the contrast of traditional Company chart and the application of sociometry to data sets; keeping attention to show how employees make informal contact and the knowledge this brings. Furthermore, companies in society, are a system of actors joined by relationships.

### 1 Introduction

The interest in Social Networks has been increasing and evolving across a wide variety of fields and researches, such as Physics, Psychology, and Computer Science [4] [6]. Social Network Analysis was developed in a relatively non-technical manner from the structural concerns of the anthropologist Radcliffe-Brown. He started to develop a concept of social structure and a web of social life. Social networks have also been studied by Milgram's small world research [10] [15].

In this research we show Social Network Analysis (SNA) as a methodological tool for the analysis and study of Social Networks. We will define the qualitative way of relations between the different actors and their consequences. In order to make this proposal practical, we present a case study developed in the NodeXL tool [12] to create visualizations of social networks and to assist us in our analysis. We considered the company [8] as the main target of this investigation, because this is the environment where bosses and employees interact every day, involving relational data set to obtain the patterning of relationships among employees. We tried to develop a comparative analysis contrasting the main advantage of SNA that bring a qualitative analysis, which makes it easy and intuitive over classical theory organization.

This paper is organized as follows: in section 2, we introduce the main Social Network concepts, while section 3 describes the theory of organizations. Section 4 presents a Case Study with NodeXL in a company environment. Section 5, describes some results obtained through different metrics about the case study. Finally, conclusions and future work are presented in Section 6.

## **2 Social Networks: Structure and Basic Concepts**

Social networks can be named as a well-defined set of actors such as individuals, groups, organizations, communities, among others, linked to each other, through a relationship or a set of social relations. Another field which formally studies Social Networks is Graph Theory, which is a branch of Mathematics [13]. A graph  $G$  in graph theory is defined as an ordered pair subject to the following conditions:

- $V$  is a set, whose elements are variously referred to as nodes, points, or vertices.
- $A$  is a set of ordered pairs of vertices, called arcs, arrows or directed edges. An edge is said to be directed from  $x$  to  $y$ , where  $x$  is the tail of  $e$  and  $y$  is the head of  $e$ .

In social networks, nodes and vertices in a graph represent the actors and relations respectively. In the next sections we will present both concepts by using graphs.

### **2.1 Social Networks: Actors and Relations**

A social network is formed by actors and it is very important to try to identify the central individuals in the network. On the one hand, its attributes refer to different aspects, characteristics, and intrinsic properties of the individuals such as opinions, age and so on. Actors do not act independently. On the other hand, relational data are the contacts, ties and connections, which relate one actor to another and so cannot be reduced to the properties of an individual actor. They are specific to the context, and the context depends on the interactions between them. The relations connect pairs and express linkages among them. Examples of relations are friendship, job relations, flow of information, among others topics [10].

### **2.2 Social Network Analysis (SNA)**

Social Network Analysis (SNA) is the mapping and measuring of relationships and flows between people, groups, organizations, computers or other information/knowledge processing entities. SNA is a method for visualizing our people and connection power, leading us to identify how we can best interact to share knowledge [4]. Thus, SNA brings the explanation of behavior of relations that requires an analysis of how the actors are connected to one another considering a particular environment with contextual factors. In the next section, we provide the

relation between social network analysis and the structure of a typical organization, a company [10].

### 3 Organizational Theory: Formal Organizations

The classical theory of organization stressed the importance of formal structure organization [1]. Some authors define it as a specific configuration of structure, people, task and techniques. Structure describes the form of departments, hierarchy and committees. It influences the organization's efficiency and effectiveness. People refers to the skills, attitudes and social interaction of the members of the organization. Task refers to the goals of the individual and the organization. Techniques refers to the methodological approach used to perform tasks. In this way, organizational structure thus refers to the institutional arrangements and mechanisms for mobilizing human, physical, financial and information resources at all levels of the system, taking into account some aspects of the formal organizations, like work specialization, organization charts, hierarchy as shown in Figure 1.

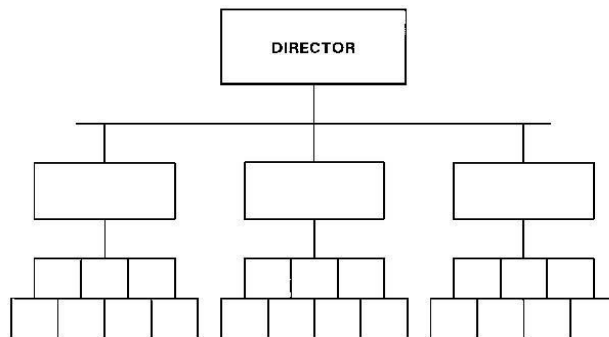


Fig. 1. An organizational chart of a Formal Organization

From the perspective of some classical authors, formal organization is something rigid. For Taylor [14] it must be based on work division, and the specialization of workers. So organization must be structured to bring specific goals, minimize risk and maximize performance. In other words, it is structured to bring an integral component of the company.

### 4 A Case Study Applying NodeXL

NodeXL is a tool for interactive network visualization that leverages the widely available MS Excel application as the platform for representing generic graph data, performing advanced network analysis and visual exploration of networks [12]. Likewise, Node XL is a practical tool, because it uses a highly structured workbook

template that includes multiple worksheets to store all the information needed to represent a network graph.

We implemented this software tool, which allows us to show how an organization is from within, by using certain metrics from SNA. Furthermore, we have used this case study to show how the combination of social network and qualitative analysis work together, characterized by communication network defined as a set of “interconnected individuals who are linked by patterned communication flows” [10].

#### 4.1 A typical organization company

A company is a typical organization, which only exists when employees are able to communicate and willing to work together to achieve a common goal. As we saw earlier, an organization must be structured to bring specific goals, minimize risk and maximize performance. As a graphical method, we use an organization chart that can be defined as an abstract and systematic model which provides insight synthetic uniform and formal structure of an organization. This doesn't play only an informative role in the organization, it also presents all the elements of authority, hierarchy levels and the relationship between them, as shown in Figure 2. But this is a method which only represents a static figure without showing the employee's interactions.

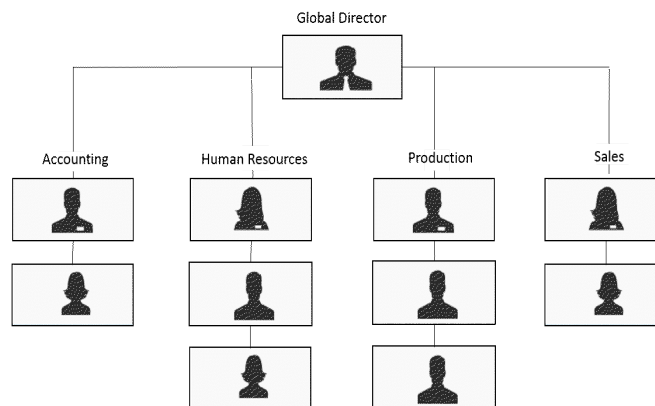


Fig. 2. Chart of a company

#### 4.2 Why and how mapping social relationships

Burt [2] specifies that all social actors involved in a social system that incorporate other actors are significant landmarks in each other's decisions. The relationships that an actor has with others can affect their actions, perceptions and behaviors. So, SNA is focused on uncovering the patterning of how people's interaction will result on data

sets. The analysis of the relations between actors allows delimiting the dynamics of flow circulation between actors located in different places in the network.

Most of the bounds between actors have a purpose. The interpersonal bounds in a network are characterized by the roles and the context of the roles they have developed. The dynamic character of the network appears because sometimes the relations are more or less persistent or also it might be for the existence or not of its actors.

#### **4.3 Data sets: Collecting the information**

As Hoffman [5] points out, “Sociometry is based on the fact that people make choices in interpersonal relationships. Whenever people gather, they make choices about where to sit or stand; choices about who is perceived as friendly and who is not, who is central to the group, who is rejected, who is isolated”. Moreno [9] pointed that all criteria have this in common: that the respondents have some actual experience in reference to them, whether ex post facto or present; in sociometric language, they are still “warmed up” to them otherwise the questions would not arouse any significant response.

Sociometric methods became part of SNA and have been developed like a tool that generates an excellent material from the group from specific questionnaires. In our study case, we simulate a set of questions to employees to obtain a data set. With this information, it is plausible for us to illustrate the most appropriate way in which managers might make decisions in the company. Sociometric data were collected by questions that are formulated online to the employees listed in the flow chart above:

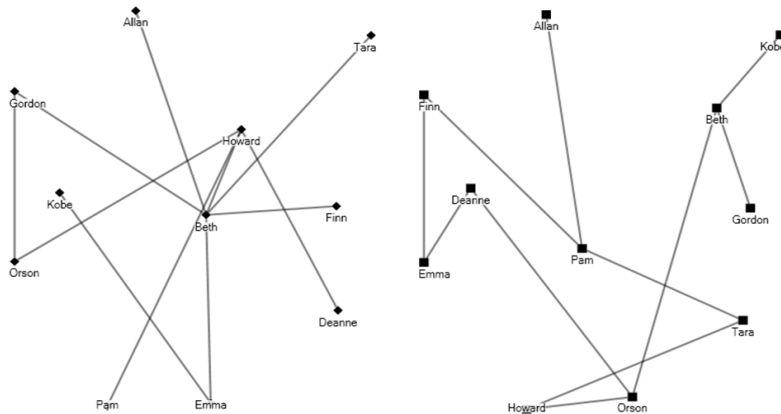
1. Who do you choose to become a manager?
2. Who doesn't get on with whom?
3. Who will be chosen for project teams?
4. Who do you trust in knowing what is really taking place?

SNA is the study of social structures. We acquire the relational datasets from the regularities in the patterning of relationships among the employees involved. As such, Sociometry is an assessment and intervention is a powerful tool which offers principles to predict and guide more comprehensive and powerful. The system applies synergistically to the multiple foci and levels of human relatedness addressed by the interconnected sub theories [7].

#### **4.4 How to map the network with the tool and what result obtains**

We use NodeXL to represent graphs from data sets previously obtained from sociometric questionnaires [3] [12]. In this case, each node represents an employee, considering: Allan the president; Pam, Emma, Howard, Gordon (managers to each department); Orson, Beth, Finn, Kobe, Deanne and Tara. Each actor was provided with a list of all actors in the network and asked to indicate those with whom he or

she has a particular relation according to the questions previously mentioned. According to the questions set out above, it is correct to note that the connections might involve identifying people with whom the employee expresses he or she frequently socializes. After that, we display the graph by clicking on the Read Workbook button directly above the graph pane, a network showing the ties is displayed, as we show in Figure 3.



**Fig. 3.** Social Network with a flow of information in a company (questions 1 and 3)

As regards question 1, we highlight several issues about relationships in the organization. First, there are no mutual choices because relationships require bilateral content of two actors involved; therefore similarity between members partly increases the likelihood of forming the links within the groups. Then, we emphasize that 5 people elect Beth, which makes it a great informal leader (managers chosen by both current and by peers). After that, there are a number of people within the company we describe as isolates, such as a group of individuals prevented by social barriers from interbreeding with others of their kind and social exclusion.

They are: Kobe, Allan, Finn, Tara, Deanne and Pam. As in the previous case, there are no mutual choices in response to question 3. It happens that Beth and Pam have been chosen by two people. Then, we point that between Orson, Deanne, Emma, Finn, Pam, Tara and Howard occurs what graph theory calls a cycle graph which consists of a single cycle with some vertices connected in a closed chain. In this case, we have a directed cycle graph with all the edges being oriented in the same direction. We could say that these relationships suggest a certain relationship where friends choose each other (without prior agreement). Since we obtain the graph of the company conferring to the questions 1 and 3, we will continue to analyze some metrics. It is important to understand that metrics ultimately became the principal aspect of analysis, and they are obtained with the same software tool.

## 5 Some Results: Calculate graph metrics

Network data are collected at the individual level, but the analyses occur at the structural level, with the use of different measures. This allows us to obtain the company structural characteristics. This property refers to the overall pattern of relationships between the system's actors, by capturing the size and internal connectivity of a network as well as attributes of each node. NodeXL supports a minimal set of the most crucial network measures for individual nodes, such as: density, distance, reachability, degree and betweenness.

**Table 1.** Analysis of graph metrics

Name	Characteristic	Result question 1	Result question 2
Cohesion -Density	Negative. If all your alters are tied to each other, they are redundant.	There are 11 ties out of a possible 121 for the organizational network, giving a density of 0.091.	
Cohesion-Distance	Negative. Is calculated by summing the number of distinct ties that exist along the shortest route between two nodes.	In figure 4, Beth is a distance of 2 from Orson, Pam, Deanne and Kobe.	In figure 4, Beth is a distance of 7 from Howard instead of Tara who can reach Howard within an only tie.
Cohesion -Reachability	Positive. Measures whether actors within a network are related, either directly or indirectly, to all other actors.	With the exception of the five isolates (Finn, Tara, Allan, Deanne, Kobe), all of the remaining actors in figure 4 can reach one another.	With the exception of the three isolates (Gordon, Kobe, Allan), all of the remaining actors in figure 4 can reach one another.
Degree Centrality	It means activity or popularity. Lots of ties coming in and lots of ties coming out of an actor would increase degree centrality.	In figure 4, Beth has the highest degree centrality with five direct ties and Howard is the next most central with three direct ties.	In figure 4, Beth and Pam has the highest degree centrality with two direct ties each.
Betweenness Centrality	Positive. Betweenness measures the number of times an actor connects pairs of other actors, who otherwise would not be able to reach one another.	Beth is by far the most powerful actor. All actors on the network must go through Beth to reach Allan, Tara, Finn, Emma and Kobe. The next most powerful is	All actors in the network must go through Orson to reach Deanne, Emma, Finn, Pam, Tara and Howard. By going through Pam,

Howard, because all we can reach Allan.  
actors must get through In the other way,  
him to reach Pam and through Beth we can  
Deanne. reach Gordon and  
Kobe.

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## 6 Conclusions and future work

Beyond considering a group of employees and determining the dynamics, this research focused on deepening the search for a simple way in which it is plausible to help not only the manager, but mainly the employees, paying attention to their views and needs. As Moreno said: "a sociometric test can only be called sociometric if the intention is to identify the feelings of individuals towards others, and secondly, to specify this with respect to certain criteria such as work or visit" [9].

We made use of a software tool called Node XL, from which we obtained different results on relations in the company, and by the metrics we appreciate and support the textual analysis of the graphs. Nevertheless it was not a mere description of the graph, it was an objective assessment of the hidden reality on employees, their feelings, their relationships with colleagues and bosses, as well as their perception of the organizational hierarchy.

As we mentioned at the beginning, the ARS and sociometry not only can be applied to an organization, but also to different environments. One of them is the school, a very important environment for children and teenagers, to improve their character through emotions, feelings but especially, by fulfilling the meaning of relationships. They learn how to interact with the equals, how to build what we know as social consciousness. The connection and exchange between students are the most important sources of information and knowledge, and this is it because students trust more those they know than those they don't.

Considering future work, we will try to analyze the network formed by students, and after that, we are going to study their choices, which will determine what others will see and how they will be connected to others. So we will intend to consider the concept of trust and the different concepts related to trust, like confidence and their differences. In this way, we will introduce trust to Computer Science, and we will also place it in the center of our attention in SNA. Moreover, we are going to use NodeXL to represent that. In this manner, we will take into account the properties and the most important components: the trustor and the trustee, and how they interact.

## Referencias

1. Ader, J.J (1993). Organizaciones, Editorial Paidós, tercera reimpression, Buenos Aires.
2. Burt, R. S. (1980). "Models of Network Structure", Annual Review of Sociology, Vol. 6, pp 79-141



3. Dunne, C. and Shneiderman, B. (2012) Motif Simplification: Improving Network Visualization Readability with Fan and Parallel Glyphs. University of Maryland. HCIL Tech Report. <http://hcil2.cs.umd.edu/trs/2012-11/2012-11.pdf>
4. Hanneman, R.A. and Riddle, M. (2005). Introduction to social network methods. Riverside, CA: University of California, Riverside
5. Hoffman, C., Wilcox, L., Gomez, E. & Hollander, C. (1992). Sociometric Applications in a Corporate Environment, *Journal of Group Psychotherapy, Psychodrama & Sociometry*, 45, 3-16.
6. Klukas, C., Schreiber, F and Schwöbbermeyer, H. (2006) Coordinated perspectives and enhanced force-directed layout for the analysis of network motifs, in APVis '06: Proc. 2006 Asia-Pacific Symposium of Information Visualisation, 2006, pp. 39-48.
7. Kursman, Charles (2007) Sociometry. International encyclopedia of the social sciences, 2nd edition, pp. 370. <http://www.uky.edu/~rremer/sociometry/Sociometry.pdf>
8. Leavitt, H.J. 1962. Applied organization and readings. Changes in industry: structural technical and human approach. pp. 55-70, in: Cooper, W.W., Leavitt, H.J., & Shelly, M.W. (eds) *New Perspectives in Organization Research*. New York, NY: John Wiley.
9. Moreno, J. (1953) The sociometric system. *Who Shall survive, A new approach to the problem of human relationships*. (pp. 99). Beacon, N.Y.: Beacon House.
10. Scott, J (2000). *Social Network Analysis: A Handbook*. Sage Publications.
11. Smith, M.; Shneiderman, B.; Milic-Frayling, N.; Mendes Rodrigues, E.; Barash, V.; Dunne, C.; Capone, T.; Perer, A.; Gleave, EC. (2009). Analyzing (social media) networks with NodeXL. In *C&T '09: Proc. fourth international conference on Communities and Technologies*, pages 255\_264. ACM
12. Matei, S.A. (2011) Analyzing Social Media Networks with NodeXL: Insights from a Connected World by Derek Hansen, Ben Shneiderman, and Marc A. Smith. *International Journal of Human-Computer Interaction*, 27(4):405-408.
13. Tang, L. and Liu, H. (2010). Graph Mining applications to social Network Analysis.
14. Taylor, F. W. (1911), *The Principles of Scientific Management*, New York, NY, USA and London, UK: Harper & Brothers, LCCN 11010339, OCLC 233134. Also available from Project Gutenberg.
15. Watts, D. (2003). *Six Degrees: The Science of a Connected Age*. W. W. Norton & Company.