

# Identificación de Redes de Conocimiento mediante el Análisis de Redes Sociales

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## RESUMEN

Las *redes de conocimiento* facilitan la transferencia de conocimiento, especialmente conocimiento tácito. Identificar la *red de conocimiento* dentro de la organización permite utilizar mejor los recursos organizacionales y guía los esfuerzos relacionados a la gerencia del conocimiento. En este trabajo de investigación hemos desarrollado un procedimiento para identificar las *redes de conocimiento*. Este procedimiento utiliza el análisis de redes sociales. Su aplicación en una unidad de una institución gubernamental, nos ha permitido hacer ajustes y los resultados obtenidos son un buen indicador de que el procedimiento revela las *redes de conocimiento* y las personas clave al interior de ellas. Identificar las *redes de conocimiento* dentro de una organización permite canalizar de mejor manera los recursos y esfuerzos relacionados a la gerencia del conocimiento. Mediante la identificación de la *red de consultoría* y la *red de amistad* se identificó a los actores clave dentro de la organización que sirven de facilitadores para la gerencia del conocimiento. Para ello se utilizan las medidas de grado, intermediación y fluidez.

## Palabras clave

Gerencia del Conocimiento, Análisis de Redes Sociales, Redes de Conocimiento, Transferencia del Conocimiento.

# Identifying Knowledge Networks with Social Network Analysis

## ABSTRACT

Knowledge networks facilitate knowledge transfer, particularly tacit knowledge. Identifying the knowledge network within an organization provides a means to better use the organizational resources and guide the efforts related to knowledge management. In this paper we describe a procedure to identify knowledge networks. This procedure is based on Social Network Analysis. Its application in one organizational unit within a government institution allowed us to make adjustments and the results are a good indicator that the procedure reveals the knowledge network along with the key people. The consulting and the friendship networks enabled identifying the key actors who serve as facilitators for knowledge management efforts. The combination of those two networks forms the *knowledge network*. Measures used include: *indegree*, *betweenness centrality*, and *flow betweenness centrality*.

## Keywords

Knowledge Management, Social Network Analysis, Knowledge Networks, Knowledge Transfer.

## INTRODUCTION

The importance of knowledge as a key asset for the survival of the organization is widely accepted both among academics as well as practitioners. Organizations recognize that knowledge is a valuable resource and therefore they implement knowledge management initiatives. In the strategic management literature, a *knowledge-based perspective* has emerged (Cole 1998; Nonaka y Takeuchi 1995; Spender 1996a; Spender 1996b) as an extension of the *resource-based theory of the firm* originated several decades ago (Penrose 1959) and later expanded by others (Barney 1991; Conner 1991; Schulze 1992; Wernerfelt 1984). This indicates that knowledge is a strategic resource and as such is a source of competitive advantage. From the information systems perspective, its importance is recognized by the emergence of a special type of information systems known as knowledge management systems (KMS) (Alavi y Leidner 2001).

Knowledge transfer is one of the main processes of knowledge management (Davenport y Prusak 2001) which in turn facilitates the other processes. However, there is a special type of knowledge particularly difficult to transfer, tacit knowledge. According to Nonaka and Takeuchi (1995), tacit knowledge is difficult to articulate and represent, therefore it is more difficult to transfer from one person to another compared to explicit knowledge, which is better represented and codified in artifacts such as procedure manuals, policies, training materials, books, papers, videos, etc. Also, Nonaka and Takeuchi (1995) explain that transferring tacit knowledge (in the mind of one individual) to tacit knowledge (to the mind of another individual) occurs through the “socialization” process. *Knowledge networks* represent the space for socialization and therefore facilitate the transfer of tacit knowledge.

A recent article in BusinessWeek shows an application of Social Network Analysis to identify the “office chart that really counts” (McGregor 2006). The article describes how social network analysis is being used more and more by corporations. It also shows some limitations and downsides, but emphasizes the advantages of having a vision of the social networks within the organization. The *knowledge network* is just a part of the social network; however it is the main reason why the social network and its visualization are important. The ultimate goal is to have the work done, not the transfer of knowledge per se; however, knowledge transfer facilitates not just doing the job but doing it efficiently.

The objective of this paper is to review the existing literature on *knowledge networks* and how to uncover or make explicit these *knowledge networks*. Social Network Analysis (SNA) was chosen as a methodology. The process to reveal the *knowledge network* is explained in the following sections as well as the application of the procedure in one organization.

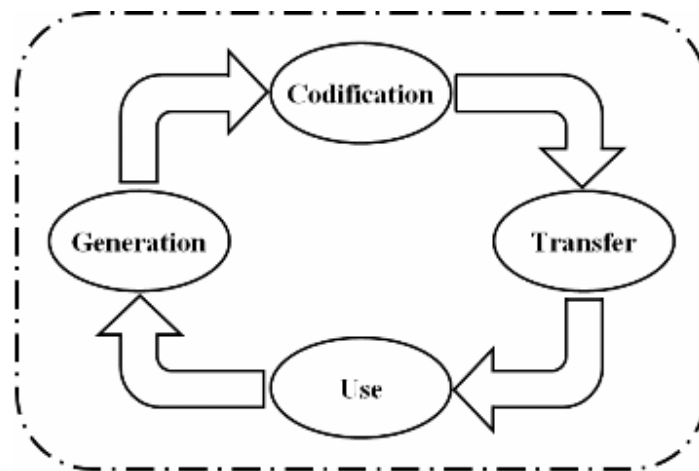
Research in a government organization is interesting because it is difficult to have access; however, when support is granted by the upper management, the strong hierarchy in these institutions facilitates cooperation of the participants. Also, the special conditions in this type of organizations require careful consideration of our conclusions. The selected institution, although it has many of the typical characteristics of government institutions of a Latin-American country (unwillingness for change, low technology, bureaucracy, extended hierarchies, etc.), has distinguished among government entities for its effectiveness to reach its mandated goals and by acquiring several desirable characteristics of the private sector. Not surprisingly, its operating budget is tied to results. By the time of this study, the institution enjoys a good reputation, in recent years it merged with another government institution and is still in the integration process.

## LITERATURE REVIEW

### Knowledge Management and Knowledge Management Processes

Following previous research (Davenport y Prusak 2001, Bocchio et al 1999, Matute 2003), we define knowledge management as: “the organization, planning, management and control of a network of individuals embedded in an organizational culture and supported by information technology. The network’s objective is to create, renew, organize, transfer, use, and protect knowledge in order to provide tangible and intangible benefits, and developing competitive advantages and distinctive skills” (Bocchio, et. al., 1999).

In the same literature, knowledge management processes are essentially four: Generation, Codification, Transfer, and Use or Application of knowledge. Knowledge generation includes both acquisition and internal or external creation of knowledge. Codification refers mainly to the transformation of tacit knowledge into explicit knowledge so it is possible to store it in knowledge bases. Knowledge transfer includes all activities to facilitate availability of knowledge for those who require it within the organization. Finally, the use or application of knowledge is the ultimate objective of the previous processes and represents knowledge in action, helping solve problems and supporting decision making. The *knowledge networks* support all these processes, particularly the transfer of knowledge. Figure 1 shows the four processes in a sequential representation, however, these processes often occur simultaneously.



**Figure 1. Knowledge Management Processes**

Source: self elaboration based on Bocchio et al. (1999), Davenport and Prusak (2001), and Matute (2003)

### Knowledge Transfer

In this paper we concentrate our attention in the transfer of knowledge. Knowledge transfer is possible not just by implementing information systems to facilitate it, but also by the willingness of the people to share their knowledge. Tacit knowledge is relatively easy to manage because it is possible to use similar techniques from database management (from the technology perspective). The main problem is the tacit knowledge, which is difficult to codify and therefore difficult to share and exchange. Tacit knowledge is sometimes more valuable than explicit knowledge. Nonaka and Takeuchi (1995) describe the transfer of tacit knowledge through a process of socialization to exchange the tacit knowledge as experience and personal knowledge. The meaning of the shared experiences is shared tacit knowledge embedded in the common values and in the common technical skills. What we describe here as a *knowledge network* is a type of social network, based in the social interrelationships of the people who are part of the organization, therefore it facilitates tacit knowledge transfer.

### Knowledge Networks

In this research, a *knowledge network* is defined as the set of people and the interactions among them resulting from at least one of the knowledge management processes: generation, codification, transfer and use. In our definition, *knowledge networks* focus in the interrelationships among people who are part of the network and our proposal is that this network is more efficient and useful when it is visualized and supported by information and communication technologies including information systems and more specifically knowledge management systems.

A *knowledge network* includes resources which, along with the people and the relationships among them, are assembled to accumulate and use knowledge, mainly through the processes of generation and transfer. The final objective is to create value. An important feature is that this network is constantly updating itself with knowledge through learning. Therefore, a *knowledge network* should be considered a dynamic structure (Back, von Krogh, Seufert, and Enkel 2005).

Our literature review on *knowledge networks* has identified several other contexts. Although there are similarities, there are also clear differences. For example, IBM uses the term in the context of *communities of practice* (Hildreth 2004). *Knowledge networks* are also described as collaboration networks in the supply chain (Peña 2002).

Within information systems, *knowledge networks* are mainly the set of people, the interactions among them and the information and communication technologies that facilitate the transfer of knowledge which strengthens the network (Bush and Tiwana 2005, Chase 2004).

### Social Network Analysis

Social network analysis (SNA) has its roost in sociometry during the 1930's when Moreno (1934) described the sociogram. However, the term "social network" is attributed to Barnes (1954) working in the field of anthropology. Wasserman and Faust (1994) dedicate the first chapter of their book to describe the historical and theoretical foundations of social networks.

Social network analysis is the examination of social interactions within a group of actors, focusing in the patterns of the relationships (Wasserman y Faust 1994). This definition is aligned with the definition of *knowledge networks*; therefore SNA is appropriate to study them. As described in the previous section, *knowledge networks* are used in other contexts. Previous research describe SNA as an appropriate method to represent organizations supported by information systems to allow the flow of information and therefore they are able to understand, create, share and work based on information and knowledge (Zack 2000).

Social networks are becoming popular in different areas, beyond the traditional areas related to sociology. For example, Google supports a project called "Orkut Social Network" to study the use of information about social relationships to improve search results (see [www.orkut.com](http://www.orkut.com) and a more complete description in [SearchEngineWatch.com](http://SearchEngineWatch.com)).

### Terms Used in Social Networks Analysis

To better understand social networks we need to review, at least, a few basic terms. Here, we extracted some definitions from Hanneman and Riddle (2005).

- Density: Is the proportion of ties that are actually present from all possible relationships. It gives an idea of intensity of the relationships within the network.
- Centrality: Analyzes the central actors, those who are more prominent, powerful and prestigious. There are several indicators, each one providing specific information of the dimensions of prestige and power. Some of the measures are: degree centrality, betweenness centrality, and flow betweenness centrality.
- Degree centrality: Is a measure of power. If one actor has more ties with other actors, he/she will have more ways to connect and will be less dependent from other individuals; he/she will have more access and more resources within the network; and he/she will have more opportunities to take advantage of his/her position as intermediary of other actors.
- InDegree: The number of actors directly related to another actor. The actor contacted by many other actors is considered prestigious. It is a good indicator to analyze power and prestige.
- OutDegree: Number of direct ties/relationships originating in one actor towards other actors. It shows the social attitude of the actor as well as his/her potential to access the other actors.
- Betweenness centrality: Another measure of power. Indicates how much the actor is in an intermediary position between the shortest communications links of other actors. The actors with greater betweenness centrality have more power because they control the flow of communication.
- Flow betweenness centrality: Expands the concept of betweenness centrality by adding the level of involvement of one actor in the connections of other pairs of actors beyond the shortest link.
- Cliques (sub-groups): Are special groups whose members have direct links with each of the other members. This is the most cohesive structure and it is considered the spinal cord of the network.

## METHODOLOGY

### Setting of Application

The selected organization is a government entity. Its objective is to collect and oversee taxes and tributes. It has approximately 7,000 employees. The target population is a subset of the universe of employees, specifically the information systems unit. This unit has approximately 300 workers, and its main functions are to provide services, solutions and information for the upper management decision making, through the innovation and the maintenance of processes and technology.

The reasons to select this unit are: size, access to collect the data, support and interest from the senior managers, and motivation of the participants. Senior management support is a key consideration because, in theory, 100% participation is required.

**Analysis of the data: Social Network Analysis**

In this paper we use social network analysis as described in the literature section. Likewise, the measurements explained in the same section are utilized. We used the software UCINET (Borgatti et al. 2002) as a tool for the analysis and also to create graphs of the networks.

**The Procedure**

First, the questionnaire was created to collect the data about the relationships. This questionnaire is not anonymous since the study requires the identification of each respondent. There is no need for sampling because it is a census. To facilitate the collection of responses, a piece of software was developed to administer the questionnaire in such a way that respondents select from a list of all possible actors. This procedure enabled standardization of the data collected and there was no need to codify responses. Invitations were sent by email.

A database was designed and created for the data. Since the SNA software used in this study has limitations to handle large matrices, a computer program was developed to consolidate and format the data in matrices to be loaded into UCINET. With the SNA software, interrelationships are analyzed and key actors are identified. In this case, we analyzed the *consulting network* and the *friendship network*. For each network, measures of density and centrality were used.

For centrality, three measurements were used: indegree, betweenness centrality, and flow betweenness centrality. With those, three rankings were generated for the *consulting network* and another three for the *friendship network*, all of them ordered from highest to lowest scores. Then, for each network, a consolidated ranking was calculated adding the positions in each of the initial rankings. For example, if one person was ranked second by indegree, seventh by betweenness centrality, sixteenth by flow betweenness centrality, its consolidated score will be  $(2+7+16) = 25$ . Next, the entire list is ordered from lowest to highest consolidated score. The key group of people in each network is the top 10% of the consolidated ranking (those with the lowest consolidated score). Figure 2 summarizes the proposed methodology.

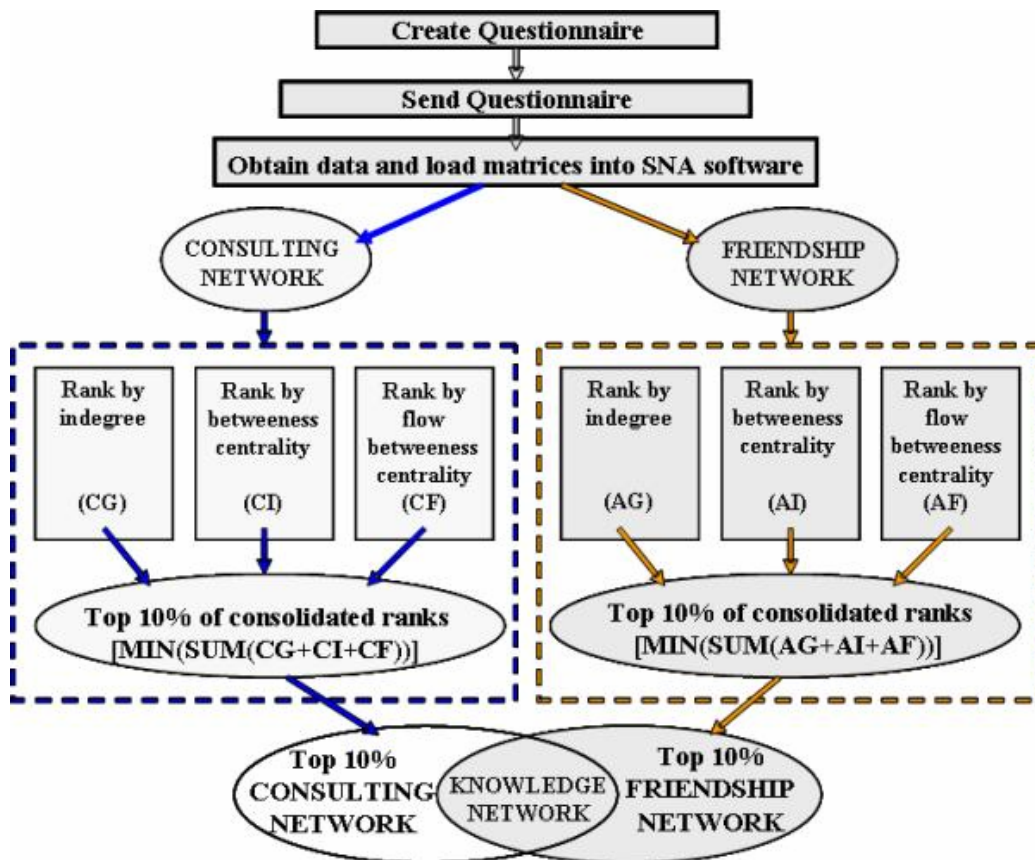


Figure 2. Procedure to identify the knowledge network

## ANALYSIS OF THE DATA

We obtained 255 completed questionnaires out of a target population of 280, a response rate of 91%. All participants were fully identified, as required by the SNA methodology. We examined all references that each individual indicated having with others. Supported by the SNA software UCINET v6, we analyzed the interactions within two networks: the *consulting network* and the *friendship network*.

### Consulting Network

The *consulting network* identifies experts within the organization. First, density was calculated at 0.0222, which means 2.22% of all possible links were observed. This value can be considered low and therefore the search for cliques or subgroups should be irrelevant.

To analyze this network we used the question: *Who do you ask for advice related to your work because you consider his/her experience valuable?* The objective is to identify the actors who are more frequently asked for advice related to work and/or to help solve problems and/or discuss in depth significantly difficult issues.

The indegree index can be interpreted as “local power” within a network. The indegree scores are ordered from high to low (Order CG). The most requested expert has an indegree of 28 (number of people who ask), as seen in Table 1.

Betweenness centrality is another measure of power that refers to how central is the role of the expert as a link between other actors, what Davenport and Prusak (2001) call “brokers” in their “knowledge market” model. The scores provided by the SNA software are ordered from high to low (Order CI).

Although betweenness centrality unveils the experts who may play the role of links within the *consulting network*, it is also important to understand if these actors are facilitators or barriers for knowledge transfer. The flow betweenness measure is used and the scores are ordered from high to low (Order CF).

A consolidated ranking was created to obtain the key actors by adding the positions in the three rankings for each actor and ordering from low to high. The top 10% of this consolidated ranking lists the key actors within the *consulting network*. They have potential to leverage and strengthen the knowledge generation and codification processes.

Code	Indegree		Betweenness Centrality		Flow Betweenness cent.		Consolidated	
	Indegree	Order CG	Betweenness	Order CI	FlowBet	Order CF	CG+CI+CF	Final Order
C140	25	4	3378.91	11	5250.74	3	18	1
C139	21	10	11414.80	1	2946.35	18	29	2
C119	23	5	5740.90	5	2514.23	22	32	3
C133	26	2	2560.85	15	2073.07	27	44	4
C122	25	3	8113.35	3	1100.78	44	50	5
C107	11	35	8830.17	2	3066.70	17	54	6
C103	21	11	6561.16	4	1351.67	41	56	7
C111	22	7	1194.54	42	4624.92	11	60	8
C114	17	17	4836.10	6	1119.85	43	66	9
C136	21	12	867.93	53	5242.98	4	69	10
C106	13	25	3063.13	14	1721.37	34	73	11
C117	7	55	2450.53	17	7291.61	1	73	12
C135	12	33	1589.21	35	4873.44	7	75	13
C121	9	47	2128.60	22	4205.27	14	83	14
C104	22	6	3385.76	10	410.21	68	84	15
C109	8	52	1987.08	23	4843.27	9	84	16
C124	7	57	3685.62	8	2598.53	20	85	17
C127	13	26	832.61	54	4981.46	5	85	18
C108	17	18	597.45	66	4847.50	8	92	19
C116	16	20	3419.09	9	523.01	64	93	20
C113	9	44	3871.01	7	1087.05	45	96	21
C137	28	1	1673.96	32	497.98	65	98	22
C128	12	29	1942.03	25	851.43	52	106	23
C126	10	42	2340.39	18	919.25	51	111	24
C130	22	8	1029.31	45	610.28	60	113	25

**Table 1: Rankings Consulting Network**

Analyzing the list of key actors, we noticed high variability in the three rankings. This reveals that there are several experts who are highly consulted but also need to improve their level of betweenness and/or flow betweenness in the network.

### Friendship Network

The *friendship network* identifies the groups of friends. These are important because of their influence in the workplace. First we look at the density of the network, in this case 0.0826, which means 8.26% of all possible links. This is a higher level compared to the *consulting network*. To analyze the *friendship network*, the question used was: “You have been awarded a free day at a cabin in the countryside with all expenses included, but you must invite some people from your organization, who would you choose to come with you?” The question was a subtle way of asking “Who are your friends?” The answers lead to find the groups of friends. Some actors included almost all other actors in the same organizational unit.

First, the indegree scores are used to create a ranking (Order AG). This shows a list of each respondent and the number of friends associated. The most “popular” person has an indegree of 54, as seen on Table 2.

Through the betweenness centrality scores we have identified actors who belong to different groups of friends, particularly those who are links between groups of friends. This provides a second ranking (Order AI).

The flow betweenness scores in the *friendship network* reveal the extent to which actors may serve as links between groups and if they enable or hinder communications within the network. A third ranking was generated for the flow betweenness scores (Order AF).

Finally, a consolidated ranking was generated by adding the rank obtained by each actor in each ranking and ordering from low to high. The top 10% of this consolidated ranking contains the key actors in the *friendship network*. These actors have the potential to leverage the transfer and use of knowledge through their groups of friends.

Comparing with the *consulting network*, the key actors in the *friendship network* do not have such a large variability among the three rankings. This could be interpreted as a high interrelationship between the groups of friends since those actors who favor the flow betweenness also seem to be those who have more friends (indegree).

Code	Indegree		Betweenness centrality		Flow Betweenness Cent.		Consolidated	
	Indegree	Order AG	Betweenness	Order AI	FlowBet	Order AF	AG+AI+AF	Final Order
C102	44	4	7463.03	1	1695.53	7	12	1
C119	37	19	4500.24	2	2749.48	2	23	2
C125	41	9	3547.70	3	952.37	14	26	3
C110	42	6	3056.42	4	599.15	28	38	4
C118	29	48	2226.46	6	1953.14	4	58	5
C104	50	2	1143.04	21	443.75	38	61	6
C112	54	1	660.52	37	629.36	24	62	7
C129	38	17	1921.35	7	398.48	43	67	8
C138	31	36	756.81	27	1797.03	6	69	9
C101	37	18	1160.12	20	556.84	32	70	10
C113	40	13	1375.22	14	373.16	44	71	11
C107	40	11	1388.23	13	319.78	49	73	12
C123	29	50	1085.71	22	994.43	12	84	13
C128	28	56	1396.74	12	606.78	26	94	14
C134	25	81	1369.39	15	1654.06	8	104	15
C141	39	15	458.49	46	370.36	45	106	16
C127	28	54	482.77	42	952.19	15	111	17
C117	22	107	2348.22	5	2908.46	1	113	18
C103	25	75	1194.03	18	678.43	21	114	19
C108	38	16	448.92	47	317.43	51	114	20
C105	29	47	467.70	45	581.39	29	121	21
C115	31	33	743.75	28	281.88	62	123	22
C120	37	20	812.37	25	209.53	81	126	23
C131	35	24	436.39	49	312.42	54	127	24
C132	30	44	471.23	44	443.64	39	127	25

Tabla 2: Rankings Friendship Network

### Knowledge Network

Considering that the key actors in the *consulting network* favor the generation and codification of knowledge, and that the key actors in the *friendship network* are those who facilitate the transfer and use of knowledge, the *knowledge network* emerges from the intersection of both networks.

The intersection contains 9 actors. They hold special value for the organizational unit because they are not only seen as experts but also belong to several groups of friends. Therefore these actors have the potential to be facilitators in the knowledge management initiatives.

### CONCLUSION

This research work and application of the proposed procedure provides specific results for one organization. In addition, it showed that the described procedure is feasible and may be repeated. Also, we were able to verify that social network analysis is applicable to identify *knowledge networks*. Our results have implications both for practice as well as for research.

The implication for managers interested in developing knowledge management initiatives, particularly for knowledge transfer, is the procedure itself to identify *knowledge networks* within their organizations. SNA represents an objective way to select key actors for the management of knowledge.

Particularly, within the selected organization, the top 10% obtained for each of the social networks provides an interesting, as well as surprising, group of people who may be selected to leverage organizational knowledge. They are key people for knowledge management and they are scattered around several areas of the organizational unit holding different roles. They generate and codify knowledge and, by being part of several groups of friendship, they facilitate the transfer and use of knowledge.

When working with large numbers of actors (>100), the graphic tools provided by the version of SNA software that we have used, does not enable proper visualization of the interrelationships. An alternative is to do the analysis clustering actors by organizational or functional units and treat each cluster as an actor. By doing this, it is feasible to analyze the interactions among units and then move one level down to analyze the interactions between actors of each unit. Interestingly, it is possible to find the actors who serve as links between the different organizational units.

Although we were able to achieve our goals, this paper also has limitations. The application of the procedure in one single organization prevents generalization of our findings. In this regard, we frame our research as a case study. However, we believe that the procedure is easily applicable for other organizational units within the same institution and across other organizations which provides opportunities for future research to compare results and test the applicability of the procedure.

Also, it was not possible to obtain a 100% response rate. This is because some workers were temporarily commissioned to other geographical areas of the country or were on vacation. These circumstances cannot be avoided even having upper management support; therefore they should be anticipated in future research.

During the investigation we identified several opportunities for future research. Having identified the *knowledge network* within the selected organization, the next step is to implement information systems to leverage the networks and support the actors, particularly those who are less involved, in participating more actively in the networks. In this regard, once some initiatives to leverage the networks are implemented, it is recommended to go back to the organization and apply the procedure to identify the *knowledge network* once again. Using the measures described in the procedure, it is possible to compare results to establish the effectiveness of the implemented initiatives.

By following the described procedure in this paper, we intend to evaluate the social and knowledge networks in other institutions with similar characteristics in order to compare results searching for similarities and differences. Similarly, we are planning on using the procedure in private and public companies in order to find the characteristics that differentiate *knowledge networks* in government institutions from those in the private sector.

Another research opportunity identified during this investigation is about the use of results. Revealing the “map” may be disrupting in some environments because those who do not appear as key actors may feel threatened. Also, those who are leaders or managers not referred by their subordinates may feel as they are not good leaders. In general, there is need to investigate how to best use and disclose these maps and how people react when revealing the key actors in the *knowledge network*.

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