Knowledge Network Analysis: a technique to analyze knowledge management bottlenecks in organizations

Remko Helms
Utrecht University
Institute of Information and Computing Sciences
R.W.Helms@cs.uu.nl

Kees Buijsrogge
Utrecht University
Faculty of Geosciences, Department of Innovation Studies
C.M.Buijsrogge@geog.uu.nl

Abstract

Before companies can improve their knowledge management they should have a clear picture of the bottlenecks. The Knowledge Network Analysis technique presented in this paper provides companies with an aid to construct this picture in a structured way. It approaches knowledge management from a network perspective. In the first phase, the main actors, including their roles and expertise level, in a specific knowledge area are identified. Consequently, the knowledge transfer between the actors is analyzed using the concept of velocity and viscosity of the knowledge transfer. The result is push and a pull knowledge network graph that show the potential bottlenecks.

1. Improving knowledge management in organizations

For many organizations, if not all, knowledge has become a primary asset that needs to be managed carefully. Therefore, knowledge management has received a lot of attention and has been applied in many organizations [1, 2]. Several assessments have been developed to aid organizations in improving their knowledge management; examples can be found in [3-6]. These models use an approach that has much in common with Capability Maturity Models (CMM) [7]. Basically, the focus of these assessments is to determine whether an organization has the processes and measurements systems in place to support knowledge management. However, our experience with these types of models is that it provides an abstract overview on how to improve knowledge management in general. Consequently, companies find it hard to improve knowledge management in a particular knowledge area.

In this paper the Knowledge Network Analysis (KNA) technique is presented to overcome this problem. The technique focuses on knowledge management within a specific knowledge area and is based on Social Network Analysis (SNA) [8, 9]. This type of analysis approaches knowledge management from a network perspective [10], which should provide a more concrete insight in the knowledge management bottlenecks with respect to specific knowledge areas in an organization. In section 2 the basic concepts of our technique are introduced. Next, in section 3 it is discussed how to use the knowledge network graphs for analysis purposes. The approach for applying the Knowledge Network Analysis is described in section 4. Related work from other authors is described in section 5. Finally, conclusions and future work are discussed in section 6.

2. Knowledge Network Analysis

The Knowledge Network Analysis technique is based on modeling knowledge network graphs. The basic concepts that are used in modeling these graphs include:
- A *Knowledge area* defines the scope of the knowledge network graph. Only specific knowledge belonging to a specific knowledge area is taken into consideration.
- *Knowledge actors* are knowledge workers or knowledge systems, which create, share or apply knowledge. In the knowledge network graph actors are represented by nodes.
- *Knowledge flows* are regular knowledge transfers between actors in a particular knowledge area. The knowledge flows are represented by arcs in the knowledge network graph.

In the next sections each of the concepts is discussed in more detail. This is followed by introducing 'push' and

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'pull' knowledge network graphs for analyzing knowledge management bottlenecks.

2.1 Knowledge area

The technique that we propose analyzes knowledge management on knowledge area level instead of organizational level. In our opinion, this should result in more concrete recommendations for improving knowledge management within a company. A knowledge area is defined as "*a coherent cluster of insights, experiences, theories, and heuristics*" [11]. Within an organization there can be many of such knowledge areas, but the Knowledge Network Analysis is applied to one knowledge area at the time.

The actual identification of knowledge areas within the organization is not part of the technique. For this purpose the Knowledge Strategy Process can be applied as described in [13]. Moreover, this process also assists in prioritizing knowledge areas by linking them to organizational goals. Those knowledge areas with the highest impact on the organizational goals should be analyzed first using the technique as proposed in this paper.

2.2 Knowledge actors

The knowledge actors in the knowledge network graph include employees as well as knowledge systems. Specific knowledge management roles are assigned to each actor in order to visualize their role. During the analysis of the graph, these roles should give a better understanding of how knowledge management is organized. The following roles are distinguished:

- A *Knowledge creator* is an actor that creates new knowledge that is used by others in the organization. It can involve knowledge such as new insights, theories, experiences and heuristics. In the knowledge graph such an actor is recognized while knowledge will mainly flow from this actor to other actors, i.e. mainly outgoing arrows. A knowledge creator is represented by a square (■=employee, □=system) in our technique.
- A *Knowledge sharer*, often also referred to as a knowledge steward or knowledge broker [1, 2], is an actor that is responsible for sharing knowledge that is created by the knowledge creators. In other words, they function as an intermediary between creators and users of the knowledge. In the knowledge graph this actor is recognized while knowledge will flow from this actor to other actors and vice versa, i.e. ingoing and outgoing arrows. A knowledge sharer is represented by a dot (● = employee, ○ = system) in our technique.
- A *Knowledge user* is an actor that depends on knowledge for executing its job. Once new knowledge becomes available, the actor should internalize this knowledge for improved job performance. In the knowledge graph this actor is recognized while knowledge will mainly flow to this actor, i.e. mainly ingoing arrows. A knowledge user is represented by a triangle (▲= employee, △= system) in our technique.

The role of an actor is determined by analyzing the knowledge flows 'from' and 'to' an actor. However, this reveals the dominant role of an actor as perceived by the other actors in the network. In practice, an actor can fulfill different roles at different times.

From a knowledge management point of view, the level of knowledge or expertise of each actor is also of interest. A high level of expertise does have a positive influence on the job performance. Therefore, the following levels of expertise are defined:

- A *Trainee* is an actor that heavily depends on the knowledge of others for the execution of his job. Therefore, he will regularly consult other actors in the network. The level of expertise of a trainee is indicated with the letter 'T' next to the actor (e.g. ▲ [T]).
- A *Specialist* is an actor that has mastered the knowledge in the knowledge area and therefore does not heavily depend on others for the execution of his job. The level of expertise of a specialist is indicated with the letter 'S' next to the actor (e.g. ● [S]).
- An *Expert* is an actor with broad experience in a particular knowledge area. As such, an expert typically creates new knowledge within the knowledge area. The level of expertise of an expert is indicated with the letter 'E' next to the actor (e.g. ■ [E]).

Levels of expertise are associated with the development of knowledge of knowledge workers and are therefore not applied to knowledge systems.

2.3 Knowledge flows

The actors in the knowledge network graph are connected to each other by knowledge flows. These flows are represented by arrows between the actors in the network graph. The direction of the arrow indicates the direction of the knowledge flows. In the context of knowledge management, two properties of knowledge flows are of interest: viscosity and velocity [1]. These properties provide information on the richness and the speed of the knowledge that is transferred respectively.

Knowledge velocity

The term knowledge velocity has been introduced by Davenport and Prusak, they defined it as "*the speed with which knowledge moves through the organization*" [1]. For the execution of their jobs knowledge workers also need to access knowledge that they do not possess themselves. When such a situation occurs it is important

that knowledge is quickly exchanged with those people who need it. The knowledge that is exchanged in such situations is typically explicit knowledge.

The velocity of the knowledge transfer between two actors in the network is the time between contacting another actor and finally receiving the requested knowledge, either directly from this actor or via this actor from another actor. In the knowledge network graph, the velocity of the knowledge transfer between two actors is indicated next to the arrow as a number between 1 and 8, which is placed between brackets. On this scale, 1 means that it takes less than an hour before the knowledge user receives its knowledge while an 8 on this scale means that it takes a month or longer to receive the information.

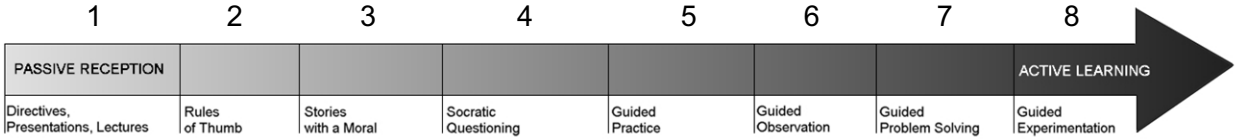

Figure 1. Types of knowledge transfer

Knowledge viscosity

The term viscosity has also been introduced by Davenport and Prusak, they defined it as "*the richness (or thickness) of the knowledge transferred*" [1]. A rich transfer of knowledge will result in a substantial increase of the level of expertise. Hence, rich knowledge transfer contributes to an improved job performance. The viscosity of knowledge transfer largely depends on the type of transfer that is applied. For example, knowledge that is acquired by a long-term apprenticeship or mentor relationship has a high viscosity. During this relationship, which can last for months or years, the apprentice will receive a huge amount of detailed and in-depth knowledge.

In their article on Deep Smarts, Leonard & Swap present a model (see figure 1) that perfectly describes different types of knowledge transfer that range from low viscosity to high viscosity [15]. In their terms, the highest viscosity is achieved by means of active learning such as 'guided experimentation', e.g. experimenting under the supervision of a senior colleague. The lowest viscosity is achieved by 'passive reception', e.g. by attending a presentation or reading a report. In other words, the higher the viscosity the more tacit knowledge is transferred between the actors.

In the knowledge network graph, the viscosity of the knowledge transfer is indicated next to the arrow as a number between 1 and 8, which is placed between brackets. On this scale, 1 means a low viscosity and 8 means a high viscosity.

3. Analysis of the knowledge network graphs

For the actual analysis of the knowledge management bottlenecks in an organization we use two different types of graphs: a 'push' graph and a 'pull' graph. Both are based on the concepts as discussed in the previous section.

3.1 Push graph

A push graph is used to model how an organization actively increases the knowledge of its employees using a '*push*' strategy. To reveal this it is important to identify the roles of the actors in the network, their levels of expertise and the viscosity of the knowledge transfer. The results can be a push graph as shown in figure 2.

By identifying the actor's roles it becomes clear where knowledge is created and how it reaches the actors that use that knowledge. For example, are knowledge users directly connected to knowledge creators or do they depend on one or more knowledge sharers. Moreover, if actors are located in different buildings it is possible to study the influence of distance on relations between actors, e.g., more relations between actors on the same location than relations between actors on different locations.

By identifying the expertise levels in the network, the distribution of expertise within the network becomes visible. This might reveal whether there are enough trainees to replace the specialists or experts when they retire. Finally, the viscosity indicates if the expertise level is likely to increase over time. In order to truly increase the expertise level of employees, a high viscosity type of transfer is preferred over a low viscosity type of transfer. The first type of transfer results in a deep understanding while the latter results in only superficial understanding.

Besides the bottlenecks mentioned so far, the goal of applying the 'push' graph is also to discover bottlenecks, such as:

- Actors that are only connected to other actors with low expertise levels;
- Actors that only receive knowledge by a transfer with low viscosity
- Loosely connected sub-groups that do not profit from the knowledge in other groups;
- Dependency on a few actors for keeping the network together, without them only loosely connected sub-groups will remain;

- Actors that are not well integrated in the network, because they no or only a few relationships with other actors

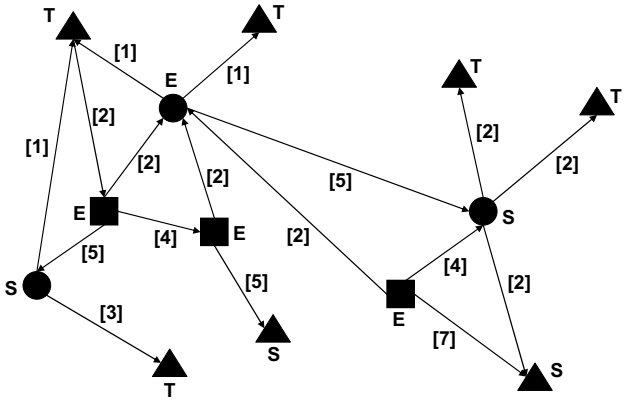

Figure 2. Example of push graph

3.2 Pull graph

The second type is used to represent how the knowledge workers in an organization can tap into the corporate knowledge when they need it using a '*pull*' strategy. In this case it is required that knowledge workers know where to find knowledge. Consequently, knowledge workers should be aware of the knowledge in the organization. Besides awareness, it is also important that the knowledge workers actually have access to the knowledge when they need it. Moreover, when they need it they should also receive the knowledge as fast as possible. The awareness network and the access network can be modeled independently and combined afterwards [9]. This combination reveals if people are aware of valuable knowledge sources and if they have access to them, either directly or indirectly. For modeling the awareness and access network the velocity of the knowledge transfer is important. The knowledge management roles and expertise levels are of less importance and can therefore be omitted in the pull graph.

Besides the bottlenecks mentioned so far, the goal of applying the 'pull' graph is also to discover bottlenecks, such as:

- Actors that have valuable knowledge but don't want to share it;
- Low velocity of exchange between certain actors;
- A few recognized experts that are overloaded with knowledge requests;
- Knowledge awareness affected by location or departmental borders;
- Velocity of knowledge exchange affected by location or departmental borders.

4. Approach for applying the Knowledge Network Analysis

This section proposes an approach for constructing and analyzing the knowledge network graphs. In the first phase, the knowledge areas of the organization should be identified. As mentioned before, we suggest using the Knowledge Strategy Process for this purpose [13]. The second phase involves the creation and analysis of the knowledge network graphs. For this purpose we suggest to use a similar approach as used for Social Network Analysis [9, App. A].

It starts with identifying the main actors for each knowledge area. These actors are used for collecting the input for knowledge network graphs using (on-line) questionnaires. Here it is important that all actors participate in the questionnaire, which is only possible if the management of the organization is committed. Finally, the completed questionnaires are processed by the researcher resulting in the knowledge network graphs.

Next, the graphs are analyzed by the researcher and representatives of the organization. The results have to be discussed with the actors that provided input in order to validate them. Finally, the observations can result in an action plan to improve knowledge management in the particular knowledge area.

5. Related work

Social Network Analysis (SNA) is a well established field of research and focuses on interaction patterns between actors in a network [8, 9, 10]. Besides visual analysis it also provides techniques for quantitative analysis, e.g. calculation of density, distance, and centrality [12].

The fact that we propose to use SNA to study knowledge management is not completely new. Anklam and Liebowitz already explained how SNA can be used to study the transfer of knowledge at an organization level [14, 16]. Another application of SNA in the context of Knowledge management is described by Meuller-Protmann & Finke [17]. Their SELaKT method is a strategic tool to localize experts, to identify knowledge communities and to analyze the structure of knowledge flows within and between organizations.

Previous work uses SNA to apply it in a knowledge management context, but they do not alter the SNA technique. Our proposed Knowledge Network Analysis technique is an extension to SNA, because it introduces knowledge management related roles and properties such as knowledge velocity and viscosity. This extension should make SNA more suitable for analyzing knowledge management on knowledge area level.

6. Conclusion and future work

In this paper we propose a new technique for analyzing knowledge management on knowledge area level. The technique is called Knowledge Network Analysis, which is an extension to SNA. By introducing knowledge management related concepts, such as knowledge management roles, expertise levels, and knowledge velocity and viscosity, the technique is more focused on analyzing knowledge management than SNA. Besides the technique, also an approach for applying KNA is proposed. This approach is to a large extent based on other existing approaches.

So far, the proposed technique has not been validated yet. However, at the moment a case study is conducted at a civil engineering contractor and an international producer of animal feed. In both case studies the Knowledge Network Analysis is used and evaluated. This should provide more insight in the applicability of the technique in a business context and whether it provides the expected results, i.e. identification of knowledge management bottlenecks in a particular knowledge area. Moreover, the case studies will probably also reveal new applications of the technique.

Finally, the method of collecting data is quite resource intensive. Therefore, other possibilities should be explored for collecting data. Scanning e-mail logs is an option, for example, which automates the data collection process.

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