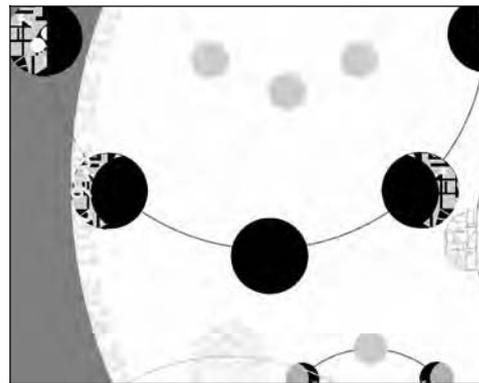


Social Network Analysis: A Practical Method to Improve Knowledge Sharing

Tobias Müller-Prothmann



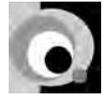
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**Communities, Knowledge Management, Innovation, Social Network
Analysis**



Social Network Analysis: A Practical Method to Improve Knowledge Sharing

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Snapshot (Quick Learning)



Social network analysis is a sociological paradigm to analyse structural patterns of social relationships (e.g., Scott, 1991, Wasserman and Faust, 1994, Wellman and Berkowitz, 1988). It provides a set of methods and measures to identify, visualise, and analyse the informal personal networks within and between organisations. Thus, social network analysis provides a systematic method to identify, examine and support processes of knowledge sharing in social networks (Müller-Prothmann, 2006).

According to the literature, organisations that develop networks both internal and external to their organisation are supposed to be able to deal with knowledge more effectively (e.g., Kanter, 2001). Discussions of the role of networks in knowledge management primarily stress the importance of informal networks (as opposed to formalised networks). Furthermore, networks are often emphasised as result of an activity, i.e. “networking” (Seufert et al., 1999).

Social network analysis can help support knowledge sharing by focusing on various core applications of knowledge management, for example (Müller-Prothmann, 2005):

- identification of personal expertise and knowledge,
- research into the transfer and sustainable conservation of tacit knowledge, and
- discovery of opportunities to improve communication processes and efficiency.

While social network analysis as a method of academic research remains mostly on a descriptive level, its use and application as a knowledge management tool goes beyond a merely descriptive-analytical focus. Thus, the steps and applications outlined below provide suggestions for practical interventions and follow-up activities to influence network actors, their relationships, and network structure to improve knowledge sharing between individuals, groups, and organisational units or whole organisations.

Especially with regard to processes of inter-organisational knowledge community building, social network analysis provides a powerful tool. Based on the insights of a social network analysis, interventions can be derived to facilitate communication processes and community activities, to strengthen boundary-spanning knowledge exchange and to increase the informal inter-organisational relationships for better knowledge sharing. Therefore, social network analysis should become an integral method of organisational design and strategy to support processes of inter-organisational community building, communication and knowledge sharing.

Keywords: communities, knowledge management, innovation, social network analysis

Context (Where & What)



Knowledge, communication and their social organisation constitute the central dimensions of knowledge management. Taking this position as a starting point, the paradigm of social networks and the method of social network analysis is widely recognised as a potential approach to analyse, evaluate, and influence communication processes. Here, it is argued that social network analysis is a highly effective tool for the analysis of knowledge sharing in networks as well as for the identification and implementation of practical methods in knowledge management.

With regard to purposes of knowledge management, social network analysis may help to evaluate availability and distribution of critical knowledge and thus facilitates

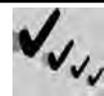
- strategic development of organisational knowledge,
- transfer and sustainable conservation of implicit knowledge,
- development of core competencies (like leadership development),
- creation of opportunities to improve communication processes,
- identification and support of communities of practice,
- harmonisation of knowledge networks (after mergers and acquisitions),
- sustainable management of external relationships.

Particularly in research and service organisations, where the members' innovative potentials, creativity, and abilities for self-organisation play an important role, it is of primary interest to pool individual competencies and resources and to create synergetic effects and co-operations. Therefore, knowledge about potential core competencies and individual resources, facilitation of existing personal relationships, as well as development of new personal relationships and co-operations, are necessary prerequisites. This is where social network analysis provides a powerful tool for measuring and increasing performance of knowledge sharing.

The number of participants surveyed through methods of social network analysis may range from small groups of 10 or 20 people to large networks consisting of several thousands (or even millions) actors. Limits are not set by methods of social network analysis itself, but only by empirical conditions and available resources to observe network actors and their relationships.

Social network analysis can help to gain useful insights into network structures and roles using simple patterns of relationships (like who talks to whom) based on a single event of data collection (questionnaire, email analysis, document analysis) with a minimum effort in terms of time and money. A more sophisticated analysis could include various dimensions of relationships, data collection from different resources, and longitudinal studies with continuous data collection (e.g., email traffic) or multiple surveys (e.g., monthly, weekly). Implementation of results from social network analysis would need follow-up activities, e.g., workshops and team development, and thus involve more personal involvement and additional resources.

Preparation (The Checklist)



Social network analysis uses various techniques to empirically identify underlying patterns of social structure. It compares the existing patterns and their influence on specific network behaviour variables and performance outcomes. From the perspective of knowledge management, social network analysis helps us identify basic network properties, positions of network members, characteristics of relations, cohesive sub-groups, and bottlenecks of knowledge flows.

The application of social network analysis for the examination of organisational knowledge sharing as proposed here is divided into seven steps:

1. clarifying objectives and defining the scope of analysis (knowledge domain),
2. developing the survey methodology and designing the questionnaire,
3. identifying the network members,
4. collecting the survey data and gathering further information from other resources,
5. analysing the data through formal methods of social network analysis,
6. interpreting the results of analysis,
7. designing interventions and taking actions.

Preparation of the network analysis should focus on steps 1-3.

First, for purposeful examination of networks, the scope of analysis must clearly be defined. The analytical scope might be defined by existing problems within a concrete domain of knowledge. Needs for doing a social network analysis could also be identified through means of knowledge audits within one or a selection of various knowledge domains that is of critical importance for success or failure of an organisation.

Second, a methodology must be developed that meets the specific need to reach the goals defined in the previous step. In the majority of cases, application of social network analysis in knowledge management uses surveys for the collection of data. But analysis of knowledge communication should also make use of all other available resources that are suitable to identify social relationships with regard to the defined scope. Basically, these could include expert interviews, email tracking, observations, and other relevant documents (e.g., meeting protocols, publications). As a result of the second step, a survey method (questionnaire) should be at hand.

Third, for the analysis of whole networks, all network participants must be identified. Identification of network members makes use of specific attributes like organisational membership, specific expertise, or participation in teams and projects. Identification of network members is closely related to the defined scope of analysis. For analytical purposes, this step also defines the network's boundaries for empirical study. Nevertheless, the real network relationships may go beyond these boundaries. While this so-called positional approach seems to be most useful for organisational network studies, another method to identify network members is the reputational approach, where a list of nominees is produced by knowledgeable informants ("snowballing"). This approach is useful for the analysis of networks across organisational boundaries when there are no positional inclusion methods available, but boundary specification remains an empirically unsolved problem.

Finally, all participants should be provided with background information about the goal of the social network analysis and its importance. Communication activities should create personal involvement and organisational openness for the social network analysis (see also Tips & Tricks and Pot-holes).

Toolkit (The Essentials)



As outlined for the methodology conceptualisation above, in the majority of cases, social network analysis as a knowledge management tool uses surveys for data collection.

Data collection through surveys must be scheduled within an appropriate period of time. Calls for participation should individually address each network member.

Data analysis of social networks needs coding of the collected data and application of formal methods. Using graph theory, a sociogram visualises networks and their structures (see figure 3). It consists of nodes, representing individual network members, and ties, representing the

connections between the members (relations). Formally, graphs are defined as a set of actors (g - nodes) and a set of their relations (l - lines). The set of actors N is defined by the nodes $\{n_1, n_2, n_3, \dots, n_g\}$.

Another advocated means to represent information about social networks is in matrices. In their simplest form, network data consist of a square matrix, the rows of the array represent the network actors, the columns of the array represent the same set of network actors, and the elements represent the ties between them (so-called “adjacency matrix”). Ties can exist or not, and they can be dichotomous (0 or 1) or valued (e.g., 0, 1, 2, 3 or 4 – see figure 1). These matrices are also used as data input for social network analysis processing (for an introduction to graph theory and the use of matrices in social network analysis see, e.g., Scott 1991).

Commonly, data processing is done through software tools for social network analysis as provided by the popular UCINET package (Borgattie et al., 2002), for example, including the additional tools NetDraw for network visualisation, Mage for 3D visualisation, and pajek for large networks, or other similar software applications.

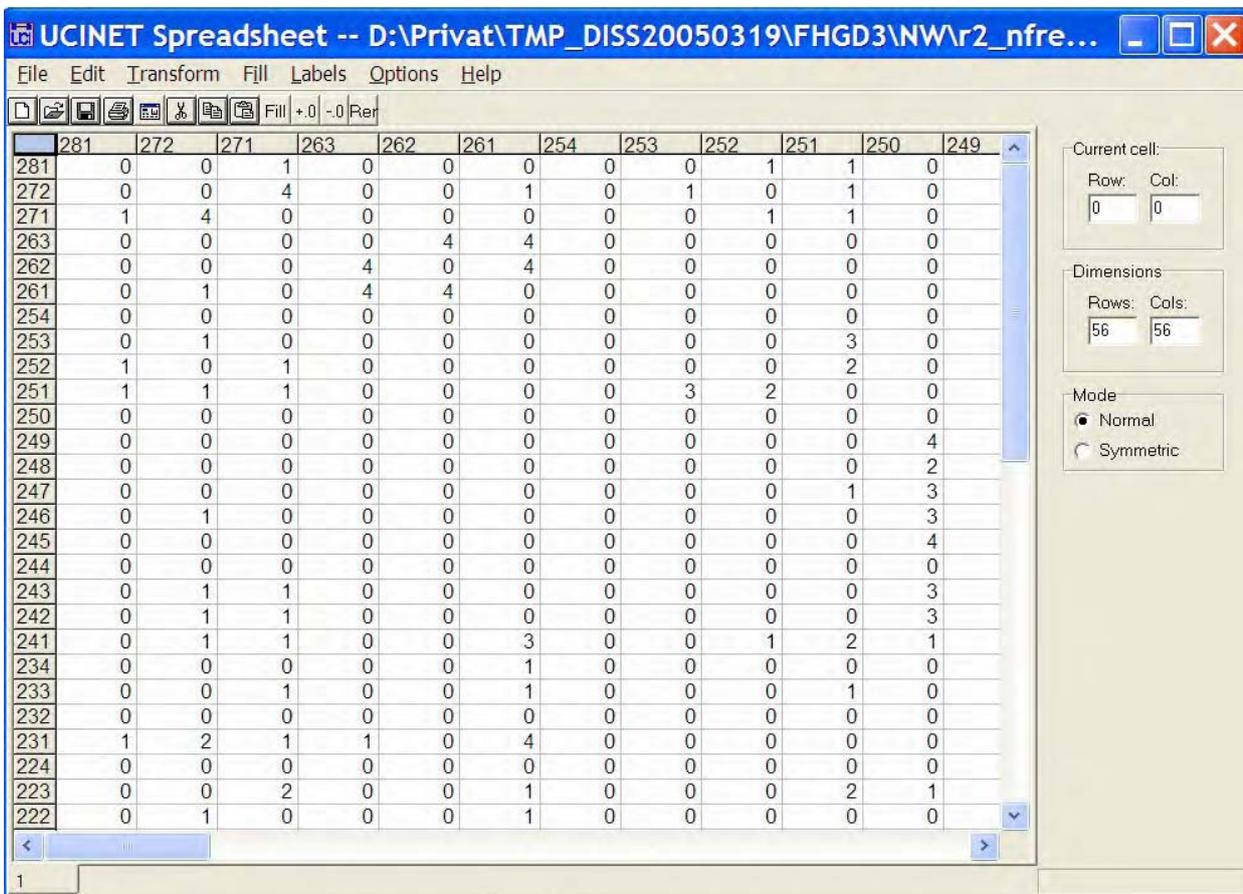


Figure 1: Adjacency Matrix in the UCINET Spreadsheet Editor

Making it Happen (The Approach & the Action)



Social network analysis, as understood here, is a method to improve knowledge sharing through analysis of positions and structures between people, i.e. their relationships. From an analytical point of view, it remains on a descriptive level. Nevertheless, the methodical steps and applications presented here go beyond a merely descriptive position of a neutral passive observer in that they provide suggestions for practical interventions and follow-up activities to influence network actors, their relationships, and network structure to improve communication of knowledge within and between individuals and organisations.

Network data is commonly analysed by use of software tools as mentioned above. Data analysis itself is complex and its explanation in detail goes far beyond the scope of this chapter. Here, only those network concepts and metrics are explained that play a central role for knowledge sharing in social networks within and between organisations.

The interpretation of results of a network analysis can be distinguished according to three different analytical levels:

1. interpretation of the whole network;
2. interpretation of clusters and components;
3. interpretation of individual positions.

For the case of knowledge sharing within social networks, three whole-network measures should be taken into account due to their basic relevance:

The *size* of a network is defined by counting its members (nodes). It is a basic property of a network – directly sharing knowledge between all members of a large network (e.g., between 100.000 employees of a multinational enterprise) would be extremely difficult compared to sharing knowledge between all members of a small network (e.g., within a research team).

Network centralisation is the global centrality of a network and measures the degree to which relationships within a network are focused around one or a few central network members. High network centrality means that knowledge flows within a network are dependent on few single nodes, i.e. removal of these network members means corruption of knowledge flows.

Density is defined as the total number of ties divided by the total number of possible ties. As a measure that is especially relevant for knowledge community building within and between organisations, density describes the overall linkage between network members.

Three basic types of network structures have been found in the literature and in the case study presented below to be central for processes of knowledge sharing:

Sub-groups and *clusters of expertise* are build through dense connections between sub-sets of network members. They are important for understanding the behavior of the whole network. For example, organisational sub-groups or cliques can develop their own culture toward knowledge sharing and their own attitude toward other groups.

Cut-points build bottlenecks for free flows of knowledge. They emerge when networks are split into loosely coupled components. Network members of pivotal significance in holding components together are also called bridges. While bottlenecks are critical to knowledge sharing within a network, too many links can lead to inefficiency of knowledge exchange. Therefore, links between sub-groups must be coordinated effectively and efficiently.

Hubs are enablers of effective knowledge transfer. As networks are clustered, some members are important as simultaneous actors in many clusters. These are known as hubs. They can effectively link different sub-groups of the network and facilitate knowledge flows, e.g.,

between different departments or to external resources. On the other hand, network efficiency can be strongly dependent on hubs, i.e. they provide a potential risk to the overall functioning of the network.

On the level of individual positions, the following roles and positional models of social network analysis are of primary importance with regard to knowledge sharing (see also figure 2):

Degree centrality is an indicator of expertise and power of network members. It measures the incoming and outgoing connections held by an individual network member. For non-symmetric data, incoming connections (in-degree) define the popularity of a member; those with many ties are members who are considered particularly prominent or have high levels of expertise. Out-degree defines the number of outgoing connections; a person with a high out-degree is considered particularly influential in the network. Thus, degree centrality is a measure that helps to purposefully support individual members in a knowledge network.

Closeness centrality shows the integration or isolation of network members. It measures the reachability of members by including indirect ties. Closeness centrality focuses on the distance of a member to all others in the network through means of geodesic distance and thus, determines a member's integration within the network. High closeness centrality indicates the greater autonomy of an individual person, since he or she is able to reach the other members easily (and vice versa). Low closeness centrality indicates higher individual member dependency on the other members, i.e. the willingness of other members to give access to the network's resources.

Betweenness centrality helps identify knowledge brokers and gatekeepers within a network. It is a measure of the extent that a network member's position falls on the geodesic paths between other members of a network. Thus, it determines whether an actor plays a (relatively) important role as a broker or gatekeeper of knowledge flows with a high potential of control on the indirect relations of the other members. In innovation and knowledge management literature, the role of brokers and gatekeepers is always stressed as being of overall importance and it is considered advantageous to identify gatekeepers, since they are performing a vital role in knowledge communication processes.

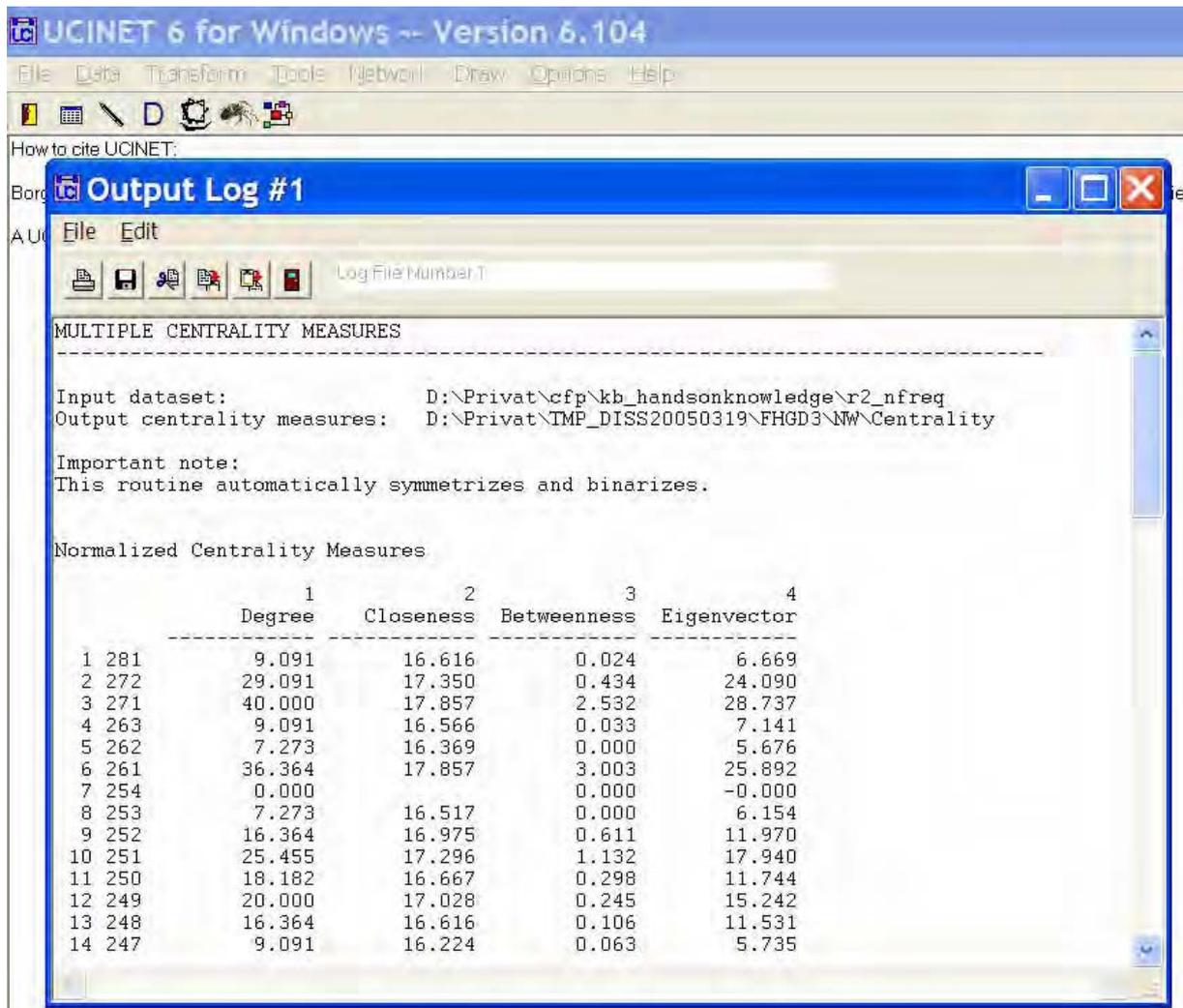


Figure 2: UCINET Screenshot of Centrality Measures

Strength and multiplexity of ties: Strength (or intensity) of communication relationships between members is commonly measured in terms of frequency of contacts. Focusing on the nature of linkages more closely, network members may maintain a tie based on one single type of relationship only or they may maintain a variety of relations. The latter is known as multiplexity of ties. Network multiplexity is the relation between the number of actual multiplex ties and the number of possible multiplex ties in a network. On the one hand, multiplex (strong) relationships share more intimate, voluntary, supportive and durable ties and thus, form a solid basis for trust. On the other hand, most people only share a small number of strong relationships, so that especially weak ties are a warranty for access to a large variety of resources (see the popular study about “strength of weak ties” by Granovetter 1973). With regard to communities of practice, the importance of multiplex relationships gives reason for various kinds of community building activities that are a prerequisite for shared identity, trust, and mutual understanding.

In addition, measuring the boundary-spanning character is of primary interest when analysing knowledge sharing within inter-organisational networks. As applied in the case study below, this can be done very easily by means of social network analysis. The *E-I index*, as formulated by Krackhardt and Stern (1988), simply measures the ratios between external ties (between different organisational units) and internal ties (within organisational units) and normalises them to a value with a range of -1.0 to +1.0. An E-I index of -1.0 would indicate that only internal relationships exist, while all relationships would be external for an E-I index of +1.0. The E-I

index provides not only a measure for the boundary-spanning character of inter-organisational networks (or of networks between organisational sub-units), moreover it can be used as an indicator of the identity of the network members, i.e. their internal or external orientation. It must be noted that there is no optimum value of the E-I index. The desirable relation between internal and external links is always dependent on the circumstances of a specific situation.

Results & Next Steps (The Follow-Up)



The method of knowledge network analysis as presented here aims at the analysis of network structures and positions within a clearly defined scope of analysis, i.e. a specific domain of knowledge. The interpretation of results based on the basic measures of social network analysis as outlined above must include the existing organisational conditions.

With a focus on knowledge sharing, interpretation of individual network members is of primary importance. Here, four different roles can be considered as being essential (Müller-Prothmann, 2006):

- *Experts* who have detailed and specific knowledge and experience within the domain of analysis. They have a central network position, mostly with a high number of external linkages.
- *Knowledge brokers* who have some knowledge of who knows what. They build bridges between different clusters of otherwise unconnected sub-parts of the network.
- *Contact persons* (or agents) who take a brokerage position in that they provide the contact with the experts without actively communicating the relevant knowledge themselves. They have an intermediary position between central (experts) and peripheral (consumers) network members.
- *Knowledge consumers* who ask for knowledge from the experts. They have a peripheral network position.

Given the positional and structural network metrics as well as the subsequent validation of the results and interpretation through the network members themselves, interventions and activities to improve network structures and relations for better knowledge communications can be derived and conceptualised.

As a result of a social network analysis that aims at leveraging knowledge sharing, interventions and follow-up activities may focus on

- development of personal competencies and expertise;
- integration of hidden expertise;
- exploitation of marginally connected members;
- promotion of cross-departmental knowledge transfer.

The examples outlined in the case study below will give some illustrative examples for interventions and follow-up activities.

Real Cases (As it has Happened)



Here, a real case illustrates the application of social network analysis as a method to support inter-organisational knowledge community building between research institutes of the Fraunhofer-Gesellschaft, a large German organisation for contract research in all fields of the applied engineering sciences. The study was undertaken due to concrete organisational needs and its results were used to provide practical solutions for interventions and follow-up activities (Müller-Prothmann et al., 2005).

Institutionalisation of knowledge transfer was studied with regard to the development of the informal contacts between the community members and the inter-organisational linkages on an aggregated level. The main focus was put on the relationships of knowledge exchange between the formal organisational boundaries and the informal inter-organisational network structures.

The Fraunhofer-Gesellschaft started activities for the sharing of expert knowledge by establishing a Knowledge Management (KM) Community with experts from all the different research institutes. Data for the network study was collected through two on-line surveys at different points in time, the first shortly after a community meeting in October 2004 (=t1), and the second at the end of February 2005 (=t2). 38 of 56 people answered the questionnaire in the first network survey (t1), which equals a high return rate of 67.9 per cent. In the second network survey (t2), 35 of 56 people participated, which amounts to a return rate of 62.5 per cent. Names of network members have been replaced by numbers, grouped by affiliation to the different research institutes (headquarters and 17 research institutes).

Expert knowledge communication and networking processes were evaluated by a multi-level approach. The patterns of communication structures between the community members were studied with regard to the following dimensions: (1) intensity and relevance of contacts between the members, (2) domain-related communication patterns, (3) use of information and communication tools, (4) importance of community activities with regard to general information exchange, transfer of specialised knowledge and expertise, joint projects and cooperation, and (5) relevance of community activities with regard to individual tasks of the community members and with regard to networking activities across organisational boundaries.

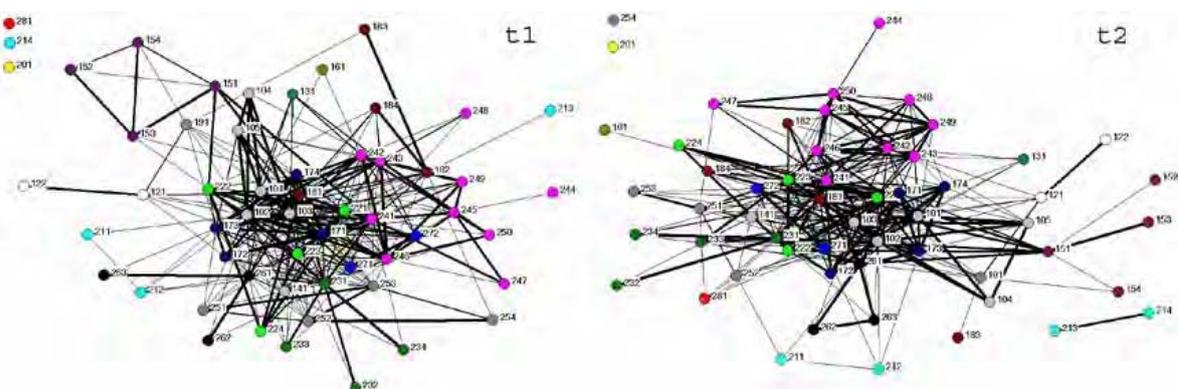


Figure 3: NetDraw Visualisation of Communication Networks in t1 and t2

The general communication network in t1 integrates all actors, except for three isolates. In t2, we can find a dyadic component and two isolates besides the main component (see figure 1). Network centralisation of the main component marginally decreases from 0.4672 in t1 to 0.4282 in t2 and density marginally increases from 0.4311 in t1 to 0.4585 in t2, both on a medium level. Indicated by the measure of the E-I index, internal linkages within the research institutes clearly dominate the external linkages between the different institutes, with a marginal shift to more

inter-organisational relationships from t1 to t2 (see table 1). The networks related to a specific domain include different actors and vary in size, density, and centralisation.

Table 1: E-I Index in t1 and t2 (isolates excluded)

	t1	t2
E-I index	0.532	0.546
expected value	0.856	0.862
re-scaled E-I index*	-0.455	-0.434

* For given network density and group size the range of the E-I index may be restricted and therefore it is re-scaled to a range from -1 to +1.

Findings suggest that community building may prove to be an effective measure to overcome organisational boundaries. The overall communication network integrates almost all members and specific domain-related network activities especially gained importance during the period of observation of approximately four months. Results of the network analysis can contribute to the development of clearly focused interventions to further facilitate the network relationships and strengthen the community building process across organisational boundaries.

Based on these insights, suggested interventions include

- better integration (or exit) of isolated and marginally involved members – or, alternatively, their exploitation in their role as “lurkers”;
- promotion of central members within the community and with regard to specialised topics as coordinators or moderators;
- putting a stronger focus on topics of primary relevance;
- strengthening domain-related core-groups by providing additional resources.

Various follow-up activities, based on the results of the analysis, were undertaken to further leverage the boundary-spanning knowledge community building process. The first very basic but nevertheless extremely useful kind of intervention was to present the results at a follow-up meeting and discuss them with the community members themselves. As Cross et al. (2002) wrote, simply ask people to spend five minutes on their network visualisations and “to identify what they ‘see’ in the map, the structural issues impeding or facilitating group effectiveness, and the performance implications for the group”. The presentation of results impressively demonstrated the integration of almost all community members, the primary role of a few central actors, and the strong connections established through a project of joint research, integrating a large number of members from different institutes.

The primary importance of joint projects as a driver to strengthen inter-organisational relationships, as highlighted by the results of social network analysis, led to the initiation of follow-up projects and extended acquisition activities. In addition, joint efforts were made to improve marketing instruments for the specification of the community’s profile.

The future agenda of follow-up activities based on the social network analysis could include developing rules of inclusion and exclusion. Results of the social network analysis also showed a prominent role of the headquarters for coordination and facilitation tasks of the community organisation. Since the community should become more self-sustained, members of the headquarters made efforts to successively withdraw their engagement as community coordinators. Selected community members from the various research institutes were encouraged to take more initiative on their own. Results of the social network analysis could help identify the key players from the research institutes within the community and to promote them as coordinators or moderators with regard to their specialised domains of knowledge.

Tips & Tricks (To-Do)



- ☑ Create personal involvement and organisational openness! Internal communication between involved people, involved departments, and other third parties during an early stage of the process is highly important to reach successful results of social network analysis.
- ☑ Provide information and make all involved people sensible for social network analysis! The target group, which is subject to study, and all other involved parties should be informed about the next steps and should be provided with basic background information and goals of analysis.
- ☑ Articulate the relevance and importance of social network analysis! Management on the middle and top level should clearly communicate strategic relevance of the network analysis for the whole organisation (or the organisational unit that is concerned).
- ☑ Facilitate straightforward actions! When personal involvement and the willingness to participate in the social network analysis is reached, it must be ensured that there are no other organisational or technical barriers that hinder straightforward actions. For instance, these include a questionnaire that is easily accessible in terms of technical aspects.

Potholes (Not-to-Do)



- ☒ Privacy issues: It is of primary importance to assure confidential handling of all data and to clearly communicate this confidentiality through the publication of privacy guidelines, for example. Confidential handling of data includes:
 - anonymisation of all personal data and analysis of de-personalised data only,
 - security of stored data,
 - authorisation and control for data access,
 - data analysis through confidential persons only.
- ☒ Existing concerns about exploitation of knowledge and expertise or negative sanctions: Social network analysis includes the description of the characteristics of individual network members like social behavior, influence, expertise, control, and power. Since the network analysis aims at improving knowledge sharing, the evaluation and assessment of the individual member and his or her preferences is definitely not the subject of analysis. Therefore,
 - Social network analysis should not be abused as a tool for evaluation and assessment of employees,
 - imposition of sanctions as a direct result from network analysis must be avoided,
 - communications should highlight (positive) outcomes and not individual mistakes.
- ☒ All concerns should be taken very seriously and met by means of active communication so that barriers can be gradually removed. Guarantee of anonymity, careful use of collected data, as well as privacy agreements are necessary preconditions to reach successful results.
- ☒ Finally, it always has to be considered that social networks dynamically evolve over time. Network structures and positions may rapidly change and, often, a social network analysis is nothing more than a snapshot. Nevertheless, it is a powerful tool to gain useful insights into social structures and processes of knowledge sharing.

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