5 Social Network Analysis as a Knowledge Management Tool – Methods and Applications

5.1 Introduction to Social Network Analysis

> Homo sapiens are about pattern recognition [...]. Both a gift and a trap.
> (GIBSON 2004 (2003): 23)

5.1.1 About the Approach of Network Analysis

Network analysis, as understood for our purposes, is a method to analyze people and their relationships. This approach aims at the description of structures and positions from a network perspective. This kind of network research describes relationships of interactions between network members, known as "actors",[52] like individuals or organizations through precise and subtle analysis that tries to avoid simplifications. This approach remains on a merely descriptive level (see also section 4.6.3). In the case studies presented here, network analysis is used in the descriptive-analytical tradition of this kind of approach. Nevertheless, the methodical steps and applications presented below 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 organizations.

5.1.2 Social Network Analysis as a Methodical Instrument

The method of social network analysis has become an established method of research in social sciences during the late 1970s and early 1980s, especially due to the foundation of the International Society of Social Network Analysis (INSNA) in 1978 by Barry Wellman and its journals "Connections" and "Social Networks", dedicated to social network analysis, as well as organizing the annual "Sunbelt International Conference on Social Network Analysis". Although a research method

[52] Social network analysts always talk of "actors" rather than of "members".

of social science, social network analysis has always been open to and strongly influenced by other disciplines and vice versa.

Following Scott (1991: 7-38), social network analysis has its origins in three main traditions of research. First, there are the two approaches from social-psychology of Kurt Lewin's field theory (Lewin 1936, 1951) and Jacob Moreno's sociometry (Moreno 1934). Both are strongly influenced by the tradition of "gestalt" theory (Köhler 1951 (1925)) in psychology which studies processes of small group dynamics. Moreno investigated inter-personal relationships in groups and their influence on individual behavior. His main innovation was the graphical representation of structural relationships in so-called "sociograms". While Moreno's research was rooted in a therapeutic orientation toward interpersonal relationships, Lewin's field theoretic approach aimed at studying group behavior and the influence of its surrounding social forces ("field" or "space" in which the group is located). He analyzed the properties and interdependencies between the group and its environment through mathematical techniques of topology and set theory. The insights of Moreno and Lewin have been systematically elaborated by Cartwright and Harary (1956) in the 1950s and integrated within the concepts of graph theory (formulated first by König 1936).

The second main line of social network analysis as perceived today is the exploration of patterns of interpersonal configurations and the formation of "cliques" developed at Harvard University during of the 1930s and 1940s. The major influences on this tradition were Radcliffe-Brown (1965 (1952)) and his research team (and, through them, Durkheim). They investigated the "informal relations" in large-scale systems (like organizations or cities, for example) and the phenomenon of sub-group or "clique" building. Their approach is strongly influenced by anthropology. In the classical Hawthorne studies of the 1930s (see Roethlisberger and Dickson 1947 (1939)), work teams were analyzed and results were presented in various sociograms. In 1939 already, the report of this study discussed results literally as insights into the "informal organization" (Roethlisberger and Dickson 1947 (1939)).

The third tradition of social network approach, also inspired by the research of Radcliffe-Brown (1965 (1952)), is the work of active field workers at the Department of Social Anthropology of the University of Manchester, among them John Barnes and Clyde Mitchell. During the early 1960s, they studied character and quality of individual relations in social systems, their reciprocity, duration, and intensity, emphasizing conflict and change instead of integration and cohesion. Their arguments were influential in Britain, nevertheless, it was in fact at Harvard that the real breakthrough occurred. Harrison White and his associates "produced a torrent of papers which firmly established social network analysis" (Scott 1991: 33). It was the public reception of Mark Granovetter's article "The Strength of Weak

Ties" of 1973, published in the American Journal of Sociology, that popularized the viewpoint of social network analysis and stimulated many other studies.

In addition to the origins of social network analysis as outlined by Scott (1991), the concentration on communication processes in networks adds another historical line of concept development: approaches of communication science (see also Schenk 1984: 270-317). Origins of network analysis in communication science can be found in the model of the two-step flow of communication by Lazarsfeld et al. (see Lazarsfeld et al. 1965 (1944): 151-152, Katz and Lazarsfeld 1955: 32-34). They found that interpersonal communication plays an important role for the diffusion of information through so-called opinion leaders. "The opinion leaders were found to be highly exposed to sources of information [...] outside their immediate community" while at the same time it is the same set of people "who attract organizational colleagues to them for consultation" (Allen 1977: 150). The underlying causality of this communication structure implies that people turn to a person with the expectation that he or she had the needed information and/or that this person, who obtains information from the outside, gains a reputation for "knowing the answers" and thereby attracts colleagues for consultation (see also Allen 1977: 150). Other variables that play a role include propensity of others to turn to him or her for information as well as administrative positions that encourage or deter this communication patterns (relationships between these variables were explored by Frost and Whitley 1971; Allen 1977). While the two-step flow of communication takes into account only direct relationships between a set of people (the opinion leader and others), this model was extended to more complex network structures that also take the indirect relationships of network actors into account.[53] Influences of the opinion leader model can be found until today in the discussions of brokerage and gatekeeper positions in network structures. Their basic assumptions date back to the model of the two-step flow of communication.

5.1.3 Social Networks and Knowledge Networks: Definitions and Basic Properties

Basically, a network is defined by its nodes and relations (see also section 3.5.2). Some authors add to these basic features of a network, as a further characteristic, the resources that are transferred between the actors through their connections. From this perspective, actors perform activities and control resources (see, e.g., Hakansson 1989: 17-22).

[53] Studies include the propagation of agricultural innovations as hybrid seed corn by Rogers and Shoemaker (1971) or the introduction of a new drug to community of physicians by Coleman et al. (1966).

Actors can be individuals, a group of people, an organization or organizational unit, an industrial sector or a societal sphere, for example. Activities are performed by the actors. According to Hakansson (1987: 15-16), there are the two main categories of transformation activities (carried out within the control of one actor and characterized by one resource being improved by the use of other resources) and those of transaction activities (linking transformation activities and creating relationships with other actors). Resources may consist of physical, financial, human, or social assets.

Pairs of actors are connected through ties. These ties can be directed or undirected and can be dichotomous or valued. A set of ties of a given type constitutes a binary social relation. Each relation defines a network from the given type. According to Scott (1991), Barnes (1974) introduced the distinction of two approaches to social network analysis: ego-centric versus socio-centric concepts. Ego-network analysis puts its focus on a single focal actor ("ego") and his or her ties to other actors ("alteri"). This approach seeks to "anchor social networks around particular points of reference" (Scott 1991: 75). Socio-centric concepts put their focus on the pattern of relationships in the network as a whole (they are also known as whole-network analysis).

Using graph theory, a sociogram visualizes networks and their structures. It consists of "nodes" (or points), representing individual network members, and "ties" (or lines), representing the connections between the members (relations). Formally, graphs are defined as a set of actors (g - nodes) and a set of their defined relations (l - lines). The set of actors N is defined by the nodes $\{n_1, n_2, n_3, \ldots n_g\}$. These graphs clearly record and visualize social relationships (see figure 5.1).

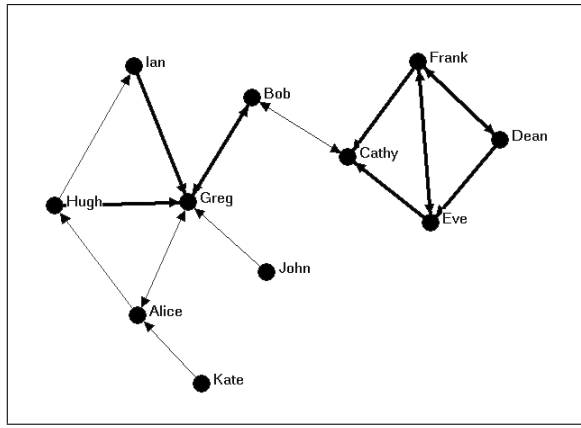

Figure 5.1: A Graph of Social Relationships

	Alice	Bob	Cathy	Dean	Eve	Frank	Greg	Hugh	Ian	John	Kate
Alice	0	0	0	0	0	0	1	1	0	0	0
Bob	0	0	1	0	0	0	2	0	0	0	0
Cathy	0	1	0	0	0	0	0	0	0	0	0
Dean	0	0	0	0	2	2	0	0	0	0	0
Eve	0	0	2	0	0	2	0	0	0	0	0
Frank	0	0	2	2	2	0	0	0	0	0	0
Greg	1	2	0	0	0	0	0	0	0	0	0
Hugh	0	0	0	0	0	0	2	0	1	0	0
Ian	0	0	0	0	0	0	2	0	0	0	0
John	0	0	0	0	0	0	1	0	0	0	0
Kate	1	0	0	0	0	0	0	0	0	0	0

Table 5.1: Adjacency Matrix of Social Relationships (as visualized in the graph of figure 5.1)

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 persons, the columns of the array represent the same set of persons, and the elements represent the ties between the persons (so-called "adjacency matrix"—see table 5.1). Ties can exist or not exist, and ties can be dichotomous (0 or 1) or valued (e.g., 0, 1 or 2). Matrices are also used as data input for social network analysis processing.[54]

Here, we put our focus on knowledge networks. Following the definition of (social) network given above and in section 3.5.2, a knowledge network is a set of actors, with the characteristic of attributes and relations that focus on a specific domain of knowledge (see also section 3.5.5). Relationships of members within knowledge networks primarily consist of communication and their resource is information, knowledge, or expertise. Therefore, we can define knowledge networks as a set of individual people with regard to knowledge communication within a specified domain of knowledge. From this perspective, the interactions that are subject to analysis of knowledge networks are the flows of knowledge between the actors, based on communication. From a given set of actors, these interactions may exist or not. The role of social networks for knowledge communication within and between organizations has been found to be important through various empirical studies (see the references mentioned in section 5.2.1), and their importance was also stressed by the participants of the expert survey as outlined in sections 2.4, 3.2, and 4.2. Here, it is argued that social network analysis can serve as a proper method to analyze informal communication of knowledge and, thus, help to localize expertise and transfer knowledge.

[54] For an introduction to graph theory and the use of matrices in social network analysis see, e.g., Scott (1991: 39-65) or Hanneman (2001: 2-4, 26-36).

Tichy et al. (1979a: 508) systematize the properties of networks according to their (1) transactional content, (2) nature of links, and (3) structural characteristics. A characterization of knowledge networks basically stresses the dimension of transactional content as the exchange of information and knowledge. Nature of links (like intensity, reciprocity, or multiplexity) and structural characteristics (like size, density, clustering, openness, stability, reachability, centrality, or brokerage) are subject of the network analysis and outlined in detail in the sections below.

5.1.4 Basic Network Structures

Monge and Eisenberg (1987: 312-317) distinguish (1) network articulation and participant roles, (2) levels of analysis, (3) content of linkages, (4) properties of linkages, and (5) individual and network metrics.

"Network articulation is the process of identifying the various component parts of the network" (Monge and Eisenberg 1987: 312; with reference to Farace and Mabee 1980) which consist of (1) the groups or clusters that make up the network, (2) the individuals who connect the clusters, and (3) the people not highly involved in the network, i.e. who are marginally linked through indirect relationships only and, thus, who do not belong to a group or connect groups). Among a variety of role typologies in network research, the roles of network participants that are commonly distinguished are (1) group member, (2) group linker, and (3) isolate. Often, the role of a "star" is added, which is a network member who has significantly more linkages than most others in a network (e.g. Tichy et al. 1979a). Another prominent typology of network roles, concentrating especially on the various kinds of brokerage roles, is the distinction between so-called gatekeepers, liaisons, opinion leaders, and cosmopolites (see Rogers and Agarwala-Rogers 1976: 133-140).

"The content of a linkage is important in that it defines what flows between people, that is, it specifies the nature of the network" (Monge and Eisenberg 1987: 314). Several typologies can be found in the literature. For example, Tichy and Fombrun (1979b) propose four major types of content: (1) exchange of goods, (2) affect and liking (expressive), (3) information and ideas (cognitive), and (4) influence and power (prescriptive). In their study of communication linkages in organizations, Farace et al. (1977) distinguish three types of messages: (1) production, (2) innovation, and (3) maintenance (as cited by Monge and Eisenberg 1987: 314). Since we put our focus on knowledge networks, exchange and communication of information and knowledge within innovative environments are the basic constituents of the networks studied here.

Commonly, three major properties of linkages are identified by network analysts: (1) strength or intensity, (2) symmetricality, and (3) multiplexity. Moreover, some authors make the important distinction between symmetricality and

reciprocity: "While symmetricality focuses on the definition of the relationship, reciprocity centers on the degree to which two people agree about the existence or strength of the linkage" (Monge and Eisenberg 1987: 315).

For a pragmatic adaptation of social network analysis to suit practical needs, the focus here is put on a small selection of very basic, although highly meaningful properties for the analysis and facilitation of knowledge networks. The exploration focuses on selected crucial issues key to understanding knowledge flows of networks.

The basic concepts introduced here, then, are those of network members and their relationships, clusters, and cut-points:[55]

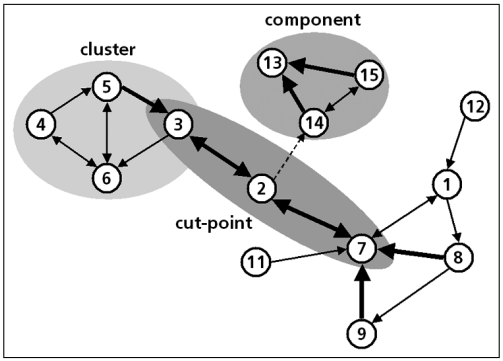

Figure 5.2: Basic Network Structures

- *Network members and relationships:* Social network analysis perceives social structure as the pattern organization of network members and their relationships. Network data are defined by the members of the network and their relation. Ties between members of a network are characterized through direction (directed and undirected ties, represented by arrows in figure 5.2) and intensity (weak and strong ties, indicated by strength of lines).
- *Cliques and clusters:* Sub-sets of members can build dense connections and develop cohesive sub-groups of the network (like for example the members 3, 4, 5 and 6 in figure 5.2). These are known as cliques and clusters (Watts and Strogatz 1998).
- *Cut-points:* Persons of pivotal significance in holding components or individual actors together are called cut-points or bridges. Cut-points are central

[55] For a comprehensive introduction to social network analysis and its analytical concepts see, e.g., Scott (1991) or Hanneman (2001).

nodes that provide the only connection between different parts of the network (like, e.g., members 1 or 2 in figure 5.2). They build bridges between sub-groups that would otherwise have been cut-off and split into separate, unconnected components or actors (like the members 13, 14 and 15 in figure 5.2). The weak connections between these groups of densely connected actors are called structural holes (like member 2 in figure 5.2; see also Burt 1992).

- *Hubs:* As networks are clustered, some members are important as simultaneous actors in many clusters (see figure 5.3). These are known as hubs (Kleinberg 1999; Rosen 2000). As Barabási (2003: 61) puts it, these persons "have played in very different genres during their careers".

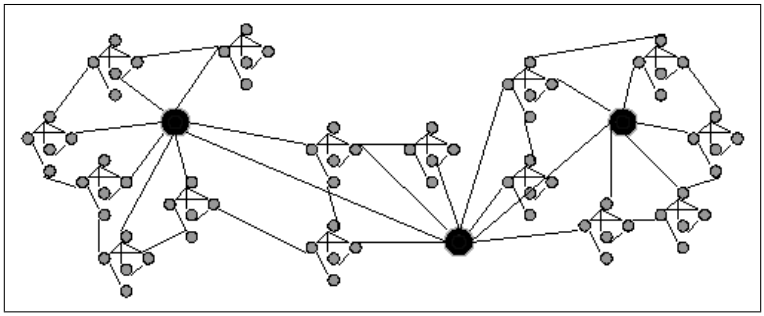

Figure 5.3: Hubs

5.2 Social Network Analysis as a Knowledge Management Tool – Method Development

> Creativity is not an inherent quality of a person, process, product, or place. Rather, it is a domain-specific social construction legitimized by judges who serve as gatekeepers for a particular domain.
>
> (FORD 1995: 353)

5.2.1 Aims of Application

A variety of literature examines informal networks and communities and their role in knowledge and innovation management (see, e.g., Armbrecht et al. 2001, Brown and Duguid 1991, Collinson and Gregson 2003, Jain and Triandis 1990, Lesser 2001, Liyanage et al. 1999, Mertins et al. 2003, Nahapiet and Ghoshal 1998, Wenger 1999, Zanfei 2000). Discussions of network structures in management literature were strongly influenced by Drucker (1989) and Savage (1990). All of these authors stress the importance of networks for knowledge sharing. Organizations that develop networks both internal and external to their organization are supposed to be able to deal with knowledge more effectively (see, e.g., Kanter 2001).

Networks can be distinguished according to their level as between individuals, groups, communities, organizational units (departments), organizations (companies), collectives of organizations, or even between societies. Discussions of the role of networks in knowledge management and communication tend to stress the importance of informal networks (as opposed to formalized networks). Often, networks are viewed in the context of knowledge management as an activity, that of "networking" (see, e.g., Seufert et al. 1999a,b; see also section 4.5.1).

Even so, despite all of the literature that identifies communities and networks as effective environments for the sharing of personal knowledge, there is a lack of systematic methods for practical use to identify knowledge communities and networks, to analyze their structure and to take measures to actively support them. The next sections present basic methods and steps for the application of social network analysis as a method for expert localization and knowledge transfer as well as models of interpretations and ways of interventions. It argues that social network analysis provides a rigorous analytical foundation for the implementation of practical methods in knowledge communication and management for analyzing informal communities and networks.

The primary importance of informal communities and networks in knowledge management has become widely accepted as outlined in the previous sections

(see chapter 3). This shift of focus toward a social perspective as the dominant paradigm in studies of knowledge communication and management, outlined for the case of academic networks in the early 1970s already (called "Invisible Colleges" by Crane 1972; see also Merton 1974 and section 4.4.1) takes into account that the majority of individual knowledge transfer does not follow formal hierarchies or processes but is instead driven by personal and informal communications. Such a social constructionist view of knowledge exchange (see also McDermott 2002; Wersig 2000) considers single individuals as well as social aggregates and their structural patterns. This demands a set of appropriate tools and methods to analyze personal relationships and flows of informal knowledge exchange. In the following sections it is argued that social network analysis is a highly effective tool not only for the theoretical conceptualization of knowledge networks but also for the empirical localization of informal expertise and facilitation of sustainable knowledge transfer. Thus, social network analysis is seen as a valuable contribution to a wider set of practical methods for the implementation of knowledge management.

As outlined above, social network analysis is a sociological method to undertake empirical analysis of the structural patterns of social relationships in networks (see also Scott 1991; Wasserman and Faust 1994; Wellman 1988). It lays the foundation for developing a methodical knowledge management tool to help us identify, visualize, and analyze the informal personal networks that exist within and between organizations (see also, e.g., Cross et al. 2002a; Cross et al. 2002b). The steps outlined below provide an adaptation of social network analysis to suit practical needs as a strategic tool for expert localization, identification of knowledge communities and analysis of the structure of intra- and inter-organizational knowledge flows.[56] Based on social network analysis, this method evaluates availability and distribution of critical knowledge (core competencies) and facilitates

- the strategic development of organizational knowledge,
- the transfer and sustainable conservation of implicit knowledge,
- the development of core competencies (like leadership development),
- the creation of opportunities to improve communication processes,

[56] With regard to results from case study 1 (pre-test study): "Leveraging Organizational Expertise" (see 5.4), the adaptation of social network analysis for practical purposes of analysis and facilitation of knowledge transfer within and between organizations and the outline of guidelines and approaches to interpretations was developed as part of the project "Wachstum mit Wissen" (economic growth through knowledge), sponsored by the German Federal Ministry of Education and Research (BMBF), at the Fraunhofer Institute for Production Systems and Design Technology (Fraunhofer IPK), Berlin, in co-operation with the author at the Department of Information Science, Freie Universität Berlin. In a previous publication, this methodical approach was given the acronym *SELaKT* for *S*ustainable *E*xpert *L*ocalization *a*nd *K*nowledge *T*ransfer (see Müller-Prothmann and Finke 2004a, Müller-Prothmann and Finke 2004b).

- the identification and support of communities of practice,
- the harmonization of knowledge networks (for example, after mergers and acquisitions),
- the sustainable management of relationships between distributed sites and external partners.

5.2.2 Fields of Application

The influence of the individual worker on the performance of an economic enterprise is undoubted since the beginnings of industrialization. Early management and business analysts like Frederick Winslow Taylor or Henry Ford focused on the optimization of manual interaction processes, whereas today personnel managers and analysts are concerned with the task to optimize social interactions and thus, particularly, communication processes. Allen's study of 1977, already repeatedly cited in previous sections, concluded that people prefer to discuss questions and ideas with friends and colleagues instead of making use of other (impersonal) information resources.

Particularly in research and service organizations, where the members' innovative potentials, creativity, and abilities for self-organization play an important role, it is of primary importance to pool individual competencies and resources and to create synergetic effects and co-operations. Therefore, knowledge about potential competencies and individual resources, facilitation of existing personal relationships, and co-operation activities, 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 interpersonal relationships.

Studies of organization culture or opinion polls of employees can only indirectly point to possibilities of interventions, for example, whereas the analysis of personal knowledge networks provides more detailed information about informal social relationships. This way, from a social network analysis we can derive new insights for possibilities of interventions to influence structures and processes of interpersonal communication design. The mere visualization of social relationships can be viewed as a process of intervention already in that it makes the people realize their formerly unconscious relationships with others and their importance. Often, this measure alone triggers a careful pondering on relevance of personal relationships of the involved people.

Although the importance of informal relationships within organizations has been subject to academic research for a long time already (see section 3.1.4), the recent demand for methods and tools to analyze and actively leverage and influence informal relationships is a relatively new phenomenon. On the one hand it is a result

of an increasing realization of the importance of informal personal relationships within and between organizations, on the other hand it is a logical consequence of the recent trends of the reduction of hierarchical levels toward flat hierarchies and flexible, team- and project-based settings.

Usually, informal personal relationships emerge ad hoc, i.e. accidentally and spontaneously, and evolve over time. These networks influence work performance, decisions and decision-making processes, knowledge sharing and, thus, overall efficiency and effectiveness of an organization (see sections 3.1 and 4.3). Without any doubt, there is indeed a need to analyze existing social networks, to understand their relationships and functions and to search for means and measures to facilitate, leverage, and enable successful knowledge communication within these networks.

To illustrate its usefulness on some examples here, a social network analysis of a given set of people can provide answers to questions such as: Are all people within a team or any organizational unit well connected with each other? Who is excluded and, thus, does not allow for the exploitation of his or her knowledge for the other network members? Who has the central position(s) within a network? Are there any sub-groups within the network? Are there any components of the network that are not connected with the larger network? Of what kind are the connections between the organizational network to external resources?

Results of social network analysis are of a descriptive nature (see also section 4.6.3). Formal methods allow for precise measures, visualizations allow for illustrative description. Thus, social network analysis provides basic means to evaluate character and efficiency of knowledge communication as influenced by network structures and performance. With regard to knowledge management projects, social network analysis can also particularly be used to identify experts within certain domains of specialized knowledge.

Results of social network analysis can help to identify or facilitate so-called communities of practice (although community concepts within organizational settings must be considered with care, see section 3.5). Experts can be identified and enabled to act as central brokers and disseminators of useful information and knowledge. Results of social network analysis can contribute to decisions on personal competence and leadership development. Outsiders can be identified and supported in such a way that they are better integrated in teams and projects. Barriers of knowledge flows can be uncovered and interventions for their removal can be introduced. Furthermore, knowledge about social network structures may contribute to realize efficiency loss through hierarchical structures or through a lack of hierarchical power.

5.2.3 Multi-level Social Network Analysis

Literature on organization and management theory distinguishes between individuals, organizations, and their environments with clearly defined demarcation lines. These clearly defined demarcations do not take into account that "[o]rganizations are *in* environments, and environments are *in* organizations, penetrating them through the personal networks of boundary spanners and other members" (Dubini and Aldrich 1991: 306, with reference to Aldrich and Herker 1977; Weick 1979). The network perspective helps to depict and analyze the patterned relationships between individuals, groups, organizations, and their environments. Although network analysis mostly is a snapshot of network actors and their relationships at a certain point in time (see also section 4.6.3), the inclusion of a process perspective in the empirical and theoretical framework takes stabilization, change, and breaking up of relations and structural patterns into account.

In theory, network models as well as entrepreneurial networking activities should "weave a seamless web in which the distinction between individuals, organizations, and networks are blurred or even ignored" (Dubini and Aldrich 1991: 306). Although in practice, of course, it is most often necessary to create a language and clearly defined terms for keeping track of the distinct levels of separation and aggregation and their contexts. We must discipline our thinking when we shift between individuals, groups, organizations, and environments: "Thus, we distinguish between personal networks—centred on focal individual—and extended networks, focusing on collectives" (Dubini and Aldrich 1991: 306).

The analysis of social networks can distinctively focus on the different levels. Burt distinguishes between (1) the personal level, (2) the clique level, and (3) the overall network level (see Burt 1980a). With a focus more oriented toward organizational knowledge communication, we may add (4) the environmental (or inter-organizational) level (as introduced by Tichy et al. 1979a; Tichy 1981). Social network analysts talk of multi-level analysis when they analyze the different levels with their corresponding actors and relations. Especially when studying organizational communication processes, multi-level social network analysis helps to identify knowledge flows, their enablers, and their barriers on the different levels of individuals, groups, organizational units, organizations, industries, etc.

For the purposes of this study, the author proposes a multi-level approach that focuses on the three levels with different degrees of aggregations:

- *micro-level:* networks of individual people as actors and their relations;
- *meso-level:* networks of organizational units and organizations, enterprises, and other formal organizations as actors and their relations;
- *macro-level:* networks of corporate actors, industries, or other societal spheres of high-level aggregations as actors and their relations.

5.3 Application of Social Network Analysis as a Knowledge Management Tool – Basic Steps

> Many creativity researchers and consultants typically have treated creativity as an individual trait and have underestimated its social and organizational components. [...] In contrast, we believe that organizational creativity, which emphasizes social and group creative processes, will be a key factor in corporate success in the future, particularly in industries with complex, changing business environments.
> (CSIKSZENTMIHALYI AND SAWYER 1995: 167)

5.3.1 Basic Steps and Conditions of Application

The application of social network analysis for the examination of organizational knowledge communication as proposed here is divided into seven different steps. These primary steps of the application process include:

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. analyzing the data through formal methods of social network analysis,
6. interpreting the results of analysis,
7. designing interventions and taking actions.

Although these procedures are common methodical steps of network analysis, or even of empirical social research in general, the examination of knowledge communication in social networks shows some very special requirements that are subject to discussion in this section and the outlines below.

Here, the focus of the adaptation of the method of social network analysis is put on the successful integration of specific organizational conditions and requirements into the methodological process. The research of social network analysis puts its focus on inter-personal relationships. Due to this subject of analysis these kinds of studies are very complex. To assure application of social network analysis and to make the analysis successful, it is absolutely necessary to take into account some basic conditions during the stage of conceptualization and strategic development of the examination. Above all, basic conditions include (1) issues concerning the needs to undertake a social network analysis and (2) the fact that participants

always anticipate certain results which in return may influence the methodical process itself.

1. *Needs, objectives and reasons:* Clarification of objectives and definition of scope of analysis means to explore the interests, challenges, or difficulties that we find in an organizational setting. Explanation of objectives and underlying reasons and the consideration of personal, organizational, and cultural conditions are very important primary steps to successfully undertake a social network analysis. Reasons can be, for example:

    - strategic considerations by ex ante definition of critical knowledge domains,
    - lack of expert knowledge, or expertise is not available where it is needed (because of lack of transparency or inefficiency of knowledge communication, for instance),
    - studies on the distribution of personal knowledge along the process chain,
    - foundation or facilitation of communities of practice,
    - visualization of networks to foster team development or the merger of originally independent departments or business units.

2. *Anticipation of results by the participants:* Since social network analysis focuses on inter-personal relations, it is of critical importance to take the fact into consideration that involved participants always anticipate certain results before and during the process already. This is a very controversial issue. From an organizational perspective, for example, it seems reasonable to achieve as much transparency as possible on competencies and expertise of the organization's members. But, for almost all cases, measures to increase transparency are paralleled by general concerns about violations of privacy. This makes it necessary to precisely define objectives and communicate the benefits of a social network analysis to all involved parties (see also Mei et al. (2004) and section 5.3.6 below). It is very helpful to the situation when everybody who is involved specifically sees his or her own benefits.

5.3.2 Creation of Personal Involvement and Organizational Openness

The factors outlined above have to be considered during the design of the process of analysis and are met by means of internal communication and motivation for participation as integral parts of the adaptation of the method of social network analysis. 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. This continuous communication process has to be designed from the perspective of the recipients. It should address the determinants of behavior of the recipients known from psychology (see Rosenstiel 1997: 201-202; Rosenstiel and Koch 2001: 200):

- *Provide information and make all involved parties sensible for the network analysis!* The target group, which is subject to study, and all other involved parties should be informed about the coming steps and should be provided with basic background information and goals of analysis. This means that the reasons for the network analysis should be actively communicated to meet objections and reservations of the participants in advance. It is advisable to inform about (1) existing deficits, (2) the measures taken to systematically analyze them, and (3) intended steps to eliminate them. The participants must not be informed about every single detail and all strategic goals that are intended with the performance of a network analysis, but it is very helpful if each participant knows that it makes sense to perform a network analysis and that the basic method is easily and rationally comprehensible for everyone.
- *Articulate the relevance and importance of the network analysis!* Management on the middle and high level should clearly communicate strategic relevance of the network analysis for the whole organization (or the organizational unit that is concerned). Use and contribution to improve quality of the results to reach more efficient knowledge flows must be articulated and integrated within the overall strategic organizational orientation. Every individual manager plays the important role of a disseminator of information, multiplicator of internal communication and targets, and creator of personal involvement with regard to his or her subordinates.
- *Produce personal concern for and reduce reservations against the network analysis!* Taking the individual (rational) understanding for the need of a network analysis as the starting point, it is necessary to evoke the personal involvement of all participants. This can be done by simply asking questions and providing possible answers like the following: How do the existing organizational deficits influence my own tasks and what problems do they cause for my everyday work? How can a network analysis help tackle these problems and provide personal use for me and my work in the future? Highlighting individual use allows for the identification of the individual with the overall goals and fosters intrinsic motivations for participation. Existing concerns, like the fear of absolute transparency, i.e. the introduction of the employee who has no secrets, concerns about privacy issues or exploitation of expertise and informal contacts 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 and results, and agreement of the workers' council or other institutions who safeguard personal interests of the employees are essential elements for the establishment of individual involvement. Moreover, contact persons should be clearly named who can be addressed by all participants for feedback, suggestions, and questions.

- *Facilitate straightforward actions!* When personal involvement and the willingness to participate is reached, it must be ensured that there are no other organizational or technical barriers that hinder straightforward actions. These include a questionnaire that is easily accessible in terms of technical aspects as well as the survey items themselves.

Taking these considerations about the network members as a starting point, means and measures of communication management can be adjusted according to the objectives defined above. A communication process that accompanies the network analysis could in a prototypical situation include the following steps and activities:

1. Communication activities before data collection and analysis:

    - *Announcement and information:* Managers give background information about the planned study to all selected participants through circular emails or letters and announce furhter steps. Key people on the middle management level are provided with more detailed information to gain deep personal involvement and are integrated as disseminators of information through management meetings and personal discussions. Top management announces the network analysis to all participants and requests participation.
    - *Instruction leaflet for the middle management:* The middle management level is provided with an instruction leaflet containing detailed information about the process and potentials of the network analysis. Contact information of the project team is included for feedback.
    - *Invitation to participation:* The project team refers to the announcement of the top management, relevant details are provided in the form of a flyer and instructions are given for participation in the survey. They include a final deadline and a reminder. To get instant replies, it can be considered to give some sort of incentive for the first people who answer the questionnaire.

2. Communication activities after the analysis of results:
    - *Participant feedback:* The participants are provided with a summary of selected results. Additionally, they may be invited to a follow-up workshop.
    - *Workshop(s) (optional):* All participants, sub-groups of participants, or selected individuals may be invited to attend workshops where strengths and weaknesses of knowledge communication as identified through the network analysis are discussed. Then, possible solutions and further activities are developed and discussed together.
    - *Management feedback:* Results of the analysis are provided as a management abstract and as a detailed report to the client and the higher management level. Feedback may include additional results from the follow-up workshop(s). All results taken together, recommendations for interventions should be derived, discussed with the management, and, finally, put into guidelines of recommendations for concrete follow-up activities.
    - *Final information (optional):* All participants (as well as all other members of the organization or of the relevant organizational unit) are informed about (selected) results of the network analysis. These include a thank-you letter to all involved participants for their contribution to the overall goals of the network analysis.

This prototypical communication process design must be adjusted according to the concrete needs and, especially, according to the specific communication processes and culture given in a concrete organization. Generally, it is recommended to make use of the existing communication structures and the personal involvement of key leaders. In addition to the primary steps outlined above, it can prove to be useful to promote the analysis for example in an existing periodical newsletter, to discuss it at the meeting of the workforce and, thus, to gain the attention that is needed and to make the importance of the issue clear. Lacking formal communication channels can be compensated by use of neutral, even external communicators, as, for example, the central communication department or the network analysis project team itself.

5.3.3 Definition of the Analytical Scope

For purposeful examination of networks, the scope of analysis must be clearly defined. The analytical scope might be defined by existing problems within a concrete domain of knowledge. Needs for undertaking a 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 and competitive

force. But often, the domain of knowledge that is subject to analysis will be not precisely defined from the given task alone. The following questions, that must be addressed to managers and experts from the client organization, should help to identify the specific knowledge domain and, thus, to define the scope of analysis:

- What are your main tasks and topics that are relevant to your daily work and that are critical to your success?
- What specific knowledge is essential to solve these tasks?
- What are the core competencies of your organization?
- What specific knowledge is essential to maintain and expand your organizational competencies?
- What knowledge and expertise do you need to solve a specific problem?

These questions will lead to a collection of topics and domains of knowledge. They should be discussed in more detail with the experts and, additionally, with external consultants to identify further topics, knowledge domains, and critical issues for future development. Then, the focus is put on a specific domain of knowledge that will provide the scope of analysis. This domain of knowledge should should be identified as being

- critical to the overall success of the organization,
- highly relevant for the organization or organizational unit that is subject to analysis,
- characterized through high degrees of expertise, i.e. personal and tacit knowledge,
- distributed throughout the whole organization.

5.3.4 Conceptualization of the Survey Methodology

In the majority of cases, social network analysis uses surveys for the collection of data. Examples of other methods for the application of social network analysis are citation analysis, analysis of email communication, and data collection from all kinds of available resources. Analysis of knowledge communication within and between organizations should also make use of all available resources that are suitable to identify social relationships with regard to the defined goal. Basically, this can be done through

- surveys and expert interviews,
- gathering of other relevant documents, e.g., meeting protocols, publications,
- email tracking,
- observations.

Here the focus is primarily put on surveys as a method for data collection, supplemented by information from other documents and written resources, since observations are very time consuming and email tracking is quite problematic due to (1) the focus on only one channel of communication, which makes additional surveys necessary, (2) technical difficulties in heterogeneous environments as often found due to a variety of email-clients within an organization, and, above all, (3) serious privacy problems.

Experience shows that on the one hand surveys within organizations tend to be used as an instrument to gather as many information as possible, i.e. to ask numerous questions, while on the other hand people are little motivated to participate and, moreover, motivation for participation of course decreases with the number of survey items. This makes it necessary to match both sides. People should not be overstrained by a large number of survey items or questions that are difficult to understand, while a the same time all information that is necessary for analysis must be collected properly.

Without focusing on the concrete domain of analysis, selection and wording of questions for the survey and conceptualization of the questionnaire are essential for the success of network analysis. The conceptual procedure generally consists of the following steps (given the target and scope of analysis as outlined above):

1. generation of ideas and collection of assumptions,
2. identification of relevant dimensions,
3. operationalization of the relevant dimensions as concrete survey items,
4. production of the questionnaire,
5. pre-test, and modifications if needed,
6. realization of the survey.

The generation of ideas aims at collecting all relevant ideas and assumptions with regard to the goal of analysis to refine the scope of analysis and more precisely define the domain of knowledge. This stage should also help to gather background information of the organization that is helpful for the examination. Approaches and methods for idea generation include brainstorming, interviews with managers, experts, and other highly involved people.

The identification of dimensions aims to clearly define the subject of analysis in detail with its relevant dimensions. Identified dimensions should be discussed with people who are experts with regard to the several dimensions and the domain of knowledge that is subject to analysis. Identification of dimensions helps to operationalize the domain of knowledge as concrete survey items. Relevant dimensions for the examination of knowledge networks are for example: knowledge about processes, projects, experts, co-operation partners, specific topics, key people. It has to be assured that all relevant dimensions have been considered.

Operationalization is the concretion of identified dimension into specified survey items. Survey items that are typically used for the analysis of knowledge networks are, for example, questions about seeking and giving advice, naming of experts, contact persons, use of communications channels, and frequency of communication. The questionnaire should be tested with selected participants (pretest) and, then, be modified if needed.

When the conceptualization of the questionnaire is finished, a suitable method for the survey has to be found. This can be a written survey, on-line or email survey, interviews, and all other known kinds of survey methods. The selection of an appropriate method should depend on the culture given within a specific organization to ensure as much feedback as possible.

5.3.5 Identification of Network Members

For the analysis of whole networks, all members of the network, known as "actors", must be identified. Identification of network members is made by the use of specific attribute data (like organizational membership, specific domain of knowledge, for example) that defines inclusion of network members (see also sections 3.5.2 and 3.5.5). For analytical purposes, this step also defines the network's boundaries for empirical study. Nevertheless, the real network relationships may go beyond the network boundaries and include additional actors who are not part of the study (on the limits of social network analysis as an empirical method and especially the boundary specification problem see also section 4.6.3). The identification of the members of the network is closely related to the defined scope of analysis. In some cases, the scope of analysis clearly defines the network members already. Common criteria to define the set of network actors who are subject to study with regard to intra-organizational analysis are:

- boundaries of the complete organization, e.g. company,
- boundaries of the organizational unit, e.g. divisions, departments,
- boundaries according to other formal criteria, e.g. projects, teams, clusters,
- geographical boundaries, e.g. national divisions, locations.

Other criteria for the inclusion of network members, including inter-organizational analysis, are, for instance (see also Jansen 1999: 65):

- participation in relevant activities, e.g. meetings, (formal or informal) groups,
- selected characteristics of participants, e.g. people with a certain expertise within a specific domain, people of a certain hierarchical or functional position,
- certain relationships according to a defined criterion, e.g. people who talk with each other at least twice a week.

These approaches to identify the network members are all positional, i.e. the participants are sampled "from among the occupants of particular formally defined positions or group memberships" (Scott 1991: 58). The set of network actors is defined by means of a distinctive attribute of network nodes for selective purposes (see also section 3.5.2). The positions or groups which are of interest are identified in a first step and, then, their members are sampled in a second step. This approach seems to be most useful for organizational network studies.[57]

Another method to identify network members is the reputational approach, where a list of nominees is produced by knowledgeable informants. One prominent variant in social network analysis is the "snowballing" technique, where a small number of participants is studied and each is asked to nominate others for study, who are in turn asked for further nominations. Here, the set of actors is defined by their relationships, and network boundaries are defined by closure (i.e., no new members are named by the participants) or network boundaries are arbitrarily defined by the researcher. The reputational approach can be used where the network members cannot be defined according to their positions or "where the knowledge of the agents themselves is crucial in determining the boundaries of the population" (Scott 1991: 59). This approach is useful to identify network participants in networks across organizational boundaries when there are no positional inclusion methods available, but boundary specification remains an empirically unsolved problem.[58]

Generally, given the situation of a network study within an organization where the scope of analysis does not provide a clear definition of the network boundary, the network members should be identified within a wider process of consultation to specify the relevant attribute dimensions, i.e. taking the advice of higher management and other expert people into consideration. Questions that help to identify the network members according to distinctive attributes may be, for example: Which departments are mainly affected by the issues identified as being within the scope of analysis? For which departments and people is the domain of knowledge most important? Identification of participants according to precisely defined criteria should lead to a definite list of people who are included as network members in the analysis.

5.3.6 Strategies to Gain Commitment: Other Involved Parties

During the stage of planning, a strategy has to be developed to gain commitment of all involved people and parties. Principal steps toward this kind of strategy

[57] The boundary definition problem is discussed in section 4.6.3.

[58] Some authors distinguish decisional and interactional analysis in addition to the positional and reputational approaches (see, e.g., Tichy et al. 1979a).

are outlined above (see also section 5.3.2). Here, a closer look is taken at some basic needs for the special situation of network studies in German organizations, since the third party of the "Betriebs- (or Personal-) rat" (workers' council) has a powerful position in German companies of more than five employees.[59]

First of all, it seems to be helpful to deal with the workers' council not as a barrier or hindrance, but to try to gain its involvement as a driver of the analysis. In an ideal situation, the workers' council can be integrated into the whole process from the planning stage until the final communication of results and implementation of follow-up activities. As a suitable means, a member of the workers' council can be assigned as member of the project team (see, e.g., Berner 2002). Even in the case that formal negotiations or agreements will become necessary, these are easier to reach on the basis of an affirmative attitude and general commitment with regard to the goals of the network analysis.

The strategy of dealing with the workers' council is strongly dependent on whether it has "soft" rights only or further rights that need formal agreements even for the case of performing a network analysis.[60] The concrete rights of the workers's council determine the necessary degree of its involvement into the process. The existence of weak rights only means that the workers' council should be informed about the network analysis during an early stage of the project and it should have the opportunity to give a statement and its advice, but it has no influence on the final decision itself. Strong rights necessarily require its formal agreement.

In the next paragraphs, we will take a look at the general concerns of participants and workers' representatives toward undertaking a social network analysis in organizations and how they can be met with adequate measures and arguments. Basically, there are three foci of concerns often mentioned by participants and workers' representatives: (1) privacy issues, (2) individual descriptions, profiles, and monitoring of the people, and (3) follow-up activities based on the results of the network analysis.

1. *Privacy issues:* Obviously, data collection for social network analysis includes collection of personal data. From the perspective of the network analysis, it seems to be most profitable to collect as much data as possible and available (or at least as accessible and measurable). Aside from the excessive demand (in costs of time) of the participants to answer numerous questions and from the foreseeable work overload during the stage of data

[59] The rights of the workers' council in Germany are mainly based on the Betriebsverfassungsgesetz of 1972.

[60] "Soft" rights, for instance, include rights for information and consultation according to §§ 74 and 106 Betriebsverfassungsgesetz. Further rights are especially based on rights of co-determination according to § 87 Betriebsverfassungsgesetz.

analysis, this kind of approach is not to be recommended since it would raise serious privacy issues from the very beginning. The method of social network analysis, as adapted for business practice and favored here, is (as mentioned above) purposefully focused, i.e. it examines relationships of knowledge communication within a precisely defined scope of analysis (domain of knowledge). Therefore, it is recommended to collect only data which is absolutely necessary to reach the defined goal. This approach shows several advantages:

- the process of analysis becomes cheaper in terms of time and money,
- the participants (and their time budgets as well) are not exceedingly demanded,
- problems concerning privacy issues can be minimized.

It is of primary importance to assure confidential handling of all data and to clearly communicate this confidentially through the publication of privacy guidelines, for example. Confidential handling of data includes

- anonymization of all personal data and analysis of de-personalized data only,
- security of stored data,
- authorization and control for data access,
- data analysis through confidential persons only.

Privacy issues should be subject to discussions from the early planning stage already; alternative solutions to potential problems should be always at hand. As a final remark, it must be noted that anonymization is not always necessary for a social network analysis. Analysts have to consider that anonymization sometimes must not and sometimes even cannot be assured during the whole process, although all possible efforts for de-personalization of data have been made. Especially in the case of small networks, participants are able to identify themselves and their colleagues even in wholly de-personalized results, like in network visualizations, for example. In that case, it is essential to convince the participants and all other involved parties that the network analysis is of high use for the organization and its members with regard to the clearly defined goal and, thus, to ensure acceptance for the network analysis.

2. *Individual descriptions, monitoring and profiles of participants:* The analysis of knowledge networks by means of social network analysis tries to describe network structures, relationships, and positions of the individual network members. The analysis of network positions 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 effectiveness and efficiency of knowledge communication, increasing transparency of knowledge flows, and leveraging expertise with regard to the defined domain of knowledge, the evaluation and assessment of the individual member and his or her preferences is definitely not the subject of analysis. This means that the analytical focus is not put on failures and faults of individual network members ("Who is not talking to whom?"), but on the overall goal ("Who is talking to whom?" and "How can we improve our knowledge flows?") within the precisely defined domain of knowledge ("Whom do I ask for help with regard to topic X?" and "Whom do I give advise with regard to topic X?"):

- the network analysis should not be abused as a tool for evaluation and assessment of employees,
- the imposition of sanctions as a direct result from the network analysis must be avoided,
- all communications should focus on the (positive) goal and not on individual mistakes and failures.

A clear orientation toward the overall goal and staying within the limits of the analytical scope during the whole process will surely help to resolve existing doubts and concerns and help gain commitment, involvement, and agreement on the network analysis.

3. *Follow-up activities:* Social network analysis as understood and actively promoted here, does not remain on the mere analytical stage as its final result only. Instead, results from the analysis must be transferred into concrete activities and measures that should help to improve knowledge flows and facilitate personal knowledge communication within and between organizations with regard to the domain of knowledge that is subject to analysis. Follow-up activities may include changes of work and process organization, communication tools and cultures. Changes may deeply affect existing structures and, moreover, influence personal routines, practices, and habits. Therefore, changes will not always be met with approval, but rather with more or less strong resistance and opposition. This seems to be especially true for those people who expect to have unfavorable network positions in the produced results, nevertheless, the existence of unfavorable positions per se is one of the big misunderstandings of people who are not acquainted with the method of social network analysis. There are no bad positions—the analytical focus presented here is always just one focus on a network picture within a very specialized domain of knowledge among various others! The network picture might look completely different with regard to another domain of knowledge. To avoid such kind of misunderstandings,

precise communication of the targets becomes important again and should be translated into possibilities for follow-up activities from the beginning of the process to avoid unnecessary fears. Generally, follow-up activities must be

- comprehensible and fair,
- precisely communicated and explained,
- elaborated through co-operation by all people who are affected.

It is strongly recommended to take all concerns of participants and other involved parties very seriously and consider them during the process of analysis. The person or team responsible for the network analysis must be careful not to be exploited by one interest group (management, individuals, workers' council, etc.), but try to conduct an objective and reliable analysis. This can best be assured through compliance with the following basic guidelines for communication:

- communication as open as possible from the early beginning of the planning stage until the final results under protection of privacy issues and information access according to the different hierarchical levels,
- consideration of concerns and critique and their documentation,
- neutral position with regard to the different interests or interest groups.

A network analysis that aims at precisely defined goals that are of overall use for the organization, help to facilitate knowledge communication and increase effectiveness of knowledge flows, and are clearly communicated to all participants will presumably gain personal involvement and general agreement by all involved parties.

5.3.7 Collection of Data

As outlined for the methodology conceptualization above, in the majority of cases social network analysis uses surveys for the collection of data. Other methods, mentioned above as well, include citation analysis, analysis of email communication, and data collection from all kinds of available resources.

The collection of data through surveys should be scheduled within an appropriate period of time. If the time period is too short, the rate of participants would be to low. If the time period is too long, the survey might provide a distorted picture due to the process character of networks. Furthermore, a longer period does not help to proportionally increase the participation rate. From the author's experience, a period of 2+1 weeks is suggested for data collection according to the following scheme:

1. invitation for participation and announcement of a deadline two weeks later;
2. after one week up to three days before the deadline, a reminder to participate in the survey;
3. one day after exceeding the deadline, reminder and announcement of an extended deadline about one week later.

Invitations should individually address each participant and it must be avoided to send reminders to those who have already filled out the questionnaire. Additionally, analysis of knowledge communication within and between organizations should also make use of other available resources that are suitable as valuable sources to identify the existing social relationships or, at least, to serve as indicators for validity of the survey.

5.3.8 Analysis of Data

Data analysis of social networks needs the coding of the collected data and use of formal methods. Commonly, this is done through software tools for social network analysis, as provided by the popular UCINET package, for example, including the additional tools NetDraw for network visualization, Mage for 3D visualization, and pajek for large network analysis,[61] or other similar software applications. Data analysis is complex and cannot be explained in detail here. Nevertheless, those network concepts and metrics that are of special interest for the analysis of knowledge networks within and between organizations will be introduced and discussed in more detail in the later sections (see case studies presented in sections 5.4 to 5.6 and detailed explanations in section 5.7).

5.3.9 Interpretation of Results

Following the data analysis, the next step is the interpretation of results. It includes referencing the results to the existing organizational conditions, given as the network environment. Therefore, participation of the network members during the interpretation is recommended, especially when the analysis aims at supporting and facilitating organizational change management. Again, it should be noted that 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; network members with a central or a marginal position may occupy a completely different position in a network within a different domain of knowledge. Moreover, it has to be considered that networks dynamically evolve over time; network structures and positions may rapidly change and, often, a network analysis is nothing more than a snap shot (see also section 4.6.3).

[61] See http://www.analytictech.com (Borgatti et al. 2002).

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

1. interpretation of the whole network;
2. interpretation of clusters and components;
3. interpretation of individual positions (network members, known as actors).

Network analysis and interpretation of results with regard to communication of knowledge according to these levels is outlined in section 5.7.

5.3.10 Interventions and Follow-up Activities

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 conceptualized. The examples outlined below in section 5.7 will give some illustrative examples for interventions and follow-up activities based on the results of the case studies presented in the next sections.

5.4 Case Study 1 (Pre-test Study): Leveraging Organizational Expertise[62]

5.4.1 Social Network Analysis as a Method for Identification of Expertise and Knowledge Transfer

The case studies presented here and in the following sections (5.5 and 5.6) give empirical illustrations on the adaptation of social network analysis for analytical purposes of organizational practice and aim at

1. demonstrating use and application of social network analysis to identify, visualize, and analyze the informal personal networks that exist within and between organizations according to structure, content, and context of knowledge flows,
2. exploring possibilities for interventions and follow-up activities based on the analysis to facilitate, foster, and support processes of knowledge communication (see section 5.7).

Identification, development, and conservation of expertise are critical to organizational success or failure. Social network analysis provides a tool to identify expertise within organizations. Reasons to undertake a network analysis for the identification of expertise can be, for example:

- evaluation of quantity and quality of existing expertise or development of new expertise due to strategic reasons,
- lack of experts and expertise,
- lack of transparency of expertise,
- barriers in the communication of expertise,
- poor conservation of existing expertise,
- overload of individual experts.

Due to the primary importance of these issues within organizations, the first case study explores the potentials and benefits of social network analysis for business practice as a strategic tool on the example of expert localization and knowledge transfer. The case study has been undertaken in a research and service organization to examine its expertise within the domain of acquisition of EU fundings for

[62] Preliminary results were presented and discussed at the Sunbelt 2004, XXIV. International Social Network Conference, May 12-16, 2004, Portoroz / Slovenia (see Müller-Prothmann 2004) and at the I-KNOW 04, 4th International Conference on Knowledge Management, June 30-July 2, 2004, Graz / Austria (see Müller-Prothmann and Finke 2004b, also published as Müller-Prothmann and Finke 2004a).

research projects.[63] To illustrate this example, the purpose of this case study can be outlined briefly as follows:

> Consider that you are working in a research and service organization. You have to acquire funding for new research projects and you know that programs and financing are available from the European Union (EU). You have an idea for a new project, but you do not know how best to prepare a project proposal. However, there are other people in your organization who have successfully acquired EU funding for their projects. The question is: How do you find out who knows about developing a winning proposal for an EU project acquisition? Who are the experts in your organization and who do you need to know and contact outside of your organization to assist you (for instance, at the European Commission)?

5.4.2 Basic conditions

The case study exemplified here aims at the identification of expertise with regard to knowledge about the acquisition of EU fundings for research projects. This domain of knowledge was differentiated into five sub-domains that are important for success or failure of the acquisition of EU funding. These basic sub-domains were derived through methods of integrated enterprise modeling (see Spur et al. 1996; Mertins and Jochem 1997) and validated with process experts.

The relevant sub-domains that were identified are:

- knowledge of the acquisition process,
- knowledge of finished or ongoing projects,
- knowledge of potential partners,
- knowledge of funding topics,
- knowledge of key people in the relevant EU institutions.

Other basic conditions were derived from the assumptions of factors that facilitate or hinder knowledge communication between people in personal networks. Factors that have been studied were:

[63] This case study was undertaken as a small part of the project "Wachstum mit Wissen" (economic growth through knowledge), sponsored by the German Federal Ministry of Education and Research (BMBF), at the Fraunhofer Institute for Production Systems and Design Technology (Fraunhofer IPK), Berlin, in co-operation with the author at the Department of Information Science, Freie Universität Berlin. Names have been changed at the request of the company; selected visualizations have been simplified for presentation.

- Factors that facilitate knowledge transfer:
  - experience,
  - specialized knowledge and competence,
  - continuous exchange of knowledge,
  - spatial proximity,
  - mutual understanding,
  - mutual completion.
- Barriers that hinder knowledge transfer:
  - hierarchies,
  - lack of time and availability,
  - organizational boundaries.

In addition, it was taken into account that people make use of the possibility to avoid existing barriers. This is especially relevant for the case that people contact experts who are not easily available to them through the intermediation of third persons who are easier to contact.

5.4.3 Method

A questionnaire was mailed to collect the data for the social network analysis about expertise of EU funding. The questionnaire was used to identify the experts according to the relevant sub-domains outlined above. This was reached through a combination of self-assessment of the participants, through assessment by others, and through results of the network analysis (see figure 5.4). Besides, integration and availability of expert knowledge was analyzed. Barriers and factors to facilitate the contacts between the network members were explored with regard to the different sub-domains.

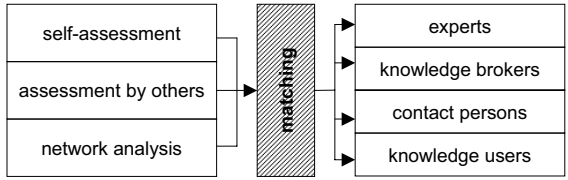

Figure 5.4: Case Study 1: Matching Method for Expert Identification

The underlying structure of the questionnaire with regard to the network analysis was as follows:

1. Identification of experts: identifying those people who have specialized expertise and knowledge with regard to the acquisition of EU funding.
2. Identification of contact persons: identifying those people who are contacted by others with regard to the acquisition of EU funding.
3. Comparison of the experts and contact persons and evaluation whether the expertise identified in 1 is really used if needed.

The identification of potential networks with regard to the central position of experts, compared with the existing network of central contact persons, allows insights into

- knowledge transfer between experts and non-experts,
- knowledge transfer between experts,
- popularity of experts across organizational boundaries,
- boundary-spanning knowledge transfer.

The questionnaire was divided into three parts:

1. questions about personal details,
2. questions about potential experts and actual contact persons. Barriers and facilitators of knowledge communication were explored through closed questions with defined categories and the possibility for additional statements as an open question.
3. questions for self-assessment of the participant's own expertise with regard to the different sub-domains on a 4-grade scale.

The survey was held in November 2002. All research staff of the organization was invited to participate. A total of 25 people finally participated in the survey which is equal to a participation rate of 28 per cent (see also section 5.4.5).

5.4.4 Results

This case study lead to a set of important findings, some of the most important are presented here. In this section, the main findings are presented with regard to (1) size of the network, (2) number of experts, (3) seniority, (4) self-assessment of the participants, and (5) barriers and enablers. In addition, visualizations and analysis of the results are presented with regard to the different sub-domains concerning (1) knowledge of the acquisition process, (2) knowledge of finished or ongoing projects, (3) knowledge of potential partners, (4) knowledge of domains of ongoing fundings, and (5) knowledge of key people in the relevant EU institutions.

1. *Network size:* The network analyzed in this study has 42 members (actors). Although the data is based on the answers of 25 participants only, people could name other persons as experts or contacts who did not submit a questionnaire themselves. Therefore, the network size is larger than the number of answered questionnaires. 86 per cent of the network members are part of the research staff (in the fields of automation and robotic, virtual product development, enterprise management) or administration / management staff of the organization, and 14 per cent are external people (members of the corporate administration or partners in joint projects).
2. *Number of experts:* Different people were named as experts with regard to the different sub-domains. All sub-domains aggregated, 10 people could be identified as experts by four or more participants. With regard to the different sub-domains, only three people could be identified as experts named by four or more participants. In the following sections, only those network members are called experts who were named by four or more people.
3. *Number of contact persons:* As for the experts, those people are called contact persons who were identified as contact persons by four or more participants. Thus, a total of six people were identified as contact persons according to this criterion.
4. *Seniority:* About 50 per cent of the network actors were members of the organization for four years or more. Figure 5.5 shows the seniority distribution according to the percentage share between experts and non-experts. The higher seniority of experts is obvious.

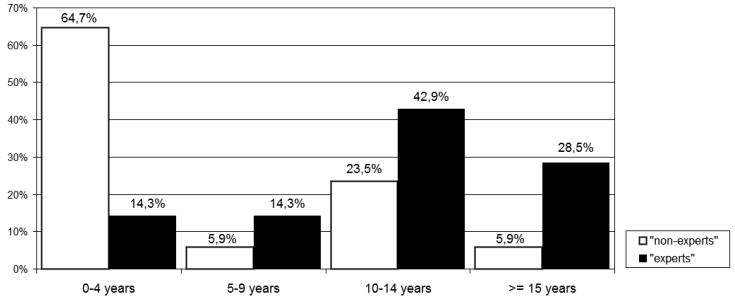

Figure 5.5: Case Study 1: Seniority Distribution Between Experts and Non-Experts

5. *Self-assessment of the participants:* As illustrated in figure 5.6, self-assessment of the participants shows that experts rank their own expertise as relatively high. The self-assessment of non-experts matches the assessment by

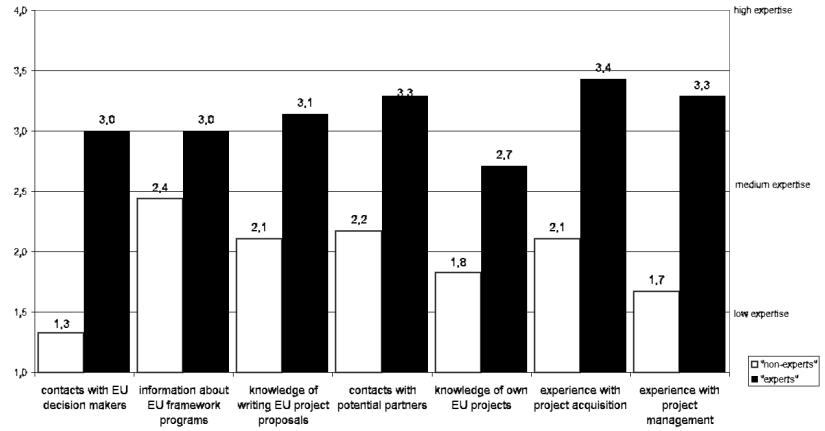

Figure 5.6: Case Study 1: Self-assessment of Expertise Within the Different Domains of Knowledge

the others. This leads to the conclusion that the perception of the participants of themselves corresponds positively with the perception by others.

6. *Barriers and enablers:* Asking whether barriers exist to gain access to existing expertise was negatively answered by 84 per cent (= no barriers, see figure 5.7). Only less than 10 per cent of the answers indicate barriers to contact expert people who are on a different hierarchical level. Lack of time or unavailability of experts, membership in a different organizational unit, or possibilities to gain knowledge through the intermediation of third persons were not treated as existing barriers by the participants. Also other barriers were not given as an answer to the open question.
   As enabling factors to contact a colleague for his or her knowledge, above all experience (39 per cent) and specialized knowledge (27 per cent) were mentioned. 17 per cent indicated exchange on a regular basis as relevant. Spatial proximity, mutual understanding, and mutual completion, or other factors were not mentioned.
   This favorable situation of apparently non-existing barriers and the functional factors of experience and specialized knowledge as enabling factors for gaining access to expertise, as derived through this simple survey data, will be strongly modified through the findings of the network analysis presented in the next paragraphs; results of the network analysis indicate that, if really required, experts are not always contacted, and organizational membership is a critical factor that influences the processes of knowledge communication.

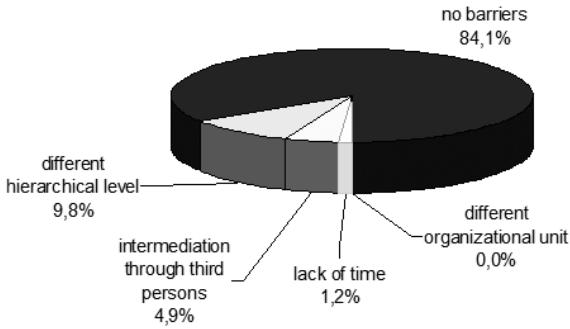

Figure 5.7: Case Study 1: Barriers to Access of Expertise

In the next paragraphs, visualizations of the results and key findings of the network analysis are presented with regard to the different sub-domains: (1) knowledge of the acquisition process, (2) knowledge of finished or ongoing projects, (3) knowledge of potential partners, (4) knowledge of funding topics, and (5) knowledge of key people in the relevant EU institutions. Coloring and grouping of the nodes, which represent the network members, indicate their membership to organizational sub-units. The directed lines indicate who has been named an expert or contact person by whom. The strength of lines indicates the priority of expertise as named by the participants. Experts are indicated by an "E", contact persons by an "A".

1. *Knowledge of the acquisition process:* Figure 5.8 shows the relationships of expert identifications with regard to knowledge of the acquisition process of EU projects ("Whom do you consider as an expert with regard to successful acquisition of EU projects?"). Figure 5.9 shows the corresponding relationships of contact persons as identified in the study ("Whom do you contact for expertise about the acquisition of EU projects?").
   One expert could be identified according to the definition criterion given above (four people or more consider him or her an expert). Considering all expert-relationships, 13 participants mentioned experts from their own organizational unit, while 8 were mentioned across organizational boundaries. The ratio between internal and external ties (we could call this the "intra-/inter-ratio"), i.e. the number of identified experts from the own versus the number of identified experts from other organizational units, has a value of 1.625. To compare configurations of internal and external linkages, Krackhardt and Stern (1988) introduced the E-I index as a normalized measure of

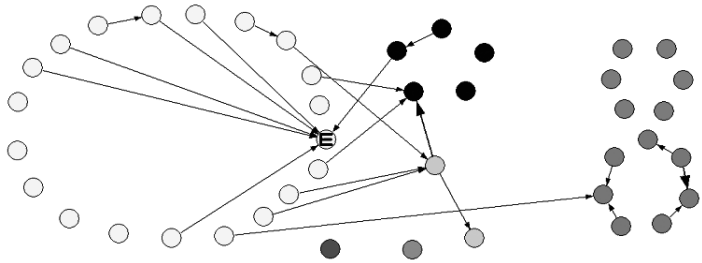

Figure 5.8: Case Study 1: Experts Project Acquisition

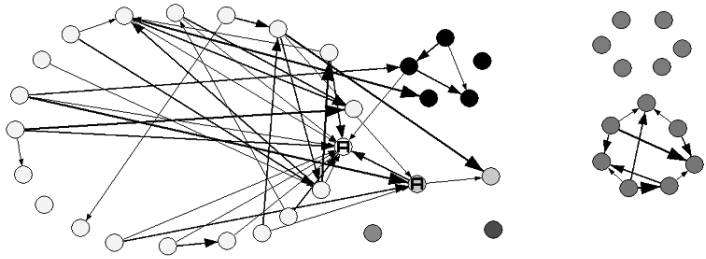

Figure 5.9: Case Study 1: Contact Persons Project Acquisition

the ratio between external and internal relationships.[64] The E-I index measures the ratios between external and internal ties and normalizes them to a value within the 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. Here, the E-I index reaches a score of -0.2381. The expert identified in figure 5.8 is also a contact person (see figure 5.9). In addition, one more contact person was identified. The cluster in the lower right is characterized through internal relationships of contacts only. Moreover, it is remarkable that 36 contact relationships are internally established within organizational units, while inter-organizational relationships exist only for 10 relations (E-I index = -0.5652). We can conclude with regard to knowledge of the acquisition process that knowledge of the experts is requested by others, but requests mainly remain internal to the corresponding organizational sub-unit.

2. *Knowledge of finished or ongoing projects:* Figure 5.10 shows the relationships of expert identifications with regard to knowledge of finished or ongoing projects ("Whom do you consider as an expert with regard to information about finished or ongoing projects?"). Figure 5.11 shows the corresponding relationships of contact persons as identified in the study ("Whom do you contact for expertise about finished or ongoing projects?").

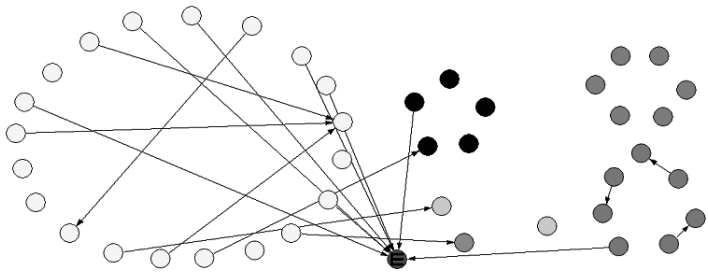

Figure 5.10: Case Study 1: Experts Ongoing or Finished Projects

One person was identified as an expert of ongoing or finished projects. The E-I index here is -0.4444. The identified expert is actually contacted for his or her expertise. In addition, four other contact persons could be identified within different organizational sub-units. Here, the E-I index is significantly higher with a value of -0.1556. Obviously, the organizational bound-

[64] See section 5.7.4 for a discussion in more detail.

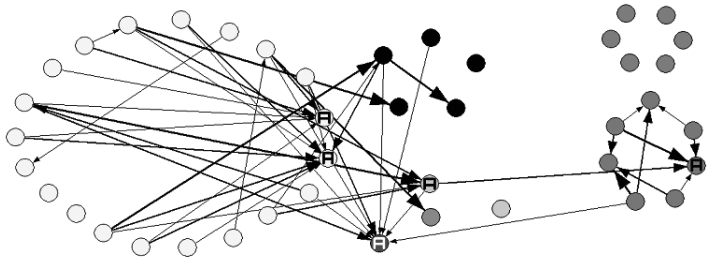

Figure 5.11: Case Study 1: Contact Persons Ongoing or Finished Projects

aries here represent a lower barrier to inquire about the process of internal projects.

3. *Knowledge of potential partners:* Figure 5.12 shows the relationships of expert identifications with regard to knowledge of potential partners ("Whom do you consider as an expert with regard to information about potential project partners?"). Figure 5.13 shows the corresponding relationships of contact persons as identified in the study ("Whom do you contact for information about potential project partners?").

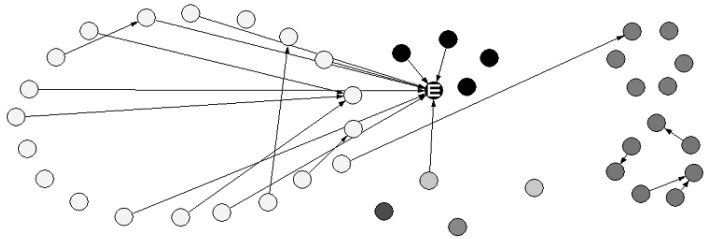

Figure 5.12: Case Study 1: Experts Potential Project Partners

As illustrated in figure 5.12, one expert of potential partners could be identified. The E-I index is -0.2000. Surprisingly, the identified expert is contacted only by one person from his or her own organizational unit. The identified contact persons are all from different organizational units. With regard to contact relationships, the E-I index is extremely low with a score of -0.6757.

4. *Knowledge of funding topics:* Figure 5.14 shows the relationships of expert identifications with regard to knowledge of funding topics and opportunities

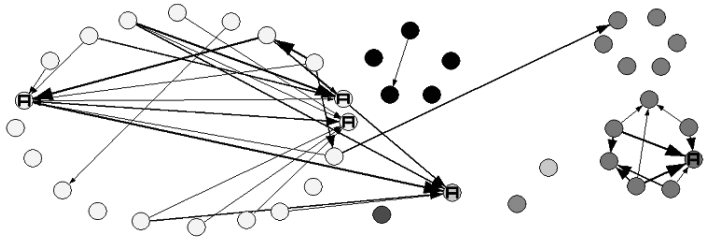

Figure 5.13: Case Study 1: Contact Persons Potential Project Partners

("Whom do you consider as an expert with regard to information about current and future funding themes and topics?"). Figure 5.15 shows the corresponding relationships of contact persons as identified in the study ("Whom do you contact for information about current and future funding themes and topics?").

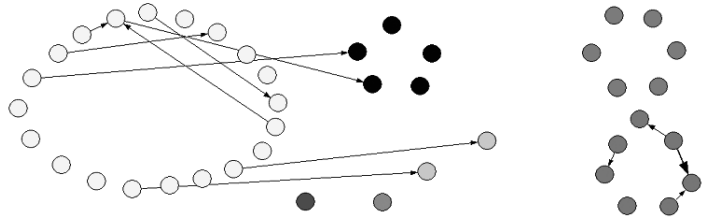

Figure 5.14: Case Study 1: Experts Current and Future Funding Topics

Nobody could be identified as an expert with regard to knowledge of relevant funding topics. It is a striking fact that generally only a small number of people were named as experts within this sub-domain of knowledge at all. The E-I index is -0.3333. Nevertheless, two people could be identified as contact persons who are from the same organizational unit. The E-I index with regard to contact relationships is again relatively low (-0.6000).

5. *Knowledge of external key persons in the relevant EU institutions:* Figure 5.16 shows the expert identifications of people who have knowledge of and relationships with key persons from relevant EU institutions ("Whom do you consider as an expert with regard to connections to key persons from relevant EU institutions?"). Figure 5.17 shows the corresponding relation-

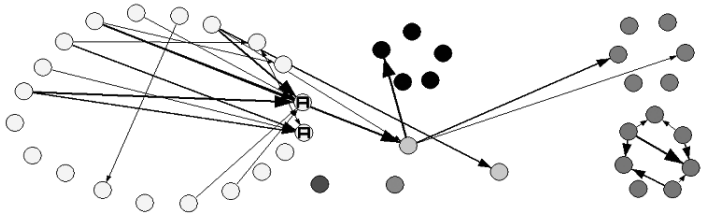

Figure 5.15: Case Study 1: Contact Persons Current and Future Funding Topics

ships of contact persons as identified in the study ("Whom do you contact for information about key persons from EU institutions?").

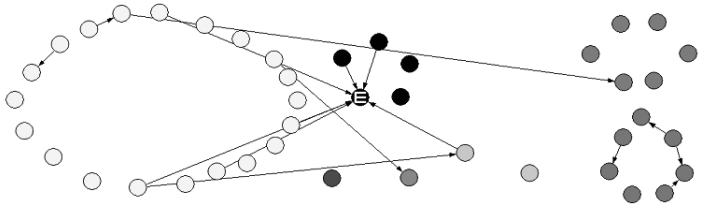

Figure 5.16: Case Study 1: Experts External Key Persons

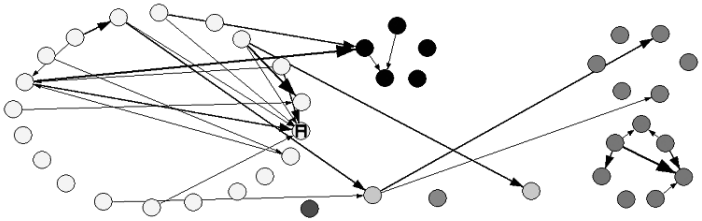

Figure 5.17: Case Study 1: Contact Persons External Key Persons

One person could be identified as having informations about and connections to external key people from relevant EU institutions. The E-I index is well-balanced (0.0000). But it is obvious that only a small number of people is named as expert again. Also, the identified expert is contacted only by two people from his or her own organizational unit. The identified contact

person is exclusively contacted from his or her own organizational unit as well. The E-I index of identified contact relationships is -0.5000.

These results show that for each sub-domain of knowledge one expert could be identified (i.e. a person who is identified as an expert by four or more people), except for the case of knowledge of funding topics. With regard to the first two sub-domains, the identified expert is also contacted for his or her knowledge by people from his or her own organizational unit as well as by people from the other units. With regard to the third sub-domain, the identified expert is contacted by people from his or her own organizational unit only. The same expert was identified with regard to the last sub-domain of knowledge and he or she is contacted only by people from his or her own organizational unit again. Within the fourth sub-domain no expert was identified. Altogether, three people from three different organizational units were mainly identified as experts with regard to different sub-domains of knowledge.

The results impressively show that not the people with the best expertise are contacted but that other people play the role of contact persons. Moreover, contacting people strongly depends on organizational membership. The average E-I index for experts (i.e. the normalized measure of the ratio between the number of identified experts from the own versus the number of identified experts from other organizational units) is -0.2432 (std. dev.: 0.1481) whereas the average E-I index for contact persons (i.e. the normalized measure of the ratio between the number of identified contact persons from the own versus the number of identified contact persons from other organizational units) is -0.4993 (std. dev.: 0.1810). This leads to the conclusion that people know about existing expertise throughout the organization, but when they need to actually contact people, they address members of their own organizational unit. This gives reason to assume the existence of other factors besides expertise which influence the informal flows of knowledge. While organizational barriers (i.e. membership within different organizational units) have not been mentioned by the participants as answers to the direct question about existing barriers, network analysis clearly indicates the influence of organizational membership on informal relationships of knowledge flows, particularly on contacting people. Moreover, other barriers than organizational membership seem to be relevant as well, as the position of the expert in the third and fifth sub-domain of knowledge suggests. Due to the differences between results from direct answers about barriers and results from the actual network, the suspicion arises that factors of social acceptance have influence on the answers given by the participants, i.e. the persons questioned are supposed to give answers that seem to be socially wanted for the case of direct questions. These differences could be revealed through the results of social network analysis.

Based upon the results of this case study and their interpretation, interventions (like workshops, dialogs, establishment of communities of practice) were recommended to improve knowledge flows. These can be designed to foster knowledge communication, strengthen relationships within the network, build relationships to other networks, and develop strategies for the creation of flourishing knowledge environments and for sustainable knowledge transfer. Results of the study were presented to the network members and discussed in a workshop in January 2003. The follow-up activities and recommendations for interventions were derived from these discussions. They are summarized with other general suggestions for interventions and follow-up activities in section 5.7.5.

5.4.5 Lessons Learned

As mentioned above, only a total of 25 people finally participated in the survey which is equal to a participation rate of 28 per cent. Although this return rate is at a common level, network analysis aims at reaching a return rate of at least 66 per cent or, better, even more. The low return rate in this case study is a result primarily due to two reasons:

- although all data was anonymized for the analysis, network data collection is always person-related—therefore, social network analysis in organizations is always very sensitive to privacy issues (see sections 4.6.3 and 5.3);
- a majority of the research staff was never involved in processes of project acquisition—therefore, these people did not feel addressed to participate in the study.

Although the low return rate reduces the validity of an extensive interpretation of the results, the primary goal of this pre-test study was reached: to pragmatically adapt the method of social network analysis for organizational practice, to gain experience, and to provide explorative explanation of its use and limits. The results of this case study have been documented and have been the foundation to develop a guideline to apply social network analysis as an analytical knowledge management method in other business units of the organization as well.

From a methodical point of view, the questionnaire design was well elaborated, but did miss to check validity of the answers with regard to one aspect: reciprocity. Network linkages in this case study are directed, but the questionnaire collected only data for one direction only (“Whom do you consider as an expert with regard to...?”) and did not ask for the reciprocal connection (like, e.g., “Who did assist you with his or her expertise with regard to...?” and “Whom did you assist with your expertise with regard to...?”). Despite this methodical weakness of the survey

design, the workshop discussions finally indicated the correctness and usefulness of the results anyway.

To conclude, this example shows that social network analysis provides a method to trace knowledge flows, analyze network structures and personal expertise with additional value to a simple knowledge map or yellow pages. On the one hand, social network analysis tries to identify knowledge flows wherever they may go. On the other hand, social network analysis gives us a detailed picture of actors' positions, the characteristics of their connections and the overall structure of relationships. Social network analysis provides us with a well-elaborated set of methods and measures for various applications in knowledge management that especially help us to foster organizational expertise and transfer of knowledge.

5.5 Case Study 2 (Evaluation Study): Entrepreneurial Network Evolution[65]

5.5.1 Social Network Analysis for Evaluation and Support of Entrepreneurial Networking

In the literature, entrepreneurs are characterized as people maintaining excessive networking activities (e.g., see references in Falemo 1989; Dubini and Aldrich 1991). Generally, they have a high capability of taking advantages from hidden opportunities, are able to mobilize resources, to find opportunities to open up new markets, and to link existing products, services, or ideas for new combinations (see section 4.5). Taking these theoretical considerations as a starting point, entrepreneurial networking activities among the participants of an advanced training program are explored with regard to information and knowledge exchange through social network analysis in the case study presented in this section.

The advanced training program "Unternehmertum in der Wissensgesellschaft" (entrepreneurship in the knowledge society) aims at providing entrepreneurs and managers direction and assistance for their action within the knowledge-based economy. As "global cities" like New York, London, or Amsterdam (Grabher 1998) recognize the growing importance of knowledge-based services, they provide benchmarks for the future economic development of Berlin. Following recent studies, entrepreneurial activity is increasingly based on knowledge at the local level of the city of Berlin as well (see, e.g., DIW 2002). As the center of information and communication based services, Berlin and its entrepreneurs were hit hard by the burst of the new economy's bubble. Especially Berlin's considerable entrepreneurial potential is currently hidden in dependent employment or in the stage of job search. Therefore, the project aims at contributing to the regeneration of Berlin's economic power in the sectors of interregional information- and communication-based corporate services. It is particularly directed at the entrepreneurs' as well as intrapreneurs' personal potentials.[66] In doing so, the curriculum incorporates the most important aspects of the knowledge society and what both entrepreneurs and intrapreneurs need to know in order to act adequately within the knowledge-based economy. The project is funded by the European Social Fund (ESF) for a period of 2.5 years (2004-2006) and encompasses five classes à six months of blended learning.

[65] Preliminary results were presented and discussed at the Sunbelt 2005, XXV. International Social Network Conference, February 16-20, 2005, Redondo Beach, CA / USA (see Müller-Prothmann 2005).

[66] Intrapreneurs are employees in higher hierarchical positions within organizations who provide a strong potential of self-organized work, entrepreneurial thinking, and social responsibility.

The social network analysis presented here studies the initial relationships between the participants of the first course and their evolution during a six months period. Data was collected through questionnaires at two different points in time: the first immediately after the first two weeks of class-room learning in August 2004 (=t1), the second shortly before the final presentation of the participants' projects in February 2005 (=t2). 24 of 29 people answered the questionnaire in the first network survey (t1), which equals a very high return rate of 82.8 per cent. During the course, six people dropped out. Therefore, the total of potential participants decreased from 29 in t1 to 23 people in t2. In the second network survey (t2), 18 of these 23 people answered the questionnaire, which makes a nearly equally high return rate of 78.3 per cent (or 62.1 per cent related to the initial total of 29 people). Nevertheless, in the second round all but one network members were still more or less integrated in the network and are therefore still taken into account for the analysis of network evolution (see section 5.5.4). Names of network actors have been replaced through numbers for anonymization purposes that were assigned through a process of random number generation.[67]

5.5.2 Subjective Relevance of Knowledge Exchange for Entrepreneurial Action

In a first step, the study explored the subjective importance of networking for knowledge exchange with regard to the entrepreneurial activities of the participants. Therefore, knowledge exchange and communication in networks were distinguished according to the following domains:

- general exchange of information and knowledge,
- exchange of specialized knowledge and expertise,
- knowledge exchange for project and customer acquisition, and
- knowledge exchange for co-operations and joint projects.

These domains were explored with regard to the dimensions of

1. the individual relevance in general,
2. the specific projects of the individual participants, and
3. the individual's expectations toward networking with the other participants of the advanced training program.

Relevance of each domain with regard to each dimension was scored with a value from 0 = "unimportant" to 4 = "very important".

[67] Random numbers were generated by the Research Randomizer (see http://www.randomizer.org/), a "pseudo-random number generator" that uses the JavaScript "Math.random" method.

As presented in table 5.2 and 5.3 and illustrated in figures 5.18 to 5.20, importance of networks with regard to knowledge exchange is rated from medium to high. Networking for knowledge communication in general is rated as being important, with a slight decrease of importance regarding the specific projects of the participants and their expectations toward networking with the other participants of the advanced training program (see figure 5.18). General information and knowledge exchange as well as exchange of specialized knowledge and expertise in networks are rated as highly important, while networking for knowledge exchange for project and customer acquisition is rated as not very important. Networking for knowledge exchange for co-operations and joint projects is still rated as important, but on a low level (see figure 5.19).

Indications of relevance with regard to the different domains and dimensions are all positively related with each other. Significantly high levels of correlations can be especially found between relevance of knowledge exchange for project and customer acquisition and relevance of knowledge exchange for co-operations and joint projects with regard to knowledge exchange in general, project-specific, and expected, as they point to a closely related domain (see table 5.4). Correlations are also on a high level between relevance of networking for knowledge exchange in general, project-specific, and expected within each domain (see table 5.5).

The participants indicated the status of their actual entrepreneurial activity (i.e., idea, project, foundation, enterprise) on a scale from 0 = "vague idea" to 4 = "concrete realization". The status of entrepreneurial activity is generally positively related to subjective relevance of networking for knowledge exchange with regard to all domains, but levels of correlations differ (see table 5.6). Results strikingly show that correlation between the status of entrepreneurial activity is generally lower with regard to networking for exchange of specialized knowledge and expertise, while it is significantly higher with regard to joint project and customer acquisition as well as with regard to co-operations and joint projects.

5.5.3 Knowledge Network Characteristics and Central Actors

Network characteristics and network evolution of the participants are described in two stages: first, network characteristics are described immediately after the first two weeks of class-room learning in August 2004 (=t1) with regard to status of entrepreneurial activity and subjective relevance of knowledge exchange; second, network evolution is analyzed in terms of changes between the first (t1) and second results (t2). Network evolution is described below in section 5.5.4 with a focus on the changes of network characteristics and correlations between network evolution among the participants and their actual entrepreneurial activity.

	N	mean	std. dev.
relevance of networking activities			
in general	24	2.927	.7204
project-specific	24	2.562	.9006
expected	24	2.448	.8242
relevance of networking with regard to			
general information exchange	24	3.083	1.0180
exchange of specialized knowledge and expertise	24	3.097	.6701
joint customer and project acquisition	24	1.653	1.0654
co-operations and joint projects	24	2.333	1.1336

Table 5.2: Case Study 2: Descriptive Statistics of Subjective Relevance of Knowledge Exchange and Networking

domain	**N**	**mean**	**std. dev.**
relevance of exchange of general information			
in general	24	3.208	.9315
project-specific	24	3.000	1.1421
expected	24	3.042	1.1221
relevance of exchange of specialized knowledge and expertise			
in general	24	3.417	.7173
project-specific	24	3.083	.9286
expected	23	2.783	1.0426
relevance of knowledge exchange for joint customer and project acquisition			
in general	22	2.000	1.2344
project-specific	22	1.591	1.3683
expected	22	1.636	.9535
relevance of knowledge exchange for co-operations and joint projects			
in general	22	2.955	1.0901
project-specific	22	2.364	1.3290
expected	22	2.045	1.2902

Table 5.3: Case Study 2: Descriptive Statistics of Subjective Relevance of Domain-related Knowledge Exchange and Networking

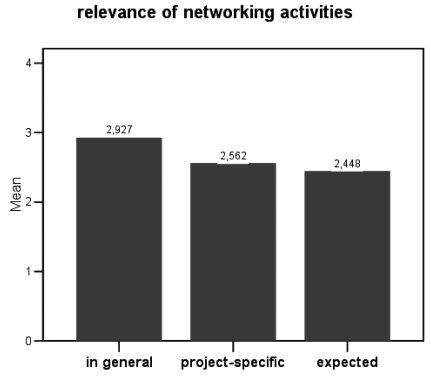

Figure 5.18: Case Study 2: General, Project-specific and Expected Relevance of Networks (0 = "unimportant" to 4 = "very important")

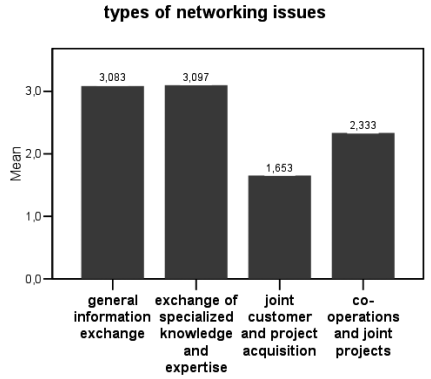

Figure 5.19: Case Study 2: Relevance of Domain-related Networks: a) General Information Exchange, b) Exchange of Specialized Knowledge and Expertise, c) Joint Project Acquisition, and d) Co-operations and Joint Projects (0 = "unimportant" to 4 = "very important")

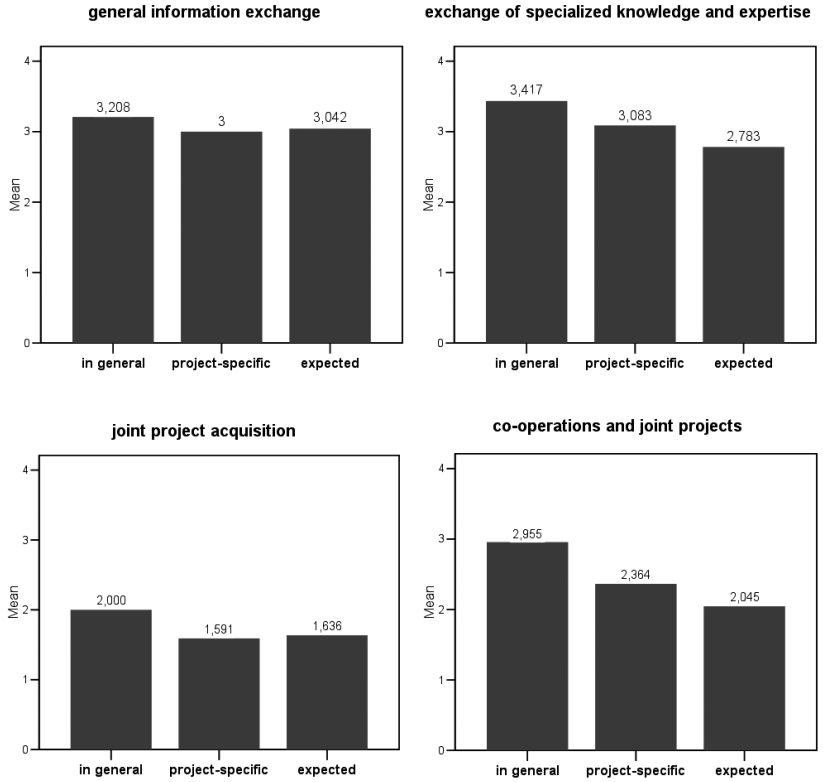

Figure 5.20: Case Study 2: General, Project-specific and Expected Relevance of Networks with Regard to a) General Information Exchange, b) Exchange of Specialized Knowledge and Expertise, c) Joint Project Acquisition, and d) Co-operations and Joint Projects (0 = "unimportant" to 4 = "very important")

		relevance of networking in general with regard to			
		general information exchange ($=F4_1$)	exchange of specialized knowledge and expertise ($=F4_2$)	joint project acquisition ($=F4_3$)	co-operations and joint projects ($=F4_4$)
$F4_1$	Pearson Corr.	1			
	Sig. (2-tailed)				
	N	24			
$F4_2$	Pearson Corr.	.255	1		
	Sig. (2-tailed)	.229			
	N	24	24		
$F4_3$	Pearson Corr.	.201	.230	1	
	Sig. (2-tailed)	.369	.303		
	N	22	22	22	
$F4_4$	Pearson Corr.	.419	.160	.637**	1
	Sig. (2-tailed)	.052	.477	.001	
	N	22	22	22	22
		relevance of networking related to the specific project or entrepreneurial activity with regard to			
		general information exchange ($=F5_1$)	exchange of specialized knowledge and expertise ($=F5_2$)	joint project acquisition ($=F5_3$)	co-operations and joint projects ($=F5_4$)
$F5_1$	Pearson Corr.	1			
	Sig. (2-tailed)				
	N	24			
$F5_2$	Pearson Corr.	.410*	1		
	Sig. (2-tailed)	.047			
	N	24	24		
$F5_3$	Pearson Corr.	.106	.295	1	
	Sig. (2-tailed)	.637	.182		
	N	22	22	22	
$F5_4$	Pearson Corr.	.377	.361	.740**	1
	Sig. (2-tailed)	.083	.099	.000	
	N	22	22	22	22
		expected relevance of networking with the other participants with regard to			
		general information exchange ($=F6_1$)	exchange of specialized knowledge and expertise ($=F6_2$)	joint project acquisition ($=F6_3$)	co-operations and joint projects ($=F6_4$)
$F6_1$	Pearson Corr.	1			
	Sig. (2-tailed)				
	N	24			
$F6_2$	Pearson Corr.	.236	1		
	Sig. (2-tailed)	.278			
	N	23	23		
$F6_3$	Pearson Corr.	.173	.330	1	
	Sig. (2-tailed)	.441	.134		
	N	22	22	22	
$F6_4$	Pearson Corr.	.192	.260	.788**	1
	Sig. (2-tailed)	.393	.242	.000	
	N	22	22	22	22

* Correlation is significant at the 0.05 level (2-tailed);

** Correlation is significant at the 0.01 level (2-tailed).

Table 5.4: Case Study 2: Correlations of Domain-related Relevance of Knowledge Exchange (i.e. correlations *between* the different domains)

		relevance of networking for general information exchange		
		in general ($=F4_1$)	project-specific ($=F5_1$)	expected ($=F6_1$)
$F4_1$	Pearson Corr.	1		
	Sig. (2-tailed)			
	N	24		
$F5_1$	Pearson Corr.	.899**	1	
	Sig. (2-tailed)	.000		
	N	24	24	
$F6_1$	Pearson Corr.	.906**	.814**	1
	Sig. (2-tailed)	.000	.000	
	N	24	24	24
		relevance of networking for exchange of specialized knowledge and expertise		
		in general ($=F4_2$)	project-specific ($=F5_2$)	expected ($=F6_2$)
$F4_2$	Pearson Corr.	1		
	Sig. (2-tailed)			
	N	24		
$F5_2$	Pearson Corr.	.403	1	
	Sig. (2-tailed)	.051		
	N	24	24	
$F6_2$	Pearson Corr.	.370	.296	1
	Sig. (2-tailed)	.082	.171	
	N	23	23	23
		relevance of networking for joint project and customer acquisition		
		in general ($=F4_3$)	project-specific ($=F5_3$)	expected ($=F6_3$)
$F4_3$	Pearson Corr.	1		
	Sig. (2-tailed)			
	N	22		
$F5_3$	Pearson Corr.	.708**	1	
	Sig. (2-tailed)	.000		
	N	21	22	
$F6_3$	Pearson Corr.	.497*	.628**	1
	Sig. (2-tailed)	.022	.003	
	N	21	20	22
		relevance of networking for co-operations and joint projects		
		in general ($=F4_4$)	project-specific ($=F5_4$)	expected ($=F6_4$)
$F4_4$	Pearson Corr.	1		
	Sig. (2-tailed)			
	N	22		
$F5_4$	Pearson Corr.	.654**	1	
	Sig. (2-tailed)	.001		
	N	21	22	20
$F6_4$	Pearson Corr.	.628**	.479*	1
	Sig. (2-tailed)	.002	.033	
	N	21	20	22

* Correlation is significant at the 0.05 level (2-tailed);

** Correlation is significant at the 0.01 level (2-tailed).

Table 5.5: Case Study 2: Correlations of Dimension-related Relevance of Knowledge Exchange (i.e. correlations of relevance of knowledge exchange in general, project-specific, and expected *within* each domain)

	relevance of networking in general with regard to			
activity status	general information exchange	exchange of specialized knowledge and expertise	joint project acquisition	co-operations and joint projects
Pearson Corr.	0.418*	0.204	0.378	0.569**
Sig. (2-tailed)	0.047	0.350	0.091	0.007
N	23	23	21	21
	relevance of networking related to the specific project or entrepreneurial activity with regard to			
activity status	general information exchange	exchange of specialized knowledge and expertise	joint project acquisition	co-operations and joint projects
Pearson Corr.	0.422*	0.213	0.236	0.386
Sig. (2-tailed)	0.045	0.329	0.303	0.084
N	23	23	21	21
	expected relevance of networking with the other participants with regard to			
activity status	general information exchange	exchange of specialized knowledge and expertise	joint project acquisition	co-operations and joint projects
Pearson Corr.	0.316	0.003	0.614**	0.664**
Sig. (2-tailed)	0.141	0.991	0.002	0.001
N	23	23	22	22
	means of expected relevance of networking with regard to			
activity status	general information exchange	exchange of specialized knowledge and expertise	joint project acquisition	co-operations and joint projects
Pearson Corr.	0.401	0.172	0.511*	0.681**
Sig. (2-tailed)	0.058	0.432	0.013	0.000
N	23	23	23	23
	means of expected relevance of networking			
activity status	in general	project-specific	expected	
Pearson Corr.	0.442*	0.373	0.420*	
Sig. (2-tailed)	0.035	0.079	0.046	
N	23	23	23	

* Correlation is significant at the 0.05 level (2-tailed);

** Correlation is significant at the 0.01 level (2-tailed).

Table 5.6: Case Study 2: Correlations Between Status of Entrepreneurial Activity and Relevance of Networking for Knowledge Exchange

Network analysis explores four types of networks corresponding to the different domains of knowledge exchange rated in the first part of the survey. Participants were asked to indicate communication with others with regard to:

- general exchange of information and knowledge,
- exchange of specialized knowledge and expertise,
- knowledge exchange for project and customer acquisition, and
- knowledge exchange for co-operations and joint projects.

For analytical purposes, networks were symmetrized (maximum method) and missings were added through existing data due to the non-directed nature of ties (as already mentioned above, 24 of 29 people answered the questionnaire in the first network survey, which is equal to a very satisfying return rate of 82.8 per cent). Nevertheless, it must admitted that the assumption of symmetry of non-directed ties is a weak point indeed for this case study, since reciprocity is very poor (from 0 per cent to 58.2 per cent), 71.6 per cent are only reached when taking the different kinds of knowledge exchange together and dichotomize them in a second step (see also table 5.7). Studies on reciprocity in social networks are subject to a variety of past and recent research (see, e.g., Hammer 1985; Aviv and Ravid 2004; Herring et al. 2005), but approaches to the exploration of different reciprocity levels in non-directed network data that were gathered through surveys cannot be found in the literature. Further research is needed on this issue. Here, we can attempt to explain that a low level of reciprocity in basically non-directed relationships is a result of one of the following reasons:

- wrong assumptions about the non-directed nature of ties, (i.e. instead assumption of directed ties), or
- wrong information given by the participants in the survey (which renders all results invalid or at least very weak), or
- relationships are strongly subject to the individual's perceptions and therefore an artifact of socially constructed reality itself.

Based on the latter explanation, network relationships can be considered as existent, i.e. as symmetrical communication of knowledge, although not present in both memories of dyadic actors. Moreover, differences between the different domains of knowledge exchange (general information and knowledge, specialized knowledge and expertise, acquisition knowledge, and knowledge exchange for co-operations and joint projects) are only gradual and cannot be clearly distinguished and, therefore, are subject to individual perception as well. This consideration can probably explain the relatively high rate of reciprocity of 71.6 per cent for the case of the summarized and dichotomized network taking into account all domains of knowledge exchange.

domain	N	min.	max.	mean	std. dev.
general exchange of information and knowledge	24	0.000	1.000	0.582	0.241
exchange of specialized knowledge and expertise	19	0.000	0.667	0.386	0.185
knowledge exchange for project and customer acquisition	7	0.000	0.000	0.000	0.000
knowledge exchange for co-operations and joint projects	11	0.000	1.000	0.348	0.450
all types of knowledge exchange (dichotomized)	24	0.222	1.000	0.716	0.176

Table 5.7: Case Study 2: Descriptive Statistics of Reciprocity of Networks with Regard to the Different Domains

	degree	nrmdegree
mean	16.069	57.389
std. dev.	5.105	18.233
min.	7.000	25.000
max.	28.000	100.000

Table 5.8: Case Study 2: Descriptive Statistics of Actor Degree Centrality for the Overall Dichotomized Network

The overall multiplex network, including all types of knowledge exchange as illustrated in figure 5.21, integrates all participants without isolates or independent components and is quite densely connected (density is 0.5739) with medium network centralization (network centralization is 0.4577, see also the descriptive statistics for degree centrality presented in table 5.8).

Multiplexity of the networks, i.e. relations between actors with regard to the four different domains of (1) general exchange of information and knowledge, (2) exchange of specialized knowledge and expertise, (3) knowledge exchange for project and customer acquisition, and (4) knowledge exchange for co-operations and joint projects at the same time, is illustrated in figure 5.22.

The networks related to a specific domain vary in size, density, and centralization and are split into different independent components that are not wholly connected with each other for the case of knowledge exchange for project and customer acquisition (see figure 5.23 and tables 5.9 and 5.10).

Degree and betweenness centrality of actors are presented in table 5.11 with regard to the four different network domains. Since the network of general information and knowledge exchange is connected through more links and actors are more densely connected, degree centrality is on a higher level than in the other networks. But betweenness centrality shows the highest value for the case of knowledge exchange networks for co-operations and joint projects. This leads to the conclusion

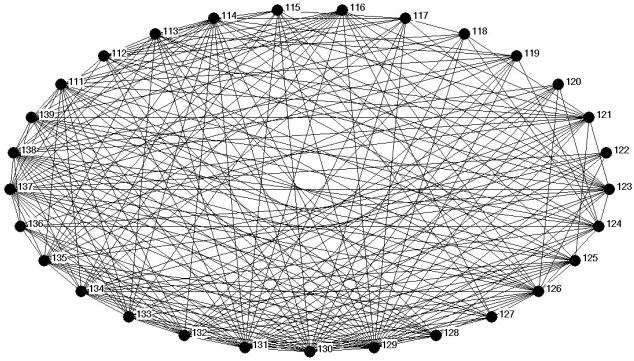

Figure 5.21: Case Study 2: Simple Network in Circle View

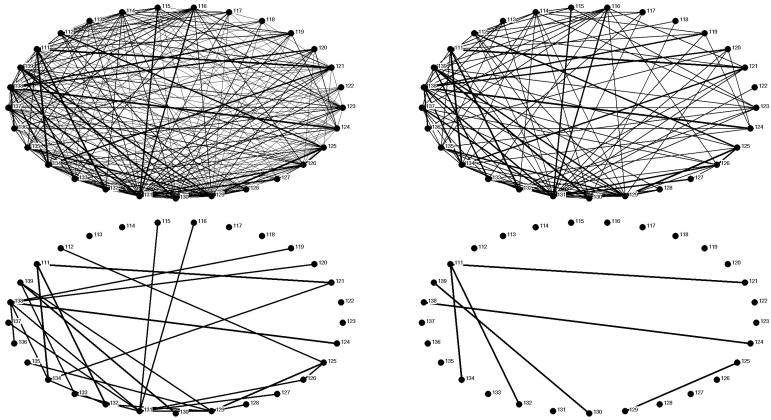

Figure 5.22: Case Study 2: Domain-related Networks in Multiplex Circle View with Different Line Strengths indicating Multiplexity of Relationships

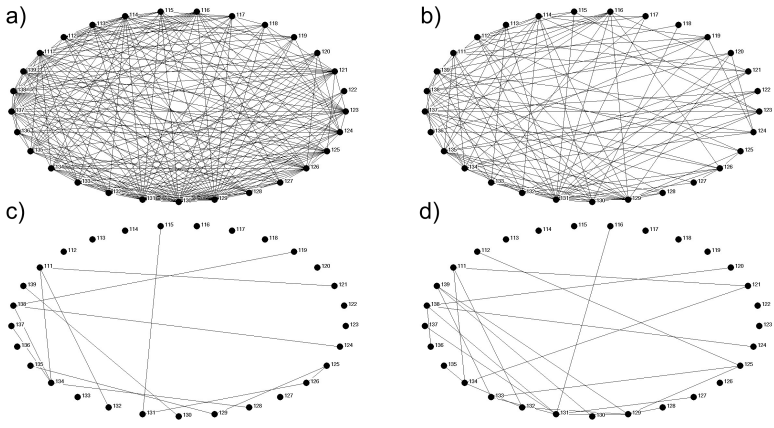

Figure 5.23: Case Study 2: Domain-related Networks in Circle View: a) Network of General information and Knowledge Exchange, b) Network of Specialized Knowledge and Expertise Exchange, c) Network of Knowledge Exchange for Project and Customer Acquisition, and d) Network of Knowledge Exchange for Co-operations and Joint Projects

domain	N	density	std. dev.	centralization
general exchange of information and knowledge	29	0.5419	0.4982	0.4921
exchange of specialized knowledge and expertise	29	0.2906	0.4541	0.4550
knowledge exchange for project and customer acquisition	17	see table 5.10		0.1667
knowledge exchange for co-operations and joint projects	20	0.1150	0.3190	0.2164

Table 5.9: Case Study 2: Domain-related Networks: Density and Centralization

that central brokerage positions play a more important role for the network of knowledge exchange with regard to co-operations and joint projects.

For the exploration of central positions and roles, those actors were selected that show levels of degree centrality and betweenness centrality with a value higher than the 75 per cent quartile of the actors' centrality measures for all four domains of (1) general exchange of information and knowledge, (2) exchange of specialized knowledge and expertise, (3) knowledge exchange for project and customer acquisition, and (4) knowledge exchange for co-operations and joint projects. These actors are individually described with their normalized centrality measures in table 5.12. It is very obvious that the majority of central actors is identical for all four network domains. A total of 12 actors build the central core of all four networks, most of them centrally present in two, three, or, for one case, even in all four net-

block	members	density: average value within blocks	std. dev. within blocks
1	111 119 121 124 128 132 134 137 138	0.2222	0.4157
2	115 125 126 129 131 135	0.3333	0.4714
3	130 139	1.0000	0.0000

Table 5.10: Case Study 2: Blocks and its Densities of the Knowledge Exchange Network for Project and Customer Acquisition

	degree centrality				betweenness centrality			
domain	Mean	std. dev.	min.	max.	mean	std. dev.	min.	max.
general exchange of information and knowledge	54.187	18.760	14.286	100.000	1.697	1.960	0.000	8.371
exchange of specialized knowledge and expertise	29.064	15.144	7.143	71.429	2.947	4.147	0.000	19.873
knowledge exchange for project and customer acquisition	10.294	5.648	6.250	25.000	3.333	5.169	0.000	18.333
knowledge exchange for co-operations and joint projects	12.105	7.999	5.263	31.579	11.871	18.640	0.000	59.259

Table 5.11: Case Study 2: Domain-related Actor Degree and Betweenness Centralities and Descriptive Statistics (normalized centrality measures)

works. This allows the conclusion that these central actors build a multiplex core of the overall network (see figure 5.24).

The core network of central actors that were derived as the 75 per cent quartile of degree and betweenness centrality measures, is analyzed in more detail with regard to the actors'

- status of actual entrepreneurial activity (activity status) and
- subjective relevance of
  - general exchange of information and knowledge,
  - exchange of specialized knowledge and expertise,
  - knowledge exchange for project and customer acquisition, and
  - knowledge exchange for co-operations and joint projects.

Moreover, these domains were again explored with regard to

1. the individual relevance in general,
2. the specific projects of the individual participants, and
3. the individual's expectations toward networking with the other participants of the advanced training program.

As tables 5.13 and 5.14 show with much evidence, the central actors rate the relevance of networking with regard to all domains as higher than the average actor of the overall network (also with a slightly lower value of std. dev.). Their activity

general exchange of information and knowledge: Central actors			
split value at 75 per cent quartile degree centrality: 66.072, betweenness centrality: 2.042			
member	actor degree centrality	member	actor betweenness centrality
129***	100.000	129***	8.371
131***	92.857	131***	6.852
130	82.143	130	4.973
138****	75.000	132**	3.084
126	67.857	126	3.049
114**	67.857	138****	2.776
132	67.857	111**	2.116
exchange of specialized knowledge and expertise: Central actors			
split value at 75 per cent quartile degree centrality: 41.071, betweenness centrality: 4.377			
member	actor degree centrality	member	actor betweenness centrality
131***	71.429	131***	19.873
129***	53.571	129***	8.332
137	50.000	135	7.925
135	50.000	139	7.306
138****	46.429	138****	6.719
114**	42.857	137	6.260
134***	42.857	134**	4.480
knowledge exchange for project and customer acquisition: Central actors			
split value at 75 per cent quartile degree centrality: 12.500, betweenness centrality: 5.000			
member	actor degree centrality	member	actor betweenness centrality
134***	25.000	134**	18.333
138****	18.750	138****	10.833
111	18.750	111**	10.833
knowledge exchange for co-operations and joint projects: Central actors			
split value at 75 per cent quartile degree centrality: 15.789, betweenness centrality: 14.376			
member	actor degree centrality	member	actor betweenness centrality
131***	31.579	131***	59.259
129***	26.316	129***	59.064
138****	21.053	132**	35.088
134***	21.053	138****	29.825
		134	15.205

** Central member with regard to two domains; *** Central member with regard to three domains;

**** Central member with regard to four domains (within centrality measure).

Table 5.12: Case Study 2: Domain-related Central Actors (normalized centrality measures)

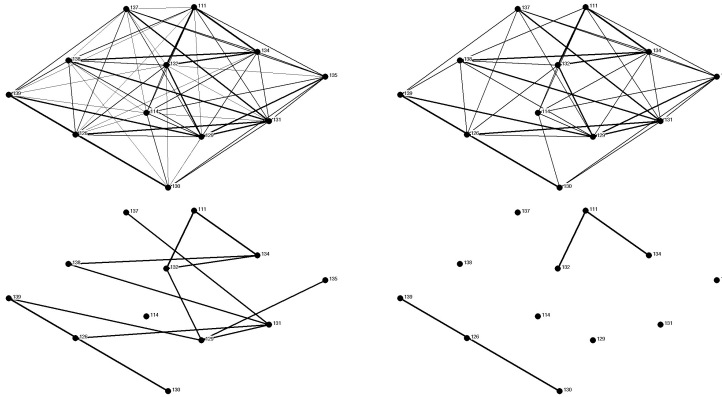

Figure 5.24: Case Study 2: Multiplexity of the Core Network (relationships with regard to more than 1, more than 2, more than 3, and more than 4 domains)

status is also higher, i.e. they have advanced projects and activities. While there is no significant difference with regard to relevance in general, project-specific, and expected, differences between the four domains are hardly to be overlooked. The difference between the central actors and the average actor of the overall network is especially high for the case of knowledge exchange for project and customer acquisition, followed by knowledge exchange for co-operations and joint projects. This leads to the conclusion that advanced entrepreneurial activity and higher estimation of networking activities, mainly for the very concrete entrepreneurial purposes of knowledge exchange for project and customer acquisition, co-operations and joint projects, are realized through higher networking activities that lead to central network positions.

5.5.4 Network Evolution

The study of network evolution compares the initial relationships between the participants of the advanced training program and their evolution during a six months period with regard to network characteristics, subjective relevances of networking issues and individual progress of entrepreneurial activity. As outlined above (see section 5.5.1), data was collected at two different points in time immediately after the first two weeks of class-room learning in August 2004 (t1) and shortly before the final presentation of the participants' projects in February 2005 (t2). During this period, six people dropped out, which lead to a decrease of all program participants from 29 to 23 people. Nevertheless, all network members

	all actors			central actors			difference	
	N	mean	std. dev.	N	mean	std. dev.	diff. mean	diff. std. dev.
activity status	23	2.217	1.476	12	2.417	1.240	0.199	-0.236
relevance of networking in general with regard to								
general exchange of information and knowledge	24	3.208	0.932	12	3.333	0.985	0.125	0.053
exchange of specialized knowledge and expertise	24	3.417	0.717	12	3.500	0.674	0.083	-0.043
knowledge exchange for project and customer acquisition	22	2.000	1.234	12	2.500	1.000	0.500	-0.234
knowledge exchange for co-operations and joint projects	22	2.955	1.090	12	3.333	0.651	0.379	-0.439
relevance of networking related to the specific project or entrepreneurial activity with regard to								
general exchange of information and knowledge	24	3.000	1.142	12	3.083	1.240	0.083	0.098
exchange of specialized knowledge and expertise	24	3.083	0.929	12	3.167	1.030	0.083	0.101
knowledge exchange for project and customer acquisition	22	1.591	1.368	12	2.333	1.371	0.742	0.002
knowledge exchange for co-operations and joint projects	22	2.364	1.329	12	2.833	1.267	0.470	-0.062
expected relevance of networking with the other participants with regard to								
general exchange of information and knowledge	24	3.042	1.122	12	3.167	1.193	0.125	0.071
exchange of specialized knowledge and expertise	23	2.783	1.043	12	3.167	0.937	0.384	-0.105
knowledge exchange for project and customer acquisition	22	1.636	0.953	12	2.000	0.739	0.364	-0.215
knowledge exchange for co-operations and joint projects	22	2.045	1.290	12	2.333	1.155	0.288	-0.135
mean of all network relevances							**0.302**	**-0.076**

Table 5.13: Case Study 2: Comparison between All Actors and Central Actors 1

	diff. mean	diff. std. dev.
relevance of networking in general, project-specific, and expected with regard to		
general exchange of information and knowledge	0.111	0.074
exchange of specialized knowledge and expertise	0.184	-0.016
knowledge exchange for project and customer acquisition	0.535	-0.149
knowledge exchange for co-operations and joint projects	0.379	-0.212
relevance of networking (all domains)		
in general	0.272	-0.166
project-specific	0.345	0.035
expected	0.290	-0.096

Table 5.14: Case Study 2: Comparison between All Actors and Central Actors 2

except member 135 are still part of the network and therefore taken into account for the analysis of network evolution.

In the second network survey (t2), participants were asked about their estimation of the advanced training program with regard to relevance of knowledge exchange. Exchange of general information and knowledge as well as exchange of specialized knowledge and expertise are rated on a medium level, while exchange of knowledge for project and customer acquisition and for co-operations and joint projects is rated on a lower level (see table 5.15 and figure 5.25). But those actors who have a central position in the network of round 1 (see above section 5.5.3), rate the actual relevance of knowledge exchange in the program as higher with regard to all domains, especially for project and customer acquisition and for co-operations (see also table 5.15 and figure 5.25).

	all actors			central actors		
domain	N	mean	std. dev.	N	mean	std. dev.
general information exchange	18	2.722	1.1275	8	2.875	.9910
exchange of specialized knowledge and expertise	18	2.389	1.1448	8	2.750	1.3887
joint customer and project acquisition	18	1.000	1.2367	8	1.750	1.3887
co-operations and joint projects	18	1.167	1.0981	8	1.625	1.1877

Table 5.15: Case Study 2: Descriptive Statistics of All vs. Central Actors for Actual Relevance of Knowledge Exchange in the Advanced Training Program

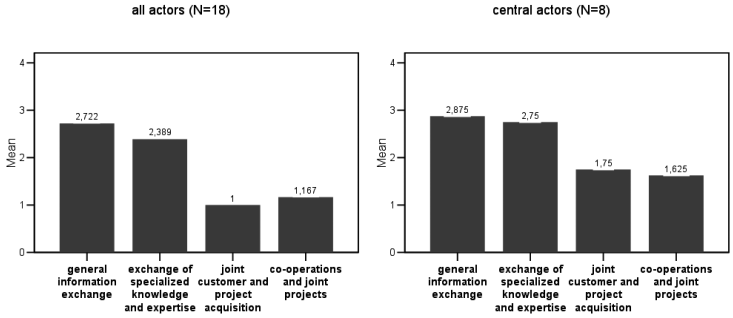

Figure 5.25: Case Study 2: Actual Relevance of Knowledge Exchange in the Advanced Training Program (0 = "unimportant" to 4 = "very important")

After the first two weeks of the advanced training program, the participants were grouped in teams of five to six people. People were encouraged to support and discuss the others' entrepreneurial ideas and activities within these small groups.

Moreover, they got professional team coaching. Altogether, relevance of these teams for networking issues was rated lower than relevance of the training program in general. But here again, those members who have a central position in the network of round 1 (see above section 5.5.3), rate the relevance as higher for both cases (team and training program in general).[68]

In the second round of the survey (t2), network relationships were analyzed with regard to frequencies of communications between its members. Therefore, participants were asked to indicate with whom they have contact on a scale with the options of 0 = "never", 1 = "half-year", 2 = "monthly", 3 = "weekly", and 4 = "daily". Results show that the existing relationships are based on

- half-year contacts for 43.2 per cent,
- monthly contacts for 50.7 per cent,
- weekly contacts for 6.1 per cent, and
- none daily contacts.

These findings indicate that nearly half of the relationships were only present during the first period and then, did not exist anymore. The other half of the relationships is based on monthly contacts. This can be explained by the monthly meetings of the training program after the first two weeks of class-room learning. The overall network, including all frequencies of communications, still integrates all members with the exception of member 135[69] and is less densely connected (density is 0.3201 for the dichotomized network) and more centralized (network centralization is 0.6923 for the dichotomized network) than the initial network (see figure 5.26). Density for the case of monthly or higher communication frequencies is even lower (density is 0.1852 for the dichotomized network with relationships ≥ 2), but the network is less centralized (network centralization is 0.4786 for the dichotomized network with relationships ≥ 2; see also the networks with regard to the different communication frequencies presented in figure 5.27).

For the exploration of network evolution, central actors in t2 were selected according to the same characteristics as in t1 (see section 5.5.3), i.e. those actors were selected that show levels of degree centrality and betweenness centrality with a value higher than the 75 per cent quartile. Individual centrality descriptions of these actors with their normalized measures (dichotomized network) can be found in table 5.16.

As the results presented in table 5.17 indicate, central actors in t2 (a total of 6 people) show a significantly higher activity status. They also rate relevance of the

[68] Teams are not subject to further discussion, since results of the analysis do not indicate any significant influence of teams on network characteristics or performance.

[69] Here and in subsequent steps of analysis, member 135 is still present in the illustrations but eliminated for analytical purposes.

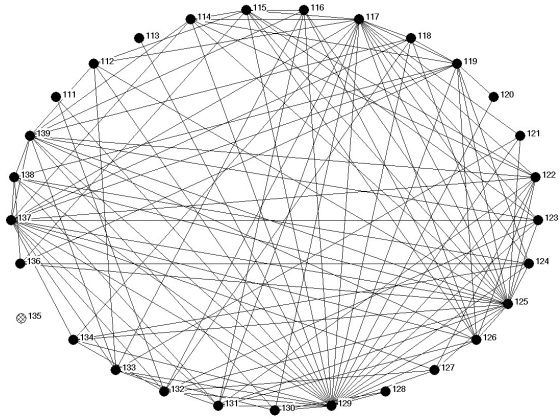

Figure 5.26: Case Study 2: Communication Network in t2 in Simple Circle View

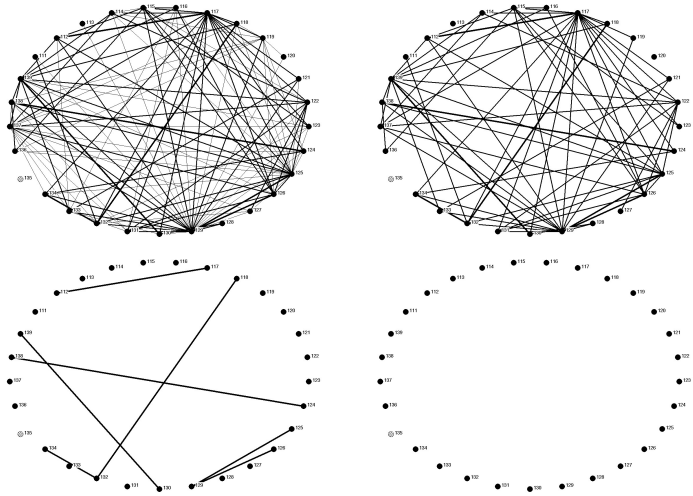

Figure 5.27: Case Study 2: Communication Network in t2 with Different Strengths Indicating Communication Frequencies (half-year, monthly, weekly, daily)

Communication Network (dichotomized ≥ 1): Central actors

split value at 75 per cent quartile degree centrality: 37.037, betweenness centrality: 1.765

member	actor degree centrality	member	actor betweenness centrality
129*	96.296	129*	36.463
125	77.778	125	11.233
117	62.963	117	6.277
137*	59.259	137*	4.225
139*	48.148	139*	3.139
119	40.741	119	2.827
(115	37.037)	115	1.861
(122	37.037)	(132*	1.477)
(126*	37.037)	(133	1.099)
(132*	33.333)	(138*	1.055)
(131*	33.333)	(122	0.717)
(133	29.630)	(131*	0.696)

* Also a central member in t1.

Table 5.16: Case Study 2: Central Actors in t2 (normalized centrality measures)

	all actors $(=A)$			**central actors t2** $(=A_{t2})$			**central actors t1&t2** $(=A_{t1t2})$			A_{t2} -A	A_{t1t2} -A
	N	mean	std. dev.	N	mean	std. dev.	N	mean	std. dev.	diff. mean	diff. mean
activity status	17	2.588	1.176	6	3.000	1.095	5	3.000	0.707	0.212	0.412
relevance of the advanced training program for networking activities	18	1.722	1.179	6	2.167	1.472	5	2.600	1.140	0.460	0.878
relevance of the individual teams for networking activities	18	1.111	1.183	6	1.833	1.329	5	2.200	1.483	0.525	1.089
relevance of the advanced training program with regard to											
exchange of general information and knowledge	18	2.722	1.127	6	2.667	1.033	5	2.800	1.095	0.187	0.078
exchange of specialized knowledge and expertise	18	2.389	1.145	6	2.833	0.983	5	3.000	1.000	0.247	0.611
knowledge exchange for project and customer acquisition	18	1.000	1.237	6	2.000	1.414	5	2.600	0.894	0.545	1.600
knowledge exchange for co-operations and joint projects	18	1.167	1.098	6	1.833	1.169	5	2.400	0.548	0.470	1.233
mean of all network relevances										**0.406**	**0.915**

Table 5.17: Case Study 2: Comparison Between Central Actors in t1&t2 and All Actors

advanced training program and of the teams for networking activities as higher. The same results apply with regard to all four domains of knowledge exchange, especially for knowledge exchange for project and customer acquisition as well as for co-operations and joint projects. The intersection of central actors sets in t1 and t2 (a total of 5 people) shows the same results, but on a significantly higher level.

Although relevance of networking and knowledge exchange is on the average rated on a medium level only, results of the case study clearly indicate significant correlations between subjective assessment of networking issues and knowledge exchange, network positions and network evolutions, and status of the individual entrepreneurial activity. Especially the core network of central actors rates relevance of networking for knowledge exchange as very important and shows a high level of entrepreneurial activity status. These findings raise three central questions that should be explored through further research:

- Is the entrepreneurial person's awareness of relevance of networking and knowledge exchange an individual characteristic that leads to successful entrepreneurial activity?
- Are people with high involvement in networking activities more successful entrepreneurs?
- Have the networking activities within the advanced training program contributed to the successful progress of the individuals' entrepreneurial activities or are networking, knowledge exchange, and successful entrepreneurial activity not related to the training program but a general practice and skill of the individual person?

5.6 Case Study 3 (Application Study): Inter-organizational Knowledge Community Building[70]

5.6.1 Background

Research into understanding expert knowledge communication within innovation processes has become a primary interest of study. Increasingly, the focus is put on inter-organizational settings and forms of network organizations. Hereby, the social perspective has emerged as a dominant paradigm in studies on organizational and inter-organizational knowledge sharing. A growing literature focuses on the socially-derived concepts such as communities (see, e.g., Brown and Duguid 1991, Erickson and Kellogg 2001, Lesser et al. 2000, Wenger et al. 2002, Scarbrough and Swan 2001) and knowledge networks (see, e.g., Collinson and Gregson 2003, Liyanage et al. 1999, Powell 1998, Seufert et al. 1999a, Swan et al. 1999; on differences and similarities between these concepts see section 3.4).

The basic idea of the institutionalization of social networks as intermediaries for knowledge transfer, particularly in the field of research and development (R & D) and innovation processes, is supported by various empirical studies. In the 1960s and 1970s already, researchers in business science started investigations in network structures of R & D laboratories; see, e.g., Allen and Cohen (1969), Allen (1977). In the 1980s and 1990s, research on intra-organizational networks in industrial enterprises increased excessively and lead to the general consensus that networks matter (see also sections 4.3 and 4.4). While there are various studies on general networks within and between organizations, studies strongly focused on knowledge sharing through social networks within very specific domains that are of critical relevance to success and failure of R & D organizations are hard to find. Moreover, studies of social networks in the field of applied research are rare (only few studies can be found in the field of product development; see, e.g., Biemans 1992, Gabbay and Zuckerman 1998).

5.6.2 Social Network Analysis as a Method for the Evaluation and Support of Inter-organizational Community Building

The argument presented here is explored through an empirical case study on inter-organizational knowledge community building between the 17 research institutes of the Fraunhofer-Gesellschaft and their headquarters, a large German organization for contract research in all fields of the applied engineering sciences

[70] Results were presented and discussed at the I-KNOW 05, 5th International Conference on Knowledge Management, June 29-July 1, 2005, Graz / Austria (see Müller-Prothmann et al. 2005a), and at the KnowTech 2005, 7th Conference on Knowledge Management in Industry and Administration, October 24-25, 2005, Munich/Germany (see Müller-Prothmann et al. 2005b).

(see also Müller-Prothmann et al. 2005a). The Fraunhofer-Gesellschaft started activities for the sharing of expert knowledge by establishing a Knowledge Management (KM) Community. The patterns of communication structures between the community members are studied through methods of social network analysis, including the following dimensions:

- intensity and relevance of contacts between the members,
- domain-related communication patterns,
- use of information and communication tools,
- importance of community activities with regard to general information exchange, transfer of specialized knowledge and expertise, joint projects and co-operation,
- relevance of community activities with regard to individual tasks of the community members and with regard to networking activities across organizational boundaries.

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 are evaluated by a multi-level approach taking whole network properties into account as well as specific structural characteristics and individual positions. Moreover, the study focuses on internal versus external orientation of relationships. Institutionalization of knowledge transfer is studied with regard to the development of the informal contacts between the community members and the inter-organizational linkages on an aggregated level. Results of the network analysis contribute to the development of clearly focused interventions to facilitate the network relationships and strengthen the community building process across organizational boundaries (for a selection of results from this study with regard to the examination of processes of inter-organizational community building and its contributions to sustaining or overcoming organizational boundaries see also Müller-Prothmann et al. 2005a).

5.6.3 Subjective Relevance of Knowledge Sharing

Similar to case study 2 (see 5.5), the relevance of the KM Community for knowledge sharing was rated by its members with regard to

- general exchange of information and knowledge,
- exchange of specialized knowledge and expertise,
- joint project acquisition, and
- co-operations and joint projects.

	N	mean	std. dev.
general information exchange	38	2.895	1.0601
exchange of specialized knowledge and expertise	38	2.605	1.0011
joint project acquisition	38	2.263	1.2667
co-operations and joint projects	38	2.605	1.2420

Table 5.18: Case Study 3: Descriptive Statistics of Relevance of the KM Community

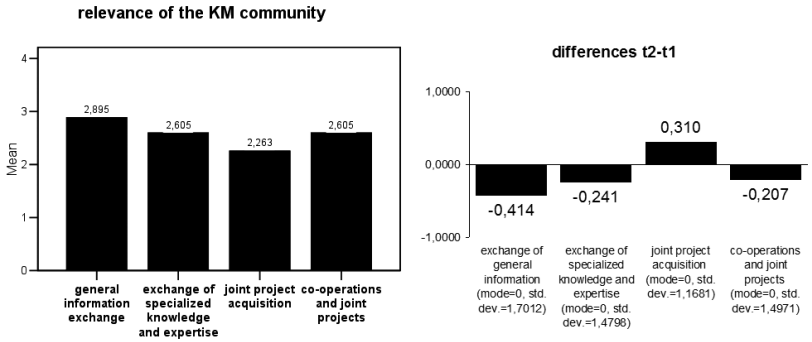

Figure 5.28: Case Study 3: Relevance (t1) and Change of Relevance (t2-t1) of the KM Community with Regard to a) General Exchange of Information and Knowledge, b) Exchange of Specialized Knowledge and Expertise, c) Joint Project Acquisition, and d) Co-operations and Joint Projects (0 = "unimportant" to 4 = "very important", t2-t1 measures differences of means between answers of individual participants that are identical for t1 and t2)

As table 5.18 and figure 5.28 show, relevance of the KM Community was considered in t1 as being important on a medium level with regard to all four dimensions on a scale from 0 = "unimportant" to 4 = "very important" (mean 2.592). A slight decrease of relevance must be noticed during the evolution from t1 to t2 (mean -0.287), except for the dimension of joint project acquisition which gained some importance, although at a low level as well (+0.310).

Additionally, subjective relevance of co-operation and information exchange within the KM Community was explored

- in general,
- with regard to the personal work of the individual member,
- with regard to inter-organizational networking.

With regard to these dimensions, the study points to significant differences (see table 5.19 and figure 5.29). While the participants rate the relevance of the KM Community on a medium level for their personal work, its importance in general and for inter-organizational networking is scored significantly higher. Here again, we notice a decrease at a low level from t1 to t2 with regard to all three aspects (mean -0.218) .

	N	mean	std. dev.
relevance of co-operation and information exchange within the KM Community			
in general	38	3.211	.7766
with regard to personal work	38	2.579	.8893
with regard to inter-organizational networking	38	3.447	.7240

Table 5.19: Case Study 3: Descriptive Statistics of Relevance of Co-operation and Information Exchange within the KM Community

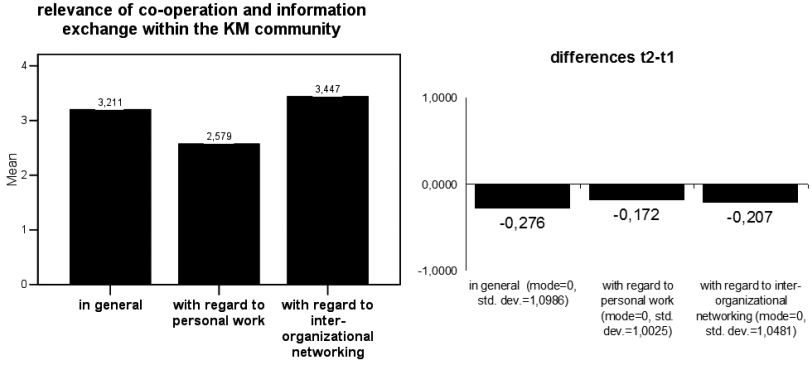

Figure 5.29: Case Study 3: Relevance (t1) and Change of Relevance (t2-t1) of Co-operation and Information Exchange within the KM Community a) in General, b) with Regard to Own Needs and Personal Work, and with Regard to Inter-Organizational Networking across Institutional Boundaries (0 = "unimportant" to 4 = "very important", t2-t1 measures differences of means between answers of individual participants that are identical for t1 and t2)

As presented in table 5.20, estimation of relevance of the KM Community for joint project acquisition and co-operations and joint projects are highly positively

correlated and thus indicate a closely related dimension. Moreover, relevance of the KM Community for general knowledge exchange is positively related at a significant level with relevance of co-operation and information exchange in general, exchange of specialized expertise with regard to information exchange in general and with regard to individual work. And finally, relevance of co-operations and joint projects is positively correlated with co-operations and knowledge exchange in general, with regard to individual work, and with regard to inter-organizational networking. These correlations are intuitively plausible and prove validity and reliability of the answers. The latter especially points to the basic interest of the KM Community members in developing co-operations and joint projects across organizational boundaries.

5.6.4 Communication Media Use

Examination of the communication channels used within the KM Community clearly indicates a rank of media use as follows (see also table 5.21 and figure 5.30):

1. personal email,
2. telephone (including tele-conference),
3. meetings (including face-to-face communication),
4. mailing list, and
5. on-line platform.

A more detailed look at communication media use as presented in figure 5.31 shows that

- daily communication is dominated by the use of the telephone (21 per cent), followed by personal email (11 per cent),
- weekly communication is also clearly dominated by the use of the telephone (42 per cent), followed by personal email (29 per cent), mailing list (26 per cent), and meetings (24 per cent),
- whereas monthly communication is mainly characterized by meetings (53 per cent), followed by the use of the mailing list (32 per cent),
- and the on-line platform is rarely used (never used by 66 per cent).

Here, it is interesting to note that, on the one hand, frequency of contacts between the community members in terms of media use increased from t1 to t2 for personal email, telephone and meetings, while subjective relevance of the community for knowledge sharing decreased during this period as shown above. On the other hand, use of the community mailing list and on-line platform, although on a

		relevance of the KM Community with regard to			
		general exchange of information and knowledge	exchange of specialized knowledge and expertise	joint project acquisition	co-operations and joint projects
relevance of the KM Community with regard to					
general exchange of information and knowledge	Pearson Corr.	1			
	Sig. (2-tailed)				
	N	38			
exchange of specialized knowledge and expertise	Pearson Corr.	0.342*	1		
	Sig. (2-tailed)	0.036			
	N	38			
joint project acquisition	Pearson Corr.	-0.180	0.042	1	
	Sig. (2-tailed)	0.279	0.805		
	N	38	38	38	
co-operations and joint projects	Pearson Corr.	0.029	0.219	0.480**	1
	Sig. (2-tailed)	0.862	0.186	0.002	
	N	38	38	38	38
relevance of co-operation and information exchange within the KM Community					
in general	Pearson Corr.	0.553**	0.423**	0.134	0.369*
	Sig. (2-tailed)	0.000	0.008	0.421	0.023
	N	38	38	38	38
with regard to the personal work of the individual member	Pearson Corr.	0.152	0.446**	0.197	0.384*
	Sig. (2-tailed)	0.361	0.005	0.236	0.017
	N	38	38	38	38
with regard to inter-organizational networking	Pearson Corr.	0.169	0.101	0.133	0.382*
	Sig. (2-tailed)	0.311	0.546	0.425	0.018
	N	38	38	38	38

* Correlation is significant at the 0.05 level (2-tailed); correlation is significant at the 0.01 level (2-tailed).

Table 5.20: Case Study 3: Correlations of Relevance of Knowledge Exchange Within the KM Community

very low level in t1 already, decreased (see table 5.21 and figure 5.30). This finding suggests, although at a low level only, that relationships between community members tend to be based on individual personal ties (personal email, telephone) rather than on institutionalized communication channels established for the sole purpose of the KM Community (mailing list, on-line platform).

	communication media use			difference t2-t1		
	N	mean	std. dev.	N	mean	std. dev.
personal email	38	2.000	1.2520	35	.514	1.8845
telephone (including tele-conference)	38	1.553	1.1318	35	.514	1.8210
meetings	38	1.158	.7893	35	.086	1.4627
KM Community mailing list	38	1.000	.9300	35	-.229	1.1903
KM Community on-line platform	38	.553	.8605	35	-.086	1.1212
others	38	.263	.6851	35	.143	1.1668

Table 5.21: Case Study 3: Descriptive Statistics of Frequencies (means in t1) and Change of Frequencies (means t2-t1) of Communication Media Use within the KM Community (0 = "never", 1 = "half-year", 2 = "monthly", 3 = "weekly", 4 = "daily", t2-t1 measures differences of means between answers of individual participants that are identical for t1 and t2)

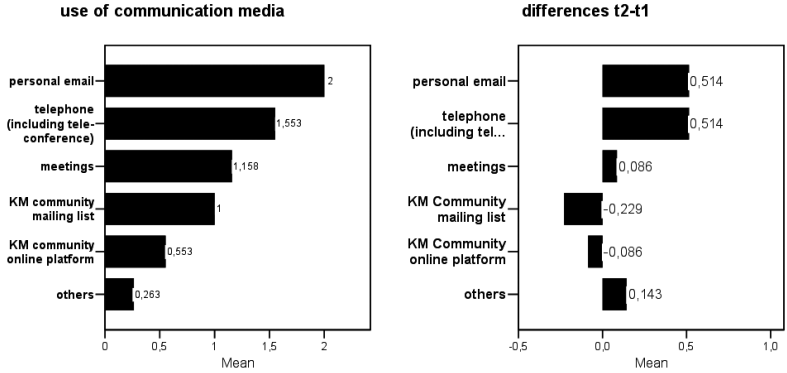

Figure 5.30: Case Study 3: Frequencies (means in t1) and Change of Frequencies (means t2-t1) of Communication Media Use within the KM Community (0 = "never", 1 = "half-year", 2 = "monthly", 3 = "weekly", 4 = "daily", t2-t1 measures differences of means between answers of individual participants that are identical for t1 and t2)

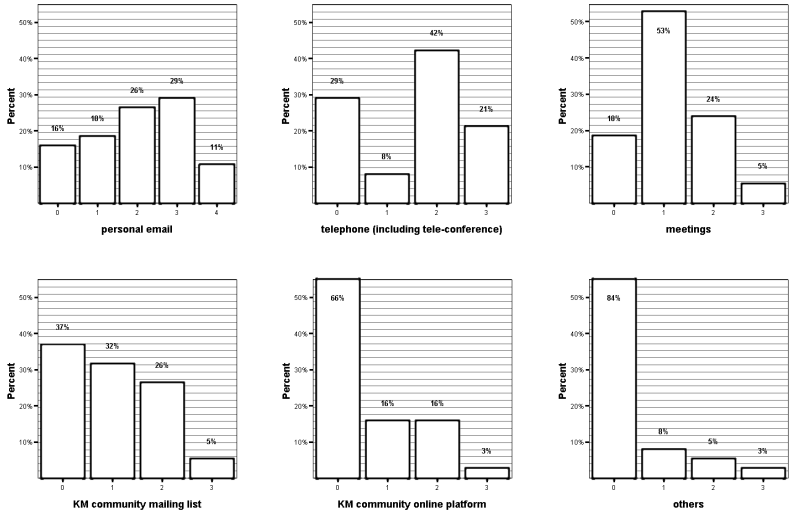

Figure 5.31: Case Study 3: Frequencies (per cent in t1) of Communication Media Use within the KM Community (0 = "never", 1 = "half-year", 2 = "monthly", 3 = "weekly", 4 = "daily")

5.6.5 Communication Network Characteristics and Central Actors

The network patterns of communication structures between the KM Community members are studied through methods of social network analysis. This network analysis distinguishes between

- general communication relationships, based on frequencies of contacts, and
- domain-related communication patterns (see section 5.6.6).

Analysis of the general communication network includes

- intensity and
- relevance of contacts between the members.

Intensity of contacts between the members was measured in terms of frequency of contacts (0 = "never", 1 = "half-year", 2 = "monthly", 3 = "weekly", 4 = "daily"). Relevance of contacts was rated on a scale from -2 = "not relevant" to +2 = "highly relevant" (recoded for computational purposes to a scale with values from 0 to 4).

Frequency and relevance of contacts are positively correlated with each other, except in two cases. Generally, individual contacts are considered relevant on a medium to high level (see table 5.22 and figure 5.32).

measure		value
N		53
mean		0.4909
std. dev.		0.2650
min.		-0.3039
max.		0.9476
quartiles	25 per cent	0.2794
	50 per cent	0.5601
	75 per cent	0.6950

Table 5.22: Case Study 3: Descriptive Statistics of Correlations Between Frequency and Relevance of Contacts

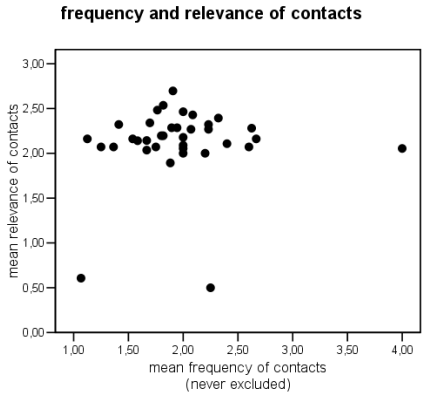

Figure 5.32: Case Study 3: Means of Frequency and Relevance of Contacts within the KM Community ("never" excluded for visualization)

The general communication network in t1 integrates all actors, except for three isolates. In t2, the main component consists of all actors besides a dyadic component and two isolates (see figure 5.33). In the first round (t1), average reciprocity of the communication relationships is 67.1 per cent, while it is considerably higher in the second round (t2) with a value of 80.1 per cent.

Centralization is on a medium level, decreasing marginally from t1 to t2, density within the main component is on a medium level, too, with a marginal increase (see table 5.23).

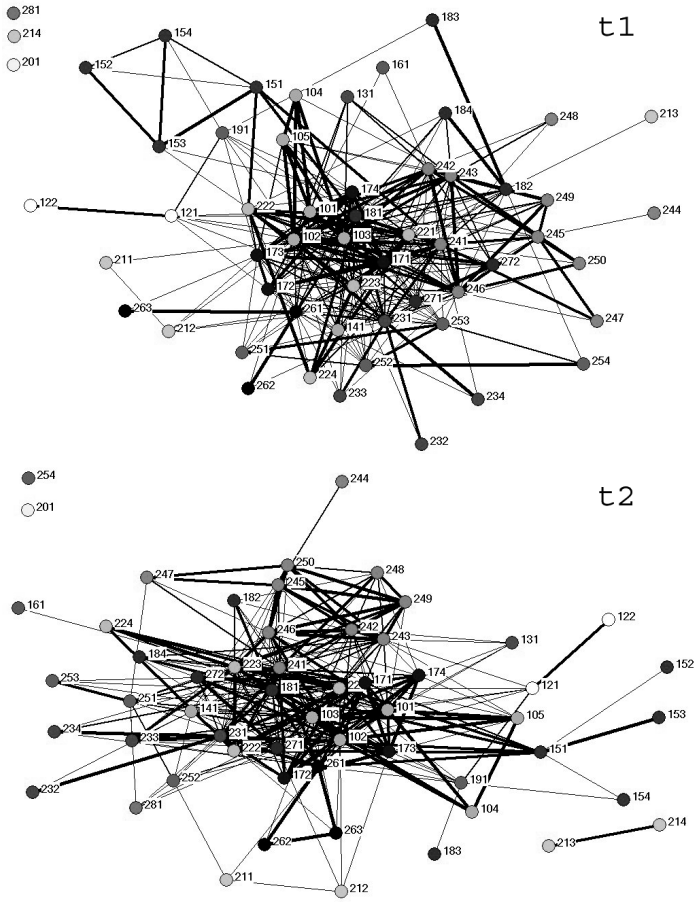

Figure 5.33: Case Study 3: Communication Networks in t1 and t2

	comm. network t1	comm. network t2
centralization overall dichotomized network	0.4525	0.4114
centralization main component	0.4672	0.4282
density within main comp	0.4311	0.4585
std. dev. of density within main comp	0.9440	0.9776

Table 5.23: Case Study 3: Centralization and Density of the Communication Network

Focusing on the ratio between internal (within the same research institute) and external (between the different research institutes) linkages, figure 5.34 clearly indicates internal dominance of more frequent contacts and external dominance of less frequent contacts. Nevertheless, we can identify a marginal shift to more frequent inter-organizational contacts from t1 to t2. Increase of boundary-spanning relationships is also supported by a marginal increase of the E-I index from t1 to t2 (see table 5.24).[71]

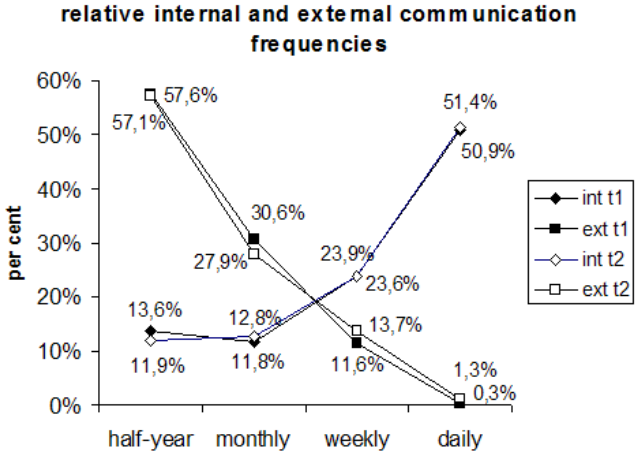

Figure 5.34: Case Study 3: Frequencies (per cent in t1 and t2) of Internal and External Communications within the KM Community (1 = "half-year", 2 = "monthly", 3 = "weekly", 4 = "daily", 0 = "never" is excluded)

	communication network t1	communication network 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 sizes the range of the E-I index may be restricted and therefore it is re-scaled to a range from -1 to +1.

Table 5.24: Case Study 3: E-I Index of Communication Networks in t1 and t2 (isolates excluded)

[71] Krackhardt and Stern (1988) introduced the E-I index as a normalized measure of the ratio between internal and external relationships. It measures the ratios between external and internal ties and normalizes them to a value within the 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 same argument applies for communication network blocks and their frequencies as presented in table 5.25. While blocks based on daily communication consist mainly of members from one organizational unit, weekly communication already integrates members from various research institutes, with an even higher number of members in t2 than in t1.

	communication network t1	**communication network t2**
blocks with strength $= 4$		
1	101 102 103 104 105	101 102 103 104 105
2	151 153	151 153
3	171 172 173 174	171 172 173 174 221 222 223 224
4	182 183 184	181 241
5	221 222 223 224	242 243 245 246 249 250
6	231 234	231 232 233 234 261 262 263
7	181 241	271 272
8	242 243 246 249	
9	245 250	
10	252 254	
11	261 262 263	
12	271 272	
blocks with strength ≥ 3		
1	101 102 103 104 105 151 152 153 154 171 172 173 174 181 221 222 223 224 231 232 233 234 241 242 243 245 246 247 249 250 271 272	101 102 103 104 105 151 153 171 172 173 174 181 182 184 221 222 223 224 231 232 233 234 241 242 243 245 246 247 248 249 250 261 262 263 271 272
2	121 122	121 122
3	182 183 184	213 214
4	251 252 253 254	251 253
5	261 262 263	

Table 5.25: Case Study 3: Communication Network Blocks According to Frequencies

The aggregation of individual network members to the level of the organization is presented in figure 5.35. Affiliation of individual actors to the different research institutes is shown in table 5.26. The figure depicts clearly the organizations which are predominantly present within the network and their inter-organizational linkages.

block	B2	B3	B4	B5	B6	B7	B8	B11	B12	B14	B17	B18
members	271 272	261- 263	251- 254	241- 250	231- 234	221- 224	211- 214	181- 184	171- 174	151- 154	121 122	101- 105

Table 5.26: Case Study 3: Blocks of Organizational Sub-groups

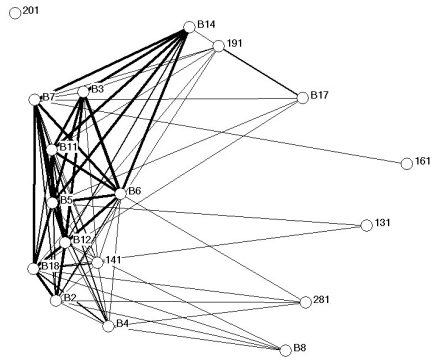

Figure 5.35: Case Study 3: Communication Network in t2 Collapsed to Organizational Blocks (in principal components layout; for block-building see table 5.26)

5.6.6 Domain-related Knowledge Networks and their Characteristics

In addition to the communication relationships in general, network characteristics were explored with regard to eight domains:

1. joint organization of events (e.g., Fraunhofer Forum, CeBit),
2. joint participation in events (e.g., conferences),
3. special-interest topics (e.g., research, dissertations),
4. new ideas, plans, and developments,
5. experience from finished projects (e.g., development of methods and solutions),
6. joint project acquisition,
7. working groups (e.g. “knowledge mapping”, “co-operations”),
8. joint research (e.g. “market research”)

Besides the main component and some isolates, actors 213 and 214 build an independent component in all domain-related networks in t2. Reciprocity for the domain-related networks is low. Here, average reciprocity is only 33.6 per cent (std. dev. 0.316). Centrality of the domain related networks is averagely on a medium level (mean 0.4641, std. dev. 0.1243), while density is low (mean 0.1725, std. dev. 0.0250; see also table 5.27).

According to our findings, domain-related network activities significantly gained importance during the period from t1 to t2. Only 17 actors are members of the main component of eight different domains in t1 (21 people are not a member within the main component of any domain-related network). In t2, a multiplex main component consisting of 29 members can be identified (only six people are not part of any

domain	centralization	density
joint organization of events	0.7073	0.1556
joint participation in events	0.5349	0.1406
special-interest topics	0.3642	0.2202
new ideas, plans, and developments	0.3720	0.1823
experience from finished projects	0.4232	0.1823
joint project acquisition	0.4858	0.1795
working groups	0.5076	0.1492
joint research	0.3175	0.1705

Table 5.27: Case Study 3: Centrality and Density in Domain-related Networks (within main components)

domain-related main component) (see table 5.28 and figure 5.36 for the multiplex domain-related network in t2 collapsed to organizational blocks, i.e. members are aggregated to blocks by institutional affiliation, in principal component layout).

	domain-related networks in t1		domain-related networks in t2	
number of domains	number of members	members	number of members	members
8	17	101 102 103 104 105 171 172 173 174 181 221 222 223 224 231 241 261	29	101 102 103 105 141 171 172 173 174 181 221 222 223 224 231 234 241 242 243 245 246 247 249 250 261 262 263 271 272
7	3	246 271 272	4	104 182 233 251
6	1	141	4	184 248 252 253
5	2	242 243	3	151 191 281
4	3	251 252 253	3	121 131 153
3	0		4	154 211 212 232
2	7	121 131 182 184 191 234 254	1	122
1	2	151 183	2	161 254
0	21	122 152 153 154 161 201 211 212 213 214 232 233 244 245 247 248 249 250 262 263 281	6	152 183 201 213 214 244

Table 5.28: Case Study 3: Members of Main Components in Number of Different Domains in Domain-related Networks

Taking a closer look at the characteristics of the domain-related networks and their network regions, we find 9 members from 5 different institutes and the headquarters within the k-cores of 6 or more different domains (see table 5.29).[72] Cut-point positions are occupied by a variety of different members and build bridges

[72] A k-core in an undirected graph is a connected maximal induced sub-graph which has minimum degree greater than or equal to k, i.e. every person within a k-core is connected to at least k other people; see Seidman (1983).

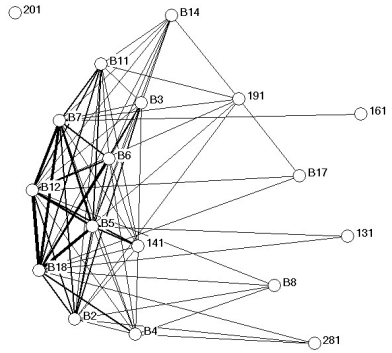

Figure 5.36: Case Study 3: Multiplex Domain-related Network in t2 Collapsed to Organizational Blocks (in principal components layout; for block-building see table 5.26)

between sub-groups that would otherwise have been cut-off and split into separate, unconnected components (see also table 5.29).

In a next step, the central members of the domain-related networks are identified as those actors who have high scores of centrality according to degree and betweenness (degree and betweenness centrality ≥ 0.95 quantile).[73] We can find a small number of 9 actors from 4 different research institutes and the headquarters who have a central position according to these criteria within one or, for most cases, even more different domains: (1) joint organization of events: 102 103 171, (2) joint participation in events: 102 103 171, (3) special-interest topics: 102 223 241 243 271, (4) new ideas, plans, and developments: 102 103 171 271, (5) experience from finished projects: 102 103 223 271, (6) joint project acquisition: 103 221 223, (7) working groups: 102 103 246, and (8) joint research: 171 241.

The ratio between internal and external ties, measured by the E-I index again, varies strongly with regard to the different domains (see table 5.31). While internal orientation can be found for all domain-related networks, it is on a low level only for the case of joint research, followed by joint participation and organization of events and working groups, and on a higher level especially for the case of special-interest topics (based on the re-scaled E-I indices).

[73] Degree centrality is a measure of the incoming and outgoing connections held by an individual network member. "Degree centrality is a measure that helps to purposefully support individual members of community" (Müller-Prothmann 2006b: 568). Betweenness centrality is a measure of the extent that a network member's position falls on the geodesic paths between other members of a network; see Freeman (1977). "Thus, it determines whether an actor plays a (relatively) prominent role as a broker or gatekeeper of knowledge flows, with a high potential of control on the indirect relations of the other members" (Müller-Prothmann 2006b: 568).

domain	k	k-core members	cut-points
joint organization of events	6	101 102 103 171 181 221 223 231 246 271 272	102 231 250
joint participation in events	6	101 102 103 141 171 231 241 261 271 272	103 141 151 174 231 250 271
special-interest topics	10	101 102 103 171 173 181 221 222 223 231 241 242 243 261 271 272	102 151 191 231 252
new ideas, plans, and developments	7	101 102 103 171 173 174 181 221 223 242 243 271	121 191 231 251 252
experience from finished projects	7	101 102 103 141 171 172 173 174 181 221 223 242 243 271	121 141 191 231 243 251 271
joint project acquisition	6	101 102 103 141 171 172 173 181 221 222 223 231 233 241 242 243 251 271	121 191 223 231 261
working groups	4	101 102 103 171 172 173 181 221 222 223 231 241 246 261 271 272	102 191 222 231 250
joint research	6	102 103 151 171 181 222 231 241 261	105 241 250 261 271

Table 5.29: Case Study 3: k-cores of Domain-related Networks in t2

domain	central actors (degree)	central actors (betweenness)
joint organization of events	102 103 171	102 103
joint participation in events	103 102 171	103 102
special-interest topics	102 271 241 223 243	271 102
new ideas, plans, and developments	103 102 171	271 103
experience from finished projects	102 223 103	271 223
joint project acquisition	103 223 221	103 223
working groups	102 103	102 246
joint research	171 241	241 171

Table 5.30: Case Study 3: Central Actors within Domain-related Networks in t2 ($\geq$ 95 per cent quantile of degree and betweenness centrality; normalized centrality measures)

	domain							
	1	2	3	4	5	6	7	8
E-I index	0.407	0.343	0.412	0.358	0.367	0.380	0.271	0.231
expected value	0.854	0.847	0.860	0.853	0.846	0.856	0.844	0.782
re-scaled E-I index*	-0.159	-0.114	-0.512	-0.342	-0.370	-0.294	-0.148	-0.077

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

Table 5.31: Case Study 3: E-I Index of Domain-related Networks in t2

5.6.7 Evolution of the KM Community Building Process

The results of the case study presented here focus on the integration of knowledge sharing within innovation processes into organizational practice. Through means of social network analysis they explore inter-organizational formation and utilization of expert knowledge, their social relationships and corresponding knowledge flows. Results presented here especially concentrate on the relationships of knowledge exchange between the formal organizational boundaries and the informal inter-organizational network structures.

Above all, findings suggest that community building activities could serve as an effective mean to overcome organizational boundaries, although relationships largely remain internally oriented. Institutionalization of inter-organizational relationships takes time, as the marginal changes within a period of approximately 4 months indicate. Nevertheless, the general communication network integrates almost all actors. A marginal shift to more frequent inter-organizational contacts and an increase of boundary-spanning relationships can be identified. Furthermore, domain-related network activities significantly gained importance during the period of observation, although the ratio between internal and external ties varies strongly with regard to the different domains. Moreover, a small number of members is of critical importance and key to knowledge flows within the different domain-related networks. Findings of media use suggest, although at a low level only, that relationships between community members tend to be based on individual personal ties (personal email, telephone) rather than on institutionalized communication channels established for the sole purpose of the KM Community (mailing list, on-line platform).

To conclude, observed community evolution shows approaches toward boundary-spanning relationships. Based on the results of social network analysis, interventions and follow-up activities will be derived and discussed at the next KM Community meeting to further contribute to overcoming organizational boundaries through inter-organizational knowledge community building. These could include, for instance, integrating (or separating) isolated and marginally connected members, strengthening the positions of central actors as domain-related network coordinators, putting a stronger focus on primarily relevant domains, and providing network cores with additional resources (see also section 5.7.5).

5.7 Leveraging Knowledge Communication Networks – Approaches to Interpretations and Interventions

> The creative environment is not always comfortable. For comfort join a club. To organize for creativity, prepare for life without certainty. You enjoy less order, you institutionalize more uncertainty, you share leadership, you run what others see as an untidy ship, and to top it all, you have no guarantee of success. Why do it? The presence of this climate, it is true, is no guarantee of success. Its absence, however, does in time guarantee failure.
>
> (O'CONNOR 1995: 296)

5.7.1 Whole-Network Properties and Knowledge Communication

As applied in the case studies presented in the previous sections 5.4 to 5.6, a variety of formal measures allows for systematic analysis of networks. For a pragmatic adaptation of social network analysis to suit practical needs, the focus here and in the following sections is put on a small selection only of very basic, although highly meaningful properties for the analysis and facilitation of knowledge networks that were used in the case studies above. The exploration focuses on selected crucial issues that are key to understanding knowledge flows of networks.

Whole-network measures describe the properties of a network without taking the specific characteristics of individual network members or sub-groups of the network into account. Therefore, they are only of very basic explanatory power. For the case of knowledge communication within social networks, two whole-network measures indicate the network properties that must be taken into account for analysis due to their basic relevance: (1) size, (2) network centralization, and (3) density.

1. *Knowledge flows within large and small networks: Size.* The size of a network is indexed by counting its members (nodes). It is a basic property of a network—sharing knowledge between all members of a large network (say, for example, between a total of 25.000 members of a whole business unit) would be extremely difficult compared to sharing knowledge between all members of a small network (say, for example, between a total of 11 members of a single research team).
2. *Centralization and decentralization of knowledge flows: Network centralization.* Network centralization, i.e. global centrality within a network, measures the degree to which relationships within a network are focused around one or a few central network members (Freeman 1977; Freeman

1979; for degree centrality of individual actors see also section 5.7.3 below). High network centralization means that knowledge flows within a network are dependent on few single nodes. If these network members are removed, knowledge flows are corrupted. A single central member can become a focal point of success or failure.

3. *Linkages of networks: Density.* Density describes the global level of linkage of a network. The density of a network is measured as the total number of ties divided by the total number of possible ties.[74] Even if fully saturated networks are empirically rare (where all possible ties are actually present), measures of density look at "how closely a network is to realizing this potential" (Hanneman 2001: 41). As a measure that is especially relevant for the case of community building within and between organizations, density describes the overall linkage between the community members.

5.7.2 Knowledge Communication and Impact of Network Structures

Three basic types of network structures have been found in the literature and in the case studies presented above to be of primary influence on knowledge communication (as already briefly introduced in section 5.1.4): (1) Sub-groups and cliques, (2) cut-points and structural holes, and (3) hubs.

1. *Sub-cultures and clusters of expertise: Sub-groups and cliques.* Sub-sets of members can build dense connections and develop cohesive sub-groups of the network. These are known as cliques and clusters (Watts and Strogatz 1998; Roethlisberger and Dickson 1947 (1939): 508-510, already wrote about "cliques" in their 1939 report). Cores, cliques, or clusters are of special interest to network analysts as they are important for understanding the behavior of the whole network. For example, organizational sub-groups or cliques can develop their own sub-cultures and attitudes toward other groups (see Cross et al. 2002b: 6). They can also gain influence on the overall network. Exploitation and integration of the sub-groups' potential resources can be a critical factor to failure or success of a community of practice.[75]

[74] Density $\Delta = \frac{1}{g(g-1)} \sum \sum_{i,j=1}^{g} x_{ij}$ $(i \neq j)$. In a network the number of unique ordered pairs is derived from $g(g-1)$. If not indicated otherwise, all formal notations given in this section follow Wasserman and Faust (1994).

[75] Several methods exist for the identification of sub-groups, clusters, cliques, and clans (like the graph theoretical methods of cliques and its extensions like n-cliques and n-clans, k-cores, k-plexes, k-components, and the algorithmic methods of factions, NEGOPY, KliqueFinder etc.). Nevertheless, there are some undeniable difficulties with any of these methods for empirical data. Commonly, real data is complex and for most cases there is no other way than to simply try the various methods and to gain experience with their handling and intuition for the exploration of network structures.

2. *Bottlenecks and knowledge gaps: Cut-points.* Often, networks are not only clustered into cohesive sub-groups, but are also split into loosely coupled components. In this case, not all possible connections are present, i.e. potential relations are empty. Persons of pivotal significance in holding components together are called cut-points or bridges: central nodes that provide the only connection between different parts of the network (i.e., the weak connections between these groups of densely connected actors that are called "structural holes" by Burt (1992)). Cut-points build bridges between sub-groups that would otherwise have been cut-off and split into separate, unconnected components. They represent the network's bottlenecks and are critical to the knowledge flow of a network. Yet too many links can lead to inefficiency of knowledge exchange. Generally speaking, links between sub-groups (for example, between members of different departments) must be coordinated effectively and efficiently (see for example the role of hubs described below).
3. *Enablers of effective knowledge transfer: Hubs.* As networks are clustered, some members are important as simultaneous actors in many clusters. These are known as hubs (Kleinberg 1999; Rosen 2000). As Barabási puts it, these persons "have played in very different genres during their careers" (Barabási 2003: 61). They can effectively link different sub-groups of the network and can facilitate knowledge flows between different departments or to external organizations. On the other hand, network efficiency can be strongly dependent on hubs, so that they provide a potential risk to the overall functioning of the network.[76]

Visualizations of networks can be arranged according to different layouts, depending on different network properties and foci of research. While network visualizations of the case studies presented in sections 5.4 to 5.6 are arranged according to structural characteristics of the networks themselves, informal networks can be compared with the formal structure of organizations by an arrangement of network members according to their formal positions. A simplified picture of the basic structural characteristics that are important for knowledge communication as found in the network study on leveraging organizational expertise is presented in figure 5.37 (here, even the arrangement of the members within the independent component is oriented toward their formal position; of course, with regard to network characteristics their position may be anywhere else, i.e. their position is completely arbitrary). Since results of a social network analysis are of a descriptive nature, knowledge about the specific organizational background is needed for

[76] The case studies presented above in sections 5.4 to 5.6 do not include hubs since they focus on rather small networks that do not allow for proper analysis of hubs.

their interpretation. To illustrate interpretation by a concrete example, an organization chart will provide the organizational background information here. Person 1 is head of a business unit with 3 departments. Person 2 is head of department a with the members 3, 4, 5, and 6. Person 7 is head of department b with the members 8, 9, 10, and 11. Person 12 is head of department c with the member 13, 14, and 15. The visualization of the informal network structure has been rearranged corresponding to the the visualization of the formal organization structure.

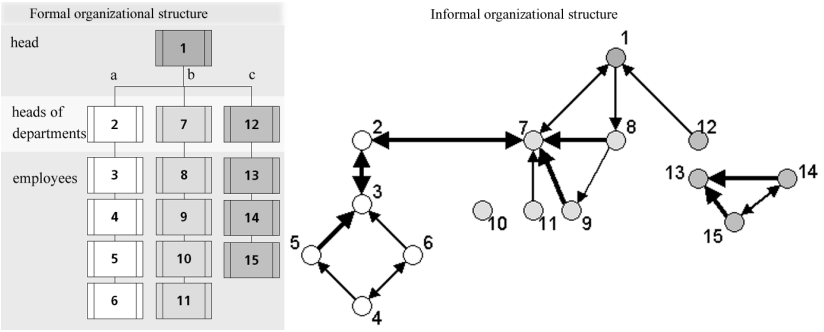

Figure 5.37: Formal Versus Expert Structure in a Research Organization (i.e., members within the informal organizational structure are arranged according to their formal position)

- *Clusters and components:* Members of department c build dense connections and develop a cohesive sub-group independent of the rest of the network since all of its members are connected.
- *Bottlenecks and knowledge gaps:* In this example, a majority of expert communication is centred around the heads of departments. For instance, if member 7 leaves the organization, there would be an excessive lack of expertise and, moreover, he would create a structural hole so that parts of the network would split into unconnected independent components.

5.7.3 Roles and Positional Models of Knowledge Communication Networks

1. *Expertise and power: Degree centrality.* Degree centrality is a measure of the incoming and outgoing connections held by an individual network member.[77] 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—in the case of knowledge networks—have

[77] Degree centrality counts incoming and outgoing connections of an individual network member n_i: $d(n_i) = \sum_{j=1}^{g} x_{ij} = \sum_{i=1}^{g} x_{ij} = x_{i.}$ $(i \neq j)$.

high levels of expertise. Out-degree defines the number of outgoing connections or the power of a member; a person with a high out-degree is considered particularly influential in the network.[78] Insufficient member links (as well as links between sub-groups—see below) might indicate the potential resources of network members that are not used. Excessive linkages might indicate the stress and overload of individual members. Degree centrality is a measure that helps to purposefully support individual members in a knowledge network. Allen (1977) speaks of "internal consulting" as the diversity in communication (or contacts) that is "the number of different individuals with whom a project member maintains contact" (Allen 1977: 115).

2. *Integration or isolation: Closeness centrality.* While degree centrality is a measure of the immediate ties of a network member, closeness centrality, as well as betweenness centrality (see below), measures the reachability of members. This is achieved by including indirect ties. Closeness centrality focuses on the distance of a member to all others in the network through means of geodesic distance.[79] It determines a member's integration within the network. Thus, 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 on the other hand indicates higher individual member dependency on the other members, i.e. the willingness of other members to give access to the network's resources. By determining the average closeness centrality of a network, the relative isolation or integration of persons can be identified. People who are not well integrated into a group could represent untapped skills. They may be highly expert people who are not being utilized appropriately (see Cross et al. 2002b: 6).
3. *Knowledge brokers and gatekeepers: Betweenness centrality.* Betweenness centrality is a measure of the extent that a network member's position falls on the geodesic paths between other members of a network.[80] 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

[78] For non-symmetric data the in-degree of a member n_i is the number of ties received by this member: $d_I(n_i) = \sum_{j=1}^{g} x_{ji} = x_{.i}$ $(i \neq j)$. Out-degree is the number of ties initiated by member n_i: $d_O(n_i) = \sum_{j=1}^{g} x_{ij} = x_{i.}$ $(i \neq j)$. In case of symmetric data, in-degree and out-degree are identical.

[79] Geodesic distance $d(i,j)$ indicates how many intermediary persons are on the shortest path from member n_i to member n_j. The sum of all geodesic distances for each member is the farness of the member from all others. Taking the reciprocal, this measure is converted into a measure of closeness, called closeness centrality. Closeness centrality of member n_i is $C_C(n_i) = \left[\sum_{j=1}^{g} d(n_i, n_j)\right]^{-1}$ $(i \neq j)$.

[80] Betweenness centrality is the sum of all probabilities that a member n_i lies on the path between other pairs of members: $C_B(n_i) = \sum_{j<k} g_{jk}(n_i)/g_{jk}$ $(i \neq j \neq k)$.

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 (see, e.g., Allen 1977: 161).[81]

4. *Strength and weakness of ties: Strength and multiplexity.* Strength (or intensity) of communication relationships between members is commonly measured in terms of frequency of contacts (as applied in all the case studies, see sections 5.4 to 5.4). Focusing on the nature of linkages more closely, network members may maintain a tie based on one single type of relationship only (a narrowly specialized relationship, for example, sharing news on only one topic of research). Alternatively, they may maintain a variety of relations. Broadly multiplex relationships may consist of sharing information, working together on projects, and playing golf together, for example. The latter are known as multiplex ties (as analyzed in all the case studies above with regard to different domains of knowledge, see sections 5.4 to 5.4). Network multiplexity is the relation between the number of actual multiplex ties and the number of possible multiplex ties in a network.[82] On the one hand, multiplex (strong) relationships share more intimate, voluntary, supportive and durable ties (see Wellman and Wortley, 1990), 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 the first case study on “Leveraging Organizational Expertise” (see section 5.4), four different roles are considered as being of primary importance for knowledge communication:

[81] The “technological gatekeeper” as outlined by Allen (1977: 141-181) is different from the concept of betweenness centrality. His gatekeeper model is based on a “star” structure, where the central person is in touch with nearly everyone else in the organization. Of course, in the case of a simple star structure only with a central person and peripheral others, and without any other more complex structures, the central person is a gatekeeper (and the only gatekeeper) according to the betweenness centrality concept as well.

[82] Multiplexity of member i is $Mi' = \frac{\Sigma_{j=1}^{n} x_{ij(m)}}{(n-1)}$ $(i \neq j)$, whole network multiplexity is $M = \frac{\Sigma_{i=1}^{g} \Sigma_{j=1}^{g} x_{ij(m)}}{g(g-1)}$ $(i \neq j)$ (see Jansen 1999: 104-105).

1. *Experts* who have detailed and specific knowledge and experience within the domain of analysis. They have the relevant "know-how". A special type of expert is the "silent expert" who has expert knowledge, but who does not share his or her knowledge and nobody knows that he or she is an expert.
2. *Knowledge brokers* who have some knowledge about who knows what ("know-who"). They may have expert knowledge as well, i.e. they understand the subject, but their knowledge is not as detailed as that of the experts. Often, knowledge broker are able to communicate the expert knowledge themselves without contacting the expert.
3. *Contact persons* (also called "agents"—see below) are people who take a brokerage position as well in that they provide the contact to the experts without communicating the relevant knowledge themselves.
4. *Knowledge consumers* who ask for knowledge from the experts.

The positions of network actors, their linkages, and their structural roles are illustrated in figure 5.37:

- *Expert networkers:* Network member 7, head of department b, is a contact person with high expertise for his colleagues. This is indicated by degree centrality, a measure of the incoming and outgoing connections held by an individual network member. Incoming connections (in-degree) define the popularity of a member; those with many ties are members who are considered having high levels of expertise. On the other hand, excessive linkages might indicate the stress and overload of member 7.
- *Silent experts:* Expertise of member 13 is received only by his direct colleagues. This probably results from the fact that his expert knowledge is not transparent throughout the organization. Insufficient links mean that these members are not well integrated into knowledge flows. They might indicate the potential resources of network members that are not used.
- *Experts and agents:* Results of the analysis indicate that member 2, head of department a, is considered an expert; nonetheless, he is not a popular contact person with regard to his expertise. Instead of member 2, network member 3 internally communicates the knowledge of member 2 within the department (with members 4, 5 and 6); he is the "agent" of member 2.
- *Experts of highly specialized knowledge:* Member 8 gives an example for a network actor that has a relationship across formal hierarchies with member 1 (compare with organization chart). This relationship may indicate highly specialized expertise of member 8.

Table 5.32 gives an overview over the different roles and their network positions.

Role	Network position	Popularity
Expert	Central network position, mostly with a high number of external linkages	low ("silent expert") to high
Knowledge broker	Bridge (between different clusters or otherwise unconnected sub-parts of the network) or star with a high number of relationships, often also with external resources	high
Contact person	Intermediary position between central (experts) and peripheral (consumers) positions	medium
Knowledge consumer	Peripheral positions	low

Table 5.32: Roles, Network Positions and Popularity

5.7.4 Measuring the Boundary-spanning Character of Inter-Organizational Networks

As introduced in case study 1 (see 5.4) and further applied in case study 3 (see 5.6), it is very simple to measure the boundary-spanning character of networks between organizations with relation to internal relationships by means of social network analysis. The E-I index, as formulated by Krackhardt and Stern (1988: 127), simply measures the ratios between external and internal ties and normalizes them to a value within the range of -1.0 to +1.0.[83] 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. These ideal types of configurations are presented as the "silo" and the "spaghetti" organization in figure 5.38.[84]

While the E-I index indicates the relationships between internal and external links, there is no optimum of its value. The desirable relation between internal and external links is always dependent of the circumstances of a specific situation.

The E-I index provides not only a measure for the boundary-spanning character of inter-organizational networks (or of networks between organizational subunits), moreover it can be used as an indicator of the identity of the network members, i.e. their internal or external orientation.

[83] E-I index $= \frac{EL-IL}{EL+IL}$ where $EL =$ number of *E*xternal *L*inks and $IL =$ number of *I*nternal *L*inks (Krackhardt and Stern 1988: 127).

[84] These terms are adopted from David Krackhardt's presentation at the Sunbelt 2005, XXV. International Social Network Conference 2005, Redondo Beach/CA, USA.

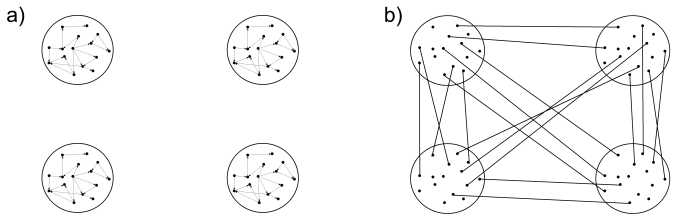

Figure 5.38: a) "Silo" Organization (E-I index: -1.0) and b) "Spaghetti" Organization (E-I index: +1.0)

5.7.5 Examples of Interventions for Leveraging Knowledge Communication in Social Networks

The impact of informal organization is evident without doubt. Although formal organization is found in many studies to be the more important of the two determinants of communication, informal organization makes its own independent contribution to individual and organizational performance or failure. And with flatter hierarchies the impact of informal organization is supposed to increase. This leads to the question: Agreeing on the importance of informal organization, what can management do about it? As Allen already suggests, "[m]anagement cannot dictate friendships or force them to develop. On the other hand, it can create the necessary conditions" (Allen 1977: 223). And we may add: it is the primary task of the management to create and facilitate the conditions of successful informal communication. With regard to our very specialized field of knowledge communication within clearly defined domains of knowledge, the method here does not aim at providing suggestions for interventions on the creation of all kinds of social relationships and friendships. Rather, the selection of interventions presented here clearly aims at purposefully facilitating knowledge communication with regard to our specified domain of knowledge.

Based on the results of the social network analysis and their interpretation, interventions are recommended to improve knowledge flows, to foster knowledge communication, and to strengthen relationships within the network, to built relationships to other networks, and to develop strategies for the creation of flourishing knowledge environments and for sustainable knowledge transfer. This section gives examples of very effective ways for interventions. Since every network shows its individual strength and weakness, the following examples are relevant for the given case studies only and cannot be treated as general recommendations. Nevertheless, they provide detailed illustrations and could be adopted with modifications for other specific cases.

As results of the case study on leveraging organizational expertise, the interventions that have been recommended aim at (1) the development of personal competencies and expertise, (2) the integration of hidden expertise, and (3) the promotion of cross-departmental knowledge transfer.

1. *Development of personal competencies and expertise.* With the exception of department c, identified expertise is focused on the heads of the departments. The question is if this is the appropriate position for experts with regard to the studied domain of knowledge; perhaps, people in other hierarchical positions should also become experts. Member 2, head of a department as well, has chosen a different approach: he shares his expert knowledge with member 3 who is the contact person for other people. Thus, member 2 is able to keep his expertise up-to-date, while in return member 3 gets the knowledge from member 2 and becomes an expert himself. This is an example of sustainable knowledge transfer based on an efficient structural relation.
2. *Integration of hidden expertise.* Marginally connected members (or isolated components like the members of department c) should be integrated into the knowledge network. A very basic, but nevertheless very effective measure for intervention is "[s]imply asking people to spend five minutes [...] to identify what they 'see' in the map, the structural issues impeding or facilitating group effectiveness, and the performance implications for the group" (Cross et al. (2002b)). But marginally connected members and isolated components can be quite resistant to change. This makes it necessary to precisely communicate the benefits of knowledge transfer for all participants and to create an environment for open knowledge exchange.
3. *Exploitation of marginally connected members.* Alternatively to the integration of marginally connected members, roles of isolated or marginally involved members could be taken seriously and exploited in their roles similar to "lurkers" as known from on-line environments, i.e. as passive promoters of the community with regard to their own networks outside the community without playing an active role within the community.[85]

[85] "Lurkers" are those people in on-line discussion boards, mailing lists, etc., who do not post messages by their own but who only passively participate as readers of the messages posted by others. "Lurkers are the biggest single disenfranchised group on the Net and the Web. Even though there are far more Lurkers than participants in most websites that permit posting and open discussions, they are invisible, sometimes counted but almost never seen or heard" (Katz 1998). Kollock and Smith (1996) describe lurkers as free-riders: "asking question but not answering them; gathering information but not distributing it; or reading ongoing discussions without contributing to them (termed lurking)". But every lurker can be considered as a potential promoter of the community's interest to the outside world. Therefore, their role in on-line communities and influence on their outside environments has become subject to a variety of studies (see, e.g., Nonnecke and Preece

4. *Promotion of cross-departmental knowledge transfer.* As illustrated in the example, knowledge is primarily communicated within the individual departments. Knowledge transfer between the departments is mediated by their heads (with the exception of the direct relationship between member 1 and 8). Knowledge exchange without the heads of departments as bottlenecks could be organized more efficiently through means of cross-departmental meetings or facilitation of communities of practice (this does not mean eliminating certain hierarchical positions, rather, people should be connected with regard to specific, strongly focused domains of knowledge without bottlenecks as barriers).

Table 5.33 gives an overview over the different targets and the related technical and social possibilities for interventions and follow-up activities.

Target	Description	IT Solutions	Social Solutions
Transparency	Improvement of knowledge of existing expertise	Expert profiles, yellow pages	Communities of practice, topic-related help-desks
Access	Facilitation and fostering of communication related to specific domains of knowledge	Knowledge navigator, intranet-based document and project management	Cross-departmental or -organizational meetings and activities
Involvement	Increase of motivation for individual knowledge sharing	On-line discussion boards, weblogs, knowledge navigator	Supporting knowledge brokers by a set of incentives (financial, trainings etc.)
Conservation	Conservation of critical knowledge	Project documentation etc. in databases	Mentoring, apprenticeship model

Table 5.33: Aims, Examples and Solutions for IT-based and Social Interventions

In final workshops, where results were presented to the network members of the case study, inefficiency of knowledge communication due to a lack of transparency was often subject to discussion. With regard to the first case study about project acquisition processes, this inefficiency could be met by popular knowledge management solutions like IT based tracking systems, knowledge navigators and yellow pages to avoid multiple project applications at the same time or to avoid "project cannibalism", to provide an overview over finished and ongoing projects and to easily find experts.

Results of the network analysis of the third case study about knowledge community building were discussed with the workshop participants according to their

2000; Nonnecke et al. 2004; Takahashi et al. 2003).

contribution to the development of clearly focused interventions to facilitate the network relationships and strengthen the community building process across organizational boundaries. The range of interventions that were discussed especially include the above mentioned aims with regard to the promotion of cross-departmental knowledge transfer, like

- better integration (or exit) of isolated and marginally involved members—or, alternatively, their exploitation as passive promoters of the community;
- promotion of central members within the community and with regard to specialized topics as co-ordinators or moderators;
- putting a stronger focus on topics of primary relevance;
- strengthening domain-related core-groups by providing additional resources.

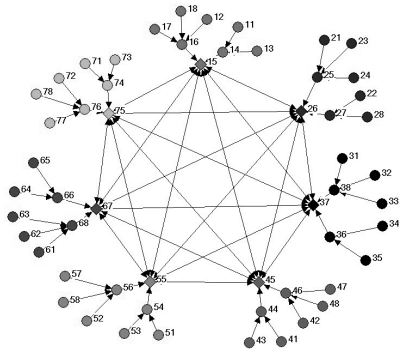

Figure 5.39: Example of a Network Structure for Expert Knowledge Communication

A network structure focusing on expert relationships that ensures high efficiency for the communication of organizational knowledge (as derived from the case study on leveraging organizational expertise, see section 5.4) could look like figure 5.39, for example. Here, we see an organizational setting with seven organizations (or one organization, consisting of seven organizational sub-units) and their expert relationships (directed toward experts). Each organization (or organizational sub-unit) has eight members. One member is an expert, two members are his agents. This makes a total of seven experts and 14 agents. Network centralization (0.1037) and density (0.0295) are low, nevertheless this network structure provides high efficiency of knowledge transfer. On the one hand, the number of experts ensures sustainable conservation of expert knowledge. On the other hand, their knowledge is effectively communicated while the experts themselves are released from

excessive contacts. The experts have a hub position. But their potential nature of bottlenecks is avoided by the position of their agents. In case an expert leaves the organization, his or her agent can take his or her place. Moreover, contacts between experts lead to knowledge exchange and continuous update of knowledge on an expert level between the different organizations (or sub-units), although the E-I index is not necessarily high (here -0.400). At the same time, this network structure shows a low level of hierarchy (expert, agent, and knowledge consumer roles are not the same as functional hierarchical positions but related to levels of individual expertise within a clearly defined domain of knowledge only).