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FACILITATING KNOWLEDGE TRANSFER IN VIRTUAL TEAMS TROUGH A SOCIAL NETWORK APPROACH

Petra M. Bosch-Sijtsema & Sonja Rispens

SOM-theme B: Innovation, knowledge and interaction

Abstract

Due to geographical dispersion and high use of information technology in virtual settings, face-to-face communication and therefore transfer of knowledge is made more difficult in virtual teams. Virtual teams (VT) are characterized by geographical dispersion, use of IT for communication, members have little history, members have organizational and cultural heterogeneity and members have lateral and weak relationships (Wong & Burton, 2000). We developed a theoretical framework with the use of one case study (a virtual team) description, in which a social network approach was applied in order to stimulate communication, and hence the transfer of knowledge concerning different knowledge areas. We found that by applying a social network approach and evaluating and re-using the data with the VT members the communication structure within the dispersed team became clearer. Furthermore, two types of knowledge transfer were stimulated: organizational knowledge transfer (how to organize a virtual team) and task knowledge transfer (how to solve a problem). Furthermore, it was found that the social context (trust and friendship) facilitated knowledge transfer.

Keywords: virtual teams, social network perspective, organizational and task knowledge transfer, social context

1 Introduction

More and more organizations work internationally and their members can be geographically dispersed. The virtual team is an example that is recently discussed in literature (Jarvenpaa & Leidner 1999; Durnell Crampton 2001). In virtual teams (VTs) employees cannot always communicate or share knowledge in person with their colleagues due to the geographical dispersion. Virtual teams are geographically dispersed teams consisting of people who carry out interdependent tasks towards a common goal and using mostly technology for communication (Durnell Crampton 2001). A VT involves participants from several organizations and different cultures, a context in which team history is low, and a tendency to work on non-routine tasks. The VT is characterized by communication structures with lateral, and typically weak relationships (Wong & Burton 2000). Virtual teams promise lower costs, flexibility and improved resource utilization to meet ever-changing task requirements in highly turbulent and dynamic environments (Jarvenpaa & Leidner 1999; Mowshowitz 1997). These promises have been tempered since researchers have argued that VTs suffer from low individual commitment, role ambiguity, role overload and social loafing (Jarvenpaa & Leidner 1999). Especially in virtual settings, communication is important for coordination (Kraut et al. 1999; Wiesenfeld et al. 1999), building trust (Jarvenpaa & Leidner 1999) and for transferring knowledge (Nonaka 1994).

An increasing body of literature discusses virtual organizations and virtual teams (Ahuja & Carley 1999; Davidow & Malone 1991; Kraut et al. 1999; Maznevski & Chudoba 2000; Moshowitz 1997; Wiesenfeld et al. 1999), however, little is discussed about means of communication in virtual settings or how communication can stimulate knowledge transfer when members are geographically spread. The literature states that developments in information technology can overcome communication over distance (Davidow & Malone 1991), but on the other hand a lack of physical proximity is negatively related to transferring knowledge (Nonaka, 1994; Galegher et al. 1990; Håkansson 1992; Kraut et al. 1999). Several studies mention the importance of both face-to-face and informal contact in the shaping and

functioning of a virtual team, since they enhance the willingness to transfer knowledge (Ahuja & Carley 1999; Kraut et al. 1999; Ring & van de Ven 1994; Wiesenfeld et al. 1999). Some studies relate social network theory to VTs in order to increase performance (Wong & Burton 2000) and build trust (Jarvenpaa & Leidner 1999). Work has been performed to study the communication structure of a virtual setting (Ahuja & Carley 1999; Wiesenfeld et al. 1999), however, these studies only describe a social network in a certain period of time. Not much is known about how social networks develop or if knowledge transfer can be increased through stimulating the awareness of the network structure within VTs.

Knowledge transfer is defined as the process through which one unit is affected by the experience of another (Argote & Ingram 2000). Knowledge transfer can occur through a variety of mechanisms, i.e., personnel movement, training, communication, observation (Argote et al. 2000). In this paper we focus on knowledge transfer occurring through communication (Levine et al. 2000; Rulke et al. 2000; Stasser et al. 2000). The success of knowledge transfer depends on the ease of communication and intimacy of the overall relationship between source unit and the recipient unit (Szulanski 1996). Due to geographical dispersion and high use of information technology (Hinds & Kiesler 1995) in virtual settings, face-to-face communication and therefore transfer of knowledge is made more difficult. In this paper we argue why a social network method is applicable and contributes to the knowledge transfer in virtual teams. We develop a theoretical framework with the use of one case study description, in which a social network approach was applied in order to stimulate communication, and hence the transfer of knowledge concerning different knowledge areas. We conclude this paper with theoretical concepts that can be tested in future research.

We found that by applying a social network approach and evaluating and re-using the data with the VT members, power relations and a communication structure became clearer. Furthermore, problems of low history and lack of trust (Jarvenpaa & Leidner 1999) could be decreased by the increase of social interaction with help of an interactive network approach. The outline of the paper is as follows. In the following

section we discuss the theoretical background of virtual teams and knowledge transfer. We present the social network approach in section three. We describe the methodology and case study (section 4) and the findings are discussed and propositions formulated in section 5. In the discussion part of the article we relate the findings to current literature within this field and make suggestions for future research.

2 Virtual teams, communication and knowledge transfer

Organizational context and interpersonal relationships are important for knowledge transfer (Nonaka & Takeuchi 1995; Szulanski 1996). Knowledge is very individual and rooted in experience and expertise (Choo 1998). Knowledge as an individual characteristic is spread through behavior, i.e. interactions (Van Veen et al. 2002). Transferring knowledge in traditional organizational settings is difficult, due to inertness (Kogut & Zander 1992), stickiness (Heath & Staudenmayer 2000; Szulanski 1996; 2000) and immobility (Simonin 1999) of knowledge. Previous research shows that physical proximity is important for transferring knowledge (Galegher et al. 1990; Håkansson 1992; Kraut et al. 1999; Nonaka 1994). Geographical dispersion of virtual teams (VT) threatens transferring knowledge via communication because virtuality drastically lowers the frequency of face-to-face contact (Davenport & Prusak 1995; Galegher et al. 1990; Sproull & Kiesler 1992). Face-to-face communication between participants of a VT is important for the shaping and functioning of a VT (Ahuja & Carley 1999; Kraut et al. 1999; Ring & van de Ven 1994; Wiesenfeld et al. 1999). Communication over distance can increase problems such as not being able to retain contextual information of the VT participants (e.g., organizational and cultural information) and differences in the salience of information (Durnell Cramton 2001). Recent research shows that a geographical dispersion has a negative impact on the more tacit (deeply rooted) knowledge transfer in VTs (Bosch-Sijtsema 2003).

3 A social network perspective

Several authors discuss the importance of patterns of relationships between VT members (Ahuja & Carly 1999; Wong & Burton 2000; Wiesenfeld et al. 1999). Recent research (Wong & Burton 2000) defines the VT into three characteristics: context (dispersion, low history and novel task), composition (organizational and cultural heterogeneity) and structure (the patterns of relationships between members in VTs). A VT that covers all these characteristics faces itself with an escalating coordination volume and the number of days to complete a task increase (Wong & Burton 2000). The relationships between virtual members are likely to be lateral but weak (related to weak ties of Granovetter, 1973) due to both a lack of prior relationship and the cultural and organizational barriers (Wong & Burton 2000). Besides the patterns of relationships in VTs, research discusses the relationship between social networks and knowledge transfer (Hansen 1999; Teigland & McLure Wasko 2000; Van Veen et al. 2002). The transfer of knowledge is an interactive process (Haythornthwaite & Wellman 1998; Van Veen et al. 2002) and the nature of knowledge transfer is partly constrained by the types of relationships people have.

The building blocks of a social network are a set of individuals and the relationships (ties) among them. Network analysis is an analytical method to study the structure of the interpersonal interactions. The focus is on the relationships among social actors, and on the patterns and implications of these relationships (Wasserman & Faust 1994). This means it is not relationships per se that are the primary focus of network researchers, but the structural pattern of those relationships. Network research, for example, concerns the impact of such structural features as network density (Burt 1982), or qualitative features such as the basis of the network (e.g. differentiating networks built around a financial source or professional affiliations; see Powell 1990; Saxenian 1994). Network structures are not stable but they change over time for several reasons. People who initially did not know each other can

become friends, some people make promotion, colleagues can leave the organization, new people can join, and so on¹.

The theoretical rationale of network research is the argument that behavior is affected by the kinds of ties and networks in which people are involved (Wellman & Berkowitz 1988). A network perspective emphasizes how the network positions of actors constrain or enable their actions. This does not rule out the possibility that actors can change their own network positions.

Recently the focus in network research has changed from only regarding networks as independent variables to regarding them as well as dependent variables, in which more attention is paid to the evolution or emergence of networks (e.g. Banks & Carley 1996; Brass & Burckhardt 1992). The focus in this area is on how these networks are constructed and used by their members. From this perspective managers derive their interest in networks (Kanter & Eccles 1992), it opens the possibility of actively manage the different relationship structures among their employees. It is important to monitor and manage communication structures, and to align the communication structure to the task characteristics (Ahuja & Carley 1999). Nevertheless, research on the emergence of networks largely ignores the possible role managers or decision-makers can play in developing and maintaining effective structures. Social network analysis (SNA) has the potential to be used as a diagnostic tool (Parker, Cross & Walsh 2001) in VTs. The diagnostic tool can help to overcome the problems stated within VTs, i.e., lack of commitment and communication problems due to dispersion and multi-disciplinarity, by stimulating more personal interaction and the transfer of knowledge. We claim that investigating the communication structure at several points in time, and feeding this information back to the organization members will be beneficial for the development of knowledge transfer. In the following section, we theorize how the use of SNA can be beneficial for stimulating knowledge transfer in a VT illustrated with data from a case study.

¹ For a more thorough introduction into social networks and their analysis we refer the reader to J. Scott (1998) *Social Network Analysis. A Handbook*, and to Wasserman & Faust (1994) *Social network analysis: Methods and Applications*.

4 Case description

The case is a virtual team (it had no single location, members communicated mainly with help of information technology) in which different partners from utility and utility-related companies combined finances, equipment and human expertise. The VT was a research project to develop ideas and tools for a deregulated electricity market. In order to accomplish this final goal within three years, members from several disciplines (business administration, computing science and telecommunication) cooperated in nine different subprojects. These subprojects were functionally divided and all fulfilled a partial goal of the whole VT goal (see appendix for the list of subprojects). The VT members were geographically dispersed over Sweden, the Netherlands, Germany and France. In table 1, several characteristics of the case study are mentioned.

Insert table 1 about here

A questionnaire was distributed in 1996 and again in 1998, in order to measure communicative and cooperative activities in the VT. The response rate of the questionnaire was 80% in 1996 to 90% in 1998. The questionnaire data were completed with semi-structured interviews (which were held twice in 1996 and in 1998) and participant observations in all meetings (see table 1). One author had a participant observation role (Adler & Adler 1994) within the case study, in which she participated as a member of subgroup 4 that investigated the virtual team's communication and information distribution. Respondent validation was applied in three team-building meetings with the VT members. Comparing the data of the questionnaires, observations and interviews performed triangulation of the data.

The direction and intensity of communication were measured by several questions in the questionnaires (see appendix 1). The frequencies and directions of communication were presented to the members of the VT during team-building discussions. In total three team-building sessions were held between 1996 and 1998 whereby all VT members were physically present. The results from the first questionnaire were presented to the VT members and after consideration the team decided that the communication structure should be adjusted so that members could gain from each other's knowledge (figure one presents the data of 1996 and 1998). In the team building sessions it was discussed what the purpose of the team was and in what direction their research should go. In the second questionnaire, the communication structure of the VT was measured again to detect changes.

Insert figure 1 about here

In the first and second team-building session all team members introduced themselves in individual presentations by telling their life track (i.e. educational and professional background) and major research interests. Also the members discussed the goals of each sub-project and how the sub-projects would fit together, and perhaps most importantly, the communication patterns were discussed (see table 2). Members were confronted with examples like: "X has a high out-degree level and cries for feedback, but there is very little in-degree, so why is the cry for information not answered?" The discussions moved further to the content of these cries for help and were related to the goals of each subproject. After the second teambuilding session several groups of sub-projects merged spontaneously to solve a specific research problem, i.e., the construction of a questionnaire in which people from several subprojects cooperated to develop future scenarios for household electricity use.

During the third team building session members discussed their prides and sorrows concerning the development of the VT, the progress of the research, and the commitment of members to the project. Perception assignments were held in which members could indicate what aspects of other team members they appreciated and

what aspects they would like to see improved. After this third session the second questionnaire was distributed. The results of the second questionnaire indicated that more knowledge was transferred in comparison to the 1996 results. These results were investigated in more detail in the second round of interviews.

Insert table 2 about here

The outgoing and incoming communication flows (out-degree and in-degree) for each member are presented in table 2. The box for *pattern* indicates if there is a balance in the incoming and outgoing degree communication of members (> out, means that there is more outgoing communication than incoming, while < is the other way around). The patterns of 1996 and 1998 are compared and both stable and dynamic patterns were found. In figure 1 it is clear that in 1998, two groups evolved who were rather coherent. These groups communicated intense internally. The interviews and observations showed that the groups were based on two scientific disciplines, a technical science group (square) and a social science group (circle).

5 Stimulating knowledge transfer: SNA as a diagnostic tool

Knowledge transfer via the communication network is critically important for sound organizational performance (Lathi et al. 2002). The key challenge for a knowledge-sharing or knowledge-transferring network is to motivate members to participate and contribute knowledge to the collective good (Dyer & Nobeoka 2000). Using SNA as a diagnostic tool can ensure that people become better connected so the organization can get the benefit of their expertise more quickly (Cross et al. 2001). We observed a difference in communication pattern in 1996 and 1998. The transfer of knowledge became more and more successful after the 1996 questionnaire which results were presented to and discussed with members in various meetings. In this section we discuss the progress in knowledge transfer by explaining how two different knowledge domains developed in the VT we studied: organizational and task knowledge. Furthermore, we found a third domain of social knowledge, which enabled knowledge transfer within the team.

5.1 Knowledge about the organization

Knowledge about the organization refers to knowledge about the structure within the VT and the responsibilities and roles that are communicated within the VT. In the interviews and questionnaire of 1996 several members complained about the fact that the organization was unclear, vague and that responsibilities and leadership roles were not clearly defined.

- *“Within ISES it was a little tricky, whom the actual project leader of the ISES project was. (PL6)”*
- *“The organisation has been so unclear, this virtual aspect, I have not seen it. It changed form exactly all the time; it was like a strange amoeba. It did not become at all what I expected. It lost people on the way. ..The organisation structure was very flat in the beginning, but grew more hierarchical towards the end (PM12).”*

After the first two team-building sessions, a group of people (consisting of members of subprojects 1, 4, 6 and 8, see appendix) gained a central role in the VT. This group consisted of both social and technical scientists and performed two roles within the VT. The first role implied having discussions and making decisions about the final goal and the development of the VT, i.e., administrative routines, communication and information distribution routines (this role was mainly initiated by members from the technical discipline, subprojects 6 and 8). The second role contained communicating, negotiating and mediating research results between the different members, autonomous partners and the project environment (this role was initiated by the social science group, subprojects 1 and 4). Over time the members of this “management” group cooperated more on both roles. It took some time before all VT members acknowledged that this group guided the content integration of the project. Although there was no explicit hierarchy in the VT, not all members had the same power for making decisions as this group did (which corresponds to studies performed by Ahuja & Carley, 1999). Especially the members of the subprojects that performed facilitating tasks had less influence on the content of the research in the VT.

Presentation of the communication pattern during the team-building sessions contributed to discussions about the VT structure and roles, in other words, knowledge about the organization was shared during these meetings. In organizations with co-location, knowledge about the job task and role is either provided by training newcomers or by the already existing informal network (cf. Wiesenfeld et al. 1999). However within a VT there is not (always) an already existing network and members have little history (Jarvenpaa & Leidner 1999; Wong & Burton 2000). Moreover, at the start of the VT we described in this paper, there was not much information available about the organizational structure, norms, and the like.

VT literature states little about the responsibility and organization structure, but within the VT described here it was clear that members needed distinct information about their roles, their responsibilities and about the management structure. One member mentioned the following in the beginning of the project:

“Case A is actually only a development project. However, here I think there is a problem, if one sees the project from the outside, people might believe that we produce a ready product when the project disbands, this opinion can lead to problems and therefore it is necessary that the goals and visions within the project are defined clearly (PM3).”

The discussion based on the communication data made the VT members more aware of their current communication pattern and that they could alter the way they interacted. This corresponds to strategies discussed in a study by Wong and Burton (2000) who state that VTs with physical dispersion, low history, a novel task, a heterogeneous culture and organization background, need clarification of role expectations and more ease of communication in order to improve performance. All this leads to the following proposition:

Proposition 1: Performing network analysis on the communication relationships in VTs and evaluating the results in team-building sessions with all VT members will enhance the transfer of knowledge about the organization.

The above mentioned knowledge transfer includes both implicit and explicit knowledge (knowledge that can be expressed). With help of network analysis and evaluation discussions, implicit expectations and communicative behaviour can become more explicit and discussable. Problems of role overload and ambiguity as stated in literature (Jarvenpaa & Leidner 1999) are made discussable with help of an interactive network approach, in order to visualize and act upon the power relationships and communication structure.

5.2 Knowledge about the task

The VT was divided into several subprojects (see appendix). Within the social and technical science group, the members shared experiences about performing research, delivering articles and how to present the work to other researchers, to the management of the project and also to the industrial partners. In contrast, the rest of the VT members had difficulty in crossing disciplines and sharing knowledge with other subprojects. For example the facilitating subprojects (2, 5, 6) did not perform

fundamental research but supplied tools and software to enable the research goal. Within these projects members found it less necessary to share knowledge.

The team-building sessions stimulated discussions about how to transfer knowledge about solving research problems of the several sub-projects and thus how to increase interaction between members. After the second team-building session, two meetings with different subgroups were initiated in which members from different subprojects shared experiences. The social science group shared experiences with the whole VT about how to deal with industrial partners. From this, the entire VT decided to present their results in a more interactive way to the industrial partners and could in the end require more information about the market, and technical problems from the industrial partners.

Proposition 2: Performing network analysis on the communication relationships in VTs and evaluating the results in team-building sessions with all VT members will enhance the transfer of knowledge across different disciplines.

5.3 Knowledge transfer facilitated by social context

Knowledge about the social context refers to knowledge that is mainly transferred via trust and friendship relationships. Friendship, for example, is suggested to facilitate both social and task relevant communication (Jehn & Shah 1996). Interpersonal trust relationships are considered being important for sustaining individual and organizational effectiveness (McAllister 1995). We assume that this should hold for a VT as well. From empirical research, it appears that the chance of knowledge transfer is much higher, when advice relationships are embedded in mutual trust relationships (Witteck 1999). Others state that knowledge connections are formed through both formal and informal relationships between individuals and groups (Inkpen & Dinur 1998). Based on this research, knowledge transfer via social relationships becomes important in VTs.

The aforementioned technical science group consisted of members who had previous affiliations, and became recognizable as a group from the start of the VT. Friendship relations existed between persons A, B and C.

In the social science group hardly any previous history was present when the VT was formed. After the second questionnaire in 1998 it became visible that friendship relations had developed between persons H and F (these members did not cooperate, but were physically co-located), between persons H and P (these members were both PhD students, following a PhD program and shared research interest) and between persons E and G (these members started to cooperate on other projects).

The question is if and how friendship and trust can be stimulated within a VT. From the descriptive data we have on this case study, it appears that somehow friendship relations emerged in the social science group after the team building sessions. We do not suggest that these kinds of relationships can be forced upon team members, however they can be *facilitated*. Holding the team building sessions, in which everyone introduced himself or herself and in which lively discussions about the functioning of the VT arose, we believe facilitated the forming of trust and friendship relationships. This leads us to the following proposition:

Proposition 3: Organizing team building sessions for VT members in which the communication structure and functioning of the team is discussed has a positive effect on building friendship and trust relationships between dispersed members who do not have previous affiliations.

Furthermore, network analysis on the friendship and trust relationships could reveal the informal social communication structure that might or might not be effective. Unfortunately this was not taken into account in the case study presented here. Network results on the informal social communication structure and hence further discussing these results in team meeting might improve knowledge transfer within the VT, in the same manner as we proposed above.

6 Discussion

The purpose of this paper was to argue why and how social network analysis can contribute to knowledge transfer in virtual teams. Knowledge transfer in VTs is quite problematic mainly because of the geographical distribution of its members. With help of one case study we developed a theoretical framework, resulting in three propositions. We theorized that applying SNA in VTs and making the data available to and discuss the results with all members can overcome several problems within VTs such as communication over distance, lack of trust and low commitment. An analysis of the communication network provides VT members with a clearer picture of the structure of their team. Furthermore, knowledge transfer between VT members can be stimulated when SNA data are discussed and evaluated within the team. We argued that different knowledge areas as knowledge about the organization (e.g., structure, roles, responsibilities, and ways to communicate), knowledge about the task (problem solving knowledge) and social knowledge (friendship and trust, cf. Jarvenpaa & Leidner 1999), were enhanced. In the literature several studies on VTs confirm that through communication patterns the organizational structure can be made more explicit (Ahuja & Carley 1999) and organizational identity can be found (Wiesenfeld et al. 1999). In figure 2 we summarize the different elements of the framework and the relationships among them.

Insert figure 2 about here

We provided a first step to build a theoretical framework to use social network analysis to enhance knowledge transfer in VTs. We propose that such a theoretical framework contributes to the literature in three ways. First, it is a first step in facing the knowledge transfer problem in virtual teams. As we illustrated with the case study, discussing the results of SNA facilitates the emergence of trust and friendship

and enhances the transfer of organizational and task knowledge. Second, the relationship between social networks and knowledge sharing is acknowledged in the literature (e.g., Hansen 1999; Nonaka & Takeuchi 1995), however, these studies are not applied to actually change communication patterns actively in a virtual setting. Most (if not all) network researchers suggest that results of network analysis can be used in order to improve or change organizational structures (Flap et al. 1998), but these pointers are not described in such a way that the results of the research can be easily applied. The “interactive” SNA approach we described here is theorized to be stimulating communication among VT members to create a more efficient structure in terms of knowledge transfer. Third, several papers have been written in which SNA was used in an organizational setting to map the network structures and to advise management how to deal with it (Lathi et al. 2002; Cross et al. 2001) however, these papers do not exceed the specific organizational setting in which it was applied. We provided three propositions about how a diagnostic use of social network analysis can stimulate communication and hence the transfer of knowledge. These propositions shall be tested in future empirical research. We provided a first step in revealing how knowledge transfer between members of a virtual team can actually be managed.

Clearly this paper is explorative in nature. The case study data suggests that the discussions about the first SNA results lead to altered communication patterns, however, based on one case study we can only hint at a causal relationship. The communication pattern might as well have changed due to developments in time, i.e. people get more acquainted over time, even if all communication only takes place with use of IT and no team building meetings are held. Therefore, we stress that more empirical research in this area is needed. Cross-case analysis (Eisenhardt 1989) is a promising approach that can be applied in future research, in order to investigate the application of SNA for knowledge transfer.

Furthermore, characteristics of the task have also been found to affect knowledge transfer (Argote & Ingram 2000). The most fundamental task characteristic found to affect transfer is the similarity across tasks in different contexts. The more similar the number of elements across the tasks, the greater will be the likelihood of transfer

(Argote & Ingram 2000). In the case study described here, the primary task for most VT members was research. In that sense the tasks show great similarity even though the subject of study differed among the researchers. Future research should address this variable explicitly and investigate if and how the use of SNA as a diagnostic tool might overcome the problems of task differences.

Finally, in this paper we merely focused on the amount of communication and not so much on the actual structure of the communication network. Future research should also include testing explicit hypotheses about structural features. For instance, in the case study we found that the results of the first questionnaire showed that some individuals occupied a central position within the team, for example person A (see figure 1). Such a central position can be both powerful and rather vulnerable. If this person would leave, the project would have much difficulty to continue since knowledge used to be transferred via this person. Initially person A was the main contact person between the project members and the industrial partners, later on, as the results of the second questionnaire indicate, person A was also the main person who communicated between the social and technical science group. Whether or not such a position is powerful, depends of course on the viewpoint of the VT. However, scientific research might investigate if such a position might be more or less powerful depending on the social communication structure. It may very well be the case that social communication relationships exist between the two groups for which person A appears to be a bridge. In such a situation that position is not necessarily a vulnerable one; if person A would leave it might be very likely that the two groups fall back upon the social communication relationships.

In sum, future research needs to sort out the causal order among the several components of our framework, and more elements need to be implemented in the framework. To realize its full potential, network analysis must move beyond mere description to make normative statements about what kinds of networks supports organizational effectiveness and how such networks are formed and maintained (cf. Nelson 1989: 389).

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Table 1: Key characteristics of the organizational example.

<i>Case study characteristics</i>	
<i>Primary process</i>	Research, development of ideas and tools for a future deregulated energy market.
<i>Dispersion</i>	No single location, members dispersed internationally
<i>IT use</i>	File-sharing system, e-mail, ICQ, internet
<i>Domain</i>	Energy industry (public-private partnership)
<i>Size</i>	20-30 members (core group)
<i>Members</i>	Members hired from universities, consultant firms and companies. Most members were engineers; a small group were social scientists.
<i>Task</i>	Research, non-routine task. Some interdependency (individual research based upon other research).
<i>Project Duration</i>	Early 1996 to the end of 1998
<i>Research method</i>	1996-1998 (whole project duration), questionnaires (2x), interviews (2x) and observations.

Figure 1: Communication map of the case study in 1996 (left) and 1998 (right); [1] A, means subproject 1, person A.

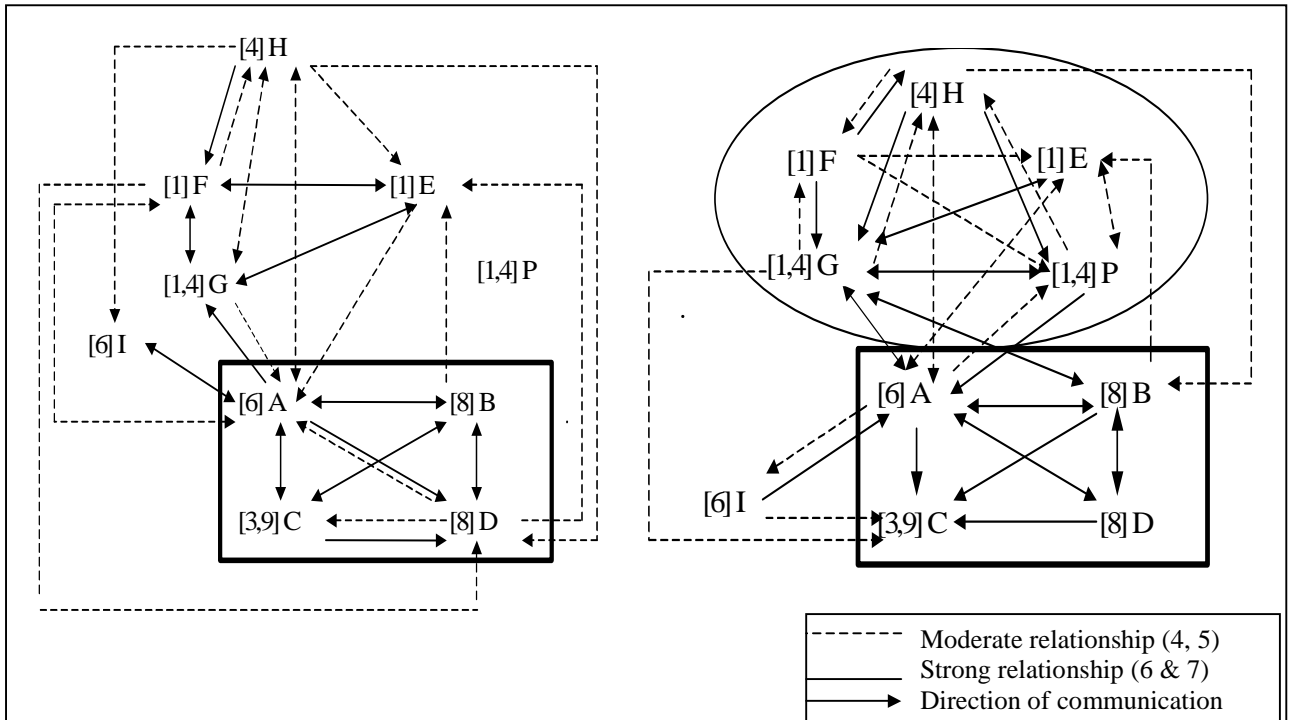


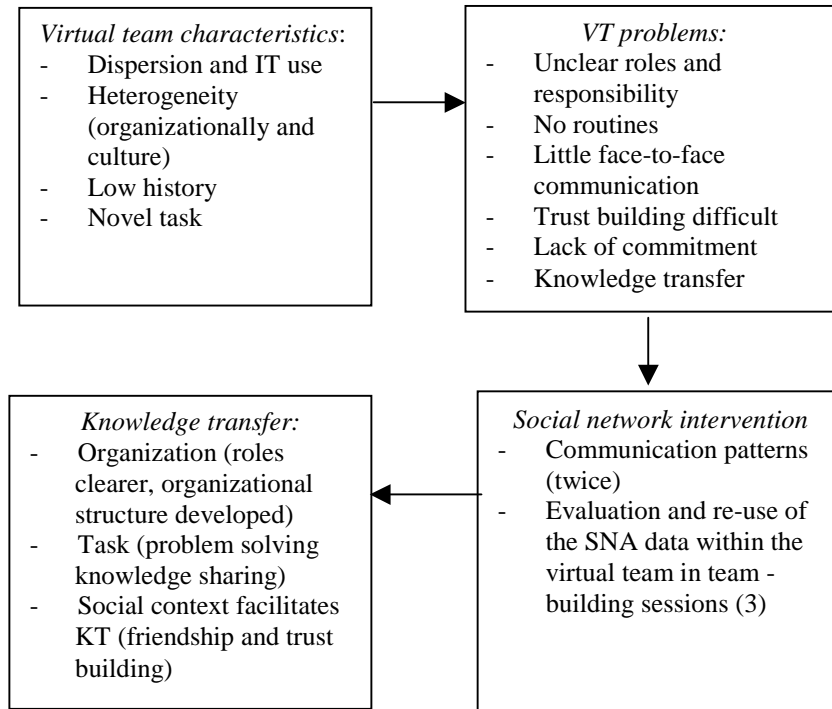
Table 2: Output/ input analysis the organizational example: 1996-1998. Values presented are the total amount of values stated by members to other named participants in the questionnaire. The input analysis is based on the total sum of all values given to a single participant. Person P just started in 1996 when the questionnaire was held and had no interaction with persons yet. In column “member” the S = Sweden, the number stands for different locations in Sweden, N = the Netherlands, U = USA, D = Germany.

Member	<i>Out 1996</i>	<i>In 1996</i>	<i>Pattern</i>	<i>Out 1998</i>	<i>In 1998</i>	<i>Pattern</i>	<i>Pattern 1996-1998</i>
A (S1)	60	72	> in	50	48	balance	In → balance (Dynamic)
B (N)	50	39	> out	45	31	> out	Out → out (Stable)
C (S2)	69	52	> out	-	38	missing	
D (S3)	46	47	balance	34	31	balance	Balance → balance (stable)
E (S4-U)	34	35	balance	26	33	> in	Balance → in (Dynamic)
F (S2)	47	40	> out	37	24	> out	Out → out (Stable)
G (S5)	49	43	balance	47	44	balance	Balance → balance (stable)
H (S2-N)	59	42	> out	37	31	> out	Out → out (Stable)
I (S5-D)	23	35	> in	23	15	> out	In → out (Dynamic)
P (S1)	-	-	-	28	32	balance	

Table 3: Intensity of communication flows of the organizational example team members. 5/6 means a value of 5 in the measurement of 1996 and a value of 6 in 1998. Person C did not respond to the second questionnaire and person P had no interaction with any of the members in 1996 (he just started at that point in time).

<i>Members</i>	<i>A</i>	<i>B</i>	<i>C</i>	<i>D</i>	<i>E</i>	<i>F</i>	<i>G</i>	<i>H</i>	<i>I</i>	<i>P</i>
<i>A</i>		5/6	6/6	6/6	3/5	4/3	6/6	5/4	7/4	-/5
<i>B</i>	6/7		7/7	7/7	4/5	3/2	3/6	2/2	2/2	-/2
<i>C</i>	7/-	7/-		7/-	3/-	2/-	3/-	2/-	2/-	-/-
<i>D</i>	4/6	7/7	5/6		4/2	3/2	3/2	3/2	2/2	-/2
<i>E</i>	4/4	3/2	1/1	3/1		6/3	6/7	3/2	1/1	-/4
<i>F</i>	4/2	3/3	2/1	5/3	6/5		7/7	5/7	2/2	-/5
<i>G</i>	5/7	3/5	1/4	-/3	6/7	6/4		5/5	1/2	-/6
<i>H</i>	5/4	3/4	3/2	4/2	4/2	6/5	5/6		4/-	-/6
<i>I</i>	6/6	1/2	1/5	1/3	1/1	1/2	1/1	1/1		-/1
<i>P</i>	-/6	-/-	-/-	-/-	-/4	-/3	-/7	-/4	-/-	

Figure 2: Summary of the article.



Appendix: questionnaire questions and subprojects

Scale is: not at all 1 2 3 4 5 6 7 very much

1. For each person in ISES, please rate the following questions by writing the most descriptive number in each column; except for those you have no interaction with.
2. How much interaction is there with the person?
3. How well do you know her/him?
4. How much data do you think that s/he typically wants to receive?
5. How broad do you think her/his interests are?
6. How much interest does s/he have in your subproject?
7. How much does s/he contribute information or ideas to your subproject?
8. How much do you work together to generate creative ideas?
9. How much emotional support do you get from her/him?
10. How much contact do you want with her/him?
11. How interested is s/he in non-work, social communication?
12. What mode(s) of communication do you use with (*not with yourself*): (list of all names)
13. What mode(s) of communication would you prefer to use with (*not with yourself*): (list of all names)

Subprojects of the case study

Market and organization	Enabling technologies	Computing science
(1) New business strategies (4) The virtual organization	(2) Human machine interfaces (5) Cost optimisation of energy systems (6) Energy system control technology (7) Global and local communication	(3) Databases and structured documents (8) Distributed load control (9) Distributed autonomous agents