

Collaboration Patterns in Distributed Work Groups: A Cognitive Network Approach

TOM E. JULSRUD



Tom E. Julsrud
is a research
scientist in
Telenor R&I

A promising and relatively new approach for studying distributed work groups is the application of social network techniques and theories (Ahuja and Carley 1999; Sparrowe, Liden et al. 2001; Cummings and Cross 2003; Hinds and McGrath 2006). A social network approach to distributed groups draws attention towards the social relations between the nodes in a network of distributed employees. Growth of new data coming out of on tele- and computer based traffic offers new opportunities to conduct such studies, and to analyse structures of collaboration patterns in distributed groups. Yet, the emerging field of network studies calls for a closer understanding of the relationship between patterns of mediated interaction and other more subjective relations, like trust and friendship. Based on a cognitive network approach (Krackhardt 1987; Corman and Scott 1994) this paper argues that observable interaction may be seen as indicative representations of a close relation, but not as confirmation. In particular in work settings, a high interaction level should not be seen as confirmative for close relationship, since much interaction is related to formal tasks. Interaction based ties should therefore be handled with care, and supplemented with other relational network indicators in network studies of distributed groups. The arguments are substantiated with results from a recent study of a group of distributed workers in an ICT company.

1 Introduction

While earlier studies of ICT-based work primarily focused on individual teleworkers (Jackson and der-Wilen 1998), recent studies tend to embrace the larger group of distributed and co-located employees. As such, work in the field of *distributed work* groups and virtual teams has accumulated rapidly the last decade (DeSanctis and Monge 1999; Lipnack and Stamps 2000; Hinds and Kiesler 2002; Duarte and Snyder 2006). This trend draws the study of telework closer to research fields concerned with teams and collaboration in computer-based environments¹⁾.

A promising and relatively new approach (in this field) is the application of *social network techniques and theories* (Ahuja and Carley 1999; Sparrowe, Liden, Waynes and Kraimer 2001; Cummings and Cross 2003; Hinds and McGrath 2006). Social network analysis is a theoretical and methodological paradigm that studies the patterning of relations among social actors, as well as the patterning of relationships among actors at different levels (Wellman 1988; Wasserman and Faust 1994; Scott 2000; Breiger 2004). A social network approach to distributed groups, then, draws attention to the social relations between nodes in a network of distributed employees or to the relations surrounding a single individual among distributed workers.

Growth of new user friendly software and access to new data coming out of on tele- and computer based traffic offers however new opportunities to conduct such studies and to analyze structures of collaboration patterns in distributed groups. This new wave of network mapping tools offers representations of distributed groups as dynamic communication networks. Yet, the question of how to interpret communication based networks is still often left unanswered. I will argue here that the field calls for a more elaborated understanding of the relationship between mediated interaction and other more affective relations, like trust, friendship, and identification.

This paper will illuminate some of these new opportunities and challenges represented by this development. It is suggested that a cognitive network approach (Krackhardt 1987; Corman and Scott 1994) may be a useful point of departure to entangle the diverse networks involved within a group. A Case study of distributed workers is used as illustrative evidence to the general argument proposed here; that different media may be related to different types of relations, and that intensive communication ties do not necessarily indicate affective closeness. The central objective of this paper is then 1) to suggest a theoretical framework useful to analyze patterns of mediated interaction as well as affective ties in distributed groups and; 2) present preliminary findings

¹⁾ I will use the term distributed work groups in this paper, to denote groups that work together across time and space supported by the use of various ICT. Although several of the works cited in this paper use other terms like "virtual teams" and "computer supported collaborative work groups", I will stick to this term.

based on a case study of distributed workers utilizing this framework.

2 Distributed Group as Structural Networks

Social networks analysis is a strong approach to analysis of distributed collaboration. Based on a structural understanding of groups, it draws attention to the particular ties and bonds that hold a group of collaborators together. Groups are seen as a dynamic network of relations represented by constellations of direct and indirect ties (Scott 2000; Breiger 2004).²⁾ It can on the one hand be perceived as a methodological approach where the structural relations of a group is the basic area of interest, opening for a rich set of techniques for analysis of data (Wasserman and Faust 1994). However, in a wider perspective it may also be seen as a particular analytical approach founded on structural theories in social sciences (Wellman 1988).

Approaching distributed groups as networks of relations offers significant benefits: Firstly, it helps to locate, visualize and understand *roles* employees have within social networks. For instance, a network analysis of communication patterns can locate individuals that are disconnected from the information flow, or individuals that are particularly central in a dispersed structure. Secondly, the social network approach is useful to detect *cohesive sub units* and constellations within distributed groups. If there is, for instance, a clique³⁾ of strongly connected employees located at one geographical place, this might give a distributed group an imbalance. Thirdly, a network approach opens for comparative analysis of *different types* of structural networks. Comparing different distributed work groups' structural patterns might shed light on differences in performance and stability. And fourthly, if we have the opportunity to include also external ties in our analysis, it can help understand how well a group is connected to its surrounding environment. A group's performance is often strongly dependent on how well it is connected to its surrounding environments (Ancona and Caldwell 1992). In addition we should note the particular advantage of having access to the rich set of tools and techniques for analyzing network patterns developed within this field over the last three decades.

The social network approach is not all new to studies of telework and distributed work. Network studies of distributed workers and collaborative communities have occurred (although sparsely) during the last two decades.⁴⁾ These studies have on the one hand been focusing on structures of communication and coordination of tasks in distributed groups compared to collocated groups. The studies in this category have had a bias towards finding "the one best structure" for information flow in distributed environments. As such the emphasis has been on functional interaction and communication. So far, however, the evidence has been inconclusive: While some studies have found that a centralized structure works best for distributed groups (Ahuja and Carley 1999; Hinds and McGrath 2006), others have found that a decentralized structure works best for distributed groups with complicated tasks (Cummings and Cross 2003).

Another line of research has focused on the diverse use of ICT in distributed groups and communities (Haythornthwaite and Wellman 1998; Haythornthwaite 2001; Salaff 2002; Quan-Haase and Wellman 2006). These studies have had a descriptive orientation and have tended to include a broader set of relational variables. A central finding has been that affective ties are closely related to multiplex⁵⁾ use of media. Studies of students indicate that closer ties go together with more multiplex use of media. This line of research has included affective ties and bonds in their study. The focus here has had a bias toward looking at individual networks (ego networks) rather than complete networks of groups. As such the perspective of the group is often missing.

Yet, there is in the field of distributed work a growing interest for more affective relations and structures. It has been widely recognized that issues like trust and identity are highly important for the functioning of such groups (Jarvenpaa and Leidner 1999; Kanawatanchai and Yoo 2002; Zolin, Hinds, Fruchter and Levitt 2004). In this field the network approach is a largely untapped source that may help understand how and why affective relations develop within such groups⁶⁾. Yet, as I will argue here, there is a strong need for a clearer understanding of the relationship between communication ties and other more affective

2) *Social network studies involve different types of approaches: Egocentric data, focusing on individuals' network of relations; analyses of all relations within a restricted set of nodes (1-mode data); and studies of members' co-participation in groups or events (2-mode data). The focus for this paper is on 1-mode data.*

3) *A "clique" describes a maximal complete subgraph in a larger network structure. (Scott 2000, p. 117-118)*

4) *See for instance: Belanger 1999; Ahuja and Carley 1999; Salaff et al. 2002; Wellmann et al. 1996; Hinds et al. 2006; Yuan and Gay 2006.*

5) *"Media multiplexity" indicates the use of multiple media channels to support a dyadic social relation.*

6) *The potential use of a network approach for studying trust in distributed groups is outlined in more detail in Julsrud and Schiefloe (2007).*

Type	Sources	Example
Closer networks	Personal archives	Address book on mobile phones
	Direct interaction	Personal e-mail traffic or call-lists
Distant network	Public network archives	Belong to the same e-mail list, relations on Facebook
	Communication similarities	Use the same websites, read the same magazines

Table 1 Some new electronic sources for network analysis of organizations and groups

types of ties. I will return to this issue later in this paper. First, however, I will draw some attention to the new and emerging tools used to gather network data in distributed groups.

3 New Network Data Sources

The core of the network analysis is relational ties, and different social relations have been the objects of researchers' interest. Some of the most frequently studied are communication networks (for instance daily interaction pattern), formal ties (who is supposed to report to whom), affective ties (friends, trust), advice ties (who seeks advice from whom). In the early days of organizational networks studies, divergences between formal and emergent networks were much studied. A central finding coming out of this was that successful accomplishment of the work usually depended on regular use of informal networks (Tichy and Fombrun 1979).

The communication and interaction networks have always been at the centre of attention in network analysis, and in particular studies of media use in organizations.

A central facet of distributed work is the collaboration that takes part in a virtual space, and that communication through electronic media plays a more prominent role. Even though most such groups and teams have face-to-face communication, the balance is certainly pushed in the direction of mediated communication. Thus, the mediated ties are in particular relevant for studies of distributed groups.

Moreover, the application and use of new communication media have cleared the way for a number of new electronic sources, ready to use for network analysis. Records of communication through e-mail, mobile phones, SMS, and blogs can in many cases be used as inputs to network analysis. Traces of interaction can be concerted into network matrices and thus give researchers new data to conduction of network

structures. A stream of new software that captures the mediated interaction within groups has emerged the last years. A random selection of some popular network-tracking tools includes TecFlow, Com-matrix, InFlow, Buddygraph and Enronic.⁷⁾

As a tool for analyzing communities and groups they are clearly on the rise (Tyler, Wilkinson and Huberman 2006). The importance of these electronic communication sources has been recognized by researchers almost since the dawn of the personal computer, and network studies of e-mail interaction and messaging systems have been conducted (sparsely) since the 1980s (ref: Rice et al.). The access to electronic sources has however now become much easier, due to software that is designed to track interaction based networks within predefined groups. For the most part these tools are directed towards analyzing e-mail interaction in a particular group of employees or collaborators, for instance Tyler and his colleagues who use e-mail files as a way to locate communities of practice in a research organization (Tyler, Wilkinson et al. 2006). Others have used mailing lists (Adamic and Adar 2002), mobile phone dialogues (Eagle, Pentland and Lazer 2007), and mobile phone address books (Lonkila 2004) as input sources for network studies.

In addition to the personal communication – accessible through e-mails and mobile phone logs – electronic sources include network sources like Facebook, Blogs or mailing lists. Such sites give the opportunity to capture more indirect relations based on the use of common network sources. As such, the new network sources seem to capture dimensions of both “weaker” and “stronger” ties (Granovetter 1973).

There are important differences embedded in networks based on personal interactions, public or private archives, direct interaction or similarities in activities visible in electronic sources. While interaction through e-mails is an intended and direct communication form, co-participating in the same e-mail

⁷⁾ For more information on these programs, see: <http://www.buddygraph.com/> <http://www.ickn.org/ickndemo/> <http://www.orgnet.com/>, <http://www.orgnet.com/>, <http://jheer.org/enron/>

list is a much more indirect relationship. For network analysis of organizations and distributed groups the first two types are probably the most relevant. Therefore this paper will pay more attention to these types.

Interaction between individuals can of course also be captured without the use of software tracking the actual communication. This has been done by several earlier contributions in the field of network studies. Traditional survey instruments can be applied to ask individuals about their communication behavior. The software had, however, obvious advantages related to data reliability. Studies have indicated that memory based records in many cases have proved to be unreliable (Bernhardt, Killworth and Sailer 1982). As such the network tracking software has great advantages related to methodologies relying on individuals' recollection of communication activities.

The mediated interaction network diagram gives a picture of the mediated communication at a given time slot, and when various media are used in combination the media networks can be very useful as a point of departure for a study of distributed groups. The distributed group emerges out of the interaction data as a communicating electronic community. As a strategy for collecting reliable data of communication patterns within an organization or a group, the network-generating software is highly efficient. Yet, the strategy also has clear limitations: The first is that it is usually possible only to capture small pieces of the communication traffic that is going on within a group. Gathering all communication, including the informal talks and gestures, is an almost impossible task. Therefore the use of computer data rarely reflects the complete communication environment. Second, there are usually difficulties interpreting interaction-based ties and bonds. For instance, does an intense exchange of e-mails indicate the same kind of relations as an intense interchange of text messages on the mobile phone? Or does a high level of interaction between two collaborators indicate that they have a "close" relation? Although important, these issues have been the object of only limited discussions⁸⁾.

The work setting typical for distributed work groups appear as particularly challenging when it comes to analyzing interaction patterns. The reason is that the formal system or formal tasks heavily affect on the interaction. As described by Kadushin (2005) and others, the "pure" informal network interferes with a system of expected interaction ties described in work

assignments and organizational charts. In a distributed group, the assigned tasks will be central for much of the interaction going on. Further, certain nodes in a network will be more "popular" than others due to formally assigned roles as leaders or specialists. Thus, work group ties are bound up with several factors that make interaction per se difficult to interpret directly.

4 A Cognitive Network Approach

To better understand and investigate networks of interaction in distributed groups it is necessary to ground this in a more elaborated theory of interaction and communication. As a point of departure I suggest drawing a clearer distinction between affective and interaction based relations. This perspective finds support in cognitive network theories, focusing on individuals' or groups' subjectively perceived relations in contrast to objective and interaction-based relations (Krackhardt 1987; Corman and Scott 1994). Corman and Scott have applied elements from Giddens' structuration theory to clarify the connections between observable communication networks and the latent networks of perceived relationships (Giddens 1984). They argue that social networks in general can be described as "cognitive" since they are based on individual perceptions of other individuals.⁹⁾ They argue further that different modalities explain the recursive relationships between cognitive social structure and interaction. Much in line with Giddens' description of "the duality of structures" they explain:

"... we define a communication system as a set of continually reproduced communicative interactions between individuals and collectives situated in time and space. The network is an abstract structure of rules and resources of communicative actors in a given social collective, instantiated in communication systems, but having only a 'virtual existence'" (Corman and Scott, p 174).

The social network is here described as a cognitive resource embedded within a particular social community or culture, where spatial and temporal aspects are included in the analysis. Further, the authors propose that the cognitive network structures are activated through taking part in common activities (activity foci) or enacted through various triggering events.¹⁰⁾

There is no room for further elaboration of the theoretical point made in the cognitive network theory

⁸⁾ For a discussion of possibilities and advantages related to the use of data based on computer mediated communication systems, see Rice (1990).

⁹⁾ Note that Krackhardt uses the term cognitive network structures in a slightly different way than Cormann and Scott, denoting how individuals understand relations among other persons in their organization or community. (Krackhardt 1987)

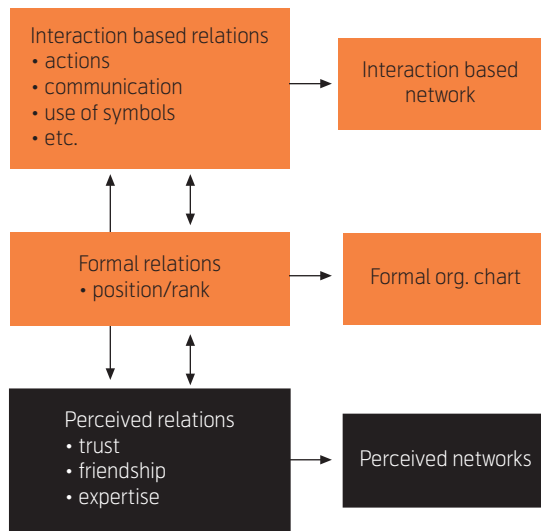


Figure 1 Interaction-based, formal and perceived relations

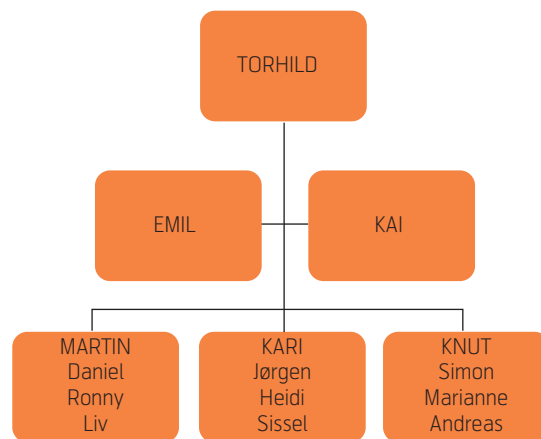


Figure 2 Omega's formal structure

here. The main point, however, is that social networks in general are seen as abstract cognitive constructs that are instantiated through participation in particular activities. The advantage of this perspective is that it helps to establish a clear distinction between a (cognitive) network structure, and a system of observable communicative actions. These structures are clearly related, but they are not isomorphic. Instead studies of the ways these structures are inter-related constitute an interesting and fertile area for empirical studies. I will in the next section of this paper use this approach as a point of departure for a case study of interaction patterns in a distributed work group.

5 The Case of Omega

The results presented here are based on a study of several work groups in a Nordic company, here called NOMO.¹¹⁾ NOMO is a Norwegian ICT-provider with a fairly strong position in the Nordic markets. Approximately one year prior to our study, the company acquired and merged with a smaller Danish company to get an even stronger position in the Scandinavian market. This process was experienced as stressful for the employees in both companies. A major objective for the company after the acquisition was to integrate its operations across the national markets to create market synergies. This led to the setting up of a number of permanent work groups encompassing employees in different locations in Norway and Denmark. Since different functions now had to be coordinated across distances and national boundaries, distributed work was initiated and formalized in several different areas. The analysis in this paper will focus on one such group; Omega.

The core task of the Omega group was to manage and develop products for a particular segment of NOMO's customers. The group consisted of 16 product managers; 12 in Norway and four in Denmark, with the manager located at the headquarters in Norway.¹²⁾ Virtually all respondents had previous employment within the respective organizations, and most of them made deliberate efforts to maintain relations with previous colleagues.

The investigations followed the group from August 2005 to December 2006. When we first got in contact with members of Omega, they had operated as a distributed work group for about 15 months. The design of the study was based on a triangulation of different methodological strategies, including qualitative interviews with individuals as well as quantitative studies of group-based social networks.

5.1 Methodologies

The study started with an *explorative qualitative study* and was followed up with a *quantitative study* targeted at more specific issues evolving from the explorative phase. Yet, in the initial phase a general questionnaire was distributed to get baseline information about satisfaction, performance and interaction patterns. In this article we will mainly deploy the group-based network data supplemented with data from the qualitative interviews.

¹⁰⁾ The theory also draws on Feld's theory of activity foci, as well as Homans' theory of social groups (Homans 1950; Feld 1981).

¹¹⁾ Note that results from this case are to be published in Julsrud and Bakke (2008).

¹²⁾ Danish and Norwegian were the working languages within the groups. The languages are fairly similar, but there are certain differences that can potentially lead to misunderstandings.

Prior to the main quantitative network study, *semi-structured interviews* were conducted with employees and managers to get a better picture of their work situation. The interviews followed an interview guide focusing on the respondents' main work tasks, social relations, identity in group/organization and trust issues, and lasted 30-40 minutes. Fourteen of the sixteen employees in Omega were interviewed.

In the *social network part module*, interactions were registered through a web-based questionnaire and coded in a case-by-case social network matrix. We asked the persons to indicate interaction-based relations as well as perceived relations. A traditional "roster" design was used to the network study, where each group member received a list of the other members in the group (Wasserman and Faust 1994). The respondents were then asked to report the frequency of interaction with other members in the group as well as the type of media used in the interaction and the three perceived ties. We used a single question to map the *trust-based relationships*: "If you decided to search for another job similar to the one you have today, but in another company; whom on the list would you most likely talk to about this?" The idea behind this formulation is that this type of discussion would imply trustfulness, as disclosure of such plans would be negative for the reputation of the individual in question.¹³⁾ Indirect questions are the most usual way to analyze trust-based relations in organizations. It should be noted, however, that such questions involve a risk of neglecting individuals that have a more introvert nature or simply prefer not to talk to anybody about such plans (even if they have trustful ties within the group).

The *expertise relations* were based on a question asking whom the informant preferred to speak to when facing problems in his/her work. Starting with the list of group members, we asked them to indicate whom on the list they would most likely turn to if they needed advice in their daily work. This expertise network does not address the affective aspect (like the trust ties), but the network with the most central professionals in the group.

The *friendship relations* were derived from our question whether there was someone on the list they considered as close friends in their group. Thus, we asked specifically for close friends, not regular work mates.

5.2 Description of Relations and Networks

As it turned out, the Omega group was handling the long-distance collaboration relatively well when measured along traditional network indicators for integra-

Interaction based relations	Face-to-face meetings Mobile phone dialogues E-mail SMS Overall daily interaction
Prescribed relations	Formal work relations
Perceived relations	Trust (affective) Friendship Expertise

Table 2 Relations investigated in Omega

tion and coherence. For example, when looking at interaction via e-mail and mobile voice, none of the members were isolated from the others. All employees in the group were in contact with at least one other person during a regular week. In addition, the dialogues connected the employees through a network that crossed the geographical boundaries of the sub-units. It is easy to see, however, that e-mail interaction followed rather closely the formal interaction lines, in particular for the group managed by Martin (see Figure 3). It is also evident that much interaction seems to go through Martin, Kai and Emil. The manager Torhild was fairly central in the information flow. The mediated relations suggested that much of the information circulated between the sub-unit managers Martin, Kari, Knut, as well as Emil (see figures). It is also evident that most of the Danish employees were well integrated in the group, despite their geographical distance from the majority of employees in Omega.

Table 3 provides more precise details for the networks based on interactions and on the perceived relations.

Among the *interaction-based relations*, the e-mail network was the most active, followed by mobile phone dialogues and SMS. The e-mail networks were denser and they also had higher reciprocity, indicating that they were not simply used to distribute information, but for two-way interaction. The lower level of *reciprocity* for SMS may suggest that this was a less formal channel, but also that the traffic here is less intense and task-related than in the e-mail network. The *average degree* score is a ratio of the number of incoming and outgoing ties for a network of relations (Freeman 1979). An average degree score reaching above six for e-mail relations then indicates that the average member had been in e-mail contact with approximately six other persons in the group during the last week. The corresponding numbers for mobile and SMS were 4.1 and 2.6. The score for e-mails was, interestingly, also higher than the face-to-face interaction (4), illustrating how e-mail connected

¹³⁾ This strategy is similar to the one used by earlier network studies on trust in organizations (Krackhardt and Hanson 1993; Krackhardt and Brass 1994; Burt and Knez 1996).

	Relation	Scale	Links	Density	Average degree	Reciprocity	Core-Periphery	E/I index
Interaction based rel.	Interaction	Daily (weekly)	45	0.188 (0.546)	2.812	0.356	0.519	-0.301
	Mobile	1-4/5-10/11-20/>21	66	0.275	4.125	0.515	0.518	-0.208
	E-mail	1-4/5-10/11-20/>21	106	0.442	6.625	0.736	0.485	-0.083
	SMS	1-4/5-10/11-20/>21	43	0.179	2.688	0.512	0.370	-0.5
	Face-to-face	Daily (weekly)	64	0.267 (0.733)	4	0.688	0.829	-0.375
Perceived rel.	Trust	Yes/no	13	0.054	0.812	0.308	0.433	-0.818
	Friendship	Yes/no	10	0.042	0.625	0.4	0.466	-0.5
	Expertise	Yes/no	66	0.275	4.125	0.515	0.377	-0.250

Table 3 Selected network characteristics of interaction-based and perceived relations

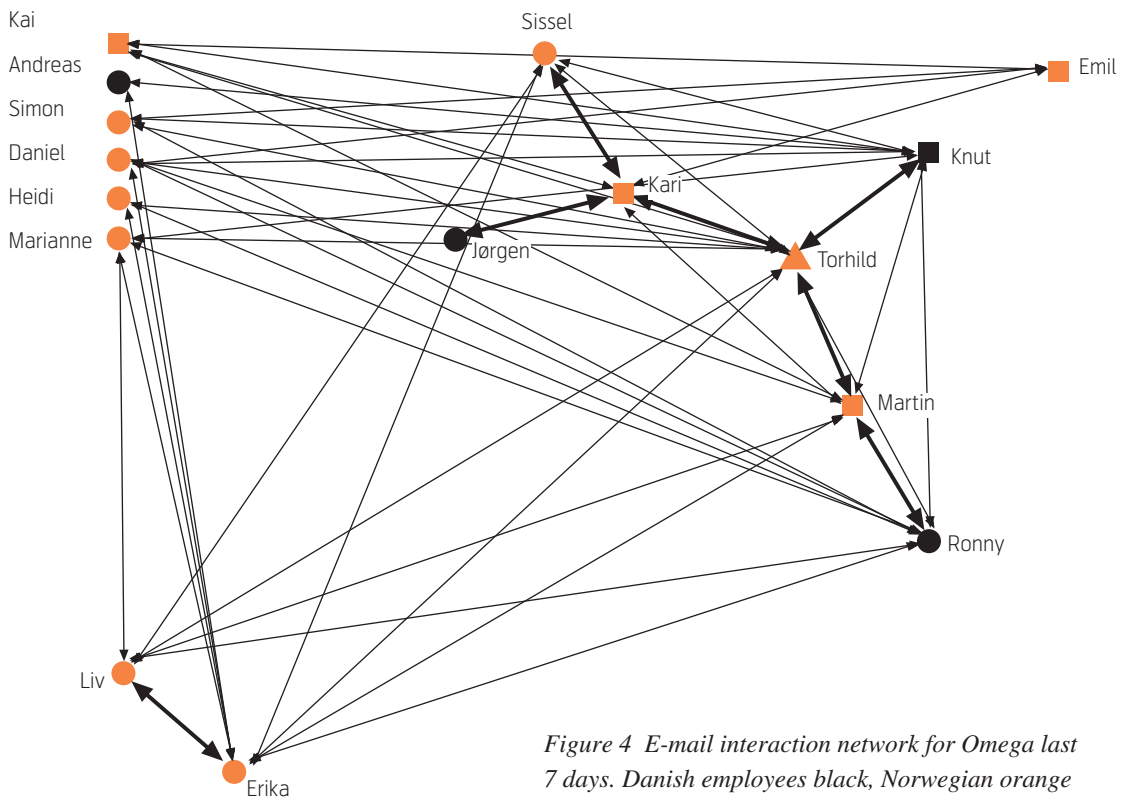
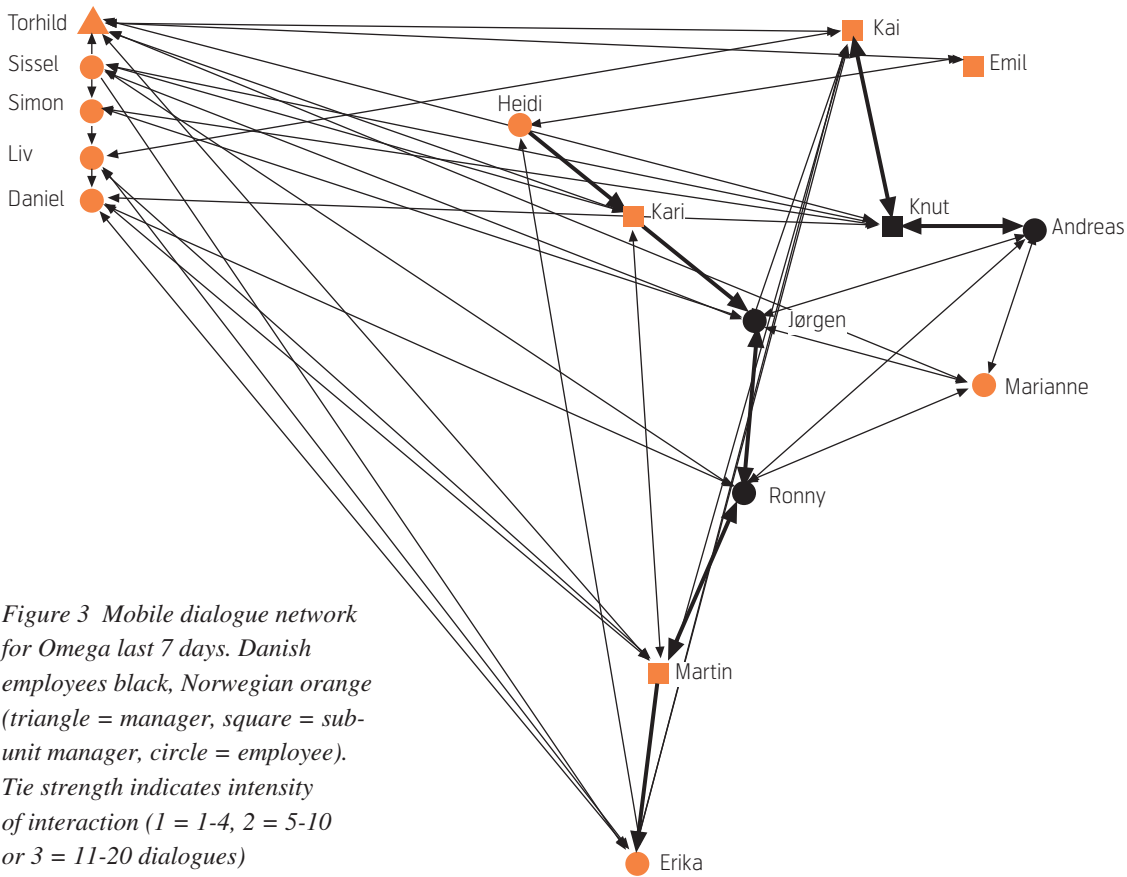
far more people in the group than physical interaction. The *core/periphery* score indicates how well the registered values approximate to an ideal core/periphery structure (Borgatti and Everett 1999). This value was relatively high for the face-to-face networks due to the fact that there is a clear co-located core situated at the Norwegian headquarters, and that face-to-face follows close to this structure. This structure is softened in the mediated networks. However, while there was a relatively clear core/periphery structure reflected in the mobile network; this was less spelled out in the SMS network.

For distributed work groups it is of particular interest to see the extent to which the relations cross physical distance or not.¹⁴⁾ To compare the number of ties within and across the two involved countries, we applied the *E-I Index*, as developed by Krackhardt and Stern (Krackhardt and Stern 1988). This indicator compares the external ties with the internal ties for groups within a network, ranging from -1 to +1. Given a partition of a network into a number of mutually exclusive groups, the E-I index is the number of ties external to the groups minus the number of ties that are internal to the group divided by the total number of ties. Maximum collaboration across the boundaries is then +1 (all links are external), while equally divided links will give an index equal to zero. We categorized the employees in Denmark as “external” and the Norwegian group as “internal”. None of the interaction-based relations were equally divided, but e-mail messages was the form of interaction that was most boundary-crossing (considering the national

boundaries) in this group. Interestingly, SMS was more frequently used within each of the national sub-units, with mobile phone dialogues in a position in-between. This shows that – at least within this organization – the geography-bridging qualities of ICTs are selectively deployed; some are primarily used across larger distances, others are more commonly used within local regions. It is also interesting to observe that these technologies are important within collocated settings: While it is common to address the capacity of ICTs for bridging space and time, they are also used for communication with neighboring colleagues.

Turning to the *perceived relations* of trust, friendship and expertise, these were less cohesive in Omega than the interaction-based relations: only 10 friendship links (relations) and 13 trust links were reported. The expertise network, however, was about the same density level as for mobile communication (0.275). Reciprocity is often related to trust in organizations, as trust is often seen as stronger when relations are symmetrical (Kilduff and Tsai 2003). Interestingly, the trust relations have low levels of reciprocity, indicating that this is not a strongly interconnected network, but more open and “fluid”. This indicates the “cognitive” nature of trust, since the existence of a trust-tie is not always perceived equally by two individuals in a network. The trust network was also strongly embedded in the national units within the group, indicated by the high negative E/I index, while the expertise relations had a much more boundary-crossing nature.

¹⁴⁾ In the case of mobile work, this can of course be difficult, as these boundaries are often blurred. Yet, in this group there was one important difference between individuals situated in Denmark and those in Norway.



	Formal	Expertise	Mobile	E-mail	SMS	Trust	Face-to-face
Expertise	0.316**						
Mobile	0.389**	0.435**					
E-mail	0.296**	0.522**	0.564**				
SMS	0.375**	0.38**	0.514**	0.393**			
Trust	0.068	0.113*	0.053	0.092*	0.12*		
Face-to-face	0.207*	0.236*	0.236*	0.295*	0.227**	0.054	
Friendship	0.1	0.086*	0.086*	0.074*	0.128**	0.278**	0.05

Note: * $p < 0.05$ ** $p < 0.01$

Table 4 QAP correlations for different networks (Jaccard coefficients)

5.3 Comparing Networks

Comparing networks through general indicators gives important information regarding the general use of interaction media and the general level of trust, friendship and expertise relations. Yet, to explore the similarities between the perceived networks and the four different interaction networks further, we conducted a QAP-correlation.¹⁵⁾ This procedure is often used to see to what extent there are similarities between two social networks containing the same actors (Hanneman 2001).

As indicated in Table 4 the expertise network, as well as the formal network, were closely related in all the media channels.¹⁶⁾ In particular, the relation between expertise, e-mail and mobile was strong ($r = 0.522$ and 0.435 , respectively). The mediated networks of mobile phones, SMS and e-mail were all highly correlated, and in particular e-mail and mobile dialogues ($r = 0.564$) (all significant on a 0.01 level). This indicates that the media in Omega to a large extent followed the task related patterns of interaction, and that the media followed highly similar patterns, in particular in the case of mobile dialogues and SMS.

The trust network, however, had no significant relation to the formal network, the face-to-face network or the mobile communication network. It was however weakly (but significantly) related to the expertise network, the e-mail network and the SMS network. Trust relations were most strongly correlated to friendship relations ($r = 0.278$) but not at all with the formal relations (0.068). This indicates on the one hand that the perceived expertise relations were most closely related to the observable interaction that took place in Omega. This pattern also followed fairly

close to the formal structure of the organization.

On the other hand, the less intensive trust network diverged from the formal structure and was less similar to the mediated networks based on mobile dialogues. Yet it had high similarity to the friendship network, and also to the expertise network.

This then might suggest that trust relations are more strongly supported by text-based media like SMS and e-mail, while the more intensive work-related communication uses all media, and in particular e-mail and mobile dialogue. As such, it indicates that the instant problem-solving relations have other needs for communication than the more low-frequent trust and friendship ties. It is clear, however, that these relations do not operate as isolated structures, but have significant overlaps.

It should also be noted that physical closeness (i.e. face-to-face interaction) was positively correlated to the use of all media, and in particular the SMS network, indicating that mediated interaction is more intense among co-located workers.

6 Discussion and Conclusions

This paper has argued that interaction-based relations, represented by SMS, e-mail and so on, are important sources for analyses of distributed work. Still, the interaction-based relations and networks should not be taken as direct evidence of an affective tie or a group with high cohesion. I have proposed to draw a clear distinction between affective ties, formal ties and interaction based ties, relying in particular on cognitive network theories and structuration theory.

¹⁵⁾ UCINET's QAP correlation procedure is based on permutation of rows and columns together with one of the input matrices, and then correlating the permuted matrix with the other matrix. This is repeated hundreds of times to build up a distribution of correlations under the null hypothesis of no relationships between the matrices. A low p-value ($< .05$) suggests a strong relationship unlikely to have occurred by chance.

¹⁶⁾ Table 4 presents Jaccard coefficients since some relations (trust, friendship, face-to-face) are binary.

This framework is somewhat opposed to the much applied concepts of *weak and strong ties*, widely used in the social network field. The distinction was initially proposed by Granovetter who argued that the strength of a tie is a: “combination of the amount of time, the emotional intensity, the intimacy (mutual confiding) and the reciprocal services which characterize the tie” (1973, p. 1361).

The distinction between strong and weak ties is however often problematic. The operationalization of ties as a combination of four different qualities – as proposed by Granovetter – is not straightforward; and capturing weak ties is difficult due to the large number of potential ties, and the fact that weak ties are revealed in particular settings, whereas most of the time, they are ‘latent’ (Krackhardt 1992). Further, studies of vocational networks have often found that relations between colleagues rarely fall in one of the two (Wegener 1991; Nardi, Whittaker and Schwarz 2000).

The advantage of the cognitive network approach is that it offers a clearer distinction between observable and “cognitive networks”. For studies of mediated networks this opens for a more systematic investigation of how different types of ties are supported by the use of various media.

In this paper the cognitive network approach has been used as a theoretical framework for an analysis of various relations within a distributed work group. Clearly, the case presented has several shortcomings. Firstly, it is based on self-reported ties and not traffic generated data. Secondly, it represents just a snapshot of interactions over one week. Thirdly, only one simple case of distributed workers has been investigated. The findings should thus be seen as preliminary findings.

Still, the results suggest that the perceived networks of trust, expertise and friendship are supported in different ways by the media. Interaction through e-mail and mobile phones was following closely the expertise based ties, but not always the friendship and trust relations.

As already mentioned, some earlier studies have found that stronger relations tend to communicate more intensively and also use more numerous media (Haythornthwaite 2002). There may be different reasons why this study paints a slightly different picture: Firstly, our case involved a group of technical professionals working in permanent work groups – and although the group was recently established, the members had a history within the organization. In contrast, former studies of relations and media-use in distributed environments have used empirical data from ad hoc teams of students collaborating in tem-

poral, virtual teams (Haythornthwaite 2001; Haythornthwaite 2005) or in a community of scholars at a university (Koku and Wellman 2002). In Omega, the task-related ties were very much in focus, whereas the trust and friendship relations were less explicit. Also, this group was relatively recently established, connecting experts located in different geographical units due to a company merger. This might have made the friendship relations within the group less dense and more weakly supported by media, as compared to networks of students or university scholars. Another reason for the differences may be that we applied the term trust in addition to friendship; a term that is rarely studied in relation to mediated ties in organizations. We believe, however, that this actually unveils a relational dimension that is different from close friendship in organizations, but still important. In modern organizations it might be that it is more important – or more achievable – to have someone that you trust to discuss difficult personal matters with, than someone you consider as close friends.

The conclusion we may draw is that we should be cautious and not jump to conclusions when analyzing interaction based structures in distributed groups. There is no such thing as “the social network” of a group, but multiple different interconnected relationships. Patterns of mediated interaction – together with face-to-face interaction – are crucial as indicators of the coordination going on in a distributed group, and can be important as indicators of affective ties like trust and friendship. Yet, different media may play different roles in such networks. As such, future studies should not only rely on communication networks, but as far as possible try to capture also more affective relations as well as the formal structures. The cognitive network approach, as applied here, might be a promising point of departure.

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Tom E. Julsrud is a research scientist in Telenor Research and Innovation and is also associated to the Norwegian University of Science and Technology (NTNU). His research areas of interest include social networks, distributed work, mobile work, work-place changes, trust in organizations and social capital. He has co-authored books on telework and distributed work, and has published several articles and papers on collaboration in distributed and virtual teams. His latest work focuses in particular on the development of trust in virtual environments and distributed groups.
email: tom-erik.julsrud@telenor.com