Elise Nettelhorst Letrud

BI - Norwegian Business School

Master Thesis

- Knowledge Sharing in Virtual Teams -

Investigating the impact of Social Interaction Ties on the Quality of Knowledge

Hand-in date:
01.09.2012

Campus:
BI - Oslo

Supervisor:
Tom Rosendahl

Examination code and name:
GRA 19003 - Master Thesis

Programme:
Master of Science in Leadership and Organizational Psychology

“We are drowning in information but starved for knowledge.”

– John Naisbitt, Megatrends, 1982

Acknowledgements

This has been an all-absorbing and enriching journey. Numerous of new virtual connections have been established, and several people have helped me along the way. Accordingly, I would like to thank all my respondents for willingly sharing information about their work-related relationships. Secondly, thank you to my faculty supervisor Tom Rosendahl for guidance and useful input. At last I would like to thank all my strong ties for loads of social support. This includes especially my very strongest tie, my husband Amund Nettelhorst Letrud, thank you for encouraging me the all the way to the finish line!

Elise Nettelhorst Letrud

Oslo, 31.08.2012

Abstract

Key Words: Virtual/Distributed Teams, Knowledge Sharing, Knowledge Quality, Social Network Theory, Social Interaction Ties

Context of the Study: One unique aspect of virtual teams is that they can be comprised of expert members regardless of location. As a consequence, the use of these teams enables knowledge sharing to exceed boundaries of time and space. For this reason the ability to facilitate for the sharing of explicit-, but maybe more importantly, the sharing of tacit knowledge in virtual teams is crucial to organisations. Moreover, teams that develop mechanisms to share high-quality knowledge will be more likely to accomplish tasks effectively, perform better and reduce information overload.

Purpose: Through close social interaction, individuals are able to increase the depth, breadth and efficiency of knowledge sharing. Hence, the relationships between actors in the social network indicate what kind of knowledge is being shared, between whom and to what extent. Moreover, developing network ties becomes even more crucial for members of virtual teams, because they have only limited opportunities to learn from observing others. Considerable research supports the notion that people obtain useful knowledge from others with whom they maintain strong ties, as strong ties aid the development of trust and reciprocity. However others again suggest that weak ties provide the most useful knowledge, as these ties provide access to non-redundant information. This discussion was yet to be found in the literature on networks in virtual teams.

Consequently, the purpose of this study is to present an overview over selected theories, and enlightened by these theories investigate how the strength of social interaction ties between members in a virtual team affects the quality of work related knowledge shared in these ties. Social interaction ties are represented by strength of the relationships, the amount of time spent on interaction, interpersonal trust and communication frequency between the members in a virtual team. Whereas knowledge quality is defined as the extent to which the awareness and understanding of ideas, logics, relationships, and circumstances in a project are fit for use, easy to adapt, and relevant and valuable to the context.

Methodology: A multiple case study involving four virtual teams was employed. The teams consisted of members from a vide variety of professionals, companies and countries. Social network analyses were used as a tool to portray the social interaction ties and the quality of knowledge within the virtual teams.

Findings: Empirical evidence from this study shows that social interaction ties are multiplex, and that the perfect combination that will lead to the sharing of quality knowledge depends both on circumstances and the nature of the knowledge shared. Accordingly, some components of the social interaction ties have shown to influence the knowledge quality, whereas others show to have no extended effect. Altogether findings show that the strength of social interaction ties between members in a virtual team positively affect the quality of knowledge shared in these ties.

The component of a social interaction tie that had the most impact on the quality of knowledge shared between members of a virtual team was Competence-based Trust ties. Secondly, Frequency of Communication ties and Longer Time spent on Interaction ties had an evident effect on the quality of knowledge. Furthermore, Benevolence-based Trust ties had some effect on the knowledge shared, whereas Close Relationship ties are shown to only have a small noticeable impact on the quality of knowledge shared between team members in a virtual team. Moreover empirical evidence shows that members of virtual teams that are connected by strong Social Interaction ties can be expected to share knowledge with higher quality, than team members that are connected by weak Social Interaction ties.

Contribution: This study has attempted to contribute to the research field of both knowledge sharing in virtual teams and social interaction ties. Hence, the findings in this study should provide a potential for virtual teams to enhance the sharing of knowledge within the team. Moreover, previous research shows that many social network studies avoid the complexity of multiplex data by only focusing on a single relation, or by dealing with multiple relations separately. This study has attempted to contribute to the research of multiplexity in social interaction ties. Based on already established theory this study has interpreted social interaction ties in a virtual team as a sum of the close relationship, interpersonal trust, frequency of communication and time spent on interaction.

Table of Contents

1. Introduction

Virtual teams are becoming increasingly widespread in today's organisations. In fact, as collaboration within and across distributed teams, as well as organisational borders is made possible due to highly developed technologies, most teams can to some extent be characterized as virtual (Martins, Gilson, & Maynard, 2004). One unique aspect of virtual teams is that they can be comprised of expert members regardless of location (Townsend, DeMarie, & Hendrickson, 1998), and as a consequence, the use of these teams enables knowledge sharing to exceed boundaries of time and space (Saunders & Ahuja, 2006). Moreover, it is evident that teams that develop mechanisms for high-quality knowledge sharing will be more likely to accomplish tasks effectively (Rosen, Furst, & Blackburn, 2007).

Because virtual teams may lack formal rules, procedures or clear reporting relationships, communication is the key to success (Ahuja & Carley, 1999). However, while communication technology can serve as a platform to facilitate the process of sharing knowledge in virtual teams, it is network relationships that serve as the actual bonds that help team members overcome geographic constraints (Yuan & Gay, 2006).

1.1 Research Question

It is possible to delineate between two types of knowledge, namely *explicit*- and *tacit* knowledge (Filstad & Blåka, 2007; Newell et al., 2009). Although the two are often interconnected, they presuppose different methods of sharing knowledge. A common notion is that explicit knowledge easily can be shared with all team members using technology. Hence distributed teams will be more inclined to share knowledge that is explicit in nature, because technology more easily supports this kind of declarative knowledge. On the other hand, tacit knowledge is acquired from experience, and for this reason, healthy social relationships are consequently important for the sharing of tacit knowledge in virtual teams (Maznevski & Atanassiou, 2003). Moreover, the ability to facilitate for the sharing of explicit-, but maybe more importantly, the sharing of tacit knowledge in virtual teams is crucial to organisations, as sharing of knowledge is considered to be closely linked to establishing competitive advantage (Filstad & Blåka, 2007).

Accordingly, knowledge is an important resource, however its effective use will to a great extent depend on its quality (Yu, 2007). Important criteria for knowledge quality are that the knowledge should be intrinsically right, relevant to the context and have practical value (Yoo, Vonderembse, & Ragu-Nathan, 2011). Thus the advantages to take into consideration the quality of work related knowledge shared are many, as a high level of knowledge quality will help a team perform better, develop novel products and services, increase sales and reduce costs, including reducing information overload. This thesis will take a socio-cultural perspective on knowledge sharing, and argue that knowledge is constructed and negotiated through social interaction. Through close social interaction, individuals are able to increase the depth, breadth and efficiency of knowledge sharing (Lane & Lubatkin, 1998). Moreover it will be argued that social interaction ties between members of a virtual team will enhance a cost-effective way to access a wide range of knowledge sources, and provide an opportunity to combine and exchange knowledge (Chiu, Hsu, & Wang, 2006).

Considerable research supports the notion that people obtain useful knowledge from strong ties, that is to say, others with whom they work closely and frequently, hence strong ties aid the development of trust and reciprocity (Krackhardt, 1992). Others again suggest that weak ties provide the most useful knowledge, as weak ties constitutes non-redundant connections and enables access to information which are more likely to be novel (Granovetter, 1973; Burt, 1980). However, this discussion is yet to be found in the literature on networks in virtual teams. Consequently, this study aims to investigate how the strength of social interaction ties between members of a virtual team affects the quality of knowledge shared in these ties. Social interaction ties are represented by the strength of the relationships, the amount of time spent, communication frequency among members (Chiu, Hsu, & Wang, 2006), and trust (Petróczi, Nepusz & Bazsó, 2007), whereas knowledge quality is defined as the extent to which the awareness and understanding of ideas, logics, relationships, and circumstances in a project are fit for use, easy to adapt, and relevant and valuable to the context (Yoo, Vonderembse, & Ragu-Nathan, 2011). Accordingly the following research question is proposed:

> *How does the strength of social interaction ties between members of a virtual team affect the quality of knowledge shared in these ties?*

1.2 Thesis Structure

This thesis aims to build and investigate theory behind the relationship between social interaction ties in virtual teams and the quality of knowledge shared in these ties. In the following chapter a theoretical framework will be presented. The framework contains a comprehensive literature review, which aims to discuss already established theories concerning knowledge sharing, and especially the conditions that promote knowledge sharing in virtual teams. Moreover an elaboration will be given on why focus need to be put on the quality of the knowledge shared. In addition the theoretical framework will give an overview over social network theory, where the importance of social interaction ties in virtual teams will be put in context. Further lines will be drawn between the presented theories to set a frame for the proposed research question, and propositions for the relationship will be presented. In the methodology chapter a thorough review of the method employed will be given together with a presentation of four specific cases that will serve as a basis for the study. Furthermore, a presentation of the strengths and limitations of the method used and the whole study will be given. The main findings will be presented in an analysis chapter, before they are thoroughly discussed in the discussion chapter. Finally the practical implications for the study will be given, before at last the concluding remarks are presented.

2. Theoretical Framework

In this chapter a theoretical framework will be presented, which will serve as a foundation for the study. The theoretical framework contains a comprehensive literature review, which aims to discuss already established theory concerning knowledge sharing, knowledge sharing in virtual teams and social network theory. In addition lines will be drawn between the presented theories to set a frame for the proposed research question and propositions for the relationship between the social interaction ties and quality of knowledge will be presented.

2.1 Knowledge and Knowledge Sharing

In the subsequent discussions I will present an overview of the field of knowledge and knowledge sharing. Moreover I will present an in depth discussion of this study's dependent variable; Knowledge Quality.

2.1.1 The Concept of Knowledge

Knowledge is a widely debated concept without any agreed-upon definition, and different views exist in the knowledge management field. In some approaches knowledge and information have a tendency to be treated as equals (Wang & Noe 2010), however, we can with certainty distinguish knowledge and information from data. Whereas data represent letters and raw numbers, thus provides no meaning without a context, information is regarded as processed data (Wang & Noe, 2010). This thesis adopts the view that information can be transformed to knowledge by being combined with experience, context, interpretation, and reflection. Subsequently, knowledge represents action and development, and can be characterized as both dynamic and personal (Filstad, 2010). This thesis further focuses attention on the subjective and social constructed nature of knowledge (Alveson & Kärreman, 2001), and from this *socio-cultural perspective*, it is argued that knowledge is constructed and negotiated through social interaction (Newell, Robertson, Scarbrough, & Swan, 2009).

It is possible to delineate between two types of knowledge, namely explicit and tacit knowledge (Filstad & Blåka, 2007; Newell et al., 2009). Although the two are often interconnected, they presuppose different methods of sharing knowledge. *Explicit knowledge* refers to knowledge that can be easily articulated, stored, and reused, and as a result, this type of knowledge can relatively easily be transmitted to others through the use of language, numbers, and symbols (Filstad, 2010). Consequently, the transparency of explicit knowledge makes it available to everyone who desires it (Filstad & Blåka, 2007). *Tacit knowledge* is referred to as know-how, which again is highly personalized, based on individual experiences, context-dependent, and anchored in practical work (Newell et al., 2009). The two types are complimentary in the sense that tacit knowledge gives meaning to explicit knowledge (Maznevski & Athanassiou, 2003). Consequently, tacit knowledge cannot be communicated in the same way as explicit knowledge, therefore tacit knowledge creates different challenges related to knowledge sharing (Filstad, 2010). Moreover, although the two types of knowledge are interconnected, they accordingly presume different methods of sharing knowledge.

2.1.2 The Premise of Knowledge Sharing

In the same way as knowledge is a debated topic, so is the topic of knowledge sharing. Most definitions include an element of movement of knowledge from person, unit or organisation to another that enables creation, acquisition, integration and use of knowledge (Staples & Webster, 2008). A definition that is in line with the socio-cultural view that has been adopted in this thesis, explains *knowledge sharing* as mutual exchange of both tacit and explicit knowledge and a joint creation of knowledge (Van den Hooff & De Ridder 2004).

The knowledge sharing process can be influenced by different features of the knowledge that is shared, characteristics of the sharer, and the features of the context in which the sharing is executed (Mooradian, Renzl, & Matzler, 2006). Further the antecedents of the various processes that affect knowledge sharing can be divided into four dimensions (Mooradian, Renzl, & Matzler, 2006). The first dimension refers to *properties of the knowledge itself*, that is, tacit and explicit, where tacit knowledge is seen as much more difficult to communicate and share than explicit knowledge. The second dimension focuses on *properties of the management and its actions*, and describes the way in which management facilitates for knowledge sharing through coordination, rewards, and incentives. The third dimension concerns *properties of the environment*, both on a macro and micro level, including organisational culture, shared language, interpersonal ties between organisational members, and shared vision. The last dimension regards *properties of the individual*, such as trust, motives, and attitudes that affect knowledge sharing (Mooradian, Renzl, and Matzler 2006). Consequently, the process of knowledge sharing is both complex and uncertain (Filstad, 2010), indicating that there are several barriers to overcome.

There are mainly two types of strategies to facilitate sharing, namely *codification* and *personalization* (Hansen, Nohria, & Tierney, 1999). By *codification* strategies the organisation seeks to capture knowledge by identifying, codifying and storing it, while *personalization* strategies seek to enable knowledge sharing through direct or indirect contact (Bordia, Irmer, & Abusah, 2006). Consequently, the two strategies entail two very distinct contexts. Codification demands a database, which is quite commonly used by virtual teams, as it can be characterized a potentially large audience with different levels of expertise, whereas personalization strategies require an interpersonal context (Bordia, Irmer, & Abusah, 2006). Organisations have tended to focus on

codification strategies, hence developing information and communication technologies (ICTs) to facilitate sharing of explicit knowledge, thus more or less neglected the task of facilitating tacit knowledge (Holste & Fields, 2009). However, there exist indications of employees preferring to share knowledge interpersonally rather than through a database (Bordia, Irmer, & Abusah, 2006). Moreover, the process of sharing explicit knowledge differs from the process of sharing tacit knowledge. In other words, when the knowledge is explicit, the organisation needs an appropriate ICT system to facilitate sharing, while interpersonal relationships and trust are more important to facilitate sharing of tacit knowledge.

2.1.3 The Quality of Knowledge

As virtual team members obtain work related knowledge from their respective disciplines, and share it with other team members, the process of the interdisciplinary teams becomes more effective. However, the old saying; knowledge is power, might not be correct, as many managers and team members are overwhelmed with knowledge. That is to say, focus on the quality of the work related knowledge shared between the team members is important in terms of reducing information overload. Furthermore, some project teams might not have the expertise available that is required to solve tasks effectively. Thus the advantages to take into consideration the quality of knowledge are many, as a high level of knowledge quality will help a team perform better, develop novel products and services, increase sales and reduce costs (Yoo, Vonderembse, & Ragu-Nathan, 2011). Accordingly, although knowledge is an important resource, its effective use will to a great extent depend on its quality (Yu, 2007). It is argued that the emphasis on quality as a core business competence, will increase a firm's efficiency and capability, and consequently considerable attention has been placed on product and service quality (Yoo, Vonderembse, & Ragu-Nathan, 2011). However the subsequent discussion enlighten the fact that research on knowledge quality should grow both in scope and prominence (Yoo, Vonderembse, & Ragu-Nathan, 2011).

This study aims to explore the concept of knowledge quality in a virtual team context, hence the focus will be on the quality of the work related knowledge that is shared between members in a virtual team. Consequently,

important criteria for knowledge quality is that the knowledge should be intrinsically right, relevant to the context and have practical value (Yoo, Vonderembse, & Ragu-Nathan, 2011). Hence, *knowledge quality* is defined as the extent to which the awareness and understanding of ideas, logics, relationships, and circumstances in a project are fit for use, easy to adapt, and relevant and valuable to the context (Yoo, Vonderembse, & Ragu-Nathan, 2011). Yoo, Vonderembse, and Ragu-Nathan (2011) define three dimensions of knowledge quality; intrinsic-, contextual- and actionable knowledge quality, which are separated conceptually, however used interactively at work.

Intrinsic knowledge quality is defined as the extent to which the knowledge has quality in its own right, and associates with accuracy, reliability and the timeliness of the knowledge. Intrinsic knowledge quality lays a foundation for knowledge quality by providing an understanding of activities and relationships (Yoo, Vonderembse, & Ragu-Nathan, 2011). However, since knowledge that doesn't reflect the specific context in which it is embedded, intrinsic knowledge quality will be a necessary but not sufficient condition for knowledge quality, because the same knowledge might have different meaning in different contexts. For example will distinct and specific contexts such as time, space, culture or roles assess the quality in different manners. Moreover *contextual knowledge quality* refers to the extent to which the knowledge is considered within the task and context (Yoo, Vonderembse, & Ragu-Nathan, 2011). The dimension is related to the appropriateness, relevance and value-addedness by taking into account and understanding the environment in which a task operates (Yoo, Vonderembse, & Ragu-Nathan, 2011). Moreover a sufficient understanding of the context will increase efficient use of the knowledge (Poston & Speier, 2005). However, as knowledge is about action, it must be used to some end (Nonaka & Takeuchi, 1995). Therefore the definition of *actionable knowledge quality* refers to the extent to which the knowledge is adaptable, expandable and easily applied to tasks (Yoo, Vonderembse, & Ragu-Nathan, 2011). And to manifest its usefulness and profitability the knowledge should be converted into action (Davenport & Prusak, 1998). As knowledge quality depends on the actual use of knowledge, the dimension of actionable knowledge quality allows teams in a flexible way to adapt, widely expand and easily apply the knowledge and in this way increase effective actions.

2.2 Knowledge Sharing in Virtual Teams

In the following I will present an overview of the theory behind the classification of virtual teams, the importance of facilitating for knowledge sharing in virtual teams, and especially elaborate on interpersonal trust as an important premise for knowledge sharing in these teams.

2.2.1 Classification of Virtual Teams

Virtual teams or so-called *distributed teams* can be defined as "teams whose members use technology to varying degrees in working across locational, temporal, and relational boundaries to accomplish an interdependent task" (Martins, Gilson, & Maynard, 2004, p. 808). Research tends to treat all distributed teams the same, describing them as geographically distributed and temporary (Martins, Gilson, & Maynard, 2004). However, recently discussions about the virtuality in teams along a continuum using dimensions such as time, space, and organisational boundaries are found (Bell & Kozlowski, 2002; Griffith, Sawyer, & Neale, 2003; Martins, Gilson, & Maynard, 2004). Since there is no cut off point where a team becomes virtual one can expect that the more dimensions the team include, the more virtual it is (Zigurs, 2003).

Virtual cooperation demands access to data and information, and it is necessary with focus on interpretation and common understanding of the information in relation to the practical situation where team members work together. The reason for this is that knowledge will only be knowledge if it represents action. Thus within virtual team it will be important that data and information finds its' way as knowledge, that again develops to necessary competence. This competence will be rooted in commitment and trust among members, and rise through participation and use of knowledge in a social process at work (Filstad, 2010).

Communication technologies have been developed as tools to enable virtual teams to exceed boundaries of time and space (Saunders & Ahuja, 2006). For this reason technology has changed the social interaction among individuals (Katona, Zubcsek & Sarvary, 2011). The technology employed in virtual teams includes e-mails, discussion boards, telephone- and video-conferences, among others. This range of tools is used to replace or supplement a lack of direct face-to-face contact, which forms one of the major distinctions between virtual and

collocated teams (Bell & Kozlowski, 2002). The technologies differ in their extent of *media-richness* (Hinds & Weisband, 2003) and *degree of synchronisation* (Malhotra, Majchrzak, & Rosen, 2007). For example whereas video-conferences are high on both media-richness and synchronisation, e-mails are low on both dimensions. Common understanding of situations in virtual settings is a result of the team members interpretation of the knowledge (Filstad, 2010). The different team members might have different information resources that must be combined and coordinated to make a common understanding. The meaning of the information integrated in the technological tools, is not always clear and have to be interpreted by the team members, and the common understanding that the team members develop is a practical result of social activities and action (Filstad, 2010).

2.2.2 Knowledge Sharing in Virtual Teams

Virtual teams can be comprised of expert members regardless of location (Townsend, DeMarie, & Hendrickson, 1998), hence the use of these teams enables knowledge sharing to exceed boundaries of time and space (Saunders & Ahuja, 2006). As the technology makes it feasible to form teams that do not work in close proximity (Griffith, Sawyer, & Neale, 2003), virtual teams are more likely to have members of a greater variety of members, than more traditional teams (Griffith, Sawyer, & Neale, 2003). Because of the members' dispersion, virtual teams are likely to draw team members from different social networks (Griffith, Sawyer, & Neale, 2003). As a result, one might assume that members of virtual teams will have access to a greater base of knowledge because of their dispersion than would be the case of collocated teams (Griffith, Sawyer, & Neale, 2003). Another assumption is that more virtual teams might make use of a larger network for sources of information, due to the team members expected extended diversity (Griffith & Neale, 2001). For these reasons virtual teams may potentially be more viable promoters of knowledge sharing compared to individuals or more traditional teams (Kauppila, Rajala, & Jyrämä, 2011). However, key elements in knowledge sharing is not only hardware and software, but also the ability and willingness of team members to actively participate in the process itself (Rosen, Fürst, & Blackburn, 2007). While communication technologies can serve as a platform to facilitate the process of sharing knowledge in virtual teams, it is

network relationships that serve as the actual bonds that help team members overcome geographic constraints (Yuan & Gay, 2006).

It exists three types of knowledge that are relevant to the work of virtual teams, task- social- and contextual information (Cramton & Orvis, 2003). Task knowledge is knowledge about carrying out the task at hand, social knowledge is knowledge about individuals and their relationships with each other, whereas contextual knowledge is knowledge about environmental factors that surrounds tasks, individual and groups. A challenge is that these three types of knowledge is likely to be more distributed across locations than is the case of collocated teams. Accordingly, considerable communication is required from the team members to make unique local knowledge commonly known to the rest of the team, since distributed team members often do not share the same local environment. There is also a greater dispersion of social knowledge in virtual than face-to-face teams, as people are not able to gather socialknowledge, as accents, mood, tones of voice and background, from interaction and observation. In addition will virtualness have a larger impact on the distribution of contextual knowledge than task- and social knowledge, as the work environment of each member might differ in ways that are difficult to anticipate.

Because virtual teams may lack formal rules, procedures or clear reporting relationships, communication is the key to success (Ahuja & Carley, 1999). Internal networks provide the team with opportunities to exploit information the firm already holds (Collins & Clark, 2003), and close social interaction will make individuals able to increase the depth, breadth and efficiency of knowledge sharing (Lane & Lubatkin, 1998). Recurrent communications between individuals that have strong a emotional attachment, will make them more likely to share knowledge than those who communicate infrequently or those who are less emotionally attached (Reagans & McEvily, 2003), and in virtual teams, trust is likely to be facilitated by frequent interaction (Rosen, Furst, & Blackburn, 2007). Moreover, shared language is defined as acronyms and underlying assumptions that are the staples of day-to-day interactions, and is developed in the process of interaction through the use of communication technology. Consequently, the team members' shared language will facilitate the ability to gain access to other people in the network and their information, and provide a common conceptual apparatus for evaluating the likely benefits of exchange of information (Chiu, Hsu, & Wang, 2006). Explicit knowledge can easily be shared to all team members using for

example e-mail, discussion forums, or electronic bulletin boards. Predominantly, teams that are distributed will be more inclined to share knowledge that is explicit in nature, because this kind of declarative knowledge is more easily supported by technology. Tacit knowledge is acquired from experience, thus healthy social relationships, that is to say social capital, will be important for the sharing of tacit knowledge (Maznevski & Atanassiou, 2003). The ability to facilitate the sharing of explicit-, but maybe more importantly, the sharing of tacit knowledge in virtual teams is crucial to organisations as knowledge sharing is considered to be closely linked to establishing competitive advantage (Filstad & Blåka, 2007).

2.2.3 Interpersonal Trust as a Premise for Knowledge Sharing in Virtual Teams

"How do you manage people whom you do not see? The simple answer is; By trusting them" (Handy, 1995, 41). This quote illustrates the central role of trust in managing virtual teams. Previous research shows that trust has been shown to increase the degree of knowledge exchange (Tsai & Ghoshal, 1998), and to make these exchanges less costly (Zaheer, McEvily, & Perrone, 1998), as well as making it more likely that the knowledge receiver will make use of available expertise (Levin, Cross, & Abrams, 2004). In particular, trust in virtual teams also affects the quality and quantity of knowledge sharing (Rosen, Furst, & Blackburn, 2007), as it influences the sharing of knowledge through reducing ambiguity experienced by virtual team members who do not have a common social history to help them interpret each other's behaviour (Jarvenpaa, Shaw, & Staples, 2004). In short, developing trust in virtual teams is crucial, but also challenging as trust is closely connected to some form of physical contact (Handy, 1995).

As a concept, trust is much debated with no consensus other than that it is both complex and multifaceted, however there are two specific dimensions of trust referred to as *interpersonal trust*, which foster knowledge sharing, namely *benevolence-* and *competence-based trust* (Abrams, Cross, Lesser, & Levin, 2003). The first dimension applies to an individual's perceptions of other persons' interest in his own well-being and goals, for example if a team member feels that another team member does not take an interest in his personal well-being, he is less likely to contact that person to ask questions if that entails revealing lack of knowledge. The other dimension relates to an individual's perceptions of relevant expertise that other persons hold. If you do not find a person qualified or trust in

his competence, it is challenging to trust the knowledge he is giving you on a specific topic. I will use the term *interpersonal trust* to refer to both dimensions of trust, unless otherwise noted.

As the definition states, benevolence-based trust involves accepting a state of vulnerability, but in situations where trust is lacking, exposing oneself will involve a high risk of losing face or hurting one's self-esteem and in this way prevent team members from sharing knowledge. Interpersonal trust proves a challenge when not present, however this also applies when trust is not warranted. If an individual holds a great deal of trust in a fellow team member when there are few good reasons to do so, this trust may be taken advantage of (Dirks & Ferrin, 2001). This kind of unwarranted trust may lead individuals to be uncritical to the decisions of their colleagues, rely too heavily on their advice, or disregard the appropriate context for its application (Søndergaard, Kerr, & Clegg, 2007). Thus, this substantiates the importance of establishing interpersonal trust on a sound basis.

2.3 Social Network Theory and Social Interaction Ties

In the subsequent discussions I will give you an overview of the field of Social Network Theory and present an in depth discussion of the study's independent variable; Social Interaction Ties.

2.3.1 Social Network Theory

A social system is a network consisting of a set of relations which links an actor to other actors, and within this social system there could be subsets of similar relations. It could be economic relations linking one actor to specific others, relations of friendship, political relations or status relations, the list has no end, and each of these types of relationships between actors in a social system serves to define a network of relations among the actors (Burt, 1976). Consequently, a *network* is defined as a structure consisting of a number of actors connected by ties. Consequently, each actor has direct *ties* to a number of alters, which in turn are connected to other alters (Wasserman & Faust, 1999).

The *social network* approach examines both the content and the patterns of relationships in order to determine how and what resources that flows from one

actor to another in the network (Haythornthwaite, 1996a). In this study we are not so interested in the structure of the network as a whole, as we are in the actual ties between the actors in the network. Accordingly, a *dyad* consists of a pair of actors and the possible tie(s) between them (Wasserman & Faust, 1999). Moreover, typology divides these dyadic relations into four basic types; similarities, social relations, interactions and flows (Borgatti, Mehra, Brass, & Labianca, 2009). *Similarities* include spatial and temporal proximity, co-membership in groups and sharing socially significant attributes. Furthermore, similarities are not seen as ties in its' own rights, but rather as conditions that will increase the probabilities of forming other kinds of ties. *Social relations* are the most recognized types of ties that most sociological theorizing of social networks are based on. In contrast *interactions* are conceptualized as discrete events that can be counted over time. Interactions are often viewed as facilitating and happening in social relations. *Flows* are intangible and tangible objects that are transmitted through interactions (Borgatti, Mehra, Brass, & Labianca, 2009). Social relationships and the networks these relationships constitute are influential of explaining the use of knowledge (Phelps, Heidl, & Wadhwa, 2012). It is for example possible to view the network as a system of pipes through which resources flow. For example, if what is flowing through the network is knowledge, all else being equal, the nodes with a high number of direct ties will have a greater chance of being exposed to the information than the nodes with only a few connections will (Borgatti, Mehra, Brass, & Labianca, 2009).

Accordingly, social network data differ from standard social and behavioral science data. In this study the main focus is on the *ties* between the actors and not the characteristics of the nodes. Moreover, the social network approach leaves a different perspective for analyzing team dynamics compared to the more traditional approach of studying individual team member characteristics (Borgatti, Jones, & Everett, 1998). But in fact both approaches can be seen as complementary, as they capture different aspects of a team's workings. Since the team members' relationships matter just as much as predispositions, values, personalities and experiences (Maznevski & Athanassiou, 2003).

2.3.2 Social Interaction Ties

A fundamental proposition in social capital theory is that the types and strength of relationships between actors in a network will identify an individual's likelihood to come in contact with someone who have the relevant and desired knowledge, and who in addition is willing to share it (Nahapiet & Ghoshal, 1998; Haythornthwaite, 1996b). So far the contemporary network approach has declined to offer a non-formalistic substantive definition that gives an explanation of what kind of phenomenon social relationship is, however it is possible to distinguish the phenomenon of social relationships from other related phenomenon (Azarian, 2010). Hence, the substance of any relationship consists of the specific interaction that goes on between the individuals, and its strength is dependent upon the volume and the intensity of the interaction (Azarian, 2010). At the most basic level, a relationship establishes a tie between two actors (Wasserman & Faust, 1999). Ties can emerge from naturally occurring events in daily life, or from formal encounters and organisation charts, the latter being prevalent in relationships among employees (Azarian, 2010). Accordingly, a *tie* between actors in a social network can further be defined as a set of one or more specific interactions that connect them (Wasserman & Faust, 1999). Each tie an actor has represent an information channel (Anderson, 2008), hence *social interaction ties* are channels of information and resource flow, that will reduce the amount of time and investment to gather information (Nahapiet & Ghoshal, 1998). Moreover, the process of social interaction can be characterized by people acting and responding on information, while a social interaction tie can be characterized as a bond between two individuals based on relations maintained in a social network (Chen, 2007). Social interaction ties usually develop among members with the same resources and interests, hence will facilitate knowledge sharing among them (Chen, 2007).

The *strength of a tie* is a combination of the amount of time, emotional intensity, and intimacy and the reciprocity that characterize the tie (Granovetter, 1973), and the preferred tie strength is a much debated concept and contingent on the circumstances (Maznevski & Atanassiou, 2003). Research suggests that *strong ties* are related to higher emotional closeness whereas *weak ties* constitutes non-redundant connections and in this way enable access to non-redundant information (Granovetter, 1973; Burt, 1980). Krackhardt (1992) argues that strong ties are desirable, as they aid the development of trust and reciprocity, which

again enable parties to exchange complex information that would not be transferred over weaker links (Hansen, 1999). Moreover strong and close connections between network members promote the sharing of knowledge among members of a social network. Furthermore actors' information opportunities are affected by who they can make contact with, what information that contacts can provide, and to whom in the network the information can be forwarded for having a positive outcome (Haythornthwaite, 1996b). However as close connections will promote the sharing of knowledge their closeness can also constrain actors. For example will two individuals that have the same connections, have access to the same information, and the case might be that they will not provide any new information (Haythornthwaite, 1996b). Said in another way, people with strong ties are believed to have more of the same information, thus possess more redundant information (Burt, 1997; Granovetter, 1973). On the other hand, weak ties are assumed to provide superior information benefits than strong ties. Moreover, weak ties are expected to be related to larger networks (Anderson, 2008), and thus increase the possibility for gaining novel information from peripheral connections (Granovetter, 1973). However as weak ties might facilitate search, they might impede transfer, especially when knowledge is not codified (Nahapiet & Ghoshal, 1998). In sum it may be argued that weak ties can be useful for sharing explicit knowledge, however, strong ties are necessary for sharing tacit and complex knowledge (Hansen, 1999). Accordingly, as knowledge is important in providing a basis for action but is costly to obtain, the social interaction ties among members of a virtual community allow a cost-effective way of accessing a wider range of knowledge sources (Chiu, Hsu, & Wang, 2006). Consequently, social interaction ties between members of a virtual team will enhance a cost-effective way to access a wide range of knowledge sources, and provide an opportunity to combine and exchange knowledge (Chiu, Hsu, & Wang, 2006).

Actors in networks are frequently connected by more than one type of tie, simultaneously. That is to say, the relationship between any two actors may be *multiplex* (Hanneman & Riddle, 2005). Many social network studies avoid the complexity of multiplex data by focusing on a single relation, or by dealing with multiple relations separately. There is a good bit of virtue in this, because multiplex analysis can be quite demanding, and it exists many plausible ways of approaching any multi-relational problem. Consequently, it exists more studies that use the concept of tie-strength rather than the scarce number of empirical

studies that have made an attempt to measure them (Matthews et al., 1998). However in some cases, engaging the full complexity of multiplex data has paid huge returns (Hanneman & Riddle, 2005). For example, ties are said to be stronger if they involve many different contexts or types of ties, and summing nominal data about the presence or absence of multiple types of ties gives rise to an interval scale of one dimension of tie strength (Hanneman & Riddle, 2005). Ties are also said to be stronger if they are reciprocated (Hanneman & Riddle, 2005). Social interaction ties was by Chiu, Hsu and Wang (2006) represented by the strength of the relationships, the amount of time spent and communication frequency, while Petróczi, Nepusz and Bazsó (2007) suggested that trust was included as a component in social interaction ties. Since trust is an important element for knowledge sharing in virtual team, and in addition regarded to affect the quality and quantity of knowledge sharing (Rosen, Furst, & Blackburn, 2007), this element will be incorporated in the multiplexity of a social interaction tie in this study. Consequently, in this study social interaction ties are represented by the strength of the relationships, the amount of time spent, communication frequency (Chiu, Hsu, & Wang, 2006) and interpersonal trust (Petróczi, Nepusz, & Bazsó, 2007).

2.4. Merging Theories

The preceding paragraphs have taken measures concerning knowledge sharing, and especially the conditions that promote knowledge sharing in virtual teams. Moreover I have elaborated on why focus need to be put on the quality of the knowledge shared. Furthermore an overview of social network theory has been given, and the importance of social interaction ties has been put in context. In the following paragraph, lines will be drawn between the presented theories to set a frame for the proposed research question, and propositions for the relationship will be stated.

Organizations are not only held together by formal relations of authority, but also by informal links that connect people across departmental and hierarchical boundaries (Krackhardt & Kilduff, 1999). And in complex work that demands integration of specialized knowledge, people with ties crossing both organisational and departmental boundaries are likely to find more relevant information and be more effective in solving problems (Cross & Cummings,

2004). In addition to technical solutions, both social ties and knowledge sharing are key factors for successful collaboration in virtual teams (Kotlarsky & Oshiri, 2005). However, an unstable network, defined by a high degree of change of memberships in the network, which may be the case in many virtual teams, can limit the creation of social capital, owing the fact that when an actor leaves a network the tie to other actors disappear (Inkpen & Tsang, 2005). Hence developing network ties becomes even more crucial for members of virtual teams, because they have only limited opportunities to learn from observing others (Yuan & Gay, 2006). For example, will the sharing of tacit knowledge be more sensitive to having the right person with the right connection at the right place, thus limit the number of actors who can contribute to the sharing of tacit knowledge (Reagans & McEvily, 2003). In addition, since tacit knowledge cannot easily be articulated, building strong network ties should be an important strategy for managing knowledge (Yuan & Gay, 2006). This thesis has taken a socio-cultural perspective on knowledge sharing, and argued that knowledge is constructed and negotiated through social interaction. Through close social interaction, individuals are able to increase the depth, breadth and efficiency of knowledge sharing (Lane & Lubatkin, 1998), moreover social interaction ties between members of a virtual team will enhance a cost-effective way to access a wide range of knowledge sources, and provide an opportunity to combine and exchange knowledge (Chiu, Hsu, & Wang, 2006).

As mentioned earlier, the strength of a tie is a combination of the amount of time, emotional intensity, and intimacy and the reciprocity that characterize the tie (Granovetter, 1973). Furthermore, research suggests that strong ties are more desirable because they are related to higher emotional closeness, and aid the development of trust and reciprocity (Krackhardt, 1992) which again enables parties to exchange complex information that might not be transferred over weaker links (Hansen, 1999). Whereas weak ties constitute non-redundant connections and enables access to non-redundant information (Granovetter, 1973; Burt, 1980). However, this discussion is yet to be found in the literature on networks in virtual teams. Close relationship, more time spent on interaction, more frequent communication and interpersonal trust between members are believed to enhance the sharing of knowledge, the question is then how it will affect the quality of the work related knowledge shared between team members that are dispersed, hence do not have the same possibilities developing as strong

ties as face-to-face teams. Consequently, this study aims to investigate how the social interaction ties, represented by the strength of the relationships, the amount of time spent, communication frequency among members (Chiu, Hsu, & Wang, 2006), and trust (Petróczi, Nepusz, & Bazsó, 2007), will affect the quality of work related knowledge, defined as the extent to which the awareness and understanding of ideas, logics, relationships, and circumstances in a project are fit for use, easy to adapt, and relevant and valuable to the context (Yoo, Vonderembse, & Ragu-Nathan, 2011) of the knowledge shared in these ties.

Personal ties shape accessibility and motivation to engage with others in knowledge and learning (Nahapiet, Gratton, & Rocha, 2005). Moreover close relationships increase the possibility for team members to interact at a later point (Filstad, 2010). Hence, members in a virtual team that to some extent knows personal things about the other persons, such if they are married or the name of the other person's dog, find it easier to interact (Filstad, 2010). Furthermore, Cross and Parker (2004) found in their study that in terms of information sharing and collaboration it was highly significant that the relationship was developing from a personal front to become effective professionally. Almost universally, the respondents reported that their most valued information relationship had a starting point on discussions on non-work related issues. Moreover, when two people share information about their personal lives, especially about their similarities (e.g. neighbourhood, education, family status, values), a stronger bond and greater trust develop, as it makes the connection seem more human and approachable, and consequently more trustworthy (Abrams et al., 2003). For these reasons I argue that:

> ***Proposition 1.*** *Members in a virtual team that are connected by Close Relationship ties will share knowledge of higher quality, than team members that are not connected by Close Relationship ties.*

Trust is a crucial factor for cooperation in virtual teams, as it in these teams do not exist any reward system that reinforce the mechanism of mutual trust. Under these circumstances network ties become very important, because the resources found in the social network will foster their intention and activeness to be apart of the voluntary knowledge sharing behaviour (Chiu, Hsu, & Wang, 2006). For example when people are dealing with novel solutions and complex problems, establishing

interpersonal trust can have a substantial impact on the quality of collaboration (Cross & Parker, 2004). Furthermore interpersonal trust is considered to affect both the quantity and quality of knowledge shared in virtual teams (Rosen, Furst, & Blackburn, 2007). As trust influences the sharing of knowledge through reducing ambiguity experienced by virtual team members who do not have a common social history, thus help them interpret each other's behaviour (Jarvenpaa, Shaw, & Staples, 2004). Furthermore, when the levels of trust are higher, people are more likely to give useful knowledge (Andrews & Delahay, 2000; Tsai & Ghoshal, 1998), and more willing to listen to and absorb it (Mayer, Davis & Schoorman, 1995). For these reasons I argue that:

> ***Proposition 2.*** *Members in a virtual team that are connected by strong Interpersonal Trust ties will share knowledge of higher quality, than team members with weak Interpersonal Trust ties.*

There are especially two dimensions of interpersonal trust, namely benevolence- and competence-based trust that are considered to foster knowledge sharing (Abrams et al., 2003). If you do not find a person qualified or trust in his competence, it is challenging to trust the knowledge he is giving you on a specific topic (Abrams et al., 2003). For these reasons I argue that:

> ***Proposition 2a.*** *Members in a virtual team that are connected by Competence-based Trust ties will share knowledge of higher quality, than team members that are not connected by Competence-based Trust ties.*

Sharing unsolicited knowledge with teammates can be perceived as overloading teammates with unwanted information (Rosen, Fürst, & Blackburn, 2007). Likewise, asking for information and sharing information with virtual teammates can be a risky business. Without the ability to observe reactions to requests for information, one may fear that the request will be seen as a lack in competence. For these reasons I argue that:

> ***Proposition 2b.*** *Members in a virtual team that are connected by Benevolence-based Trust ties will share knowledge of higher quality, than team members that are not connected by Benevolence-based Trust ties.*

Trust is likely to be facilitated by frequent interaction (Rosen, Furst, and Blackburn 2007), as more frequent communication increases the amount of information available to assess the other person's abilities, behaviours and intentions within the relationship (Abrams et al., 2003). Frequent communication also provides an opportunity for people to develop a shared vision and language (Abrams et al., 2003), and accordingly the knowledge shared will be of higher quality. For these reasons I argue:

> ***Proposition 3.*** *Members in a virtual team that are connected by strong Frequency of Communication ties will share knowledge of higher quality, than team members connected by weak Frequency of Communication ties.*

In many situations it might be that people who are seeking advice are not sure about the questions they are asking. And knowledge sources willing to tolerate such a process of inquiry are viewed as more trustworthy (Abrams et al., 2003). When both sides in an interaction really listen to each other thoughts and ideas, trust is more likely to develop (Abrams et al., 2003). For example will thoughts and solutions that are not properly formed, be critical for development of trust in a relationship (Abrams et al., 2003). Interviews performed by Abrams et al. (2003) showed that people are more likely to seek out and trust others who allow exploration and brainstorming in a project. For these reasons I argue that:

> ***Proposition 4.*** *Members in a virtual team that are connected by Time Spent on Interaction ties will share knowledge of higher quality, than team members that are not connected by Time Spent on Interaction ties.*

Relationships considered critical for the sharing of information can develop along two tracks; the professional and the personal. As relationships progress on both fronts, interpersonal trust is building and will improve the quality of collaboration (Cross & Parker, 2004). Moreover a more precise awareness of the other people's skills and expertise will strengthen relationships on a professional front. At the dyadic-level, which is the focus in this study, research has found advantages for both having strong and weak ties (Levin, Cross, & Abrams, 2004). Weak ties that are characterized as distant and by infrequent interaction, are more likely to be a source of novel information (Granovetter, 1973), on the other hand strong ties

have been claimed to be important as they are more accessible and willing to be helpful (Krackhardt, 1992). As we see in the subsequent discussions, the members of a virtual team are more likely to be connected by weak ties, and I argue that strong social interaction ties will help members share knowledge with a higher quality. That is to say, sharing work related knowledge that is considered intrinsically right, relevant to the context and have practical value. Consequently, I argue that virtual team members that have close relationship, a higher level of interpersonal trust, interact frequently and that spend more time interacting will share knowledge of a higher quality, than virtual team members that do not have close relationship, have a lower level of interpersonal trust, interact less frequently and spend less time interacting. For these reasons I argue that:

> ***Proposition 5.*** *Members in a virtual team that are connected by strong Social Interaction Ties will share knowledge with higher quality, than team members that are connected by weak Social Interaction Ties.*

3. Methodology

Networks are often limited by patterns of interaction (Westphal, Seidel, & Stewart, 2001), or participation in a common activity (Owen-Smith & Powell, 2003). This does not mean that networks are isolated from the rest of the world, but due to analytical purposes, an assumption of network borders are necessary (Wasserman & Faust, 1999), hence the thesis will have focus on the network within a virtual team. Accordingly, the purpose of this study is to investigate how the strength of social interaction ties between members in a virtual team affects the quality of knowledge shared in these ties. Accordingly, in light of already existing theory, this study aims to investigate the following research question:

> *How does the strength of social interaction ties between members of a virtual team affect the quality of knowledge shared in these ties?*

The preceding paragraphs have taken measures concerning knowledge sharing, and especially the conditions that promote knowledge sharing in virtual teams. Further an overview of social network theory and social interaction ties have been given. Enlightened by already existing theory the following propositions have been suggested:

Proposition 1. *Members in a virtual team that are connected by Close Relationship ties will share knowledge of higher quality, than team members that are not connected by Close Relationship ties.*

Proposition 2. *Members in a virtual team that are connected by strong Interpersonal Trust ties will share knowledge of higher quality, than team members with weak Interpersonal Trust ties.*

Proposition 2a. *Members in a virtual team that are connected by Competence-based Trust ties will share knowledge of higher quality, than team members that are not connected by Competence-based Trust ties.*

Proposition 2b. *Members in a virtual team that are connected by Benevolence-based Trust ties will share knowledge of higher quality, than team members that are not connected by Benevolence-based Trust ties.*

Proposition 3. *Members in a virtual team that are connected by strong Frequency of Communication ties will share knowledge of higher quality, than team members connected by weak Frequency of Communication ties.*

Proposition 4. *Members in a virtual team that are connected by Time Spent on Interaction ties will share knowledge of higher quality, than team members that are not connected by Time Spent on Interaction ties.*

Proposition 5. *Members in a virtual team that are connected by strong Social Interaction Ties will share knowledge with higher quality, than team members that are connected by weak Social Interaction Ties.*

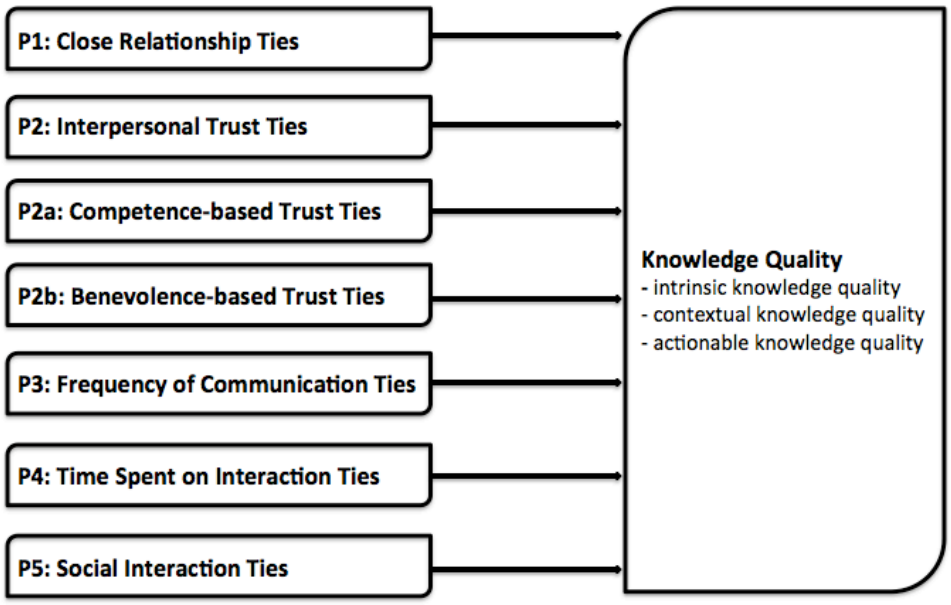


Figure 1: Conceptual Model for the Study

3.1 Research Design: Case Study

The choice of research design has to be made from the aims and goals of the study (Flick, 2009), as the research design links the data to be collected and conclusions to be drawn to the initial research question. A number of criteria were considered to determine the research strategy and research design. First the degree of fit between research objectives, methodological choices available, and appropriate type of data required to meet the objectives were taken into consideration. Second it was important to look to previous studies that have examined similar questions. Last it was important to look at practical issues such as time constraints, available resources and in this study the possibility to come in contact with an adequate sample of respondents from virtual teams. For these reasons, a decision to employ *a multiple case study* as a research design was taken. It is important to note that a case study can be used to answer questions like "how" or "why" when the phenomenon to be study happens in a real-life context where the researcher has no or little possibility to control the events. Moreover, in a case study, a theoretical foundation is used as a template with which to compare the characteristics and empirical findings from the cases. Furthermore the theoretical propositions are founded in theory and linked to the research question (Yin, 2009).

The number of case replications depends on the certainty wanted to achieve and the richness of the underlying propositions (Yin, 2009). I chose to use multiple-cases to reveal theoretical similar results or contrasting results for further

predictable reasons (Yin, 2009). The fact that data are collected from four teams with employees from several organisations and countries allows me to contrast and compare the findings.

Social Network Analysis is a very powerful tool for building knowledge maps and analysis knowledge flows within an organization. Hence, to push new frontiers of knowledge management, it is necessary to borrow and adapt new techniques from this discipline (Chan & Liebowitz, 2006). Accordingly, social network analyses were used as a tool to portray the social interaction ties and the quality of knowledge within the four virtual teams.

Participants: The selected cases should reflect the characteristics and problems identified in the underlying propositions (Yin, 2009). Four virtual teams were selected as a foundation for the study, on the basis of their work across locational, temporal, and relational boundaries. All four cases are presented from a perspective that the virtual teams are relatively stable in membership. However the team members in focus also have membership in other teams, resulting in some respondents having contact with each other in ways not measured. Accordingly, the team members in all teams reported daily interaction with people from other virtual teams, as well as with collocated others, however the communication with persons outside the virtual teams in focus lies beyond the scope of this thesis. Collegial atmosphere among the team members suggested that the team members in all four teams would exchange knowledge freely, providing a sufficient communication base for study. It was also expected that team members in all four teams would maintain both work and social relationships through computer-mediated communications. All four teams had available a number of ways in which they could communicate with others in the group, including electronic mail, telephone, chat, desktop videoconferencing system, and other available ICT systems. In addition all team members had met at least once in a face-to-face scheduled meeting.

Team 1 is a virtual project team consisting of 16 participants, 13 men and 2 women from Norway and India. The respondents were working in six different companies as consultants on a project for implementing IT-systems in one of Norway's largest banks.

Team 2 is a virtual team consisting of 7 participants, 3 men and 4 women located in Norway, working as project leaders in one of Norway's largest banks.

Team 3 is a virtual team consisting of 10 participants, 8 men and 2 women located in Norway and Singapore. The respondents in Team 3 are working in leading positions for a large Norwegian company, which is a leading supplier of services related to oil, gas and renewable energy.

Team 4 is a virtual team consisting of 8 participants, 4 men and 4 women from 7 different companies, located in Norway, Sweden, Denmark, Finland and Iceland. The respondents in Team 4 are working as country coordinators for large governmental projects that spend across the five countries.

Ethical Considerations: The study is approved by NSD - (Norsk Sammfunnsvitenskapelig Datatjeneste) Data Protection Official for Research and fulfils strict requirements of confidentiality and storage of data. In accordance with the Personal Data Act's recommendation for processing of personal data, all respondents had to sign a consent form (APPENDIX 1). The consent form clearly stated that participation in the study is voluntary. All information will be handled confidential, and all respondents will be anonymized this also applies to the company they are representing. The collected data will only be processed by the researcher and will not be accessible for any third party. The respondents may withdraw from the study at any time without stating any reason. The collected data will only be used in this master thesis, and all collected information will be deleted no later than 1. September 2012.

3.2 An Introduction to Social Network Analysis

As the desire to understand informal relationships has increased among researches within the knowledge management field, the methodology of *social network analysis* has become widely recognized as a useful tool to map and document informal networks (Allen, James, & Gamlen, 2007; Wasserman & Faust, 1999). Social network data differ from standard social and behavioural science data in a number of important ways. Most importantly social network data consist of relations measured among a set of actors, and the presence of relations has implications for a number of measurement issues. This includes the unit of observation, the modelling unit and the quantification of the relations (Wasserman & Faust, 1999). The unit of analysis should be at the same level as the research question (Yin, 2009). The unit of observation is the entity that the measurements are taken from. In this study the unit of observation is the relational tie, the

modelling unit is on the pair of actors, and the quantification of the relations is directional and valued.

In this study I will investigate the relationships between the virtual team members in both the Social Interaction Network and in the Knowledge Quality Network, and I chose to approach the four teams with a full network method. Because information is collected about ties between all pairs of actors, full network data method will give a complete picture of relations in the population. Hence, full network methods require collection on information about each actor's ties with all other actors. In essence, this approach is taking a census of ties in a population of actors, rather than a sample (Hanneman & Riddle, 2005). This approach yields the maximum of information, but can also be costly and difficult to execute, and may be difficult to generalize (Hanneman & Riddle, 2005).

The first step in assessing the information or knowledge flow among members in a group is to identify the informal network among members (Cross, Borgatti, & Parker, 2004). Since questionnaires are considered useful when the actors in the network are people, and the relations that are being studied are ones that the respondents can report on (Wasserman & Faust, 1999), a survey method was employed. Accordingly, to measure the social interaction network in a virtual team, a Social Network Analysis (SNA) was performed, as this type of analysis can provide an overview of how work is occurring in informal networks (Cross, Parker, Prusak, & Borgatti, 2001). However, according to Cross, Borgatti and Parker (2002), assessing an information network and just ask who communicates with whom, does not necessarily guarantee that the interaction ties reflect that the information shared is relevant to the work performed within the team. Therefore a second SNA was performed. This second analysis looked at the quality of knowledge shared between the team members. The two analyses were then compared and contrasted with the purpose of investigate the relationship between the strength of social interaction ties and the quality of knowledge shared in each tie.

3.3 Establishing Measurements

In the following paragraphs I will present the measurements of the dependent and independent variable in the social network analyses.

3.3.1 Dependent Variable – Knowledge Quality

Little research has been done on how knowledge might be measured. Partly because of the discussions of what constitutes knowledge in terms of epistemology and ontology. However, there exist three basic methods for measuring knowledge (Borgatti & Carboni, 2007). The first and perhaps the most common is the method based upon an underlying belief of knowledge as an objective truth. The measurement of this view is based upon a method of administering a test where all answers are known to the researcher. The second method is also fairly common and includes a more humanistic perspective where researchers ask the respondents to self-evaluate their own level of knowledge. An alternative approach can be to ask the respondents to evaluate the other respondents' level of knowledge, as socially relevant others might be able to better judge an individual's knowledge than the individual himself. An advantage of this approach could be that the knowledge of those that know only a little are accurately measured, however, respondents with greater level of knowledge will be poorly estimated as the estimates are made by people of lesser knowledge. The third method for measuring knowledge is based upon a design, where a consensus pattern between all pairs of respondents is evaluated, by asking the respondents to nominate the team members with whom they share knowledge with high quality (Borgatti & Carboni, 2007). The thesis adapts this third approach for two main reasons. First and foremost this approach is selected on the basis of the notion of reciprocity yields stronger ties. If two respondents, that is to say a pair of respondents, nominate each other, they are in consensus that high quality of knowledge is shared between them. Secondly, this approach is based upon the social constructivist perspective that this paper has adopted. If we base the measurement on the notion that knowledge is constructed and negotiated through social interaction, we can see if it exists consensus between each pair on how they view the quality of the knowledge shared between them.

Consequently, a Knowledge Quality measure was developed, which aimed to assess the quality of knowledge that is shared between all the pairs of respondents with a survey method. In the questionnaire (APPENDIX 2) all respondents were presented with a roster, which is a complete list over the members in the team. They were then given a free choice to check as many people off from the list as they felt were appropriate.

Dependent variable measure: Quality measures were adapted from inventories developed by Yoo, Vonderembse, and Ragu-Nathan (2011), and concerned intrinsic-, contextual- and actionable knowledge quality. The inventories consists of reliable and validated scales for measuring the quality of knowledge within a whole team, however the scales were modified to suit the purpose of measuring the quality of the knowledge shared between two respondents. *Intrinsic knowledge quality* measures were depicted by 7-items, measuring the respondents' understanding of the knowledge shared as; accurate, reliable, objective, unbiased, believable, current and updated. *Contextual knowledge quality* measures were portrayed by 6-items, measuring the respondents' understanding of the knowledge shared as; adding value for decision making, adding value to the team's operation, giving the team a competitive advantage, relevant to the tasks, appropriate to their jobs and context specific. *Actionable knowledge quality* measures were represented by 6-items, measuring the respondents' understanding of the knowledge as being; actionable, adaptable, expandable, applicable to their tasks, increases effective action and provides the capacity to react to circumstances. At the end of the questionnaire a control question assessed the quality of knowledge as an entirety shared between the respondents. In this question the respondents' were asked to check off the persons from the list of team members, with which they felt they shared knowledge of high quality. This question was developed to control consistency in what they had answered in the 18 preceding questions. At last the questionnaire consisted of an open question where the respondents could answer in Norwegian or English whether they in general considered the knowledge shared in the project as being of high quality.

Since some of the respondents had Norwegian as their native language, and the questionnaire was in English, thorough definitions of the items and synonyms for terminology were provided. Before sending out the questionnaire, a pre-test questionnaire was given to an external consultant in one of the teams, following an extensive unstructured interview. In addition to questions about the specific questionnaire items, the interview consisted of questions about sharing of knowledge in the whole team, knowledge in general and the quality of knowledge that is shared between the members in the project team. Moreover, all items were discussed thoroughly and suggestions for terminology were evaluated.

3.3.2 Independent Variable – Social Interaction Ties

The use of tools and scales for measuring the strength of a tie are relatively scarce, even if the strength of social ties have been in focus of social sciences for decades (Petróczi, Nepusz, & Bazsó, 2007). Social interaction ties was by Chiu, Hsu and Wang (2006) represented by the strength of the relationships, the amount of time spent and communication frequency, while Petróczi, Nepusz and Bazsó (2007) suggested that trust was included as a component in social interaction ties. Since trust is an important element for knowledge sharing in virtual team, this element was incorporated in the multiplexity of a social interaction tie in this study. Accordingly, to portray the multiplexity of social interaction ties, a Social Interaction Tie measure was developed. In the questionnaire (APPENDIX 2) all respondents were presented with a roster, which is a complete list over the members in the team. They were then given a free choice to check as many people off from the list as they felt were appropriate. Since some of the respondents had Norwegian as their native language, thorough definitions of the variables and synonyms for terminology were provided.

Independent Variable Measurement: Social Interaction Ties are represented by the strength of the relationships, the amount of time spent, communication frequency (Chiu, Hsu, & Wang, 2006) and interpersonal trust (Petróczi, Nepusz & Bazsó, 2007).

The Strength of a Relationship was addressed with a question assessing close relationship. The item was adapted from a reliable and validated inventory by Chiu, Hsu and Wang (2006)

The *Interpersonal Trust* item consisted of two questions, and was adapted from Abrams et al. (2003). The first question addressed competence-based trust, whereas the other question addressed benevolence-based trust. Together these two questions constitute the item of interpersonal trust.

The measure of *Frequency of Communication* was adapted from the social interaction tie inventory by Chiu, Hsu and Wang (2006), however the measure was divided into two questions, as suggested by Dr. David Krackhardt in his sample questionnaire on frequency of communication. The first question addressed whom the respondents communicated with about the specific project on a daily basis, and the other question whom the respondent communicated with about the specific project on a weekly basis.

The Amount of Time Spent on Interaction measure was adapted from a reliable and validated inventory by Chiu, Hsu and Wang (2006), and assessed by a question that addressed whom of the team members the respondent used the most time interacting with.

Measures of tie-strength have to vary in accordance with what is being studied (Haythornthwaite, 1996a). In all, the questionnaire contained six questions that depicted the multiplexity of a social interaction tie within a virtual team.

Before sending out the questionnaire, a pre-test questionnaire was given to an external consultant in one of the teams, following an extensive unstructured interview. Here all items were discussed in a thoroughly manner in order for the items to be correctly phrased and for correct use of synonyms in each item. In addition to questions about the specific questionnaire items, the interview consisted of general questions about close relationships, communication frequency, interpersonal trust and time spent on interaction in the project as a whole.

3.4 Scientific Value

In order to be able to ensure the scientific value of a case study, quality criteria have to be established (Yin, 2009). The most important concerns in social network measurement are the validity, reliability and measurement errors in the gathered data. Even if only little research has been done on these issues in social network analysis (Wasserman & Faust, 1999), the subsequent paragraph will focus on how to establish construct validity and reliability, and how to deal with accuracy of self-report data and measurement errors, including discuss the importance of addressing special ethical concerns in a network analysis. Furthermore, the subsequent paragraph will also address the internal and external validity of the multiple case study as a whole.

3.4.1 Internal Validity

Internal validity in a case study extends to the broader problem of making inferences. The way to assess internal validity is then to conclude that no other possibilities or other rival explanations can explain the results (Yin, 2009). The specific tactics for achieving internal validity in a case study can be based on

several tactics. As I will explain later in the analysis chapter, this study is based on a pattern matching technique where I compare the empirically found evidence with the theoretical propositions. In this study we will see that patterns coincide, thus these results help to strengthen the study's internal validity (Yin, 2009).

3.4.2 External Validity

By assessing the external validity we are aiming to understand the generalizability of the findings (Yin, 2009). By wanting to generalize the findings we have to address the case study as a whole. When it comes to external validity, it will in a case study be possible to achieve a theory related analytic generalization, however it will not be possible to achieve a statistic generalisation (Yin, 2009). In order to ensure external validity I chose a multiple case study, hence replicated the network analysis across four teams. The findings are coherent, even though the teams consisted of members from a vide variety of professionals, companies and countries.

3.4.3 Construct Validity

Very little research has been conducted on the construct validity of measures of network concepts (Wasserman & Faust, 1999). However, the validity of a concept in network theory is seldom tested in a strict way. Nevertheless the phenomenon of construct validity is said to arise when measures of concepts have behaved as expected in theoretical predictions (Wasserman & Faust, 1999). The findings are coherent across cases, and the study has taken the measures necessary to create construct validity.

It is evident that, the use of tools and scales for measuring the strength of a tie are relatively scarce, even if the strength of social ties have been in focus of social sciences for decades (Petróczi, Nepusz, & Bazsó, 2007). Social interaction ties was by Chiu, Hsu and Wang (2006) represented by the strength of the relationships, the amount of time spent and communication frequency, while Petróczi, Nepusz and Bazsó (2007) suggested that trust was included as a component in social interaction ties. Since trust is an important element for knowledge sharing in virtual team, this element was incorporated in the multiplexity of a social interaction tie in this study. Quality measures were

adapted from inventories developed by Yoo, Vonderembse, and Ragu-Nathan (2011), and concerned intrinsic-, contextual- and actionable knowledge quality. The inventories consists of reliable and validated scales for measuring the quality of knowledge within a whole team, however the scales were modified to suit the purpose of measuring the quality of the knowledge shared between two respondents.

According to Yin (2009) there are three aspects in a case study that are important to focus on concerning construct validity. First it is important to use multiple sources of evidence, to enhance the credibility of the findings. In this study, searching convergent findings from different sources of evidence to increase construct validity was done both by collecting qualitative data from two unstructured interviews and by collecting quantitative data from questionnaires to perform the network analysis. Second, it is recommended to have a key informant reviewing the case study report. This study relies on two unstructured interviews with external consultants and supervisor feedback to ensure that the method employed is appropriate. At last it is important to maintain a chain of evidence, meaning that there should be a clear connection between the questions asked, the data gathered and the conclusions drawn. In this study the research question and the theoretical propositions are based on already founded and well-documented theory.

3.4.4 Reliability

A measure or concept is considered reliable if repeated measurements give the same estimates (Wasserman & Faust, 1999). The *reliability* of a measure can be assessed by comparing measurements taken two points in time or by comparing measurements based on subsets of test items (Wasserman & Faust, 1999). For the test-retest assessment of reliability one must assume that the value of the variable has not changed over time, however this assumption is likely to be inappropriate for social network analysis, as a social phenomenon cannot be assumed to remain static over time (Wasserman & Faust, 1999). The data in this study was collected at a single point in time, however the relations are expected to change due to the nature of relationships.

3.4.5 Accuracy of Self-report Data

The selection of the right data is one problem that poses considerable problems for social network analysis. A common strategy in a small-scale social network has been to identify all the members of a certain group and then trace their various connections between them. Hence the *accuracy of self-report data* is a concern (Wasserman & Faust, 1999). Sociometric data are often collected as self-report data, where the respondents report their interactions and are asked to recall his or her interactions and/or relationships with other people. However, considerable amount of research has been done on the question of informant accuracy in social network data, and findings suggest that only half of the reported data to be correct (Wasserman & Faust, 1999).

Consequently assessing the accuracy of self-report data is far from a straightforward matter. Social relations are social constructs that are produced on the basis of the situation made by group members. For example the item that are constructed to measure the relation of close friendship, may mean different things to different people, according to what the respondents conceive as being close. In this case respondents that might have a restrictive definition of closeness will draw narrow boundaries around themselves, while the persons that might have a more inclusive conception of friendship will have more extensive boundaries.

Additionally, asking respondents to report the details of the frequency or intensity of ties by survey or interview methods can be unreliable. This is the case particularly if the relationships being tracked are not important and infrequent. The issue can be resolved by counting the number of email, phone, and inter-office mail deliveries between them (Hanneman & Riddle, 2005), however this was not possible to achieve in this analysis.

Moreover, it is often assumed that the social relations of individuals will be restricted to the particular group that are being investigated (Scott, 2004). A roster defines the population clearly to respondents and reduces the likelihood that a name was not mentioned because it was forgotten. This may be especially important when eliciting information on those whom respondents were only weakly tied to the team (Haythornthwaite, 1996b). Hence, in this research a roster with the names of all team members included in each team was used at the data collection stage.

Nevertheless, the respondents are often asked to consider reports as long-range structures, where the respondents are asked to report on a relationship

within a period of time like it was done in this study. This way of utilization might make the respondents' answers more credible, as the reporting is not based on individual incidents (Wasserman & Faust, 1999).

Attempting to address the problem of accuracy of self-report data, this study relies on the analyses of the reciprocated ties between respondents. In this way, it is easy to see that if a respondent has reported a close relationship with another respondent that is not returned, the relationship between them is weaker than a relationship where two respondents consider each other as close friends. That is to say, ties that are not reciprocated can be regarded as weaker than ties that are reciprocated (Granovertter, 1973).

3.4.6 Measurement Errors

Measurement errors occur when there are discrepancies between the true and observed value of a concept (Wasserman & Faust, 1999). It is common to assume that the observation or measurement of concepts is an additive combination of the observed score plus error. This error, that is the difference between the true and observed values, is referred to as measurement error (Wasserman & Faust, 1999). In social network research the measurement is the collection of ties between actors in the network, and is represented in a matrix or a sociogram. Error arises in fixed choice data collection designs, as this design will introduce error since it is unlikely that a respondent has for example exactly three close friends (Wasserman & Faust, 1999). To address the issue of measurement error, I gave the respondents a free choice to mark as many names as appropriate.

3.4.7 Ethical Considerations

Another matter that needs attention is that network analyses introduce, by its very nature, special ethical considerations that should be recognized (Borgatti & Molina, 2003). In order to overcome ethical issues I have followed the set of *ethical guidelines* presented by Borgatti and Molina (2003), which all were stated in the consent form given to the respondents in front of the data collection. As anonymity at the data collection stage in network research is impossible, the researcher has, for the data to be meaningful, to be able to know whom the respondent was in order to map the ties between the respondents (Borgatti &

Molina, 2003). Therefore it was necessary to make clear to the respondent who will see the data (Borgatti & Molina, 2003). In the consent form it was clearly stated that only the student and the supervisor had access to the data, consequently this made the respondents feel more secure when answering questions of a more sensitive character. Anonymity can also be addressed by offering confidentiality (Borgatti & Molina, 2003). Consequently all the respondents were guaranteed confidentiality of any gathered data. In addition, it was important to distinguish the data (e.g. remove names and other identifying attributes) so that management cannot take actions against individuals (Borgatti & Molina, 2003). In this study assigning a random number to each respondent was done to preclude this from happening. Moreover, participation in the study should be voluntary, and all studies should provide some kind of feedback directly to the respondents as a payment for their participation. This is done by offering them a copy of the finished master thesis and providing them with a tailored document with a complete analysis of their team, and suggestions for further development (Borgatti & Molina, 2003).

4. Analysis

The analysis chapter will first address how to deal with the non-respondents in the study, and secondly give a justification for the use of directed ties. It will further give an overview of how the calculus of each of the variables was performed. Moreover an individual case-report for each of the four teams is applied, before the findings are contrasted and compared. As analyses of the collected evidence are the least developed and most difficult aspect of a case study, an important factor is to have a general analytic strategy. In this study, I chose to follow an analytic strategy proposed by Yin (2009), as to rely on the theoretical propositions and let the theoretical orientation guide my analysis. Accordingly, I have used a pattern matching technique where I compare the empirically found evidence with the stated theoretical propositions.

4.1 Dealing with Non-respondents

Survey studies of complete social networks often involve non-respondents, that is to say, people within the network boundary who do not complete the sociometric questionnaire. Non-respondents might create significant problems for the network

analysis (Robins, Pattison & Woolcock, 2004), and in network analysis, missing data is exceptional troublesome (Borgatti & Molina, 2003). For example will a mapped network look quite different if one central person is left out. In figure number 2 below, panel A shows the complete network. However panel B shows the changes in network structure when nodes 7 and 10 are omitted from the study.

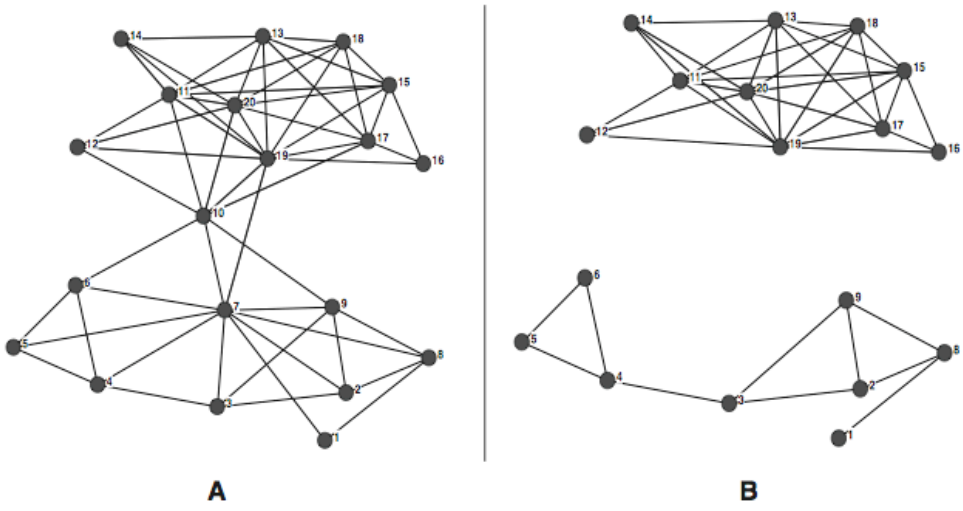


FIGURE 2: Illustration of Missing Data (Borgatti & Molina, 2003).

In general, the network literature provides little guidance on how to approach the problem of non-respondents in network studies (Robins, Pattison & Woolcock, 2004). However, if we assume that the non-respondents are missing at random, homogeneity across certain networks are invoked to infer effects as applicable to the entire set of network actors (Robins, Pattison & Woolcock, 2004). Stork and Richards (1992) propose a process to remedy the problem. This *process of reconstruction* of the network assumes that if a respondent nominates a non-respondent, a tie between the two exists, hence the respondent's description of the relationship is accorded to the non-respondent as well. Stork and Richards' advice further states that the validity of this approach should checked against the data.

In the data set it was easy to assume that if a respondent communicated daily with another respondent, that the non-respondent also communicated daily with the respondents that nominated him. However when it comes to interpersonal trust and close relationship it is more difficult to reconstruct the relationship. This also concerns the reconstruction of the quality of knowledge ties. Following Stork and Richards, I note that some ties in this study cannot be reconstructed hence they will remain missing. This approach was selected on the basis of that it in this

study is easier to deal with missing respondents since we are looking at the relationship between the team members and not the structure of the whole network. Moreover, one of the strengths in this study is the high response rate. In *Team 1* there were three non-respondents, remaining a response rate of 81,25%. In *Team 2* there were non non-respondents, remaining a response rate of 100%. In *Team 3* there were two non-respondents, remaining a response rate of 77,77%. In *Team 4* there were non non-respondents, remaining a response rate of 100%.

4.2 Addressing Virtuality

As previous clarified we find discussions about the virtuality in teams along a continuum using dimensions such as time, space and organisational boundaries (Bell & Kozlowski, 2002; Griffith, Sawyer, & Neale, 2003; Martins, Gilson, & Maynard, 2004). Moreover, the more dimensions the team include, the more virtual it is (Zigurs, 2003). Of all the teams investigated, Team 2, which consisted of 7 participants, working as project leaders in one of Norway's largest banks is regarded as the least virtual team of the four teams investigated. The team works across spatial and organisational boundaries, but reported that some of the team members met weekly in face-to-face meetings. Team 1, which consists of 16 persons from six different companies, working as consultants on a project for implementing IT-systems in one of Norway's largest banks, reported to be slightly more virtual than Team 2. This team also works across spatial, cultural and organisational boundaries, however a few of the team members reported to meet monthly in face-to-face meetings. Team 3 consists of 10 participants working in leading positions for a large Norwegian company, which is a leading supplier of services related to oil, gas and renewable energy. Team 3 reported to work over spatial, temporal and cultural boundaries, thus is regarded as more virtual than Team 2 and Team 1. In addition the fact that four of the team members are located in Singapore and five in Norway makes collaboration even more difficult with respect to time differences. Virtual Team 4 consists of 8 participants working as country coordinators for a large governmental project that spends across the five countries. The team members reported to be located in Norway, Sweden, Denmark, Finland and Iceland. This team is collaborating over temporal, spatial, cultural and organisational boundaries hence Team 4 is regarded as the most virtual team of those investigated.

4.3 Coding and Value

In the following paragraphs I will present the coding and value of the ties of the dependent and independent variable in the social network analyses.

4.3.1 Dependent Variable – Knowledge Quality

The first matter that has to be considered when looking at the Knowledge Quality (KQ) data set, is how to code and value the ties between the actors in the network. The most common approach to scaling (assigning numbers to) relations is to simply distinguish between relations being absent (coded 0), and ties being present (coded 1) (Hanneman & Riddle, 2005). Consequently I coded the nominated ties from each actor, from each question 1 and the remaining non-nominated ties 0.

It is important to acknowledge that actors in networks are frequently connected by more than one type of tie, simultaneously. That is to say, the relationship between any two actors may be multiplex (Hanneman & Riddle, 2005). In this network analysis, each actor has answered questions about 18 different aspects of knowledge quality, and the next step is to combine all these questions into one measure. In order to portray the Knowledge Quality, all teams were placed in a matrix, one for each question, and in total 18 matrices per team. Matrix addition is most often used in network analysis when trying to simplify or reduce the complexity of multiplex (multiple relations recorded as separate matrices) data to simpler forms (Hanneman & Riddle, 2005). A matrix addition was therefore performed for all 18 separate matrices in order to depict intrinsic-contextual- and actionable knowledge quality as one measure for Knowledge Quality.

Since we are interested in which ties that represent knowledge of high and low quality. The next step is to diversify the knowledge ties into groups that represents low and high knowledge quality. As a score of 0 represent no tie, the minimum score for the Knowledge Quality tie is 1, whereas the maximum score is 18. This gives us a median of 9. The mean of the scores from the data sets were 7,61. The standard deviation (SD), which is a common measure of the distribution of the data set, explains variation from the average mean. A low SD shows that the data points tend to be very close to the mean, whereas high SD shows that the data are spread out in excess of a large range of values. The SD of the scores was

6,22. The data were from here grouped into three groups based on the SD. It was necessary to decide for a cut off of the scores; hence the SD was rounded down to 6 when distributing the scores. Consequently group number 1, which is depicting the weakest ties, contains the ties that range from 1-6. This means that team members that are connected by one to six Knowledge Quality ties are considered sharing knowledge of low quality. Group number 2 is depicting the ties that is neither considered weak nor strong, and contains the scores that range from 7 to 12. This means that team members that are connected by seven to twelve Knowledge Quality ties are considered sharing knowledge of neither low nor high quality. Group number 3 is depicting the strong ties and contains the scores that range from 13 to 18. This means that team members that are connected by 13 to 18 Knowledge Quality ties are considered sharing knowledge of high quality.

4.3.2 Independent Variable – Social Interaction Ties

It is evident that, the use of tools and scales for measuring the strength of a tie are relatively scarce, even if the strength of social ties have been in focus of social sciences for decades. However, if tie strength can be objectively quantified, any attempts to measure it should yield various strengths of ties. Accordingly, any given person's ties to others will vary in strength (Petróczi, Nepusz, & Bazsó, 2007). This thesis aims to portray the strength of the social interaction ties between members within a virtual team. The first thing we have to consider when looking at our Social Interaction ties data set is how to code and value the ties. As with the Knowledge Quality ties, the nominated ties from each question was coded 1 and the remaining non-nominated ties 0. The value of the distinct Social Interaction Ties was assessed accordingly:

Close Relationship: The nominated ties were coded and valued 1 and the remaining non-nominated ties coded and valued 0.

Interpersonal Trust: The nominated ties of both competence-based- and benevolence-based trust were coded 1 and the remaining non-nominated ties coded 0. The measure of interpersonal trust consisted of two items. In this case I regard competence-based trust and benevolence-based trust to weigh equal as a component of interpersonal trust in a social interaction tie, thus both components were valued 0,5 each, so that the total sum of interpersonal trust would equal 1.

Frequency of Communication: The nominated ties of both daily and weekly communication were coded 1 and the remaining non-nominated ties coded 0. Since the measure of Frequency of Communication was measured by two questions, it was necessary to combine the two matrices of frequency into one. It was then also important for the weight of each element in the each social interaction tie to be the same, so that for example frequency of communication would not be more important in the tie than for example a close relationship. As daily communication resembles a stronger tie than communication on a weekly basis, the nominations on a daily basis were weighted 1, while the communication on the weekly basis were weighted 0,5.

Time Spent on Interaction: The nominated ties were coded and valued 1 and the remaining non-nominated ties coded and valued 0.

Social Interaction: As in the analysis of the Knowledge Quality ties, I will assess the multiplexity of the Social Interaction Ties. Since matrix addition is the most used tool for simplifying or reducing the complexity of multiplex (multiple relations recorded as separate matrices) data to simpler forms (Hanneman & Riddle, 2005), a matrix addition was then performed for all 6 separate items in order to portray the multiplexity of Social Interaction Ties. As Petróczi, Nepusz, and Bazsó (2007), this study takes into consideration the reciprocity of ties by double weight the tie if the nomination was mutual. That is to say, take into account that a tie from A to B is stronger if B confirms the same tie.

4.4 Deciding for Directed Ties

A researcher might consider that the most important is to consider the mere presence and absence of a relation and not its direction. Hence, complex types of relational data can always be reduced to more simple types, hence any data may be treated, as they were undirected and binary. Accordingly, it is possible to reduce directed data to undirected data, by simply ignoring the direction (Scott, 2004). However, it is important for researchers to take great care over the nature of their relational data, and in particular they must be sure that the level of measurement is sociologically appropriate (Scott, 2004).

In the networks investigated, I chose to hold the ties directional, and followed a procedure by Allen, James and Gamlen (2007), which let the ties be directional with an arrowhead indicating the direction of nominated collaborative

choices. Directed ties were chosen for two reasons. First, this approach is considered as eliminating part of the potential inaccuracy in the respondents' reports, since we with a directional tie are able to see who nominated whom. Secondly, nominations that are reciprocated can be considered to be stronger, as ties that are reciprocal are considered to be stronger (Granovetter, 1973).

4.5 Individual Case Reports

In this thesis I have used a pattern matching technique as suggested by Yin (1999), thus I will compare the empirically found evidence with the theoretical propositions. In order to find empirical evidence for the stated propositions, I will present four individual case-reports, where the network analyses conducted in each team will be compared. Accordingly I will check if the high Knowledge Quality ties are connecting the same actors as the Close Relationship ties, the Interpersonal Trust ties, the Frequency of Communication ties, the Time Spent on Interaction ties and the multiplex Social Interaction ties.

The response data were processed using the UCINET Software Package (Borgatti et al., 2002) and the network maps or 'sociograms' presented in the following section were developed using the NetDraw Utility (Borgatti, 2002). Software packages such as those used in this thesis automatically transform raw network statistical data to generate the sociograms (Allen, James & Gamlen, 2007). For more information about the data gathered in matrices, please see Appendix 3.

4.5.1 How to Read a Sociogram

A network can be viewed in several ways, and maybe one of the most useful ways to portray the data is by a *sociogram*, which consists of nodes (respondents) and lines (ties) (Wasserman & Faust, 1999). It is important to notice that the length of the ties and the arrangement of the nodes have no implication to the measures in the graph, since the nodes are placed in the sociogram at random. Respondents with the most ties to others are generally placed at the center of the network, and are known as focal nodes. The software used in this study consequently groups relationship clusters and will equalize the length of ties where possible. Since we are working with directed data, the direction of the lines is specified, which

accordingly specifies the direction of the relationship between two nodes. For example will the sociogram that portrays Team 1's close relationship network show the same as the matrix 1 in Appendix 3.

4.5.2 Individual Case Report Team 1

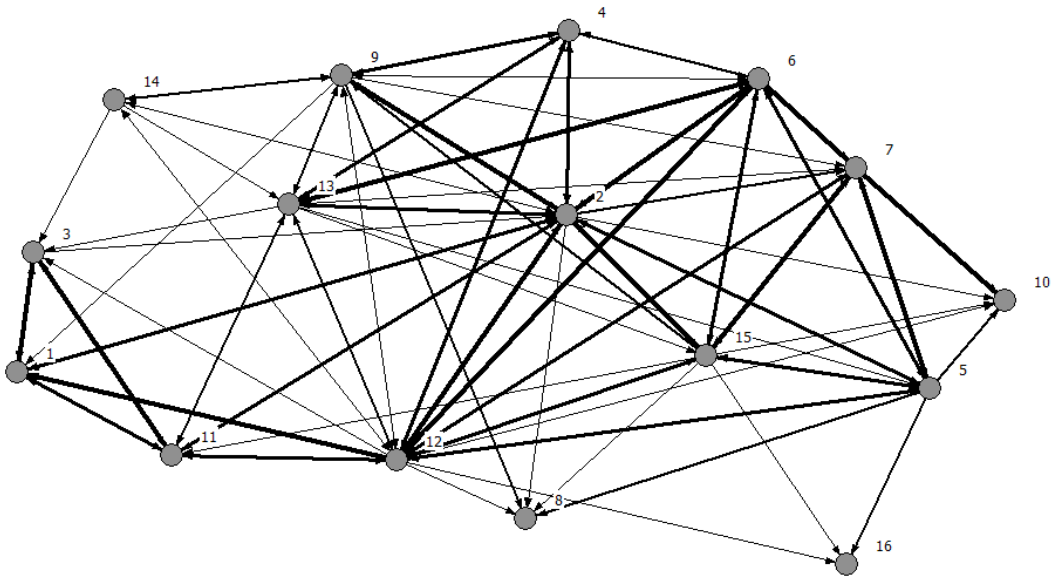
Assessing non-respondents: In Team 1, respondents 8, 10 and 16 are considered non-respondents, remaining a response rate of 81,25%. The non-respondents have not answered questions about their team members, however, as they still are represented in the roster, other team members have nominated them. As you can see this does not mean that the respondents are removed from the data set, however they are not considered when the calculus is employed.

Quality of knowledge within the whole team: Team members in Team 1 reported high quality of the knowledge shared on a general basis, and that the knowledge was shared mostly by e-mail. However, claims were made that a further development of the project's ICT-system would help further facilitate the sharing of information. One respondent reported that the team consisted of highly skilled professionals, whereas other respondents were not that optimistic and reported that the team consisted of average resources. Moreover, remarks were made about the difficulties of sharing information in a project involving professionals from different cultures, companies and proficiencies.

Assessing consistency of Knowledge Quality answers: At the end of the questionnaire a control question assessed the quality of knowledge as an entirety shared between the respondents. In this question the respondents' were asked to check off the persons from the list of team members, with which they felt they shared knowledge of high quality. This question was developed to control consistency in what they had answered in the 18 preceding questions. In Team 1 the consistency of the answers to the Knowledge Quality questions corresponded to the answers that were given in question number 19.

The sociogram below shows the entire KQ network. The lines consist of three different widths. The weakest ties are represented by the thinnest lines, and illustrate knowledge shared between two respondents that are of low quality. Pay especially attention to the non-reciprocal ties, as these ties are considered even weaker. The either weak or strong ties are represented by the medium lines, and represent knowledge shared between two respondents that are of neither low nor

high quality. The strongest ties are represented by the thickest lines, and represent knowledge shared between two respondents that are of high quality. Pay especially attention to the reciprocal ties, as these ties are considered even stronger.

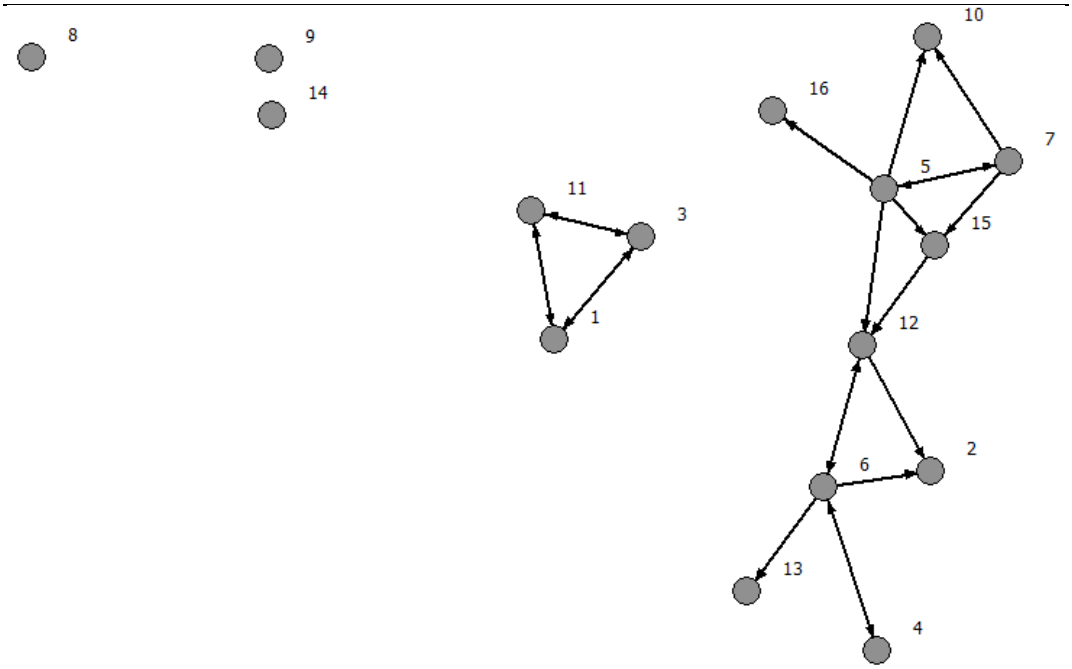


SOCIOGRAM 1: Knowledge Quality Network – Team 1

Proposition 1:

The sociogram below shows the entire *Close Relationship* network in Team 1. As you can see from the sociogram, respondent 9 and 14 did not report any close relationship and no one of the other team members nominated them. Respondent 2 and 13 did neither report any close relationships with the other members in the team, however other respondents have nominated them. This means that the close relationship ties to respondent 2 and 13 are considered weaker, since these ties are not reciprocal.

Moreover, Team 1 is divided when it comes to close relationships. We can see that respondent 1, 3 and 10 consider each other as close friends, and are disconnected from the rest of the team. Pay especially attention to the reciprocal ties, as these ties are considered stronger than the ties that go just in one direction. Remember that respondent 8, 10 and 16 are considered non-respondents.



SOCIOGRAM 2: Close Relationship Network – Team 1

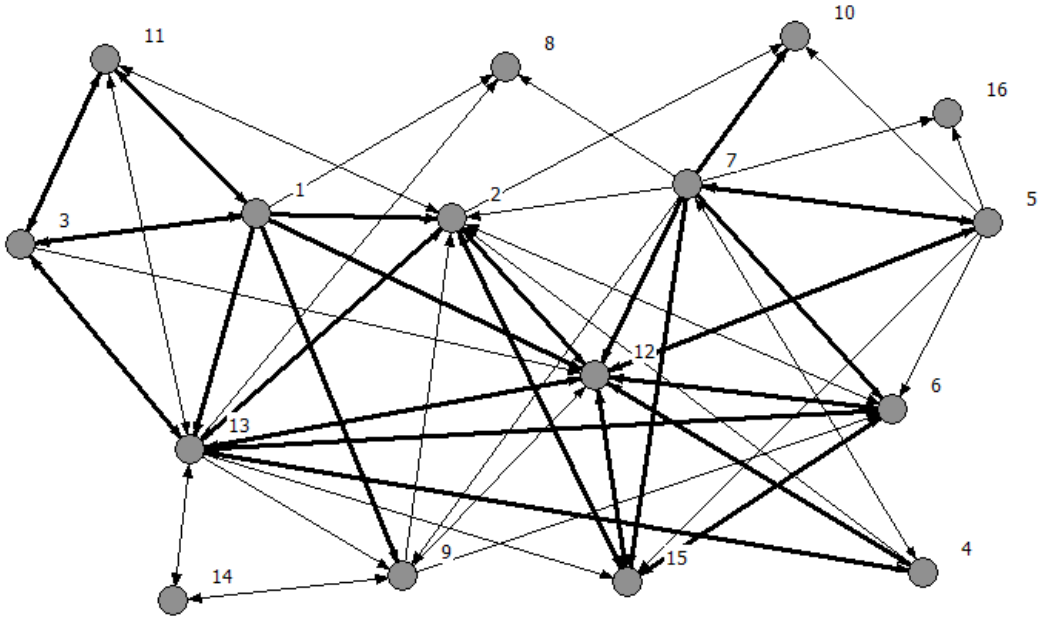
The *Close Relationship* ties were compared to the Knowledge Quality ties. Consequently, of all the team members that reported to be connected by Close Relationship ties, 2 were at the same time connected by weak KQ ties, 6 were at the same time connected by neither strong nor weak KQ ties, and 14 of the team members connected by Close Relationship ties were at the same time connected by strong KQ ties. Furthermore, the knowledge was reported to be useful in all close relationship ties. Altogether the data shows that the members in Team 1 that are connected by close relationship ties also in general are found to share strong Knowledge Quality ties.

In addition, to disclose if team members that did not reported to have close relationship with their team members reported high or low quality of the knowledge shared, a second comparison was performed. In this comparison the team members that did not report any close relationship ties, shared 52 KQ ties that could be considered weak, 10 KQ ties that could be considered neither strong nor weak, and 17 KQ ties that could be considered as strong.

Even though the knowledge was reported as being useful in all close relationship ties, team members in Team 1 that are connected by Close Relationship ties will not share knowledge of higher quality, than team members that are not connected by Close Relationship ties.

Proposition 2:

The sociogram below shows all the *Interpersonal Trust* ties in Team 1. The thick lines between the nodes represent the strong ties, whereas the thinner lines depict the weak ties. Remember that interpersonal trust is represented by both competence-based trust and benevolence-based trust. Hence the strong Interpersonal Trust ties consist of both competence- and benevolence-based trust, whereas the weak ties consists of either competence-based or benevolence-based trust. Team member 12 is the person that most of the other team members find both competent and benevolent.



SOCIOGRAM 3: Interpersonal Trust Network – Team 1

The strong *Interpersonal Trust* ties were compared to the Knowledge Quality ties. Consequently, of all the team members that reported to be connected by strong Interpersonal Trust ties, 5 were at the same time connected by weak KQ ties, 5 were at the same time connected by neither strong nor weak KQ ties, and 21 of the team members that reported being connected by strong Interpersonal Trust ties were at the same time connected by strong KQ ties. In 3 of the strong Interpersonal Trust ties it was reported no useful knowledge. Altogether the data shows that the members in Team 1 that are connected by strong Interpersonal Trust ties also in general are found to share strong Knowledge Quality ties.

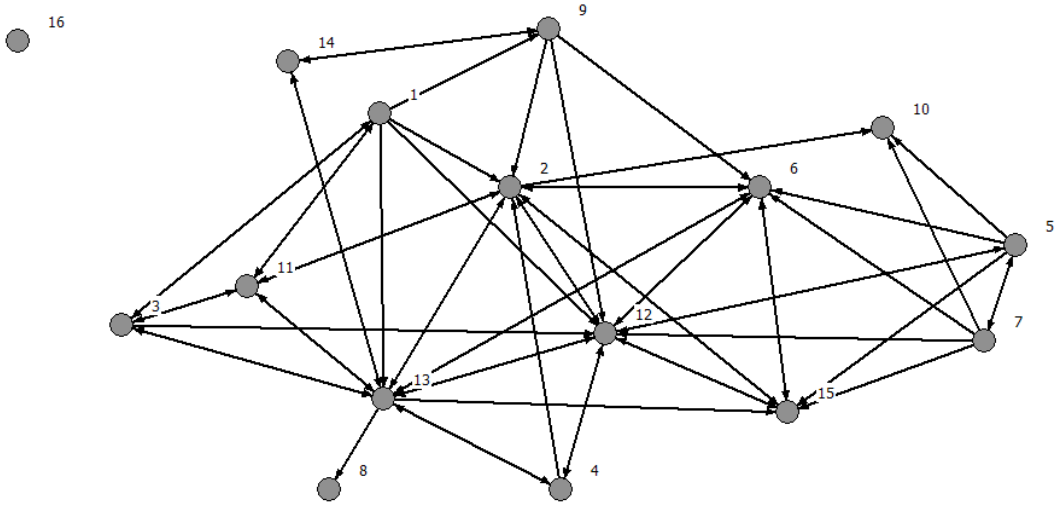
The weak *Interpersonal Trust* ties were compared to the Knowledge Quality ties. Consequently, team members that were connected by weak Interpersonal Trust ties, 13 were at the same time connected by weak KQ ties, 5

were at the same time connected by neither strong nor weak KQ ties and 8 of the team members that reported being connected by weak Interpersonal Trust ties were connected by strong KQ ties. In 10 of the weak Interpersonal Trust ties it was reported no useful knowledge. Altogether, the data shows that team members in Team 1 that is connected by weak Interpersonal Trust ties, will share weak Knowledge Quality ties.

Consequently, the data shows that the majority of team members in Team 1 that are connected by strong Interpersonal Trust ties share knowledge with higher quality, than team members that are connected by weak Interpersonal Trust ties.

Proposition 2a:

The sociogram below shows the entire Competence-based Trust network in Team 1. The members that the most people find competent are team members 2, 12 and 13. None of the respondents find team member 16 to have relevant expertise, skills and/or proficiency to accomplish his or her given assignments.



SOCIOGRAM 4: Competence-based Trust Network – Team 1

The *Competence-based Trust* ties were compared to the Knowledge Quality ties. Consequently, of all the team members that reported to be connected by Competence-based Trust ties, 16 were at the same time connected by weak KQ ties, 10 were at the same time connected by neither strong nor weak KQ ties and 29 of the team members that reported being connected by Competence-based Trust ties were connected by strong KQ ties. In 6 of the Competence-based Trust ties it was reported no useful knowledge. Altogether the data shows that the

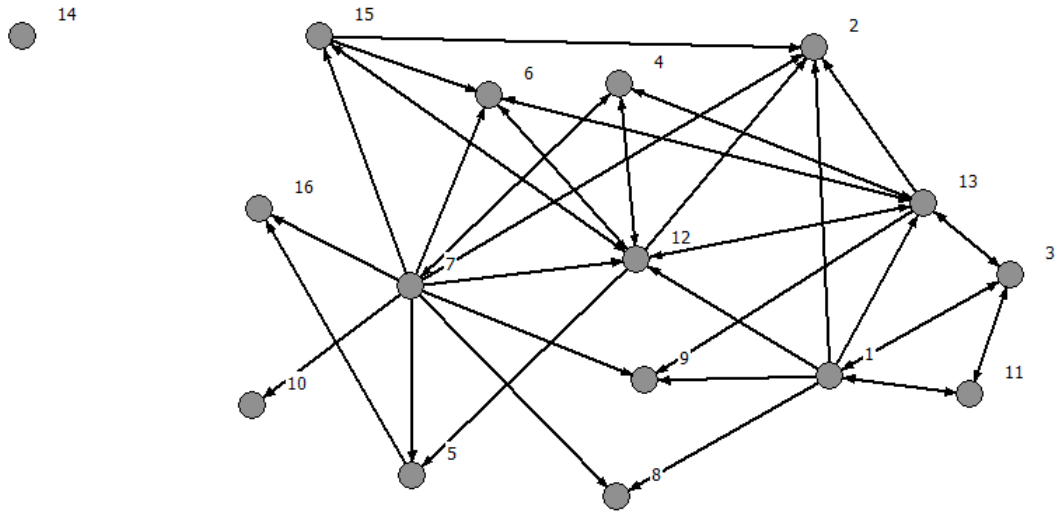
members in Team 1 that are connected by Competence-based trust ties also in general are found to share strong Knowledge Quality ties.

In addition, to disclose if team members that did not reported to have competence-based trust with their team members reported high or low quality of the knowledge shared, a second comparison was performed. In this comparison the team members that did not report any Competence-based Trust ties, shared 38 KQ ties that could be considered weak, 6 KQ ties that could be considered neither strong nor weak, and 2 KQ ties that could be considered as strong.

Consequently, the data shows that the majority of team members in Team 1 that are connected by competence-based trust ties will share knowledge of higher quality, than team members that are not connected by Competence-based Trust ties.

Proposition 2b:

The sociogram below shows the entire *Benevolence-based Trust* network in Team 1. The members that the most people find benevolent are team members 2, 12 and 13. None of the respondents find team member 14 to be benevolent, and he or she does not find anyone on the team to be benevolent either.



SOCIOGRAM 5: Benevolence-based Trust Network – Team 1

The *Benevolence-based Trust* ties were compared to the Knowledge Quality ties. Consequently, of all the team members that reported to be connected by Benevolence-based Trust ties, 7 were at the same time connected by weak KQ ties, 5 were at the same time connected by neither strong nor weak KQ ties and 21 of the team members that reported being connected by Benevolence-based Trust

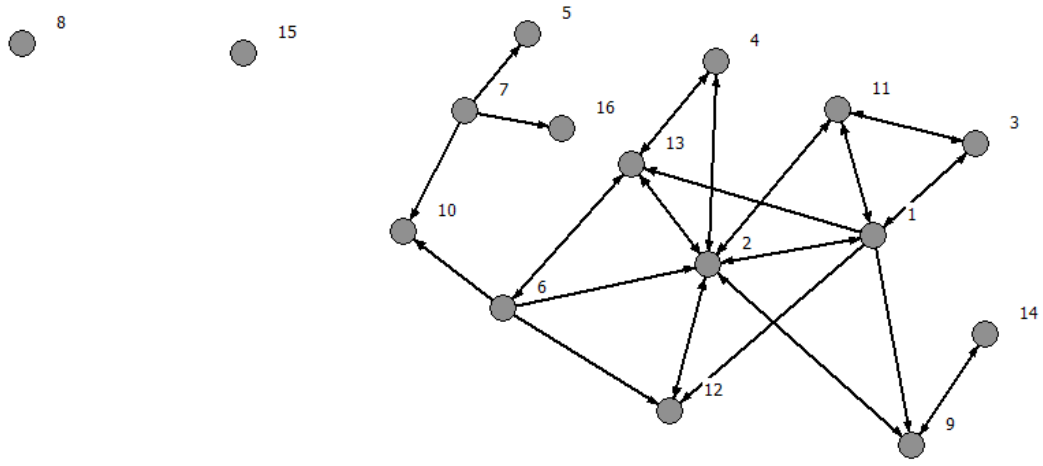
ties were connected by strong KQ ties. In 10 of the Benevolence-based Trust ties it was reported no useful knowledge. Altogether the data shows that the members in Team 1 that are connected by Benevolence-based trust ties also in general are found to share strong Knowledge Quality ties.

In addition, to disclose if team members that did not reported to have benevolence-based trust with their team members reported high or low quality of the knowledge shared, a second comparison was performed. In this comparison the team members that did not report any Benevolence-based Trust ties, shared 47 KQ ties that could be considered weak, 11 KQ ties that could be considered neither strong nor weak, and 10 KQ ties that could be considered as strong.

Consequently, the data shows that the majority of team members in Team 1 that are connected by Benevolence-based Trust ties will share knowledge of higher quality, than team members that are not connected by Benevolence-based Trust ties.

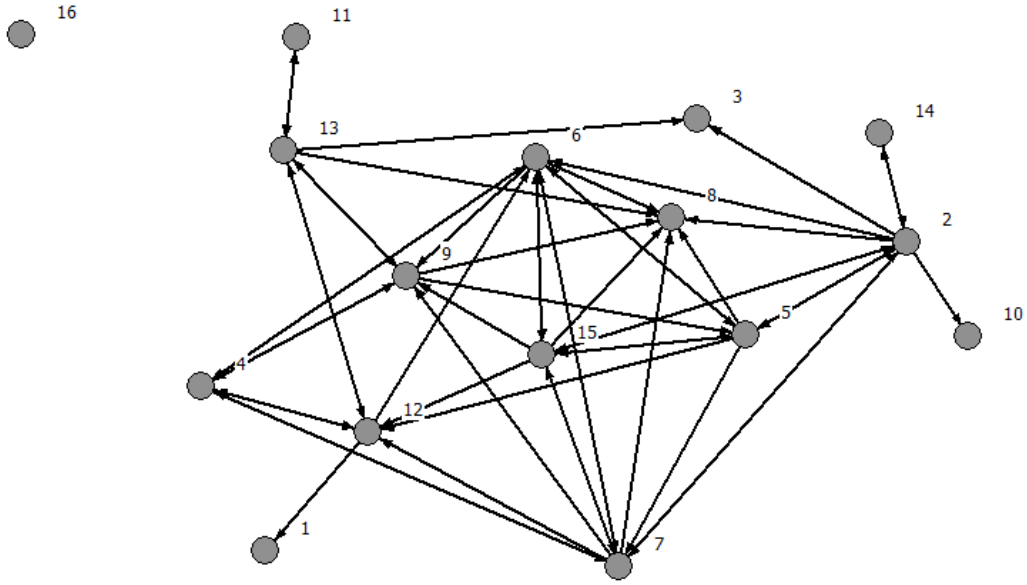
Proposition 3:

The sociogram below shows the entire *Daily Communication* network in Team 1. Respondents 5 and 15 do not report any daily communication with the project team, however respondent 7 reports daily communication with respondent 5. None of the team members report daily communication with respondent number 7, however respondent 7 reports daily communication with respondents 5, 10 and 16. The team member that most people report communicating with during a normal day is respondent 2.



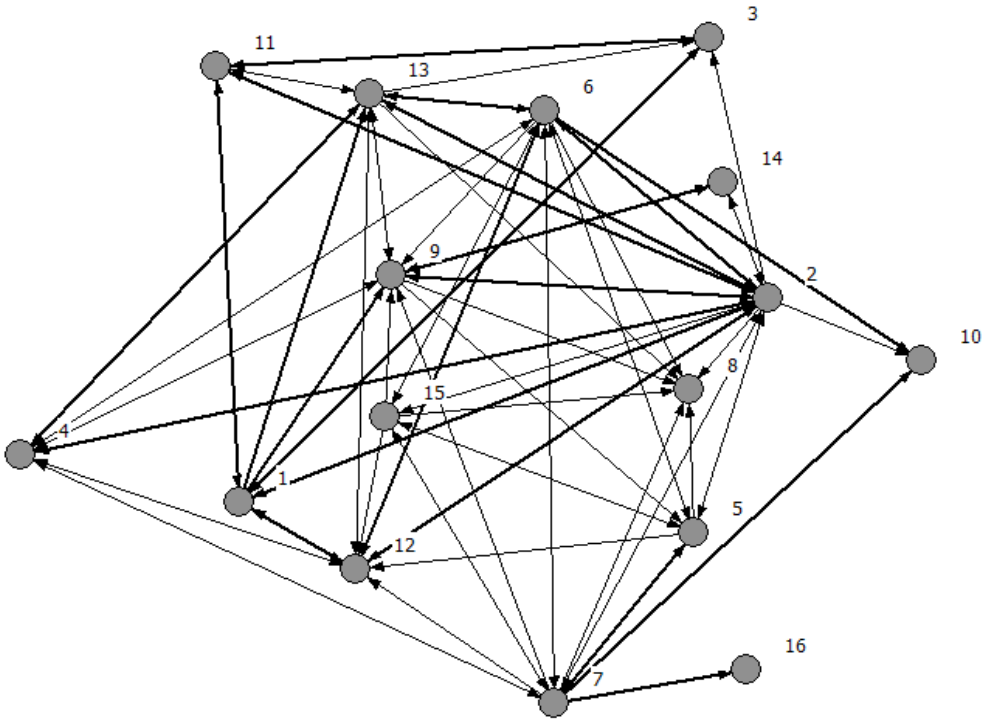
SOCIOGRAM 6: Daily Communication Network – Team 1

The sociogram below shows the entire *Weekly Communication* network in Team 1. Respondent number 12 reports weekly communication with respondent 1, however respondent 1 reports daily communication with respondent number 1.



SOCIOGRAM 7: Weekly Communication Network – Team 1

As you can see from sociogram number 9 below, the daily and weekly communication networks are added together to represent the Frequency of Communication network. The lines consist of two different widths. The thickest lines represent the strongest frequency of communication ties, whereas the thinnest lines represent the weakest frequency of communication ties.



SOCIOGRAM 8: Frequency of Communication Network – Team 1

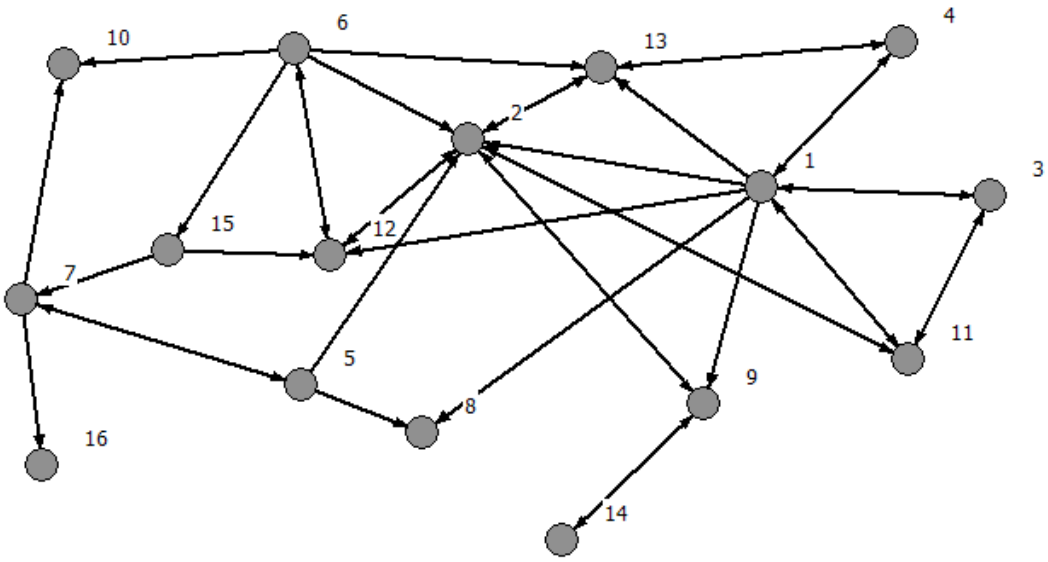
The strong *Frequency of Communication* ties were compared to the Knowledge Quality ties. Consequently, of all the team members that reported to be connected by strong Frequency of Communication ties, 8 were at the same time connected by weak KQ ties, 4 were at the same time connected by neither strong nor weak KQ ties, and 18 of the team members that reported being connected by strong Frequency of Communication ties were at the same time connected by strong KQ ties. In 3 of the strong Frequency of Communication ties it was reported no useful knowledge. Altogether the data shows that the members in Team 1 that are connected by strong Frequency of Communication ties also in general are found to share strong Knowledge Quality ties.

The weak *Frequency of Communication* ties were compared to the Knowledge Quality ties. Consequently, team members that were connected by weak Frequency of Communication ties, 23 were at the same time connected by weak KQ ties, 11 were at the same time connected by neither strong nor weak KQ ties and 10 of the team members that reported being connected by weak Frequency of Communication ties were connected by strong KQ ties. In 9 of the weak Frequency of Communication ties it was reported no useful knowledge. Altogether the data shows that the members in Team 1 that are connected by weak Frequency of Communication ties also in general are found to share weak Knowledge Quality ties.

Consequently, the data shows that the majority of team members in Team 1 that are connected by strong Frequency of Communication ties share knowledge with higher quality, than team members that are connected by weak Frequency of Communication ties.

Proposition 4:

The sociogram below shows the entire *Time Spent on Interaction* network in Team 1. The team member that people report using the longest time interacting with is team member 2.



SOCIOGRAM 9: Time Spent on Interaction Network – Team 1

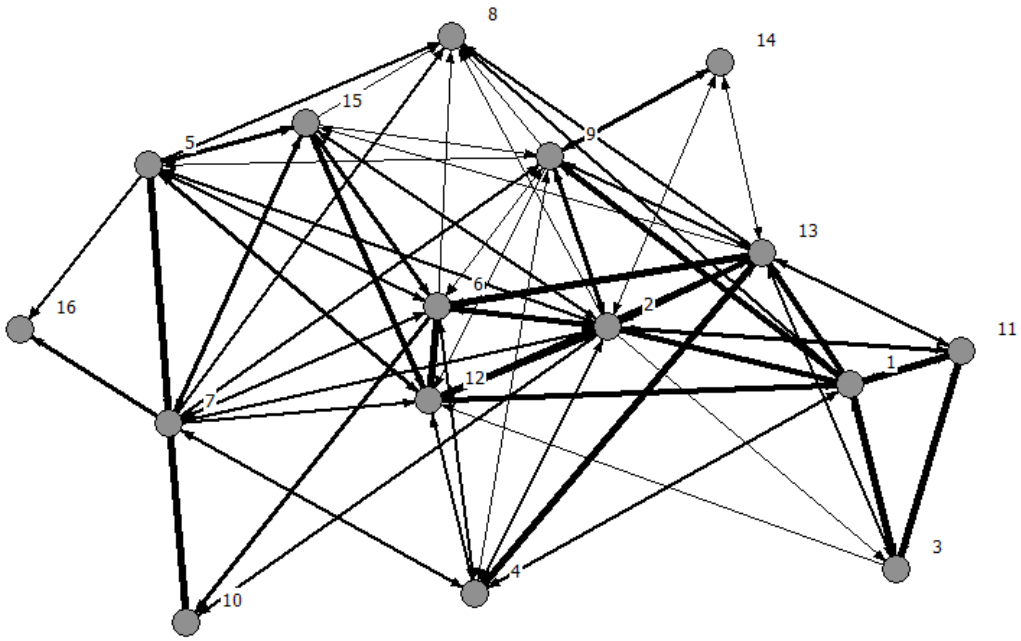
The *Time Spent on Interaction* ties were compared to the Knowledge Quality ties. Consequently, of all the team members that reported to be connected by Time Spent on Interaction ties, 8 were at the same time connected by weak KQ ties, 6 were at the same time connected by neither strong nor weak KQ ties and 19 of the team members that reported being connected by Time Spent on Interaction ties were connected by strong KQ ties. In 6 of the Time Spent on Interaction ties it was reported no useful knowledge. Altogether the data shows that the members in Team 1 that are connected by Time Spent on Interaction ties also in general are found to share strong Knowledge Quality ties.

In addition, to disclose if team members that did not reported to spent more time interaction with their team members reported high or low quality of the knowledge shared, a second comparison was performed. In this comparison the team members that did not report any Time Spent on Interaction ties, shared 46 KQ ties that could be considered weak, 10 KQ ties that could be considered neither strong nor weak, and 12 KQ ties that could be considered as strong.

Consequently, the data shows that the majority of team members in Team 1 that are connected by Time Spent on Interaction ties will share knowledge of higher quality, than team members that are not connected by Time Spent on Interaction ties.

Proposition 5:

The sociogram below shows the entire aggregated Social Interaction network in Team 1. The thick lines depict the strong ties between the respondents', the medium lines portray the neither weak nor strong social interaction ties, whereas the thinnest lines depict the weak ties.



SOCIOGRAM 10: Social Interaction Network – Team 1

The strong *Social Interaction* ties were compared to the Knowledge Quality ties. Consequently, of all the team members that reported to be connected by strong Social Interaction ties, 5 were at the same time connected by weak KQ ties, 4 were at the same time connected by neither strong nor weak KQ ties, and 17 of the team members that reported being connected by strong Social Interaction ties were at the same time connected by strong KQ ties. In 2 of the strong Social Interaction ties it was reported no useful knowledge. Altogether the data shows that the members in Team 1 that are connected by strong Social Interaction ties also in general are found to share strong Knowledge Quality ties.

The weak *Social Interaction* ties were compared to the Knowledge Quality ties. Consequently, team members that were connected by weak Social Interaction ties, 24 were at the same time connected by weak KQ ties, 11 were at the same time connected by neither strong nor weak KQ ties and 11 of the team members that reported being connected by weak Social Interaction ties were connected by strong KQ ties. In 11 of the weak Social Interaction ties it was reported no useful knowledge. Altogether the data shows that the members in Team 1 that are

connected by weak Social Interaction ties also in general are found to share weak Knowledge Quality ties.

Consequently, the data shows that the majority of team members in Team 1 that are connected by strong Social Interaction ties share knowledge with higher quality, than team members that are connected by weak Social Interaction ties.

In the preceding paragraphs we have taken a closer look at the multiplexity of social interaction ties. Empirical evidence has shown that team members in Team 1 that are connected by Close Relationship ties not necessarily share knowledge of higher quality than team members that are not connected by Close Relationship ties. However, team members that are connected by strong Interpersonal Trust ties share knowledge of higher quality than team members that are connected by weak Interpersonal Trust ties. Moreover team members that are connected by Competence-based Trust ties or Benevolence-based Trust ties share knowledge of higher quality than team members that are not connected by these ties. Furthermore, team members that are connected by strong Frequency of Communication ties share knowledge of higher quality than team members that are connected by weak Frequency of Communication ties. In addition team members in Team 1 that are connected by Time Spent on Interaction ties share knowledge of higher quality than team members that are not connected by Time Spent on Interaction ties.

Consequently, members in Team 1 that are connected by strong Social Interaction Ties will share knowledge with higher quality, than team members that are connected by weak Social Interaction Ties.

4.5.3 Individual Case Report Team 2

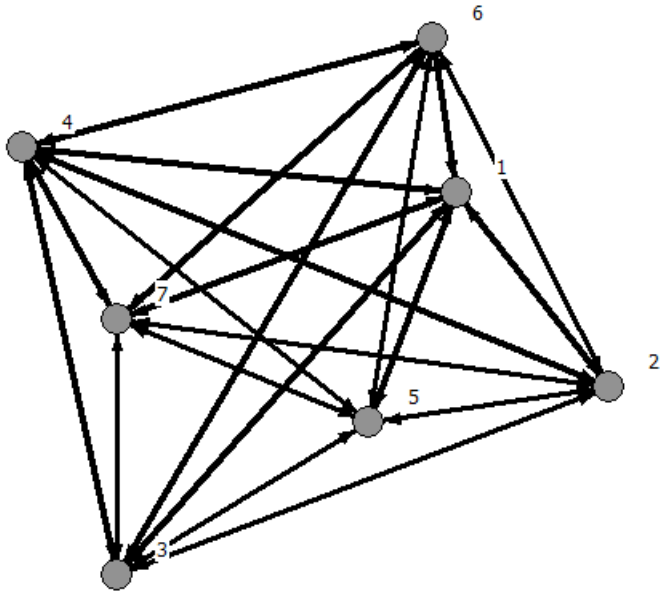
Assessing non-respondents: In Team 2, all team members answered the questionnaire, remaining a response rate of 100%.

Quality of knowledge within the whole team: All the members in Team 2 reported high quality of the knowledge shared between them.

Assessing consistency of Knowledge Quality answers: At the end of the questionnaire a control question assessed the quality of knowledge as an entirety shared between the respondents. In this question the respondents' were asked to check off the persons from the list of team members, with which they felt they shared knowledge of high quality. This question was developed to control

consistency in what they had answered in the 18 preceding questions. In Team 2 the consistency of the answers to the Knowledge Quality questions corresponded to the answers that were given in question number 19.

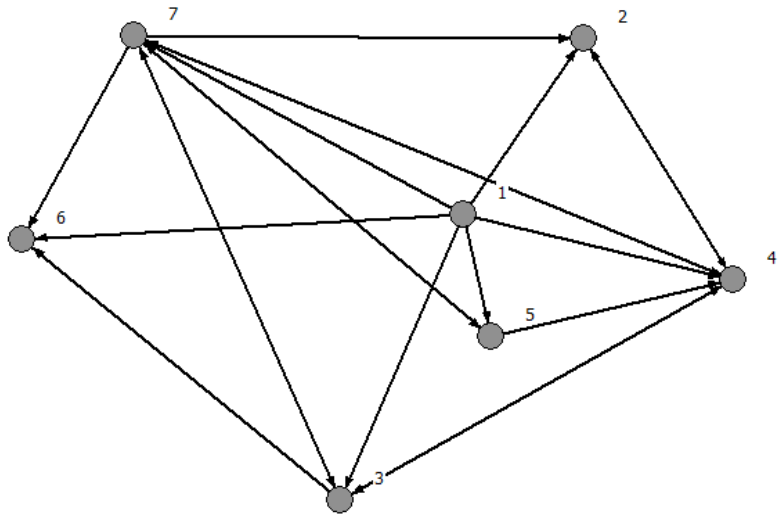
The sociogram below shows the entire KQ network. The reason for that the thinnest lines are not represented in the sociogram below, is that most of the members of Team 2 reported to share high quality knowledge with the majority of the other team members. Therefor the thinner lines represent knowledge shared between two respondents that are neither of low nor high quality. The strongest ties are represented by the thickest lines, and represent knowledge shared between two respondents that are of high quality. Pay especially attention to the reciprocal ties, as these ties are considered even stronger.



SOCIOGRAM 11: Knowledge Quality Network – Team 2

Proposition 1:

The sociogram below shows the entire *Close Relationship* network in Team 2. All of the team members report to have a close relationship with team member 4. Team member 1 reports to have a close relationship with all the other team members, however none of the other team members reciprocate this relationship.



SOCIOGRAM 12: Close Relationship Network – Team 2

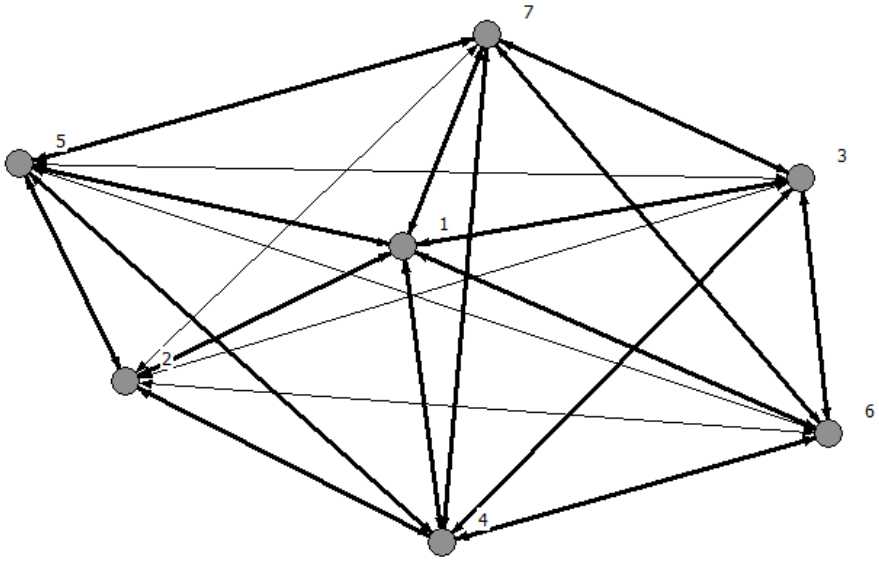
The *Close Relationship* ties were compared to the Knowledge Quality ties. Consequently, of all the team members that reported to be connected by Close Relationship ties, 0 was at the same time connected by weak KQ ties, 2 were at the same time connected by neither strong nor weak KQ ties, and 18 of the team members connected by Close Relationship ties were at the same time connected by strong KQ ties. Furthermore, the knowledge was reported to be useful in all close relationship ties. Altogether the data shows that the members in Team 2 that are connected by close relationship ties also in general are found to share strong Knowledge Quality ties.

In addition, to disclose if team members that did not reported to have close relationship with their team members reported high or low quality of the knowledge shared, a second comparison was performed. In this comparison the team members that did not report any close relationship ties, shared 3 KQ ties that could be considered weak, 6 KQ ties that could be considered neither strong nor weak, and 13 KQ ties that could be considered as strong.

Consequently, the data shows that the majority of team members in Team 2 that are connected by Close Relationship ties will share knowledge of higher quality, than team members that are not connected by Close Relationship ties.

Proposition 2:

The sociogram below shows all the *Interpersonal Trust* ties in Team 2. The thick lines between the nodes represent the strong ties, whereas the thinner lines depict the weak ties. Remember that interpersonal trust is represented by both competence-based trust and benevolence-based trust. Hence the strong Interpersonal Trust ties consist of both competence- and benevolence-based trust, whereas the weak ties consists of either competence-based or benevolence-based trust.



SOCIOGRAM 13: Interpersonal Trust Network – Team 2

The strong *Interpersonal Trust* ties were compared to the Knowledge Quality ties. Consequently, of all the team members that reported to be connected by strong Interpersonal Trust ties, 0 was at the same time connected by weak KQ ties, 2 were at the same time connected by neither strong nor weak KQ ties, and 20 of the team members that reported being connected by strong Interpersonal Trust ties were at the same time connected by strong KQ ties. Knowledge was reported to be useful in all strong Interpersonal Trust ties. Altogether the data shows that the members in Team 2 that are connected by strong Interpersonal Trust ties also in general are found to share strong Knowledge Quality ties.

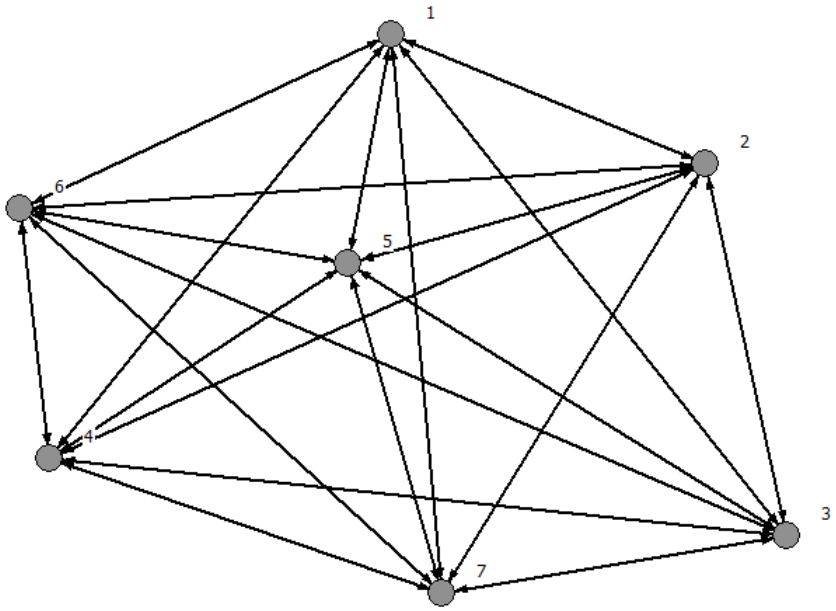
The weak *Interpersonal Trust* ties were compared to the Knowledge Quality ties. Consequently, team members that were connected by weak

Interpersonal Trust ties, 3 were at the same time connected by weak KQ ties, 6 were at the same time connected by neither strong nor weak KQ ties and 11 of the team members that reported being connected by weak Interpersonal Trust ties were connected by strong KQ ties. Knowledge was reported to be useful in all weak Interpersonal Trust ties.

Consequently, the data shows that the majority of team members in Team 2 that are connected by strong Interpersonal Trust ties share knowledge with higher quality, than team members that are connected by weak Interpersonal Trust ties.

Proposition 2a:

The sociogram below shows the entire *Competence-based Trust* network in Team 2. All team members report that all the other team members have the expertise, skill and/or proficiency to accomplish the given assignments.



SOCIOGRAM 14: Competence-based Trust Network – Team 2

The *Competence-based Trust* ties were compared to the Knowledge Quality ties. Consequently, of all the team members that reported to be connected by Competence-based Trust ties, 3 were at the same time connected by weak KQ ties, 18 were at the same time connected by neither strong nor weak KQ ties and 31 of the team members that reported being connected by Competence-based Trust ties were connected by strong KQ ties. Knowledge was reported being useful in all Competence-based Trust ties. Altogether the data shows that the

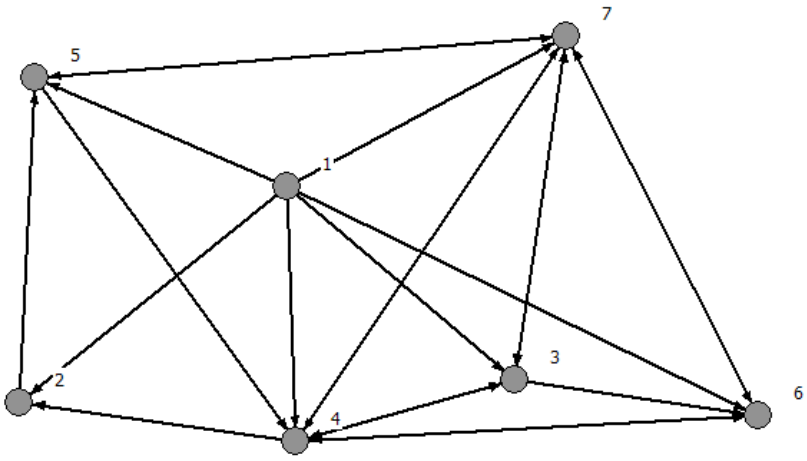
members in Team 2 that are connected by Competence-based trust ties also in general are found to share strong Knowledge Quality ties.

In addition, to disclose if team members that did not reported to have competence-based trust with their team members reported high or low quality of the knowledge shared, a second comparison was performed. In this comparison the team members that did not report any Competence-based Trust ties, shared 0 KQ ties that could be considered weak, 0 KQ ties that could be considered neither strong nor weak, and 0 KQ ties that could be considered as strong.

Consequently, the data shows that all team members in Team 2 that are connected by Competence-based Trust ties will share knowledge of higher quality, than team members that are not connected by Competence-based Trust ties.

Proposition 2b:

The sociogram below shows the entire *Benevolence-based Trust* network in Team 2. Team members 4 and 7 are the persons in the team that most of the other team members find benevolent. No one of the other team members find respondent 1 benevolent.



SOCIOGRAM 15: Benevolence-based Trust Network – Team 2

The *Benevolence-based Trust* ties were compared to the Knowledge Quality ties. Consequently, of all the team members that reported to be connected by Benevolence-based Trust ties, 0 was at the same time connected by weak KQ ties, 2 were at the same time connected by neither strong nor weak KQ ties and 20 of the team members that reported being connected by Benevolence-based Trust ties were connected by strong KQ ties. Knowledge was reported as being useful in all

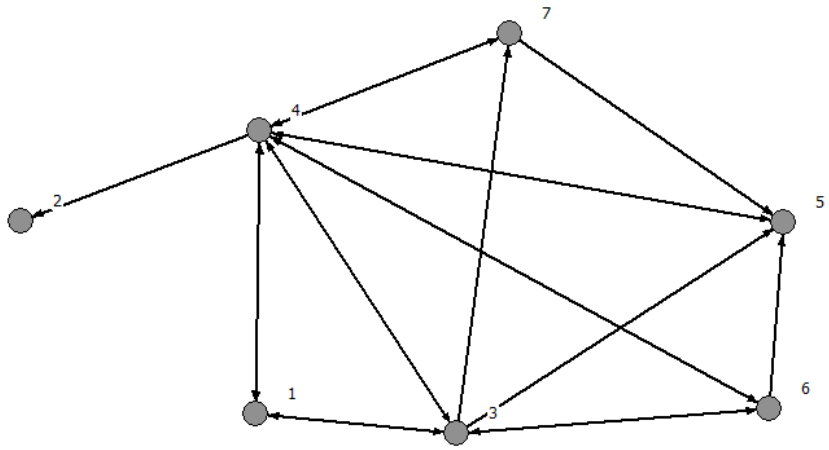
Benevolence-based Trust ties. Altogether the data shows that the members in Team 2 that are connected by Benevolence-based trust ties also in general are found to share strong Knowledge Quality ties.

In addition, to disclose if team members that did not reported to have benevolence-based trust with their team members reported high or low quality of the knowledge shared, a second comparison was performed. In this comparison the team members that did not report any Benevolence-based Trust ties, shared 3 KQ ties that could be considered weak, 6 KQ ties that could be considered neither strong nor weak, and 11 KQ ties that could be considered as strong.

Consequently, the data shows that the majority of team members in Team 2 that are connected by Benevolence-based Trust ties will share knowledge of higher quality, than team members that are not connected by Benevolence-based Trust ties.

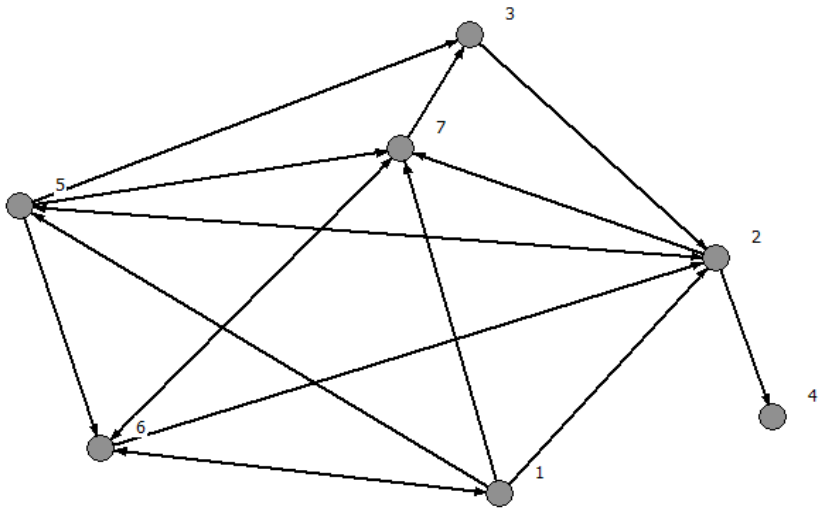
Proposition 3:

The sociogram below shows the entire *Daily Communication* network in Team 2. Respondent 2 does not report any daily interaction with the project team, however respondent 4 reports daily communication with respondent 2. The person in the team that most team members report communicating with on a daily basis is team member 4.



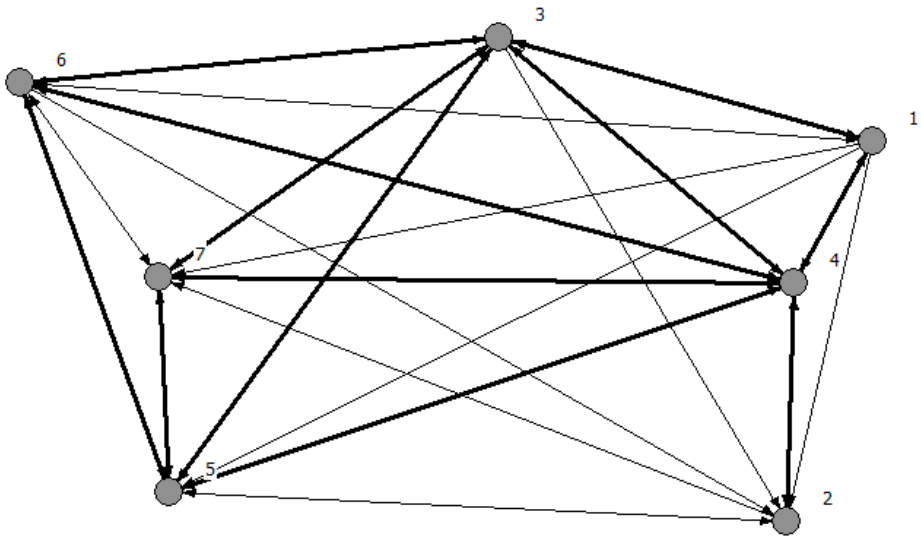
SOCIOGRAM 16: Daily Communication Network – Team 2

The sociogram below shows the entire *Weekly Communication* network in Team 2. The person in the team that most team members report communicating with on a weekly basis is team member 2.



SOCIOGRAM 17: Weekly Communication Network – Team 2

As you can see from sociogram number 18 below, the daily and weekly communication networks are added together to represent the Frequency of Communication network. The thickest lines represent the strongest frequency of communication ties, whereas the thinnest lines represent weakest frequency of communication ties.



SOCIOGRAM 18: Frequency of Communication Network – Team 2

The strong *Frequency of Communication* ties were compared to the Knowledge Quality ties. Consequently, of all the team members that reported to be connected by strong Frequency of Communication ties, 0 was at the same time connected by weak KQ ties, 1 was at the same time connected by neither strong nor weak KQ ties, and 18 of the team members that reported being connected by strong Frequency of Communication ties were at the same time connected by strong KQ

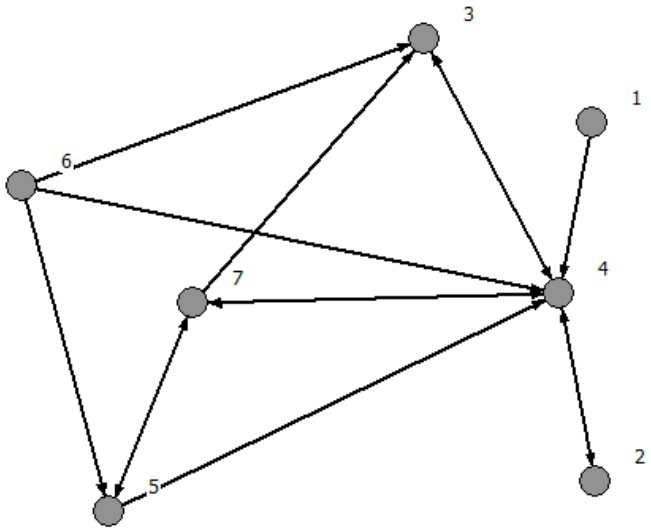
ties. Knowledge was reported to be useful in all strong Frequency of Communication ties. Altogether the data shows that the members in Team 2 that are connected by strong Frequency of Communication ties also in general are found to share strong Knowledge Quality ties.

The weak *Frequency of Communication* ties were compared to the Knowledge Quality ties. Consequently, team members that were connected by weak Frequency of Communication ties, 0 was at the same time connected by weak KQ ties, 4 were at the same time connected by neither strong nor weak KQ ties and 13 of the team members that reported being connected by weak Frequency of Communication ties were connected by strong KQ ties. Knowledge was reported to be useful in all weak Frequency of Communication ties. Altogether the data shows that the members in Team 2 that are connected by weak Frequency of Communication ties also in general are found to share weak Knowledge Quality ties.

Consequently, the data shows that the majority of team members in Team 2 that are connected by strong Frequency of Communication ties share knowledge with higher quality, than team members that are connected by weak Frequency of Communication ties.

Proposition 4:

The sociogram below shows the entire *Time Spent on Interaction* network in Team 2. The person in the team that most team members report spending the most time communicating with is team member 4. No one of the other team members report longer time spent on interacting with team members 1 or 6.



SOCIOGRAM 19: Time Spent on Interaction Network – Team 2

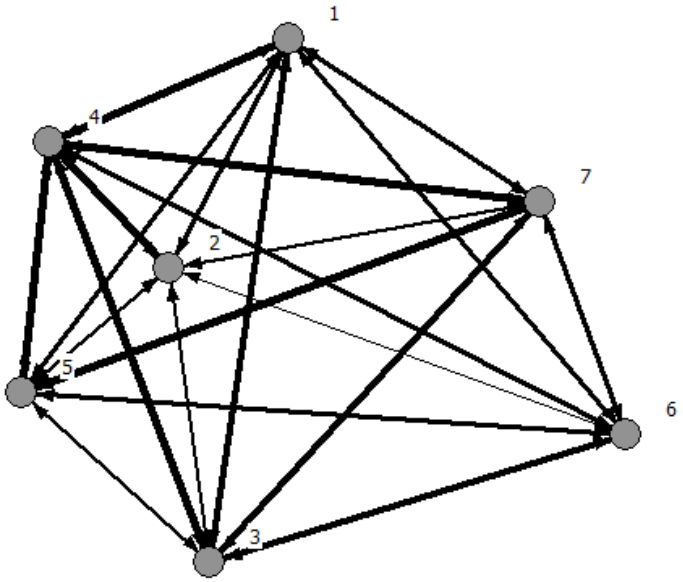
The *Time Spent on Interaction* ties were compared to the Knowledge Quality ties. Consequently, of all the team members that reported to be connected by Time Spent on Interaction ties, 0 was at the same time connected by weak KQ ties, 1 was at the same time connected by neither strong nor weak KQ ties and 13 of the team members that reported being connected by Time Spent on Interaction ties were connected by strong KQ ties. Knowledge was reported as being useful in all Time Spent on Interaction ties. Altogether the data shows that the members in Team 2 that are connected by Time Spent on Interaction ties also in general are found to share strong Knowledge Quality ties.

In addition, to disclose if team members that did not reported to spent more time interaction with their team members reported high or low quality of the knowledge shared, a second comparison was performed. In this comparison the team members that did not report any Time Spent on Interaction ties, shared 3 KQ ties that could be considered weak, 7 KQ ties that could be considered neither strong nor weak, and 18 KQ ties that could be considered as strong.

Consequently, the data shows that the majority of team members in Team 2 that are connected by Time Spent on Interaction ties will share knowledge of higher quality, than team members that are not connected by Time Spent on Interaction ties.

Proposition 5:

The sociogram below shows the entire aggregated Social Interaction network in Team 2. The thick lines depict the strong ties between the respondents, the medium lines portray neither strong nor weak ties, whereas the thinnest lines depict the weak ties.



SOCIOGRAM 20: Social Interaction Network – Team 2

The strong *Social Interaction* ties were compared to the Knowledge Quality ties. Consequently, of all the team members that reported to be connected by strong Social Interaction ties, 4 were at the same time connected by weak KQ ties, 1 was at the same time connected by neither strong nor weak KQ ties, and 4 of the team members that reported being connected by strong Social Interaction ties were at the same time connected by strong KQ ties. In 13 of the strong social interaction ties it was reported no useful knowledge. Altogether the data shows that the members in Team 2 that are connected by strong Social Interaction ties also in general are found to share either strong or weak Knowledge Quality ties.

The weak *Social Interaction* ties were compared to the Knowledge Quality ties. Consequently, team members that were connected by weak Social Interaction ties, 5 were at the same time connected by weak KQ ties, 3 were at the same time connected by neither strong nor weak KQ ties and 3 of the team members that reported being connected by weak Social Interaction ties were connected by strong KQ ties. In 9 of the weak Social Interaction ties it was reported no useful knowledge. Altogether the data shows that the members in Team 2 that are connected by weak Social Interaction ties also in general are found to share weak Knowledge Quality ties.

Consequently, the data shows that the majority of team members in Team 2 that are connected by strong Social Interaction ties share knowledge with higher quality, than team members that are connected by weak Social Interaction ties.

In the preceding paragraphs we have taken a closer look at the multiplexity of social interaction ties. Empirical evidence has shown that team members in Team 2 that are connected by Close Relationship ties share knowledge of higher quality than team members that are not connected by Close Relationship ties. Additionally, team members that are connected by strong Interpersonal Trust ties share knowledge of higher quality than team members that are connected by weak Interpersonal Trust ties. Moreover team members that are connected by Competence-based Trust ties or Benevolence-based Trust ties share knowledge of higher quality than team members that are not connected by these ties. Furthermore, team members that are connected by strong Frequency of Communication ties share knowledge of higher quality than team members that are connected by weak Frequency of Communication ties. In addition team members in Team 2 that are connected by Time Spent on Interaction ties share knowledge of higher quality than team members that are not connected by Time Spent on Interaction ties.

Consequently, members in Team 2 that are connected by strong Social Interaction Ties will share knowledge with higher quality, than team members that are connected by weak Social Interaction Ties.

4.5.4 Individual Case Report Team 3

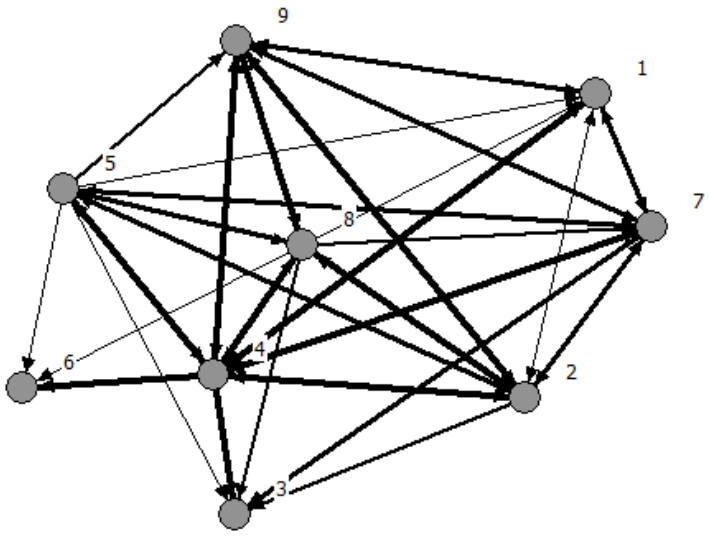
Assessing non-respondents: In Team 3, respondents 3 and 6 are considered non-respondents, remaining a response rate of 77,77%. The non-respondents have not answered questions about their team members, however, as they still are represented in the roster, other team members have nominated them. As you can see this does not mean that the respondents are removed from the data set, however they are not considered when the calculus is employed.

Quality of knowledge within the whole team: Team members in Team 3 reported high quality of the knowledge shared on a general basis. However some noted that the quality was sufficient and that it was room for improvement on the knowledge they shared, but that they nevertheless delivered results and conclusions with high quality.

Assessing consistency of Knowledge Quality answers: At the end of the questionnaire a control question assessed the quality of knowledge as an entirety shared between the respondents. In this question the respondents' were asked to

check off the persons from the list of team members, with which they felt they shared knowledge of high quality. This question was developed to control consistency in what they had answered in the 18 preceding questions. In Team 3 the consistency of the answers to the Knowledge Quality questions corresponded to the answers that were given in question number 19.

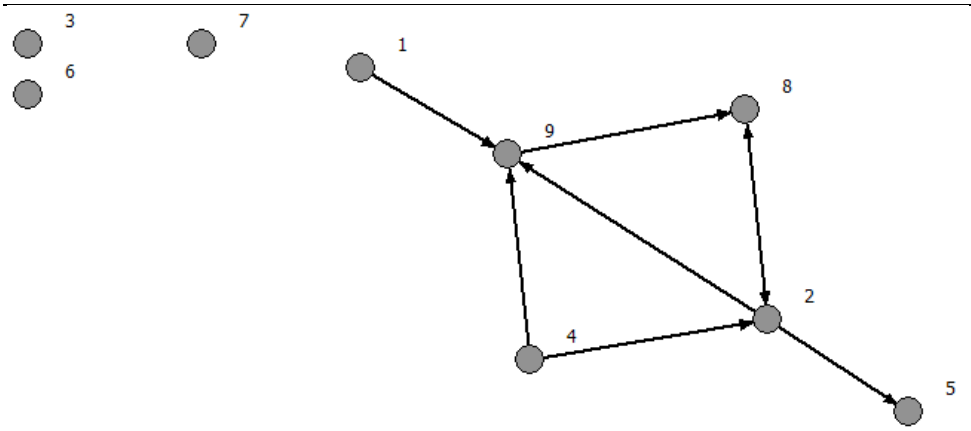
The sociogram below shows the entire KQ network. The lines consist of three different widths. The weakest ties are represented by the thinnest lines, and illustrate knowledge shared between two respondents that are of low quality. Pay especially attention to the non-reciprocal ties, as these ties are considered even weaker. The either weak or strong ties are represented by the medium lines, and represent knowledge shared between two respondents that are of neither low nor high quality. The strongest ties are represented by the thickest lines, and represent knowledge shared between two respondents that are of high quality. Pay especially attention to the reciprocal ties, as these ties are considered even stronger.



SOCIOGRAM 21: Knowledge Quality Network – Team 3

Proposition 1:

The sociogram below shows the entire *Close Relationship* network in Team 3. As you can see from the sociogram, respondent 7 did not report any close relationship and was neither nominated by the other respondents. Moreover, respondent 1 considers respondent 9 as a close friend, however respondent 9 do not reciprocate the friendship. This also applies to respondents 2 and 5 respectively. Respondent 4 has nominated two close friends in the team, however is not nominated by anyone. Remember that respondent 3 and 6 are considered non-respondents.



SOCIOGRAM 22: Close Relationship Network – Team 3

The *Close Relationship* ties were compared to the Knowledge Quality ties. Consequently, of all the team members that reported to be connected by Close Relationship ties, 1 was at the same time connected by weak KQ ties, 1 was at the same time connected by neither strong nor weak KQ ties, and 6 of the team members connected by Close Relationship ties were at the same time connected by strong KQ ties. Furthermore, the knowledge was reported to be useful in all close relationship ties. Altogether the data shows that the members in Team 3 that are connected by close relationship ties also in general are found to share strong Knowledge Quality ties.

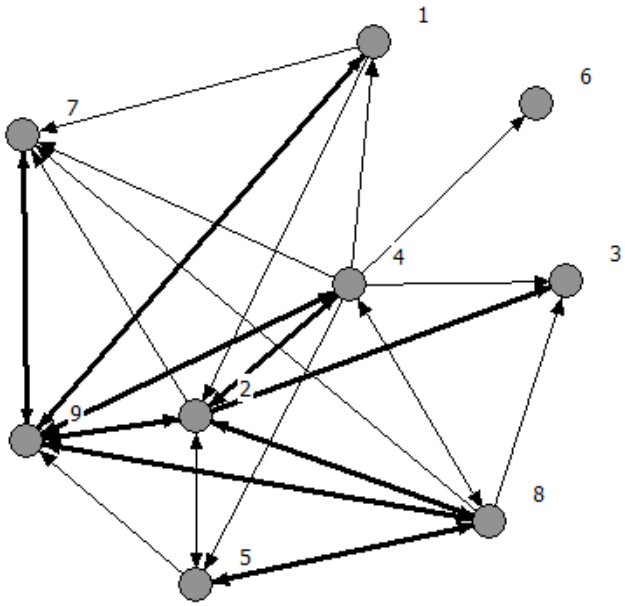
In addition, to disclose if team members that did not reported to have close relationship with their team members reported high or low quality of the knowledge shared, a second comparison was performed. In this comparison the team members that did not report any close relationship ties, shared 8 KQ ties that could be considered weak, 15 KQ ties that could be considered neither strong nor weak, and 7 KQ ties that could be considered as strong.

Even though the knowledge was reported as being useful in all close relationship ties, members in Team 3 that are connected by Close Relationship ties will not share knowledge of higher quality, than team members that are not connected by Close Relationship ties.

Proposition 2:

The sociogram below shows all the *Interpersonal Trust* ties in Team 3. The thick lines between the nodes represent the strong ties, whereas the thinner lines depict the weak ties. Remember that interpersonal trust is represented by both competence-based trust and benevolence-based trust. Hence the strong

Interpersonal Trust ties consist of both competence- and benevolence-based trust, whereas the weak ties consists of either competence-based or benevolence-based trust. Team member 9 is the person that most of the other team members find both competent and benevolent.



SOCIOGRAM 23: Interpersonal Trust Network – Team 3

The strong *Interpersonal Trust* ties were compared to the Knowledge Quality ties. Consequently, of all the team members that reported to be connected by strong Interpersonal Trust ties, 0 was at the same time connected by weak KQ ties, 5 were at the same time connected by neither strong nor weak KQ ties, and 6 of the team members that reported being connected by strong Interpersonal Trust ties were at the same time connected by strong KQ ties. Knowledge was reported as being useful in all strong Interpersonal Trust ties. Altogether the data shows that the members in Team 3 that are connected by strong Interpersonal Trust ties also in general are found to share strong Knowledge Quality ties.

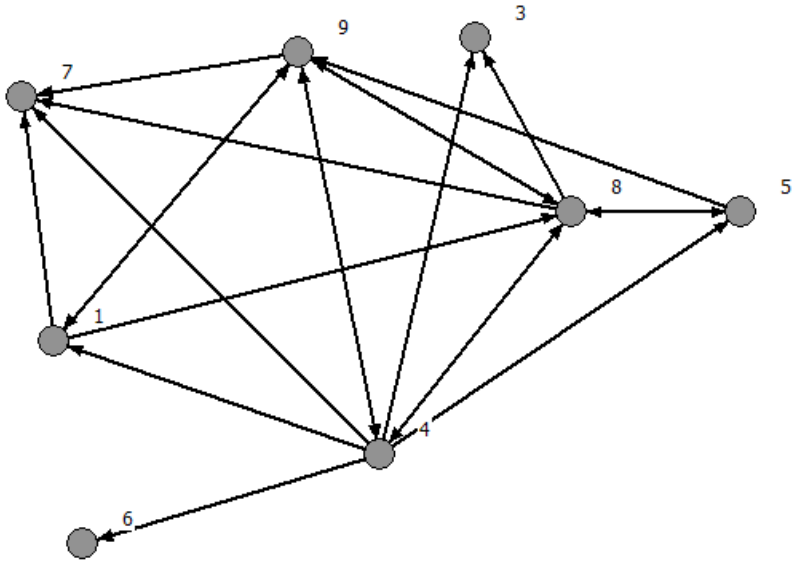
The weak *Interpersonal Trust* ties were compared to the Knowledge Quality ties. Consequently, team members that were connected by weak Interpersonal Trust ties, 4 were at the same time connected by weak KQ ties, 6 were at the same time connected by neither strong nor weak KQ ties and 7 of the team members that reported being connected by weak Interpersonal Trust ties were connected by strong KQ ties. Knowledge was reported as being useful in all weak Interpersonal Trust ties. Altogether the data shows that the members in

Team 3 that are connected by weak Interpersonal Trust ties also in general are found to share strong Knowledge Quality ties.

Consequently, the data shows that team members in Team 3 that are connected by strong Interpersonal Trust ties do not share knowledge with higher quality, than team members that are connected by weak Interpersonal Trust ties.

Proposition 2a:

The sociogram below shows the entire Competence-based Trust network in Team 3. The members that the most people find competent are team members 7, 8 and 9. Respondent 7 does not find any of the other team members to have relevant expertise, skills and/or proficiency to accomplish his or her given assignments.



SOCIOGRAM 24: Competence-based Trust Network – Team 3

The *Competence-based Trust* ties were compared to the Knowledge Quality ties. Consequently, of all the team members that reported to be connected by Competence-based Trust ties, 3 were at the same time connected by weak KQ ties, 9 were at the same time connected by neither strong nor weak KQ ties and 13 of the team members that reported being connected by Competence-based Trust ties were connected by strong KQ ties. Knowledge was reported as being useful in all Competence-based Trust ties. Altogether the data shows that the members in Team 3 that are connected by Competence-based trust ties also in general are found to share strong Knowledge Quality ties.

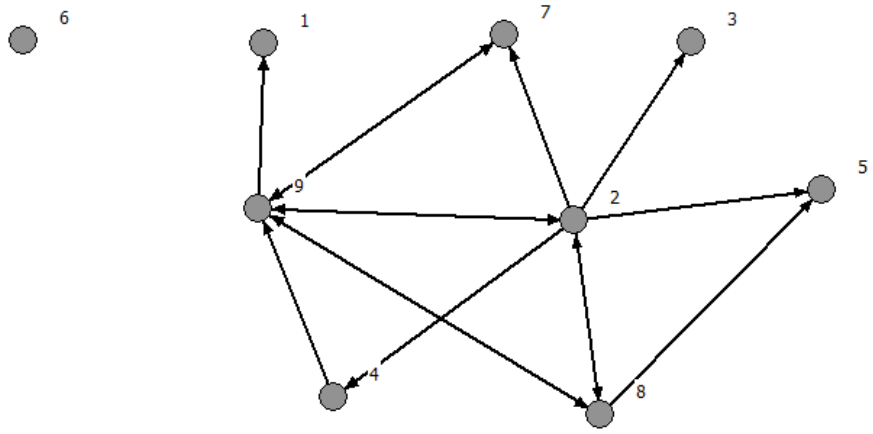
In addition, to disclose if team members that did not reported to have competence-based trust with their team members reported high or low quality of

the knowledge shared, a second comparison was performed. In this comparison the team members that did not report any Competence-based Trust ties, shared 6 KQ ties that could be considered weak, 7 KQ ties that could be considered neither strong nor weak, and 0 KQ ties that could be considered as strong.

Consequently, the data shows that team members in Team 3 that are connected by competence-based trust ties will share knowledge of higher quality, than team members that are not connected by Competence-based Trust ties.

Proposition 2b:

The sociogram below shows the entire *Benevolence-based Trust* network in Team 3. The member that the most people find benevolent is team member 9. Team members 1 and 5 do not find any of the other team members to be benevolent.



SOCIOGRAM 25: Benevolence-based Trust Network – Team 3

The *Benevolence-based Trust* ties were compared to the Knowledge Quality ties. Consequently, of all the team members that reported to be connected by Benevolence-based Trust ties, 1 was at the same time connected by weak KQ ties, 7 were at the same time connected by neither strong nor weak KQ ties and 6 of the team members that reported being connected by Benevolence-based Trust ties were connected by strong KQ ties. Knowledge was reported as being useful in all Benevolence-based Trust ties. Altogether the data shows that members in Team 3 that are connected by Benevolence-based trust ties do not share strong Knowledge Quality ties.

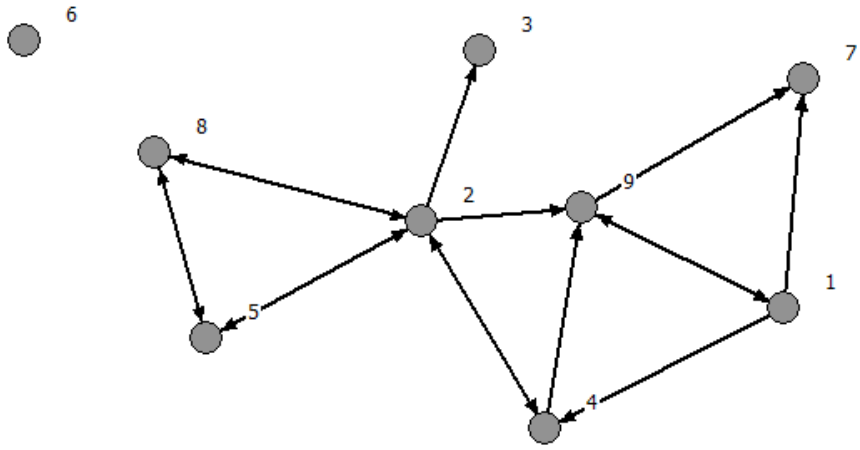
In addition, to disclose if team members that did not reported to have benevolence-based trust with their team members reported high or low quality of the knowledge shared, a second comparison was performed. In this comparison

the team members that did not report any Benevolence-based Trust ties, shared 8 KQ ties that could be considered weak, 9 KQ ties that could be considered neither strong nor weak, and 7 KQ ties that could be considered as strong.

Consequently, the data shows that team members in Team 3 that are connected by Benevolence-based Trust ties do not share knowledge of higher quality, than team members that are not connected by Benevolence-based Trust ties.

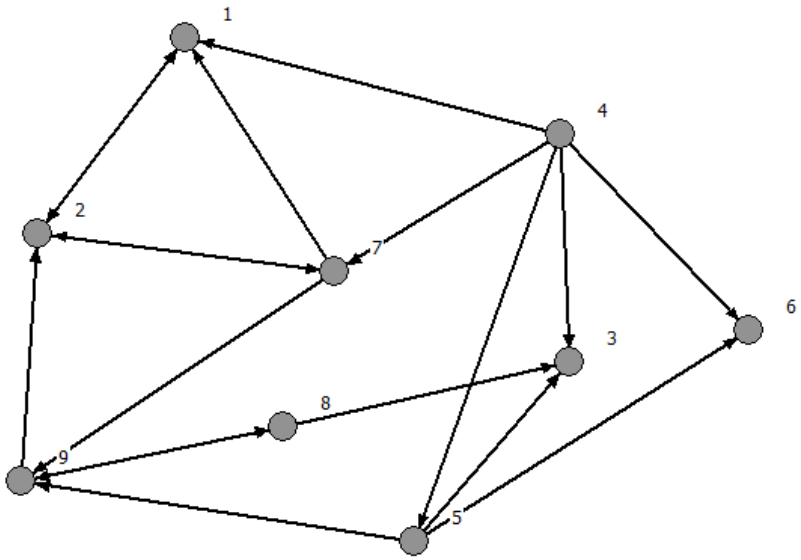
Proposition 3:

The sociogram below shows the entire *Daily Communication* network in Team 3. Respondent 7 does not report any daily communication with the project team, however respondents 1 and 9 report daily communication with respondent 7. The team members that most people report communicating with during a normal day are respondents 2 and 9.



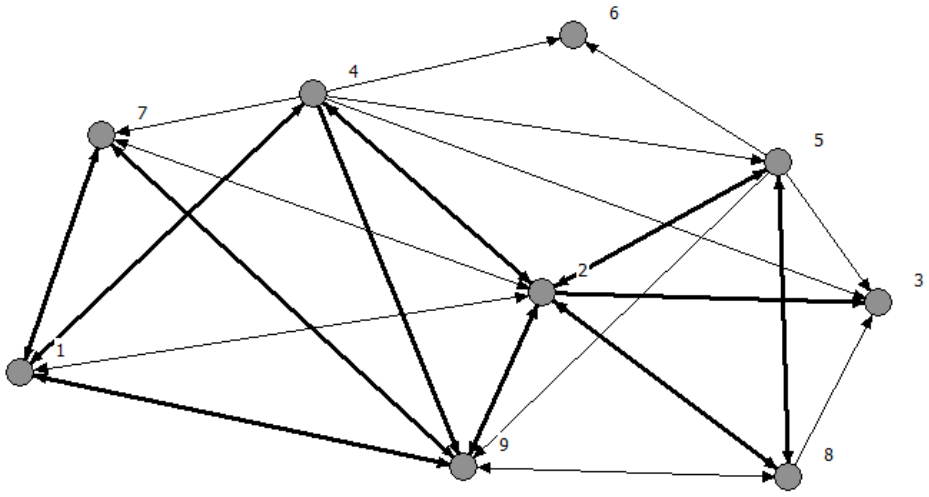
SOCIOGRAM 26: Daily Communication Network – Team 3

The sociogram below shows the entire *Weekly Communication* network in Team 3. Respondent number 4 reports weekly communication with respondents 1, 3, 5, 6 and 7, however none of the other respondents reciprocate this relationship.



SOCIOGRAM 27: Weekly Communication Network – Team 3

As you can see from sociogram number 28 below, the daily and weekly communication networks are added together to represent the Frequency of Communication network. The lines consist of two different widths. The thickest lines represent the strongest frequency of communication ties, whereas the thinnest lines represent the weakest frequency of communication ties. The most central persons in the Frequency of Communication network in Team 3 are respondents 2 and 9.



SOCIOGRAM 28: Frequency of Communication Network – Team 3

The strong *Frequency of Communication* ties were compared to the Knowledge Quality ties. Consequently, of all the team members that reported to be connected by strong Frequency of Communication ties, 1 was at the same time connected by

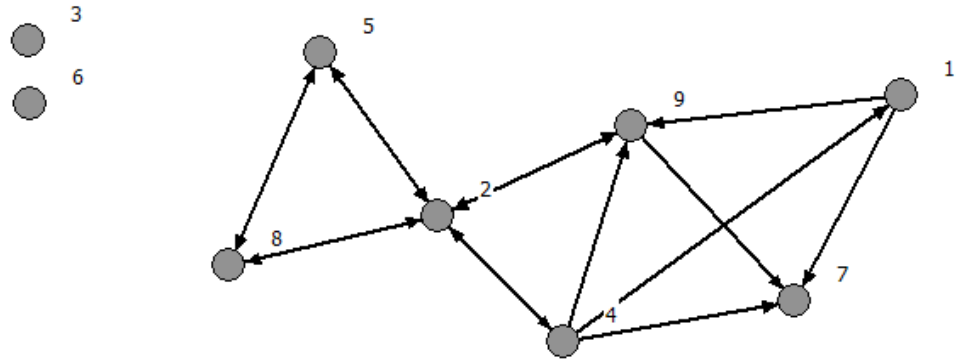
weak KQ ties, 7 were at the same time connected by neither strong nor weak KQ ties, and 7 of the team members that reported being connected by strong Frequency of Communication ties were at the same time connected by strong KQ ties. Knowledge was reported as being useful in all strong Frequency of Communication ties. Altogether the data shows that the members in Team 3 that are connected by strong Frequency of Communication ties also in general are found to share medium or strong Knowledge Quality ties.

The weak *Frequency of Communication* ties were compared to the Knowledge Quality ties. Consequently, team members that were connected by weak Frequency of Communication ties, 2 were at the same time connected by weak KQ ties, 6 were at the same time connected by neither strong nor weak KQ ties and 5 of the team members that reported being connected by weak Frequency of Communication ties were connected by strong KQ ties. Knowledge was reported as being useful in all weak Frequency of Communication ties. Altogether the data shows that the members in Team 3 that are connected by weak Frequency of Communication ties also in general are found to share strong Knowledge Quality ties.

Consequently, the data shows that the majority of team members in Team 3 that are connected by strong Frequency of Communication ties share knowledge with higher quality, than team members that are connected by weak Frequency of Communication ties.

Proposition 4:

The sociogram below shows the entire *Time Spent on Interaction* network in Team 3. The team member that people report using the longest time interacting with is team member 2. Even though team members 3 and 6 are considered non-respondents, none of the other team members report spending more time interacting with them. Respondent 7 does not report spending more time interacting with no one of the other team members.



SOCIOGRAM 29: Time Spent on Interaction Network – Team 3

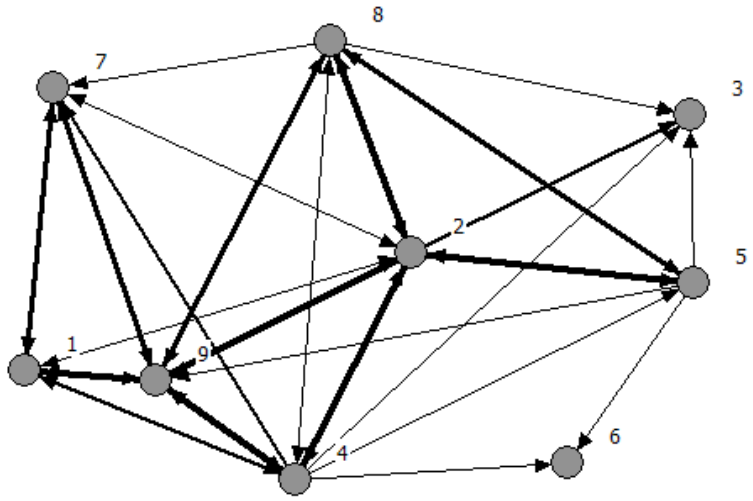
The *Time Spent on Interaction* ties were compared to the Knowledge Quality ties. Consequently, of all the team members that reported to be connected by Time Spent on Interaction ties, 1 was at the same time connected by weak KQ ties, 5 were at the same time connected by neither strong nor weak KQ ties and 10 of the team members that reported being connected by Time Spent on Interaction ties were connected by strong KQ ties. Knowledge was reported as being useful in all Time Spent on Interaction ties. Altogether the data shows that the members in Team 3 that are connected by Time Spent on Interaction ties also in general are found to share strong Knowledge Quality ties.

In addition, to disclose if team members that did not reported to spent more time interaction with their team members reported high or low quality of the knowledge shared, a second comparison was performed. In this comparison the team members that did not report any Time Spent on Interaction ties, shared 8 KQ ties that could be considered weak, 11 KQ ties that could be considered neither strong nor weak, and 3 KQ ties that could be considered as strong.

Consequently, the data shows that the majority of team members in Team 3 that are connected by Time Spent on Interaction ties will share knowledge of higher quality, than team members that are not connected by Time Spent on Interaction ties.

Proposition 5:

The sociogram below shows the entire aggregated Social Interaction network in Team 3. The thick lines depict the strong ties between the respondents' whereas the thinner lines depict the weak ties.



SOCIOGRAM 30: Social Interaction Network – Team 3

The strong *Social Interaction* ties were compared to the Knowledge Quality ties. Consequently, of all the team members that reported to be connected by strong Social Interaction ties, 1 was at the same time connected by weak KQ ties, 5 were at the same time connected by neither strong nor weak KQ ties, and 10 of the team members that reported being connected by strong Social Interaction ties were at the same time connected by strong KQ ties. Knowledge was reported as being useful in all strong Social Interaction ties. Altogether the data shows that the members in Team 3 that are connected by strong Social Interaction ties also in general are found to share strong Knowledge Quality ties.

The weak *Social Interaction* ties were compared to the Knowledge Quality ties. Consequently, team members that were connected by weak Social Interaction ties, 4 were at the same time connected by weak KQ ties, 9 were at the same time connected by neither strong nor weak KQ ties and 3 of the team members that reported being connected by weak Social Interaction ties were connected by strong KQ ties. Knowledge was reported as being useful in all weak Social Interaction ties. Altogether the data shows that the members in Team 3 that are connected by weak Social Interaction ties in general are found to share neither strong nor weak Knowledge Quality ties.

Consequently, the data shows that team members in Team 3 that are connected by strong Social Interaction ties share knowledge with higher quality, than team members that are connected by weak Social Interaction ties.

In the preceding paragraphs we have taken a closer look at the multiplexity of social interaction ties. Empirical evidence has shown that team members in Team 3 that are connected by Close Relationship ties not share knowledge of

higher quality than team members that are not connected by Close Relationship ties. Moreover, team members that are connected by strong Interpersonal Trust ties do not share knowledge of higher quality than team members that are connected by weak Interpersonal Trust ties. However, team members that are connected by Competence-based Trust ties share knowledge of higher quality than team members that are not connected by Competence-based Trust ties. Yet, members that are connected by Benevolence-based Trust ties do not share knowledge of higher quality than team members that are not connected by these ties. However, team members that are connected by strong Frequency of Communication ties share knowledge of higher quality than team members that are connected by weak Frequency of Communication ties. Furthermore, team members in Team 3 that are connected by Time Spent on Interaction ties will share knowledge of higher quality, than team members that are not connected by Time Spent on Interaction ties.

Consequently, knowledge is reported being useful in all social interaction ties, moreover the majority of team members in Team 3 that are connected by strong Social Interaction Ties will share knowledge with higher quality, than team members that are connected by weak Social Interaction Ties.

4.5.5 Individual Case Report Team 4

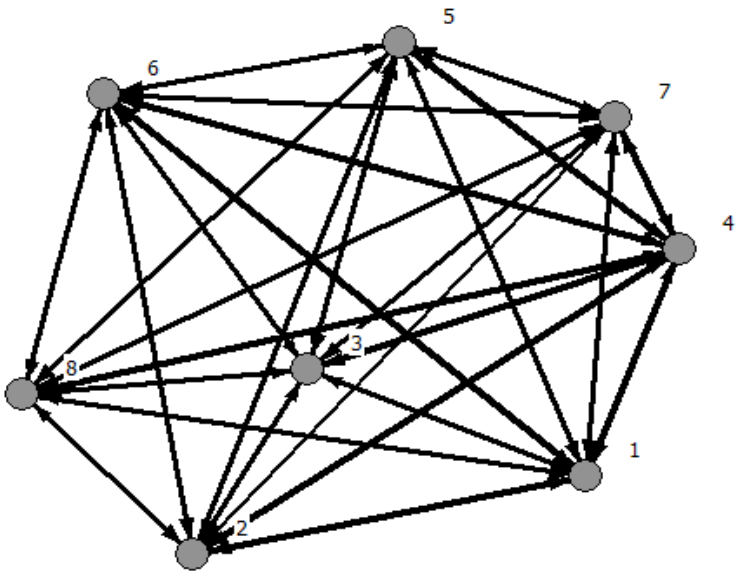
Assessing non-respondents: In Team 2, all team members answered the questionnaire, remaining a response rate of 100%.

Quality of knowledge within the whole team: All team members in Team 4 reported high quality of the knowledge shared between them.

Assessing consistency of Knowledge Quality answers: At the end of the questionnaire a control question assessed the quality of knowledge as an entirety shared between the respondents. In this question the respondents' were asked to check off the persons from the list of team members, with which they felt they shared knowledge of high quality. This question was developed to control consistency in what they had answered in the 18 preceding questions. In Team 4 the consistency of the answers to the Knowledge Quality questions corresponded to the answers that were given in question number 19.

The sociogram below shows the entire KQ network. The lines consist of three different widths. The weakest ties are represented by the thinnest lines, and

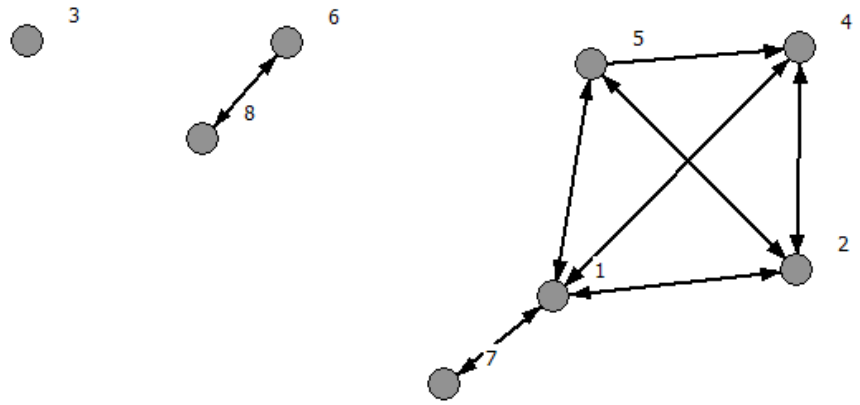
illustrate knowledge shared between two respondents that are of low quality. Pay especially attention to the non-reciprocal ties, as these ties are considered even weaker. The either weak or strong ties are represented by the medium lines, and represent knowledge shared between two respondents that are of neither low nor high quality. The strongest ties are represented by the thickest lines, and represent knowledge shared between two respondents that are of high quality. Pay especially attention to the reciprocal ties, as these ties are considered even stronger.



SOCIOGRAM 31: Knowledge Quality Network – Team 4

Proposition 1:

The sociogram below shows the entire *Close Relationship* network in Team 4. As you can see from the sociogram, respondent 3 did not report any close relationship and was neither nominated by any of the other respondents. As you can se the Close Relationship network is divided. Respondents 6 and 8 report to have a close relationship, and are separated from the rest of the team. The only relationship that is not reciprocated is between respondents 4 and 5. Respondent 5 has nominated respondent 4 as a close friend, however respondent 4 does not regard respondent 5 as a close friend, which makes the tie between them weaker than the rest of the ties.



SOCIOGRAM 32: Close Relationship Network – Team 4

The *Close Relationship* ties were compared to the Knowledge Quality ties. Consequently, of all the team members that reported to be connected by Close Relationship ties, 0 was at the same time connected by weak KQ ties, 2 were at the same time connected by neither strong nor weak KQ ties, and 13 of the team members connected by Close Relationship ties were at the same time connected by strong KQ ties. Furthermore, the knowledge was reported to be useful in all close relationship ties. Altogether the data shows that the members in Team 4 that are connected by close relationship ties also in general are found to share strong Knowledge Quality ties.

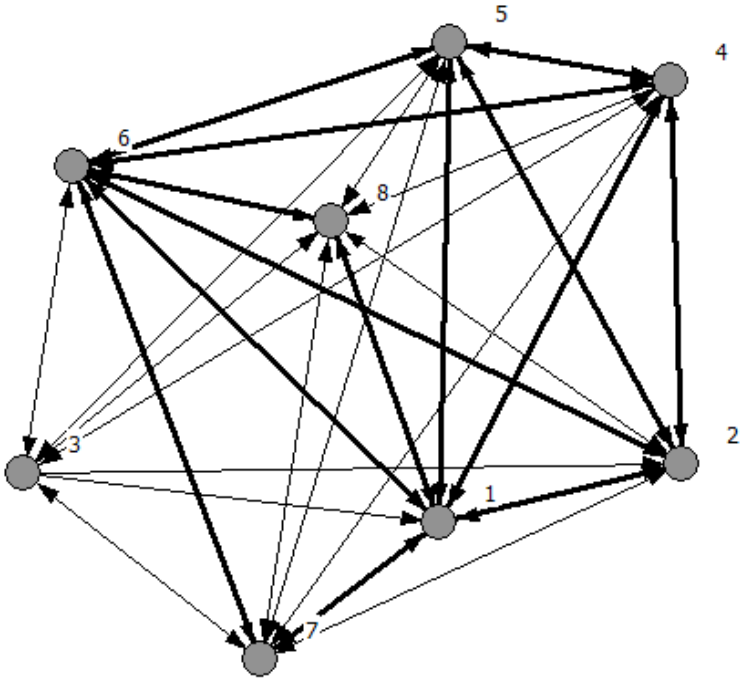
In addition, to disclose if team members that did not reported to have close relationship with their team members reported high or low quality of the knowledge shared, a second comparison was performed. In this comparison the team members that did not report any close relationship ties, shared 1 KQ ties that could be considered weak, 11 KQ ties that could be considered neither strong nor weak, and 29 KQ ties that could be considered as strong.

Even though the knowledge was reported as being useful in all close relationship ties, it is evident that members in Team 4 that are connected by Close Relationship ties will not share knowledge of higher quality, than team members that are not connected by Close Relationship ties.

Proposition 2:

The sociogram below shows all the *Interpersonal Trust* ties in Team 4. The thick lines between the nodes represent the strong ties, whereas the thinner lines depict the weak ties. Remember that interpersonal trust is represented by both competence-based trust and benevolence-based trust. Hence the strong

Interpersonal Trust ties consist of both competence- and benevolence-based trust, whereas the weak ties consists of either competence-based or benevolence-based trust. Team member 6 is the person that most of the other team members find both competent and benevolent.



SOCIOGRAM 33: Interpersonal Trust Network – Team 4

The strong *Interpersonal Trust* ties were compared to the Knowledge Quality ties. Consequently, of all the team members that reported to be connected by strong Interpersonal Trust ties, 0 was at the same time connected by weak KQ ties, 5 were at the same time connected by neither strong nor weak KQ ties, and 17 of the team members that reported being connected by strong Interpersonal Trust ties were at the same time connected by strong KQ ties. Knowledge was reported useful in all strong Interpersonal Trust ties. Altogether the data shows that the members in Team 4 that are connected by strong Interpersonal Trust ties also in general are found to share strong Knowledge Quality ties.

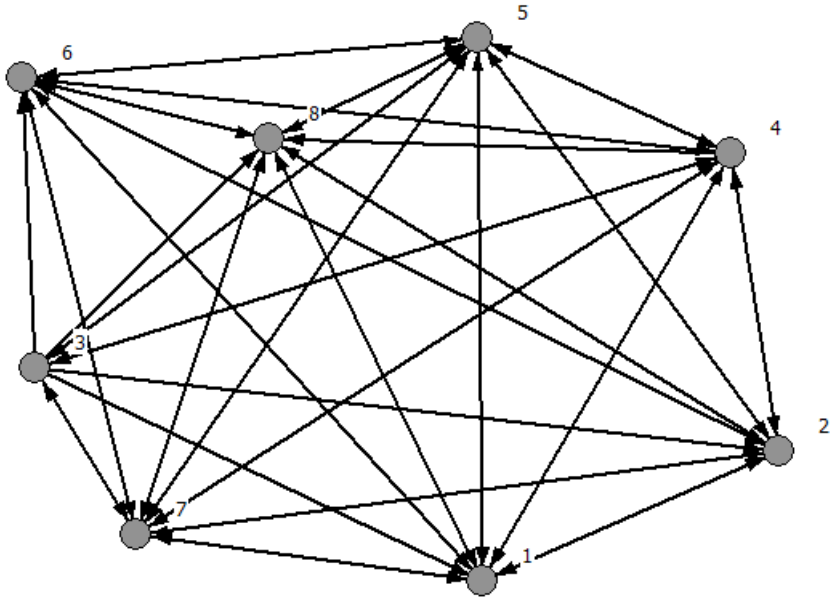
The weak *Interpersonal Trust* ties were compared to the Knowledge Quality ties. Consequently, team members that were connected by weak Interpersonal Trust ties, 0 was at the same time connected by weak KQ ties, 5 were at the same time connected by neither strong nor weak KQ ties and 25 of the team members that reported being connected by weak Interpersonal Trust ties were connected by strong KQ ties. Knowledge was reported useful in all weak Interpersonal Trust ties. Altogether the data shows that the members in Team 4

that are connected by weak Interpersonal Trust ties also in general are found to share strong Knowledge Quality ties.

Consequently, the data shows that team members in Team 4 that are connected by strong Interpersonal Trust ties, will not share knowledge with higher quality, than team members that are connected by weak Interpersonal Trust ties.

Proposition 2a:

The sociogram below shows the entire Competence-based Trust network in Team 4. The members that the most people find having relevant expertise, skills and/or proficiency to accomplish his or her given assignments are team members 1, 2, 5, 6, 7, 8 to. The team members that the other team members find least competent are team member 3.



SOCIOGRAM 34: Competence-based Trust Network – Team 4

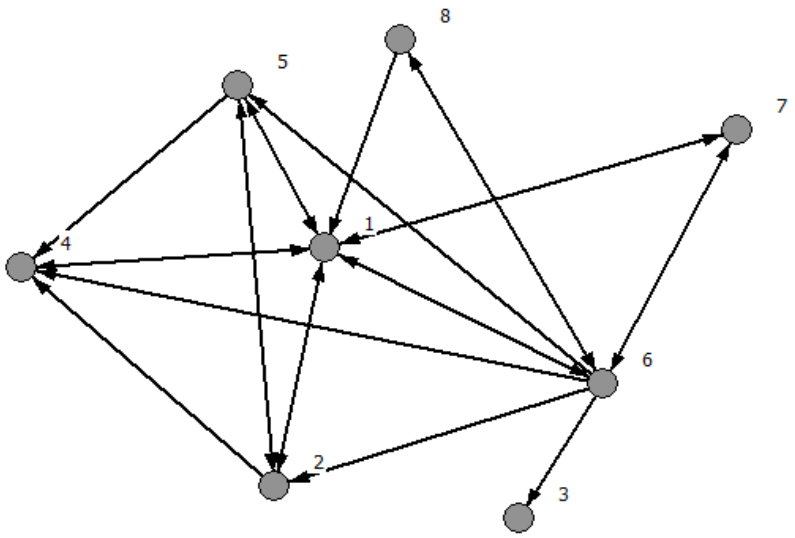
The *Competence-based Trust* ties were compared to the Knowledge Quality ties. Consequently, of all the team members that reported to be connected by Competence-based Trust ties, 0 was at the same time connected by weak KQ ties, 9 were at the same time connected by neither strong nor weak KQ ties and 42 of the team members that reported being connected by Competence-based Trust ties were connected by strong KQ ties. Knowledge was reported useful in all Competence-based Trust ties. Altogether the data shows that the members in Team 4 that are connected by Competence-based trust ties also are found to share strong Knowledge Quality ties.

In addition, to disclose if team members that did not reported to have competence-based trust with their team members reported high or low quality of the knowledge shared, a second comparison was performed. In this comparison the team members that did not report any Competence-based Trust ties, shared 1 KQ ties that could be considered weak, 4 KQ ties that could be considered neither strong nor weak, and 0 KQ ties that could be considered as strong.

Consequently, the data shows that team members in Team 4 that are connected by competence-based trust ties will share knowledge of higher quality, than team members that are not connected by Competence-based Trust ties.

Proposition 2b:

The sociogram below shows the entire *Benevolence-based Trust* network in Team 4. The members that the most people find benevolent are team member 1. Only respondent 6 finds respondent 3 to be benevolent. Respondent 3 does not find any of the other team members to be benevolent.



SOCIOGRAM 35: Benevolence-based Trust Network – Team 4

The *Benevolence-based Trust* ties were compared to the Knowledge Quality ties. Consequently, of all the team members that reported to be connected by Benevolence-based Trust ties, 0 was at the same time connected by weak KQ ties, 6 were at the same time connected by neither strong nor weak KQ ties and 17 of the team members that reported being connected by Benevolence-based Trust ties were connected by strong KQ ties. Knowledge was reported being useful in all Benevolence-based Trust ties. Altogether the data shows that the members in

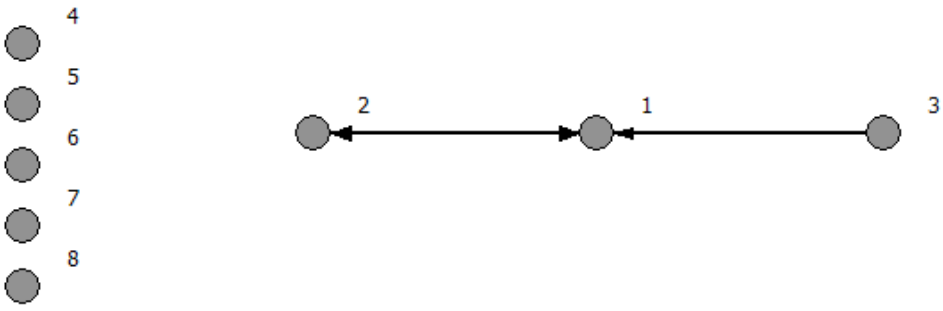
Team 4 that are connected by Benevolence-based trust ties also in general are found to share strong Knowledge Quality ties.

In addition, to disclose if team members that did not reported to have benevolence-based trust with their team members reported high or low quality of the knowledge shared, a second comparison was performed. In this comparison the team members that did not report any Benevolence-based Trust ties, shared 1 KQ ties that could be considered weak, 7 KQ ties that could be considered neither strong nor weak, and 25 KQ ties that could be considered as strong.

Consequently, the data shows that team members in Team 4 that are connected by Benevolence-based Trust ties, will not share knowledge of higher quality, than team members that are not connected by Benevolence-based Trust ties.

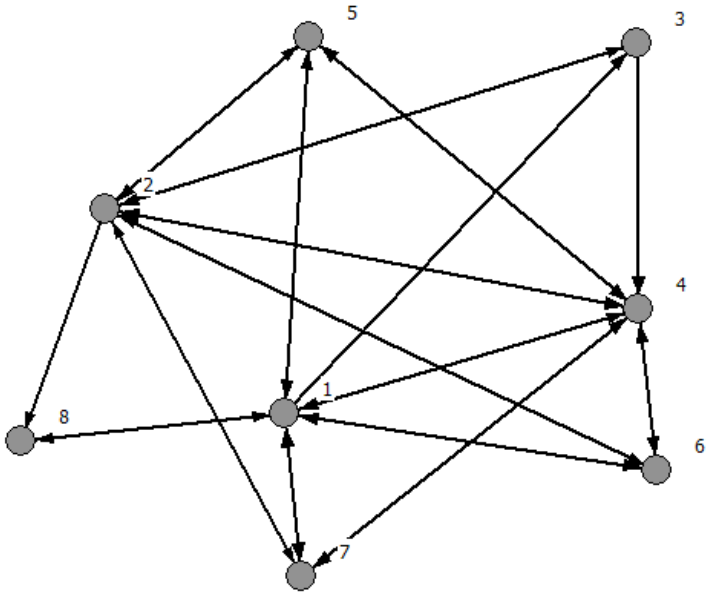
Proposition 3:

The sociogram below shows the entire *Daily Communication* network in Team 4. Respondents 4, 5 6, 7 and 8 do not report any daily communication with the project team. Respondent 1 is the most central person in the daily communication network in the team. Respondent 3 reports daily communication with team member 1, however this relationship is not reciprocated, thus is considered weaker than the relationship between respondent 1 and 2.



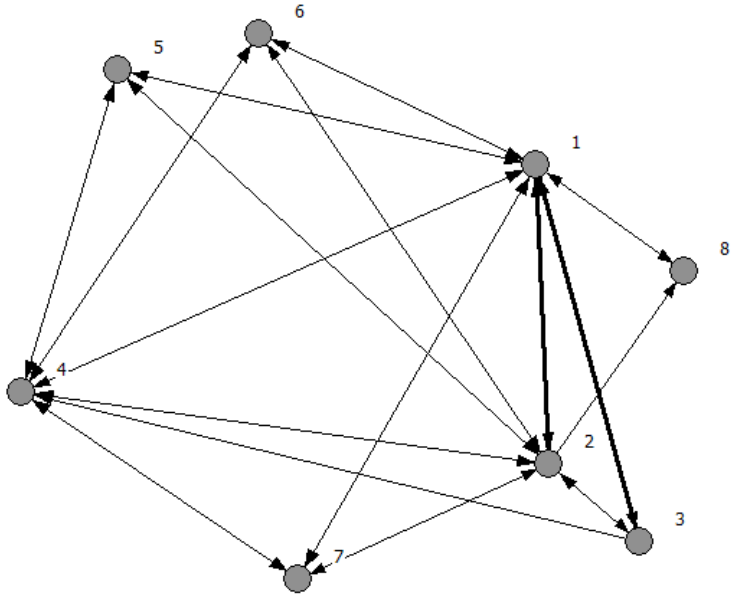
SOCIOGRAM 36: Daily Communication Network – Team 4

The sociogram below shows the entire *Weekly Communication* network in Team 4. Respondent 4 is the most central person in the weekly communication network.



SOCIOGRAM 37: Weekly Communication Network – Team 4

As you can see from sociogram number 38 below, the daily and weekly communication networks are added together to represent the Frequency of Communication network. The lines consist of two different widths. The thickest lines represent the strongest frequency of communication ties, whereas the thinnest lines represent the weakest frequency of communication ties. It is evident that this team reports to communicate on a weekly basis, rather than a daily basis.



SOCIOGRAM 38: Frequency of Communication Network – Team 4

The strong *Frequency of Communication* ties were compared to the Knowledge Quality ties. Consequently, of all the team members that reported to be connected

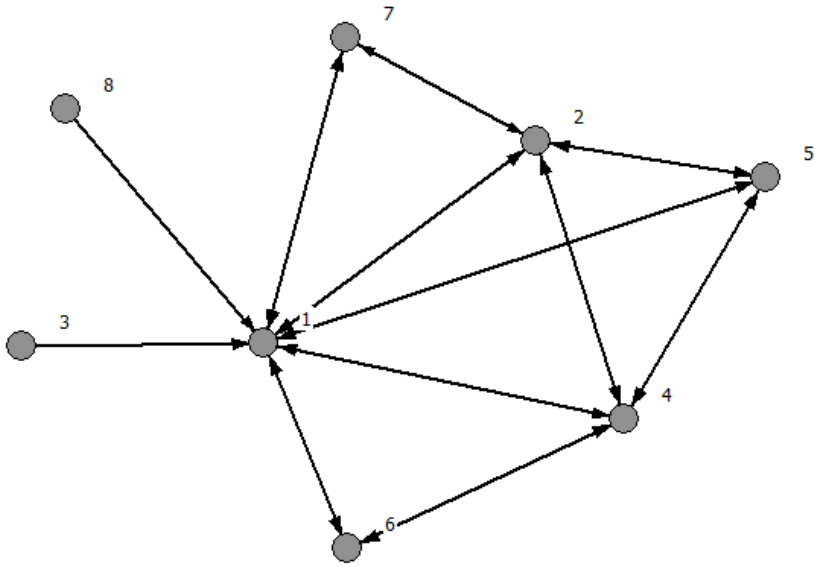
by strong Frequency of Communication ties, 0 was at the same time connected by weak KQ ties, 0 was at the same time connected by neither strong nor weak KQ ties, and 3 of the team members that reported being connected by strong Frequency of Communication ties were at the same time connected by strong KQ ties. Kowledge was reported being useful in all strong Frequency of Communication ties. Altogether the data shows that the members in Team 4 that are connected by strong Frequency of Communication ties also in general are found to share strong Knowledge Quality ties.

The weak *Frequency of Communication* ties were compared to the Knowledge Quality ties. Consequently, team members that were connected by weak Frequency of Communication ties, 1 was at the same time connected by weak KQ ties, 6 were at the same time connected by neither strong nor weak KQ ties and 22 of the team members that reported being connected by weak Frequency of Communication ties were connected by strong KQ ties. Knowledge was reported as being useful in all weak Frequency of Communication ties. Altogether the data shows that the members in Team 4 that are connected by weak Frequency of Communication ties also in general are found to share strong Knowledge Quality ties.

Consequently, the data shows that the majority of team members in Team 4 that are connected by strong Frequency of Communication ties do not share knowledge with higher quality, than team members that are connected by weak Frequency of Communication ties.

Proposition 4:

The sociogram below shows the entire *Time Spent on Interaction* network in Team 4. The team member that people report using the longest time interacting with is team member 1. None of the other team members report sending more time interacting with team member 3 and 8.



SOCIOGRAM 39: Time Spent on Interaction Network – Team 4

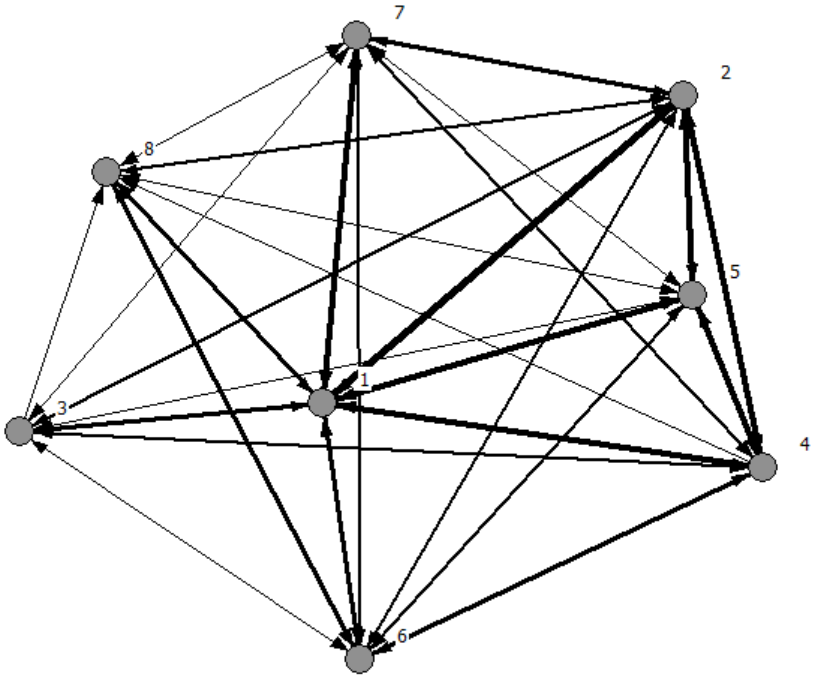
The *Time Spent on Interaction* ties were compared to the Knowledge Quality ties. Consequently, of all the team members that reported to be connected by Time Spent on Interaction ties, 0 was at the same time connected by weak KQ ties, 3 were at the same time connected by neither strong nor weak KQ ties and 19 of the team members that reported being connected by Time Spent on Interaction ties were connected by strong KQ ties. Furthermore, the knowledge was reported to be useful in all time spent on interaction ties. Altogether the data shows that the members in Team 4 that are connected by Time Spent on Interaction ties also in general are found to share strong Knowledge Quality ties.

In addition, to disclose if team members that did not reported to spent more time interaction with their team members reported high or low quality of the knowledge shared, a second comparison was performed. In this comparison the team members that did not report any Time Spent on Interaction ties, shared 1 KQ ties that could be considered weak, 10 KQ ties that could be considered neither strong nor weak, and 28 KQ ties that could be considered as strong.

Even though the knowledge was reported as being useful in all time spent on interaction ties, it is evident that members in Team 4 that spend more time interacting will not share knowledge of higher quality, than team members that that spend less time interacting.

Proposition 5:

The sociogram below shows the entire aggregated Social Interaction network in Team 4. The thick lines depict the strong ties between the respondents' whereas the thinner lines depict the weak ties.



SOCIOGRAM 40: Social Interaction Network – Team 4

The strong *Social Interaction* ties were compared to the Knowledge Quality ties. Consequently, of all the team members that reported to be connected by strong Social Interaction ties, 0 was at the same time connected by weak KQ ties, 2 were at the same time connected by neither strong nor weak KQ ties, and 17 of the team members that reported being connected by strong Social Interaction ties were at the same time connected by strong KQ ties. Knowledge was reported being useful in all strong Social Interaction ties. Altogether the data shows that the members in Team 4 that are connected by strong Social Interaction ties also in general are found to share strong Knowledge Quality ties.

The weak *Social Interaction* ties were compared to the Knowledge Quality ties. Consequently, team members that were connected by weak Social Interaction ties, 1 was at the same time connected by weak KQ ties, 9 were at the same time connected by neither strong nor weak KQ ties and 25 of the team members that reported being connected by weak Social Interaction ties were connected by strong KQ ties. Knowledge was reported being useful in all weak Social Interaction ties. Altogether the data shows that the members in Team 4 that are

connected by weak Social Interaction ties also in general are found to share strong Knowledge Quality ties.

Consequently, the data shows that the team members in Team 4 that are connected by strong Social Interaction ties share do not share knowledge with higher quality, than team members that are connected by weak Social Interaction ties.

In the preceding paragraphs we have taken a closer look at the multiplexity of social interaction ties. Empirical evidence has shown that team members in Team 4 that are connected by Close Relationship ties not share knowledge of higher quality than team members that are not connected by Close Relationship ties. Moreover, team members that are connected by strong Interpersonal Trust ties do not share knowledge of higher quality than team members that are connected by weak Interpersonal Trust ties. However, team members that are connected by Competence-based Trust ties share knowledge of higher quality than team members that are not connected by Competence-based Trust ties. Yet, members that are connected by Benevolence-based Trust ties do not share knowledge of higher quality than team members that are not connected by these ties. Furthermore, team members that are connected by strong Frequency of Communication ties do not share knowledge of higher quality than team members that are connected by weak Frequency of Communication ties. Furthermore, team members in Team 4 that are connected by Time Spent on Interaction ties do not share knowledge of higher quality, than team members that are not connected by Time Spent on Interaction ties.

Consequently, knowledge is reported being useful in all social interaction ties, however members in Team 4 that are connected by strong Social Interaction Ties do not share knowledge with higher quality, than team members that are connected by weak Social Interaction Ties.

4.6 Summing-up the Findings

In the subsequent paragraph I will sum up the findings from each team.

In *Team 1*, propositions 2, 2a, 2b, 4 and 5 were supported, whereas proposition 1 was not supported.

In *Team 2*, all propositions were supported.

In *Team 3*, propositions 2a, 3, 4 and 5 were supported, whereas propositions 1, 2, and 2b were not supported.

In *Team 4*, proposition 2a was supported, whereas propositions 1, 2, 2b, 3, 4 and 5 were not supported.

In *sum,* none of the propositions turned out not to be supported. Proposition 2a was fully supported, whereas propositions 1, 2, 2b, 3, 4 and 5 were partly supported.

Figure 3 below is a graphic presentation of the findings. The propositions that are supported are marked with a check and the propositions that are not supported are marked with a cross.

	Team 1	Team 2	Team 3	Team 4
Proposition 1: (CR)	✗	✓	✗	✗
Proposition 2: (IT)	✓	✓	✗	✗
Proposition 2a: (CbT)	✓	✓	✓	✓
Proposition 2b: (BbT)	✓	✓	✗	✗
Proposition 3: (FoC)	✓	✓	✓	✗
Proposition 4: (TSoI)	✓	✓	✓	✗
Proposition 5: (SIT)	✓	✓	✓	✗

Figure 3: Graphic Presentations of the Findings

4.7 Analytical Discussion: Comparing and Contrasting the Cases

The analysis of case study evidence is the least developed aspect of case study methodology, hence the most difficult (Yin, 2009). In this study, I have followed a general analytic strategy proposed by Yin (2009), as to rely on the theoretical propositions and let the theoretical orientation guide the analysis. Moreover, I have chosen to use pattern matching as a specific analytic technique, hence I will compare the predicted pattern with the empirical data. In the following analytical discussion I will compare and contrast the empirically found evidence across the cases. In addition I will use the pattern matching technique to further investigate the relationship between the independent and the dependent variable to find out

how the strength of social interaction ties between members of a virtual team affects the quality of knowledge shared in these ties. Consequently, a final proposition as an answer to the research question will be given.

In Team 1, members that shared strong Interpersonal Trust ties, strong Frequency of Communication ties, and Time Spent on Interaction ties are reported to share knowledge of higher quality than team members that were not connected by these ties. However members that were connected by Close Relationship ties, were not found to share knowledge of higher quality than team members that were not connected by Close Relationship ties. Altogether members in Team 1 that were connected by strong Social Interaction ties, were found to share knowledge with higher quality than team members connected by weak Social Interaction ties. This team was the largest of the teams investigated and consisted of professionals across professions, organisational, cultural and hierarchical boundaries. This fact might make it more difficult to develop trust and close relationships, in addition language may be a considerable barrier. However, Team 1 was the second least virtual of the teams investigated, which might make face-to-face communication an essential factor for the sharing of high quality knowledge. In addition this team differs from the rest, as it is not composed solely of members in management positions. Hence it is to be expected that the team share a considerable amount of technical knowledge.

In Team 2 members that shared Close Relationships ties, strong Interpersonal Trust ties, strong Frequency of Communication ties and Time Spent on Interaction ties, reported to share knowledge of higher quality than team members not connected by these ties. Altogether team members in Team 2 that were connected by strong Social Interaction ties were found to share knowledge with higher quality than team members connected by weak Social Interaction ties. Moreover, all team members in Team 2 reported to share knowledge of high quality with the other team members. This team was the least virtual and the smallest of the ones investigated, which might make it easier to build stronger social interaction ties. However, team members in this team did not on a general basis report to spend long time on interacting with each other, this might imply that when the members share knowledge they understand each other well. In addition Team 2 consists of project leaders that are working together across departments, which might imply that the team members are highly, skilled professionals. These facts might provide

alternative explanations for why the members in Team 2 are inclined to share knowledge of high quality.

In Team 3, members that shared Competence-based Trust ties, Frequency of Communication ties and Time Spent on Interaction ties, reported to share knowledge of higher quality than team members not connected by these ties. However in Team 3 members connected by Close Relationship ties and Benevolence-based Trust ties were not found to share knowledge of higher quality than team members that were in fact connected by these ties. Altogether team members in Team 3 that were connected by strong Social Interaction ties, were found to share knowledge with higher quality than team members connected by weak Social Interaction ties. Team 3 consisted of project leaders in a large company in the oil and gas sector, and was the second most virtual of the teams investigated. The fact that the team members were located in two different countries might have an impact on the results in form of difficulties sharing knowledge over cultural, spatial and temporal boundaries. In addition the team is inclined to share knowledge that is technical in nature, which might make it harder to share both tacit and explicit knowledge of high quality.

In Team 4 members that shared Competence-based Trust ties reported to share knowledge of higher quality than members that were not connected by these ties. However, members that shared Close Relationship ties, Interpersonal Trust ties, Frequency of Communication ties and Time Spent on Interaction ties, did not report to share knowledge of higher quality than the members not connected by these ties. Nevertheless, team members in this team evidently had close relationships, spent more time on interaction, communicated frequently and had trust in each other's competence and benevolence. Moreover, members in Team 4 reported to share high quality knowledge with almost all other members in the team. However, in contrast to the suggested propositions, the distinct components of social interaction ties have no extended impact on the quality of knowledge shared between the members in Team 4. This suggests that there could be alternative explanations for the propositions that were not supported, and why this team is found to be so strikingly different than the other teams investigated. Moreover, this opens for a discussion about other possible interpretations of the relationship between strong social interaction ties and the sharing of high quality knowledge.

Accordingly, empirical evidence shows that Team 4 are connected by

relatively strong Social Interaction ties, but have the potential to share knowledge of high quality without depending on the components of Social Interaction ties besides competence-based trust. Team 4 is the most virtual of all the teams investigated, thus the team members do not have the same possibility for face-to-face communication as teams that are less virtual. This fact might make it even more difficult to share knowledge that is tacit in nature. However the countries, Norway, Sweden, Denmark, Finland and Iceland can be said to share culture and norms, which might make it easier to communicate across barriers. Nevertheless, Team 2 that was found to be the least virtual, and Team 4 that was found to be the most virtual of the teams investigated, shared both knowledge of high quality and had members that were connected by strong social interaction ties. This might imply that social interaction ties can just as easy be developed between team members in the one end, as the other end of the virtual continuum. Moreover, this may entail that virtuality not always is an impediment to the sharing of high quality knowledge.

Another explanation might be that, since the members report to interact the least frequent of all teams, the knowledge shared might not be of a critical character. This might again explain why the team members do not need to communicate often. However, when the team members communicate they report to spend time on the interaction. This implies that when the members interact, they share high quality of knowledge. Team 4 is also the least technical of all team investigated. This might imply that the knowledge shared between the members is less technical and complex than the knowledge shared in the other teams. It could also be interpreted as the team share knowledge that is more explicit in nature. Consequently, this might imply that social interaction ties are important for the sharing of high quality knowledge between members of a virtual team, when the knowledge is complex and tacit.

Moreover, it is tempting to look at the characteristics of the nodes to find alternative explanations for the team that stand out. Team 4 consisted of country coordinators from five different countries. The fact that all are in management positions in their respective countries might point to that all are highly skilled, qualified and professional, thus they might not need components of social interaction ties besides trust in each others competence, to share knowledge of high quality. This team has also worked together for a long time on different projects and might have well-developed routines and shared language.

In search for an elucidation for how the strength of Social Interaction ties between members of a virtual team affect the quality of knowledge shared in these ties, I have in the previous analytical discussion compared and contrasted the empirical data, to find support for the expected patterns. In the following paragraph I will present the conclusions drawn. All together, the component of a social interaction tie that had the most impact on the quality of knowledge shared between members of a virtual team was Competence-based Trust ties. Accordingly, proposition 3 is supported. Secondly, Frequency of Communication ties and Time Spent on Interaction ties had an evident effect on the quality of knowledge shared in these ties. Accordingly, propositions 3 and 4 are partly supported. Furthermore, Benevolence-based Trust ties had some effect on the knowledge shared. Accordingly, proposition 2b is partly supported. Close Relationship ties are shown to only have a small noticeable impact on the quality of knowledge shared between team members in a virtual team. Accordingly, proposition 1 is partly supported. Knowledge was reported as being useful in all but a few Social Interaction ties. Moreover, it is apparent that members in a virtual team that are connected by strong Social Interaction ties, will share knowledge of higher quality than members that are connected by weak Social Interaction ties. Accordingly, proposition 5 is partly supported.

Empirical evidence from this study shows that social interaction ties are multiplex, and that the perfect combination that will lead to the sharing of high quality knowledge depends both on circumstances and the nature of the knowledge shared. Accordingly, some components of a social interaction ties have shown to influence knowledge quality, whereas others show to have no extended effect. Altogether findings show that the strength of social interaction ties between members in a virtual team positively affect the quality of knowledge shared in these ties. For these reasons I argue that:

> *The strength of social interaction ties between members of a virtual team will positively affect the quality of knowledge shared in these ties, when the knowledge shared is complex and tacit in nature.*

5. General Discussion

In the subsequent paragraph I will present a discussion based on the main findings from the analyses and set them in the context of the presented theoretical framework.

As computer-mediated environments develop in different domains, there is an interest in understanding how social interaction is important for successful collaboration via computer media (Haythornthwaite, 2001). Most of the studies that have investigated the challenges related to knowledge sharing in the context of virtual teams, point to the fact that knowledge sharing relies on face-to-face encounters, cohesive social ties, dialogic practices, shared norms and especially interpersonal trust (Jarvenpaa & Majchrzak, 2008; Mooradian et al., 2006). However the physical distance between the actors reduces the number of opportunities for face-to-face encounters. Moreover the absence of face-to-face encounters generally diminishes trust and cohesion between actors, thus compromises knowledge sharing (Malhotra et al., 2007). On top of this, a key challenge in knowledge sharing is that knowledge is context specific and multi-faceted by nature, and a great amount of the knowledge shared is subjective and continuously recreated and reconstituted in social interactions (Nonaka et al., 2001; Von Krogh, 1998). Research shows that social interaction ties significantly and positively affect the quantity of knowledge shared (Chiu, Hsu, & Wang, 2006), moreover close social interaction will make individuals more able to increase the depth, breadth and efficiency of knowledge sharing (Lane & Lubatkin, 1998). This is in consistency with the empirical evidence found in this study. This thesis has taken a socio-cultural perspective on knowledge sharing, and argued that knowledge is constructed and negotiated through social interaction. Accordingly, this thesis has argued that close relationships, interpersonal trust, frequent interaction and time spent on interaction will support the extent to which the awareness and understanding of ideas, logics, relationships, and circumstances in a project are fit for use, easy to adapt, and relevant and valuable to the context.

However, empirical evidence form this study shows that social interaction ties are multiplex. The component of a social interaction tie that had the most impact on the quality of knowledge shared between members of a virtual team was Competence-based Trust ties. Secondly, Frequency of Communication ties and Time Spent on Interaction ties had an evident effect on the quality of

knowledge shared in these ties. Furthermore, Benevolence-based Trust ties had some effect on the knowledge shared, whereas Close Relationship ties are shown to only have a small noticeable impact on the quality of knowledge shared between team members in a virtual team. All together, knowledge was reported as being useful in all but a few Social Interaction ties. Moreover, it is apparent that members in a virtual team that are connected by strong Social Interaction ties, will share knowledge of higher quality than members that are connected by weak Social Interaction ties. Consequently, empirical evidence supports the notion that the strength of social interaction ties between members of a virtual team will positively affect the quality of knowledge shared in these ties, when the knowledge shared is complex and tacit in nature.

Communication is a central part of working life. People communicate to form friendships, to coordinate their work, to validate their actions, to legitimate their positions, and to give each other support. In the virtual work environment, co-workers have a variety of means through which they can exchange these many kinds of information (Haythornthwaite, 1996a). Nevertheless, evidence from previous research shows that the flow of knowledge occurs in social relations, and that people are more likely to turn to other people rather than documents for information (Levin, Cross, & Abrams, 2004). Empirical evidence from this study shows that in three of four teams members that communicated more frequently and used more time on interaction, shared knowledge of higher quality. This implies that frequency of communication ties and time spent on interaction ties have an evident effect on the quality of knowledge shared between members of a virtual team. Furthermore, this is in consistency with previous research that states that the more social interactions members undertake, the greater the intensity and breadth of knowledge should be exchanged.

Research suggests that people turn to the members that they know have given them useful advice in the past. Thus shared language is likely to develop between team members that communicate frequently and that use more time on interaction. Previous research shows that because team members cannot see each other's work in the virtual setting, a shared understanding of the role, language and accountability of each actor is necessary (Kauppila, Rajala, & Jyrämä, 2011). When team members develop a shared language they are likely to gain access to other people in the network and their information, and provide a common conceptual apparatus for evaluating the benefits of information exchange (Chiu,

Hsu, & Wang, 2006). Moreover, the common understanding that virtual team members develop as they communicate through technological solutions is a result of social activities and actions (Filstad, 2010). However, frequent communication can be a function of work interdependence beyond voluntary control of the individual workers (Levin, Cross, & Abrams, 2004), because interaction in general is likely to be a part of a formal reporting pattern. Moreover commitment to a virtual project often conflict with on-site deadlines and responsibilities (Rosen, Fürst, & Blackburn, 2007). The virtual team members in this study often worked at more than one project at a time. Hence the team members felt overwhelmed with workload and pressure from on-site co-workers, which made it harder to share information with virtual team members. These facts will obvious make it harder to maintain the part of the social interaction ties that involves frequent communication and more time spent on interaction.

What a person knows is to a great extent a function of whom he knows (Nahapiet & Ghoshal, 1998). Accordingly, teams in which the members are aware of the other team members skills and expertise, perform better than teams in which the team members do not possess such knowledge (Kauppila, Rajala, & Jyrämä, 2011). Thus it is important for virtual team members to learn how to gain the best access to people and learn about their preferences for how to communicate. For example are some people quick to respond to e-mails, others easier to call, and then other again insist on using face-to-face communication. However, research shows that it is not enough to focus exclusively on whom he knows, without taking into consideration how well he knows them (Moran, 2005). Hence, developing an understanding of other people's knowledge and skills is only a part of building a collaborative relationship. Empirical evidence from this study shows that in just one of four teams, the members that maintained close relationships, shared knowledge of higher quality. However, previous research shows that the response time for professional appeals was twice as long as for personal appeals (Cross & Parker, 2004). This fact would at least suggest that close relationships impact the process of sharing knowledge.

It is not always people trust the team members they know well (Levin, Cross, & Abrams, 2004). Moreover arguments have been made that the most useful knowledge of all comes from people that you do not know very well, but who you trust to be benevolent and competent (Levin, Cross, & Abrams, 2004). Empirical evidence from all teams shows that team members that were connected

by competence-based trust ties shared knowledge of higher quality. Hence, competence-based trust was found to be the strongest component of a social interaction tie for the sharing of high quality knowledge. Additionally, it is evident that people who develop personal connections, also believe that the person with whom they share personal details also are genuine concerned about them (Abrams et al., 2003). This fact might make it easier to ask other team members for help, and thus acquire knowledge that is more relevant for the context and fit to use. However, empirical evidence from this study shows that this is the case in only two out of four teams. Hence, benevolence-based trust ties does not necessarily make team members share knowledge of higher quality. In sum, this implies that team members that are connected by strong interpersonal trust ties do not necessarily share knowledge of higher quality than team members connected by weak interpersonal trust ties.

Altogether, empirical evidence supports the notion that social interaction ties are multiplex. Accordingly, the preferred combination of social interaction tie components that will lead to the sharing of high quality knowledge depends on the circumstances and the nature of the knowledge shared. However, in three out of four teams, team members that were connected by strong social interaction ties were found to share knowledge of higher quality, than team members that were connected by weak social interaction ties. The previous discussions therefore suggest the notion that the strength of social interaction ties between members of a virtual team will positively affect the quality of knowledge shared in these ties, when the knowledge shared is complex and tacit in nature.

6. Theoretical and Practical Implications

This study has attempted to contribute to the research fields of both knowledge sharing in virtual teams and social interaction ties. By acknowledging the salient contextual factor of the virtual space in which distributed teams operate, this study demonstrates knowledge sharing within virtual teams by acknowledging the diverse nature of knowledge in a specific context. Moreover, empirical evidence in this study shows that more emphasis should be placed on investigating the impact of social interaction ties in virtual teams, as these ties are proven to be important for the quality of knowledge shared within the team.

Previous research shows that many social network studies avoid the complexity of multiplex data by only focusing on a single relation, or by dealing with multiple relations separately. This study has attempted to contribute to the research on the multiplexity of social interaction ties. Based on already established theory this study has interpreted social interaction ties in a virtual team as a sum of the close relationship, frequency of communication, time spent on interaction and interpersonal trust.

The findings in this study should provide a potential for virtual teams to enhance the sharing of knowledge within the team. A social network analysis can give a broader perspective on a knowledge network that cross geographic boundaries, and mapping this network might yield performance improvement opportunities. Moreover mapping the pattern of the flow of information across barriers, might give insight into where management should promote collaboration that provides a strategic benefit (Cross, Borgatti, & Parker, 2004). In the above analyses it is possible to see which team members that share close relationships, share interpersonal trust, communicate frequently, spend more time interacting and share the knowledge with the highest quality. Hence a network analysis yields a potential opportunity for a team to get an understanding of where knowledge of high quality flows and in which relationships. However it is important to recognize that one not always want high collaborative activity among individuals. Maintaining relationships takes time, therefore the network analyses in this thesis might yield important insight into to which relationships are worth maintaining and investing in (Cross, Borgatti, & Parker, 2002).

7. Conclusion

In a dynamic economy, knowledge is a critical organisational resource that could provide a competitive advantage (Foss & Pedersen, 2002). To gain this competitive advantage, organisations need to focus on ways to effectively exploit knowledge-based resources that already exist within the organisation (Wang & Noe, 2010). Consequently, teams that develop mechanisms for high-quality knowledge sharing will be more likely to accomplish tasks effectively (Rosen, Furst, & Blackburn, 2007).

As virtual teams are becoming increasingly commonplace in today's society, this type of teams adds another layer of complexity to teamwork in any

situation (Cascio, 2000). Even though collaborative technologies will facilitate virtual work, the technology alone cannot accomplish higher performance (Cross, Parker, Prusak, & Borgatti, 2001). Moreover, as relationships are highly critical for obtaining information, more attention should be placed on investigating the relationships that individuals rely on to accomplish their work (Cross, Parker, Prusak, & Borgatti 2001). However, social network researchers do not have a tradition for measuring the diversity of information that flows through networks instead they assume that the structure of the network alone will determine the information channels (Seibert, Kraimer, & Liden, 2001). Consequently this study aimed to investigate the quality of knowledge that flows through these channels. Accordingly, how the strength of social interaction ties between members of a virtual team affect the quality of knowledge shared in these ties.

Altogether this study has shown that social interaction ties are multiplex, and that it might exist many more dependencies that are beyond the scope of this study. Consequently, this research has discovered that the relationship between social interaction ties and the quality of knowledge shared is complex. Hence, the perfect combination of social interaction ties components that will lead to the sharing of quality knowledge depends on the circumstances and the nature of the knowledge shared. Some components of a social interaction tie are shown to influence the quality of knowledge that is shared between members of a virtual team, whereas other components are found to have no extended effect. The component of a social interaction tie that had the most impact on the knowledge quality was competence-based trust ties. In addition, frequency of communication ties and time spent on interaction ties were found to have an evident effect. Furthermore, benevolence-based trust ties seem to have some effect on the knowledge shared, whereas close relationship ties are shown to only have a small noticeable impact on the quality of knowledge shared between team members in a virtual team. Altogether, empirical evidence shows support for the notion that the strength of social interaction ties between members in a virtual team positively affects the quality of knowledge shared in these ties.

8. References

Abrams, L. C., Cross, R., Lesser, E., & Levin, D. Z. (2003). Nurturing Interpersonal Trust in Knowledge-Sharing Networks. *Academy of Management Executive,* 17(4), 64-77.

Ahuja, M. K., & Carley, K. M. (1999). Network structure in virtual organizations. *Organization Science, 10*(6), 741-757.

Allen, J., James, A. D., & Gamlen, P. (2007). Formal versus informal knowledge networks in R&D: a case study using social network analysis. *R&D Management*, 37(3), 179-196.

Alveson, M., & Kärreman, D. (2001). Odd couple: Making sense of the curious concept of knowledge management. *Journal of Management Studies*, 38(7), 995-1018.

Allen, J., James, A. D., & Gamlen, P. (2007). Formal versus informal knowledge networks in R&D: a case study using social network analysis. *R&D Management*, 37(3), 179-196.

Anderson, M. H. (2008). Social networks and the cognitive motivation to realize network opportunities: a study of managers' information gathering behaviors. *Journal of Organizational Behavior, 29*(1), 51-78.

Andrews, K. M., &, Delahay, B. L. (2000). Influences on knowledge processes in organizational learning: The psychosocial filter. *Journal of Management Studies*, 37, 797-810.

Azarian, R. (2010). Social Ties: Elements of a Substantive Conceptualization. *Acta Sociologica*, 53(4), 323-338.

Bell, B. S., & Kozlowski, S. W. J. (2002). A typology of virtual teams. Implications for effective leadership. *Group and Organization Management*, 27, 14-49.

Bordia, P., Irmer, B. E., & Abusah, D. (2006). Differences in sharing knowledge interpersonally and via databases: The role of evaluation apprehension and perceived benefits. *European Journal of Work and Organizational Psychology, 15*(3), 262-280.

Borgatti, S.P. (2002). *Netdraw: Graph Visualization Software*. Harvard, MA: Analytic Technologies.

Borgatti, S. P., & Carboni, I. (2007). On measuring individual knowledge in organizations. *Organizational Research Methods*, 10(3), 449-462

Borgatti, S.P., Everett, M.G., & Freeman, L.C. (2002). *Ucinet for Windows: Software for Social Network Analysis*. Harvard, MA: Analytic Technologies.

Borgatti, S.P., James, C., & Everett, M. (1998). Network measures of social capital. *Connections*, 21 (2), 27-36.

Borgatti, S. P., Mehra, A., Brass, D. J., & Labianca, G. (2009). Network analysis in the social sciences. *Science*, 323(5916), 829-895.

Burt, R. S. (1976). Positions in Networks. *Social Forces, 55*(1), 93-122.

Burt, R. S. (1980). Models of Network Structure. *Annual Review of Sociology, 6*, 79-141.

Burt, R. S. (1997). The contingent value of social capital. *Administrative Science Quarterly, 42*(2), 339-365.

Cascio, W. F. (2000). Managing a virtual workplace. *Academy of Management Executive, 14*(3), 81-90.

Chan, K., & Liebowitz, J. (2006). The synergy of social network analysis and knowledge mapping: a case study. *International Journal of Management and Decision Making*, 7(1), 19-35.

Chen, I. Y. L. (2007). The factors influencing members' continuance intentions in professional virtual communities – a longitudinal study. *Journal of Information Science,* 33(4), 451–467.

Chiu, C. M., Hsu, M. H., & Wang, E. T. G. (2006). Understanding knowledge sharing in virtual communities: An integration of social capital and social cognitive theories. *Decision Support Systems, 42*(3), 1872-1888.

Collins, C. J., & Clark, K. D. (2003). Strategic human resource practices, top management team social networks, and firm performance: The role of human resource practices in creating organizational competitive advantage. *Academy of Management Journal, 46*(6), 740-751.

Cramton, C. D., & Orvis, K. L. (2003). Overcomming barriers to information sharing in virtual teams. In C. B. Gibson, & S. G. Cohen (Eds.), *Virtual teams that work* (pp. 196-213). San Fransisco, California: Jossey-Bass.

Cross, R., & Cummings, J. N. (2004). Tie and network correlates of individual performance in knowledge-intensive work. *Academy of Management Journal, 47*(6), 928-937.

Cross, R., Borgatti, S. P., & Parker, A. (2002). Making Invisible work visible: Using social network analysis to support strategic collaboration. *California Management Review,* 44(2), 25-46

Cross, R., & Parker, A. (2004). *The Hidden Power of Social Networks: Understanding How Work Really Gets Done in Organizations.* Boston, MA: Harvard Business School Press.

Cross, R., Parker, A., Prusak, A., & Borgatti, S. P. (2001). Knowing what we know: Supporting knowledge creation and sharing in social networks. *Organizational Dynamics, 30*(2), 100-120.

Davenport, T. H., & Prusak, L. (1998). *Working Knowledge: How Organizations Manage What They Know*. Boston, MA: Harvard Business School Press.

Dirks, K. T., & Ferrin, D. L. (2001). The Role of Trust in Organizational Settings. *Organization Science,* 12(4), 450-67.

Filstad, C., (2010). *Organisasjonslæring.* Oslo: Fagbokforlaget.

Filstad, C., & Blåka, G. (2007). *Learning in Organizations.* Oslo: Cappelen.

Flick, U. (2009). *An introduction to qualitative research*. Los Angeles, California: SAGE

Foss, N. J., & Pedersen, T. (2002). Transferring knowledge in MNCs: The role of sources of subsidiary knowledge and organizational context. *Journal of International Management*, 8(1), 49−67.

Granovetter. Ms. (1973). The Strength of Weak Ties. *American Journal of Sociology, 78*(6), 1360-1380.

Griffith, T. L., & Neale, M. A. (2003). Information Processing in Traditional, Hybrid, and Virtual Teams: From Nascent Knowledge to Transactive Memory. In B. M. Staw, & R. I. Sutton (Eds.), *Research in Organizational Behavior* (Volume 23) (pp. 379-421). Stamford, CT: JAI Press.

Griffith, T. L., Sawyer, J. E., & Neale, M. A. (2003). Virtualness and knowledge in teams: Managing the love triangle of organizations, individuals, and information technology. *MIS Quarterly, 27*(2), 265-287.

Handy, C. (1995). Trust and the Virtual Organization. *Harvard Business Review, 73*(3), 40-&.

Hanneman, R., A. & Riddle, M. 2005. *Introduction to social network methods*. Riverside, CA: University of California, Riverside.

Hansen, M. T. (1999). The search-transfer problem: The role of weak ties in sharing knowledge across organization subunits. *Administrative Science Quarterly*, 44(1), 82−111.

Hansen, M. T., Nohria, N., & Tierney, T. (1999). What's your strategy for managing knowledge? *Harvard Business Review*, 77(2), 106−116.

Haythorntwaite, C. (1996a). *Media use in support of communication networks in an academic research environment*. (Unpublished doctoral dissertation), University of Toronto, Toronto.

Haythorntwaite, C. (1996b). Social network analysis: An approach and technique for the study of information exchange. *Library and Information Science Research*, 18, 323-342.

Haythornthwaite, C. (2001). Exploring multiplexity: Social network structures in a computer-supported distance learning class. *The Information Society,* 17, 211–226.

Hinds, P.J, & Weisband, S. P. (2003). Knowledge sharing and shared understanding in virtual teams. In C. B. Gibson, & S. G. Cohen (Eds.), *Virtual teams that work* (pp. 21-36). San Fransisco, California: Jossey-Bass.

Holste, J. S., & Fields, D. (2010). Trust and tacit knowledge sharing and use. *Journal of Knowledge Management, 14*(1), 128-140.

Inkpen, A. C., & Tsang, E. W. K. (2005). Social capital, networks, and knowledge transfer. *Academy of Management Review, 30*(1), 146-165.

Jarvenpaa, S. L., K. Knoll, D. Leidner. 1998. Is anybody out there? The antecedents of trust in global virtual teams. *Journal of Management Information Systems,* 14(4), 29–64.

Jarvenpaa, S. L., & Majchrzak, A. (2008). Knowledge Collaboration Among Professionals Protecting National Security: Role of Transactive Memories in Ego-Centered Knowledge Networks. *Organization Science*, 19(2), 260-276.

Jarvenpaa, S. L., Shaw, T. R., & Staples, D. S. (2004). Toward contextualized theories of trust: The role of trust in global virtual teams. *Information Systems Research, 15*(3), 250-267.

Katona, Z., Zubcsek, P. P., & Sarvary, M. (2011). Network Effects and Personal Influences: The Diffusion of an Online Social Network. *Journal of Marketing Research, 48*(3), 425-443.

Kauppila, O. P., Rajala, R., & Jyrämä, A. (2011). Knowledge sharing through virtual teams across borders and boundaries. *Management Learning, 42*(4), 395-418.

Kotlarsky, J., & Oshri, I. (1999). Social ties, knowledge sharing and successful collaboration in globally distributed system development projects. *European Journal of Information Systems*, 14, 37-48.

Krackhardt, D. 1992. The strength of strong ties. In N. Nohria & R. G. Eccles (Eds.), *Networks and organizations: Structure, form and action* (pp. 216-239). Boston: Harvard Business School Press.

Krackhardt, D., & Kilduff, M. (1999). Whether Close or Far: Perceptions of Balance in Friendship Networks in Organizations. *Journal of Personality and Social Psychology*, 76(5), 770-782.

Lane, P. J., & Lubatkin, M. (1998). Relative absorptive capability and interorganizational learning. *Strategic Management Journal*, 19(5), 461–477.

Levin, D. Z., Cross, R., & Abrams, L. C. (2004). The strength of weak ties you can trust: The mediating role of trust in effective knowledge transfer. *Management Science*, 50(11), 1477-1490.

Malhotra, A., Majchrzak, A., & Rosen, B. (2007). Leading virtual teams. *Academy of Management Perspectives, 21*(1), 60-70.

Martins, L. L., Gilson, L. L., & Maynard, M. T. (2004). Virtual teams: What do we know and where do we go from here? *Journal of Management, 30*(6), 805-835.

Mayer, R. C., Davis, J. H., & Schoorman, D. F., (1995). An Integrative Model of Organizational Trust. *Academy of Management Review,* 20(3), 709-734.

Maznevski, M. L., & Atanassiou N. A. (2003). Designing the knowledge-management infrastructure for virtual teams. Building and using social networks and social capital. In C. B. Gibson, & S. G. Cohen (Eds.), *Virtual teams that work* (pp. 196-213). San Fransisco, California: Jossey-Bass.

Mooradian, T., Renzl, B., & Matzler, K. (2006). Who trusts? Personality, trust and knowledge sharing. *Management Learning, 37*(4), 523-540.

Moran, P. (2005). Structural vs. relational embeddedness: Social capital and managerial performance. *Strategic Management Journal*, 26, 1129-1151.

Nahapiet, J., & Ghoshal, S. (1998). Social capital, intellectual capital, and the organizational advantage. *Academy of Management Review, 23*(2), 242-266.

Nahapiet, J., Gratton, L., & Rocha, H. O. 2005. Knowledge and relationships: When cooperation is the norm. *European Management Review, 2*, 3-14.

Newell, S., Robertson, M., Scarbrough, H., & Swan, J. (2009). *Managing Knowledge Work and Innovation*. 2nd edition. Basingstoke: Palgrave Macmillan.

Nonaka, I., & Teece, D. J. (2001). *Managing Industrial Knowledge: Creating, Transfer, and Utilization*. London: Sage.

Owen-Smith, J., & Powell, W. W. (2003). The expanding role of university patenting in the life sciences: assessing the importance of experience and connectivity. *Research Policy, 32*(9), 1695-1711.

Petróczi, A., Nepusz, T., & Bazsó, F. (2007). Measuring tie-strength in virtual social networks. *Connections,* 27(2), 39-52.

Phelps, C., Heidl, R., & Wadhwa, A. (2012). Agenda Knowledge, Networks, and Knowledge Networks: A Review and Research Agenda. *Journal of Management*, 38 (4), 1115-1166.

Poston, R. S., & Speier, C. (2005). Effective use of knowledge management systems: a process model of content ratings and credibility indicators. *MIS Quarterly*, 29(2), 221-44.

Reagans, R. & McEvily, B. (2003). Network structure and knowledge transfer: The effects of cohesion and range. *Administrative Science Quarterly,* 48(2), 240–267.

Robins, G, Pattison, P., & Woolcock, J. (2004). Missing data in networks: Exponential random graph (p∗) models for networks with non-respondents. *Social Networks*, 26, 257–283.

Rosen, B., Furst, S., & Blackburn, R. (2007). Overcoming barriers to knowledge sharing in virtual teams. *Organizational Dynamics, 36*(3), 259-273.

Saunders, C. S., & Ahuja, M. K. (2006). Are all distributed teams the same? Differentiating between temporary and ongoing distributed teams. *Small Group Research, 37*(6), 662-700.

Seibert, S. E., Kraimer, M. L., & Liden, R. C. (2001). A social capital theory of career success. *Academy of Management Journal*, 44, 219–237.

Staples, D. S., & Webster, J. (2008). Exploring the effects of trust, task interdependence and virtualness on knowledge sharing in teams. *Information Systems Journal, 18*(6), 617-640.

Stork, D., & Richards, W. D. (1992). Nonrespondents in communication network studies: problems and possibilities. *Group and Organization Management*, 17, 193–210.

Søndergaard, S., Kerr, M., & Clegg, C. (2007). Sharing Knowledge: Contextualising Socio-Technical Thinking and Practice. *The Learning Organization,* 14(5), 423-435.

Townsend, A. M., DeMarie, S. M., & Hendrickson, A. R. (1998). Virtual Teams: Technology and the Workplace of the Future. *Academy of Management Executive*, 12(3), 17-29.

Tsai, W., & Ghoshal, S. (1998). Social Capital and Value Creation: The Role of Intrafirm Networks. *The Academy of Management Journal,* 41(4), 464-476.

Van den Hoof, B. & de Ridder, J. A. (2004). Knowledge sharing in context: the influence of organizational commitment, communication climate and CMC use on knowledge sharing. *Journal of Knowledge Management*, 8(6), 117-130.

Von Krogh, G. (1998). Care in knowledge creation. *California Management Review,* 40(3), 133–153.

Wang, S., & Noe, R. A. (2010). Knowledge sharing: A review and directions for future research. *Human Resource Management Review, 20*(2), 115-131.

Wasserman, S., & Faust, K. (1999). Social Network Analysis: Methods and Application. Cambridge: Cambridge University Press.

Westphal, J. D., Seidel, M. D. L., & Stewart, K. J. (2001). Second-order imitation: Uncovering latent effects of board network ties. *Administrative Science Quarterly, 46*(4), 717-747.

Yin, R. K. (2009). *Case study research: Design and methods*. Los Angeles: Sage

Yoo, D. K., Vonderembse, M. A., & Ragu-Nathan, T. S. (2011). Knowledge quality: antecedents and consequence in project teams. *Journal of Knowledge Management*, 15(2), 329 - 343.

Yu, S., Kim, Y., & Kim, M. (2007). Do we know what really drives KM performance? *Journal of Knowledge Management*, 11(6), 39-53.

Yuan, Y. C., & Gay, G. (2006). Homophily of network ties and bonding and bridging social capital in computer-mediated distributed teams. *Journal of Computer-Mediated Communication,* 11(4).

Zaheer, A., McEvily, B., & Perrone V. (1998). Does Trust Matter? Exploring the Effects of Interorganizational and Interpersonal Trust on Performance. *Organization Science*, 9(2), 141-159.

Zigurs, I. (2003). Leadership in virtual teams: Oxymoron or opportunity? *Organizational Dynamics, 31*(4), 339-351.

9. Appendices

9.1 APPENDIX 1 – Consent Form

I'm currently writing my master thesis in Leadership and Organizational Psychology at BI - Norwegian Business School, and am about to conduct a study on knowledge sharing in virtual teams. Virtual teams can be defined as teams whose members use technology to varying degrees in working across locational, temporal, and relational boundaries to accomplish interdependent tasks. The intention of the study is to map how social interaction ties between members of a virtual team affect the quality of the knowledge shared within this team, and to complete the project it will be necessary with voluntary participation from members of a virtual team.

The following questionnaire will take you approximately 10 minutes to complete. This questionnaire consists of two parts. In this first part you will be asked to assess your relations to your team members. In part number two you will be asked to assess the quality of the knowledge that you share with your team members.

It will not be necessary with any preparations before answering the surveys. It is your own opinion that is of value, and it is important to emphasize that this study is not an assessment of your personal characteristics, performance nor procedures.

Your rights in a scientific study:

- All information will be handled strictly confidential, and all respondents will be anonymized, this also applies to the company you are representing.
- The collected data will only be processed by the master student and will not be accessible for any third party.
- You may withdraw from the study at any time without stating any reason.
- The collected data will only be used in this master thesis, and all collected information will be deleted no later than 1. September 2012.

Feel free to ask for a copy of the completed master thesis by sending a mail to the master student.

If you have any questions or wish to receive more information about the study, please contact master student Elise Nettelhorst Letrud by e-mail: elise.letrud@gmail.com or by phone: 90833313 or supervisor Tom Rosendahl by e-mail: tom.rosendahl@bi.no.

This study is approved by NSD (Norsk Sammfunnsvitenskapelig Datatjeneste) Data Protection Official for Reserch and fulfils strict requirements of confidentiality and storage of data. In accordance with the Personal Data Act's recommendation for processing of personal data, consent of voluntary participation in the study is required.

❒ I have read the information above, and I am accordingly informed about my rights in a scientific study.

9.2 APPENDIX 2 – Questionnaire

Last name: _____

In which company are you employed? _____

Role in the team: _____

1. Frequency of communication - Daily

Below you will find a list over the members that are included in the project. Please indicate which of the persons you communicate with every day about this specific project, by placing a check in the box to the left of the names.

Check as many names as appropriate. If there is only one person that you generally communicate with every day about this specific project, check only that person's name. If there is no one you generally communicate with every day, then do not check any names.

1. …
2. …
3. …

…

2. Frequency of communication - Weekly

Below you will find a list over the members that are included in the project. Please indicate which of the persons you communicate with weekly about this specific project, by placing a check in the box to the left of the names.

Check as many names as appropriate. If there is only one person that you generally communicate with weekly about this specific project, check only that person's name. If there is no one you generally communicate with weekly, then do not check any

names.

1. …
2. …
3. …
…

3. Time spent on interaction

Below you will find a list over the members that are included in the project. Please indicate which of the persons you spend the most time interacting with about this specific project, by placing a check in the box to the left of the names.

Check as many names as appropriate. If there is only one person that you generally spend more time interacting with about this specific project, check only that person's name. If there is no one you specifically spend more time interacting with, then do not check any names.

1. …
2. …
3. …
…

4. Close relationship

Below you will find a list over the members that are included in the project. Please indicate the persons that you have a close relationship with, by placing a check in the box to the left of the names. A close relationship can be defined as a personal relationship in which you share information of a more private character.

Check as many names as appropriate. If there is only one person that you have a close relationship with, check only that person's name. If there is no one on this list that you characterize as having a close relationship with, then do not check any names.

1. …
2. …
3. …
…

5. Trust

Competence - expertise, skill, proficiency

Below you will find a list over the members that are included in the project. Please indicate the persons that you find competent in this project by placing a check in the box to the left of the names. A competent person is by definition a person that you trust have relevant expertise, skills and/or proficiency to accomplish their given assignments.

Check as many names as appropriate. If there is only one person that you find competent, check only that person's name. If there is no one you generally find competent, then do not check any names.

1. …
2. …
3. …
…

6. Trust

Benevolence - kindheartedness, goodwill, compassion

Below you will find a list over the members that are included in the project. Please indicate the persons that you find benevolent by placing a check in the box to the left of the names. A benevolent person is by definition a person who is interested in your well-being and personal goals at work.

Check as many names as appropriate. If there is only one person that you find benevolent, check only that person's name. If there is no one you generally find

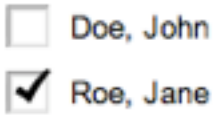
benevolent, then do not check any names.

1. …
2. …
3. …
…

In the project a large amount of work related knowledge is shared every day, and often it can be difficult to differentiate and prioritize which knowledge that is of higher quality. You will now answer questions about how you on a general level, view the quality of the work related knowledge that is shared between you and your team members in the project.

Example:
The knowledge shared between me and ... is accurate.

The knowledge shared between me and 'Jane Roe' is accurate.



1. The knowledge shared between me and ... is accurate.

(‘Accurate' can be interpreted as: the knowledge shared is correct in all details/error-free.)

1. …
2. …
3. …
…

2. The knowledge shared between me and … is reliable.

('Reliable' can be interpreted as: the knowledge shared is consistently good in quality or performance; able to be trusted.)

1. …
2. …
3. …
…

3. The knowledge shared between me and … is objective.

(‘Objective' can be interpreted as: the knowledge shared is not influenced by personal feelings or opinions in considering/representing facts.)

1. …
2. …
3. …
…

4. The knowledge shared between me and … is unbiased.

('Unbiased' can be interpreted as: the knowledge shared is showing no prejudice for or against something/impartial.)

1. …
2. …
3. …
…

5. The knowledge shared between me and … is believable.

('Believable' can be interpreted as: the knowledge shared is able to be credible.)

1. …
2. …
3. …
…

6. The knowledge shared between me and … is current.

('Current' can be interpreted as: the knowledge shared is widespread and in circulation.)

1. …
2. …
3. …
…

7. The knowledge shared between me and … is updated.

('Updated' can be interpreted as: the knowledge shared is up-to-date.)

1. …
2. …
3. …
…

8. The knowledge shared between me and … adds value for decision-making.

('the knowledge shared adds value for decision making' can be interpreted as: the knowledge being shared between us is useful/beneficial when decisions have to be made.)

1. …
2. …
3. …
…

9. The knowledge shared between me and … adds value to the team's operations.

('the knowledge shared adds value to the team's operations' can be interpreted as: the knowledge being shared between us is useful/beneficial for the whole team's performance.)

1. …
2. …
3. …
…

10. The knowledge shared between me and … gives my team competitive advantage.

('the knowledge shared gives my team competitive advantage' can be interpreted as: the knowledge shared contributes in a way that gives the project team a superior/preferred position.)

1. …
2. …
3. …
…

11. The knowledge shared between me and … is relevant to our tasks.

('relevant to our task' can be interpreted as: the knowledge shared is closely connected to our current assignments.)

1. …
2. …
3. …
…

12. The knowledge shared between me and … is appropriate to our jobs.

(’appropriate to our jobs’ can be interpreted as: the knowledge shared is suitable for your position in the team.)

1. …
2. …
3. …
…

13. The knowledge shared between me and … is context-specific.

(The same knowledge may have different meanings in different context (time, place, goals) ’context-specific’ can be interpreted as: the knowledge shared is relevant for the specific settings we work in.)

1. …
2. …
3. …
…

14. The knowledge shared between me and … is actionable.

(‘actionable’ can be interpreted as: the knowledge shared has practical value.)

1. …
2. …
3. …
…

15. The knowledge shared between me and … is adaptable.

(‘adaptable’ can be interpreted as: the knowledge shared can be modified for a new use or purpose.)

1. …
2. …
3. …
…

16. The knowledge shared between me and … is expandable.

(‘expandable’ can be interpreted as: the knowledge shared between us can without difficulties be passed on to other team members.)

1. …
2. …
3. …
…

17. The knowledge shared between me and … is applicable to our tasks.

(‘applicable to our tasks’ can be interpreted as: the knowledge shared is used to solve problems.)

1. …
2. …
3. …
…

18. The knowledge shared between me and … increases effective actions.

(‘increases effective actions’ can be interpreted as: the knowledge shared helps to solve problems quickly.)

1. …
2. …
3. …
…

19. The knowledge shared between me and ... can be characterized as being of high quality.

1. …
2. …
3. …
…

20. Do you in general consider the knowledge shared in the project as being of high quality? (You can answer in Norwegian or English)

Thank you for helping me with my master thesis!

9.3 APPENDIX 3 – Matrices

9.3.1 How to Read a Matrix

When you handle many respondents, a good way to represent information about social networks in the form of matrices (Hanneman & Riddle, 2005). Hence, one of the ways to portray the gathered data is to place the respondents in a matrix, which is consisting of rows and columns. If we for example take the respondents in Team 1, they have been given a random number from 1 to 16 and been placed in a 16 x 16 matrix. This study uses directional ties, thus the matrix will be asymmetric. Both the rows and the columns indicate the sixteen respondents. The rows represent the source of the directed ties, whereas the columns represent the targets (Hanneman & Riddle, 2005). Consequently, one reads the matrix "from row to column". For example will Matrix 1 in Appendix 3, that shows Team 1's close relationship network, display that respondent 1 (row) reports close relationships with respondents 1 and 11 (columns). In the following you will find matrices with collected data from each of the four virtual teams.

9.3.2 Matrices from Team 1

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	x	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0
2	0	x	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	1	0	x	0	0	0	0	0	0	0	1	0	0	0	0	0
4	0	0	0	x	0	1	0	0	0	0	0	0	0	0	0	0
5	0	0	0	0	x	0	1	0	0	1	0	1	0	0	1	1
6	0	1	0	1	0	x	0	0	0	0	0	1	1	0	0	0
7	0	0	0	0	1	0	x	0	0	1	0	0	0	0	1	0
8	0	0	0	0	0	0	0	x	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	x	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	x	0	0	0	0	0	0
11	1	0	1	0	0	0	0	0	0	0	x	0	0	0	0	0
12	0	1	0	0	0	1	0	0	0	0	0	x	0	0	0	0
13	0	0	0	0	0	0	0	0	0	0	0	0	x	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	x	0	0
15	0	0	0	0	0	0	0	0	0	0	0	1	0	0	x	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	x

MATRIX 1: Close Relationship Network – Team 1

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	x	1	1	0	0	0	0	0	1	0	1	1	1	0	0	0
2	0	x	0	0	0	1	0	0	0	1	1	1	1	0	1	0
3	1	0	x	0	0	0	0	0	0	0	1	1	1	0	0	0
4	0	1	0	x	0	0	0	0	0	0	0	1	1	0	0	0
5	0	0	0	0	x	1	1	0	0	1	0	1	0	0	1	0
6	0	1	0	0	0	x	0	0	0	0	0	1	1	0	1	0
7	0	0	0	0	1	1	x	0	0	1	0	1	0	0	1	0
8	0	0	0	0	0	0	0	x	0	0	0	0	0	0	0	0
9	0	1	0	0	0	1	0	0	x	0	0	1	0	1	0	0
10	0	0	0	0	0	0	0	0	0	x	0	0	0	0	0	0
11	1	1	1	0	0	0	0	0	0	0	x	0	1	0	0	0
12	0	1	0	1	1	1	0	0	0	0	0	x	1	0	1	0
13	0	1	1	1	0	1	0	1	0	0	1	1	x	1	1	0
14	0	0	0	0	0	0	0	0	1	0	0	0	1	x	0	0
15	0	1	0	0	0	1	0	0	0	0	0	1	0	0	x	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	x

MATRIX 2: Competence-based Trust Network – Team 1

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	x	1	1	0	0	0	0	1	1	0	1	1	1	0	0	0
2	0	x	0	0	0	0	0	0	0	0	0	0	0	0	0	0
3	1	0	x	0	0	0	0	0	0	0	1	0	1	0	0	0
4	0	0	0	x	0	0	1	0	0	0	0	1	1	0	0	0
5	0	0	0	0	x	0	0	0	0	0	0	0	0	0	0	1
6	0	0	0	0	0	x	0	0	0	0	0	1	1	0	0	0
7	0	1	0	1	1	1	x	1	1	1	0	1	0	0	1	1
8	0	0	0	0	0	0	0	x	0	0	0	0	0	0	0	0
9	0	0	0	0	0	0	0	0	x	0	0	0	0	0	0	0
10	0	0	0	0	0	0	0	0	0	x	0	0	0	0	0	0
11	1	0	1	0	0	0	0	0	0	0	x	0	0	0	0	0
12	0	1	0	1	1	1	0	0	0	0	0	x	1	0	1	0
13	0	1	1	1	0	1	0	0	1	0	0	1	x	0	0	0
14	0	0	0	0	0	0	0	0	0	0	0	0	0	x	0	0
15	0	1	0	0	0	1	0	0	0	0	0	1	0	0	x	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	x

MATRIX 3: Benevolence-based Trust Network – Team 1

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	x	1	1	0	0	0	0	0	1	0	1	1	1	0	0	0
2	1	x	0	1	0	0	0	0	1	0	1	1	1	0	0	0
3	1	0	x	0	0	0	0	0	0	0	1	0	0	0	0	0
4	0	1	0	x	0	0	0	0	0	0	0	0	1	0	0	0
5	0	0	0	0	x	0	0	0	0	0	0	0	0	0	0	0
6	0	1	0	0	0	x	0	0	0	1	0	1	1	0	0	0
7	0	0	0	0	1	0	x	0	0	1	0	0	0	0	0	1
8	0	0	0	0	0	0	0	x	0	0	0	0	0	0	0	0
9	0	1	0	0	0	0	0	0	x	0	0	0	0	1	0	0
10	0	0	0	0	0	0	0	0	0	x	0	0	0	0	0	0
11	1	1	1	0	0	0	0	0	0	0	x	0	0	0	0	0
12	0	1	0	0	0	0	0	0	0	0	0	x	0	0	0	0
13	0	1	0	1	0	1	0	0	0	0	0	0	x	0	0	0
14	0	0	0	0	0	0	0	0	1	0	0	0	0	x	0	0
15	0	0	0	0	0	0	0	0	0	0	0	0	0	0	x	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	x

MATRIX 4: Daily Communication Network – Team 1

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	x	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
2	0	x	1	0	1	1	1	1	0	1	0	0	0	1	1	0
3	0	0	x	0	0	0	0	0	0	0	0	0	0	0	0	0
4	0	0	0	x	0	1	1	0	1	0	0	1	0	0	0	0
5	0	1	0	0	x	1	1	1	0	0	0	1	0	0	1	0
6	0	0	0	1	1	x	1	1	1	0	0	0	0	0	1	0
7	0	1	0	1	0	1	x	1	1	0	0	1	0	0	1	0
8	0	0	0	0	0	0	0	x	0	0	0	0	0	0	0	0
9	0	0	0	1	1	0	0	1	x	0	0	0	1	0	0	0
10	0	0	0	0	0	0	0	0	0	x	0	0	0	0	0	0
11	0	0	0	0	0	0	0	0	0	0	x	0	1	0	0	0
12	1	0	0	1	0	1	0	0	0	0	0	x	1	0	0	0
13	0	0	1	0	0	0	0	1	1	0	1	1	x	0	0	0
14	0	1	0	0	0	0	0	0	0	0	0	0	0	x	0	0
15	0	1	0	0	1	1	1	1	1	0	0	1	0	0	x	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	x

MATRIX 5: Weekly Communication Network – Team 1

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
1	x	1	1	1	0	0	0	1	1	0	1	1	1	0	0	0
2	0	x	0	0	0	0	0	0	1	0	1	1	1	0	0	0
3	1	0	x	0	0	0	0	0	0	0	1	0	0	0	0	0
4	1	0	0	x	0	0	0	0	0	0	0	0	1	0	0	0
5	0	1	0	0	x	0	1	1	0	0	0	0	0	0	0	0
6	0	1	0	0	0	x	0	0	0	1	0	1	1	0	1	0
7	0	0	0	0	1	0	x	0	0	1	0	0	0	0	0	1
8	0	0	0	0	0	0	0	x	0	0	0	0	0	0	0	0
9	0	1	0	0	0	0	0	0	x	0	0	0	0	1	0	0
10	0	0	0	0	0	0	0	0	0	x	0	0	0	0	0	0
11	1	1	1	0	0	0	0	0	0	0	x	0	0	0	0	0
12	0	1	0	0	0	1	0	0	0	0	0	x	0	0	0	0
13	0	1	0	1	0	0	0	0	0	0	0	0	x	0	0	0
14	0	0	0	0	0	0	0	0	1	0	0	0	0	x	0	0
15	0	0	0	0	0	0	1	0	0	0	0	1	0	0	x	0
16	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	x

MATRIX 6: Time Spent on Interaction Network – Team 1

9.3.3 Matrices from Team 2

	1	2	3	4	5	6	7
1	x	1	1	1	1	1	1
2	0	x	0	1	0	0	0
3	0	0	x	1	0	1	1
4	0	1	1	x	0	0	1
5	0	0	0	1	x	0	1
6	0	0	0	0	0	x	0
7	0	1	1	1	1	1	x

MATRIX 7: Close Relationship Network – Team 2

	1	2	3	4	5	6	7
1	x	1	1	1	1	1	1
2	1	x	1	1	1	1	1
3	1	1	x	1	1	1	1
4	1	1	1	x	1	1	1
5	1	1	1	1	x	1	1
6	1	1	1	1	1	x	1
7	1	1	1	1	1	1	x

MATRIX 8: Competence-based Trust Network – Team 2

	1	2	3	4	5	6	7
1	x	1	1	1	1	1	1
2	0	x	0	0	1	0	0
3	0	0	x	1	0	1	1
4	0	1	1	x	0	1	1
5	0	0	0	1	x	0	1
6	0	0	0	1	0	x	1
7	0	0	1	1	1	1	x

MATRIX 9: Benevolence-based Trust Network – Team 2

	1	2	3	4	5	6	7
1	x	0	1	1	0	0	0
2	0	x	0	0	0	0	0
3	1	0	x	1	1	1	1
4	1	1	1	x	1	1	1
5	0	0	0	1	x	0	0
6	0	0	1	1	1	x	0
7	0	0	0	1	1	0	x

MATRIX 10: Daily Communication Network – Team 2

	1	2	3	4	5	6	7
1	x	1	0	0	1	1	1
2	0	x	0	1	1	0	1
3	0	1	x	0	0	0	0
4	0	0	0	x	0	0	0
5	0	1	1	0	x	1	1
6	1	1	0	0	0	x	1
7	0	0	1	0	0	1	x

MATRIX 11: Weekly Communication Network – Team 2

	1	2	3	4	5	6	7
1	x	0	0	1	0	0	0
2	0	x	0	1	0	0	0
3	0	0	x	1	0	0	0
4	0	1	1	x	0	0	1
5	0	0	0	1	x	0	1
6	0	0	1	1	1	x	0
7	0	0	1	1	1	0	x

MATRIX 12: Time Spent on Interaction Network – Team 2

9.3.4 Matrices from Team 3

	1	2	3	4	5	6	7	8	9
1	x	0	0	0	0	0	0	0	1
2	0	x	0	0	1	0	0	1	1
3	0	0	x	0	0	0	0	0	0
4	0	1	0	x	0	0	0	0	1
5	0	0	0	0	x	0	0	0	0
6	0	0	0	0	0	x	0	0	0
7	0	0	0	0	0	0	x	0	0
8	0	1	0	0	0	0	0	x	0
9	0	0	0	0	0	0	0	1	x

MATRIX 13: Close Relationship Network – Team 3

	1	2	3	4	5	6	7	8	9
1	x	1	0	0	0	0	1	0	1
2	0	x	1	1	0	0	0	1	1
3	0	0	x	0	0	0	0	0	0
4	1	1	1	x	1	1	1	1	1
5	0	1	0	0	x	0	0	1	1
6	0	0	0	0	0	x	0	0	0
7	0	0	0	0	0	0	x	0	0
8	0	1	1	1	1	0	1	x	1
9	1	1	0	1	0	0	1	1	x

MATRIX 14: Competence-based Trust Network – Team 3

	1	2	3	4	5	6	7	8	9
1	x	0	0	0	0	0	0	0	0
2	0	x	1	1	1	0	1	1	1
3	0	0	x	0	0	0	0	0	0
4	0	0	0	x	0	0	0	0	1
5	0	0	0	0	x	0	0	0	0
6	0	0	0	0	0	x	0	0	0
7	0	0	0	0	0	0	x	0	1
8	0	1	0	0	1	0	0	x	1
9	1	1	0	0	0	0	1	1	x

MATRIX 15: Benevolence-based Trust Network – Team 3

	1	2	3	4	5	6	7	8	9
1	x	0	0	1	0	0	1	0	1
2	0	x	1	1	1	0	0	1	1
3	0	0	x	0	0	0	0	0	0
4	0	1	0	x	0	0	0	0	1
5	0	1	0	0	x	0	0	1	0
6	0	0	0	0	0	x	0	0	0
7	0	0	0	0	0	0	x	0	0
8	0	1	0	0	1	0	0	x	0
9	1	0	0	0	0	0	1	0	x

MATRIX 16: Daily Communication Network – Team 3

	1	2	3	4	5	6	7	8	9
1	x	1	0	0	0	0	0	0	0
2	1	x	0	0	0	0	1	0	0
3	0	0	x	0	0	0	0	0	0
4	1	0	1	x	1	1	1	0	0
5	0	0	1	0	x	1	0	0	1
6	0	0	0	0	0	x	0	0	0
7	1	1	0	0	0	0	x	0	1
8	0	0	1	0	0	0	0	x	1
9	0	1	0	0	0	0	0	1	x

MATRIX 17: Weekly Communication Network – Team 3

	1	2	3	4	5	6	7	8	9
1	x	0	0	0	0	0	1	0	1
2	0	x	0	1	1	0	0	1	1
3	0	0	x	0	0	0	0	0	0
4	1	1	0	x	0	0	1	0	1
5	0	1	0	0	x	0	0	1	0
6	0	0	0	0	0	x	0	0	0
7	0	0	0	0	0	0	x	0	0
8	0	1	0	0	1	0	0	x	0
9	0	1	0	0	0	0	1	0	x

MATRIX 18: Time Spent on Interaction Network – Team 3

9.3.5 Matrices from Team 4

	1	2	3	4	5	6	7	8
1	x	1	0	1	1	0	1	0
2	1	x	0	1	1	0	0	0
3	0	0	x	0	0	0	0	0
4	1	1	0	x	0	0	0	0
5	1	1	0	1	x	0	0	0
6	0	0	0	0	0	x	0	1
7	1	0	0	0	0	0	x	0
8	0	0	0	0	0	1	0	x

MATRIX 19: Close Relationship Network – Team 4

	1	2	3	4	5	6	7	8
1	x	1	0	1	1	1	1	1
2	1	x	0	1	1	1	1	1
3	1	1	x	1	1	1	1	1
4	1	1	1	x	1	1	1	1
5	1	1	1	1	x	1	1	1
6	1	1	0	1	1	x	1	1
7	1	1	1	1	1	1	x	1
8	1	1	0	0	1	1	1	x

MATRIX 20: Competence-based Trust Network – Team 4

	1	2	3	4	5	6	7	8
1	x	1	0	1	1	1	1	0
2	1	x	0	1	1	0	0	0
3	0	0	x	0	0	0	0	0
4	1	0	0	x	0	0	0	0
5	1	1	0	1	x	0	0	0
6	1	1	1	1	1	x	1	1
7	1	0	0	0	0	1	x	0
8	1	0	0	0	0	1	0	x

MATRIX 21: Benevolence-based Trust Network – Team 4

	1	2	3	4	5	6	7	8
1	x	1	0	0	0	0	0	0
2	1	x	0	0	0	0	0	0
3	1	0	x	0	0	0	0	0
4	0	0	0	x	0	0	0	0
5	0	0	0	0	x	0	0	0
6	0	0	0	0	0	x	0	0
7	0	0	0	0	0	0	x	0
8	0	0	0	0	0	0	0	x

MATRIX 22: Daily Communication Network – Team 4

	1	2	3	4	5	6	7	8
1	X	0	1	1	1	1	1	1
2	0	X	1	1	1	1	1	1
3	0	1	X	1	0	0	0	0
4	1	1	0	X	1	1	1	0
5	1	1	0	1	X	0	0	0
6	1	1	0	1	0	X	0	0
7	1	1	0	1	0	0	X	0
8	1	0	0	0	0	0	0	X

MATRIX 23: Weekly Communication Network – Team 4

	1	2	3	4	5	6	7	8
1	X	1	0	1	1	1	1	0
2	1	X	0	1	1	0	1	0
3	1	0	X	0	0	0	0	0
4	1	1	0	X	1	1	0	0
5	1	1	0	1	X	0	0	0
6	1	0	0	1	0	X	0	0
7	1	1	0	0	0	0	X	0
8	1	0	0	0	0	0	0	X

MATRIX 24: Time Spent on Interaction Network – Team 4

Elise Nettelhorst Letrud

BI – Norwegian Business School

Preliminary Thesis Report

- Knowledge Sharing in Virtual Teams -

Investigating the Relationship Between Social Interaction Ties and the Quality of Knowledge

Hand-in date:
01.03.2012

Campus:
BI Oslo

Examination code and name:
GRA 19002 - Preliminary Thesis Report

Supervisor:
Tom Rosendahl

Programme:
Master of Science in Leadership and Organizational Psychology

Abstract

Virtual teams enable knowledge sharing to exceed boundaries of time and space, and for these reasons they might potentially be more viable promoters of knowledge sharing compared to traditional teams. Moreover teams that develop high-quality knowledge sharing mechanisms will be more likely to accomplish tasks effectively. The relationships between actors in the social network in a virtual team indicate what kind of knowledge is being shared, between whom and to what extent, and the value of these social relationships constitutes an individual's social capital. The purpose of this paper is to present an overview over selected theories, and enlightened by these theories, argue that the social interaction ties that connect the members of a virtual team are positively associated with the quality of knowledge shared in these ties. Social interaction ties are represented by the strength of the relationships, the amount of time spent, and communication frequency, while quality is depicted by the relevance, understandability, accuracy, reliability and timeliness of the knowledge shared.

Table of Contents

1. Introduction

Virtual teams are becoming increasingly widespread in today's organisations. In fact, as collaboration within and across distributed teams, as well as organisational borders is made possible du to highly developed technologies, most teams can to some extent be characterized as virtual (Martins, Gilson, & Maynard, 2004). Teams that develop high-quality knowledge sharing mechanisms will be more likely to accomplish tasks effectively (Rosen, Furst, & Blackburn, 2007). Virtual teams can be comprised of expert members regardless of location (Townsend, DeMarie, & Hendrickson, 1998), and as a consequence, the use of these teams enables knowledge sharing to exceed boundaries of time and space (Saunders & Ahuja, 2006). Moreover individuals do not work, learn, or share knowledge in isolation, but are embedded in social networks (Wang & Noe, 2010). However networks are often limited by patterns of interaction (Westphal, Seidel, & Stewart, 2001), or participation in a common activity (Owen-Smith & Powell, 2003). This does not mean that networks are isolated from the rest of the world, but due to analytical purposes, an assumption of network boarders are necessary (Wasserman & Faust, 1994), hence this paper will have focus on the network within a virtual team.

The value of an individual's social relationships can be seen as that person's social capital (Burt, 1992), consequently valuable relationships will lead to creation of social capital, and the most valuable asset accessed through these relationships is knowledge (Maznevski & Atanassiou, 2003). Network ties between individuals can enhance the quality of information, and in virtual teams the number of direct ties have been shown to positively relate to the quantity and perceived helpfulness of the knowledge shared (Wang & Noe, 2010). Consequently, the relationships in a social network indicate what kind of knowledge is being shared, between whom, and to what extent (Haythornthwaite, 1996b).

Social interaction ties are represented by the strength of the relationships, the amount of time spent, and communication frequency among members (Chiu, Hsu, & Wang, 2006). Strong ties are desirable, as they aid the development of trust and reciprocity (Krackhardt, 1992), which again enable parties to exchange complex information that might not be transferred over weaker links (Hansen, 1999). Further it has been shown that in virtual teams, trust is likely to be facilitated by frequent interaction (Rosen, Furst, & Blackburn, 2007), and

frequently communications between individuals that have strong emotional attachments are more likely to share knowledge than those who communicate infrequently or those who are less emotionally attached (Reagans & McEvily, 2003). For these reasons this paper aims to build and investigate theory behind the relationship between social interaction ties and the quality of knowledge shared over these ties. That is to say to show that the knowledge that flows in strong social interaction ties will have a higher quality than the knowledge that flows in the weaker ties. This will be done by a two-staged study. The first stage will be to map the virtual team's social network ties. For this reason a Social Network Analysis will be conducted. To determine the quality on the knowledge that flows in these relationships, the second stage will consist of qualitative analysis in the form of unstructured interviews. Consequently, this study aims to show that the strength of the relationships, the amount of time spent, and communication frequency among members of a virtual team will be positively associated with the relevance, understandability, accuracy, reliability and timeliness of the knowledge that is shared. Accordingly the following research question is suggested:

Will the social interaction ties between members of a virtual team be positively associated with the quality of knowledge shared?

2. Knowledge and Knowledge Sharing

2.1 The Concept of Knowledge

Knowledge is a widely debated concept without any agreed-upon definition, and different views of the concept exist in the knowledge management field. Knowledge and information have a tendency to be treated as equals (Wang & Noe 2010), however, knowledge and information can be distinguished from data. Whereas data represent raw numbers and letters, and provides no meaning without a context, information is regarded as processed data (Wang & Noe, 2010). This paper adopts the view that information can be transformed to knowledge by being combined with experience, context, interpretation, and reflection. Subsequently, knowledge represents action and development, and can be characterized as both dynamic and personal (Filstad, 2010). This paper further focuses attention on the subjective and social constructed nature of knowledge (Alveson & Kärreman,

2001), and from this socio-cultural perspective, it is argued that knowledge is constructed and negotiated through social interaction (Newell, Robertson, Scarbrough, & Swan, 2009).

It is possible to delineate between two types of knowledge, namely explicit and tacit (Filstad & Blåka, 2007; Newell et al. 2009). Although the two are often interconnected, they presuppose different methods of sharing knowledge. *Explicit knowledge* refers to knowledge that can be easily articulated, stored, and reused, and as a result, this type of knowledge can relatively easily be transmitted to others through the use of language, numbers, and symbols (Filstad, 2010). Consequently, the transparency of explicit knowledge makes it available to everyone who desires it (Filstad & Blåka, 2007). *Tacit knowledge* is referred to as know-how, which again is highly personalized, based on individual experiences, context-dependent, and anchored in practical work (Newell et al., 2009). The two types are complimentary in the sense that tacit knowledge gives meaning to explicit knowledge (Maznevski & Athanassiou, 2003). Consequently, tacit knowledge cannot be communicated in the same way as explicit knowledge, therefore tacit knowledge creates different challenges related to knowledge sharing (Filstad, 2010). Moreover, although the two types of knowledge are interconnected, they accordingly presume different methods of sharing knowledge.

2.2 The Premise of Knowledge Sharing

In the same way as knowledge is a debated topic, so is the topic of knowledge sharing. Most definitions include an element of movement of knowledge from person, unit or organisation to another that enables creation, acquisition, integration and use of knowledge (Staples & Webster, 2008). A definition that is in line with the socio-cultural view that has been adopted in this paper, knowledge sharing is explained as mutual exchange of both tacit and explicit knowledge and a joint creation of knowledge (Van den Hooff & De Ridder 2004).

The knowledge sharing process can be influenced by different features of the knowledge that is shared, characteristics of the sharer, and the features of the context in which the sharing is executed (Mooradian, Renzl, & Matzler, 2006). The antecedents of the various processes that affect knowledge sharing can be divided into four dimensions (Mooradian, Renzl, & Matzler, 2006). The first

dimension refers to *properties of the knowledge itself*, that is, tacit and explicit, where tacit knowledge is seen as much more difficult to communicate and share than explicit knowledge. The second dimension focuses on *properties of the management and its actions*, and describes the way in which management facilitates for knowledge sharing through coordination, rewards, and incentives. The third dimension concerns *properties of the environment*, both on a macro and micro level, including organisational culture, shared language, interpersonal ties between organisational members, and shared vision. The last dimension regards *properties of the individual*, such as trust, motives, and attitudes that affect knowledge sharing (Mooradian, Renzl, and Matzler 2006). Consequently, the process of knowledge sharing is both complex and uncertain (Filstad, 2010), indicating that there are several barriers to overcome.

There are mainly two types of strategies to facilitate sharing, namely *codification* and *personalization* (Hansen, Nohria, & Tierney, 1999). By *codification* strategies the organisation seeks to capture knowledge by identifying, codifying and storing it, while *personalization* strategies seek to enable knowledge sharing through direct or indirect contact (Bordia, Irmer, & Abusah, 2006). Consequently, the two strategies entail two very distinct contexts. Codification demands a database, which is quite commonly used by virtual teams, as it can be characterized a potentially large audience with different levels of expertise, whereas personalization strategies require an interpersonal context (Bordia, Irmer, & Abusah, 2006). Organisations have tended to focus on codification strategies, hence developing information and communication technologies (ICTs) to facilitate sharing of explicit knowledge, thus more or less neglected the task of facilitating tacit knowledge (Holste & Fields, 2009). However, there exist indications of employees preferring to share knowledge interpersonally rather than through a database (Bordia, Irmer, & Abusah, 2006). Moreover, the process of sharing explicit knowledge differs from the process of sharing tacit knowledge. In other words, when the knowledge is explicit, the organisation needs an appropriate ICT system to facilitate sharing, while interpersonal relationships and trust are more important to facilitate sharing of tacit knowledge.

3. Virtual Teams and Knowledge Sharing

3.1 Classification of Virtual Teams

Virtual teams or so-called *distributed teams* can be defined as "teams whose members use technology to varying degrees in working across locational, temporal, and relational boundaries to accomplish an interdependent task" (Martins, Gilson, & Maynard, 2004, p. 808). Research tends to treat all distributed teams the same, describing them as geographically distributed and temporary (Martins, Gilson, & Maynard, 2004). However, recently we find discussions about the virtuality in teams along a continuum using dimensions such as time, space and organisational boundaries (Bell & Kozlowski, 2002; Griffith, Sawyer, & Neale, 2003; Martins, Gilson, & Maynard, 2004). Since there is no cut off point where a team becomes virtual, we can expect that the more dimensions the team include, the more virtual it is (Zigurs, 2003).

Communication technologies have been developed as tools to enable virtual teams to exceed boundaries of time and space (Saunders & Ahuja, 2006), hence technology has changed the social interaction among individuals (Katona, Zubcsek & Sarvary, 2011), thus. The technology employed in virtual teams includes e-mails, discussion boards, telephone- and video-conferences, among others. This range of tools is used to replace or supplement a lack of direct face-to-face contact, which forms one of the major distinctions between virtual and collocated teams (Bell & Kozlowski, 2002). The technologies differ in their extent of *media-richness* (Hinds & Weisband, 2003) and *degree of synchronisation* (Malhotra, Majchrzak, & Rosen, 2007). For example whereas video-conferences are high on both media-richness and synchronisation, e-mails are low on both dimensions.

3.2 Knowledge Sharing in Virtual Teams

Virtual teams can be comprised of expert members regardless of location (Townsend, DeMarie, & Hendrickson, 1998), hence the use of these teams enables knowledge sharing to exceed boundaries of time and space (Saunders & Ahuja, 2006). For these reasons virtual teams may potentially be more viable promoters of knowledge sharing compared to individuals or more traditional teams (Kauppila, Rajala, & Jyrämä, 2011).

Because virtual teams may lack formal rules, procedures or clear reporting relationships, communication is the key to success (Ahuja & Carley, 1999). While communication technologies can serve as a platform to facilitate the process of sharing knowledge in virtual teams, it is network relationships that serve as the actual bonds that help team members overcome geographic constraints (Yuan & Gay, 2006). Internal networks provide the team with opportunities to exploit information the firm already holds (Collins & Clark, 2003), and close social interaction will make individuals able to increase the depth, breath and efficiency of knowledge sharing (Lane & Lubatkin, 1998).

Recurrent communications between individuals that have strong a emotional attachment, will make them more likely to share knowledge than those who communicate infrequently or those who are less emotionally attached (Reagans & McEvily, 2003), and in virtual teams, trust is likely to be facilitated by frequent interaction (Rosen, Furst, & Blackburn, 2007). In particular, trust in virtual teams will affect the quality and quantity of knowledge sharing (Rosen, Furst, & Blackburn, 2007). Trust influences the sharing of knowledge through reducing ambiguity experienced by virtual team members who do not have a common social history, thus help them interpret the other part's behaviour (Jarvenpaa, Shaw, & Staples, 2004). In short, developing trust in virtual teams is crucial, but also challenging as trust is closely connected to some form of physical contact (Handy, 1995).

Shared language is defined as acronyms and underlying assumptions that are the staples of day-to-day interactions, and is developed in the process of interaction through the use of communication technology. Consequently, the team members' shared language will facilitate the ability to gain access to other people in the network and their information, and provide a common conceptual apparatus for evaluating the likely benefits of exchange of information (Chiu, Hsu, & Wang, 2006).

Explicit knowledge can easily be shared to all team members using for example e-mail, discussion forums, or electronic bulletin boards. Predominantly, teams that are distributed will be more inclined to share knowledge that is explicit in nature, because this kind of declarative knowledge is more easily supported by technology. Tacit knowledge is acquired from experience, thus healthy social relationships, that is to say social capital, will be important for the sharing of tacit knowledge (Maznevski & Atanassiou, 2003). The ability to facilitate the sharing

of explicit, but maybe more importantly, the sharing of tacit knowledge in virtual teams is crucial to organisations as knowledge sharing is considered to be closely linked to establishing competitive advantage (Filstad & Blåka, 2007).

4. Introducing Social Capital and Social Networks

4.1 Social Capital Theory

Different scholars define social capital differently, but most agree that it exists through social structure and can create a competitive advantage for certain individuals or groups in pursuing their ends (Burt, 2001). Nahapiet and Ghoshal (1998, p. 243) define social capital as "the sum of the actual and potential resources embedded within, available through, and derived from the network of relationships possessed by an individual or social unit". Social capital can reside in individuals, teams and organisations; however, it exists only through a specific relationship between two people or groups (Maznevski & Athanassiou, 2003), therefore in contrast to financial and human capital, social capital is not owned by a single individual, but jointly by both parts in the relationship (Burt, 1992; Maznevski & Athanassiou, 2003). Social capital apprehends the impersonal configuration of linkages between actors and the quality of these linkages (Nahapiet & Ghoshal, 1998), and to be able to understand a relationship between two actors in a network, we need to get an understanding of the relevant relationship, but also look at it in contrasts to the two actors' relationship with other actors in the network (Burt, 1976; Burt, 1992).

Social capital can be divided into three dimensions; structural, relational, and cognitive (Nahapiet & Ghoshal, 1998). The *structural dimension* describes whom you reach and how you reach them (Burt, 1992). It is the pattern of interactions among individuals, and includes the ties or connections among network members as well as the overall network configuration. The *relational dimension* is the affective part of social capital, and refers to the personal relationships people have developed with each other (Nahapiet & Ghoshal, 1998). This dimension takes into consideration the importance of interpersonal trust, existence of shared norms and identification with other individuals in the network, thus, deals with the nature or quality of network connections (Cabrera & Cabrera, 2005). The *cognitive dimension* refers to the resources that provide shared representations, interpretations, and meaning, which again will increase mutual

understanding among individuals and enables them to communicate more effectively.

Even though Nahapiet and Ghoshal (1998) examine the three dimensions of social capital independently, they recognize that several characteristics of social capital might be linked. For example structural configurations, such as network positions, have consistently been associated with relational characteristics as interpersonal affect and trust, which again will affect knowledge sharing (Krackhardt, 1992). Moreover the closeness of relationship between the recipient and the source is a social capital characteristic that facilitates knowledge transfer, especially if the knowledge is tacit (Hansen, 1999; Reagans & McEvily, 2003). This paper chooses to focus on the structural dimension, which determines individuals' opportunity to share, and in this way facilitate knowledge sharing, together with the relational dimension which encourages knowledge sharing by fostering trust and identification in the individual relationships (Cabrera & Cabrera, 2005). Trust is a crucial factor for cooperation in virtual teams, as it in these teams do not exist any reward system that reinforce the mechanism of mutual trust. Under these circumstances social capital becomes very important, because the resources found in the social network will foster their intention and activeness to be apart of the voluntary knowledge sharing behaviour (Chiu, Hsu, & Wang, 2006). Social interaction ties between members of a virtual team will enhance a cost-effective way to access a wide range of knowledge sources, and provide an opportunity to combine and exchange knowledge (Chiu, Hsu, & Wang, 2006).

4.2 Social Network Theory

A social system is a network consisting of a set of relations which links an actor to other actors, and within this social system there could be subsets of similar relations. It could be economic relations linking one actor to specific others, relations of friendship, political relations or status relations, the list has no end, and each of these types of relationships between actors in a social system serves to define a network of relations among the actors (Burt, 1976). Furthermore, a *network* is defined as a structure consisting of a number of actors connected by ties. Each actor (ego) has direct ties to a number of alters, which in turn are connected to other alters (Wasserman & Faust, 1994). Actors that structure their

own networks to optimize their position are able to make the most of the information opportunities present. Consequently well-structured networks provide information benefits in terms of access to information, timing, and referrals (Burt, 1992). Access involves not just receiving valuable knowledge, but is also connected with people that are in need of the knowledge (Haythornthwaite, 1996b). Burt (1992) states that an actor with a network rich in information benefits has contacts established in the places of the network where useful bits of knowledge are likely to be and contacts that provides a reliable flow of information to and from these places. For this reason, the network can promote and legitimate knowledge. At the same time it can promote and legitimate a network member who is instrumental in receiving and forwarding knowledge (Burt, 1980).

4.3 Social Interaction Ties

A fundamental proposition in social capital theory is that the types and strength of relationships between actors in a network will identify an individual's likelihood to come in contact with someone who have the relevant and desired knowledge, and who in addition is willing to share it (Nahapiet & Ghoshal, 1998; Haythornthwaite, 1996b). A *tie* between actors in a social network can further be defined as a set of one or more specific interactions that connect them (Wasserman & Faust, 1994). Each tie an actor has represent an information channel (Anderson, 2008), hence social interaction ties are channels of information and resource flow, that will reduce the amount of time an investment to gather information (Nahapiet & Ghoshal, 1998).

The strength of a tie is a combination of the amount of time, emotional intensity, and intimacy and the reciprocity that characterize the tie (Granovetter, 1973), and the preferred tie strength is contingent on the circumstances (Maznevski & Atanassiou, 2003). Research suggests that strong ties are related to higher emotional closeness and weak ties constitutes non-redundant connections and therefore enable access to non-redundant information (Granovetter, 1973; Burt, 1980). Krackhardt (1992) argues that strong ties are desirable, as they aid the development of trust and reciprocity, which again enable parties to exchange complex information that would not be transferred over weaker links (Hansen, 1999). Moreover strong and close connections between network members

promote the sharing of knowledge among members of a social network. Furthermore actors' information opportunities are affected by who they can make contact with, what information that contacts can provide, and to whom in the network the information can be forwarded for having a positive outcome (Haythornthwaite, 1996b). However as close connections will promote the sharing of knowledge their closeness can also constrain actors. For example will two individuals that have the same connections, have access to the same information, and the case might be that they will not provide any new information (Haythornthwaite, 1996b). Said in another way, people with strong ties are believed to have more of the same information, thus possess more redundant information (Burt, 1997; Granovetter, 1973). On the other hand, weak ties are assumed to provide superior information benefits than strong ties. Moreover, weak ties are expected to be related to larger networks (Anderson, 2008), and thus increase the possibility for gaining novel information from peripheral connections (Granovetter, 1973). However as weak ties might facilitate search, they might impede transfer, especially when knowledge is not codified (Nahapiet and Ghoshal 1998). In sum it may be argued that weak ties can be useful for sharing explicit knowledge, however, strong ties are necessary for sharing tacit and complex knowledge (Hansen, 1999).

In complex work that demands integration of specialized knowledge, people with ties crossing both organisational and departmental boundaries are likely to find more relevant information and be more effective in solving problems (Cross & Cummings, 2004). In addition to technical solutions, both social ties and knowledge sharing are key factors for successful collaboration in virtual teams (Kotlarsky & Oshiri, 2005). However, an unstable network, defined by a high degree of change of memberships in the network, which may be the case in many virtual teams, can limit the creation of social capital, owing the fact that when an actor leaves a network the tie to other actors disappear (Inkpen & Tsang, 2005). If we for example take a close look at the internal network of a virtual team, the network will either be dense, with most people connected to other people in the team, or loose, with fewer ties among the members (Ahuja, 2000). Developing network ties becomes even more crucial for members of virtual teams, because they have only limited opportunities to learn from observing others (Yuan & Gay, 2006), moreover network ties play a large role in which media will be used for communication purposes (Haythornthwaite, 1996a). The sharing of tacit

knowledge is more sensitive to having the right person with the right connection at the right place, thus limiting the number of actors who can contribute to the sharing of tacit knowledge (Reagans & McEvily, 2003). In addition, since tacit knowledge cannot easily be articulated, building strong network ties should be an important strategy for managing knowledge (Yuan & Gay, 2006).

Yuan and Gay (2006) found that members of virtual teams are more likely to build relationships with other team members in the same location. The theory of homophily predicts that people are more likely to interact with individuals that are similar to themselves with respect to a variety of qualities and characteristics (McPherson, Smith-Lovin, & Cook, 2001). However it also supports the reverse effect that the likelihood of interacting with dissimilar others are reduced (Yuan & Gay, 2006). Homophily in location has an important impact of the development of network ties, and affects both group membership and location (Yuan & Gay, 2006).

5. Merging Theories

The preceding paragraphs have taken measures concerning knowledge sharing, and especially the conditions that promote knowledge sharing in virtual teams. Further an overview of social capital theory and social network theory has been given. In the following, lines will be drawn between the presented theories to set a frame for our proposed research question. In addition reasons for why new theories on this novel area of research need to be developed will be stated.

Chiu, Hsu and Wang (2006) found that social interaction ties significantly and positively affected quantity of knowledge sharing. This paper will argue based on established theory that the social interaction ties, will be positively associated with the quality of knowledge shared in these ties. Social interaction ties are represented by the strength of the relationships, the amount of time spent, and communication frequency, while quality is measured by the relevance, understandability, accuracy, reliability and timeliness of the knowledge shared in these ties.

This paper has taken a socio-cultural perspective on knowledge sharing, and argued that knowledge is constructed and negotiated through social interaction. Through close social interaction, individuals are able to increase the depth, breath and efficiency of knowledge sharing (Lane & Lubatkin, 1998), moreover social interaction ties between members of a virtual team will enhance a

cost-effective way to access a wide range of knowledge sources, and provide an opportunity to combine and exchange knowledge (Chiu, Hsu, & Wang, 2006). As mentioned earlier, the strength of a tie is a combination of the amount of time, emotional intensity, and intimacy and the reciprocity that characterize the tie (Granovetter, 1973). Research suggests that strong ties are related to higher emotional closeness and weak ties constitutes non-redundant connections and enables access to non-redundant information (Granovetter, 1973; Burt, 1980), and that strong ties are desirable, as they aid the development of trust and reciprocity (Krackhardt, 1992), which again enables parties to exchange complex information that might not be transferred over weaker links (Hansen, 1999). Moreover trust in virtual teams is likely to be facilitated by frequent interaction (Rosen, Furst, & Blackburn, 2007), and frequently communications between individuals that have strong emotional attachments are more likely to share knowledge than those who communicate infrequently or those who are less emotionally attached (Reagans & McEvily, 2003). For these reasons we argue that the strength of relationships, the amount of time spent and the frequency of interaction connecting members within a virtual team, will be positively associated with the relevance, understandability, accuracy, reliability and timeliness of the knowledge shared between them.

6. Motivation for Further Study

In a dynamic economy, knowledge will be a critical organisational resource that could provide a competitive advantage (Foss & Pedersen, 2002). To gain this competitive advantage, organisations need to focus on ways to effectively exploit knowledge-based resources that already exist within the organisation (Wang & Noe, 2010). Virtual teams are becoming increasingly commonplace in today's society, however this type of teams adds another layer of complexity to team-work in any situation (Cascio, 2000). Therefore teams that develop high-quality knowledge sharing mechanisms will be more likely to accomplish tasks effectively (Rosen, Furst, & Blackburn, 2007), and the ability to facilitate for the sharing of explicit, but maybe more importantly, the sharing of tacit knowledge in virtual teams are crucial to organisations (Filstad & Blåka, 2007).

Collaborative technologies will facilitate virtual work, however the technology alone cannot accomplish higher performance (Cross, Parker, Prusak, & Borgatti, 2001). As relationships are highly critical for obtaining information, more attention must be placed on investigating the relationships that individuals

rely on to accomplish their work (Cross, Parker, Prusak, & Borgatti 2001). Social network researchers do not have a tradition of measuring the diversity of information that flows through networks, instead they assume that the structure alone will determine the information channels (Seibert, Kraimer, & Liden, 2001). This might be a critical argument to investigate the quality of knowledge that flows through these channels. At the same time assessing patterns of relationships that hold a group together might reveal many actionable and interesting points. For example will identifying individuals in the network structure that are central and thus have the opportunity to control the flow of information, help a manger to relocate informational domains, and thus make the team more effective (Cross, Borgatti, & Parker, 2004). On the other side it can be wise to gain an understanding of who is peripheral in the network, and thus invent ways to engage these people so that their expertise may be utilized (Cross, Borgatti, & Parker, 2004).

Mapping the pattern of the flow of information across barriers, might give insight into where management should promote collaboration that provides a strategic benefit (Cross, Borgatti, & Parker, 2004). Moreover, a social network analysis can also give us a broader perspective on information network that cross geographic boundaries, as people in different physical locations have to collaborate effectively, and mapping this network might yield performance improvement opportunities (Cross, Borgatti, & Parker, 2004). However it is important to recognize that one not always want high collaborative activity among individuals. Maintaining relationships takes time, therefore network analysis might yield important insight to which relationships that is worth investing in (Cross, Borgatti & Parker, 2004).

7. Research Design

The choice of research design has to be made from the aims and goals of the study (Flick, 2009). To get a better understanding of how social interaction ties within a virtual team is related to the quality of knowledge shared, a two-part study will be established.

Participants: The Norwegian company Aibel AS is a leading supplier of services in the oil and gas industry and has 4.300 employees in Norway and abroad. Since 2002 Aibel AS has performed maintenance and modification work at the Ekofisk oil field for ConocoPhilips. A unique aspect of this work is that

operations offshore are managed from an operations room located onshore at Aibel's main office in Stavanger, hence this project will serve as a basis for studying virtual teams.

Ethical Considerations: Participation in the study is considered voluntary. All participants will be ensured confidentiality of any gathered information. Prior to the interview, the subjects will sign a consent form, which will ensure anonymity and their right to withdraw at any time without stating a reason. The audiotaped records will be deleted after they are transcribed, and the transcription will remain within the department, and will not be used for other purposes than stated in the consent form.

Stage One

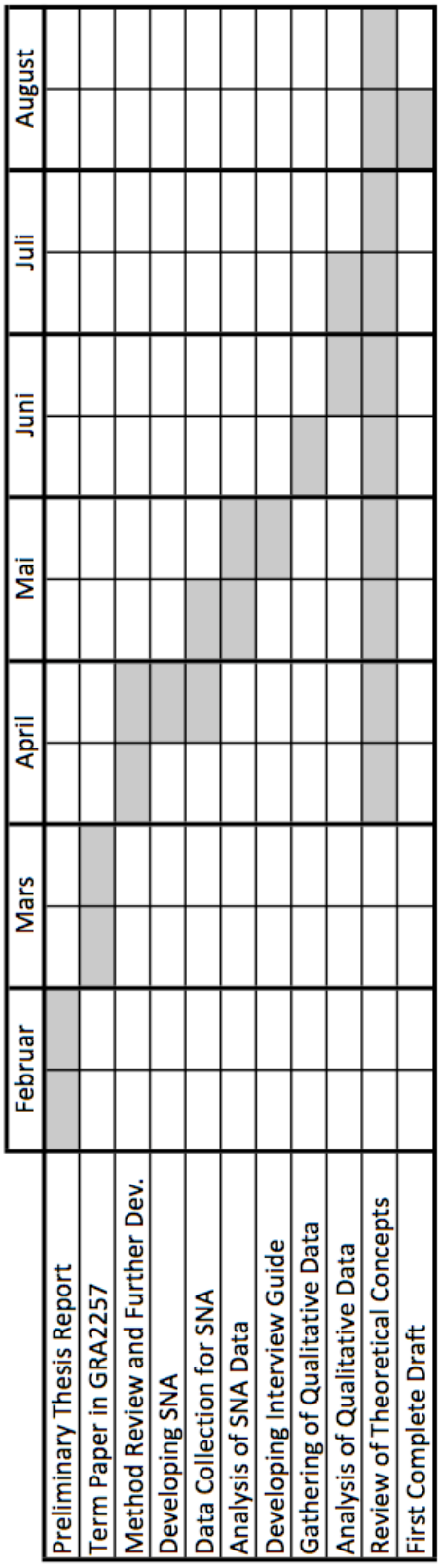
The first step in assessing the information or knowledge flow among members in a group is to identify the informal network among members (Cross, Borgatti, & Parker, 2004). To portray the social interaction ties, the first stage of the study will be to address the strength of relationships, the amount of time spent, and the communication frequency between members of a virtual team. For this reason a Social Network Analysis (SNA) will be performed, as this type of analysis can provide an overview of how work is occurring in informal networks (Cross, Parker, Prusak, & Borgatti, 2001). Binary measures of relations will be used according to Hanneman and Riddle (2005), which is considered the most common measures for scaling relations.

Stage Two

According to Cross, Borgatti and Parker (2002), assessing an information network and just ask who communicates with whom, does not necessarily guarantee that the interaction ties reflect that the information shared is relevant to the work performed within the team. Therefore, after analysing the team members' social interaction ties, the quality of knowledge shared will be assessed. Quality measures will be adopted from DeLone and McLean (2003) and McKinney, Yoon and Zahedi (2002), and relate to relevance, understandability, accuracy, reliability and timeliness of the knowledge shared. For this purpose, qualitative analysis in the form of *interviews, document analysis* and *observations* will be conducted. Semi-structured interviews are chosen since they allow the researcher to tailor the

interview to the specific subject and situation (Flick, 2009). An interview guide will be used as a basis for the interview, and comprise relevant topics and questions grounded in research. Interviews will be audiotaped with the subjects' permission and transcribed verbatim, leaving out words with minimal semantic significance, such as repetitions and hesitations.

7. Plan for Thesis Progression



8. References

Alveson, M., & Kärreman, D. (2001). Odd couple: Making sense of the curious concept of knowledge management. *Journal of Management Studies*, 38(7), 995-1018.

Ahuja, G. (2000). Collaboration networks, structural holes, and innovation: A longitudinal study. *Administrative Science Quarterly, 45*(3), 425-455.

Ahuja, M. K., & Carley, K. M. (1999). Network structure in virtual organizations. *Organization Science, 10*(6), 741-757.

Anderson, M. H. (2008). Social networks and the cognitive motivation to realize network opportunities: a study of managers' information gathering behaviors. *Journal of Organizational Behavior, 29*(1), 51-78.

Bell, B. S., & Kozlowski, S. W. J. (2002). A typology of virtual teams. Implications for effective leadership. *Group and Organization Management*, 27, 14-49.

Bordia, P., Irmer, B. E., & Abusah, D. (2006). Differences in sharing knowledge interpersonally and via databases: The role of evaluation apprehension and perceived benefits. *European Journal of Work and Organizational Psychology, 15*(3), 262-280.

Burt, R. S. (1976). Positions in Networks. *Social Forces, 55*(1), 93-122.

Burt, R. S. (1980). Models of Network Structure. *Annual Review of Sociology, 6*, 79-141.

Burt, R. S. (1997). The contingent value of social capital. *Administrative Science Quarterly, 42*(2), 339-365.

Burt, R. S. (1992). *Structural Holes: The Social Structure of Competition*. Cambridge: Harvard University Press.

Burt, R. S. (2001). Structural Holes Versus Network Closure as Social Capital. In N. Lin, K. Cook, & R. S. Burt (Eds.), *Social Capital: Theory and Research. Sociology and Economics: Controversy and Integration series,* (pp. 31-56). New York: Aldine de Gruyter.

Cabrera, A., & Cabrera, E. F. (2002). Knowledge-sharing dilemmas. *Organization Studies, 23*(5), 687-710.

Cabrera, E. F., & Cabrera, A. (2005). Fostering knowledge sharing through people management practices. *International Journal of Human Resource Management, 16*(5), 720-735.

Cascio, W. F. (2000). Managing a virtual workplace. *Academy of Management Executive, 14*(3), 81-90.

Chiu, C. M., Hsu, M. H., & Wang, E. T. G. (2006). Understanding knowledge sharing in virtual communities: An integration of social capital and social cognitive theories. *Decision Support Systems, 42*(3), 1872-1888.

Collins, C. J., & Clark, K. D. (2003). Strategic human resource practices, top management team social networks, and firm performance: The role of human resource practices in creating organizational competitive advantage. *Academy of Management Journal, 46*(6), 740-751.

Cross, R., & Cummings, J. N. (2004). Tie and network correlates of individual performance in knowledge-intensive work. *Academy of Management Journal, 47*(6), 928-937.

Cross, R., Borgatti, S. P., & Parker, A. (2002). Making Invisible work visible: Using social network analysis to support strategic collaboration. *California Management Review,* 44(2), 25-46

Cross, R., Parker, A., Prusak, A., & Borgatti, S. P. (2001). Knowing what we know: Supporting knowledge creation and sharing in social networks. *Organizational Dynamics, 30*(2), 100-120.

DeLone, W. H., & McLean, E. R. (2003). The Delone and Mclean model of information systems success: a ten-year update. *Journal of Management Information Systems*, 19(4), 9–30.

Filstad, C., (2010). *Organisasjonslæring.* Oslo: Fagbokforlaget.

Filstad, C., & Blåka, G. (2007). *Learning in Organizations.* Oslo: Cappelen.

Flick, U. (2009). *An introduction to qualitative research*. Los Angeles, California: SAGE

Foss, N. J., & Pedersen, T. (2002). Transferring knowledge in MNCs: The role of sources of subsidiary knowledge and organizational context. *Journal of International Management*, 8(1), 49−67.

Granovetter. Ms. (1973). The Strength of Weak Ties. *American Journal of Sociology, 78*(6), 1360-1380.

Griffith, T. L., Sawyer, J. E., & Neale, M. A. (2003). Virtualness and knowledge in teams: Managing the love triangle of organizations, individuals, and information technology. *Mis Quarterly, 27*(2), 265-287.

Handy, C. (1995). Trust and the Virtual Organization. *Harvard Business Review, 73*(3), 40-&.

Hanneman, R., A. & Riddle, M. 2005. *Introduction to social network methods*. Riverside, CA: University of California, Riverside.

Hansen, M. T. (1999).The search-transfer problem: The role of weak ties in sharing knowledge across organization subunits. *Administrative Science Quarterly*, 44(1), 82−111.

Hansen, M. T., Nohria, N., & Tierney, T. (1999). What's your strategy for managing knowledge? *Harvard Business Review*, 77(2), 106−116.

Haythornthwaite, C. (1996a). Media use in support of communication networks in an academic research environment. (Unpublished doctoral dissertation), University of Toronto, Toronto.

Haythornthwaite, C. (1996b). Social network analysis: An approach and technique for the study of information exchange. *Library and Information Science Research*, 18, 323-342.

Hinds, P.J, & Weisband, S. P. (2003). Knowledge sharing and shared understanding in virtual teams. In C. B. Gibson, & S. G. Cohen (Eds.), *Virtual teams that work* (pp. 21-36). San Fransisco, California: Jossey-Bass.

Holste, J. S., & Fields, D. (2010). Trust and tacit knowledge sharing and use. *Journal of Knowledge Management, 14*(1), 128-140.

Van den Hoof, B. & de Ridder, J. A. (2004). Knowledge sharing in context: the influence of organizational commitment, communication climate and CMC use on knowledge sharing. Journal of Knowledge Management, 8(6), 117-130.

Inkpen, A. C., & Tsang, E. W. K. (2005). Social capital, networks, and knowledge transfer. *Academy of Management Review, 30*(1), 146-165.

Jarvenpaa, S. L., Shaw, T. R., & Staples, D. S. (2004). Toward contextualized theories of trust: The role of trust in global virtual teams. *Information Systems Research, 15*(3), 250-267.

Katona, Z., Zubcsek, P. P., & Sarvary, M. (2011). Network Effects and Personal Influences: The Diffusion of an Online Social Network. *Journal of Marketing Research, 48*(3), 425-443.

Kauppila, O. P., Rajala, R., & Jyrama, A. (2011). Knowledge sharing through virtual teams across borders and boundaries. *Management Learning, 42*(4), 395-418.

Kotlarsky, J., & Oshiri, I. (1999). Social ties, knowledge sharing and successful collaboration in globally distributed system development projects. *European Journal of Information Systems*, 14, 37-48.

Krackhardt, D. 1992. The strength of strong ties. In N. Nohria & **R.** G. Eccles (Eds.), *Networks and organizations: Structure, form and action* (pp. 216-239). Boston: Harvard Business School Press.

Lane, P. J., & Lubatkin, M. (1998). Relative absorptive capability and interorganizational learning .*Strategic Management Journal*, 19(5), 461–477.

Malhotra, A., Majchrzak, A., & Rosen, B. (2007). Leading virtual teams. *Academy of Management Perspectives, 21*(1), 60-70.

Martins, L. L., Gilson, L. L., & Maynard, M. T. (2004). Virtual teams: What do we know and where do we go from here? *Journal of Management, 30*(6), 805-835.

Maznevski, M. L., & Atanassiou N. A. (2003). Designing the knowledge-management infrastructure for virtual teams. Building and using social networks and social capital. In C. B. Gibson, & S. G. Cohen (Eds.), *Virtual teams that work* (pp. 196-213). San Fransisco, California: Jossey-Bass.

McKinney, V., Yoon, K., & Zahedi, F. M. (2002). The measurement of Web-customer satisfaction: an expectation and disconfirmation approach. *Information Systems Research*, 13(3), 296-315.

McPherson, M., Smith-Lovin, L., & Cook, J. M. (2001). Birds of a feather: Homophily in social networks. *Annual Review of Sociology*, 27, 415–444.

Mooradian, T., Renzl, B., & Matzler, K. (2006). Who trusts? Personality, trust and knowledge sharing. *Management Learning, 37*(4), 523-540.

Nahapiet, J., & Ghoshal, S. (1998). Social capital, intellectual capital, and the organizational advantage. *Academy of Management Review, 23*(2), 242-266.

Newell, S., Robertson, M., Scarbrough, H., & Swan, J. (2009). *Managing Knowledge Work and Innovation*. 2nd edition. Basingstoke: Palgrave Macmillan.

Owen-Smith, J., & Powell, W. W. (2003). The expanding role of university patenting in the life sciences: assessing the importance of experience and connectivity. *Research Policy, 32*(9), 1695-1711.

Reagans, R. & McEvily, B. (2003). Network structure and knowledge transfer: The effects of cohesion and range. *Administrative Science Quarterly,* 48(2), 240–267.

Rosen, B., Furst, S., & Blackburn, R. (2007). Overcoming barriers to knowledge sharing in virtual teams. *Organizational Dynamics, 36*(3), 259-273.

Saunders, C. S., & Ahuja, M. K. (2006). Are all distributed teams the same? Differentiating between temporary and ongoing distributed teams. *Small Group Research, 37*(6), 662-700.

Seibert, S. E., Kraimer, M. L., & Liden, R. C. (2001). A social capital theory of career success. *Academy of Management Journal*, 44, 219–237.

Staples, D. S., & Webster, J. (2008). Exploring the effects of trust, task interdependence and virtualness on knowledge sharing in teams. *Information Systems Journal, 18*(6), 617-640.

Townsend, A. M., DeMarie, S. M., & Hendrickson, A. R. (1998). Virtual Teams:

Technology and the Workplace of the Future. *Academy of Management Executive*, 12(3), 17-29.

Wang, S., & Noe, R. A. (2010). Knowledge sharing: A review and directions for future research. *Human Resource Management Review, 20*(2), 115-131.

Wasserman, S., & Faust, K. (1994). Social Network Analysis: Methods and Application. Cambridge: Cambridge University Press.

Westphal, J. D., Seidel, M. D. L., & Stewart, K. J. (2001). Second-order imitation: Uncovering latent effects of board network ties. *Administrative Science Quarterly, 46*(4), 717-747.

Yuan, Y. C., & Gay, G. (2006). Homophily of network ties and bonding and bridging social capital in computer-mediated distributed teams. *Journal of Computer-Mediated Communication, 11*(4).

Zaheer, A., McEvily, B., & Perrone V. (1998). Does Trust Matter? Exploring the Effects of Interorganizational and Interpersonal Trust on Performance. *Organization Science*, 9(2), 141-159.

Zigurs, I. (2003). Leadership in virtual teams: Oxymoron or opportunity? *Organizational Dynamics, 31*(4), 339-351.