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Designing for Collaboration Using Social Network Analysis

– Towards a Conceptual Method to Understand Organisational Interaction

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Abstract: The spreading of innovation within organisations is an area of interest for both academics and practitioners. Within information systems research collaboration issues are often addressed and solved through implementation of technology artefacts to meditate communication. With more and more resources being spent on collaborative technologies we argue that there can be cost advantages in looking at the socio-technical aspects of the information system when trying improving organisational communication.

As an initial step of information system interventions we argue that an overview of the information exchange network within organisations can lead to valuable insights into where to start and we argue that social network analysis can provide such an bird's-eye view over organisational interaction. This leads us to our research question: How can social network analysis be used to describe, understand and explain organisational interaction in designing information systems for collaboration?

Taking a design science approach to the research question we aim to construct a meta-artefact, i.e. in our case knowledge about how to design for collaboration with the help of social network analysis. To test the applicability of social network analysis we collect sociometric interaction data from a knowledge intensive organisation using a name generating survey. The usability of the visualisations that are the output of the social network analysis is evaluated by decision makers within the organisation through interviews.

We conclude that social network analysis is a time-efficient method of collecting empirical data that can lead to deep insights into the structure of the organisational communication network. The visualisation can be seen as a map used to pinpoint the emergence of social networks within organisations and thereby acting as a tool to drive continuous change and innovation.

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1. Introduction

This is a thesis about design. More specifically, it explores methods through which we can understand organisational interaction in efforts to design for collaboration. Collaboration is a concept within knowledge-intensive organisations that is increasingly viewed as a key capacity to achieve innovative results in a global context. While contemporary discourse on collaboration focuses on the 'enterprise' (Teasdale, 2012), few studies provide comprehensive methods that consider structural exchange of social interaction by targeting an organisational unit of analysis. We argue that conventional data collection methods used for gathering information about employees' relationships, interactions, and information exchanges for the purpose of design – such as workshops, interviews, and observations – oversee critical abstraction levels of workplace dynamics. Therefore, a bird's-eye view of the distributed nature of modern knowledge work is not provided, which can be an important tool for understanding overarching requirements to effectively design for collaboration. In the light of this, we propose a social network analysis approach that enables us to further identify structural understanding of interaction; analyse their implications for information systems requirements, and thus effectively design for collaboration in organisations.

Consider the following hypothetical situation. As an information systems design consultant, you are hired to carry out an analysis and present design propositions to a multinational organisation describing how they can enhance their cross-border collaboration. The organisation is knowledge-intensive, and its performance thus relies on its capacity to leverage available knowledge and innovation capabilities. You are provided with scarce time and resources, and need to consider an effective and efficient initial step that provides comprehensive analysis and understanding of the current status and characteristics of the collaborative nature of the organisation. You are committed to a problem-solving approach to the task, and to keep an open mind in regards to alternative solutions, whether that is organisational changes through human resources, replacing legacy communication systems with social software for collaboration, or developing customised in-house solutions. This thesis aims to theoretically motivate descriptive design methods and visualisations of organisational interactions through social networks that provide crucial information systems design utility in situations as above.

1.1 Theoretical Problematisation

By looking closer at the title of this thesis, we will get a grasp of what problem is being addressed and what purpose motivates this study. Firstly, *designing* refers to the very core of information systems research, being a design-oriented discipline seeking to advance knowledge to solve problems within the intersection of organisation and information technology (Peffers et al., 2007). As the domain for our inquiry is dominated by a normative discourse that is of limited relevance for practitioners

(Schultze and Leidner, 2002), design science in collaboration research offers a way forward by applying more creative, inventive, and problem-solving thinking to advance towards more descriptive knowledge (Simon, 1996; Hevner et al., 2004; van Aken, 2005). As collaboration in the form of social interaction is seen as an increasingly vital capacity for organisations to attain goals (Robert et al., 2008), there is a need for information systems design theory that describe methods to specify collaboration needs on an organisational level.

Secondly, *collaboration* reflects modern work in knowledge-intensive organisations, which is characterised by knowledge workers who are autonomously engaging in complex and emerging problem-solving contexts that increasingly require interaction with various people and information entities (Augier et al., 2001; Markus et al., 2002). With its close relation to innovation collaborative work is gaining strategic importance as it is getting more pervasive at the workplace, transcending organisational charts and models through social networks (Inkpen and Tsang, 2005; Cross and Parker, 2004). As work and technology are increasingly understood through interaction, studies focusing on collaboration are gaining more relevance in information systems research as the field transcends this fuzzy boundary.

A necessary starting point that needs to precede an effective design is to conceptualise collaboration in the context of our inquiry. An ontology of collaboration can be described as a set of participants that work together towards one or several common goals, where the social interaction between participants form relationships that from a structural level can be viewed as a topology of a collaborative network (Camarinha-Matos and Afsarmanesh, 2006). As collaboration in an organisational setting constitutes shared engagement of participants to work together, share information, and jointly coordinate activities to achieve common goals; their interactions often require the support of artefacts. Roschelle and Teasley (1995, p. 70) describe collaboration as "coordinated, synchronous activity that is the result of a continued attempt to construct and maintain a shared conception of a problem". A vital aspect of this definition is the contextual aspect of the coordinated activity of solving problems (collaboration). Hence, conceptualising collaborative artefacts as stable 'tools' comes with some risk as this assumes that they are settled and independent of organisational or social context (Latour, 1987). In line with Orlikowski and Iacono (2001), we take a view of the collaborative artefact as a productivity enabler that mediates social relations, with respects to a wider organisational practice through which users articulate their knowledge work.

While research within computer-supported cooperative work seeks to understand collaborative practices through ethnomethodological and social constructivist perspectives (Schmidt, 2011), its unit of analysis for information systems design implications is mainly on a group level (Nardi et al., 2002). Other collaboration design studies focus their unit of analysis on the activity between actors and objects drawing upon activity theory (Kutti, 1991; Zander, 2007), however few studies are concerned with structural aspects of collaboration by considering organisational wide interaction. As contemporary discourse of collaboration stresses the 'enterprise' level (Teasdale, 2012), surprisingly scarce fo-

cus has been devoted to consider a wider organisational context and awareness in designing for collaborative work. With the pretense that designing for collaboration concerns the support of shared conceptualisations of problems by enabling exchange of information through patterns of relationships, we need a method that provides descriptive knowledge of the social structure in which it occurs (Haythornthwaite, 1996). For that, we need to look beyond the conventional information systems design toolbox.

The third theme of our title, *social network analysis*, represents an attempt to approach this theoretical gap in information systems literature on collaboration. In contrast to collaboration, the exchange of information and communication in a social network does not necessarily imply that there must be a shared goal, as participants in a network are more autonomous than in a collaborative relationship (Camarinha-Matos and Afsarmanesh, 2006). Social network analysis provides a perspective to view and analyse social phenomena that in this thesis will be applied in order to understand the structural characteristics of collaboration. As discussed, efforts to determine requirements and design for collaboration must follow conceptual understanding of organisational interaction and the dynamics of emerging knowledge work (Bardram, 1998). From this perspective, we argue that social network analysis has promising potential that has yet to be fully explored, with its focus on visualising employees' interactions and the emerging patterns through which they are interconnected by a variety of relationships (Tichy et al., 1979). Emergence is an underutilised concept in information systems design, and is described as a coherent pattern that arises from collaborative interaction and can be understood through social network analysis (Odell, 1998), as discussed below.

> "When we construct complex business systems, we need to think of agents as functioning as a society or ecosystem. In designing such systems, we need to consider how we can effectively employ homogeneous and heterogeneous agents." (Odell, 1998, p. 4)

The ecosystem metaphor is beneficial for our level of analysis as it emphasises the emergence perspective of organisational interaction. By understanding how information in a social network evolves as agents collaborate, designers may be able to improve information routes by putting in place positions and structures to facilitate information delivery between people and groups to enhance organisational innovation and learning (Feld, 1981; Haythornthwaite, 1996). As to the "homogeneous" agents: The reduction of people into 'nodes' in an information system might appear troublesome to readers. However, there are influential theories such as actor-network theory that inform us that all networks are heterogeneous, as there is no socio-technical system consisting of only humans or only technology artefacts (Hanseth et al., 2004). Rather, networks exist in dynamic contexts of social structure, where agents, their relationships, and technology artefacts coexist in 'entanglements of practice' (Orlikowski, 2010). In line with Odell (1998), we argue that the emergence perspective is useful in conceptualising information systems use, and provides an understanding of how collaborative work relationships are entangled with interactive technology artefacts that self-organise in a way where the sum of the whole is greater than its parts.

Why then study social networks in information systems? As actor-network theory provides an important analytical tool for understanding local aspects of information systems practice, it does not address the broader social structure (Walsham, 1997). While we in this thesis are more concerned with the structural characteristics of social collaboration and their implications for information systems design, we do not direct our focus on the technology artefact in determining such descriptions. Furthermore, Klovdahl et al. (1994) shows that strengths of the social network analysis include its capacity to see both micro (individual) and meso (group, organisation) levels as interconnected, which is advantageous for the design for collaboration as it transcends these levels of abstraction.

Through social network analysis, we assume that individual behaviour, exchange, and work are structurally embedded in wider social networks, and interventions in that structure thus can affect the agency within that structure (Granovetter, 1973; Scott, 1988; Burt, 2004; Cross et al., 2002). Although, whether adopting constructivist or positivist ontological perspectives, studies in organisation theory agree that organisations are much more than just structure (Jelinek et al., 2008), and inquiries attempting to understand structural dimensions of collaboration need to acknowledge their limitations. For instance, to grasp the contextual practice of what actors actually do as they collaborate, interact, or communicate; Hollstein (2011) emphasises that social network inquiries need to be accompanied by phenomenological approaches (see cf. Bjørn, 2011).

However, social network analysis does not necessarily take a deterministic view that is limited to study prescriptive cause and effects of social phenomena. Rather, it should be conceptualised as a research tool through which we can describe organisational structures that enables the interpretation of individual behaviour (Marsden, 1990). Social network analysis can thereby provide a non-dualistic view of the structure/agency relationship similar to Giddens' structuration theory (Jones and Karsten, 2008). While structuration theory conceptualises 'structure' as rules and resources used by actors in interaction (Giddens, 1984), social network analysis is not as constrained with formal procedures and goes beyond such artefacts by depicting a more seamless interaction between actors, thus reflecting collaborative structures that might appear closer to reality. By not focusing on the technology artefact as an enabling/constraining structure, social network analysis provides additional capacity to describe individual agency in relation to their varying positions within social networks.

From this perspective, the visualising capacity of social network analysis enables insights at an organisational unit of analysis; collaborative interaction is provided with an embedded contextual structure used to unveil emerging hidden social structures of collaboration through which we can derive understanding and meaning for subsequent design (Cross et al., 2002). This positions us to approach our research problem in line with the design science paradigm, as designing is about constructing context that define artefacts as much as it is about understanding context through artefacts (Jelinek et al., 2008).

Having positioned designing for collaboration theoretically, we will briefly problematise how collaboration is debated by practitioners to get a sense of where collaboration stands empirically. We then proceed in merging these perspectives to form a research question, which the remainder of the thesis seeks to answer.

1.2 Empirical Problematisation

Collaboration is not solely theoretically interesting for academic purposes, but also of practical relevance for real world problems. Being on the current agenda for many organisations, businesses acknowledge the value and potential for innovation gained by supporting collaboration of knowledge-workers. A typical collaboration issue seen from a practitioner's agenda is the lack of interaction between individuals within an organisation. The solution is often to tear down the information silos by introducing a technical aid to increase interactions between collaborative clusters. There is a rise of enabling communication technologies to leverage collaboration on an enterprise level, and Brosnan et al. (2012) report that organisations are expected to increase their spending on enterprise social software for collaboration by 64 per cent through 2016, a year in which the market for these tools is expected to reach US$6.4 billion, compared to $600 million in 2012.

However, social networks and social media are not synonymous. This appears as a necessary distinction, as general popular discourse is increasingly meshing the two together as if social networks would not exist if it were not for enabling technologies. This is a common misconstruction, and points to a general tendency among practitioners that appears to be technology-focused rather than people-focused. As we have argued, the point of departure in designing for collaboration needs to be informed by sound analysis of collaboration requirements that consider organisational interaction, contextual work practices, and strategic goals rather than sweeping push-down implementation strategies of various commercial off-the-shelf enterprise social software tools. In their Gartner report *Social Collaboration Go Deeper and Wider*, Mann et al. (2012) predict that by 2015, 80 per cent of corporate investments in workplace related social efforts would fail to achieve the intended goal due to overemphasis on technology.

In the light of this, decision makers and designers need to harness innovative capabilities to understand collaboration problems on an organisational level, and thereby match the actual needs with theoretically grounded and focused solutions. We argue that social network analysis, with its capacity to visualise collaborative relationships and emerging work structures graphically, has a descriptive and communicative value for decision making in this area, which can have important consequences for organisational change and development. By producing a snapshot of an organisational communication network we hope to raise the interest of practitioners for the potential of social network analysis in identifying problems related to social collaboration and network structure. Social network analysis is not new to the market, e.g. the potential in visualising the flow of influence through social

networks has been picked up by SAS System and included in their business analytics framework for fraud detection and customer link analytics.

We argue that social network analysis is an underutilised and often misunderstood framework for conducting research on organisational interaction and innovation. Empirically, due to the focus on information technology rather than information systems; and theoretically as designing tends to be too narrowly focused on individual and group levels of analysis, rather than organisational structures.

1.3 Research Question

How can social network analysis be used to describe, understand, and explain organisational interaction in designing information systems for collaboration?

1.4 Purpose

A slowly emerging field in information systems literature is recognising the potential of social network analysis in understanding workplace dynamics. The social network approach can be applied to provide important knowledge supporting core areas such as decision making (Sykes et al., 2009), implementation (Oinas-Kukkonen et al., 2010), and adoption (Sasidharan et al., 2012) of information systems in organisations. However, the potential of the approach in the context of designing for collaboration remains to be fully explored.

The purpose of this thesis is hence to show how social network analysis can be used to understand structural patterns of social collaboration in organisations. As this is an underestimated unit of analysis in designing artefacts enabling collaborative work, there is a need for more comprehensive methods to understand organisational interaction. This can prove to be of relevance for future solutions-oriented prescriptive research as well as in practice when designing for collaboration in the requirements gathering phases of information systems development projects.

1.5 Delimitations

This study incorporates social network analysis in design science information systems research. From social networks theory, being a rigorous field in itself, we apply theoretical concepts that are of special relevance for the understanding of relational patterns between people in the bounded context of work organisations. The selection of theories is done on the basis of what is required to design for collaborative work. By focusing on core theories that explain structural aspect of such patterns, our study is limited not only in the application of the rich source of social network theories, but also on the abstraction level of the way we aim to describe and explain collaboration in organisations.

We will not complement this study with qualitative inquiries to gather phenomenological data explaining the practice of collaboration. Even though this is of importance for information systems design, this falls outside the scope of this thesis. Furthermore, we refrain from discussing critical the-

oretical perspectives that could be approached through a social network analysis, such as emancipatory discussions or interventionist inquiries in relation to power positions within network structures, and so forth.

This being a design science study, the most important output is the artefact that is the result of our design (see Chapter 5.3). As it is from the application of this artefact our knowledge contribution can be derived, a brief reflection is in order concerning the limitations of this application. Empirically, we use a university faculty in Sweden (see Chapter 4.1) as a case organisation to gather data and evaluate our design. The case is a public organisation within academia, which means it has certain characteristics in terms of collaboration that are specific and perhaps contrasts from the practice of corporate organisations. Even though we aim to contribute with descriptive design-process knowledge that is of relevance for applications beyond the context of this study, as reflected in the research question and purpose for this study, our results are to a limited extent biased based on the empirical context.

1.6 Thesis Structure

As this is a thesis on design we part from a traditional thesis structure and split the methodology of our research by removing the practical discussion related to the creation and application of the data collection instrument from the more scientific philosophical underpinnings. We are faced with a causality dilemma in the presentation of design science and social network analysis where we argue that it is important to understand the philosophical underpinnings of design science before attempting to go into depth with the theoretical constructs of social network analysis. To get an overview of the structure of the thesis, a schematic figure is given in Figure 1 below.

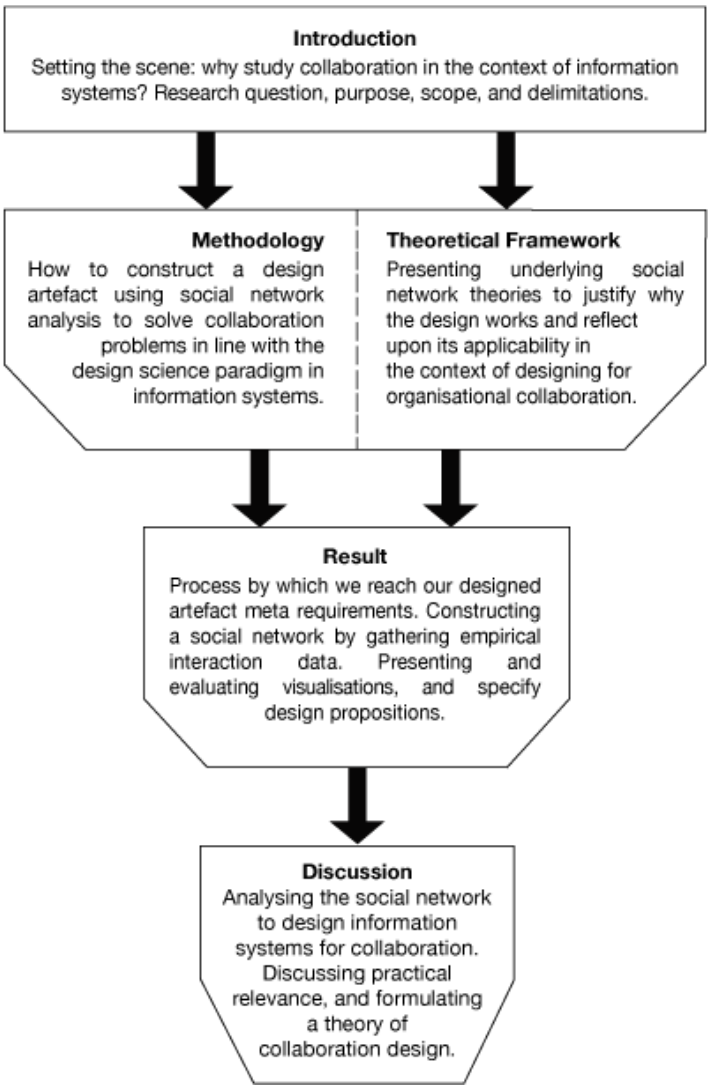


Figure 1: Thesis overview

The quagmire related to the structure of the thesis originates in the dualistic properties of methodology. Methodology traditionally includes both a discussion about the nature of research, i.e. 'know-how' (ontology, epistemology, etc.) and a discussion about the practical 'do-how' (instrument creation, rigour, ethics). The challenge in terms of outlining the thesis is that we want to present the 'know-how' before the theoretical framework, to be able to include a philosophical discussion throughout the entire thesis, which forces us to split the methodology and present the 'do-how' after the theoretical framework. At the same time the methodology and theoretical framework are highly interconnected and should be viewed as parallel parts of the thesis. Without knowing about the role of design science and the design artefact, the theoretical framework of social network analysis will be misdirected. We take a funnel approach beginning in the philosophical realm, moving onto the theoretical constructs of social network analysis, building onto the instrument creation and data analysis, finally landing in our discussion.

2. Methodology

In short, the methods used in this thesis involve a social network analysis that is based on the construction of a survey instrument grounded in social network theories. The theoretical framework used to design the online questionnaire is given in Chapter 3, and the response generated from the questionnaire is based on perceived interaction data from the respondents within the boundaries of an empirical organisation, which is presented in Chapter 4 along with the results of the social network analysis through a series of visualisations. The visualisations of the social network are evaluated by interviewing decision makers within the empirical organisation in Chapter 4.4. However, this being a design study, we devote our methodology chapter to motivate and ensure that our design is scientifically grounded in order to approach the above stated research question in a rigorous way that fulfills the purpose of our study. Further, as we aim to design for collaboration using social network analysis, which in itself is both a theory and a method (Borgatti and Lopez-Kiwell, 2011), it is necessary to thoroughly position this thesis so that the results of the study can be informed by design theories as well as social network theories. In this section we start by discussing alternative paradigms in research, as described by Mingers (2001) below:

> "...a paradigm is [...] a construct that specifies a general set of philosophical assumptions covering for example ontology (which is assumed to exists), ethics or axiology (what is valued or considered right), and methodology." (Mingers, 2001, p. 242)

The ontological view is a necessary reflection as this is the structural context in which employee collaboration occurs and thus has an influence for designing. We proceed by introducing design science in information systems research and its application in our inquiry. We will further argue that the epistemological varieties within the converging fields of our study – organisation studies, information systems, and social network analysis – can be beneficial when designing for collaboration. Conducting trans disciplinary research, however, comes with some vital epistemological and methodological challenges (Wickson et al., 2006), but through reflexive analysis new insights can be gained and applied through innovative design. In the light of this, we devote additional reflections to ensure research rigour in our design. As our study includes an empirical social network analysis, discussing a research strategy that assures an ethical design concludes the chapter.

2.1 Ontological and Epistemological Stance: A Step Towards a Grey Area

Good research requires an ontological and epistemological stance to be taken and made explicit. The researcher needs to explain how the world is viewed and how knowledge is created (Creswell, 2007). Traditionally, the discussion of ontology and epistemology within social science has been between choosing a paradigm that supports either a quantitative or qualitative methodology. Seale (1999) states that the traditional methodological debate focuses on the wrong issues; the researcher is expected to choose one of two opposites instead of incorporating both traditions. Therefore, Seale

(1999) promotes intense methodological awareness, where the researcher incorporates multiple views rather than dichotomising. Within the social network perspective the different paradigms can be depicted as measuring the structural features of the network (quantitative) and explaining the social interactions (qualitative) within the network (Jack, 2010).

In social network analysis there is no preferred approach although the traditional quantitative social science paradigm has dominated research. Purely quantitative studies limit the level of detail that can be represented (Jack, 2010), especially when it comes to representing relationships (Emirbayer, 1997). Belvias (1950) showed that the structure itself is not enough to explain efficient communication network structures, there is need to understand what type of relationships the actors share which is not possible through pure quantitative studies. Studying the structural properties of a network does not presume that a certain paradigm has to be chosen; on the contrary sticking to a certain paradigm limits the researchers mode of explanation.

The origin of social network analysis is in mathematics and graph theory, where the dominant ontological assumption is that the world can be represented through structures (Borgatti et al., 2009: Jack, 2010). A key contributor to this line of thought is Durkheim who developed Comtes notion of social physics:

> "Durkheim [...] argued that human societies were like biological systems in that they were made up of interrelated components. As such, the reasons for social regularities were to be found not in the intentions of individuals but in the structure of the social environments in which they were embedded." (Borgatti et al., 2009, p. 892)

The theoretical domain of social network analysis can be split into theories used to explain, originating from social science, and theories used to visualise, originating from network theory a part of graph theory (Figure 2). Within social network theory the emergence of network structures are explain through both social theories (how structures are formed through e.g. social exchange) and graph theory (the toolbox to visualise the social structure.).

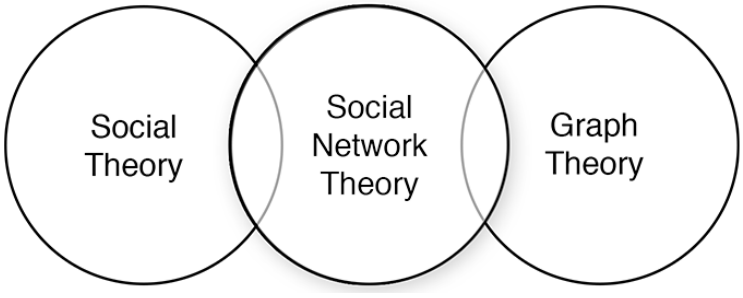


Figure 2: The theoretical domain of social network analysis

Borgatti et al. (2009) claim that one of the most common criticism against social network analysis is the proposed lack of theoretical understanding, a misunderstanding rooted in the notion that social

network analysis is the same as social network theory and therefore purely descriptive. Social network analysis consists of theories to explain, theories to analyse and data collection methods making it hard to pinpoint on the traditional scientific map. It is not a paradigm by because it makes no pretence of taking an ontological or epistemological stance, it is not a theory although it lays heavy emphasis on theoretical constructs and incorporates theories from multiple domains, it is not a data collection tool even though it provides a toolbox for collecting sociometric data. Social network analysis thus moves in a gray area of science making it more of a conceptual framework loaded with a toolbox able to transcend traditional scientific paradigms.

The world as an interconnected social network

Viewing the world as a constructed network postulates viewing networks through different levels of abstraction. We propose three levels of analysis inspired by previous classifications (Borgatti et al., 2009; Hossain et al., 2013).

Table 1: Three levels of network studies. Inspired by Borgatti et al. (2009); Hossain et al. (2013).

Level of analysis	**Objects of interest**	**Network boundary**
Behavioural level	Actor, tie	Micro: Ego, dyad, triad
Structural level	Networks of nodes, groups, organisations	Meso: Bounded networks
Conceptual level	Networks of networks, network society	Macro: Complex social networks

Parkhe et al. (2006) concentrate on the behavioural level and see the actors and the ties between them as the main area of interest when studying the overall network structure. Borgatti et al. (2009) choose to view networks from the structural level, moving away from the actor and looking at "social structure as a network of roles rather than individuals" (p. 893). At the conceptual level Castells (1999) explains that society can be viewed as a network where structure is created through the flow of the primary resource: information. To discuss social networks, regardless level of analysis, we use the term topology. Network topology relates to the process of studying the structure of networks as links and nodes, where viewing social structures can create visibility of the behaviour of complex systems. Social network analysis has the potential to create a common language transcending traditional research areas "allowing researchers from different disciplines to embrace network theory as a common paradigm" (Barabási, 2009, p. 412).

Organisations as interconnected social networks

Within organisation studies the debate on ontology and epistemology can be traced to the difference in how organisations are structured. Appelbaum (1997) depicts organisations as mechanic or organic structures. A mechanistic organisation consists of hierarchical control structures through formal processes and procedures. Organisations as organic structures are constructed by groups of individuals interrelated to other groups of individuals all with their own structural characteristics (Tichy et al.,

1979). Within organic organisations, control is decentralised by spreading key knowledge throughout the entire organisation (Tichy et al. 1979; Haythornthwaite, 1996).

Social network analysis takes a pragmatic approach to the structure of organisations. The organisation structure is seen as embedded in the relationship structures within the social network (Wasserman and Faust, 1994). At the same time social network analysis does not take into account how the structures are created only that they exist and can be represented through visualisation. Therefore, Wasserman and Faust (1994) propose that within social network analysis organisations are viewed as network structures at different levels of abstraction moving towards the grey area of ontological and epistemological considerations.

2.2 Design Science

Research in information systems is often divided according to a design science and behavioural science paradigm, where the behavioural science field is closer to what we tend to think of as traditional social science research. While behavioural science seeks to build and expand existing theories that explain the behaviour of people and organisations in relation to information technology, design science has a different approach to construct new knowledge. Design science is centred on the design of new artefacts that seek to expand individual and organisational capabilities (Hevner et al., 2004). Through the application of these artefacts, new understanding of a domain can be developed that support the shaping of a possible future reality (Löwgren and Stolterman, 2004). Knowledge through design science is thereby constructed from the application of designed artefacts on a problem domain that seek to expand the boundaries that limit our understanding of that specific area (Hevner et al., 2004).

Behavioural science and design science, however, should not be seen as dichotomous (Avital et al., 2009). This becomes particularly evident in information systems, as the performance of a design artefact is dependent on the environment in which it operates (March and Smith, 1995). This can be understood through the earlier mentioned structuration theory, which argues on the notion that structure cannot be separated from agency (Giddens, 1984). From this perspective, sound behavioural understanding of the environment is an important aspect of designing and evaluating artefacts. This is particularly the case of information systems seen as socio-technical systems, as technology and human behaviour can not be seen in separation due to the interwoven coexistence of social structure and technology artefacts (Latour, 1987). The two research paradigms can thereby be viewed as complementary in information systems research; as 'justified belief' through behavioural theories (Nonaka, 1994) and the utility of effective artefacts (Hevner et al., 2004) both operate in a continuous interplay in advancing the field forward.

However, the research on collaboration suffers from being characterised by a normative discourse (Schultze and Leidner, 2002), which generally is of little relevance for practitioners. This opens up possibilities for design science, whose mission is to "develop knowledge that the professionals of the

discipline in question can use to design solutions for their field problems“ (van Aken, 2005, p. 20). This study aims to provide such descriptive insights by applying social network analysis to elaborate on the organisational and social practices that enable the adoption of collaborative artefacts, rather than the collaborative artefacts themselves. Through our empirical social network analysis, we collect interaction data between employees of a university faculty and describe, analyse, and explain the visualisations of the network through our theoretical framework. In order to evaluate the visualised design artefacts as well as the design process through which they are constructed, they are evaluated in order to construct descriptive design knowledge of high research rigour and practical utility (see Chapter 4).

The ontology and epistemology of design science

As this thesis explores organisational collaboration through design, a brief reflection on the ontological assumptions this research approach entails is in order. Iivari (2007) argues for a sound ontology within design research, seen as a knowledge-building activity. Due to the central role of artefacts in design science, the ontological stance must allow for a multiple worldview due to the different properties and roles of the artefact. Iivari (2007) proposes the three worlds of Popper (Popper, 1978) as a relevant ontology due to the different characteristics of the worlds.

Popper's first world depicts artefacts and nature e.g. how collaborative technologies (artefacts) can be embedded in the social practice of knowledge-intensive work settings. The second world revolves around how the artefact affects perceptions of the world through invasion of consciousness and mental state of its users. The third world is socially constructed and includes human artefacts, institutions, and theories, e.g. various design theories and methods used to develop information systems (Popper, 1978; Iivari, 2007).

Similar to social network analysis, the epistemology of design science takes a pragmatic approach. Iivari (2007) claims that the discussion should be lifted to include a deeper understanding of the philosophical underpinnings and proposes a three-level epistemology for information systems consisting of conceptual, descriptive, and prescriptive knowledge. Conceptual and prescriptive knowledge fail to provide truth-value produced by information system practitioners; therefore Iivari (2007) promotes descriptive knowledge (e.g. X causes Y in situation Z) to provide more pragmatic truth-value. The descriptive knowledge product of design science is thus not the artefact itself but a meta-artefact that describes a phenomenon, which can be translated into prescriptive knowledge in order to design an actual artefact. For example, a meta-artefact can be a methodology, like a social network analysis, that describes how to elicit and analyse requirements for the development and/or implementation of an information system.

Conceptualising the artefact

How, then, can we approach our research question, which aims to explore social network analysis as an approach to effectively design for organisational collaboration? Since design in research is about

exploring problems by constructing artefacts, we need to discuss what we mean by 'artefact' and thus position ourselves as we approach our problem area. In the seminal work *The Sciences of the Artificial*, Simon (1996) uses the term artefact to describe something that is artificially constructed by humans, as opposed to something that occurs naturally. Arguing from the premise that design science is a problem-driven approach in research, artefacts are what "solves the problem when [...] introduced into nature" (Baskerville, 2008, p. 442). What is considered as an artefact in information systems research is thereby dependent on the research context, and can range from pure information technology artefacts without any human components, to pure organisational systems without any software components.

The word 'design' can either be a noun or a verb, which means that design artefacts can be both products (e.g. an enterprise collaboration system) and methods (e.g. information systems design methodology). As the artefact is conceptualised as the main output of design research (March and Smith, 1995), we need to consider what the artefact of this study is and how it can be understood in relation to its surrounding environment. The output of this study is an applied social network analysis, which is tested on an empirical organisation and is visualised to represent the interaction between people graphically. We argue that this visualisation is of value and can be used to understand collaboration needs in the early stages of information systems development projects. Thus, the output of this design study is not a material artefact in the form of an instantiated system. Rather, it provides structural understanding of organisational interaction that can be used to elicit requirements for the design and/or implementation of such an instantiated system. Thereby, we can proceed by conceptualising the social network analysis produced in this design study as a meta-artefact for the object of our emerging design theory (Gregor and Jones, 2007), which in itself is a methodology to develop technology artefacts.

By going back to our ontological discussion, the relationships between the design artefacts in this study can be better understood. In Figure 3 below, the three worlds of Popper is depicted using a framework by Gregor and Jones (2007) and populated with descriptions of our design artefacts. As the social network analysis has no physical existence, it is represented and communicated through a visualisation and is characterised as a 'third world' of abstract artefacts. The visualisation can be seen as a designed meta-artefact that is constructed using a combination of network theory and empirical interaction data, which is augmented through NetDraw. NetDraw is a tool to visualise social network data developed by Borgatti (2002), which in this context is seen as an augmenting tool that visualises the analysis. The relation of the constructed social network analysis to any potential instantiated 'first world' technology artefact would need to be interpreted through a 'second world' of human understanding of artefacts (Gregor and Jones, 2007; Popper, 1978).

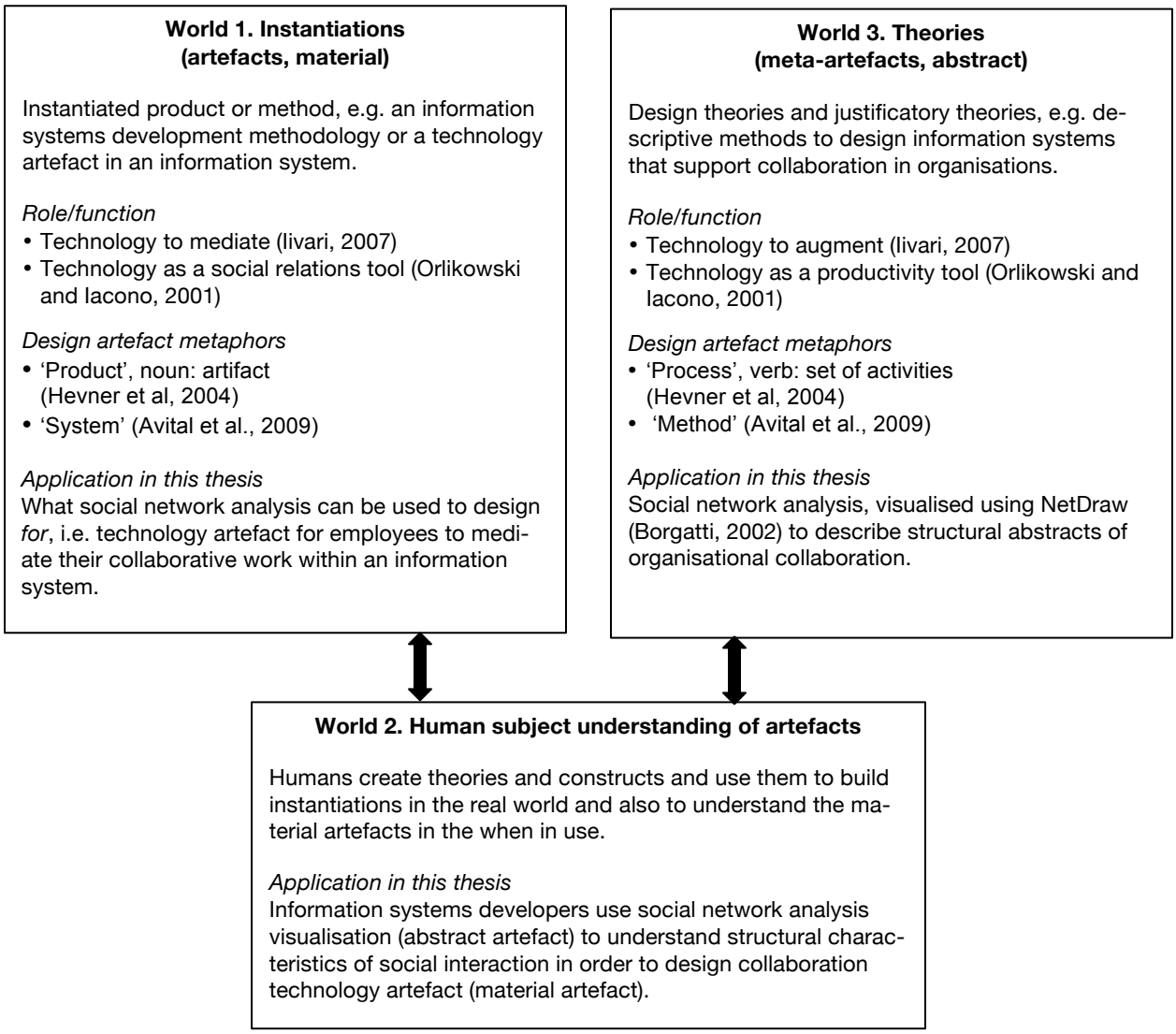


Figure 3: Relationships between information system artefacts (Adopted from Gregor and Jones, 2007, p. 321)

From Figure 3 above, the interplay between the meta-artefact that is the output of our social network analysis, and the artefact it claims to design for, is made somewhat clear. The meta-artefact is what this design study aims to construct and evaluate, and represents a social network analysis applied to understand structural descriptions of collaboration. The visualisation of the meta-artefact is to be shaped, sliced, and diced by the researcher in order to show a variety of perspectives and levels of analysis. We argue that such a meta-artefact (representing visualised social interaction) can be of rigorous utility for the design of information technology artefacts, as a social network analysis in this context can be used to elicit requirements for their subsequent design. It is through the human interplay between the meta-artefact and its intended artefact that this thesis builds its main argumentation: Social network analysis as a method can be applied to expand the boundaries of how we understand collaborative work, and consequently enable us to design information systems that support a

more focused collaboration. In order to further clarify their relationships, we proceed by discussing them in terms of descriptive and prescriptive knowledge in design science.

Descriptive and prescriptive research

Studies of social networks should not be seen as a concept from which researchers can solely study cause and effect relationships, where the social network becomes a sensitising metaphor that explains prescriptive measures of social phenomena. Rather, we need to move towards the development of social network analysis as a research tool to describe social structures and to interpret the behaviour of individual actors in relation to their varying positions within the social structure (Marsden, 1990). By viewing organisations as social structures consisting of employees and their interconnectedness within the boundaries of the organisation, social network analysis as a research tool can provide information systems design capabilities to interpret patterns of social exchange, information flow, knowledge sharing, etc. between employees in the light of their varying positions of the social network.

Marin and Wellman (2011) emphasise that social network analysis can never be prescriptive as it only provides structural aspects on where to proceed with subsequential inquiries. As it has not been thoroughly applied in the information systems design domain, we thereby aim to construct theory-driven, descriptive 'prototype' of design process knowledge of practical relevance (Iivari, 2007, p. 48). We thereby avoid prescriptive pitfalls by making the study of contextual nature for our empirical inquiry (see Chapter 4), and henceforth reducing its application outside of the specific context. By building on existing theories on collaboration, this enables us to further describe, understand and explain collaboration on an organisational unit of analysis, which according to van Aken (2005) can subsequently be used as prescriptive solution-oriented knowledge to analyse alternative methods to design for collaboration.

Knowledge construction through design

How does one, then, conceptualise knowledge contributions through design science? Ehn and Löwgren (2004) discuss whether the reflective practice of a designer's own work can be generalised and, if not, if these reflections of a designed artefact can be transferred to another designer? Lawson (2006) also focuses on the way designers think, which is described as a complex and sophisticated skill. It is put into practice in the interaction between design problems and design solutions. Similarly, Alexander et al. (1977) emphasise the process of designing as eliciting design knowledge, by using patterns to identify problems and then present solutions.

Another school of thought does not concern *design thinking* to the same extent as it concerns *design artefacts*, and their role in constructing knowledge in organisational and systems design (Simon, 1996). This line of thinking argues that additions to the knowledge base are any extensions of existing theories that are derived from applying design artefacts in their application environment (Hevner

et al., 2004). Knowledge that is constructed in this form can be derived from models, constructs, instantiations of systems, and methodologies (March and Smith, 1995).

A third school of thought, which is not as unified as the others, is a more critical one. By criticising both the design thinking and the design artefact schools of thought, researchers such as Carlsson (2006) argue that it is not only the artefact in itself that can construct new knowledge, nor the process knowledge of designing the artefact. Additionally, important contextual knowledge lies in the implementation of the design artefact, which needs to be conceptualised not only as a technical instantiation, but seen in the context of the organisation. Regardless, knowledge construction through design is thus neither as vertical nor linear as traditional hypothesis testing or interpretative studies by taking various shapes and forms.

In this study, we incorporate primarily the design thinking and design artefact schools of thought. We are concerned about the meta-artefact that follows our conducted social network analysis in the form of a series of visualisations, representing a partial result of our study, as well as its role in the design process knowledge in designing for collaboration. The organisational aspects of our empirical inquiry are limited, as the main focus of this thesis is to evaluate social network analysis as a method in information systems design. This points to the role of the social network analysis artefact in this design science study: It is a constructed meta-artefact that expands the boundaries of our descriptive knowledge of collaboration design. The meta-artefact can consequently be applied to elicit and analyse information systems requirements for the design of organisational interventions. The descriptive knowledge construction from this thesis can thus be utilised by information systems practitioners, where the social network analysis meta-artefact is translated to process-design knowledge and applied to solve collaboration design problems (Carlsson, 2006; van Aken, 2004). Thus, our study provides both descriptive collaboration knowledge from design artefacts as well as prescriptive design thinking in terms of its methodology.

Design science takes a more pragmatic epistemological approach by, to a certain extent, bridging theoretical understanding and practical action through descriptive research (Hevner et al., 2004; Iivari, 2007). Furthermore, the design artefacts can be the starting point for subsequent behavioural science inquiries seeking to validate knowledge claims through hypothesis testing and/or interpretation. This is also the case for social network analysis, which constructively can be combined with behavioural studies to further interpret the structural implications of organisational interaction (Hollstein, 2011). This again reiterates the agile epistemology of design science research.

2.3 Methods to Evaluate Design Rigour

As discussed, in this thesis we aim to explore innovative approaches to solve collaboration problems in organisations, by drawing upon social network analysis as a method for information systems designers to understand the dynamic, emerging and structural characteristics of organisational interaction. We argue that this kind of understanding can be translated into the development methodology

and implementation of technology artefacts in organisations that enable additional innovation capabilities through a more focused collaboration on an enterprise level. In design science, 'rigour' is what commonly denotes the relevance and quality of the construction and evaluation of design artefacts through the application of scientific methods (van Aken, 2005; Hevner et al., 2004). It is through rigour that research design projects are separated from the practice of everyday design.

Iivari (2007) claims that rigour can be derived from the framing of the existing knowledge base, which implies that the construction process of the artefact should be as transparent as possible. The framing of the design in this study concerns the structural exchange of collaborative work patterns, which we seek to understand using theory from social network analysis. Therefore, the rigour associated with our design artefact is closely connected to the theoretical propositions presented in Chapter 3. However, as design science is a problem-solving approach in research the practical relevance must be further evaluated empirically, and van Aken (2005) emphasises that academic rigour ought to take into account the relevance of the acquired knowledge outside of the academic world. In the light of this pragmatic view of rigour, we test our social network analysis on an empirical organisation in Chapter 4. This enables both a theoretically framed evaluation of the quality of the design artefact, as well as an evaluation of its relevance for practical utility in approaching collaboration problems.

However, the core of design science is to understand a problem and its origin in order to provide support and knowledge for further design solutions, made by professionals in a specific field (van Aken, 2005). Aiming for generalisation to a larger 'population' is not a part of design science as context is a variable and emerging descriptive knowledge is to be applied in other perspectives and situations. According to Hevner and Chatterjee (2010), rigour of design is partly achieved by ensuring the innovativeness of design artefact by thoroughly researching and referencing the existing knowledge base in the application domain. Social network analysis as a method for information systems design has not been fully explored theoretically nor empirically, the next step to ensure rigour is to ground the construction of the artefact in existing theories from the domain knowledge base. Applying concepts from social network theory that are deemed of particular relevance for the design for organisational collaboration, such as degree, closeness, bridges, structural holes, broker and eigenvectors, a theoretically grounded approach is taken to construct innovative artefacts, that expands the boundaries of our knowledge of organisational interaction as it is applied empirically.

Collecting interview data to evaluate the design artefact rigour

Hevner and Chatterjee (2010) emphasise the importance of iterative design cycles and testing the artefact in the application environments, to make rigorous contributions that are of relevance for research and practice. We will discuss the evaluation of the artefact in Chapter 4.4, however, the methods of evaluating the design artefact and process is briefly given below. Succeeding social network analyses, Lee and Jones (2008) recommend that follow-up interviews are conducted with people that are concerned with the network. Following the empirical social network analysis of a Swe-

dish university faculty (see Chapter 4), two interviews were conducted with two heads of departments within the faculty. The two departments were chosen due to their relative diverse character, both in terms of the results of the social network analysis, and due to the nature of the subjects studied at the respective department. The purpose of the interviews was to evaluate the constructed social network visualisations depicting a structural overview of the collaborative network of their organisation, by discussing the potential practical utility of the artefacts in their roles as strategic decision makers. As recommended by Myers and Newman (2007), the purpose of the study and the expected role of the interviewee was made clear prior to the interviews in order to make the interviewee feel comfortable and minimise social dissonance of the meeting.

The interviews were scheduled a week in advance and held in their respective offices. The results of the social network analysis (visualisations of their organisation seen as a social network) were e-mailed prior to the interviews. With the visualisations in front of us during the interviews, the interviewees could elaborate on the implications of the social network, and thereby produce meaning in their roles as heads of departments. Creswell (2007) stresses that it is important to anticipate what kind of answers are desired from the interview. In our case, face-to-face interviews would enable the best results, as we would get close to the interviewees in order to capture the spontaneous reactions and discuss what they saw in the social networks. In the light of this, the interviews were conducted in an unstructured arrangement. Kvale and Brinkmann (2009) recommend that in order for unstructured interviews to be successful, it is a prerequisite that the interviewers are well oriented with the research domain in order to have the ability to engage in relevant follow-up questions. By the time the interviews were conducted, which was during the last couple of weeks of finalising the thesis, we had sufficient domain knowledge in order to conduct unstructured interviews.

The open character of the interviews was suitable in order to retrieve information of what *they* saw, and thereby evaluate the utility of the visualisation from the perspective of the interviewees. Follow-up questions were asked based on the responses of the interviewee in order to encourage critical reflection as to the collaborative needs of their respective department as well as in relation to the faculty as a whole. The unstructured approach allowed us to clarify and extend interview statements and thereby enable hermeneutic interpretation of meaning (Walsham, 2006). Seen as the how knowledge is socially constructed in the interaction of the interviewer and the interviewee (Kvale and Brinkmann, 2009), this was a necessary feature in order to interpret the utility of the visualised design artefact in their capacity to manage organisational change. This allowed for a reflexive approach to interpret the transcribed interview data, with respect to the social scene of the interview (Myers and Newman, 2007), the interviewee's identity management during the interview (Alvesson, 2003), as well as the role of language and discourse throughout the interview (Kvale and Brinkmann, 2009). The interviews were, with the consent of the interviewees, recorded and later transcribed (see Appendices B and C). The empirical data was organised into clusters of meaning and common themes (Creswell, 2007), and later analysed drawing upon both social network theory and the empirical results of the study.

2.4 Ethical Research Considerations

As one of the arguments for pursuing a social network approach in designing for collaboration is its capacity to 'unveil' hidden structures of work relationships in organisations (Cross and Parker, 2004), a question of particular concern is that of ethics and how to deal with the integrity of the participants of our inquiry. In this concluding methodological part, we discuss ethical dilemmas that might arise in relation to the collection, analysis, and visualisation of empirical data (presented in our results section) and how this is maintained in our emerging design artefact.

Ethical design

From a design perspective, ethical constructions belong to Popper's (1978) third world along with justificatory knowledge and theories (Gregor, 2006), and are important in the design of sustainable information system artefacts. Iivari (2007) promotes a reflective research that carefully considers its consequences, and states: "design science research in itself implies an ethical change from describing and explaining of the existing world to shaping it" (p. 54). As the design of social network artefacts claims to represent an abstraction of reality, shaping it in accordance with a vision of an improved possible future reality entails an ethical practice of research. On an individual level, the ethical goal of research ought to take an interest in "helping people to live less alienated lives" (Seale, 1999, p. 12). As noted by Carlsson (2007), such emancipatory component is up to date poorly developed in information systems design science, but regardless poses an ethical consideration that needs to be addressed in the context of social network analysis.

Human subject protection in social network analysis

It is important to stress that the dehumanising reduction of people into nodes when drawing social network diagrams is an abstraction and offers a limited understanding of reality, as people add context, interpretation, and meaning to information as it is processed. Regarding the ethics of researching social networks, their representation disclose patterns which are otherwise difficult to identify, why we need to treat social network research with extra ethical care. In network research, up front anonymity is not possible since knowledge of who is connected to who, who collaborates with who, etc. is required. When representing the respondents' interaction data through a social network visualisation, names, department, position, and other variables of a node that might unveil the identity of a participant are disguised (Borgatti and Molina, 2003).

Newman (2001b) claims that there is a major concern with social network analysis if the respondent is asked to consider a friendship or relationship, as the respondent's perception of relationship can differ from other peoples' perceptions of the same relationship. Furthermore, Berente et al. (2011) argue that care must be taken when constructing shared attributes to stratify groups with regard to one's biased assumptions, which can shape the observations made. These ethical considerations will guide the analysis of the empirical interaction data and the construction of the design artefact.

When collecting social network data in a bounded system such as an organisation, people are asked to list people they collaborate with in a name generating survey. This implies that for members of an organisation there is a fair chance of becoming part of the social network even though one does not choose to participate. Borgatti and Molina (2003) state that non-respondents can be included in the study, as respondents might list non-respondent as associated. By including non-respondents listed by other respondents the risk of missing data is reduced (Stork and Richards, 1992). Although, non-respondents might have made an active choice not to participate in the study and therefore it is impossible to assume that they have given informed consent. Marsden (2011) emphasise the fact of researchers' responsibility of protecting non-respondents from any harm that may occur from the research data by making it impossible to identify individual nodes. It is important to consider any risks for the non-respondents and weight them against the potential research benefits.

3. Theoretical Framework

Sound conceptualisation should precede measurement and analysis, therefore design needs to be informed by justificatory knowledge (Iivari, 2007; Gregory and Jones, 2007). In this part, we aim to construct such a framework that will be applied for our empirical data collection and analysis. The evolution of social network analysis stems from social science, and is applied to show networked relationships of actors in various social phenomena. As collaboration implies social interaction between actors, the structural patterns of relationships that emerge need a theoretical framework that explains concepts of social networks. This framework will focus on theoretical constructs – such as social ties, centrality, brokers, eigenvector, and structural holes – in order to describe structural properties of employee collaboration in organisations. Through visualisation of the social network of our empirical case, the theoretical framework will not only facilitate a overview of collaborative work. Further, it will enable interpretive analysis towards an understanding of organisational interaction and identify potential boundaries of information systems automation.

Gregor (2006) recommends that the role of theory is explicitly defined, as the ontology of theory in information systems research takes a variety of shapes and forms depending on what type of study is undertaken. Referring back to Popper's (1978) three worlds, the role of social network analysis as a theoretically constructed abstract entity belongs to the third world, and exists separately from the subjective understanding of the researchers. As social network analysis both provides a lens through which collaboration is viewed and explained, as well as a method through which collaboration can be design for, its role pervades this study as it is used both for understanding and designing (Gregor, 2006). This study takes the form of a design science inquiry; therefore social network analysis informs how to design our meta-artefact (e.g. a requirement analysis) for developing information systems that enable organisational collaboration. However, as the theoretical constructs are applied to our empirical case, theory will also explain how and why collaboration phenomena occur, providing explanatory knowledge of collaboration design of new information systems artefacts. Its versatile role in this study is represented in Figure 3 below.

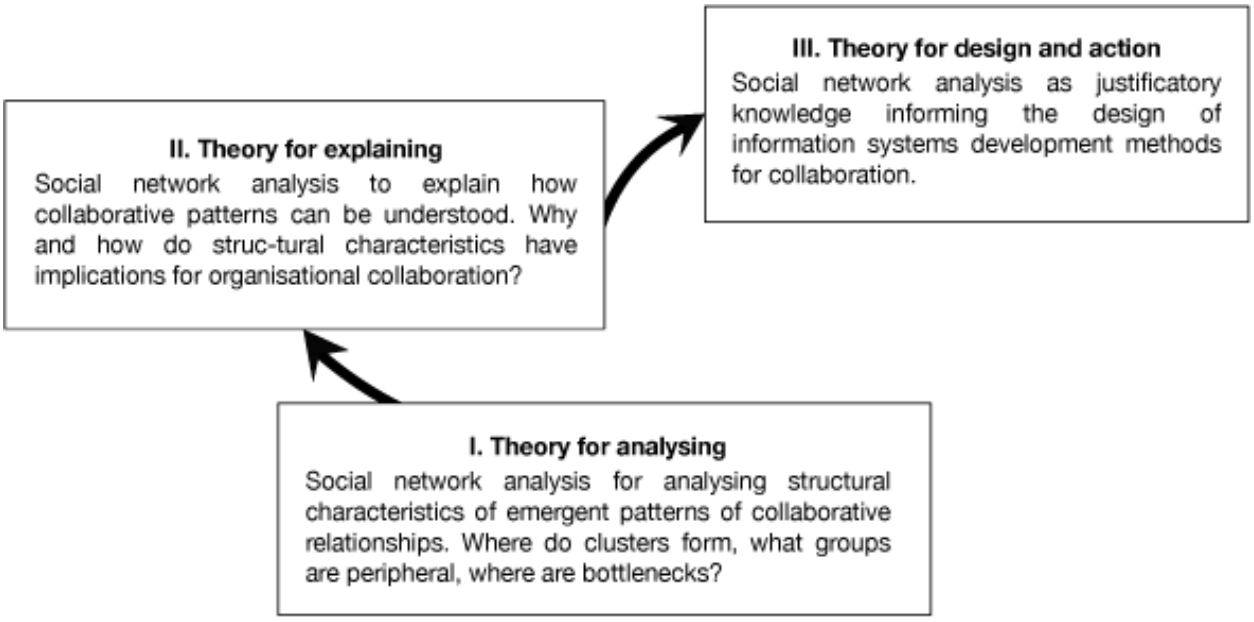


Figure 4: Interrelationships in the application of social network analysis (Adapted from Gregor, 2006, p. 630)

3.1 Why Social Network Analysis?

Within social networks analysis, networks of social interaction between actors can be defined as a set of nodes that are connected through relationships or ties (Marin and Wellman, 2011). The techniques incorporated in social network analysis can be used to study the exchange of resources between the nodes (Haythornthwaite, 1996). The small-world hypothesis entails that entities within a population can be connected by a short chain of intermediate relationships (Milgram, 1967). This theory is the basis for the six-degrees of separation (that states that an entire population can be connected by at most six relationship ties) and is central to social network analysis (Newman 2001a). Affiliation networks follow a small-word principle, linking the actors through a common membership trait and not by asking actors to rate their relationship. Newman (2001b) claims that affiliation networks tend to be more reliable than data on other social networks due to the dataset not being constructed by bias assumptions.

The social network analysis framework comprises of well-developed theoretical approaches to explore and analyse social structures within a network (Tichy et al., 1979; Wasserman and Faust, 1994). Having emerged from sociology in particular, social network analysis has been applied to a wide spectrum of societal and organisational phenomena, however the approach has, until recently, received scarce attention within the information system field (Lazer et al., 2009; Oinas-Kukkonen et al., 2010).

Within social network analysis various data collection methods can be applicable. The Colorado Spring Study (Klovdahl et al., 1994) uses interviews as data collection method to look at the relationships between individuals and analyse disease spread through a network of social ties. The goal

was to study the structure of interaction in a population of a larger number of individuals by connecting groups at the meso level. To study the structure of a population, non-random patterns of social interaction were mapped to account for a realistic representation of social structure. In a study of a chinese name generator social survey (Ruan, 1998) respondents were asked eleven unique questions related to the type of connection they had to individuals connected to them. With help of the structural properties of the connections the tie structure of the network could be represented.

3.2 The Study of Social Networks

Borgatti and Lopez-Kiwell (2011) propose a network theory called the 'network flow model' to explain network structure. The theory can be used as underlying explanation within social network analysis. The network flow model presents a topological overview where the network structure is seen as "pipes through which information flows" (p. 40) and can be used to understand e.g. capitalisation of ideas by looking how individual nodes acquire resources. This view is a contrast to the network architecture model where networks are viewed as building blocks that create structures of dependencies, which can be used to explain coordination of resources between multiple nodes in networks.

When studying the topology of networks in social network analysis there are two design patterns for modelling the network: Egocentric and whole (Haythornthwaite, 1996). Egocentric networks are created from a principal or focal actor. The starting point is the so called ego surrounded by alters that share some sort of relationship with the ego (Borgatti and Foster, 2003). Haythornthwaite (1996) claims that the egocentric network approach is preferred when the boundaries of the social network are hard to define.

The whole network pattern describes the overall structure rather than focusing on sets of relationships surrounding individual nodes. Network data is preferably collected for all relationships within a closed population (Marsden, 1990). The whole network perspective has been used to identify groups with similar information needs, to show key players within social networks and to identify areas where there is a potential problem related to the structure of the network. Social networks with clear boundaries, such as organisations, are preferred when studying whole networks. Potential problems with low response rate from the population can undermine the research rigour (Haythornthwaite, 1996) and create large divergence between the actual tie structure and the tie structure data set. The lack of certain network data can mislead and fail to visualise key players and structural properties (Borgatti and Molina, 2003).

To overcome the issue of response rate, Stork and Richards (1992) propose a method to reconstruct the social network, were non-respondents mentioned as recipients of information are represented in the social network analysis. Within the study of social networks the issue of non-respondents is problematic due to the definition of a relationship as a two-way information flow (Haythornthwaite, 1996; Stork and Richards, 1992; Borgatti and Molina, 2003). Eliminating all non-respondents will

decrease the overall quality of the social network analysis, creating missing parts within the network and potentially leading to misleading or incomplete data sets. Stork and Richards (1992) promote using partial relationships – ties named by only one respondent – to complete the overall structure of the social network. Borgatti and Molina (2003) state that when respondents report a perceived relationship with another actor, friendship symmetry assumption (Newman, 2009), this de facto constitutes some sort of information exchange.

3.3 Relationships in Social Networks

One of the central concepts in social network analysis is the relationship ties that form the network. Wasserman and Faust (1994, p 18) define a tie as "the linkage between a pair of actors" and according to Haythornthwaite (1996) a tie can be between both people and things. Bavelas (1950) states that the ties are formed through social interaction within smaller groups in an organisation. Newman (2001a) stresses the importance of relationships in social networks studies by claiming that social network analysis is performed due to the patterns of interaction found in the relationships ties. To illustrate the patterns of interaction, Haythornthwaite (1996) states that it is necessary to analyse the 'types' of information that flows between actors and proposes three attributes that can be used to explain the relationships: content, direction, and strength.

Within a social network information and resources travel between nodes (Borgatti, 2005), hence ties can be characterised by the type of *content* that is exchanged (Haythornthwaite, 1996). The content that is exchanged between nodes can be studied to gain insight into the efficiency of the information flow and thereby be used to compare social network structures (Tichy et al., 1979). Haythornthwaite (1996) stresses the importance of defining what type of content (e.g. information, resources) that is relevant for the study. In contrast, Borgatti and Lopez-Kiwell (2011) argue that the content itself is practically unmeasurable instead they recommend studying the paths of the information flow.

The topological features of the network can be studied to analyse the *direction* of the information flow (Borgatti, 2005). Haythornthwaite (1996) claims that information flows in a certain direction can be either directed and undirected. Directed information flows occurs through one-way communication, e.g. when instructions travel from one node to another. Undirected information flows are characterised by a two-way information exchange where similar resources are exchanged (e.g. project groups). Within undirected relationships the emphasis lies on the overall context, which makes the direction of the flow irrelevant. Bavelas (1950) studied different communication patterns and found that symmetric communication patterns (two-way information exchange) lead to more overall errors than a pattern with a central mediator. Stork and Richards (1992) argue that an undirected flow still constitutes a relevant relationship ties, meaning that the information does not have to be directed to represent a significant relationship tie.

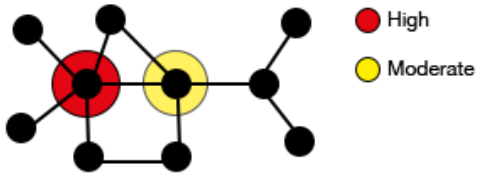
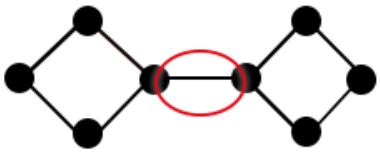
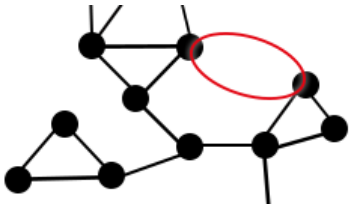
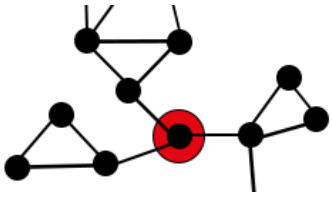
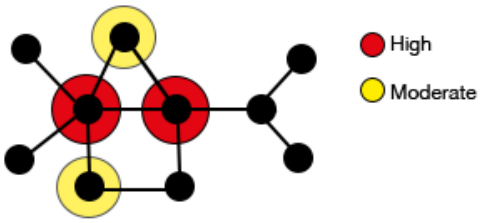
According to Granovetter (1973) the *strength* of a tie is a combination of intensity, intimacy and reciprocity in a relationship, developed over time. A strong tie between actors increases the likelihood of

being exposed to and believing in information (Haythornthwaite, 1996). Strong ties tend to create 'noise' (Granovetter, 1973) preventing an efficient information flow (Marti, 1996). Granovetter (1973) discovered that weak ties give access to larger information networks, due to the actor moving in the periphery of different networks and thereby accessing information unknown to more central actors in the network leading to the spread of innovation. Strength can be measured by giving the tie a value based of the answers from respondents on rating different relationships. There is a risk related to asking actors to rate perceived social ties and that is if the visualisation is a mirror of the actual collaborative work relationships or if it is biased with subjective perceptions of interactions (Marsden, 1990). A method to overcome this problem is measuring ties as present or absent (Haythornthwaite, 1996). This is also useful in overcoming the issue of actors inability to rate information exchanges within a specific timeframe (Marsden, 1990). In a study where non-respondents are included the preferred approach is representing tie strength as present or absent due to the inability of representing reciprocity between actors (Stork and Richards, 1992). Within tie strength the concept of reciprocity relates to which degree a relation is symmetric (Tichy et al. 1979) and is described by Hossain et al. (2013) as a tie that is present from actors A → B and B → A.

3.4 Social Network Properties

Social network analysis offers a unique perspective when answering social or behavioural research questions by giving formal definition of the structural properties in the political, economical, and social structural environment (Wasserman and Faust, 1994). As social networks analysis in itself is a theoretical construct (Cross and Parker, 2004), social networks analysis is interpreted through a series of social network theories such as centrality (Freeman 1979; Borgatti, 2005), bridges (Burt, 2002), structural holes (Burt, 1992), brokerage (Gould and Fernandez, 1989), and eigenvectors (Bonacich, 1987). In Table 2 below we present summary of the social network properties we aim to use in explaining the underlying dynamics of a social network. In this part, we explain in depth the underlying social theories to the outlined properties and their implications for designing for collaboration.

Table 2: Social network theories and their implication for designing for collaboration.

Principle	Theory	Description	Visualisation
Centrality	Degree	Degree is the number of direct links a single node has within the network (Freeman, 1979).	
	Closeness	Closeness is the distance a node has to another node. Distance is defined as the length (in links) of the shortest path (Borgatti, 2005).	
Structure	Bridges	A bridge is a link between nodes not otherwise connected and represent the shortest path between two groups (Burt, 2002).	
	Structural Holes	Structural holes places where there should exist links and bridges between groups (Burt, 1992).	
Prominence	Broker	Brokers are nodes that control and mediate information flow due to their position within the network (Gould and Fernandez, 1989).	
	Eigenvector	Defined by eigenvalue, which is a combination of degree and links with other nodes that have high degree. Eigenvector is an attempt to measure influence (Bonacich, 1987).	

Centrality

Borgatti (2005, p. 56) states that "centrality is one of the most studied concepts in social network analysis". Centrality is based on nodes location within the network and can be used to find the shortest path between nodes (Klovdahl et al., 1994). Sparrowe et al. (2001) show that centrality can be used to explain both individual and group performance. Haythornthwaite (1996) states that there are numerous theories used to explain centrality at the behavioral level including closeness and degree. Together, the properties form the overall cohesion at the structural and conceptual level within the social network.

Centrality can be used to identify clusters of highly interconnected actors (Haythornthwaite, 1996). Newman (2001a) define clusters as "local communities in which a higher than average number of people know one another" (pp. 407-408). In order to examine whether e.g. clustering of strong ties has a positive or negative effect, the nature of the interactions needs to be investigated. Cross and Parker (2004) state that heavy clustering may be the result of tightly knit collaboration in a team, however, it can also indicate bottlenecks and overdependence of a key person's knowledge.

Degree represents the number of ties a node has. Nodes that have a disproportionate high number of direct relations are deemed central. Central nodes play an important role in social networks, which can be either positive (unrecognised resources, "unsung heroes") or negative (bottlenecks) (Cross and Parker, 2004). Nodes with a high degree indicate an over dependence on the these particular nodes, which can be problematic from an information flow perspective. Freeman (1979) states that nodes with high degree centrality are focal points of communication to which actors in the network tend to turn when facing communication issues. On the other point of the scale low degree indicates an underutilised resource or an isolated node (Cross and Parker, 2004). Freeman (1979) states that nodes with low degree centrality are cut off from the ongoing communication process, i.e. they are information receivers and not contributors.

Closeness describes the overall level of connectedness between actors of a network (Tichy et al., 1979) by measuring the number of ties through which information travels between two specific nodes (Scott, 1988). Haythornthwaite (1996) states that it is the shortest path that is interesting to examine whilst Borgatti (2005) implies that it depends on what is transferred (e.g. the spread of gossip in contrast to e-mail). To clarify we will use Freeman's (1979) definition where closeness centrality is the shortest distance in links between nodes. Borgatti (2005) uses closeness centrality to define well-positioned nodes that receive information before other less central nodes. In their study, Klovdahl et al. (1994) use closeness centrality to uncover the actors most likely to spread disease within a network.

Structure

A bridge is a tie between two individual nodes that are part of different groups or clusters (Tichy et al 1979), and therefore connects nodes who otherwise would have no connection (Burt, 1992).

Granovetter (1973) argues that bridges are weak ties which conceptually is in line with Burt (2002) who claims that bridges often are created when interconnected nodes (strong ties) disappear from the network, leaving a weak tie structure between the remaining nodes. Opportunities for creating new bridges arise to eliminate structural holes in the network (Burt, 2004). Within an organisational context, structural holes between groups can lead to the creation of non-redundant information structures.

According to Burt (2002), structural holes do not necessarily mean that actors within the network are unaware of the existence of other actors outside the group. Rather, it implies that actors are more focused on the activities within the group, and not on the surrounding environment. Structural holes can thus be seen as opportunities to control the flow of information between unconnected groups within a network. Burt (2002) claims that structural holes create competitive advantage by providing opportunities to eliminate redundant information by controlling the flow of information though bridges. Hossain et al. (2012) show that structural holes provide benefits in sharing knowledge and propose the identification of structural holes to address the spread of innovation within an organisation. Borgatti et al. (2009) proposes an alternative view by implying that the lack of structural holes creates a structure that facilitates communication and coordination allowing groups of interconnected nodes to act as one. Further they claim that structural holes can create power structures by giving single actors greater influence and control over the information flow.

Prominence

Prominence represents the individual nodes importance within the network (Haythornthwaite, 1996) and is represented by brokers and eigenvectors. Identifying prominent actors can help in understanding who has actual power and influence. Haythornthwaite (1996) recommends placing information facilitators as brokers, e.g. subject matter experts or systems that mediate communication within networks.

Brokers are actors whose position in the network allows them to control the flow of information between clusters (Gould and Fernandez, 1989). The broker both controls and distributes information within the network (Haythornthwaite, 1996). Gould and Fernandez (1989) identify five types of brokers, coordinators, itinerant brokers, gatekeepers, representatives, and liaisons. Coordinators and itinerant brokers facilitate information flows within a group, where coordinators come from inside the group and itinerant brokers come from outside the group. Gatekeepers and representatives mediate communication between groups, where gatekeepers control access to groups and representatives try to establish information channels between groups. Liaisons are actors that positioned between groups and facilitate information flows. Gould and Fernandez (1989) exemplify liaisons as agents within e.g. the entertainment industry as the individuals who connect publishers with writers.

Eigenvectors are the most important, central actors in the overall structure of the network measured by eigenvalue (Börner et al, 2008). Eigenvalue is a combination of high degree centrality and the

number of connections with other actors with high degree centrality (Bonacich, 1987). Haythornthwaite (1996) states that the eigenvectors not necessarily has to be the actors with most degree centrality, making eigenvalue a better measurement than centrality when it comes to individual influence. Bavelas (1950) proposes identifying dispersion and relative centrality when comparing efficient communication patterns. This can be compared to eigenvector as Bavelas (1950) explains the combination of dispersion and relative centrality as the "sum of all internal distances to sum of distances from a particular position" (p. 727).

3.5 Towards an Understanding of Organisations through Social Networks

Social network analysis within organisational studies can be adopted as a methodology to gain insights into the dynamics of workplace interactions relating to the implementation and use of information technology (Sykes et al., 2009). It can also be used when studying socio-technical information system through looking at the emergence of organisational structure when new informal information exchange routes are created within the network to tend to changes in information needs (Haythornthwaite, 1996; Odell, 1998).

Within the network approach, depending on the level of abstraction, organisations are viewed as systems consisting of objects, actors, groups, and organisations that are joined by a variety of relationships. Tichy et al. (1979) recommend analysing social networks when studying organisations and Cross and Parker (2004) advocate social network analysis as a method for making the invisible structures within an organisation visible. The focus of the network approach within an organisation is concerned with the structure and patterns of the network and the dynamics of information exchange within the networks. Cummings and Cross (2003) show that the social network structure has implication on performance within organisations. Complex, non-routine tasks e.g. innovative collaboration require more coordination than routine tasks e.g. information processing.

If it is possible to manipulate the network structures to develop more optimal information flow, this would have implications for the spread of innovation within organisational science. According to Haythornthwaite (1996), information routes can be modified by changing networks structures or implementing information systems to facilitate a more efficient information delivery between actors. Well-managed social networks can increase the social capital of organisations by bridging structural holes and enhance learning, innovation, and performance (Cross et al., 2002). Burt (2004) found that collaboration networks that bridge structural holes learn faster and are more innovative. Kleinberg et al. (2008), inspired by Burt's (1992; 2004) theory on structural holes, showed that there is correlation between successfully managing bridges and the spread of innovation within the organisation. At an individual level, the broker nodes that bridge structural holes have unique access to resources and rewarding opportunities. Burt (2004) claims that the brokers within the network are at higher risk of having innovative ideas due to the sheer amount of innovation that flows through the

network. As actors within organisation need to collaborate to solve problems, the people they turn to in their surrounding environment can be deemed as an actors access to shared knowledge. However, if an actor is not aware of the available access of knowledge in the organisation, it is unlikely that the shared innovation capacity of the organisation will be fully utilised (Cross and Parker, 2004).

3.6 Summarising Structural Components of Design Artefact

A framework of structural components of theory in information systems research is provided by Gregor (2006), which will be used to apply and summarise our theoretical framework of social network analysis in the context of our study. As the role of theory in design science is to provide knowledge that informs us how to do something, it is necessary to clearly demonstrate principles of methods in order for them to be applied in the construction of a design artefact.

Table 3: Structural components of the design artefact (Adapted from Gregor, 2006, p. 620)

Theory component	**Applications in design**
Means of representation	Visualisation, models, words
Constructs	Requirements methods for information system design, development, and implementation in organisations.
Statements of relationships	**Centrality** ● *Degree centrality* – High degree centrality indicates over-dependence of an actor – Low degree centrality indicates under-utilised resources ● *Closeness centrality* – High closeness centrality indicates higher possibility to absorb novel information and innovation –Similarly, high closeness centrality also indicates higher possibility to spread negative influence as these actors might be change agents **Structure** ● *Bridges* – Connect otherwise fragmented groups with generally different information needs – Can create power structures as single brokers gain greater influence over information flow ● *Structural holes* – Create and diverge groups due to redundancy of information needs, implying knowledge hoarding rather than sharing **Prominence** ● *Brokers* – Mediate communications within networks by their intermediating position, allows them to control flow of information between clusters – 'Wrong' persons can become brokers, taking roles of unproportionate influence of information flow ● *Eigenvectors* – Combination of high degree centrality connected with other actors of high degree centrality, i.e. actors within a network of actual influence of decision making

Scope	Information systems that support collaboration within the boundaries of an organisational context. Provides an abstract structural level of collaboration.
Causal explanations	The network ontology of organisations enables and understanding of the social structure of which collaborative relationships are embedded.
Testable propositions	• **Centrality** – Can be used to explain both individual and group performance – Can be used to identify clusters of highly interconnected actors – Can be used to identify 'unsung heroes' or 'bottlenecks' – Can be used to identify under- and over-utilised resources • **Structure** – Can be used to identify bridges between heterogeneous groups and clusters – Can be used to identify structural holes and create competitive advantage • **Prominence** – Identifying prominent actors can help to understand who has power and influence in organisations – Identifying brokers can facilitate the positioning of the 'right' person to mediate efficient communications, or automate by information system artefact – Identifying eigenvectors can help to find appropriate change agents, e.g. when performing an information system overhaul.
Prescriptive statements	In whose hands can the social network analysis be placed? Can be an effective tool for designing innovative organisations and information systems. Methods to gather and analyse structural meta-requirements for development and/or implementation of information system artefacts supporting collaborative work.

Having summarised a theoretical framework and specified the theoretical characteristics for our design, we are now in a position to construct a design artefact. By using an empirical organisation to collect interaction data, a social network analysis can be carried out and visualised in an effort to describe, analyse, and understand organisational interaction.

4. Results

In this section we construct a theoretically grounded survey instrument to collect social network interaction data in order to further evaluate the social network analysis and its benefits for design. We start by presenting our empirical case so as to get an overview of the organisation and how it is formally organised and to see the values of the data analysis. Then we will give a description of how the survey instrument is constructed, discuss its structure and, more specifically, justify each separate question in the questionnaire by linking them to relevant social network theories. Using the collected empirical data, we present the results of the social network analysis by a series of visualisations of the case and highlight relevant organisational interaction phenomena by relating to the previously discussed social network properties. As a final part of this section, we evaluate the design artefact, both by considering the survey instrument and data collection, as well as a descriptive evaluation of utility by interviewing two decision makers at organisations that could potentially benefit from the visualisations.

4.1 Case Description

The organisation for our inquiry is the School of Economics and Management (hereinafter referred to as LUSEM), which is one of eight faculties within Lund University, Sweden. The faculty employs about 500 staff consisting of academic and administrative personnel who are divided between six departments, three research centres, two institutes, a library office, and a chancellery (see Figure 5). Like any other public academic institution in Sweden, the three main mission of the faculty is to provide education for undergraduate, graduate, and postgraduate students; conduct research to advance the respective fields forward; and cooperate with the surrounding environment to promote innovation and learning in the society as a whole. LUSEM thereby offers a diverse, complex, and knowledge-intensive organisation of an academic character that is interesting from a collaboration perspective.

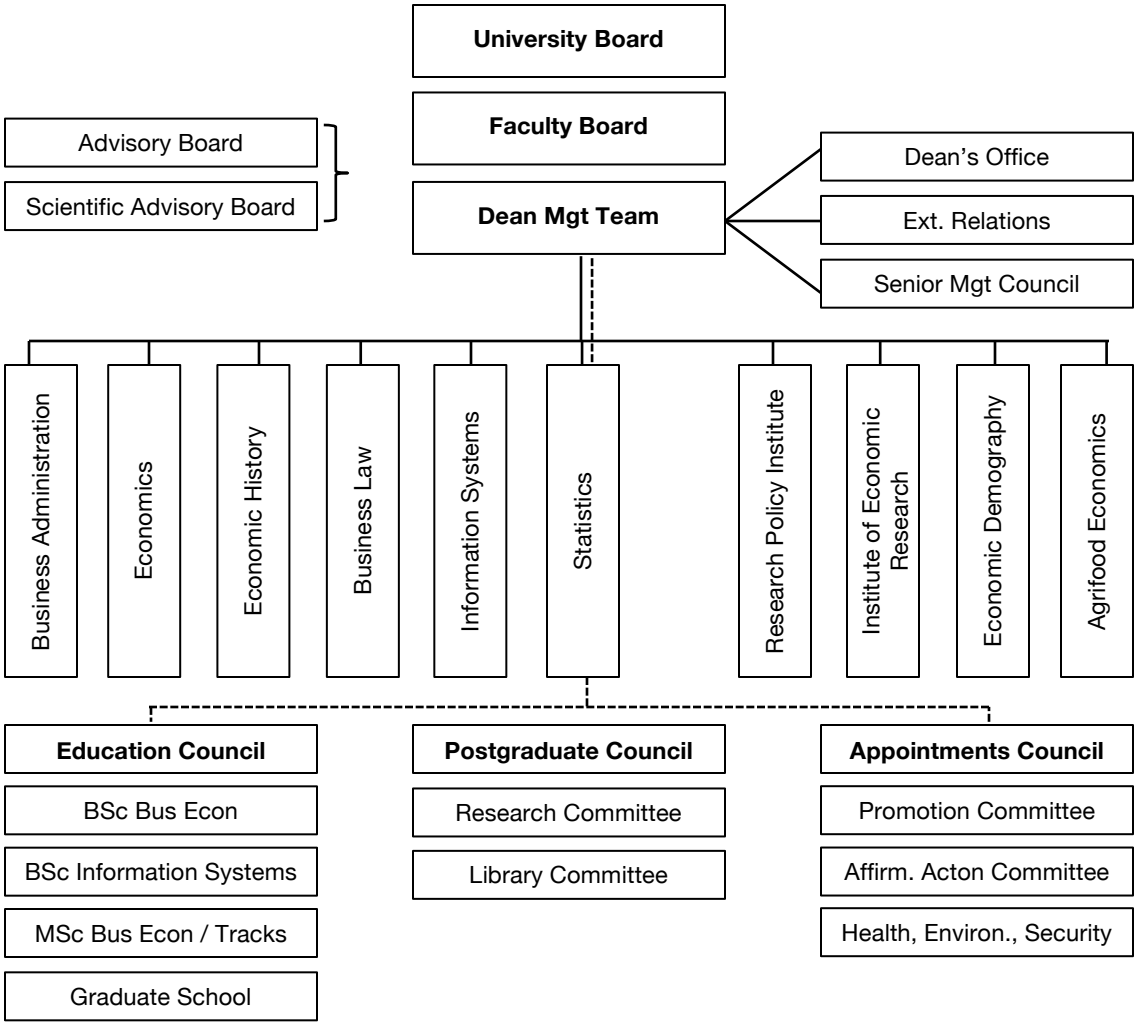


Figure 5: Organisational chart of LUSEM (adapted from lu.se, 2013)

The organisational chart above shows the formal structure of the organisation, where the hierarchical and functional boundaries often represent physical distances between units and teams. While the faculty is located at the Holger Crafoord Centre at the Lund University campus, departments are placed in two different locations. Some of the research institutes are interdisciplinary and require cross collaboration between researchers from the different academic fields. The organisational chart does not, however, provide much information regarding the collaboration between employees, which makes it difficult to assess and support the links between individuals and teams to strategically develop the organisational dynamics and innovation. Thus, proceed by discussing the creation of a survey instrument in order to collect and analyse the collaboration at LUSEM from a social network perspective.

4.2 Instrument Creation

The instrument used in this study was a name generating social survey as recommended by Cross and Parker (2004), Marin and Wellman (2011), and Ruan (1998). A traditional method of conducting social surveys is through name generators or survey questions where respondents are asked for names of colleagues with whom they share a specific relationship (Marin and Wellman, 2011). By designing a simple questionnaire, asking questions like "In a normal week, who are the people you interact with to get your work done?" (Tichy et al., 1979, p. 512) one can construct a social network of interactions. To collect data for a whole-network, as opposed to an ego-network, respondents are asked to name their perceived social ties within the boundary of their organisational context. In the era of social media and other computer-mediated communication systems, using a questionnaire to collect network data about social relationships might appear old fashioned and time consuming.

Sociometric data, e.g. electronic communications, e-mail correspondence, administrative transactions, and social media interactions have become more accessible and thus provide opportunities for researchers to study actual exchanges in social networks. However, solely relying on electronic data might have limitations in an organisational social context when studying employee collaboration, as far from all collaboration is computer-mediated (Marsden, 2011). One of the strengths of social network analysis is that it transcends boundary structures, and by asking respondents to name people they collaborate with, a more seamless social interaction can be illustrated which is likely to resemble the real nature of collaborative work. Therefore, it is likely that a social network looks rather different from the organisational chart in Figure 5.

In the list below, our survey instrument is summarised. For a copy of the questionnaire used, refer to Appendix A. The questionnaire was designed with the ambition to make it as convenient and time efficient as possible for the respondents. The questionnaire consists of five questions, each asking the respondent to name five people within LUSEM that they collaborate with in different settings. The different settings were chosen to reflect the various kind of work that is done within the faculty: social collaboration, research, education, organisational change, and administrative/technical support. Seen collectively, based on the responses to the five questions, a comprehensive social network could be constructed reflecting information exchange in the different settings. The five questions are given below.

1. Thinking back over the past month, and considering all the people at LUSEM; i.e., my superiors, subordinates, and people at the same level as myself. These are the (0-5) people with whom I have spent the most time on work matters.
2. In my research, I mainly collaborate with these (0-5) people at LUSEM.
3. If I need to discuss educational related issues at LUSEM, I mainly turn to these (0-5) people.
4. If I want to see an organisational change within LUSEM, I mainly turn to these (0-5) people.
5. When I need administrative/technical support, I mainly turn to these (0-5) people at LUSEM.

The respondents were asked to fill out their email address in order to function as a unique identifier so that each node could be represented in the social network. From the email address, some additional sociometric data could be retrieved for the subsequent analysis, including: the department of the respondent; whether the respondent's role was academic or supporting staff; and if the respondent was a manager or not. Based on these attributes, emerging patterns of relationships and information exchange could be interpreted and put into context. The questions represent different kinds of collaborative work situations, which is likely to capture potential bridges linking clusters and structural holes that are beneficial for the subsequent analysis, and can prove useful in designing for collaboration.

4.3 Data Analysis

The questionnaire was sent to employees within the empirical network, via the respective head of department. 45 employees chose to respond and a total of 207 nodes were generated through the name-generating survey. Although, it is important to stress that the visualisations do not intend to make truth claims about LUSEM, but rather are used to explore their utility in designing for collaboration. Therefore, we will argue that the response rate is not of significance for the purpose of this study. Given the low response rate, valid claims of the empirical collaborative nature of LUSEM cannot be made, however the character of the visualisation artefacts and the design processes knowledge can be evaluated. Below, we present our results of a social network analysis used on our empirical case.

Table 4: The interaction between departments, out of 100 per cent in each cell.

	Bus. Adm.	Economics	Econ. History	Bus. Law	Inf. Systems	Statistics	Dean's Office
Bus. Adm.	72,20%						
Economics	2,76%	84,62%					
Econ. History	0,48%	0,54%	86,67%				
Bus. Law	0,97%	0,55%	0,00%	58,33%			
Inf. Systems	1,44%	0,00%	0,00%	0,00%	76,62%		
Statistics	1,65%	0,00%	0,00%	0,00%	0,00%	84,00%	
Dean's Office	30,14%	19,18%	0%	2,74%	42,47%	5,48%	0,00%

The values in Table 4 represent the frequency of interactions, out of 100 per cent in each cell, between and within the departments of LUSEM. The table does not provide any structural characteristics and is only used to provide numerical information that may be difficult to visualise, (see Figure 6-12). Of all the interactions that take place the majority is within each department. Economic History, Statistics and Informatics are departments in the network that have low levels of interaction with other departments. In our sample, Economic History is the only department that has no known interaction with the Dean's Office, a group that is usually considered to be a central and important role in an academic organisation. Low interaction between departments may be due to the characteristics of the different disciplines at each department, and therefore there is no expected exchange of knowledge, information, and/or collaboration. The lack of interaction enhances formation of isolated information silos and prevents information flow throughout the network, which can hinder relevant information reaching specific departments.

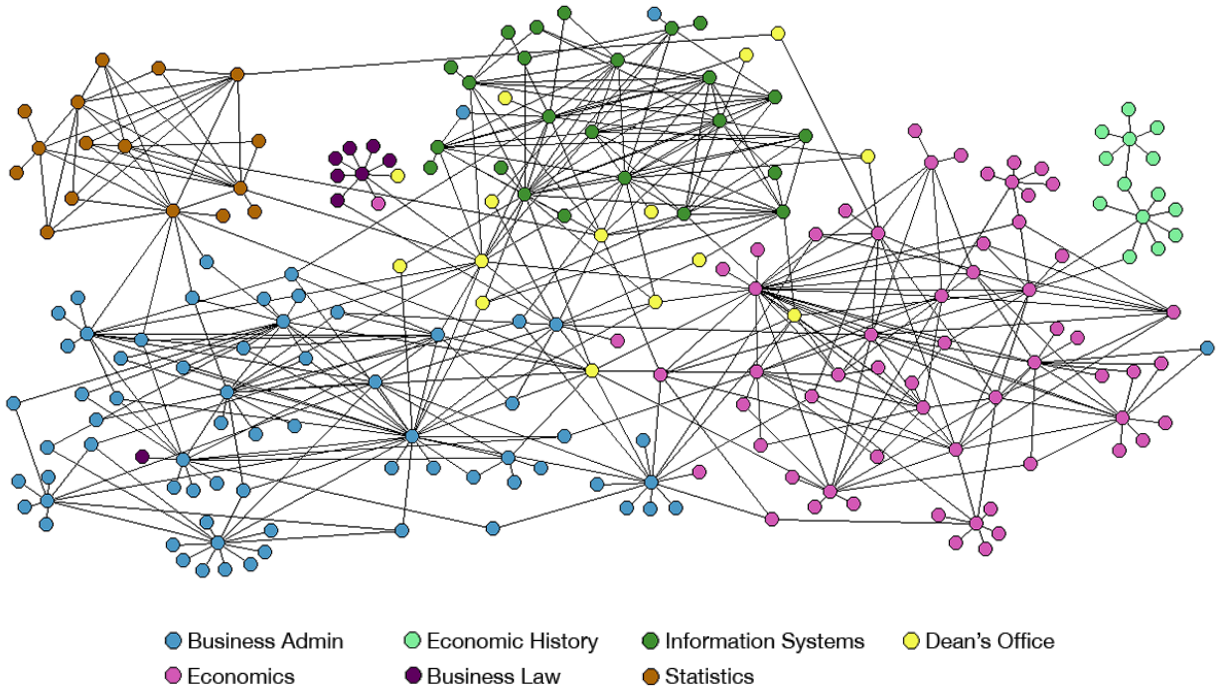


Figure 6: The empirical case as a whole network. The different departments are located by the colour of each node.

Figure 6 visualises the empirical network as a whole network. All nodes are anonymised where some nodes are better connected than others and these nodes form clusters within the network. The clusters mirror the different departments within LUSEM, as the interaction and information exchange within each department seems to be more intense, as expected, than cross-department collaboration.

Studying information flow in the social network through the network flow model can be used to understand capitalisation of ideas by looking at how individual nodes acquire resources. Studying the network flow from a topological view can highlight narrow points where implications for change in the information system reside. Studying the same network from the underlying ”pipe view” can show the type of information that clogs the information system.

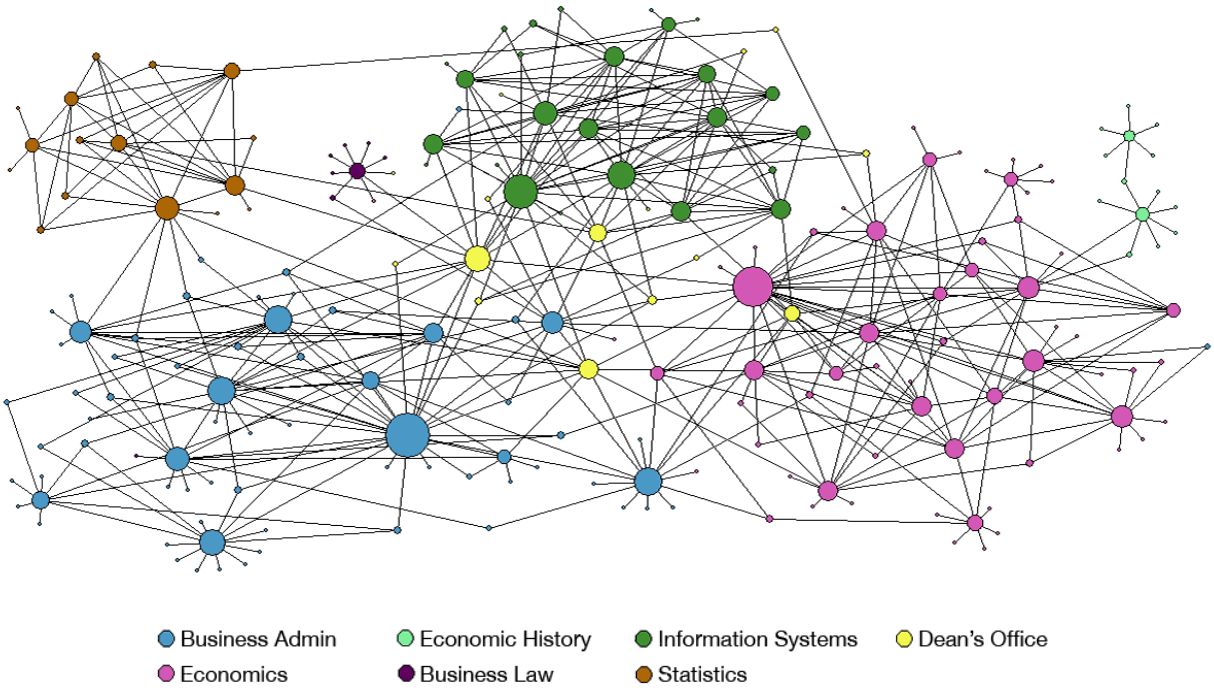


Figure 7: Degree visualised by the size of the nodes, where a large node has a large number of direct links (high degree) and a small node has a small number of direct links (low degree).

In Figure 7, the size of the nodes is determined by the degree of each node. A large node is connected to a large number of nodes and entails a high degree, and a small node visualises a low degree of centrality where the number of direct links to the node is low. This is also visualised as most nodes with a high degree is within the centre of the network, or a cluster, while the majority of nodes with a low degree is located at the periphery. A node with a high degree denotes a key actor within the cluster or the network as a whole, depending on with which the other nodes are connected. Furthermore, the degree indicates where formal and informal information flows, as a node with a high degree not necessary is a key actor, but a very active node in the network.

If a node with a low degree is a key actor in the network, Cross and Parker (2004) recommends looking at possibilities to implement a communication tool or change the network structure. Another solution according to Cross and Parker (2004) could be to re-assign responsibilities giving actors with a low degree centrality more connections by taking over administrative responsibilities increasing the social interaction. Automating certain administrative responsibilities by introducing an information technology could be another method in improving the overall efficiency of the information system, looking at degree centrality as the point of inception. Further, a node with a high degree may cause a bottleneck effect and a solution to this could be to restaff teams or move nodes with an overall high or low degree centrality to other parts of the organisation.

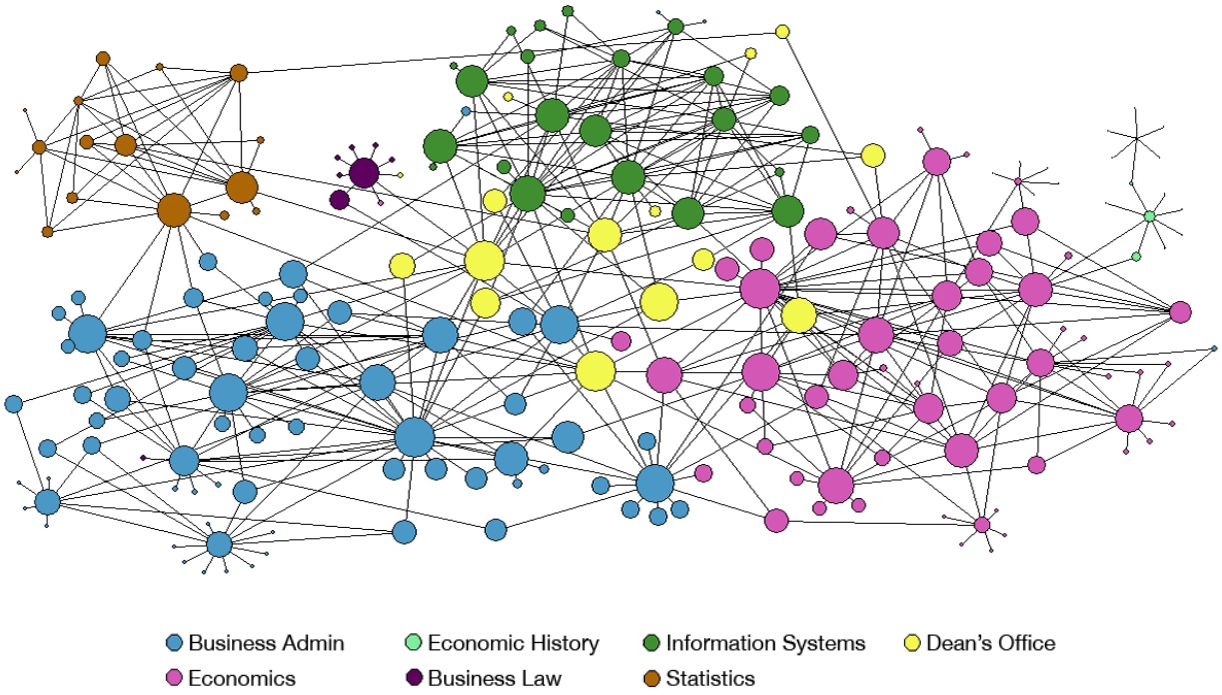


Figure 8: Closeness visualised by the size of the nodes, where a large node has a short distance (in number of links) to all other nodes in the network.

The closeness of each node is visualised in Figure 8, as the size of the nodes that are close to all other nodes in the network is larger than nodes that are more distanced. The length, in number of links, defines the closeness of each node. Nodes that are well interconnected and have many relationships are more likely to be close.

The majority of the nodes in the empirical network are relatively close, suggesting that information flows relatively short distances between the nodes that are close, and the information thus has great chance of reaching another actor in a short period of time and of being correct. Thus, a node with high closeness has the opportunity to reach other nodes in the network both in a short time and through a small number of other nodes. Another strength with high closeness is that the node has a high visibility, meaning that it is responsive to what is happening throughout the network, which ultimately creates a transparent organisation. Contrary to the empirical network, a network that generally has a low closeness centrality creates difficulties for collaboration because the nodes are far apart, and it also becomes more difficult to reach others in the network. Conversely, nodes that are not close are at higher risk of receiving novel information later than others.

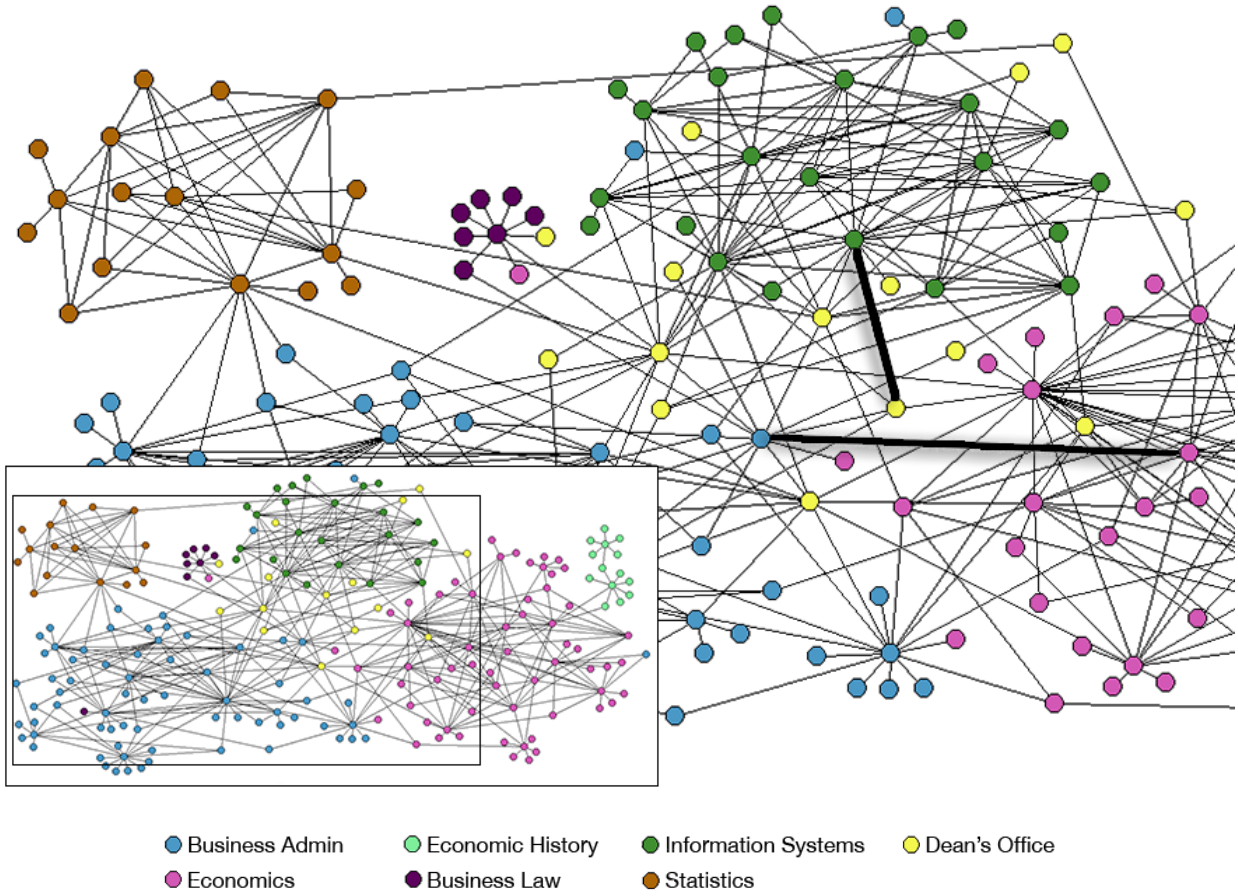


Figure 9: Bridges, visualised as thicker than other links, in the empirical network that connect nodes and clusters that otherwise have no relationship.

Figure 9 shows two significant bridges in the empirical case network that connect groups that are not otherwise connected to each other. An interconnected network is optimal for the spread of innovation. In our empirical case a bridge can be seen as positive as it separates groups with different information needs and creates non-redundancy. It can also been seen as negative by decreasing efficiency and through the increased noise it creates within the group.

A bridge can therefore be of great advantage to mediate for collaboration between different departments and thus increase the opportunity for a more interconnected network. A bridge may also involve the only link between departments, and thus provide opportunities for connecting departments. If a bridge is removed, for example through reassignment of one of the nodes that holds the bridge, then the connectedness of the network will be decreased. Therefore, a network with many bridges is at a high risk of creating isolated clusters.

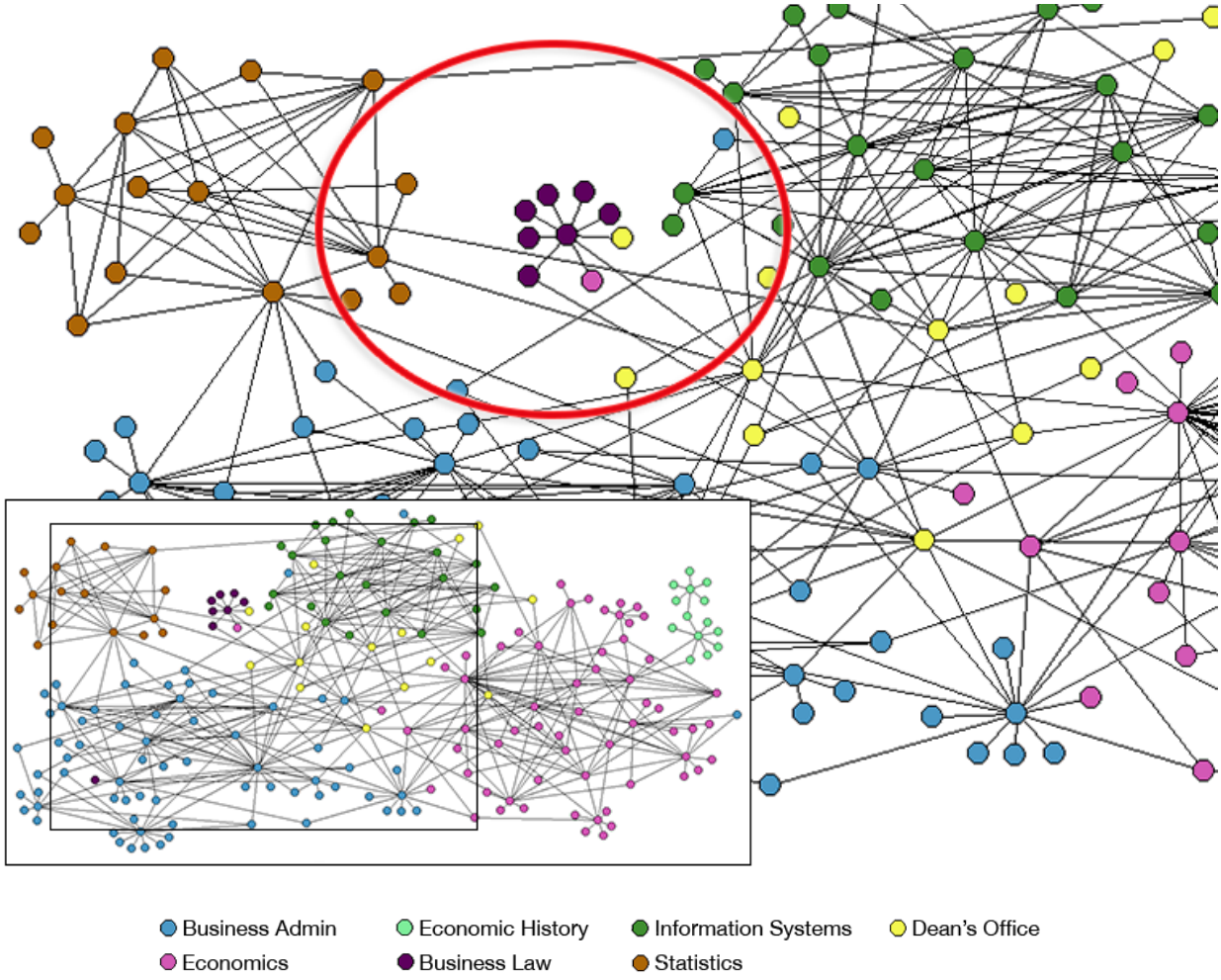


Figure 10: A structural hole in the empirical network indicates where there is a need of bridges between groups.

Figure 10 visualises a structural hole in the empirical network, as there are no direct relationships between the two clusters. Instead, the clusters are connected through other actors from another department, acting as a broker(s), as seen in Figure 11.

A structural hole in an organisation does not necessarily imply that there is a problem but rather shows how the different departments work internally. As our empirical case is an academic organisation, structural holes indicate that collaboration within each department is a priority. Although, several bridges link implied structural holes, indicating that collaboration between departments do occurs. In contrast to other departments in the network, the Dean's Office is not as interconnected. Instead, actors with a role at Dean's Office act as bridges across the network and help connecting the different departments and further prevent structural holes.

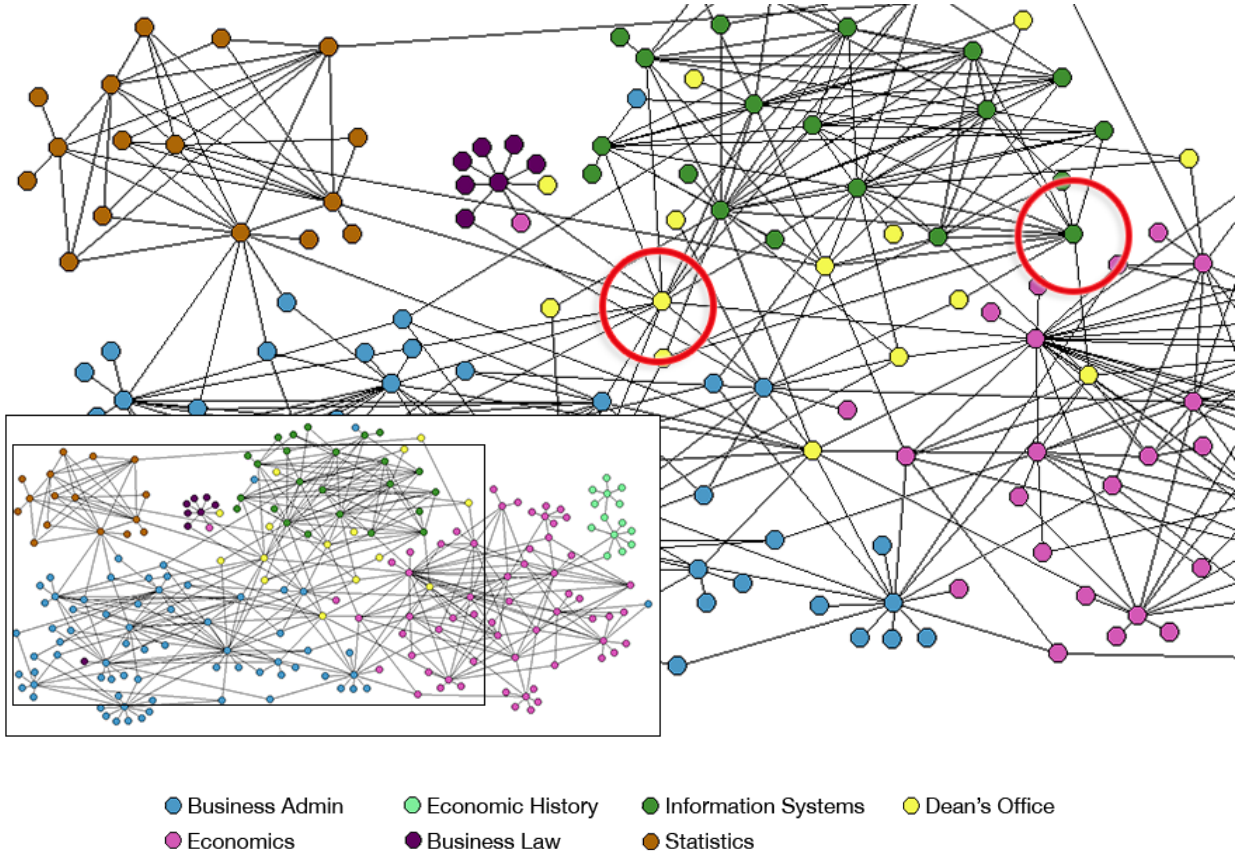


Figure 11: Brokers in the empirical network that control and mediate information flow.

A close-up of some of the brokers within the empirical network are visualised in Figure 11. The visualisation suggests actors that are in control of information flow between groups or clusters within the organisation. A broker holds a very critical position in the network and if a broker is lost the groups are at high risk of missing out on information that runs through the network and structural holes will be created.

A risk with brokers is that the actor that holds the role as broker may abuse that role for their own advantage, such as career benefits or a better negotiating position. Brokers are positioned at bridges and therefore possess a major opportunity to be able to prevent information flow. If a broker is lost, a group may be cut off from the network and thus do not receive information in the same way as the rest of the nodes in the network. The loss of a broker may also create a structural hole. It is therefore of great importance to reallocate actors so that more actors possess information that can be distributed throughout the group, cluster or whole network.

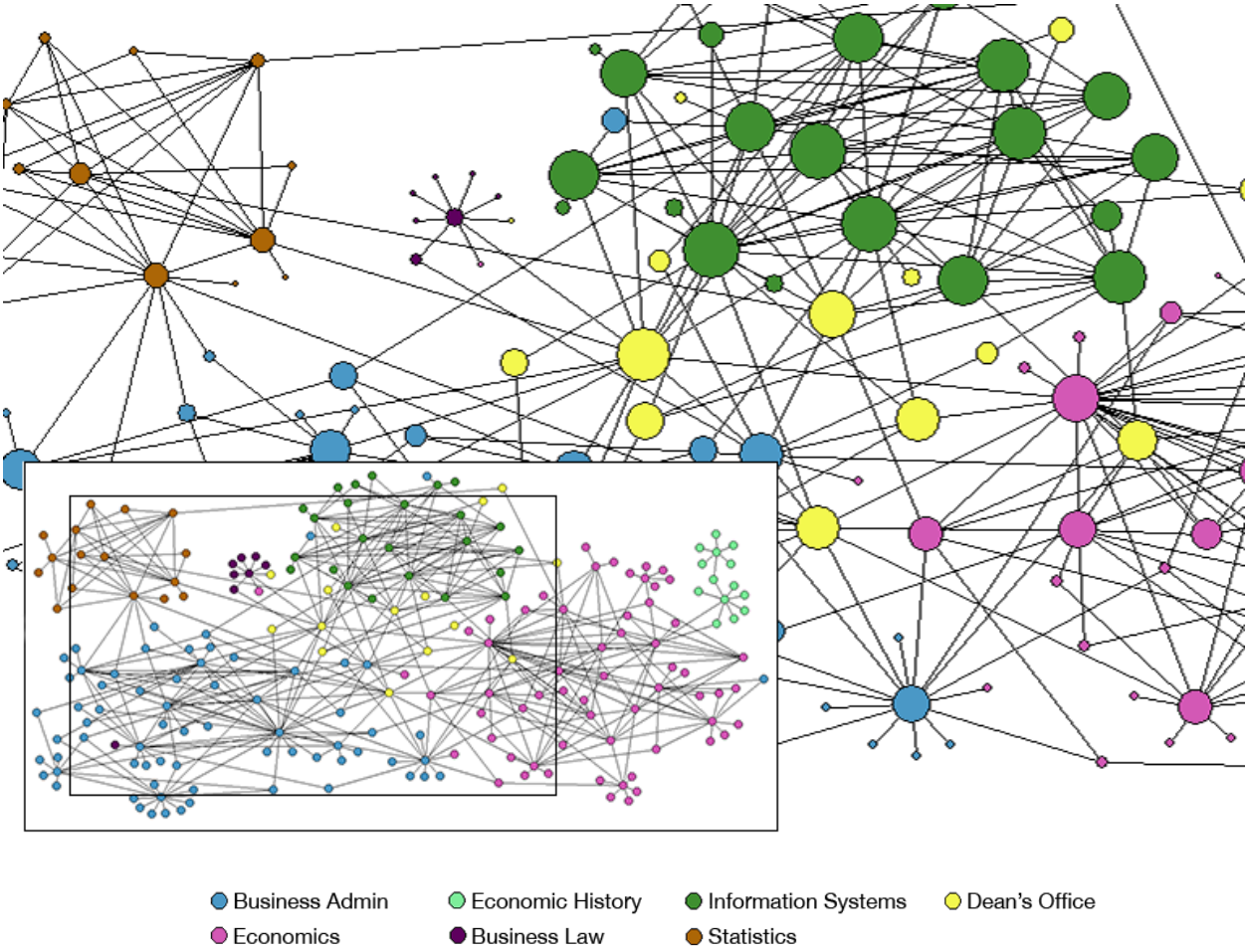


Figure 12: Eigenvectors visualised by the size of the nodes, where a large node has a high degree and is also linked to other nodes with a high degree.

The large nodes in Figure 12 are eigenvectors in the network. Eigenvectors are actors with a high degree centrality that are connected to other actors with a high degree centrality. The most notable eigenvectors are those found in clusters that are highly interconnected. In the empirical case, most of the eigenvectors are strategic and operational administrative staff. The eigenvectors illustrate actors with great influence over the network and their position possesses a considerable amount of the information that travels through the network.

Having described, analysed, and explained a series of empirical visualisation through justificatory theories; we now proceed by evaluating their descriptive value in terms of designing for collaboration. As we have discussed, we are interested in achieving research rigour both in terms of the design artefacts as well as the design processes through which they have been constructed, which is why we now turn towards evaluating both these aspects of the social network analysis approach.

4.4 Evaluation of Design Artefact

As the prime purpose of design science is utility, Hevner et al. (2004) emphasise the importance of evaluating the purposefulness of the design artefact. At present, we have progressed from conceptualising the addressed problem area (designing for collaboration) and describing a design method that has been applied to an empirical domain (social network analysis), towards a position where we need to evaluate the meta-artefact in our design (visualisation) in order to assure its utility and rigour. As the social network analysis in this study does not seek to achieve validity claims for the actual network structure of the empirical case onto which it is applied, emphasis concerning rigour will not focus on the empirical interaction data. Instead, rigour will be assessed in terms of the theoretical quality and practical utility of the social network visualisations, according to the design science paradigm. Ensuring social network validity when analysing social interactions in bounded systems like organisations, a very high response rate is required. In academic contexts, Newman (2009) states that a 90 per cent response rate for whole-network studies is expected in order to make claims of validity of the visualisation.

To assure utility of the proposed design method, we need to ask ourselves how it can be applied in practice and whether the expected benefits of the design artefact can be reached. Hevner and Chatterjee (2010) propose an iterative evaluation process to assure relevance, design, and rigour of the design artefact. The first cycle concerns the relevance of the application domain, which in our case means an evaluation of the requirements by field-testing the social network analysis within the LUSEM environment. This has been conducted through an online survey to collect empirical data, and will be evaluated below. The second cycle concerns building, designing, and evaluating the social network visualisation artefact. For this, follow up interviews are conducted with two heads of department at the faculty and is presented below. Finally, the rigour cycle concerns additions to the knowledge base within designing information systems for collaboration. This is analysed in our closing discussion in Chapter 5 where we draw upon our theoretical framework and embark in a descriptive design evaluation method in order to make informed arguments for the utility of the social network analysis visualisations (Hevner et al., 2004).

Evaluating survey instrument and data collection methods

When designing data collection tools for social network analysis, the possibility of measurement error needs to be decreased. Measurement error occurs when expected and observed data does not match, e.g. when data collection design has fixed response choices (Holland and Leindhardt, 1973). In light of this, open-ended survey questions were used in our questionnaire, the design of which is described in Chapter 4.2. Further, Burt et al. (1985) suggest that studying the reliability of the responses made by each participant may assess rigour or the reliability of measures, such as studying the number of connections/ties one node receives. It is important to know what type of social relationship we intend to examine (Marsden, 1990). Our empirical data intends to demonstrate relations and connections of a general nature, which is why the questions in the questionnaire are of

such a character. Marsden (2011) believes that any limitations on the number of relationships a respondent can specify introduces some measurement errors, as the respondent may need to enter more than the number of possible options. We have asked five different questions, where only the first one is of a general nature, we have been able to let the respondents specify more relationships and especially in different relationship contexts. However, letting respondents specify a fixed number of relations not only makes it easier for the respondents themselves (Marsden, 2011), but also for further analysis, which fits well with our ambition to simplify the visualisation. One can question if the survey is completely anonymous even as all names are anonymised in handling and visualising the data to protect individual confidentiality. Performing a social network analysis completely anonymous is essentially impossible but the data collected is carefully managed with full confidentiality.

Another approach to ensure reliability of the data collection instrument as suggested by Marsden (2011) is to carry out two measurements at different times. However, this is not considered feasible in the context of gaining a snapshot overview of an organisation's collaborative network, as such level of reliability is not sought in the design. Further, as noted by Burt et al. (1985) and Wasserman and Faust (1994), the 'truth' value does not change by multiple consecutive measurements unless the research aims to explore a longitudinal inquiry, which could be of relevance when studying e.g. changes in the emerging social structure of organisations when implementing collaborative artefacts, etc. However, as emergence is an inherent of social networks, the approach we take is to design a rigorous method for understanding organisational interaction at a given moment, i.e. as requirements are gathered in the design of information systems.

The questionnaire was distributed in cooperation with the heads of department within LUSEM in an attempt to increase the response rate. This approach backfired as the questionnaire failed to reach every respondent in the population and resulted in a low response rate. The fact that only 45 respondents chose to actively participate points towards a low general interest in completing questionnaires. The heads of department chose to distribute the questionnaire in different ways, in some departments it was distributed through e-mail, in others it was posted on the intranet and in one department it was not distributed at all. In the last case, the distribution of the questionnaire was handled by us, and an e-mail was sent out to the department staff directly.

There seems to be a preconceived notion of what a social network analysis actually is as respondents have mentioned that they did not answer the questionnaire because they are "not using any social media". The misconception of social network analysis being equal to online social media has already been discussed in 1.2 and is one of the issues we try to address in this thesis. The lack of tradition in using social network analysis approach in research within LUSEM, perhaps further contributes to this misconception.

Descriptive evaluation of the utility of visualisations

Analysing collaboration design problems from the subject's point of view is an important perspective in evaluating the social network visualisations, as this provides an indication of the usability of the descriptive and communicative value of the method. As part of our empirical design process to demonstrate the interventionist capacity of a social network analysis, we have interviewed two heads of departments within LUSEM, who in their roles as strategic decision makers for organisational change, possess valuable domain knowledge that is important for determining the relevance of the visualisations. The objective of the interviews is to evaluate the specific potential of the social network analysis approach in the context of the empirical domain, and to take part of the spontaneous impressions of the visualisations. As will become evident throughout the interviews, one head of department is generally positive although critical, whereas the other head of department takes a more sceptical approach, yet constructive. Getting both perspectives enables a more thorough and critical evaluation of the visualisations, which is presented below.

When asked about the potential utility of the visualisations in his role as head of department, the first interviewee states: "What you see best in the pictures are deviations from the norm" (Head of department 1, personal communications), while our second interviewee elaborates on the strategic value of gaining insights regarding the communications within the faculty, as quoted below.

> "I think that from the management perspective, from the leadership of LUSEM, it would be interesting to get a perception about how different things are communicated and where there are weaknesses in this communication. Universities as organisations are a bit special." (Head of department 2, personal communication)

This reflection resembles the theoretical argumentation put forward by Cross et al. (2002) and points to the potential insights of a strategic view of collaborative relationships, where the visualisations provide a basis for unveiling hidden communication structures in organisations. The interviewee refers to the leadership of LUSEM specifically, and indicates that the social network analysis can provide a basis for organising information system interventions to enhance weaknesses in specific communication patterns and how this would affect the faculty as a whole. This view is in line with our argument that there is a need for methods to understand collaboration from an organisational unit of analysis. As the interview progresses, the interviewee further reflects on the potential value of the visualisations in terms of decision making, organisational change, and action.

> "But I think that it could be... and especially when you get organisations that are not as, so to speak, hierarchically structured... that tools like this can provide an understanding of what de facto is happening. And also provide foundations for follow up, and point to where there might be risks of lets say, if a particular person who holds a central position disappears from the organisation, and another person comes in and takes over... there might be a big risk." (Head of department 2, personal communication)

This statement pinpoints the topological value of visualising information exchange through social networks. As we have argued, work in knowledge-intensive organisations (such as LUSEM) is not as governed by formal hierarchies, as knowledge workers are autonomously engaging in non-standardised problem-solving contexts that increasingly require interaction with various people and information entities (Augier et al., 2001; Inkpen and Tsang, 2005). Being provided with structural understanding and insight how work really gets done, or "what de facto is happening" appears as valuable aspects of the social network visualisations for the interviewee. The other head of department reflects on a similar notion by stating: "There are, for example people who without a doubt are outside of the network, but very central to these groupings that keep to themselves" (Head of department 1, personal communications), which reflects the contextual character of academic organisation where scholars can be very specialised in a specific area and do not require nor wish for collaboration with other scholars in other fields within the faculty.

Above, the second head of department mentions how the identification of a central node that appears as bridging two otherwise disconnected heterogeneous clusters of collaboration, is a valuable insight seen as to the degree of interconnectedness of the network as a whole. As identifying individuals who bridge structural holes within the network can have important effect of the performance of the organisation and create competitive advantage (Burt, 2004), this appears as a valuable insight by sheer glimpse of the visualisations. Similarly to Haythornthwaite (1996), this insight describes how such identification can be a foundation for putting in place positions and structures to facilitate information delivery between people and groups to reduce the risks of fragmentation, as well as enhance the organisational capacity of innovation and learning.

This points to a shared appreciation of structure/agency relationship (Giddens, 1984). As individual behaviour, social exchange, and work relationships are assumed to be structurally embedded in wider social networks (Granovetter, 1973), imposing agency change is expected to change the overall structure. As exemplified by the second head of department: If a central person in the organisation were to leave this would thus affect the information flow through that structure as a whole (Scott, 1988). A similar concern is expressed by head of department 1, who elaborates on the cause and effect of the structure/agency dynamic of the people with central roles at LUSEM, as quoted below.

> "What is the density of contacts within each department, does it differ significantly? What would happen if you removed one or more key people, how will it hold up" (Head of department 1, personal communication)

Although being sceptical of the level of detail of the visualisations, an interesting observation is the curiosity triggered by the social network and the character of the counter questions asked by the interviewee. When asked whether there is any potential utility of the visualisations, the interviewee responds by stating "I can find things but there is nothing that [strikes] me directly", and continues by asking:

> "This is a component for understanding this. So I am missing a lot of very descriptive statistics of this, of various types. For example, how many links there are, how many links there are between the various colourful figures, how many links there are between departments?" (Head of department 1, personal communication)

The presentation and level of details of the social network characteristics in this thesis is restricted according to what is deemed of relevance for designing for collaboration, and with respects to the capabilities expected for information systems designers. While the interviewee clearly demonstrates a wish to be presented with a more detailed quantification of the social network analysis, this can be provided by the empirical interaction data and analysed by social network theories, however is beyond the scope of presenting the descriptive design processes and artefact knowledge sought after in the context of this study. Further, the following is reflected upon.

> "There are groups, they are connected to each other so it is not like any large group is completely hanging in the air. There are [...] more central people than less central people. It is pretty good [that] an organisation that is not dependent on individuals. [...] The large [nodes] have a good spread." (Head of department 1, personal communication)

When interpreting these statements, it is reasonable to argue that the interviewee shifts between the administrative role as head of department within LUSEM, and the academic role as professor. While initially, and perhaps intuitively, displaying a spontaneous scepticism towards the qualitative approach to analyse the social network data through visualisations rather than through quantified formulae, the interviewee eventually reflects on the topological characteristics of the organisational interaction at LUSEM above, although reluctantly. Head of department 1 reflects upon that the overall network of the organisation appears to be well connected without any evident risk of fragmentation. This is an indication that there is an even distribution of central people in the network and the positive consequences of avoiding over-utilised 'bottlenecks' (Cross and Parker, 2004).

Below, head of department 2 reflects on the ambition of LUSEM to conduct interdisciplinary research across the departments. The interviewee points to an important limitation of the social network analysis, i.e. its restriction of only considering collaboration within the boundaries of the organisation and does not, as designed in this thesis, take inter-organisational collaboration into account.

> "I think, when it comes to research, it is very diverse how... I think you can do such an analysis, but, what does it say? One could perhaps, as shown here that there are groups that are very specialised, and have very limited collaboration with others at LUSEM, but perhaps have collaboration with other researchers in, for example, Canada. But then again, there are research projects that involve people from the different departments, and there are different research institutes, such as the Institute of Economic Research." (Head of department 2, personal communication)

Reflections of this character, we argue, are of important utility for understanding structural, although not detailed, characteristics of organisational interaction. By adopting a social network analysis approach, as shown through the descriptive knowledge retrieved from the design artefact by the interviewees, information systems designers are harnessed with important problem-solving capabilities in terms of getting an overview of the faced collaboration problem. Although, as expressed by both interviewees, the visualisations are restricted in terms of the contextual aspects of an interconnecting tie between two persons in the network, and thereby lacks the nature of the collaborative relationship. Head of department 2 further discusses the restriction of the method.

> "I think that such a visualisation can be helpful and valuable for organisations. Although, one needs to keep in mind that it represents peoples' perception of things, many times people regards some things higher and other things lower, which means that one perhaps need to complement this with something else." (Head of department 2, personal communication)

As we have argued repeatedly, and as voiced by the interviewee, social network analysis in itself can only provide an overall abstraction of the emerging collaborative relationships that are formed as people interact in a network (Wasserman and Faust, 1994). In order to gain contextual insights of the collaborative relationships, designers need to complement their analyses with phenomenological inquiries. For example, in order to determine whether a person who appears to be a prominent character in the network actually is one, the nature of the relationship needs to be contextualised. By understanding the context of the person's position, it can be determined whether that person is an 'unsung hero' or a 'bottleneck' (Cross and Parker, 2004). Later in the interview, despite being aware of the important restrictions of the social network analysis approach, the interviewee reflects on the potential of using the method in the role of a consultant and having scarce resources in terms of money and time.

> "I also think, what we know is that many are pressed for time, so the question is that if one can find things that enable doing things smarter, in different aspects, and if one look at the small questionnaire that you used, it did not take many minutes to do. That enables a lot of time saving. And that provides, given that participants have not sacrificed a particularly big effort, can be something that is valuable. [...] When you work as a consultant, many times it is about getting an idea of how the organisation that you are working with is structured, how it looks like. Usually, it takes a lot of time to acquire such knowledge, and then this method [social network analysis] can be a way to get that overview in a efficient way." (Head of department 2, personal communication)

The final statement agrees with the propositions put forward in this thesis, and captures the justification of performing a proceeding social network analysis in designing for collaboration. Through this empirical evaluation of the design artefact, which in the context of designing information systems takes the role of a meta-artefact of any future instantiation of technology artefacts, the utility of social network analysis has been critically discussed. Although having several restrictions, our argument

that the method can be used to describe, understand, and explain organisational interaction on a structural level has been empirically strengthened. A concluding remark of this utility evaluation is that social network visualisations are considered useful in designing for collaboration, however, they raise more questions than they provide answers for, and can thus be used as a trajectory of making more informed design decisions and show where subsequent in-depth inquiries are required as a way forward.

5. Discussion

A series of empirical visualisations have been presented and theoretically analysed based on our study of the organisational interaction at LUSEM. The visualisations have been empirically evaluated in terms of their practical relevance by interviewing two heads of departments, which leaves us in a position to discuss the overall results of our study. According to Hevner et al. (2004), existing theories are extended when the constructed artefact is applied to its environment by evaluating its relevance and rigour. How can the social network analysis approach as a method be understood as process-design knowledge in designing for collaboration (design thinking), and how can the descriptive design utility of the visualisations be evaluated to expand the boundaries of the existing theories of understanding organisational interaction (design artefacts)?

We have showed that the social network visualisation can be used as a snapshot to describe, understand, and explain organisational collaboration. Following our initial problematisation, we identified theoretical gaps in the literature by arguing that there is a need for information systems design theory that describe methods in order to specify collaboration needs on an organisational unit of analysis. We argued that social network analysis has promising potential that has yet to be fully utilised, with its focus on visualising actors' interactions and the emerging structural patterns through which they are interconnected by a variety of relationships. This led us to the research question:

How can social network analysis be used to describe, understand, and explain organisational interaction in designing information systems for collaboration?

In this final part, we will discuss the key learning points of social network approach in designing for collaboration, and critically evaluate its implications for research and practice. We set forth by discussing the chosen methodological approach, and precede by analysing collaboration design implications by drawing upon the results of the study. We summarise our findings in a *theory of collaboration design*.

5.1 Methodological Discussion

This design science study is 'methods heavy' in the sense that its theory also functions as a methodology, and in the sense that the object of its design is a methodology. This is an observation that is also encountered by Borgatti and Lopez-Kiwell (2011, p. 49), who notes that "a frequent confusion about network research has to do with where theory ends and methodology begins". To overcome this somewhat transcendent boundary, which we chose to call a 'grey area', a necessary recapture of how we view collaboration phenomena, i.e. a reflection of the ontology of our inquiry. The structural level of the social network view of organisations provides a pragmatic lens to describe how actors are interconnected in networks (Borgatti et al., 2009), which is beneficial when designing information systems seen as socio-technical systems (Appelbaum, 1997). From our empirical analysis the

discrepancy between the visualised social network analyses and the organisational chart or our empirical case is made evident, which advocates the value of a network ontology in efforts to understand organisational interaction.

From a design science perspective, succeeding from our theoretical framework we are harnessed with a theoretically grounded design toolbox as we approach collaboration design problems. With additional episteme, we can understand emerging patterns of collaborative networks that is constructive for a more effective and informed design. Being in the position to explain empirical observations by theoretical concepts like degree, closeness, bridges, structural holes, broker and eigenvectors in organisations, enable a richer understanding for subsequent design implications, as well as the organisational consequences of that design. The aggregate theoretical analysis and the social network visualisations provide a meta-artefact that when applied to a collaboration design domain expands the boundaries of our knowledge of how we understand organisational interaction (Hevner et al., 2004). To clarify this at times perplexing epistemology of design artefacts, we adopted Popper's (1978) ontology of viewing reality as three interacting worlds. In line with Iivari (2007), we found this a useful representation to conceptualise information systems design. In Figure 13 below, we discuss the results of our design study by drawing on the social network theoretical framework and depicting its application in the development of an instantiated collaborative technology artefact.

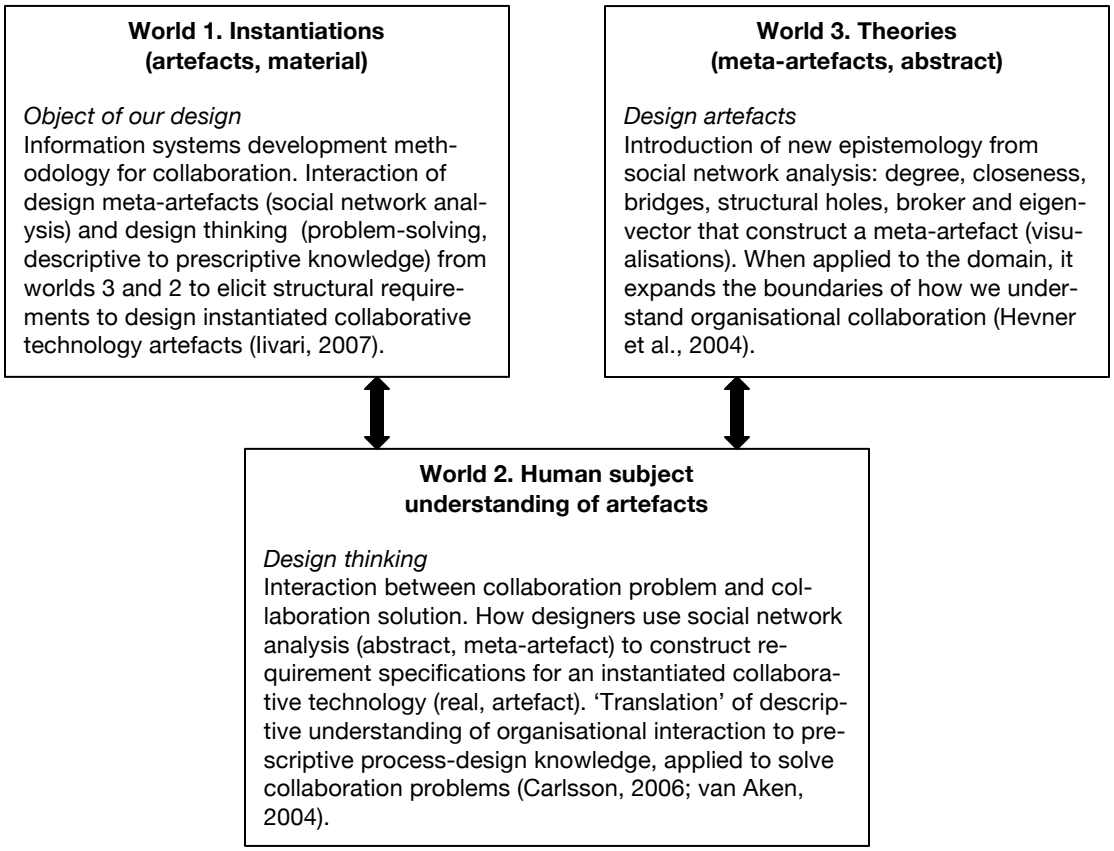


Figure 13: Converging epistemologies: Relationships between design artefacts in designing for collaboration (Adopted from Gregor and Jones, 2007, p. 321)

Importantly, the social network approach provides both process-design knowledge prescribing ways for designers to think as they approach collaboration problems, as well as descriptive meta-artefacts that can be utilised to elicit structural requirements for the design of collaborative artefacts. We argue that the versatile utility of the social network approach is of significant importance for research and practice, as it harnesses information systems designers with an innovative toolbox to understand organisational interaction that otherwise would be difficult to illustrate. Relying on subjective approximations of these structural aspects could have serious implications for the design/implementation of e.g. enterprise social software for collaboration, as it would not recognise hidden collaboration needs in organisations. In the next part, we descend a few levels of abstraction and proceed by in detail discussing the practical design implication of this ontology of collaboration, and ways information systems designers can apply it.

5.2 Understanding Organisations Through Social Networks Analysis

Looking back at Gregor (2006) and the interrelationships in the application of social network analysis (Figure 4) there are different possibilities in using social network theory in design science. When looking at the *theories for analysing* and *theories for explaining* collaboration in organisations (Table 5;

Figure 4) there are sometimes ambiguous implications of the social network theories that are context specific e.g. when looking towards degree centrality there could be implications for and against changes in the information system depending on which level of analysis is represented by the visualisation. This is both a benefit and a weakness in using social network analysis. The level of analysis will highlight different objects of interests, and shifting between the behavioural and structural levels can provide a fuzzy conception of the faced design problem area. First, there is a need to understand the complexity of a social network by drawing upon our proposed design propositions as suggested in Table 5 below, as without this preceding analysis the constructed visualisations merely represent a bird's eye view of the organisation. This might be of topological interest but lacks important contextual depth.

The social network theories used to analyse and explain are related to the implications for information system interventions, i.e. what the theories say in general about the social phenomena behind the structural properties. Invisible and informal structures within organisations are made visible through social network properties like degree, closeness, bridges, structural holes, brokers, and eigenvectors. The information exchange within the communication network form patterns of interaction within the network boundaries. Looking at an organisation as a dynamic evolving network where people constantly find new ways of collaborating can help information systems designers to improve information paths by locating positions and structures to facilitate information delivery between people and groups. Harnessing the communicative capabilities of social network visualisations in combination with understanding the emergence of social network structures can lead to enhance organisational innovation and learning.

Table 5: Theories for analysing implications for information system design

Properties	Implications for design and action
Degree Centrality	Can be used to identify focal actors who are exposed to information overflow. These actors can become bottlenecks in an information system in which case an intervention has to be performed. On the other hand actors with a low degree centrality are potential underutilised resources that can be used to distribute the information flow more evenly within the network.
Closeness Centrality	Can be used to study formal and informal information flow patterns that can be of interest when looking at optimal information flow routes. Has bearing when trying to identify influence through distinguishing personal and professional networks within the organisational context. Low closeness indicates positions with access to novel information early, when it still is novel.
Bridges	A bridge can be both positive and negative when it comes to spreading innovation. On one hand a bridge separates groups with different information needs in the network, increasing efficiency and preventing noise. On the other hand interconnected networks are optimal for the spread of innovation.
Structural Holes	Structural holes are areas within a network where the flow of information has been cut of intentionally or unintentionally. Finding and managing structural holes has implications for controlling information flow. Structural holes are created to reduce redundant information flow but at the same time create a unbalanced power structure.
Broker	Actors that have a brokerage role within a network control information flow between groups. Pinpointing brokers and the type of brokerage role can help in identifying the eventual need for restructure of the information system. As with degree centrality brokers can be sensitive to information overload, therefore if it is in the information systems best interest to keep the broker role, a possible implication can be to introduce a tool to help facilitate information flow.
Eigenvector	Actors with high eigenvalue are hard to identify nonetheless they are of great importance when determining what type of influence an actor has within the network. Prominent actors can be used to identify the actual influence in the network. This can be of importance when trying to find the starting point for an information system overhaul.

5.3 Theory of Designing Information Systems for Collaboration

We argue that designers and decision makers can leverage innovation capabilities by understanding collaboration problems in organisations. To search for explanations of the organisational collaboration problems and to determine whether the problem is related to collaborative technology, communication routines, or both, we need a theoretical framework that enables a holistic view of social networks – in short a theory of designing information systems for collaboration.

We have developed a *theory for design and action,* that is we claim that social network analysis can be used in the early stages of information system interventions to elicit a 'map' over the network that constitutes the organisation. The 'map' can thus be used together with the theories for explaining social networks creating an insightful and innovative foundation for decision making and providing important insights, plotting a trajectory when designing for collaboration. Our study provides both descriptive collaboration knowledge from the design artefacts as well as prescriptive design thinking

in terms of its methodology. In Table 6 the eight components of our theory for designing information systems for collaboration is summarised using a framework by Gregor and Jones (2007).

Table 6: Eight components of a theory for designing information systems for collaboration (Adopted from Gregor and Jones, 2007)

Component	Description
1) Purpose and scope	Within the boundaries of an organisation, the theory can be used as a problem solving method in its capacity to provide a map over an organisational collaborative network. It can also be used to identify and provide theories for analysing and explaining certain social phenomena related to social networks. Finally it can be used to design information systems for collaboration.
2) Constructs	Visualisation, models, words
3) Principle of form and function	The theory uses a multi-level method for constructing a social network snapshot through social network analysis: (1) Construct a name generating survey (2) Analyse results and present visualisation (e.g. with netdraw) (3) Use social network theory to identify areas of concern.
4) Artefact mutability	Providing snapshots of social interactions within organisation can be viewed as an evolutionary trajectory in designing for collaboration. The emergence and coexistence of technology artefacts induce a state of constant change and social interaction data over time can be used as historical performance measure.
5) Testable propositions	Following our theoretical framework of the social network characteristics and the empirical visualisations, collaboration design propositions are provided in Table 5. As the visualisations are limited to the scope of the organisation, they cannot be generalised to all contexts but the theory provides an approximation to what will work in various areas of interest.
6) Justificatory knowledge	The 'kernel theories' originate from social network theory (e.g. centrality, structural holes, eigenvector, strength of ties) and organisational studies (e.g. collaboration and spread of innovation).
7) Principles of implementation	To conduct a social network analysis and elicit useful information from the visualisation the analyst needs to be equipped with a theoretical toolbox and experience in using social network visualisation tools like NetDraw.
8) Expository instantiation	Multiple visualisations are presented with a least one visualisation per social network property. These representations are for evaluation purposes.

5.4 Conclusion

We set forth by asking ourselves what potential utility value the social network view of organisations has for designers. In particular, we hypothesised that this view could prove purposeful for the design of information systems that aim to leverage the collaborative patterns of relationships that emerge in knowledge-intensive contexts. This point of departure was theoretically motivated by Nardi et al. (2002), who show that the ontological view of collaboration conventionally adopted by designers poses some problems as the unit of analysis tends to be limited to a group level. A social network ap-

proach was suggested as an alternative conception in the design for collaboration, as the design artefact constructed through a social network analysis would expand the boundaries of our understanding of organisational interaction and thus provide a solution for the presented problem. The background of this proposition stems from the fact that social network analysis originates from social behavioural science, and the adoption of its methodology would not only inform an effective design but also offer theory for explaining collaboration problems.

Through our design inquiry, we have been able to demonstrate how social network analysis can be of important utility for information systems designers for a number of reasons. In terms of design thinking, we have defined a time-efficient data collection method by constructing an online name generating survey instrument that occupies a minimal effort for respondents, and provides seamless sociometric interaction data that reflect collaborative work relationships within boundaries of organisations. The efficient capability of the design process knowledge harnesses particular utility for practitioners, and still provides in-depth insights through the suggested design propositions.

In terms of the design artefact, we have shown that social network visualisations of collaborative relationships provide communicative value for decision makers, and are useful in terms of understanding organisational interaction and justify interventions and investment in collaboration. Social network visualisations represent a snapshot of collaborative interaction, and provide important understanding of emergence for information systems designers that can be viewed as an evolutionary trajectory in designing for strategic collaboration. Through our evaluation, we have shown that social network visualisations are insightful and inspire decision makers for further analysis and thereby constitute trustworthy foundations to drive continuous change and innovation.

On a closing note, by conceptualising the design thinking and the design artefact propositions put forward in this thesis, information systems designers are harnessed with a method to gain structural understanding of organisational interaction that can function as an important trajectory in making informed and focused interventions. This positions social network analysis as an emergent compound in collaboration design inquiries with the intention to enhance innovation capabilities through improved collaborative networks.

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Appendix A: Questionnaire

Dear Participant,
The purpose of this study is to use social network analysis to visualise and support organisational communication, collaboration and development.
For each question, you are asked to name people at LUSEM that you interact with. For each question you can answer from zero up to five names. All names will be assigned a random number and thereby kept anonymised in the social network. Please enter both first and last (sur-) name. Note that you might not be able to answer all the questions.

Your participation is voluntary and all responses will be treated confidentially. Your e-mail address will only be used as a unique identification and will be anonymised.

We appreciate your quick response; please fill out the form before April 19, 2013. If you have any questions or want to know more, please go to this page http://bit.ly/14EYpDz or contact us at:
Kristin Olsman, 0736 12 72 73, Kristin.Olsman.961@student.lu.se
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- - - - - - - - - - - - - - -

E-mail (at LUSEM):

I want to recieve a short summary of the study. (Will be sent out in June, 2013)

- ○ Yes, please.
- ○ No, thank you.

1. Thinking back over the past month, and considering all the people at LUSEM; i.e., my superiors, subordinates, and people at the same level as myself. These are the (0-5) people with whom I have spent the most time on work matters.

Person #1
Person #2
Person #3
Person #4
Person #5

2. In my research, I mainly collaborate with these (0-5) people at LUSEM.

Person #1
Person #2
Person #3
Person #4
Person #5

3. If I need to discuss educational related issues at LUSEM, I mainly turn to these (0-5) people.

Person #1
Person #2
Person #3
Person #4
Person #5

4. If I want to see an organisational change within LUSEM, I mainly turn to these (0-5) people.

Person #1
Person #2
Person #3
Person #4
Person #5

5. When I need administrative/technical support, I mainly turn to these (0-5) people at LUSEM.

Person #1
Person #2
Person #3
Person #4
Person #5

Submit

Appendix B: Interview Transcript 1

Interview transcript with head of department 1, 10 May 2013, at Holger Crafoord Centre. Duration: 1 hour 15 minutes

In your role as head of department at the LUSEM, what value could these visualisations provide in your job to development organisations?
I think it is important. I have looked at the figures, I think it's good to visualize in that way, no doubt. But I do not have numeric values on anything and I would recommend that you have that. Visualisation is important, no doubt about it. I think it may not be done by just to drawing these [visualisations]. This is a component of understanding this. So I am missing a lot of descriptive statistics of this, of various types. For example, how many links there are, how many links there are between the various colourful nodes, how many links there are between departments? So if we summarise an institution with a colour then one may wonder how much does department A communicate with department B. What is the density of contacts within each department, does it differ significantly? What would happen if you removed one or more people who are key, how will it hold up? It is fun with these colours and with these presentations and it can be a good addition, but if one were to summarise organisations, only with these [visualisations], it is difficult to get an honest impression. Then you could, for example, look at nodes and classify them, for example with age, and what is the relationship between people of certain ages.

How would age to be interesting?
Well, for example, are there contacts mostly between people of the same age? I know, you have a very thorough analysis of problems of social networks. That may be interesting, but at the same time, it is a method that might not be so controversial and it is most what one gets out of this what would be the main point, as I see it. So, you've got these structural histories. There's nothing wrong with it, I think it's great. But there is not a single number on anything.

In our case, that is because of two things. The first is that we try to see if we can use it in a way that we want to, that is a visual overview that can be used as perhaps the first step in a requirements analysis, or requirements specification. And the other thing is that we have not enough data for it to use numbers.
I do not think that one resists the other, I think it's good with visualisation, there is nothing wrong. But only visualisations will not be linked with anything. It is the visualisation that can lead to something that you see and perhaps you could clarify it or describe it more. In order to, what should I say? It is very general about theories of social networks. I think that if you collect data you should you squeeze it out.

In the role of an organisational developer, could you use this representation in some way?
Well, of course, but I need to know in what direction these links go and who responded and who did not respond.

You said yourself that the visualisations could be a complement; in what way would they be able to compliment your work as head of department?
[…] I do not know if I can get something out this. I understand your anonymity problem and to remove links or to remove anonymity then you are in deep water. […] No I do not know if I can draw some conclusions. I mean, the main conclusion I can draw is to this group [to the right] who stays primarily to themselves in some... I do not really know, I can not offhand determine something special here. There are some central people and there will be quite a few contacts anyway [if you remove the central ones], but in what direction it

goes... If it is just a central person. Well, no I do not really know. If you have had [directed] links, maybe you could see something more.

One can yet see that it is a rather dense network, just as like it is at the department and the university in general, which goes well in hand with academic departments or departments of research, where it is more interconnected than other organisations ... and that is what we have found support for. From a communications perspective, it would have been interesting to find out how dependent a node is to the connectors that go out from this group: are they there for a reason, is it because you do not want a 100% free information flow or is it just because it has become so organisationally?
Yes, there may be several key persons and heads of departments and director of studies has access to the outside. But then the question is, what would happen if we took out these central characters? […] Moreover, one should be careful of removing these, because you can not remove those [central] functions. Because, this is a central person but it is a director of studies, should you take him away? Then they have no director of studies. So the question is, this anonymity defends it a little bit, which people are not holding any formal functions that are central in the network? There are, for example people who without a doubt are outside of the network, but very central to these groupings that keep themselves to themselves. Also interesting is this with the degree, it is interesting to look at the degree and it should be related to the entire network and then the isolated structures. There is very good visualisation and one... Then, in terms of information flow, it is good to have [directed links in the visualisations] because it can go from here and there, but not the other way one. […] It is of course sensitive to small institutions to have this, but for large organisations, it would have to be interesting to see how they behave […] What you see best in the pictures are deviations from the norm. […]

So you think the visualisations in itself is fine but lacked some statistics behind them, some numbers.
And some analysis. The numbers tell a lot more than just what shown and you should try, as far as possible, to return to the original data and not directly make it to [visualisations] here as you do. You have symmetrised all, which in graph theory is also a bit sensitive... You have done a 207 times 207 matrix. One can get a lot of fun with very simple methods and very interesting interpretations of organisations by doing little things that I suggest here. […]

It's a little difficult to be specific on the departments but can you find three areas that would have been interesting to look more closely at, based the visualisations?
I do not know if there is a problem though, there are groups who keeps to themselves, but the question is how much, what kind of groups, what have they responded.

Yes, exactly. If you were to sit with this as a first step to go in and make an organisational change, then you could say "yes but they are groups had been somewhat interesting to look upon" or "the this place had been a bit more interesting ... "
Not without more data and not to these blue and green odd things... I would like to see if this person, who replied, if they did not care about it – it's very likely. Then as I said, I want to look at how many connections there are between different departments. You can count them, but it's hard to see it in the visualisation. So, I need a little more... […] If we do not focus on departments, but look at it as a one whole organisation.

Had you been able to find anything there that was of interest?
But it you can not do that, because you can immediately see that there are groupings.

Yes, but within a larger organisation, there are the smaller groups where some kind of interactivity and communication occurs. But if you see it from a wider perspective. We are not trying to see how the communication between departments is, but within the overall network, what it looks like.
These here that have the most connections they may not be connected to each other... Oh, yes they are... I can find things but there is nothing that beats me immediately. If you take away the colours. There are groups, they are connected with each other so it is not like any large group is completely hanging in the air. There are more central people than less central people. It is pretty good with how many contacts one node have, so it is an organisation that is not dependent on individuals. Especially the big [nodes] have a good spread. The bigger the closer to...

Yes... for those furthest away.
[…] It's not that much contact here [between department A and B].

No, could it be a problem? Purely strategically?
Well I think that it might be possible to interpret it like that. As you can see, you have written a whole thesis without a single number. That's tradition in informatics, that the numbers are second. Words should flow. […] So to answer your question, it's a little hard... I mean, I know what you want me to say. There are things that are not connected and there are things that are separate and there is no communication paths and so on. I understand that you have such thoughts. If it should it be serious... I mean this with a table, and then you do not even ask me, you can see that there are relatively few connections between, them and them *[pointing to the plotted chart].* You do not see it as a problem. One can probably tell that there are not so many connections. Then there is always the question of how does one relate to the number of connections. There can be very few connections here *[pointing at a group in the network]*, but they are so much bigger. But in worst case you can make a small table. It feels like, it is the central people who are close to many in most cases. […]

Is there anything that you would like to work with as method at LUSEM? Would it have been interesting to work with organisational development, by making a social network analysis
Mm, yes ...

People talk a lot about that it should be cross-border research and so on. Is it possible to somehow portray that through this kind of analysis?
It may be part of the analysis, but as I said, then you have to refine the method and have a better response rate. […]

Appendix C: Interview Transcript 2

Interview transcript with head of department 2, 13 May 2013, at Holger Crafoord Centre. Duration: 40 minutes

In your role as head of department at LUSEM, is there a descriptive value in using these visualisations?
Yes, absolutely. Many years ago we did a study of knowledge management where we did a similar analysis. We went out to an organisation with similar questions as your survey, and also looked at what medium was used, and we separated it in terms of inform somebody, or collaborate with someone, etc... And from this we could see the consequences of this, and they could also value the interaction. I think that such a visualisation can be helpful and valuable for organisations. Although, one needs to keep in mind that it represents peoples' perception of things, many times people regards some things higher and other things lower, which means that one perhaps need to complement this with something else. If you look at computers one can de facto log things, e-mails etc., which can be matched with peoples' perception of the same.

Exactly, we have chosen not to look at that kind of data in this study, but it is like you say, it is a complement.
But I think that it could be... And especially when you get organisations that are not as, so to speak, hierarchically structured, that tools like this can provide an understanding of what de facto is happening. And also provide foundations for follow up, and point to where there might be risks of lets say, if a particular person who holds a central position disappears from the organisation, and another person comes in and takes over... There might be a big risk.

We are trying to argue that this can be a first step in driving through organisational changes, and viewed as a concretisation of information systems development, there are different ways to visualise and model a business, but these are tools that one normally use after analysing the organisation. This is a tool that, we argue, can be used as a tool before analysing the organisation...
I also think, what we know is that many are pressed for time, so the question is that if one can find things that enable doing things smarter, in different aspects, and if one look at the small questionnaire that you used, it did not take many minutes to do. That enables a lot of time saving. And that provides, given that participants have not sacrificed a particularly big effort, can be something that is valuable. [...] When you work as a consultant, many times it is about getting an idea of how the organisation that you are working with is structured, how it looks like. Usually, it takes a lot of time to acquire such knowledge, and then this method [social network analysis] can be a way to get that overview in a efficient way.

How did you experience the questionnaire?
It was a while ago, but it went fast and it was simple to fill it out.

Why do you think we only received 45 responses?
The situation is that we receive, or I receive, requests to fill out questionnaires, perhaps not daily, but at least, quite often. The other is that, when you wish to get responses, then you have to make sure that respondents get some value back, or if the area is something that they are enthusiastic about. So, I can imagine that many did not care so much about this... But I think that from the management perspective, from the leadership of LUSEM, it would be interesting to get a perception about how different things are communicated and where there are weaknesses in this communication. Universities as organisations are a bit special.

We noticed this, not at least how well interconnected things are. Many individuals, whether they are researchers or administrators, the network is well connected.
Yes, and another dimension is that there are many committees, there are boards for LUSEM, there are councils for heads of departments, research, research education, basic education, equality, there are quite many groups, and in every group there is often one representative from each department.

So this makes it more interconnected?
Yes, and the councils for heads of departments, we meet every other week, and there is a lot of knowledge sharing during these sessions. If something very successful has occurred in a department, this is shared during these meetings, and the same if some problems have occurred, these are things that are discussed during these meetings.

How to view the ambition of LUSEM to be an interdisciplinary business school?
Haha, well, as you say, it is important in the sense that there is an external pressure that it should be interdisciplinary, we are going through various accreditations and the like, and there are criteria that point to that there should be overarching strategies for the entire school, and that it should fall down on the departments. And then there's a wish from the school itself that one thinks that we will get better... through, you know interacting in a good way. But, it is often up to each individual to do these things addition to things like being head of department, or part of committees, etc.

If you are teaching at one department, and want to collaborate with another, is it up to oneself to take that initial contact?
Yes, and additionally there are directors of studies who are responsible for this, and there are committees for basic education, for advanced education, and a small group with representatives from different departments who look at these things. But it is not only bottom up initiatives; there is also a wish from the management of the school that there should be this kind of collaboration... Now, these things work so and so, and there is also the financial factor, if we need a lecturer from a different department this is charged between the departments.

How do you view social network analysis as a method to evaluate the extent of how interdisciplinary the research at LUSEM is?
I think, when it comes to research, it is very diverse how... I think you can do such an analysis, but, what does it say? One could perhaps, as shown here that there are groups that are very specialised, and have very limited collaboration with others at LUSEM, but perhaps have collaboration with other researchers in, for example, Canada. But then again, there are research projects that involve people from the different departments, and there are different research institutes, such as the Institute of Economic Research.

Could a social network analysis be used to, if higher response rate, that these institutes exist?
Absolutely, this is a used to analyse our research field, scientific collaboration, and used to identify peripheral researchers and very central ones who have very many co-authors.